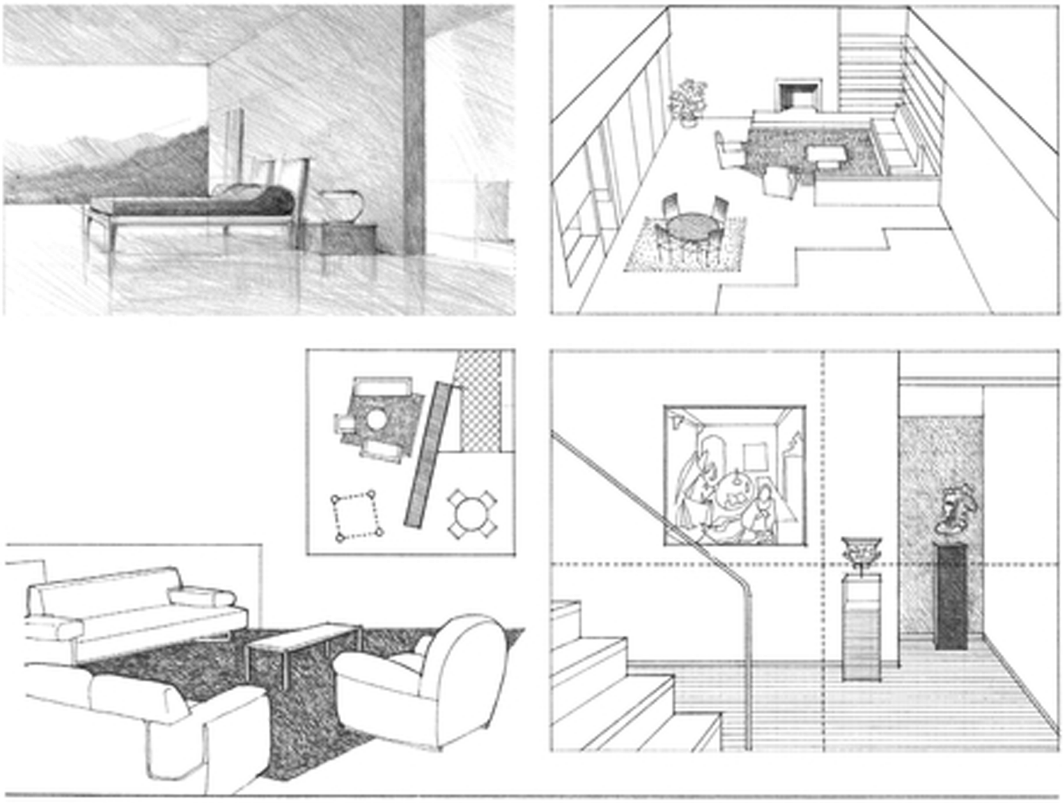
FRANCIS D.K. CHING

CORKY BINGGELI

# INTERIOR DESIGN ILLUSTRATED

FOURTH EDITION



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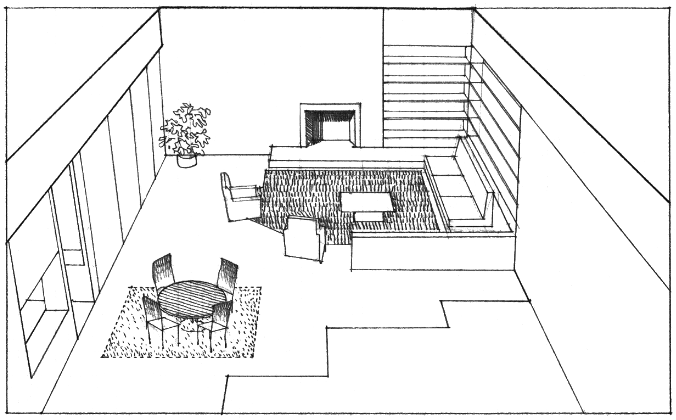
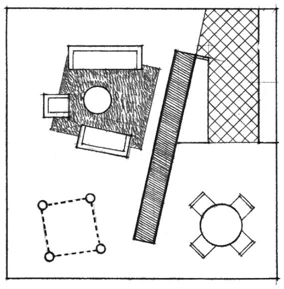
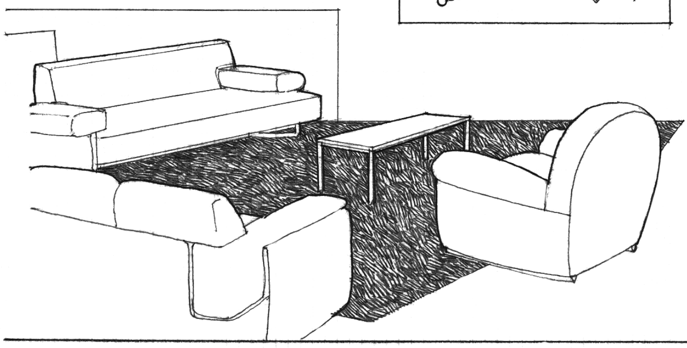
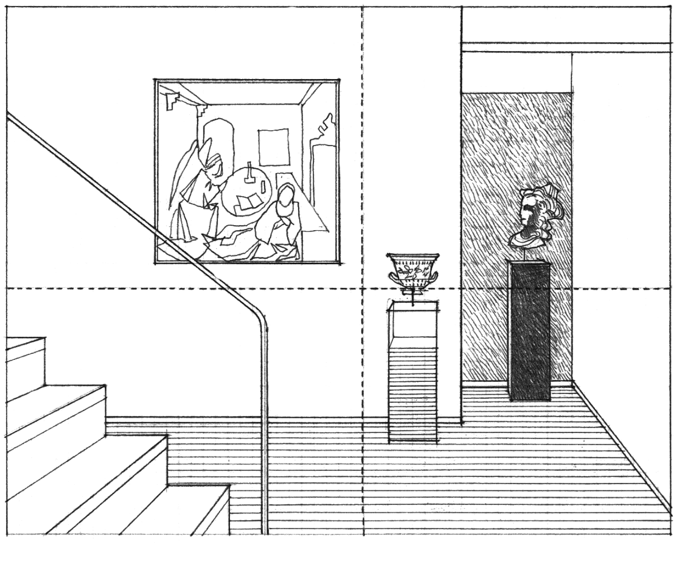
# INTERIOR DESIGN
## *Illustrated*

*4th Edition*

Francis D. K. Ching · Corky Binggeli

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# CONTENTS

# PREFACE

We spend the majority of our lives indoors, in the interior spaces created by the structures and shells of buildings. These spaces provide the physical context for much of what we do, and give substance and life to the architecture that houses them. This introductory text is a visual study of the nature and design of these interior settings.

The purpose of this primer is to introduce to students of interior design those fundamental elements that make up our interior environments. It outlines the characteristics of each element and presents the choices we have in selecting and arranging them into design patterns. In making these choices, emphasis is placed on basic design principles and how design relationships determine the functional, structural, and aesthetic qualities of interior spaces.

This fourth edition retains the organizational scheme of the third edition, with text and illustrations updated and added to cover sustainability standards, resource usage, and recent developments in the design of interior spaces. The section on lighting reflects current design practice, lamp and fixture styles, especially the growing use of light-emitting diodes (LEDs). The coverage of furnishings responds to changes in the work environment. New residential topics include accessory dwelling units (ADUs) and touchless kitchen faucets, among others. Standards and codes incorporate current International Code Council (ICC) and Americans with Disabilities Act (ADA) requirements. Finally, the Bibliography and Glossary have been updated.

This exploration of the ways and means of developing interior spaces begins with space itself, for it is the prime material with which the interior designer must work.

**Chapter 1: Interior Space** proceeds from a general discussion of architectural space to the particular characteristics of interior space in three dimensions and introduces the components of a building. The adaptive reuse of existing buildings and movement within buildings are addressed.

**Chapter 2: Interior Design** outlines a method for translating programmatic needs and requirements into three-dimensional design decisions. Interior architecture is introduced, as well as designing in existing buildings and historic preservation. The use of artisanal products and resiliency is addressed. Topics including design for an aging population and for children are covered, as are coworking spaces. Sustainable design rating systems and standards are updated as well. Three-dimensional printing and virtual reality are also introduced.

**Chapter 3: A Design Vocabulary** explores the fundamental elements and principles of visual design and applies each of them to the unique field of interior design. New information on photoreceptors in the mammalian retina and strategies for creating emphasis by using lighting and color together are presented.

**Chapter 4: Interior Building Elements** describes the major categories of interior elements and discusses how each affects the functional and aesthetic development of interior spaces. New options in glass wall systems and the importance of views of nature are introduced. Coverage of elevators is expanded to include machine-room-less (MRL) elevators.

**Chapter 5: Interior Environmental Systems** outlines the environmental control systems that must be integrated with a building's structure and the layout of the interior spaces. The role of the interior designer in educating the client about building systems is addressed. Updates in the types of plumbing fixtures are added, as is information on wireless electrical systems. Information on problems with flame retardant chemicals is also included.

**Chapter 6: Lighting and Acoustics** addresses the lively and ever-present interaction of light and sound with the interior environment. Recent changes in the process of lighting design and daylighting are addressed, including the increasing use of LEDs and lighting controls. Changes in the use of incandescent, fluorescent, and high-intensity discharge (HID) lamps are also covered. Current changes in the lighting industry are discussed. The integration of acoustical design into interior design practices is included, as is the importance of acoustic privacy and sound masking.

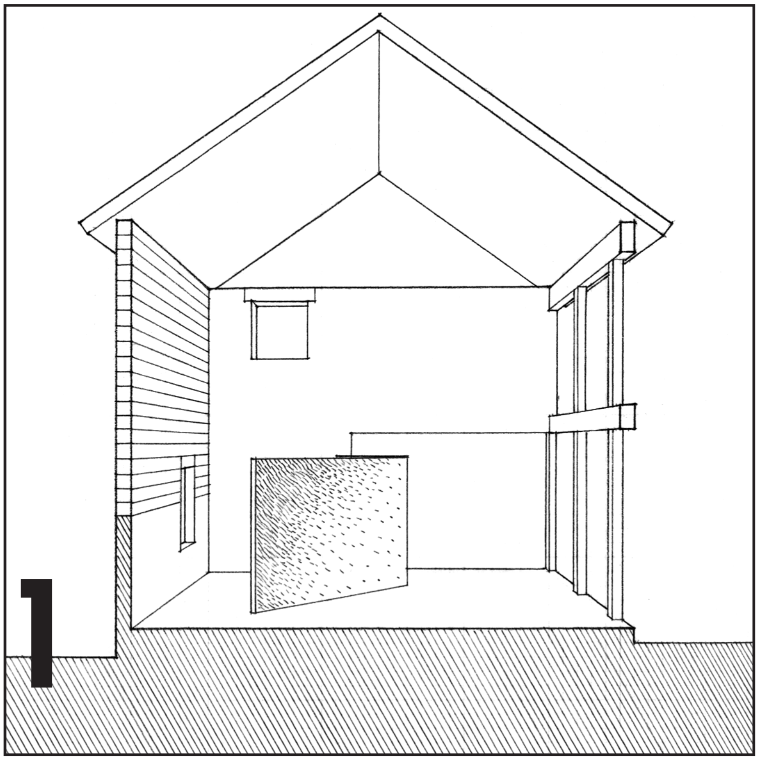
**Chapter 7: Finish Materials** introduces the palette used by interior designers to modify the architectural elements of interior spaces. Consideration of functional criteria is expanded to include hydrophobic properties. Finish flooring covers electrostatic discharge (ESD) issues. Coverage of bamboo flooring, terrazzo, and carpet cushions is expanded, and information on carpet recycling is updated. Coverage of composite wood panels, particleboard, medium-density fiberboard (MDF), and vacuum-formed 3D panel products and solid surfacing materials is added, and information on lead paint is expanded. Ceiling finish coverage now includes canopies and clouds.

**Chapter 8: Furnishings** discusses basic types of movable and built-in components within the built environment. New topics include coverage of furnishings manufactured to cross the residential/commercial barrier, and those designed to avoid undesirable materials, along with other subjects, such as Health Product Declarations (HPDs), sit-stand furniture, innovations in solar shading, and artisanal crafts.

Since interior design is to a great extent a visual art, drawings are used extensively in this book to convey information, express ideas, and outline possibilities. Some of the illustrations are quite abstract; others are more specific and particular. All of them, however, should be viewed essentially as diagrams that serve to demonstrate design principles or to clarify the relationships existing among the elements of design.

The goal of interior design education is to prepare students to be responsible, well-informed, skilled professionals who make beautiful, safe, and comfortable spaces that respect the earth and its resources. The field of interior design encompasses both visual and functional design, as well as basic knowledge of building materials, construction, and technology. This introduction to interior design is therefore broad in scope. The intent, nevertheless, is to treat the subject with clarity, make it as accessible as possible, and stimulate further in-depth study and research.

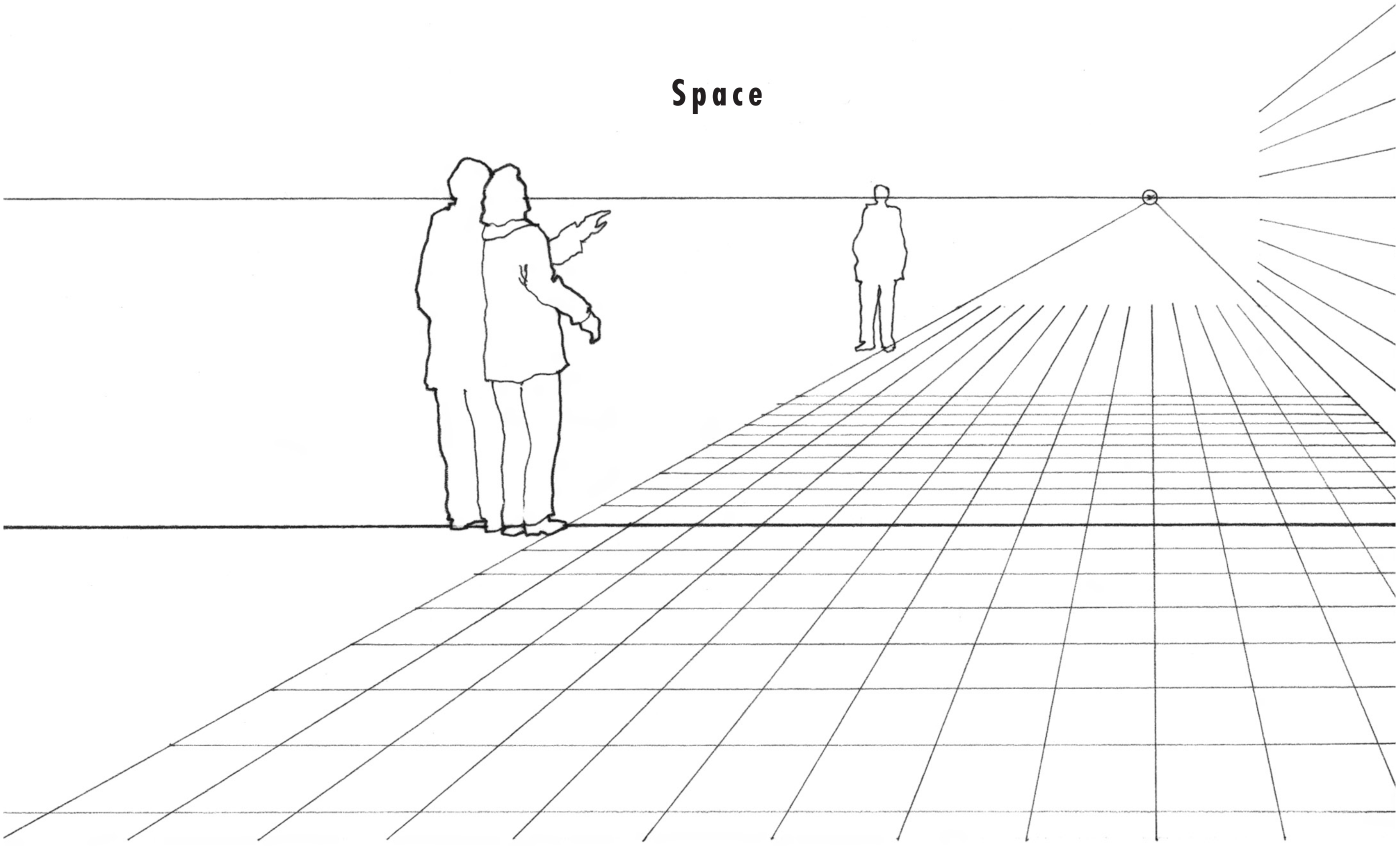
For the Instructor's Manual of *Interior Design Illustrated, 4th Edition*, go to www.wiley.com/go/IDI4e.



# 1 Interior Space

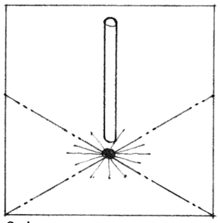
Space is a prime ingredient in the designer's palette and the quintessential element in interior design. Through the volume of space we not only move; we see forms, hear sounds, feel gentle breezes and the warmth of the sun, and smell the fragrances of flowers in bloom. Space inherits the sensual and aesthetic characteristics of the elements in its field.

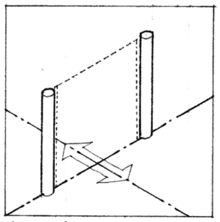
Space is not a material substance like stone and wood. It is inherently formless and diffuse. Universal space has no defining borders. Once an element is placed in its field, however, a visual relationship is established. As other elements are introduced into the field, multiple relationships are established between the space and the elements, as well as among the elements themselves. Space is formed by our perception of these relationships.

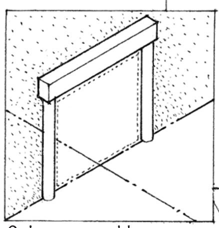


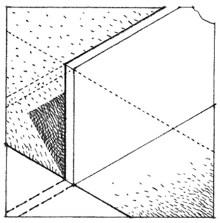
The geometric elements—point, line, plane, and volume—can be arranged to articulate and define space. In architecture, these fundamental elements become linear columns and beams, planar walls, floors, and roofs.

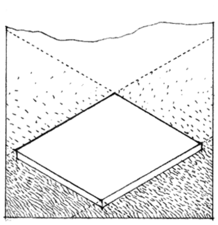
- A column marks a point in space and makes it visible in three dimensions.
- Two columns define a spatial membrane through which we can pass.
- When supporting a beam, the columns delineate the edges of a transparent plane.
- A wall, an opaque plane, marks off a portion of amorphous space and separates here from there.
- A floor defines a field of space with territorial boundaries.
- A roof provides shelter for the volume of space beneath it.

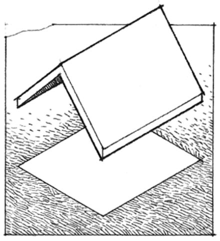

Column

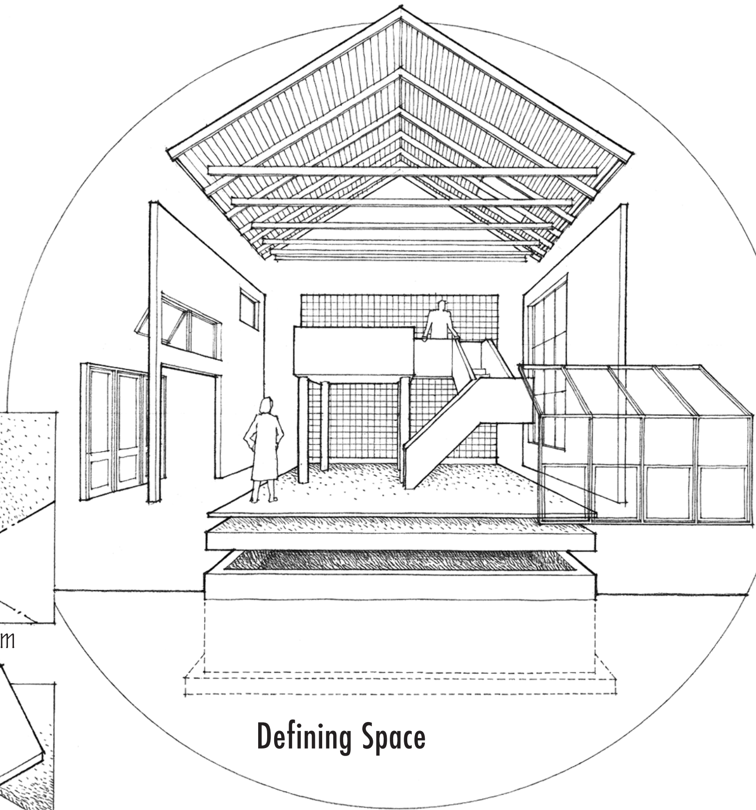

Two columns


Columns and beam

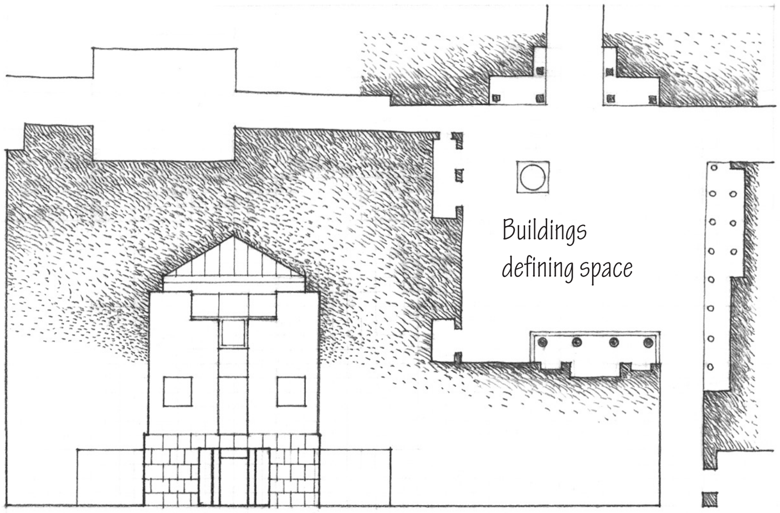

Wall


Floor


Roof


Defining Space

In architectural design, these elements are organized to give a building form, differentiate between inside and outside, and define the boundaries of interior space.



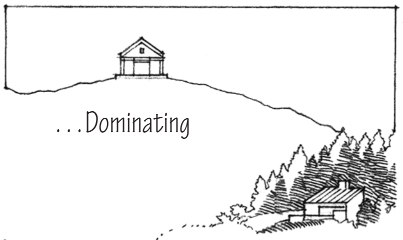

A building in space

A building's form, scale, and spatial organization are the designer's response to a number of conditions—functional planning requirements, technical aspects of *structure* and construction, economic realities, and expressive qualities of image and style. In addition, the architecture of a building should address the physical context of its site and the exterior space.

A building can be related to its site in several ways. It can merge with its setting or dominate it. It can surround and capture a portion of exterior space. One of its faces can be made to address a feature of its site or define an edge of exterior space. In each case, due consideration should be given to the potential relationship between interior and exterior space, as defined by the nature of a building's exterior walls.

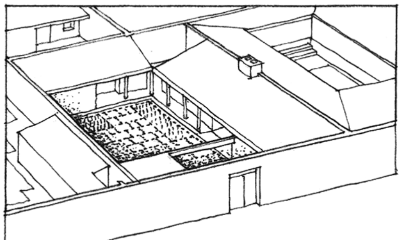
Buildings affect and are affected by conditions of their sites and the wider environment. Selecting and developing sites to reduce site disturbance, stormwater runoff, heat island effects, and light pollution contribute to *sustainable design*.

## Buildings

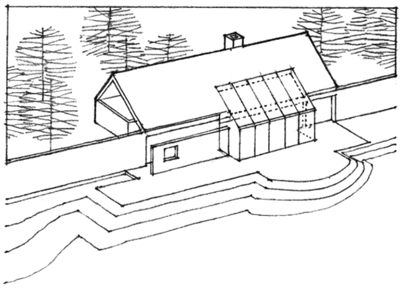


. . . Dominating

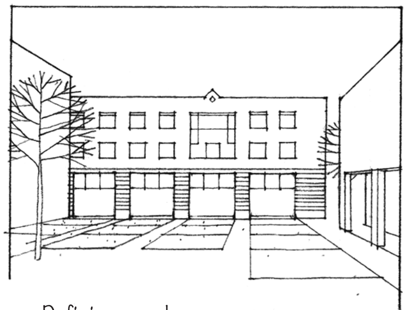
. . . Merging



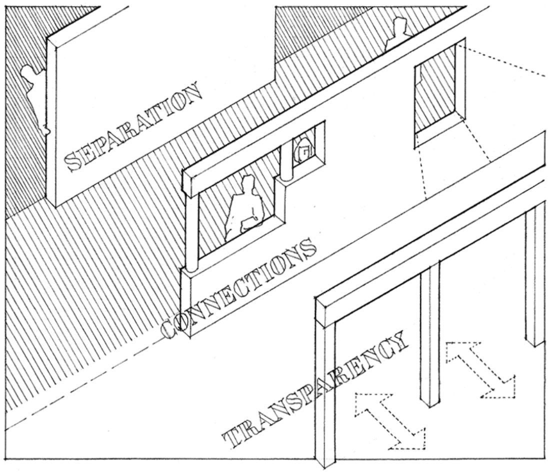
. . . Surrounding



. . . Fronting

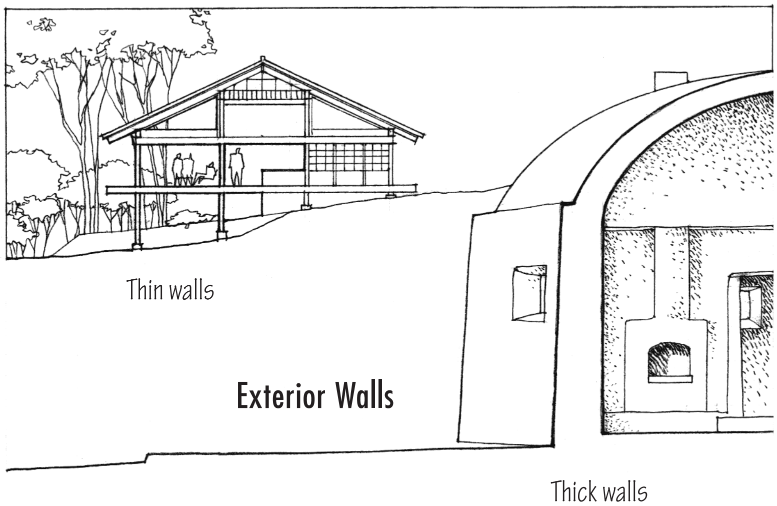


. . . Defining an edge




## Exterior Walls

A building's exterior walls constitute the interface between our interior and exterior environments. In defining both interior and exterior space, they determine the character of each. They may be thick and heavy, expressing a clear distinction between a controlled interior environment and the exterior space from which it is isolated. They may be thin, or even transparent, and attempt to merge inside and outside.

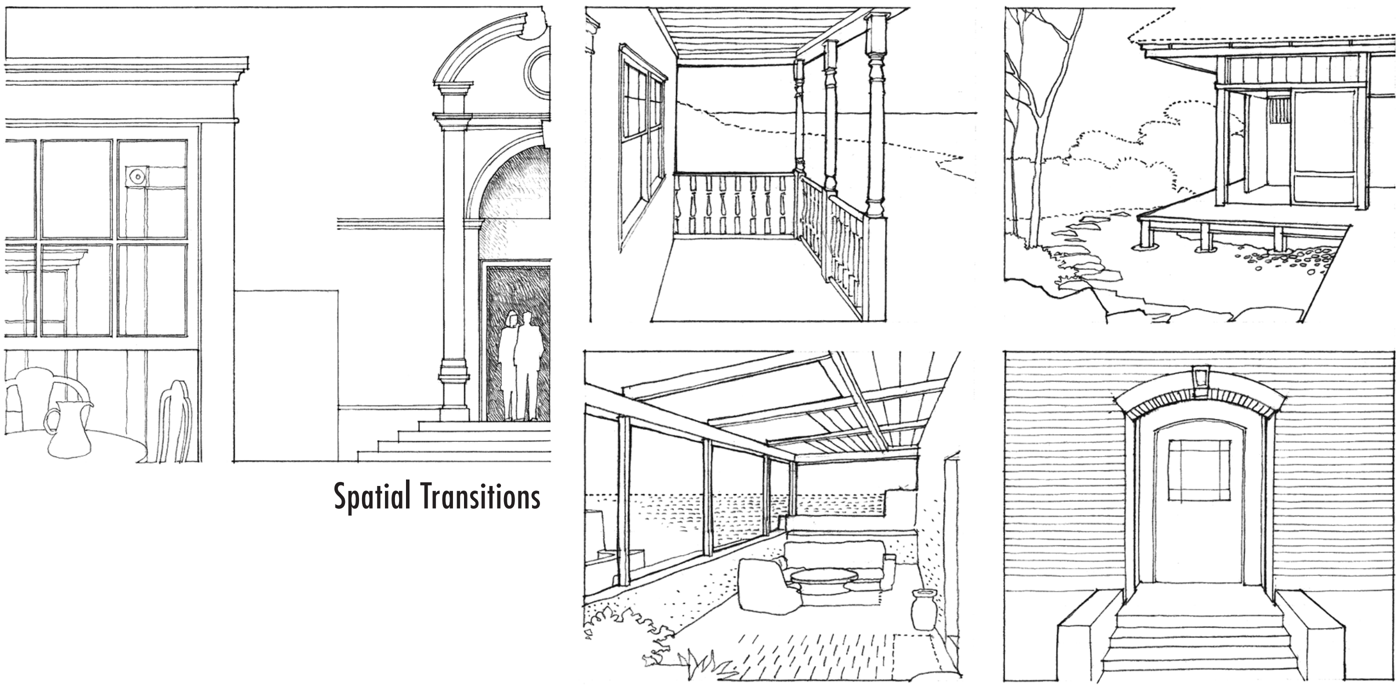



**Exterior Walls**

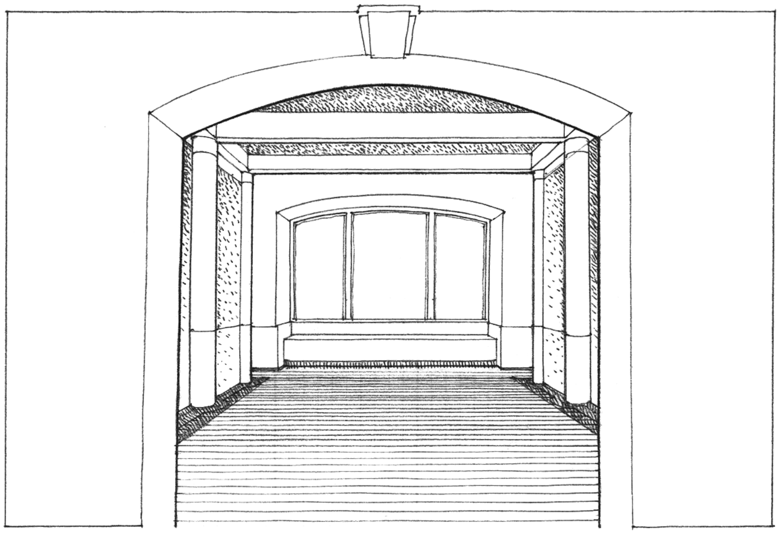
Windows and doorways, the openings that penetrate a building's exterior walls, are the spatial transitions between exterior and interior space. Their scale, character, and composition often tell us something about the nature of the interior spaces that lie between them.

Special transitional spaces, belonging to both the outside world and the inside, can be used to mediate between the two environments. Familiar examples include a porch, a veranda, or an arcaded gallery.

Many single-family residences have steps at all entrances that present barriers to people with physical disabilities. *Visitability* is a movement to construct new homes so that they can be readily lived in and visited by people with mobility impairments.



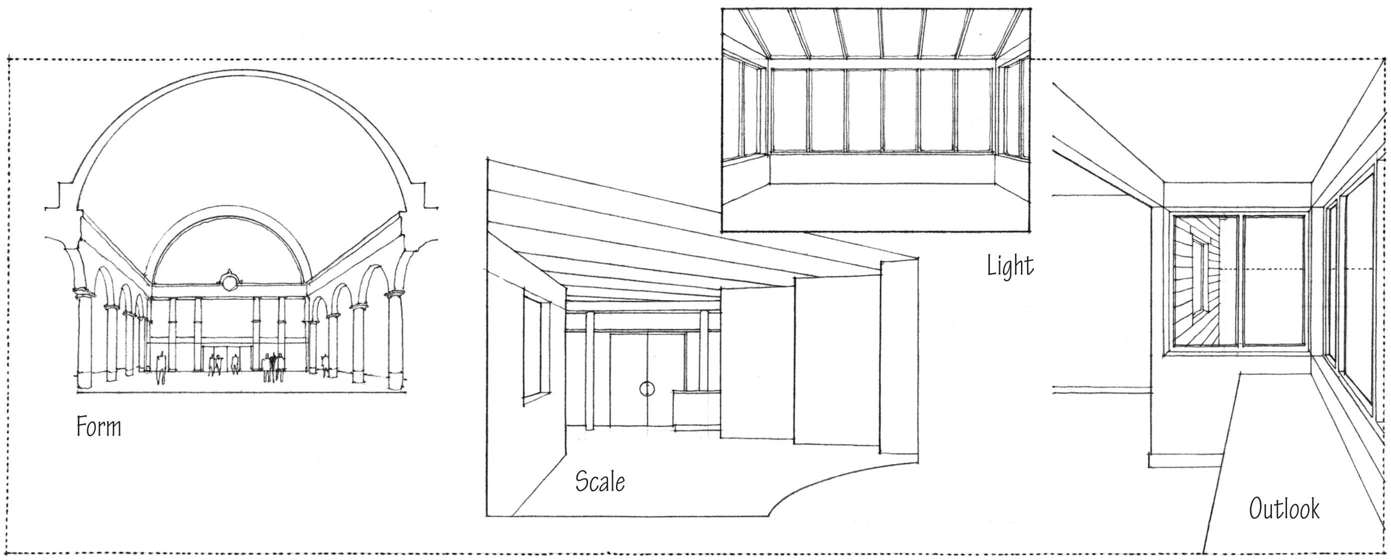
**Spatial Transitions**



Entrances mark the transition from here to there.

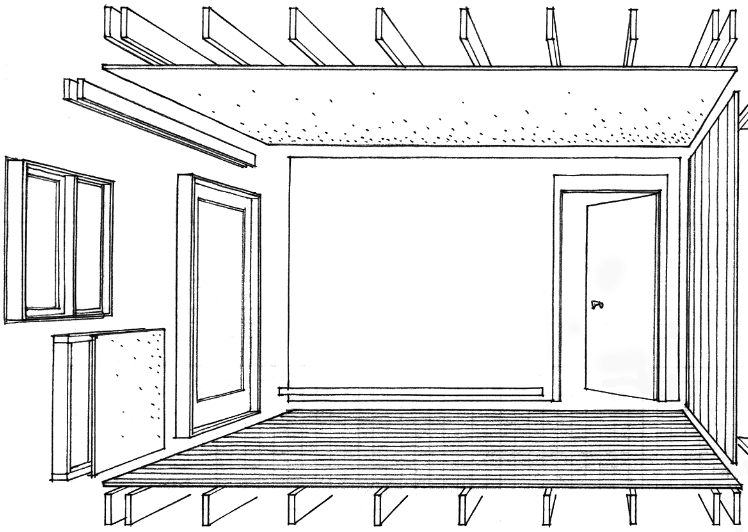
Upon entering a building, we sense shelter and enclosure. This perception is due to the bounding floor, wall, and ceiling planes of interior space. These are the architectural elements that define the physical limits of rooms. They enclose space, articulate its boundaries, and separate it from adjoining interior spaces and the outside.

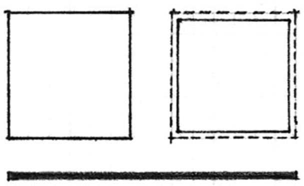
Floors, walls, and ceilings do more than mark off a simple quantity of space. Their form, configuration, and pattern of window and door openings also imbue the defined space with certain spatial or architectural qualities. We use terms such as grand hall, loft space, sun room, and alcove not simply to describe how large or small a space is, but also to characterize its scale and proportion, its quality of light, the nature of its enclosing surfaces, and the way it relates to adjacent spaces.



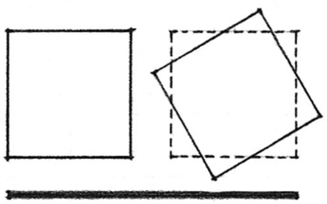

**Spatial Qualities**

Interior design necessarily goes beyond the architectural definition of space. In planning the layout, furnishing, and enrichment of a space, the interior designer should be acutely aware of its architectural character as well as its potential for modification and enhancement. The design of interior spaces requires, therefore, an understanding of how they are formed by the building systems of *structure* and enclosure. With this understanding, the interior designer can effectively elect to work with, continue, or even offer a counterpoint to the essential qualities of an architectural space.

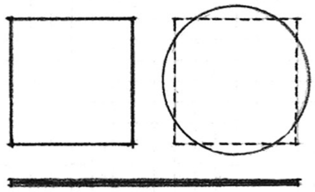




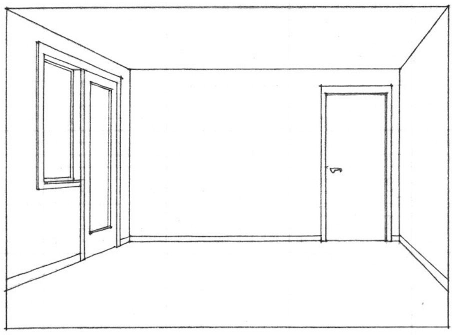
Continuation



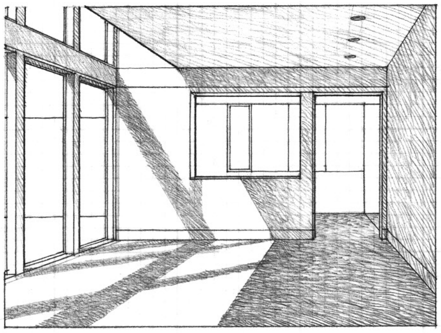
Contrast



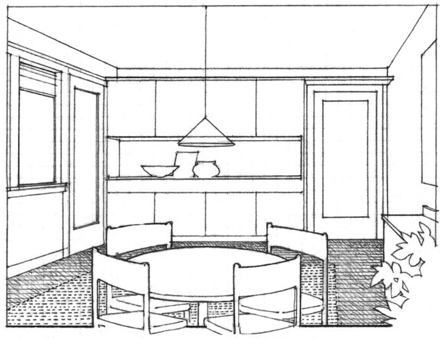
Counterpoint



The basic shell



. . . modified architecturally



. . . or through interior design

## Interior Space

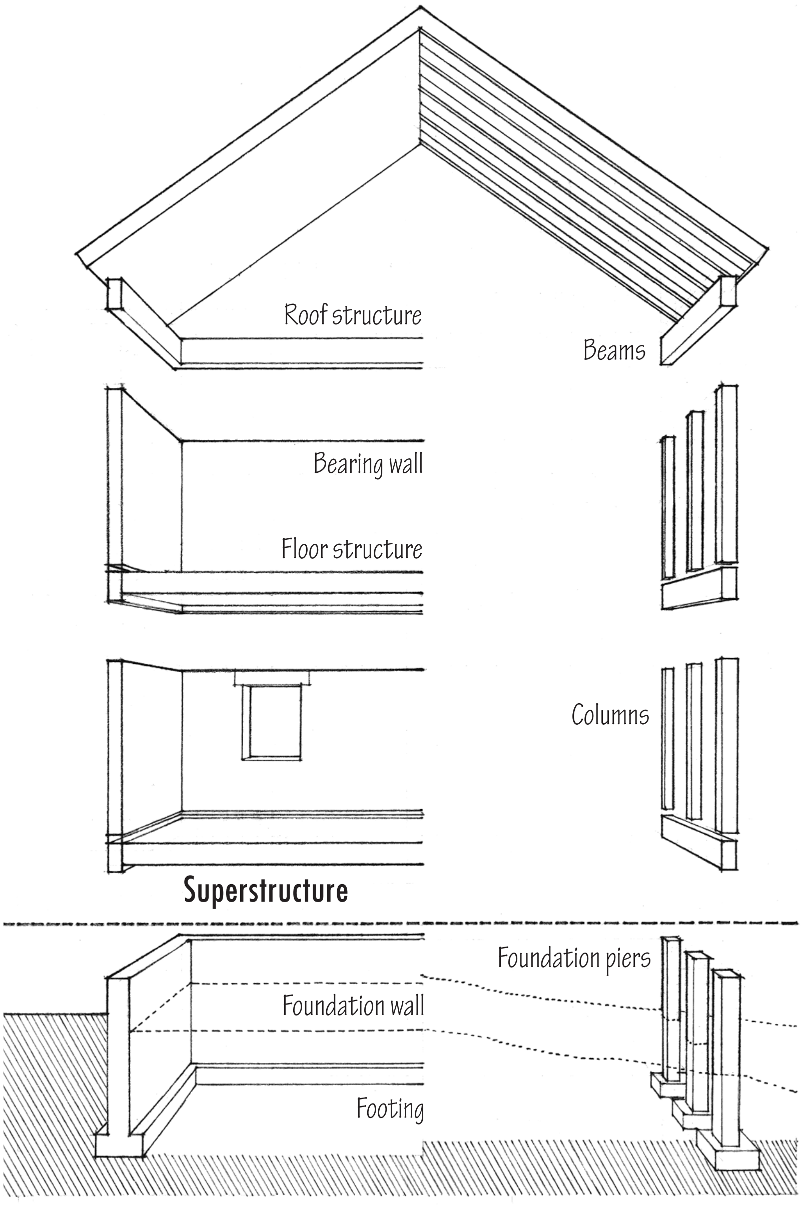
Buildings typically consist of physical systems of structure, enclosure, and building services equipment.

## Structural Systems

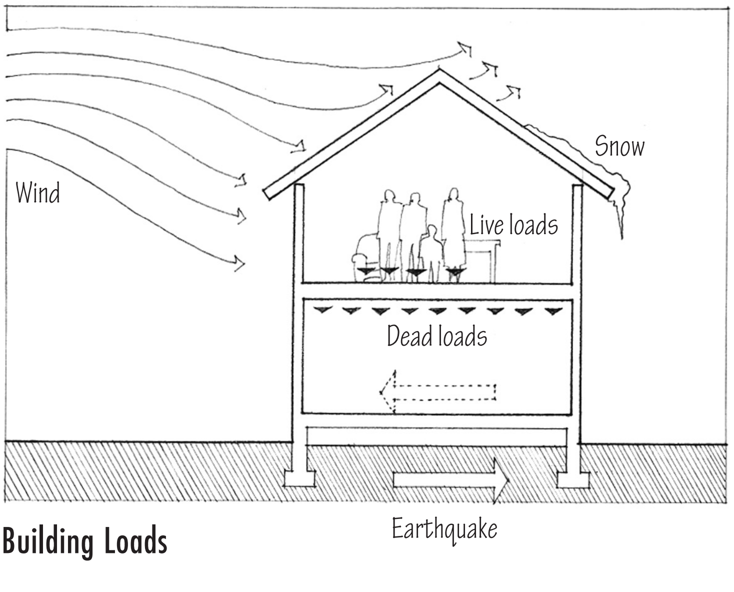
- The *superstructure* is the vertical extension of the foundation system and consists of the columns, beams, and load-bearing walls that support the floor and roof structures.
- The *foundation* system is the substructure that forms the base of a building, anchors it firmly to the ground, and supports the building elements and spaces above.

These systems must work together to support the following types of loads:

**Dead Loads:** How a building is constructed determines its *dead load*, which is a static vertical load comprising the weight of its structural and nonstructural components, including any equipment permanently attached to the structure.
**Live Loads:** How a building is used determines its *live load*, which is a movable or moving load comprising the weight of its occupants and any mobile equipment and furnishings. In cold or wet climates, collected snow and water impose an additional live load on a building.
**Dynamic Loads:** Where a building is located determines its potential to bear a *dynamic load*, which can change suddenly due to the forces of wind and earthquakes.




Foundation




Building Loads

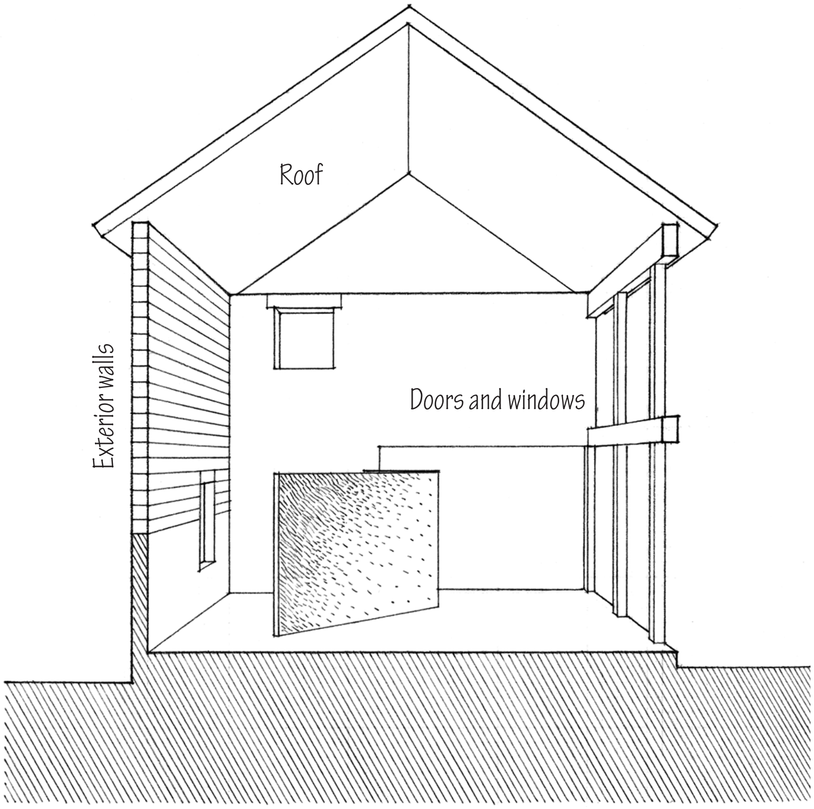
Earthquake

## Enclosure System

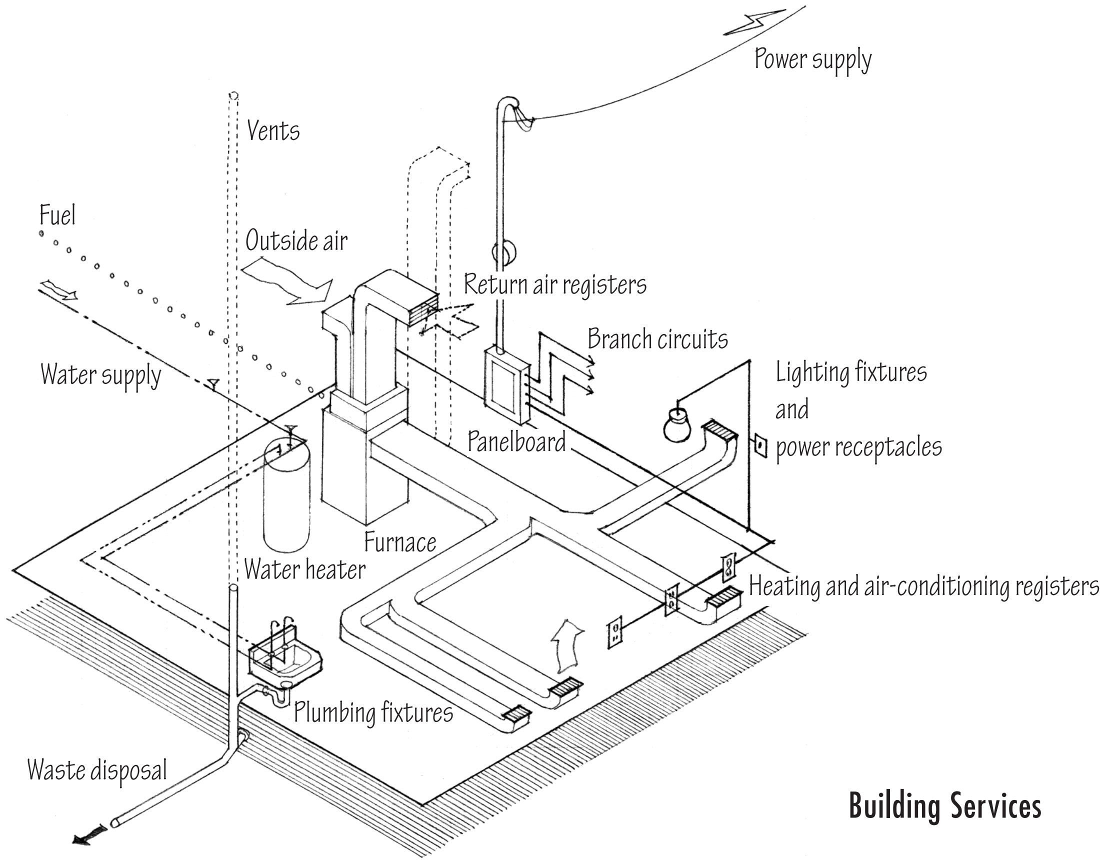
- The *building envelope* consists of exterior walls, windows, doors, and roof, which protect and shelter interior spaces from the exterior environment.
- Interior walls, partitions, and ceilings subdivide and define interior space. Many of these components are nonstructural in nature and carry no loads other than their own weight.

## Building Services

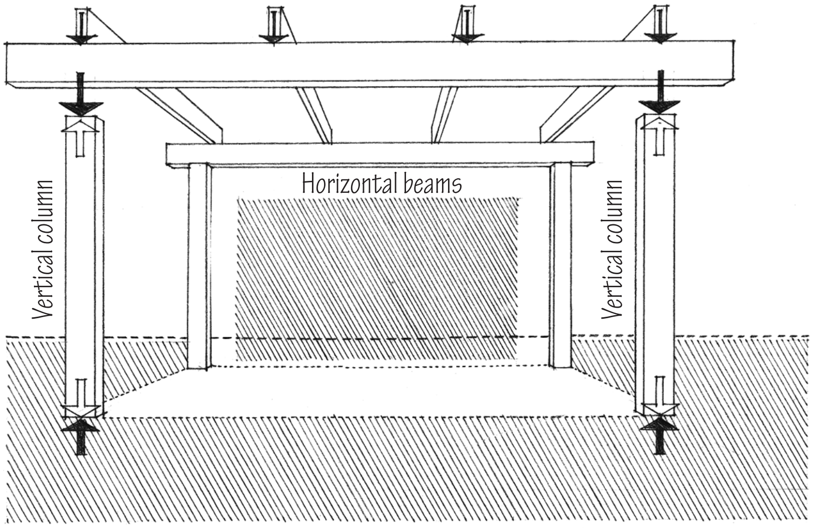
- Mechanical systems provide essential services to a building, such as the heating, ventilation, and air-conditioning of interior spaces.
- Plumbing systems supply water suitable for human consumption and firefighting, and dispose of sanitary waste.
- Electrical systems control and safely distribute power for lighting, equipment, security, communication, and vertical transportation.




**Building Envelope**



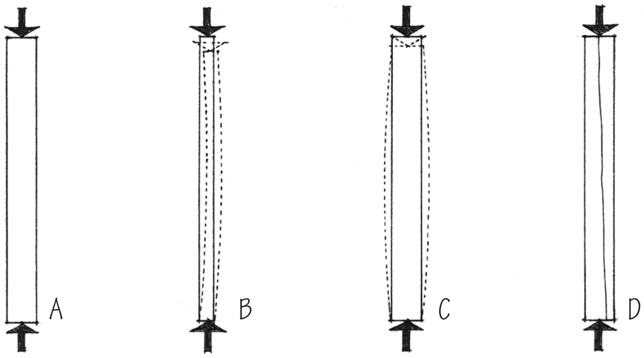

**Building Services**



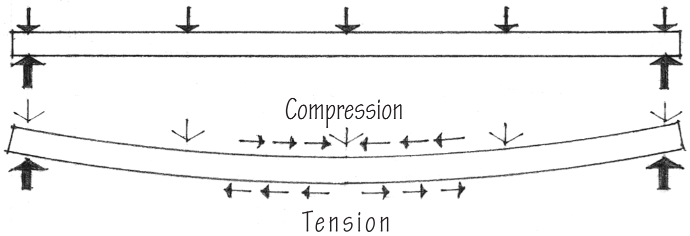

A building's structural system is formed according to the geometry of its materials and the way they react to the forces applied to them. This structural form and geometry, in turn, influence the dimensions, proportion, and arrangement of the interior spaces within the building volume.

The two basic linear structural elements are the column and the beam. A *column* is a vertical support that transmits compressive forces downward along its shaft. The thicker a column is in relation to its height, the greater its load-bearing capacity and its ability to resist buckling resulting from off-center loading or *lateral forces.*

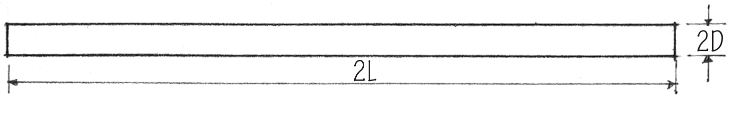
A *beam* is a horizontal member that transmits forces perpendicular to itself along its length to its supports. A beam is subject to bending and deflection, which result in an internal combination of compressive and tensile stresses. These stresses are proportionally greater along the upper and lower region of a beam's cross section. Increasing depth and placing material where stresses are greatest optimize a beam's performance.




A. Columns are subject to compression.
B. Slender columns are subject to buckling.
C. Thick columns may compress, or
D. In the case of timber or concrete, they may split or fracture.




Beams are subject to bending.

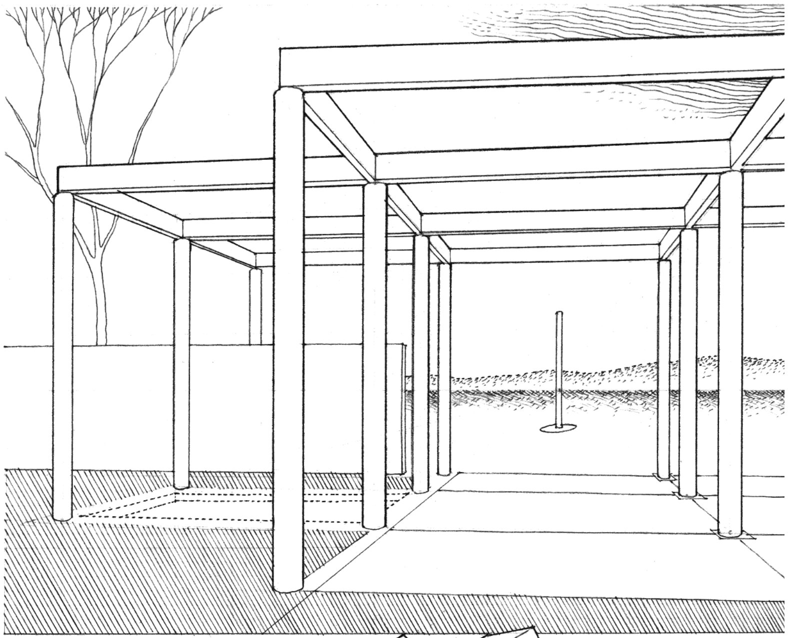


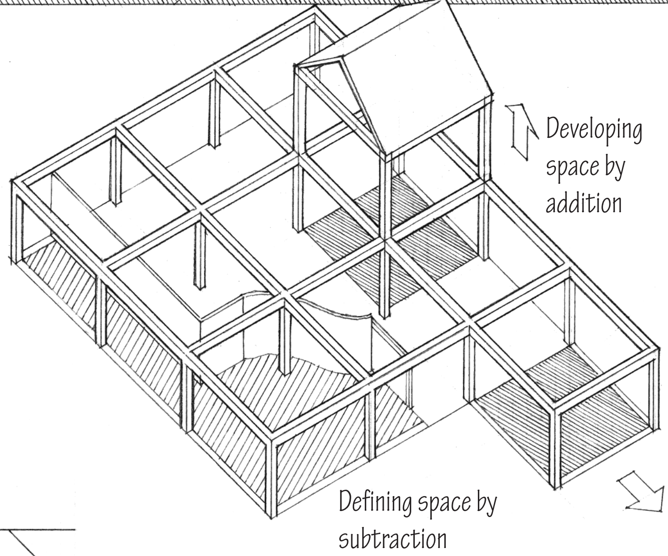

Increasing a beam's depth enables it to span greater distances.

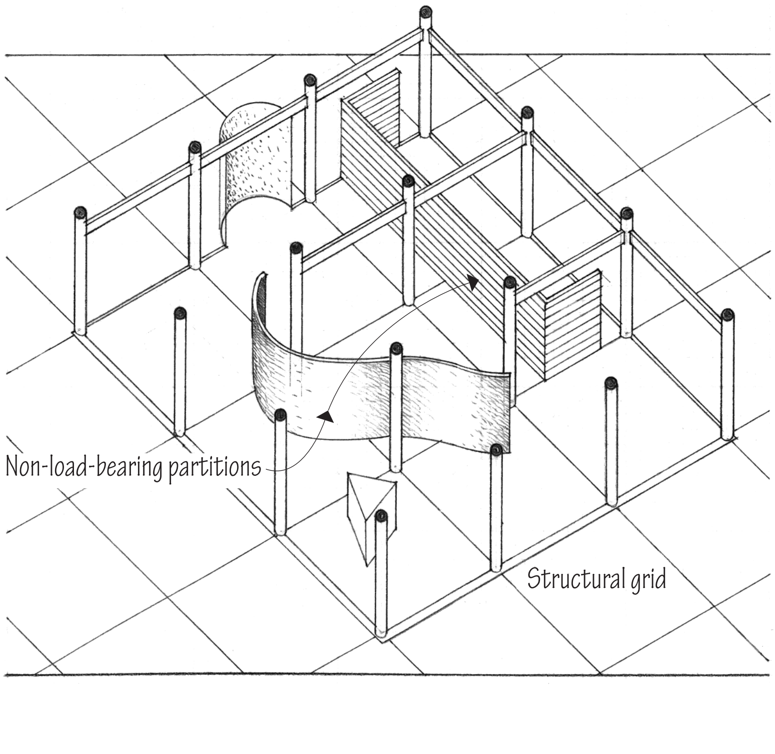
Columns mark points in space and provide a measure for its horizontal divisions. Beams make structural and visual connections across space between their supports. Together, columns and beams form a skeletal framework around interconnected volumes of space.

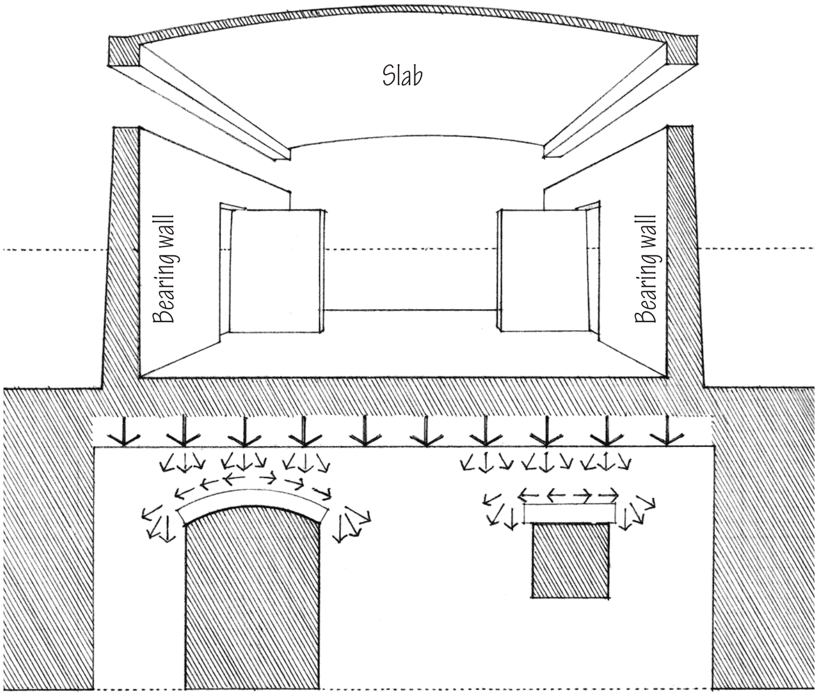
A linear structural system may suggest a grid layout of repetitive spaces, but floor, wall, and ceiling planes are necessary for the support and enclosure of interior space. Floor and ceiling planes, which define the vertical limits of space, may consist of planar *slabs* or a hierarchical arrangement of *girders* (large primary beams) and beams and *joists* (a series of smaller, parallel beams). Walls and partitions need not be load-bearing and do not have to be aligned with the columns of a structural frame, except where serving as *shear walls* and providing for lateral stability. They are free to define the horizontal dimensions of space according to need, desire, or circumstance.

Linear structural systems are cumulative by nature and eminently flexible. They allow for growth, change, and the adaptation of individual spaces to their specific uses.





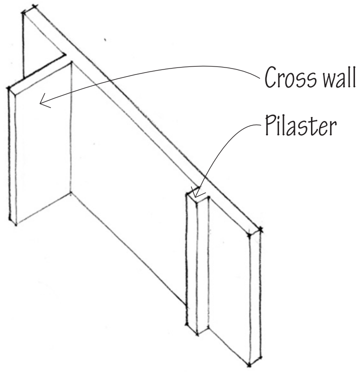


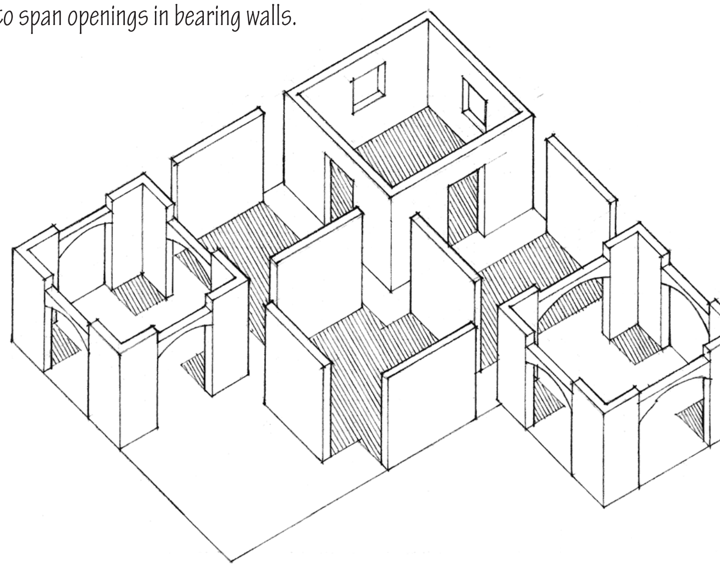

The two principal types of planar structural elements are the *load-bearing wall* and the horizontal slab. A bearing wall acts as a long, thin column in transmitting compressive forces to its support or foundation.

Window and door openings within a bearing wall tend to weaken its structural integrity. Any opening must be spanned by an arch or a short beam called a *lintel* to support the wall load above and allow compressive stresses to flow around the opening to adjacent sections of the wall.

A common pattern for bearing walls is a parallel layout spanned by floor joists and roof rafters, or by horizontal slabs. For lateral stability, *pilasters* and cross walls are often used to help brace bearing walls.

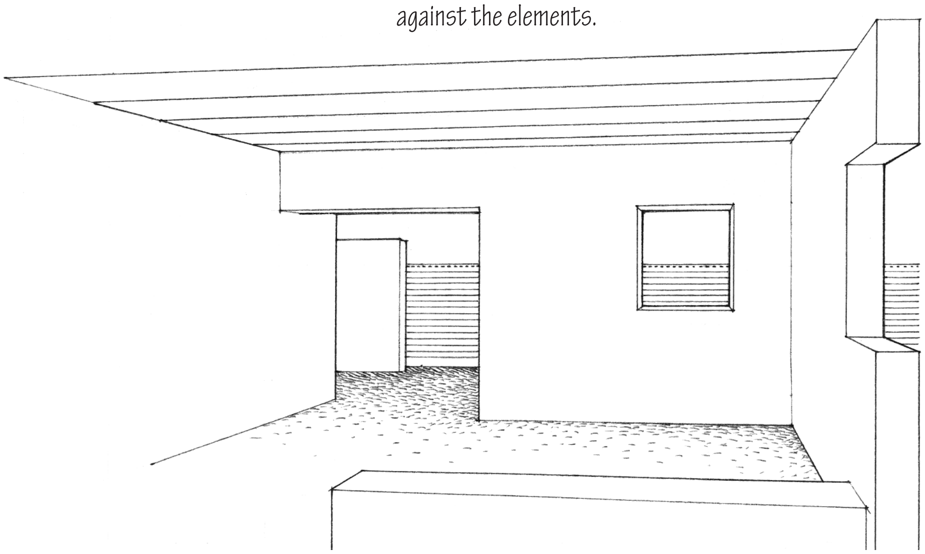
Small beams or lintels are required to span openings in bearing walls.



While linear structural elements outline the edges of spatial volumes, planar elements such as bearing walls define the physical limits of space. They provide a real sense of enclosure and privacy as well as serve as barriers against the elements.

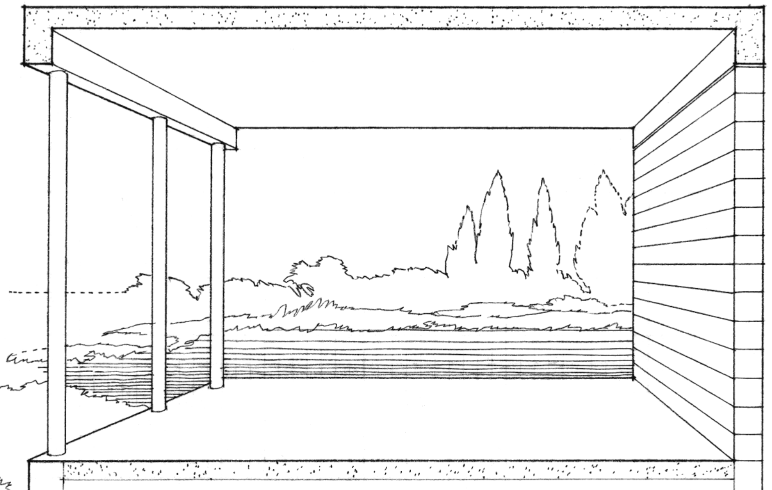
Varying degrees of spatial enclosure are possible with walls, depending on the size and location of openings within their planes.



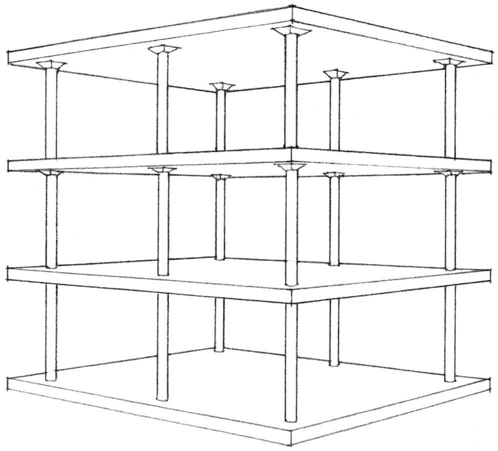
A slab is a horizontal, rigid, usually monolithic plate. A common example is a reinforced concrete slab. A slab is able to support both concentrated and distributed loads because the resulting stresses can fan out across the plane of the slab and take various paths to the slab supports.

When supported along two edges, a slab can be considered a wide, shallow beam extending in one direction. Supported along four sides, a slab becomes a two-way structural element. For greater efficiency and reduced weight, a slab can be modified in sections to incorporate ribs.

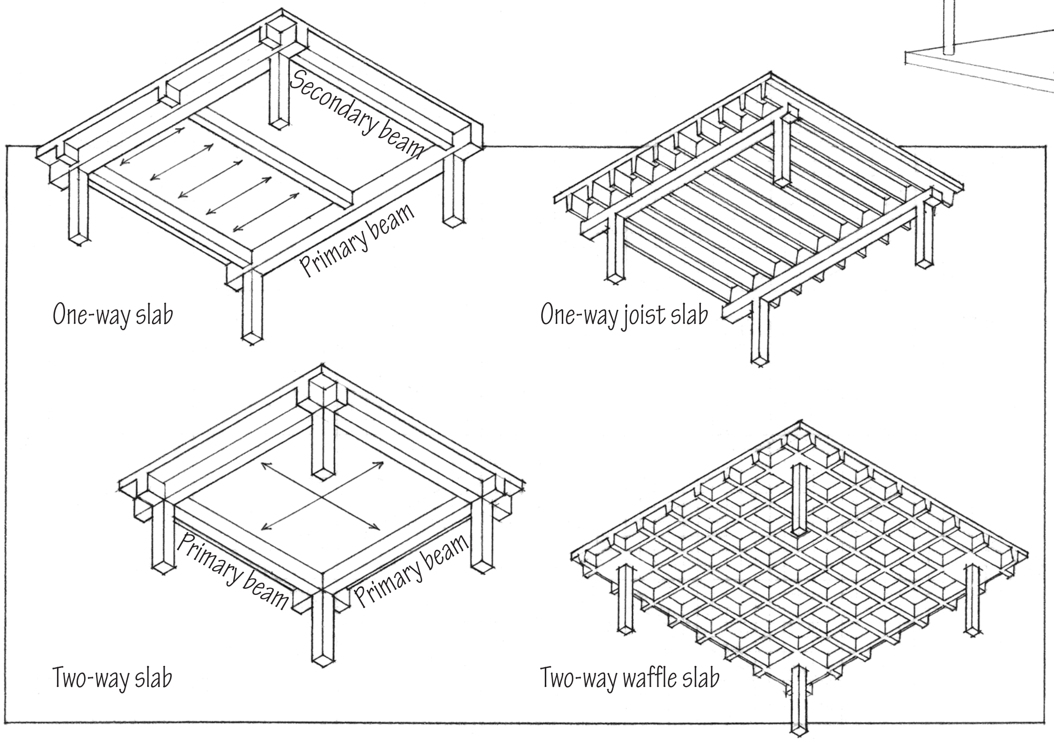
When integrally connected with reinforced concrete columns, flat slabs can be supported without beams. They form horizontal layers of space punctuated only by the shafts of the supporting columns.



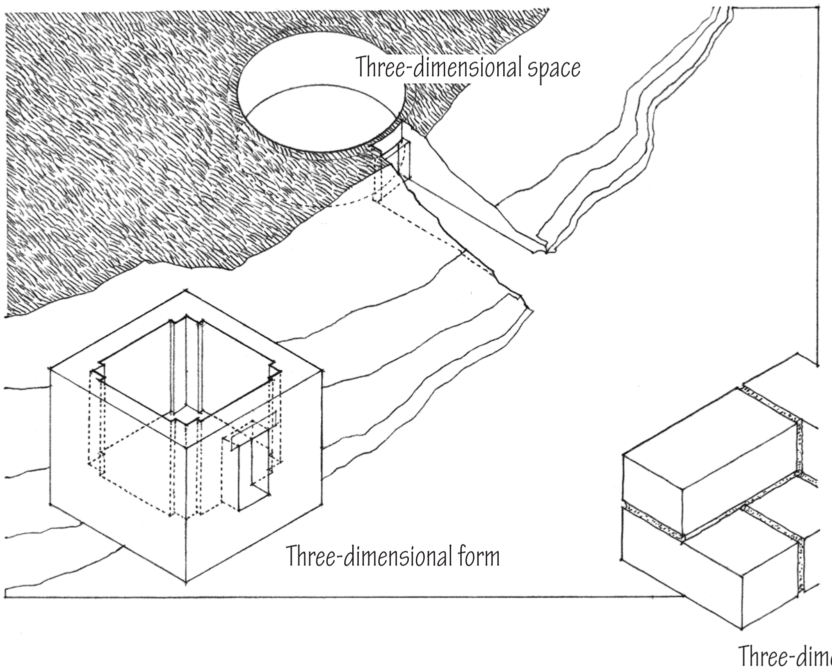
Slabs may be supported by a framework of beams and columns or by a masonry or concrete bearing wall.



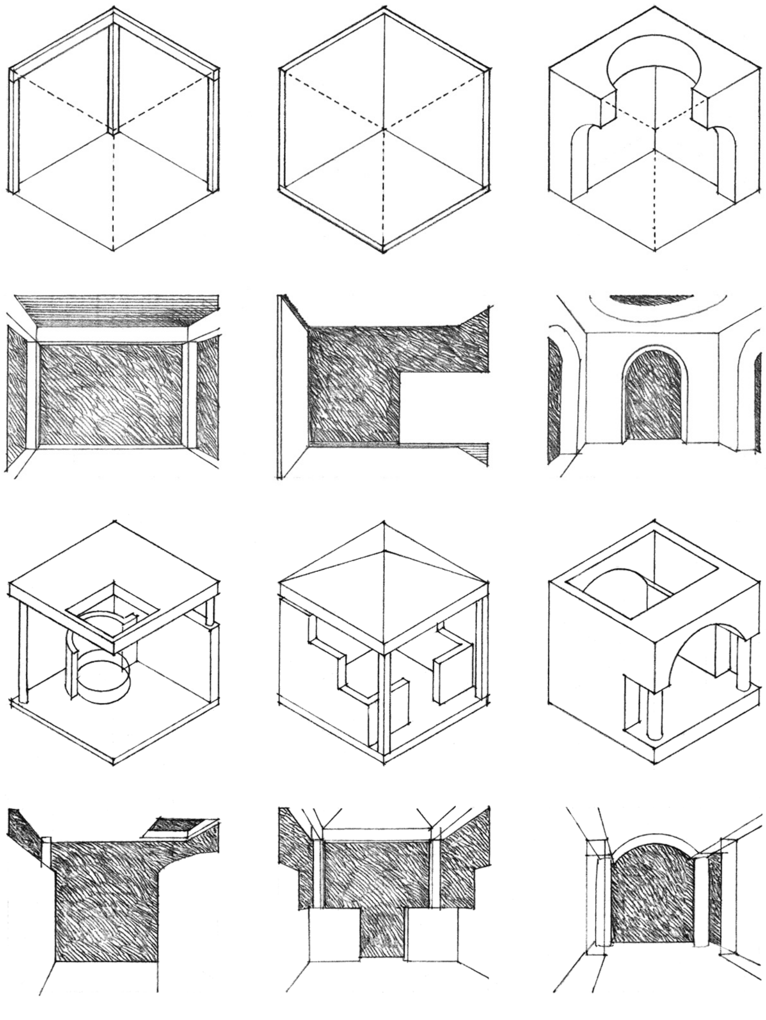
Two-way flat slabs thickened at their column supports define horizontal layers of space.

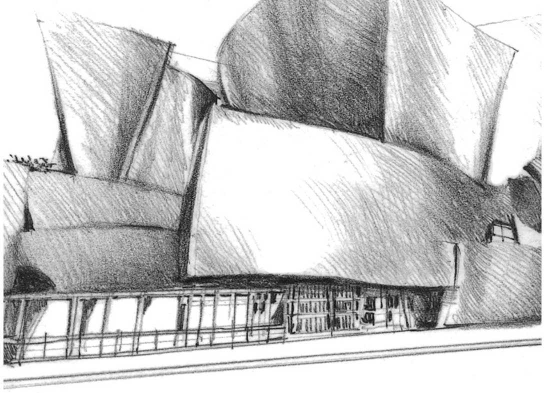



Types of Slabs




A volumetric structural system consists of a three-dimensional mass. The mass of the material occupies the void of space. The volume of interior space is carved out of the mass. The efficiency of engineering methods and the strength of modern building materials have limited the use of pure volumetric structural systems, although three-dimensional computer design is changing this; an example is the Walt Disney Concert Hall designed by Frank Gehry. At a small scale, stone and clay masonry units can be seen to be volumetric structural elements. At a larger scale, any building that encloses interior space can be viewed as a three-dimensional structure that must have strength in width, length, and depth.

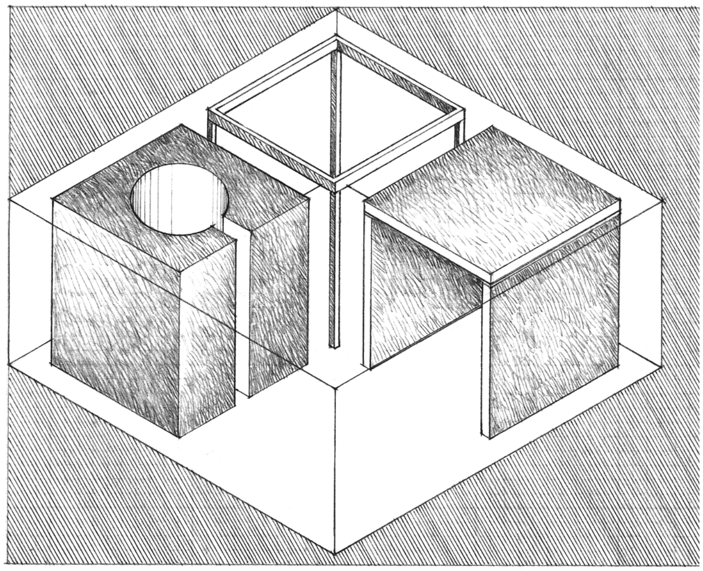


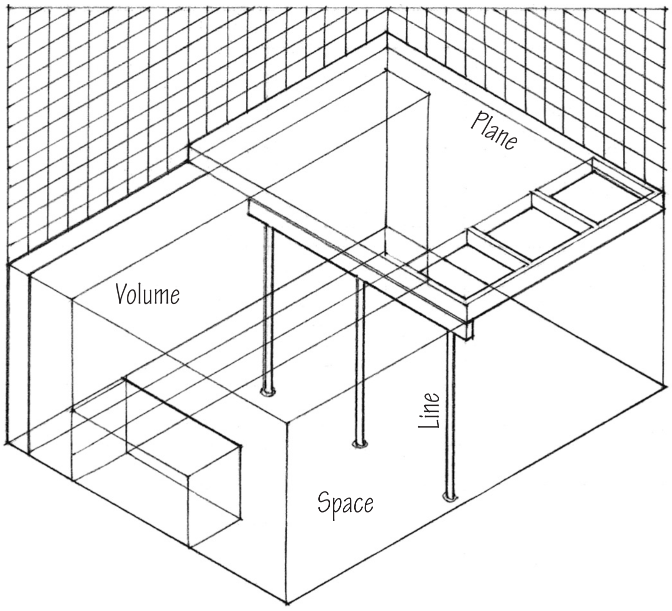


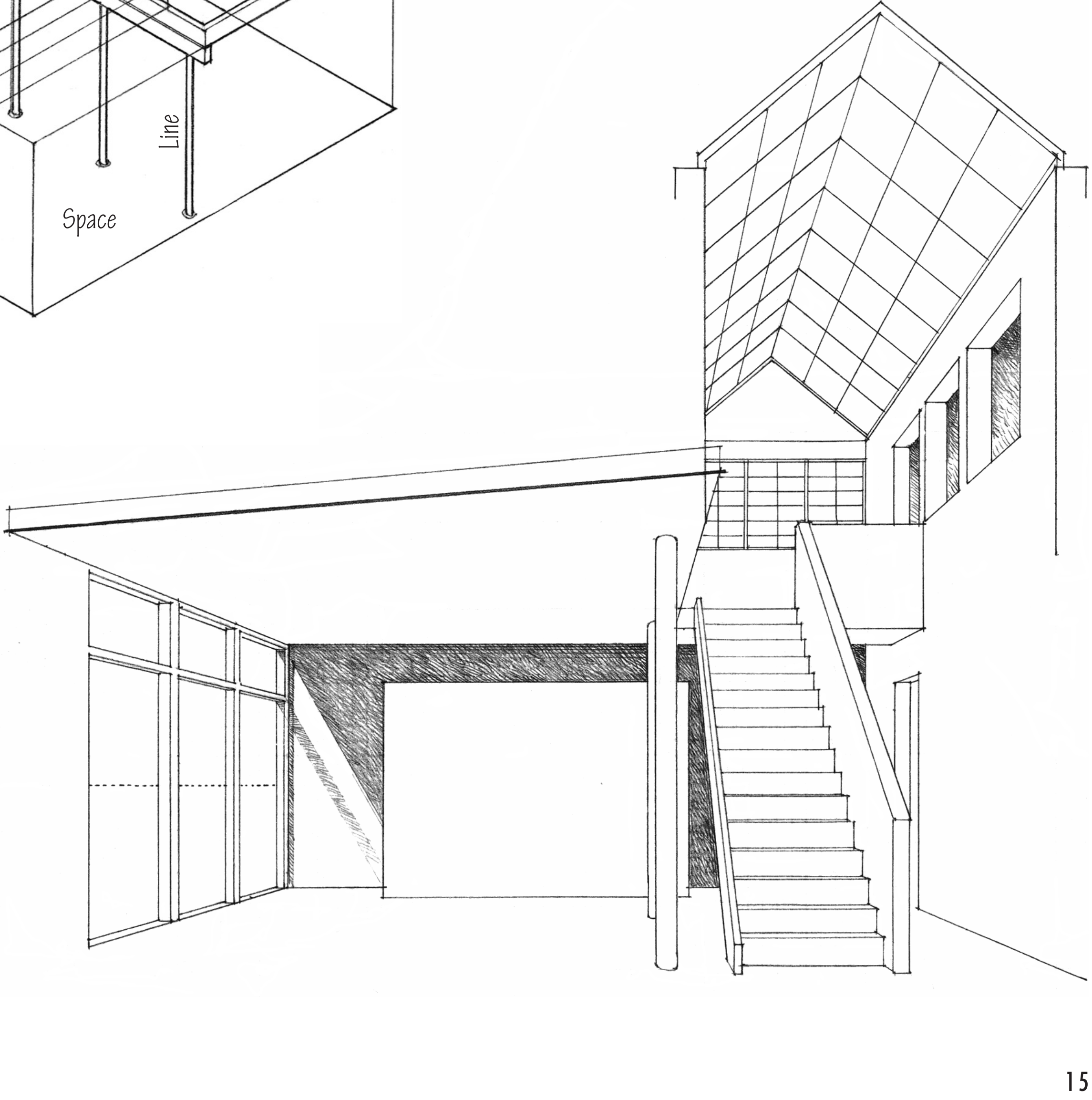
Walt Disney Concert Hall, Los Angeles, California, Frank Gehry, 2003

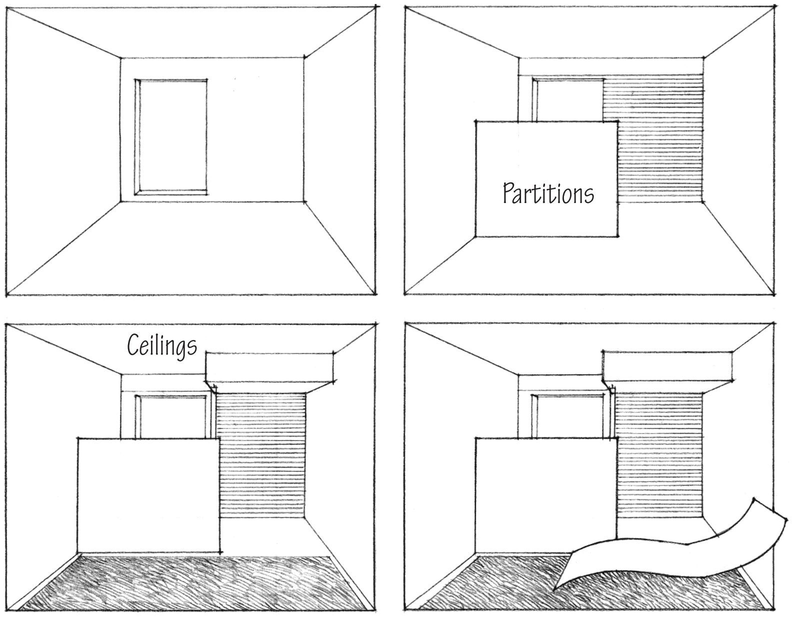
Composite systems combine linear, planar, and volumetric elements into three-dimensional compositions of form and space.

Most structural systems are in fact composites of linear, planar, and volumetric elements. No one system is superior to all others in all situations. For the structural designer, each presents advantages and disadvantages, depending on the size, location, and intended use of a building. An interior designer should be aware of the character of the interior spaces each system defines.





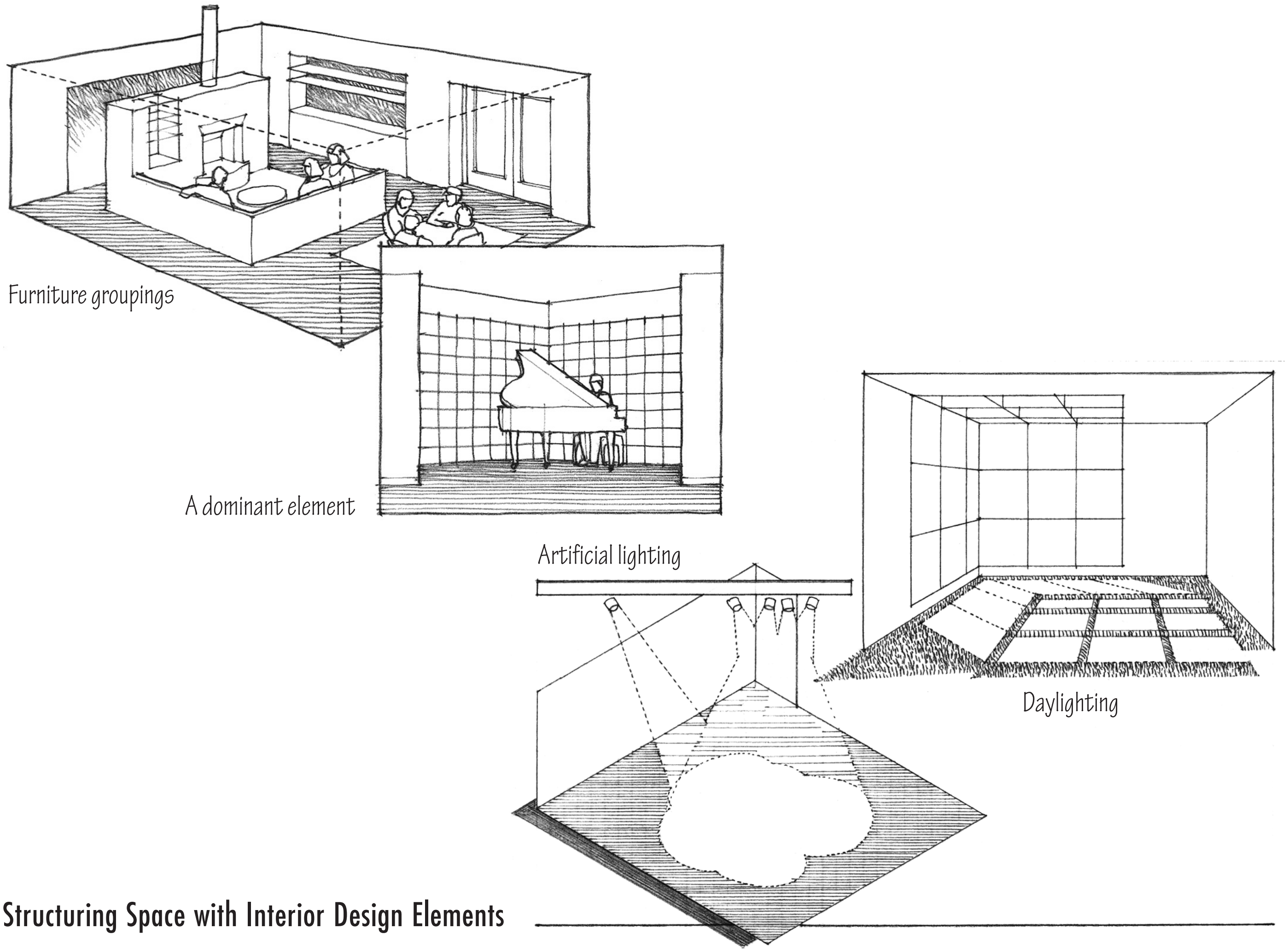






Although a building's structural system sets up the basic form and pattern of its interior spaces, these spaces are ultimately structured by the elements of interior design. The term "structure" is not used here in the sense of physical support. It refers to the selection and arrangement of interior elements such that their visual relationships define and organize the interior space of a room.

Non-load-bearing partitions and suspended ceilings are often used to define or modify space within the structural framework or shell of a building.

The color, *texture*, and *pattern* of wall, floor, and ceiling surfaces affect our perception of their relative positions in space and our awareness of the room's dimensions, scale, and proportion.



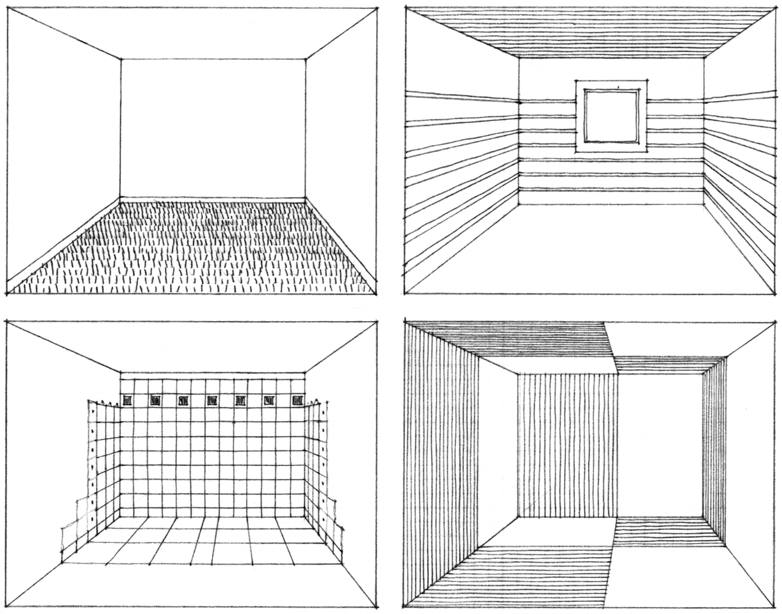

## Structuring Space with Interior Design Elements

Within a large space, the form and arrangement of furnishings can divide areas, provide a sense of enclosure, and define spatial patterns.

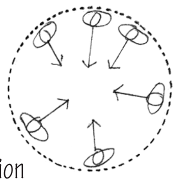
Lighting, and the light and dark patterns it creates, can call our attention to one area of a room, deemphasize others, and thereby create divisions of space.

Even the acoustic nature of a room's surfaces can affect the apparent boundaries of a space. Soft, absorbent surfaces muffle sounds and can diminish our awareness of the physical dimensions of a room. Hard surfaces that reflect sounds within a room help to define its physical boundaries. Echoes can suggest a large volume.

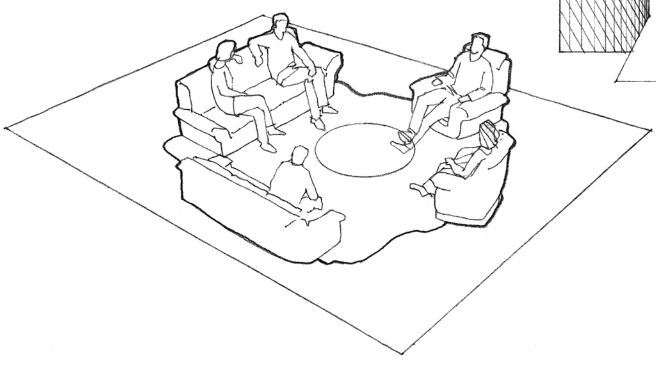
Finally, space is structured by the way we use it. The nature of our activities and the rituals we develop in performing them influence how we plan, arrange, and organize interior space.

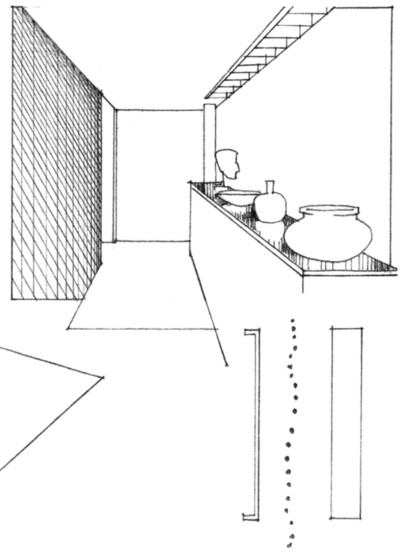


Color, texture, and pattern

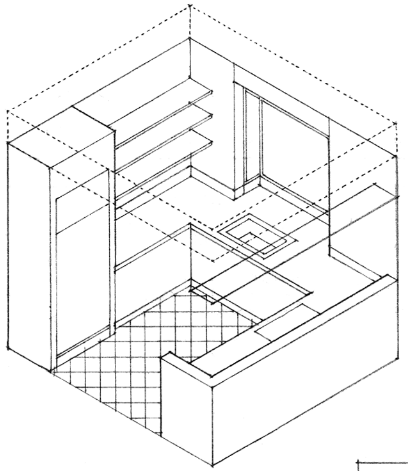


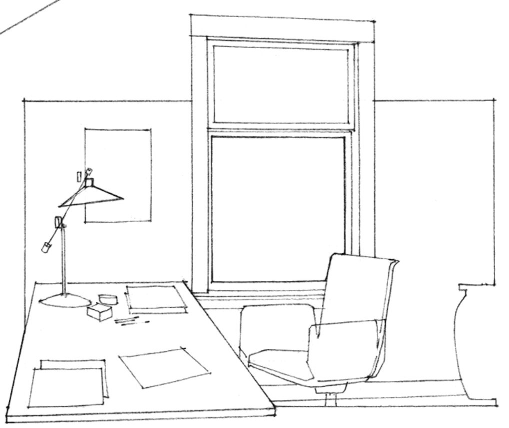
Communication



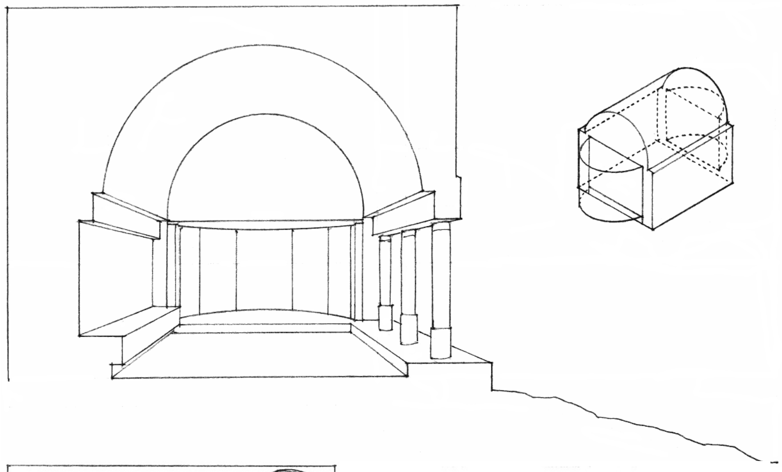


Movement



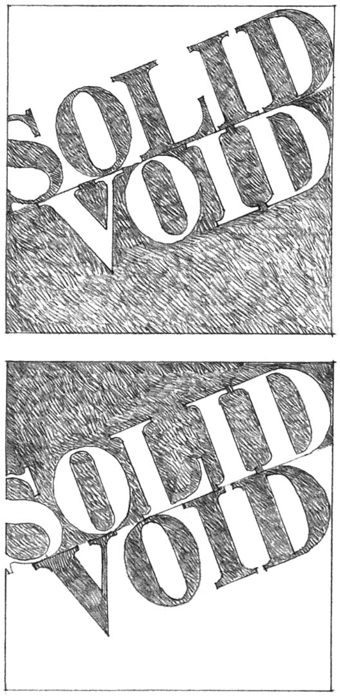


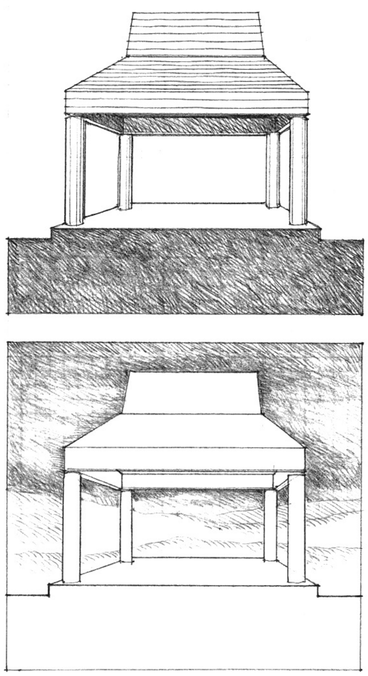
Individual and group activities

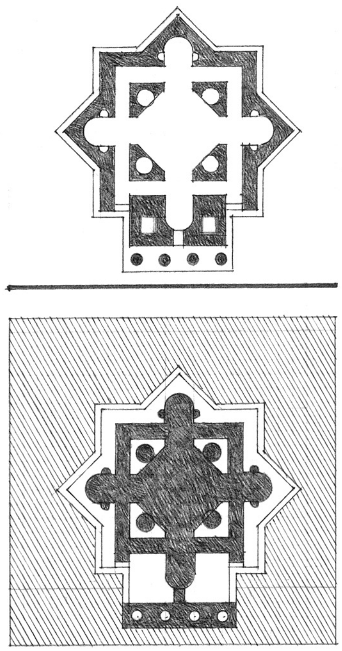


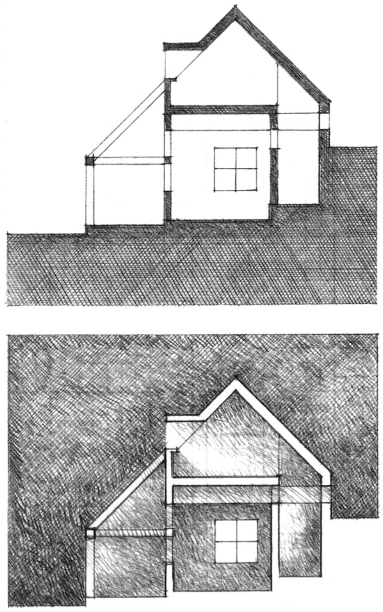
Interior spaces are formed first by a building's structural system, further defined by wall and ceiling planes, and related to other spaces by windows and doorways. Every building has a recognizable pattern of these elements and systems. Each pattern has an inherent geometry that molds or carves out a volume of space into its likeness.

It is useful to be able to read this *figure–ground* relationship between the form of space-defining elements and that of the space defined. Either the structure or the space can dominate this relationship. Whichever appears to dominate, we should be able to perceive the other as an equal partner in the relationship.



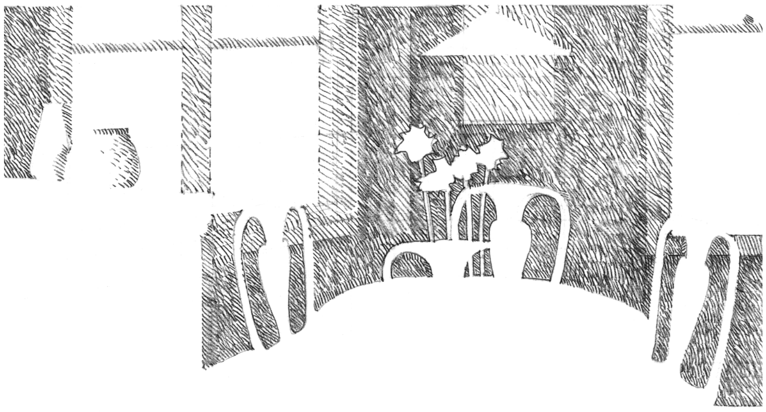


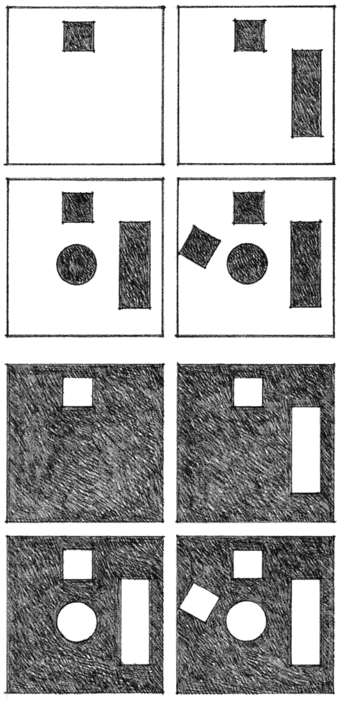


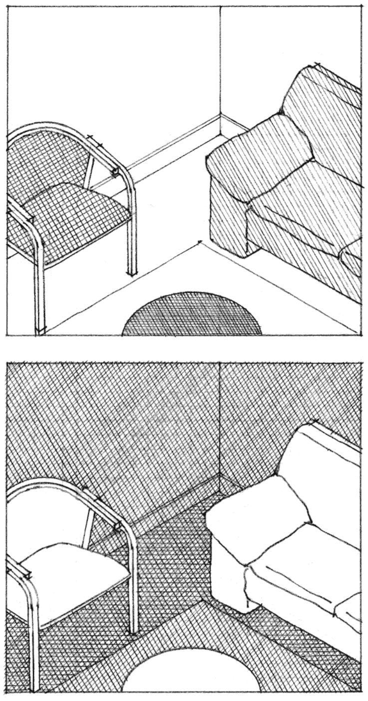
It is equally useful to see the alternating figure–ground dominance occurring as interior design elements, such as tables and chairs, are introduced and arranged within an interior space.

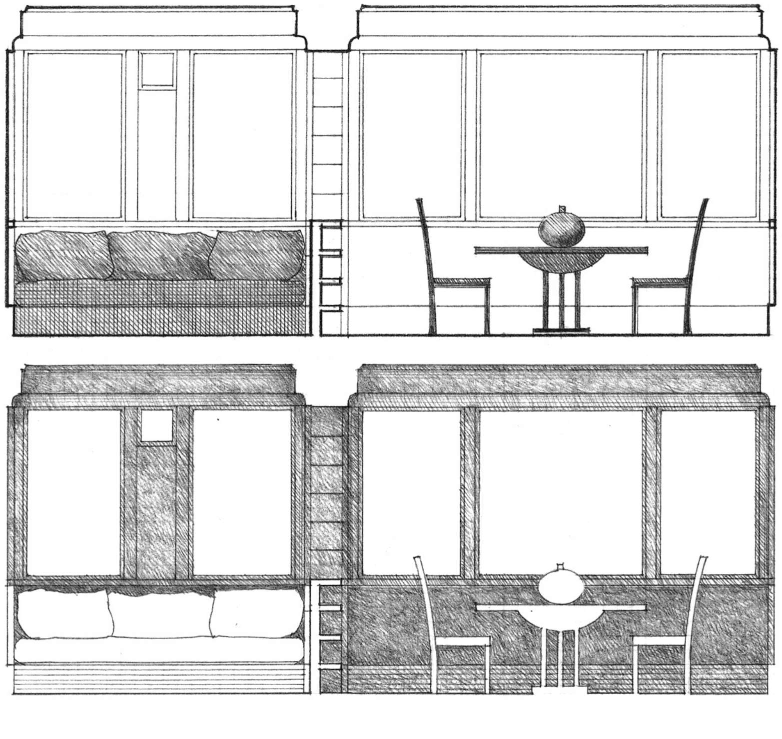
When a chair is placed in a room, it not only occupies space, it also creates a spatial relationship between itself and the surrounding enclosure. We should see more than the form of the chair. We should also recognize the form of the space surrounding the chair after it has filled some of the void.

As more elements are introduced into the pattern, the spatial relationships multiply. The elements begin to organize into sets or groups, each of which not only occupies space but also defines and articulates the spatial form.

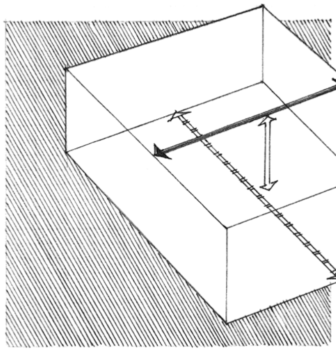


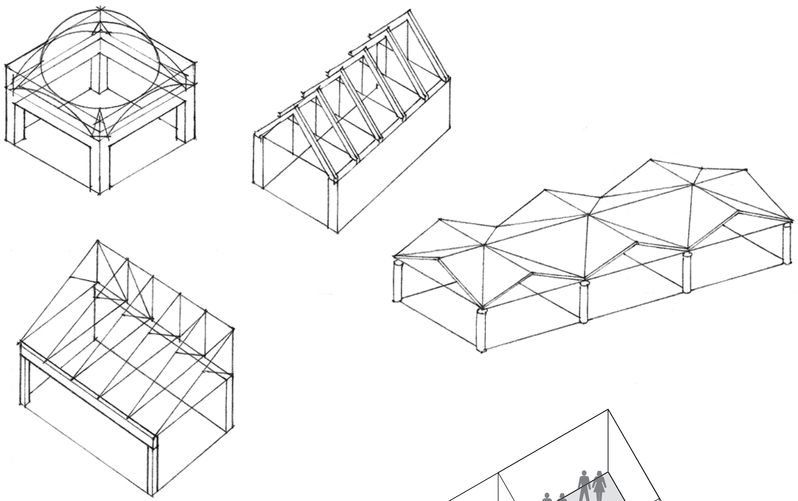


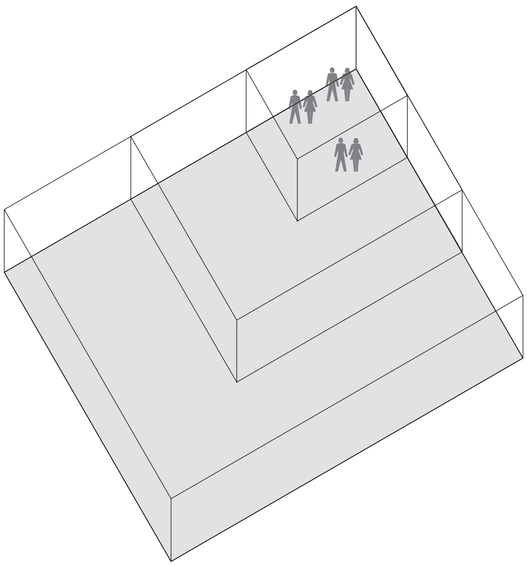




## SPATIAL DIMENSIONS







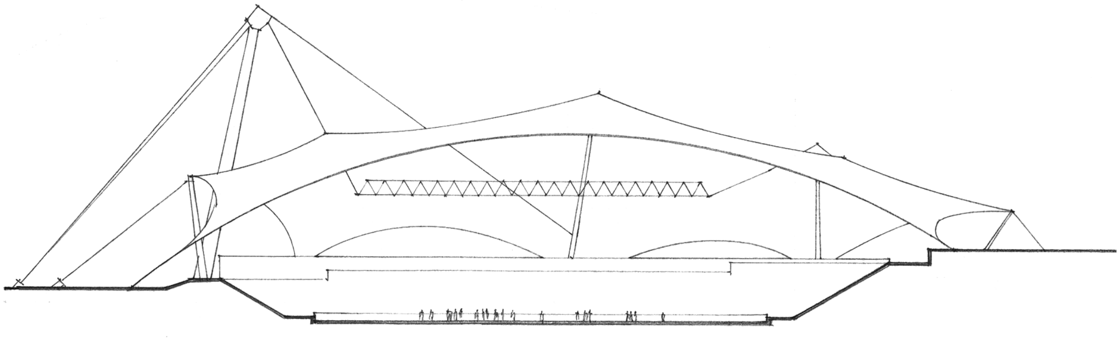
The dimensions of interior space, like spatial form, are directly related to the nature of a building's structural system—the strength of its materials and the size and spacing of its members. The dimensions of a space, in turn, determine a room's proportion and scale and influence the way it is used.

One horizontal dimension of space, its width, has traditionally been limited by the materials and techniques used to span it. Today, given the necessary economic resources, almost any architectural structure is technically possible. Wood or steel beams and concrete slabs can span up to 30 feet (9 m). Wood or steel trusses can span even farther, up to 100 feet (30 m) or more. Longer roof spans are possible with space frames and a variety of curved structures, such as domes, suspension systems, and membranes supported by air pressure.

Within the bounds of structural necessity, the width of an interior space should be established by the requirements of those who use the space and their need to set boundaries for themselves and their activities.

Building designers have traditionally developed spatial relationships by sketching and model building. *Computer-aided design (CAD)* and *building information management (BIM)* software systems are changing the way that building designers work. These computer technologies allow designers to build interactive three-dimensional computer models of buildings, and to coordinate building systems as they design.

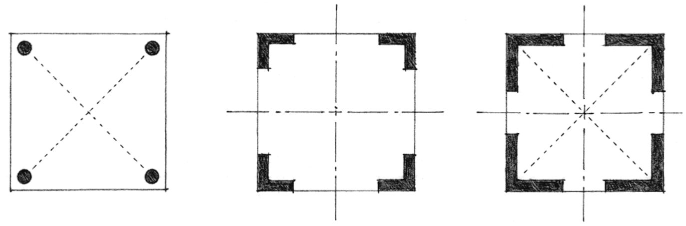
Modeling a building with a 3D CAD system can provide higher productivity, rapid generation of design alternatives, and removal of errors that result from disparities between different drawings. However, these systems do require special design and management skills.

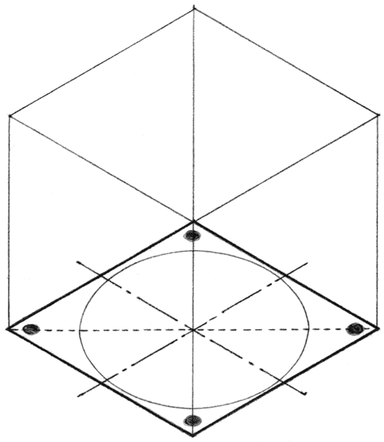


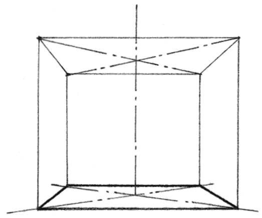
The other horizontal dimension of space, its length, is limited by desire and circumstance. Together with width, the length of a space determines the proportion of a room's plan shape.

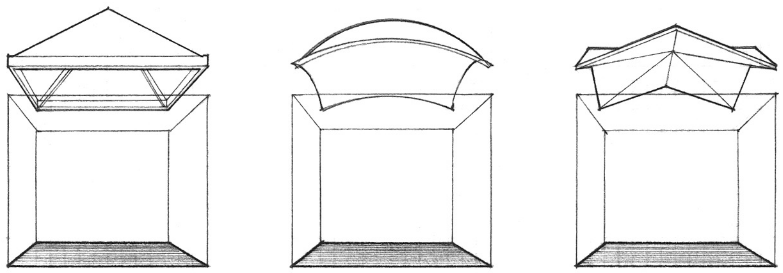
A square room, where the length of the space equals its width, is static in quality and often formal in character. The equality of the four sides focuses our attention in on the room's center. This centrality can be enhanced or emphasized by covering the space with a pyramidal or dome structure.

To deemphasize the centrality of a square room, the form of the ceiling can be made asymmetrical, or one or more of the wall planes can be treated differently from the others.

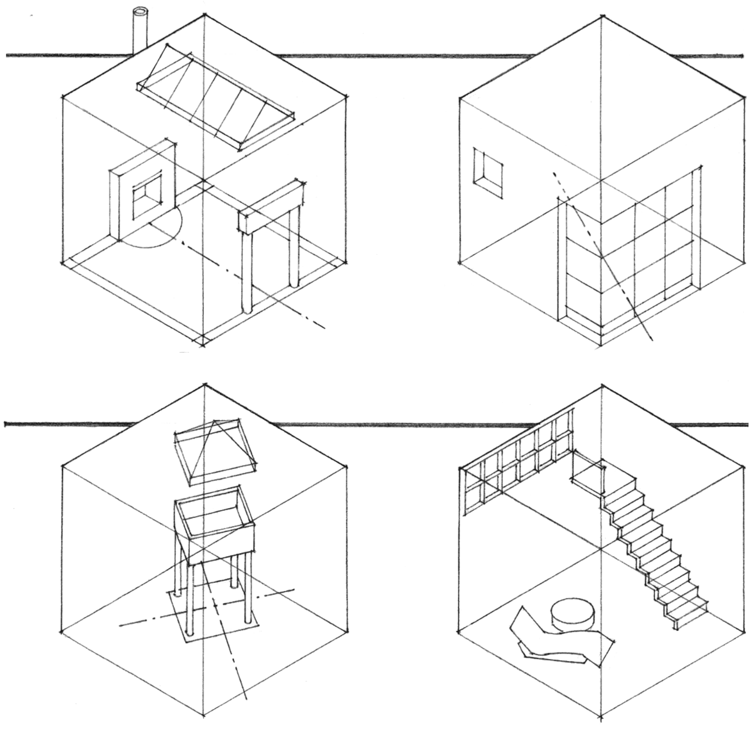




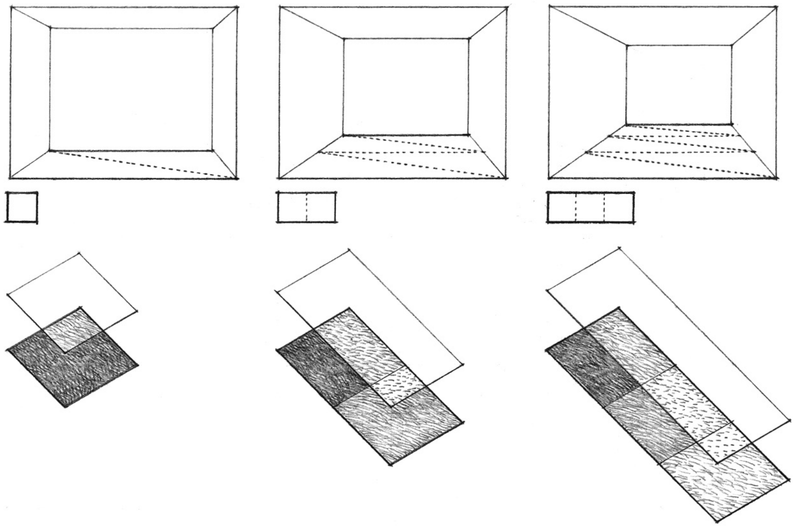




Pyramids, domes, and similar roof forms can emphasize the centrality of square spaces.



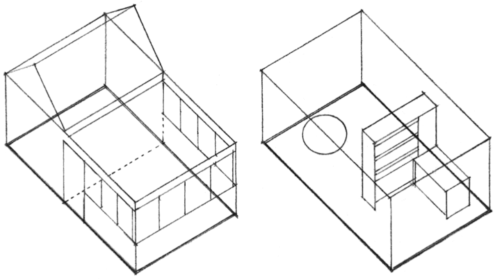
The placement of architectural elements, such as windows and stairways, can deemphasize the centrality of square spaces.



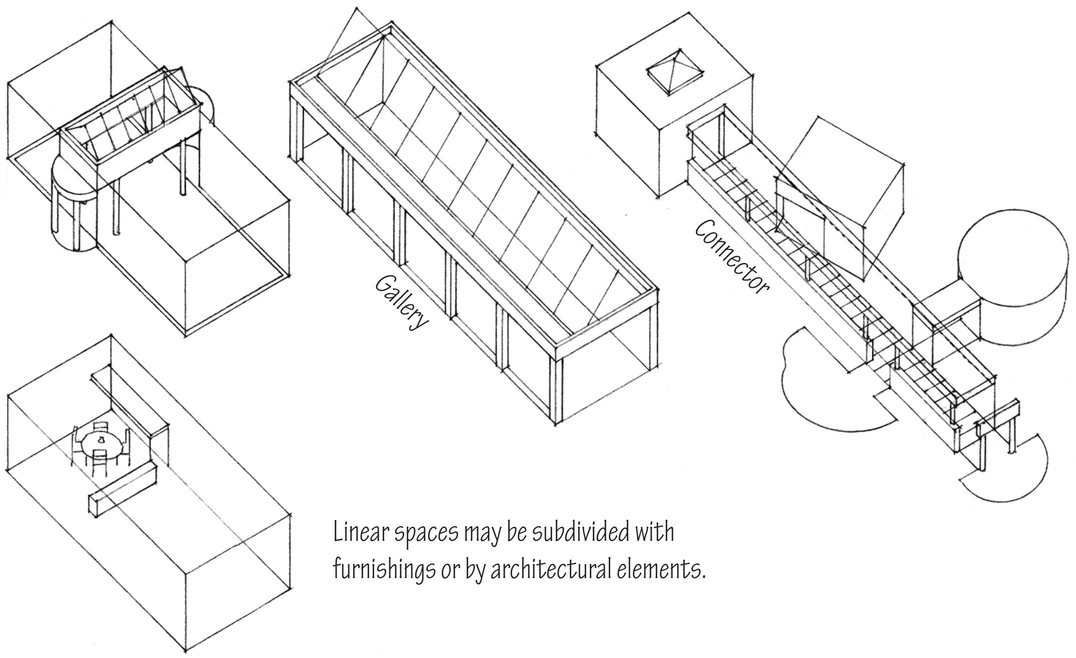
Square rooms are rare and distinctive. More often, a room will have a length greater than its width. A rectangular space, normally spanned across its width, is eminently flexible. Its character and usefulness are determined not only by its proportion of width to length, but also by the configuration of its ceiling, the pattern of its windows and doorways, and its relationship to adjacent spaces.

When the length of a space is greater than twice its width, it tends to dominate and control the room's layout and use. Given sufficient width, the space can be divided into a number of separate but related areas.

A space whose length greatly exceeds its width encourages movement along its long dimension. This characteristic of linear spaces makes them suitable for use as gallery spaces or as connectors of other spaces.

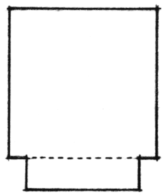


Horizontal dimensions alone do not determine the ultimate qualities and usefulness of a space. They only suggest opportunities for development.

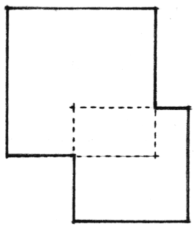



Linear spaces may be subdivided with furnishings or by architectural elements.

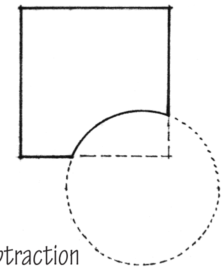
Both square and rectangular spaces can be altered by addition or subtraction, or by merging with adjacent spaces. These modifications can be used to create an alcove space or to reflect an adjoining element or site feature.



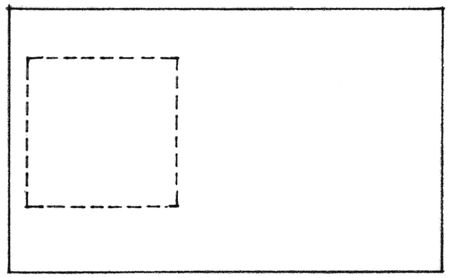
Extension



Addition

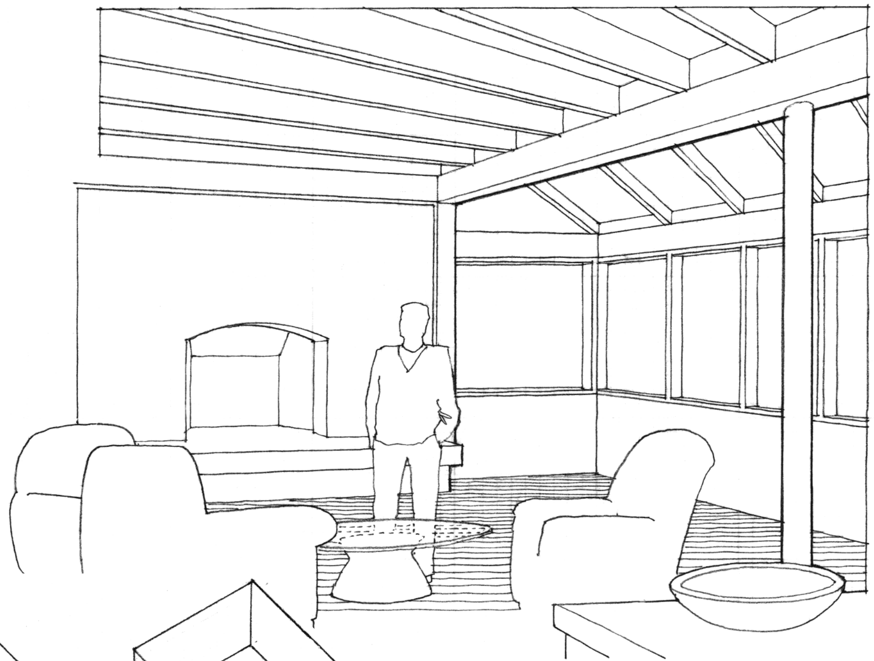


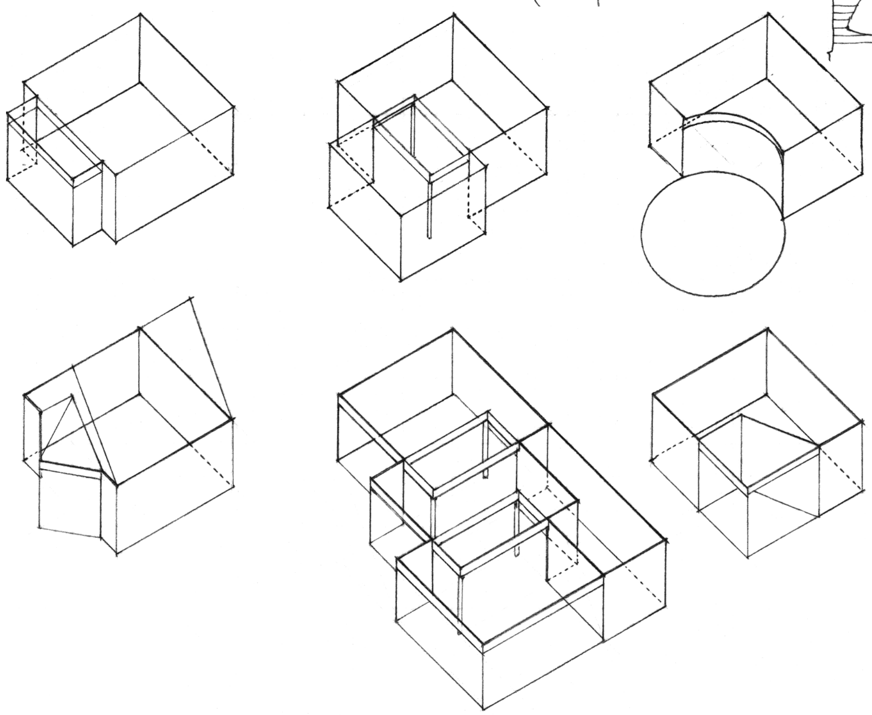
Subtraction

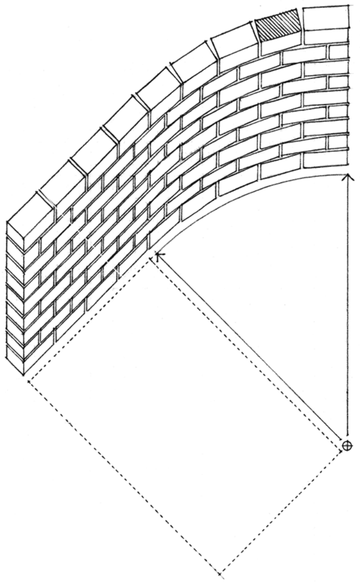


Merging

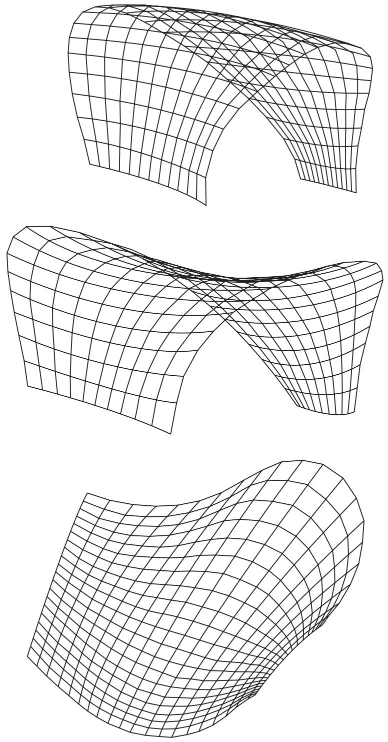
## Altering Space







The radius of the curvature of a wall depends on the scale and flexibility of the material used to build it.

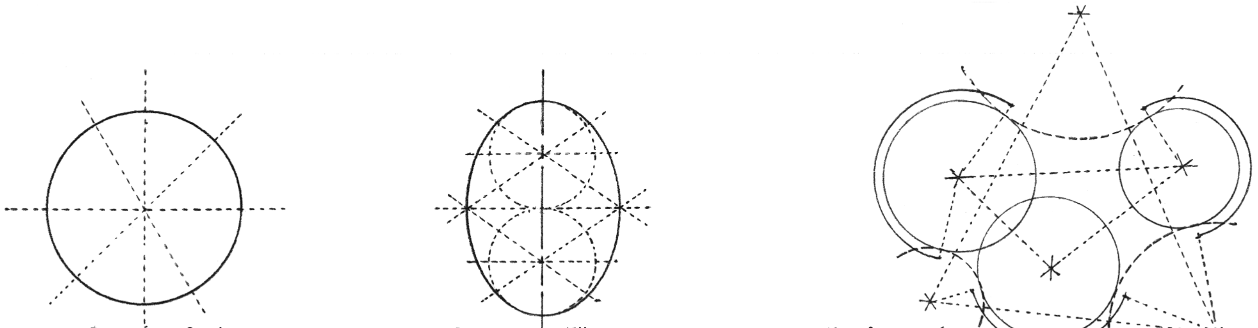


The nature of building materials and the techniques used to assemble them have traditionally established rectangular spaces as the norm. Curvilinear spaces are exceptional and usually reserved for special circumstances. However, the advent of 3D CAD systems has made the design and construction of curvilinear spaces more feasible.

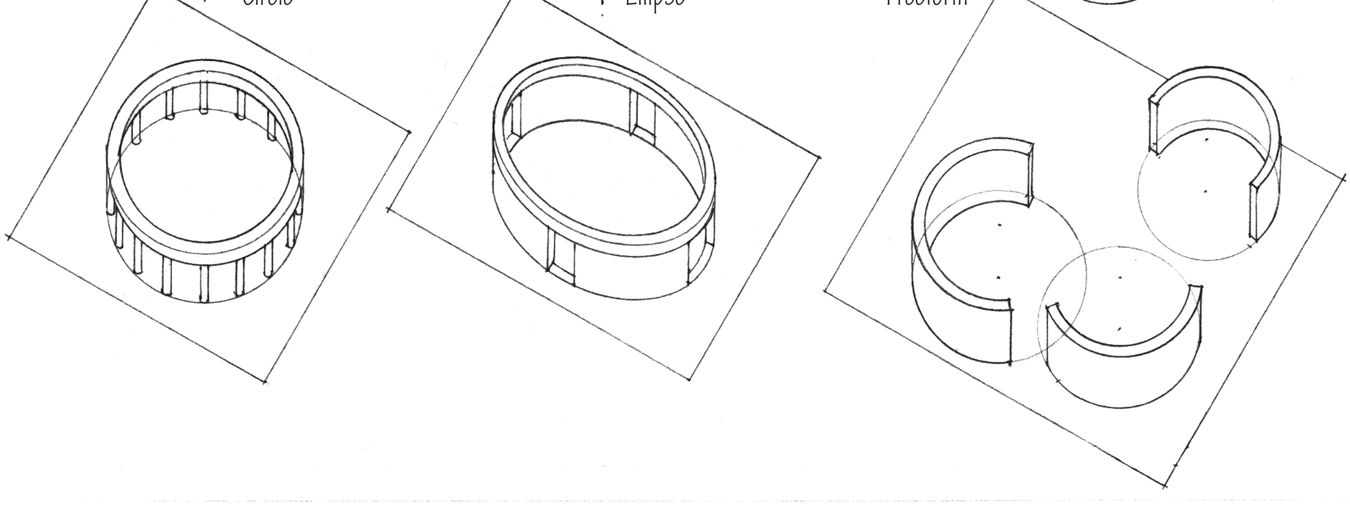
The simplest curvilinear space is a circular one. It is compact and self-centering. Although it creates a focus on its center, a circular space also relates to the surrounding space equally in all directions. It has no front, back, or sides, unless these are defined by other elements.

An elliptical space is more dynamic, having two centers and unequal axes.

Other curvilinear spaces can be seen as transformations of circular or elliptical spaces that have been combined in an overlapping manner. The use of three-dimensional computer modeling is increasing the ease of designing complex curves.



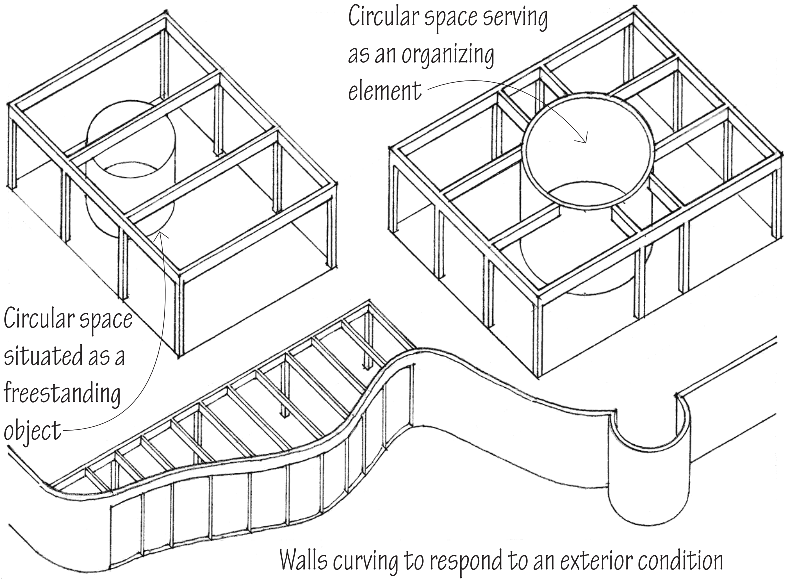
Circle Ellipse Freeform

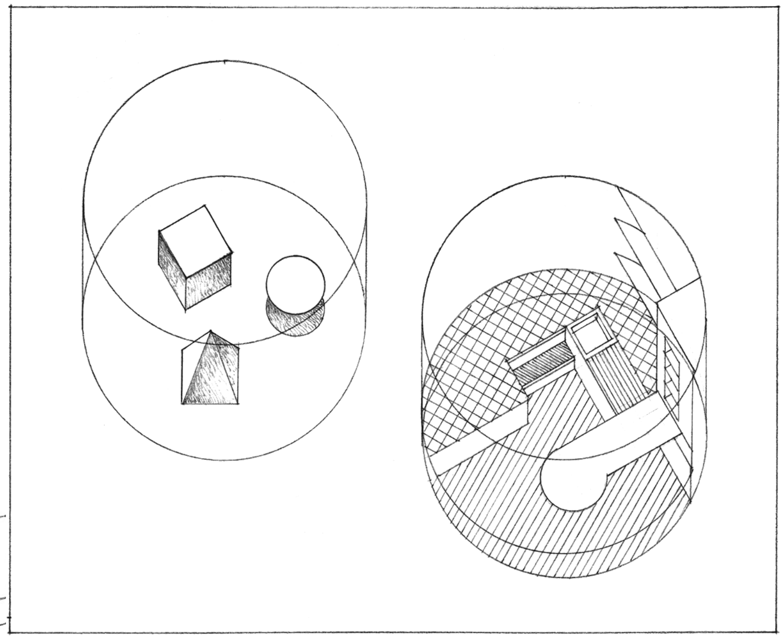


Within a rectilinear context, a curvilinear space is highly visible. Its contrasting geometry can be used to express the importance or uniqueness of its function. It can define a freestanding volume within a larger space. It can serve as a central space about which other rooms are gathered. It can articulate the edge of a space and reflect an exterior condition of the building site.

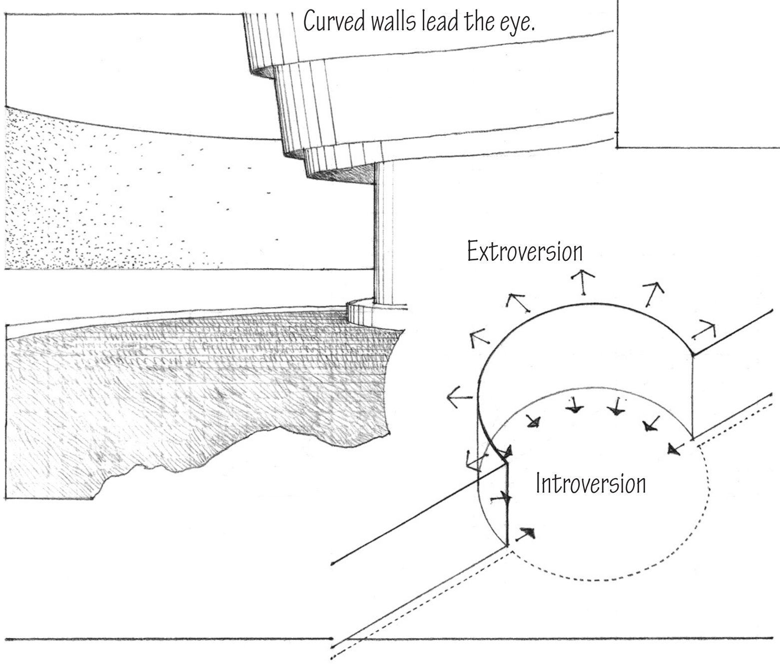
Curved walls are dynamic and visually active, leading our eyes along their curvature. The concave aspect of a curved wall encloses and focuses space inward, while its convex aspect pushes space outward.

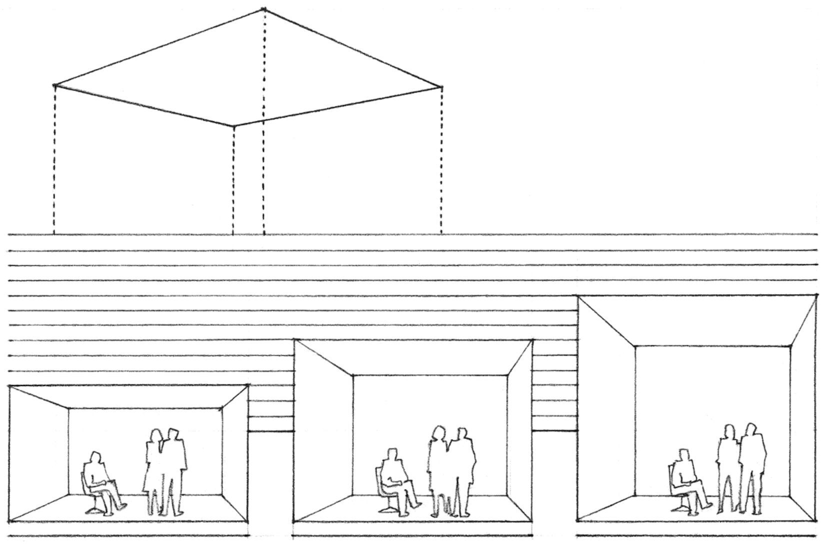
An important consideration when we are dealing with a curvilinear space is the integration of furniture and other interior elements into its volume. One way of resolving conflicting geometries is to arrange interior forms as freestanding objects within the curvilinear space. Another is to integrate the form of built-in furniture and fixtures with the curved boundaries of the space.



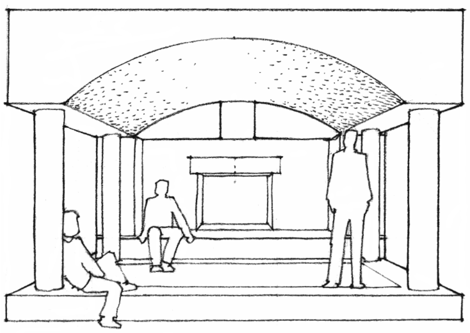
Furnishings may be placed as freestanding objects within a curvilinear space or be integrated within the curved forms.

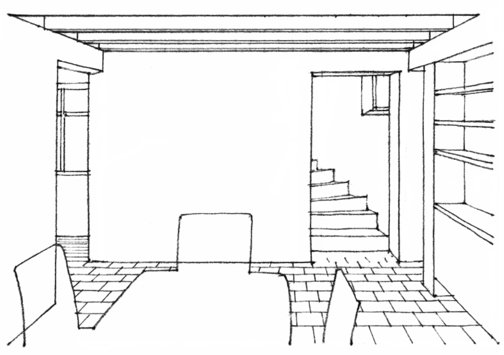


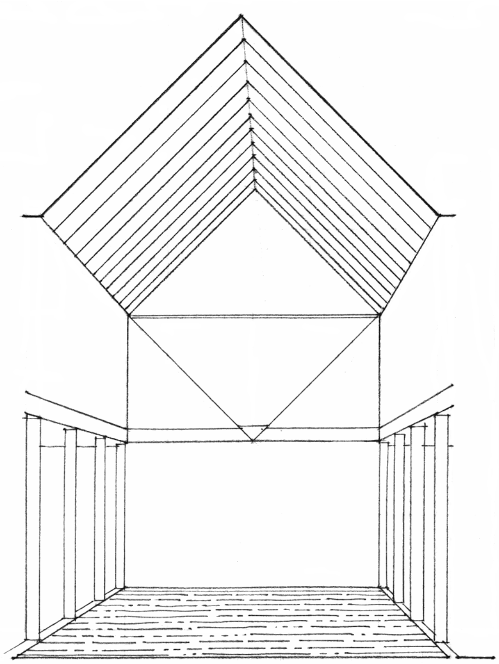


The third dimension of interior space, its height, is established by the ceiling plane. This vertical dimension is as influential as the horizontal dimensions of a space in forming the spatial quality of a room. Design of the ceiling is an important element of interior design.

While our perception of a room's horizontal dimensions is often distorted by the foreshortening of perspective, we can more accurately sense the relationship between the height of a space and our own body height. A measurable change in the height of a ceiling seems to have a greater effect on our impression of a space than a similar change in its width or length.





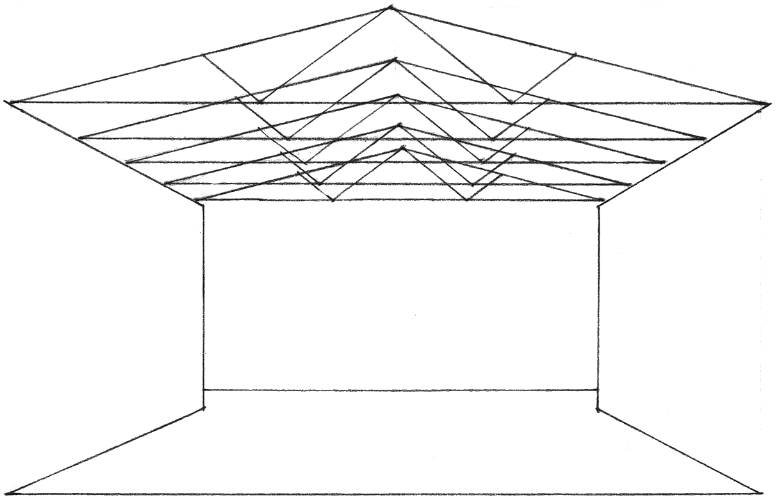


Varying the ceiling height can have a powerful effect on the perceived scale of a space.

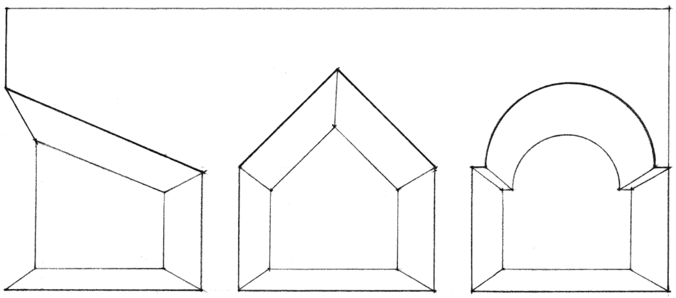
High ceilings are often associated with feelings of loftiness or grandeur. Low ceilings may connote cavelike coziness and intimacy. However, our perception of the scale of a space is affected not by the height of the ceiling alone, but by its relationship to the width and length of the space as well.

A ceiling defined by the floor plane of the room above it is typically flat. A ceiling created by a roof structure can reflect its form and the manner in which it spans the space. *Shed*, *gable*, and *vaulted* ceiling forms give direction to space, while domed and pyramidal ceilings emphasize the center of a space.

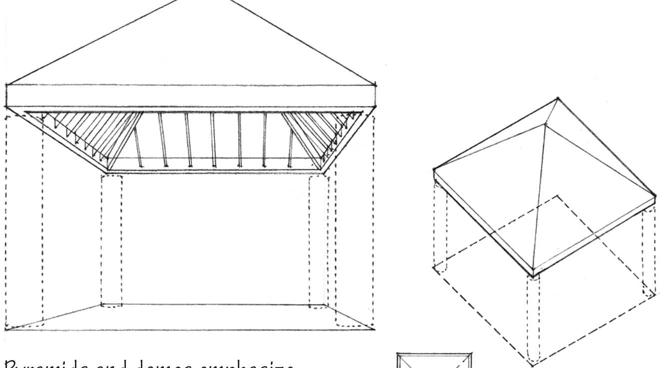
Lowering part of a ceiling can foster intimacy, modify acoustics, or add visual texture. Interior *soffits*, canopies, and clouds can be used to partially lower a ceiling at its perimeter, or over areas of interest.



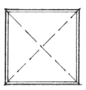
The roof structure can sometimes be left exposed, giving texture, pattern, and depth to the ceiling plane.

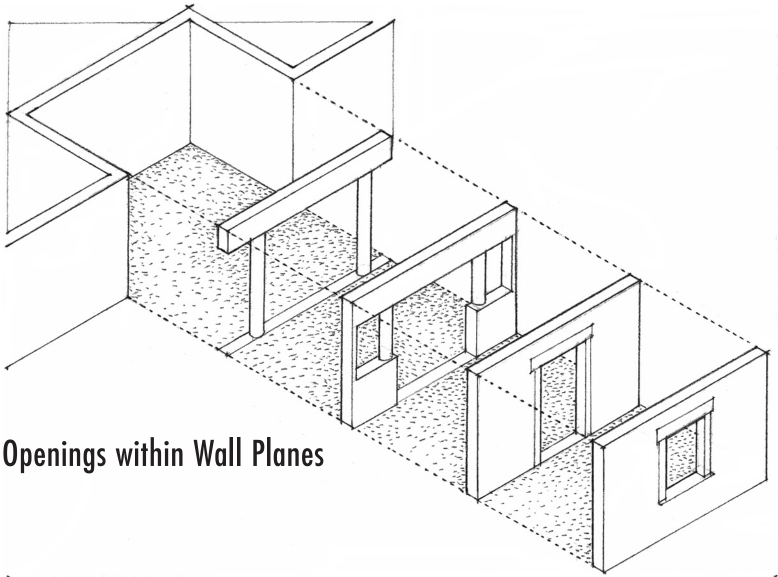


Shed ceiling Gable ceiling Vaulted ceiling



Pyramids and domes emphasize the centrality of a space.

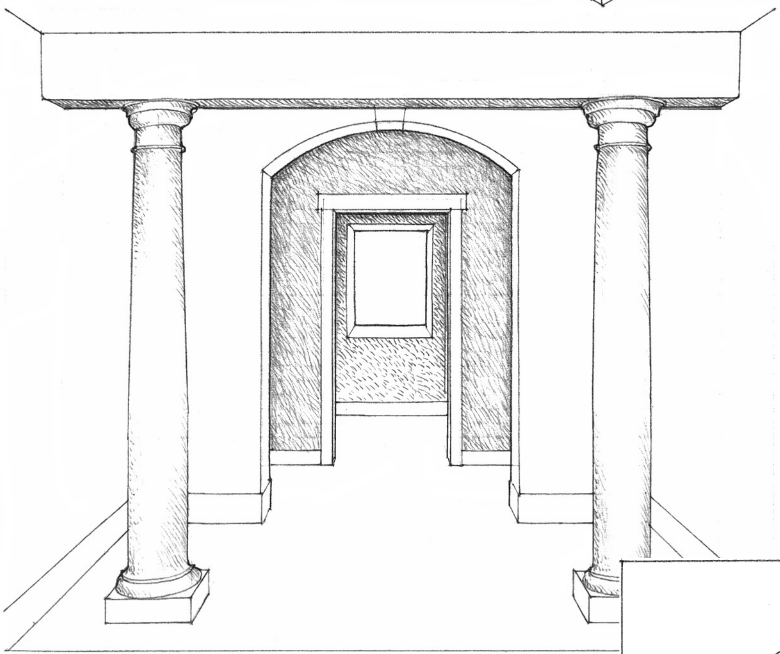


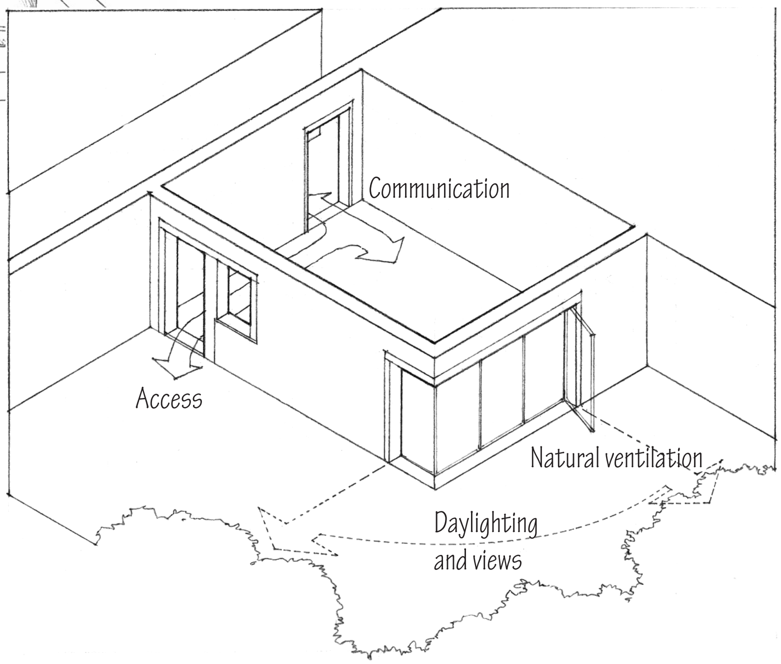


## Openings within Wall Planes

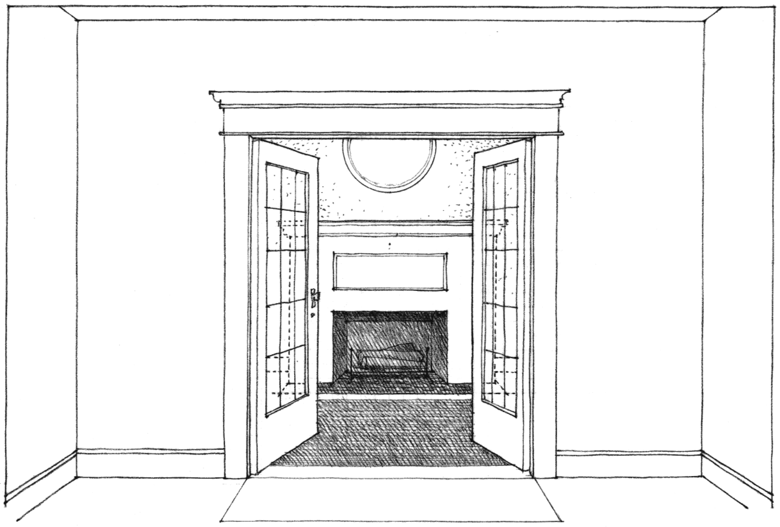
Although individual spaces may be designed and formed for a certain purpose or to house certain activities, they are gathered together within a building's enclosure because they are functionally related to one another, are used by a common group of people, or share a common purpose. How interior spaces are related to one another is determined not only by their relative position in a building's spatial pattern, but also by the nature of the spaces that connect them and the boundaries they have in common.

Floor, wall, and ceiling planes serve to define and isolate a portion of space. Of these, the wall plane, being perpendicular to our normal line of sight, has the greatest effect as a spatial boundary. It limits our visual field and serves as a barrier to our movement. Openings created within the wall plane for windows and doorways reestablish contact with the surrounding spaces from which the room was originally cut.





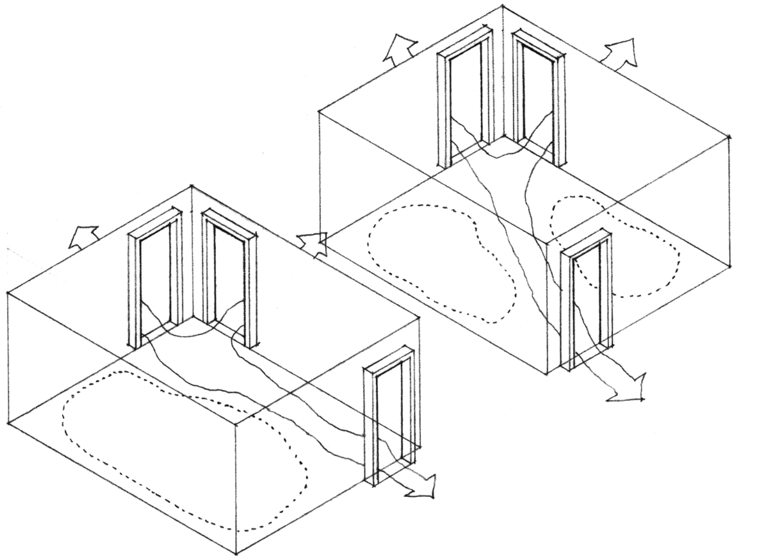
Doorways provide physical access from one space to another. When closed, they shut a room off from adjacent spaces. When open, they establish visual, spatial, and acoustical links between spaces. Large open doorways erode the integrity of a room's enclosure and strengthen its connection with adjacent spaces or the outdoors.



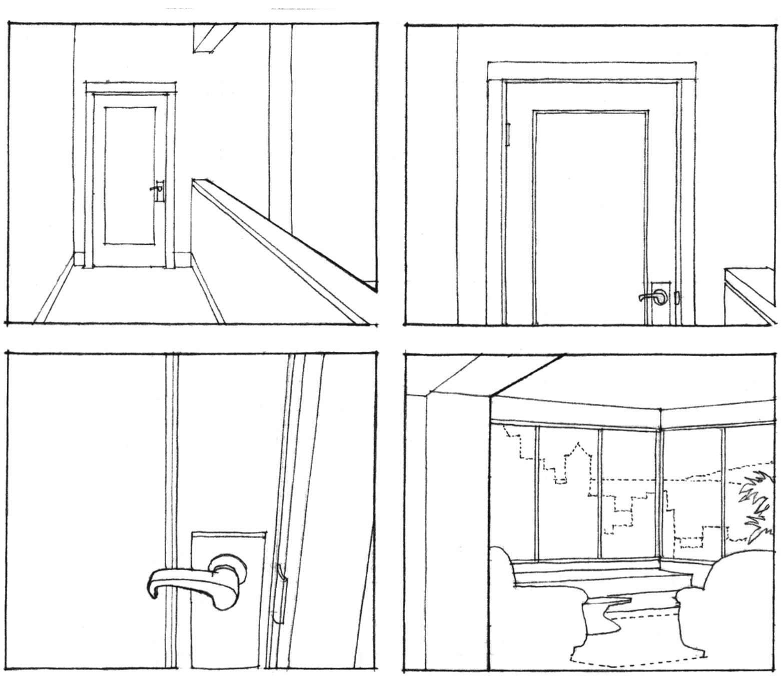
The thickness of the wall separating two spaces is exposed at a doorway. This depth determines the degree of separation we sense as we pass through the doorway from one space to another. The scale and treatment of the doorway itself can also provide visual clues to the nature of the space being entered.

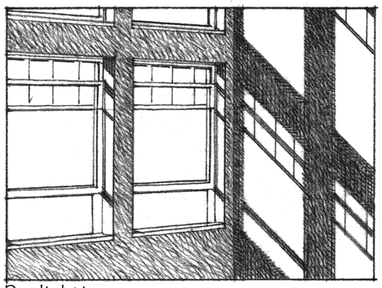
The number and location of doorways along a room's perimeter affect our pattern of movement within the space, and the ways we may arrange its furnishings and organize our activities.

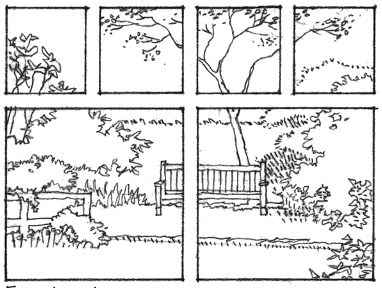
The widths of door openings affect the ease of movement for people and furnishings. A 36-inch (914-mm) wide doorway is reduced to about 32 inches (813 mm) when the thickness of the open door and that of its hardware are taken into consideration. Clear openings of less than 32 inches (813 mm) become barriers to standard wheelchairs, affecting *accessibility*, visitability, and aging-in-place.

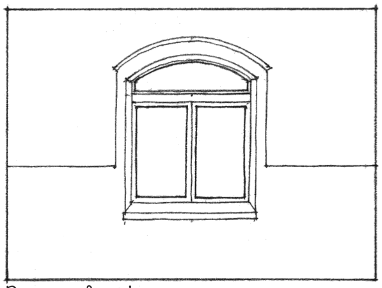


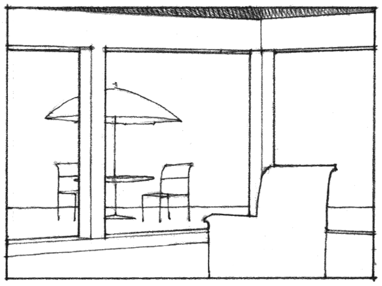
Doorway locations affect our patterns of movement and activities within a room.

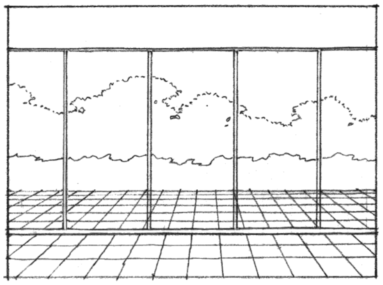


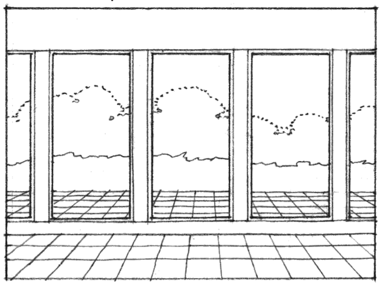

Daylighting

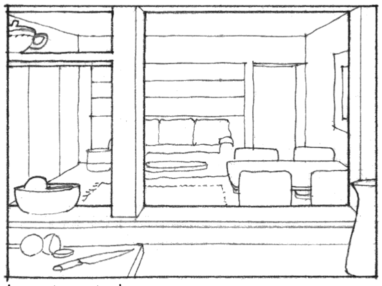

Framing views

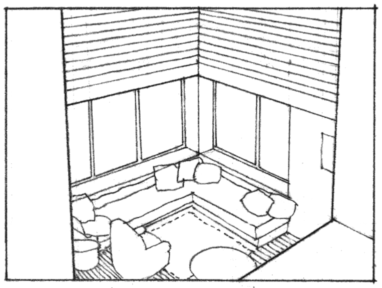

Degree of enclosure


. . . or transparency


Thin frame


Thick frame


Interior windows

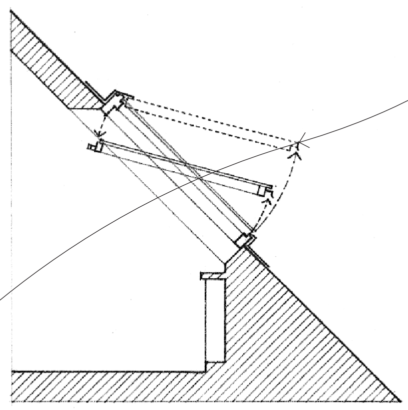

. . . connecting spaces

Windows let light and air into the interior spaces of buildings and provide views of the outdoors, or from one space to another. Their size and placement, relative to the wall plane in which they occur, also affect the degree of separation between an interior space and the exterior environment. Views to the outside and *natural ventilation* are important elements in sustainable design.

Windows framed within a wall plane attract our attention with their brightness and outlook but maintain the enclosure provided by the wall. Large windows and glass walls attempt, at least visually, to merge indoor and outdoor space. The visual treatment of the window frames in each case can either emphasize or minimize the perceived limits of interior space.

Interior windows can, in a similar manner, visually expand a room beyond its physical boundaries and allow it to become an integral part of the surrounding interior space.

Operable skylights allow overhead daylight to enter and excess heat to leave the building. They also provide building occupants with views of the sky.



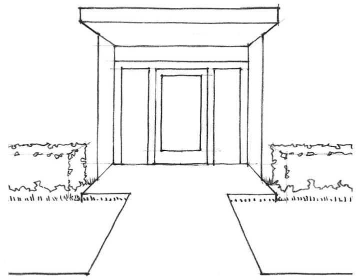
Stairways are also important forms of spatial transitions between rooms. An exterior set of steps leading to a building's entrance can serve to separate private domain from public passage and enhance the act of entry into a transitional space such as a porch or terrace. Entrances without steps support visitability and aging-in-place.

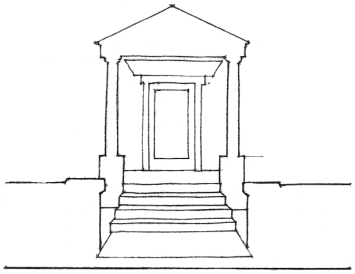
Interior stairways connect the various levels of a building. The manner in which they perform this function shapes our movement in space—how we approach a stairway, the pace and style of our ascent and descent, and what we have an opportunity to do along the way. Wide, shallow steps can serve as an invitation, while a narrow, steep stairway may lead to more private places. Landings that interrupt a flight of steps can allow a stairway to change direction and give us room for pause, rest, and outlook.

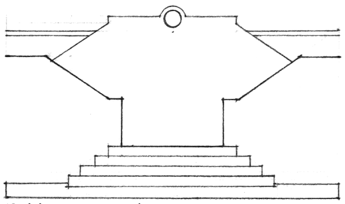
Designers are becoming more concerned with creating opportunities for movement within interior workplace spaces. One result of this has been the increasing use of wide stairs as seating areas, often connecting work or presentation spaces.

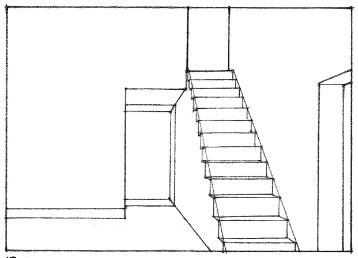
Active design focuses on the role of designers in dealing with the urgent health crises of obesity and related diseases such as diabetes. Active design guidelines go beyond Leadership in Energy and Environmental Design (LEED) programs to address people's varying needs and educate designers about opportunities to increase daily physical activity and include measures such as making stairs more visible and inviting. They seek to increase stair use by providing a conveniently located stair for everyday use, posting motivational signage to encourage stair use, and designing visible, appealing, and comfortable stairs.

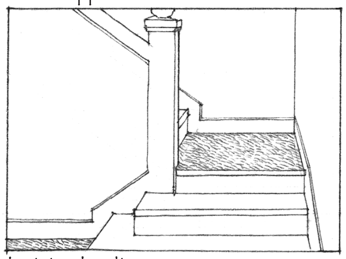
The space a stairway occupies can be considerable, but its form can be fit into an interior in several ways. It can fill and provide a focus for a space, run along one of its edges, or wrap around a room. It can be woven into the boundaries of a space or be extended into a series of terraces.

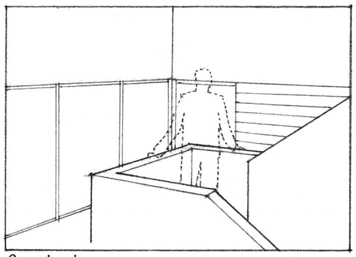

Visitable entrance

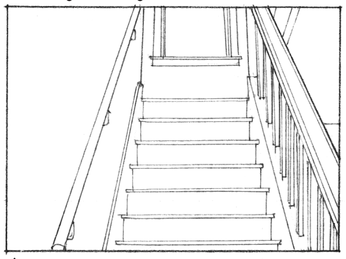

Exterior entrance

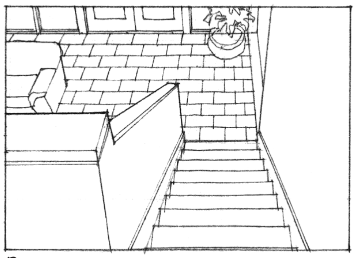

Public approach

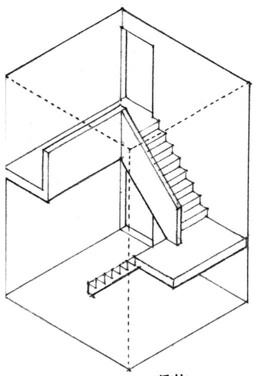

Private access

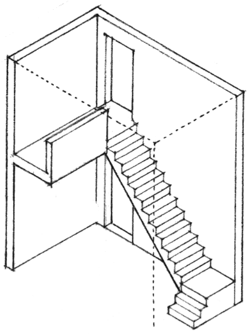

Inviting landings

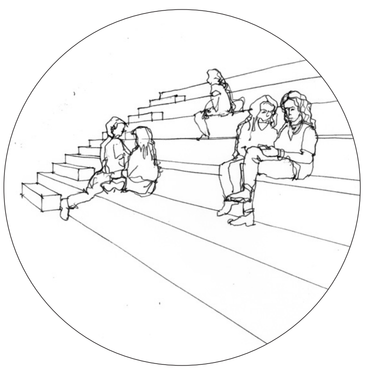

Overlooks

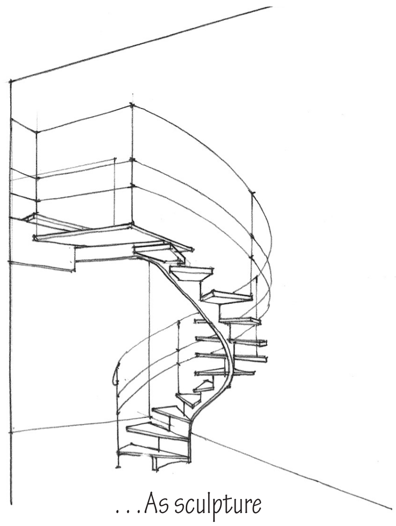

Ascent


Descent

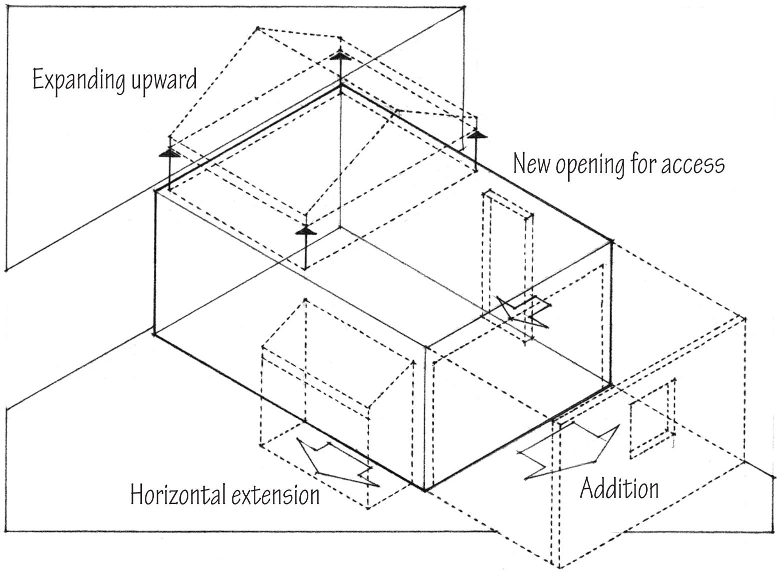

. . . Filling space


. . . Defining an edge


. . . As seating

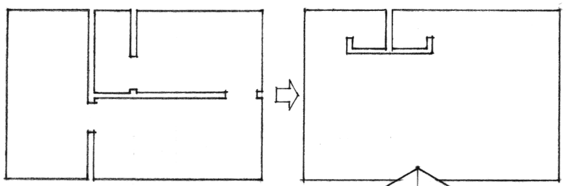

. . . As sculpture

## Stairways



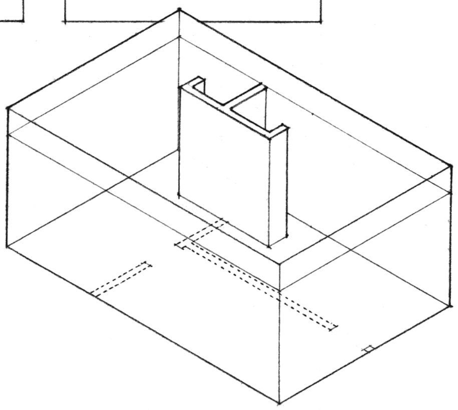

The architectural planning and design for a new building take into account the nature of the activities to be housed; the spatial requirements for form, scale, and light; and the desired relationships among the various interior spaces. When an existing building is to be used for activities other than those for which it was originally intended, however, activity requirements must be matched with the existing conditions. Where a misfit occurs, a modification of the existing spaces may be required.

Today, many interior renovations involve changes to existing buildings. Where the design involves changes in the building's use, the process is referred to as *adaptive reuse*. Reusing existing buildings can help preserve the historic qualities and architectural character of a built environment.



### Rearranging Space

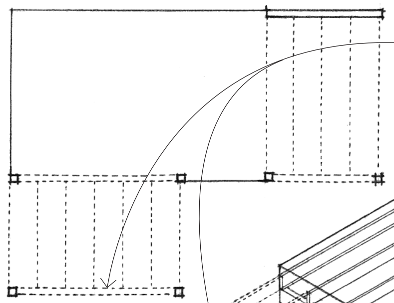
Reconfiguring an existing space requires removing walls and constructing new ones.

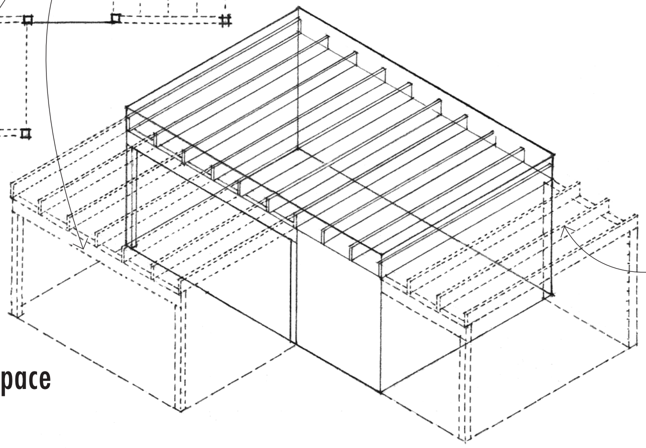


Two major types of alteration can be considered. The first involves structural changes in the boundaries of interior space and is more permanent in nature than the second. The second type of alteration involves nonstructural modifications and enhancement accomplished through interior design.

The acceptance of formerly forbidden accessory dwelling units (ADUs) offer opportunities to create residential units in existing owner-occupied one- to three-family buildings in certain neighborhoods. The ADUs create an opportunity to evolve older residences to meet 21st-century housing needs, while promoting long-term occupancy and neighborhood stability.

A structural change may involve removing or adding walls to alter the shape and rearrange the pattern of existing spaces, or to add on new space. When making such alterations, it is extremely important to understand the distinction between load-bearing walls and non-load-bearing *partitions*. It is, therefore, always advisable to consult a professional engineer or architect when making structural changes to a space.

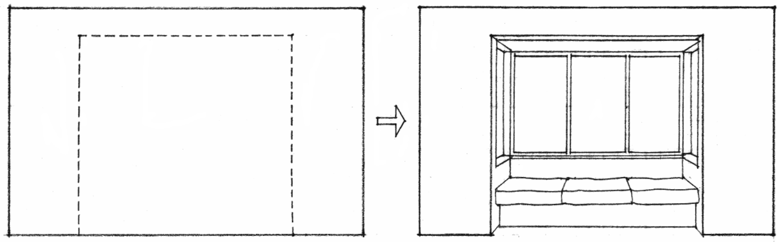


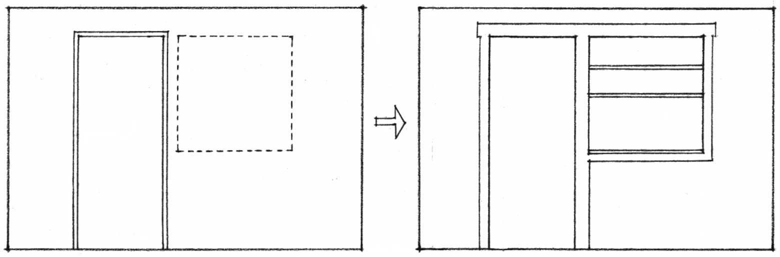



### Adding New Space

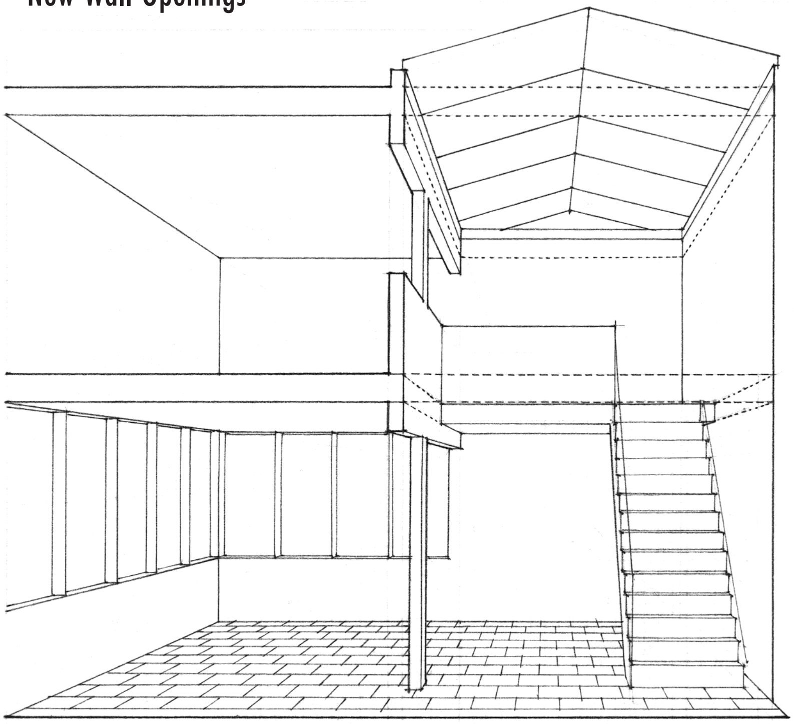
Within the boundaries of a space, the existing pattern of openings can also be altered. Windows may be enlarged or added for better daylighting or to take advantage of a view. A doorway may be moved or added for better access to a room space or to improve the movement paths within the space. A large doorway may be created to merge two adjacent spaces. Any new or enlarged opening in a load-bearing wall requires a lintel or *header* sized to carry the wall load above the opening.

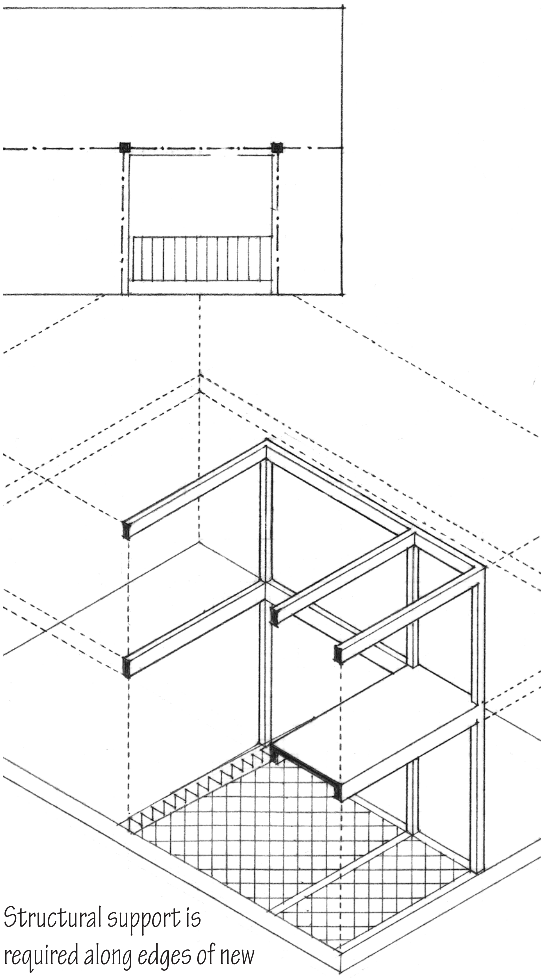
To add a stairway, daylight a space with skylights, or create a vertical relationship between two levels of space, structural changes in the floor or ceiling plane may be required. Alterations in these horizontal structures of a building may require that the edges of any new openings be reinforced and supported by a system of beams, columns, posts, or bearing walls.

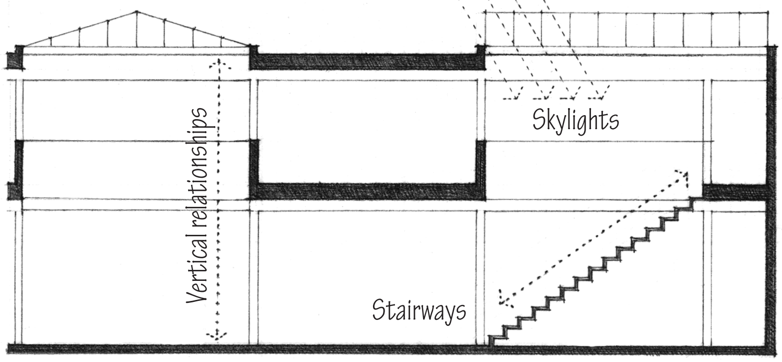

Extending space outward


Enlarging an existing opening

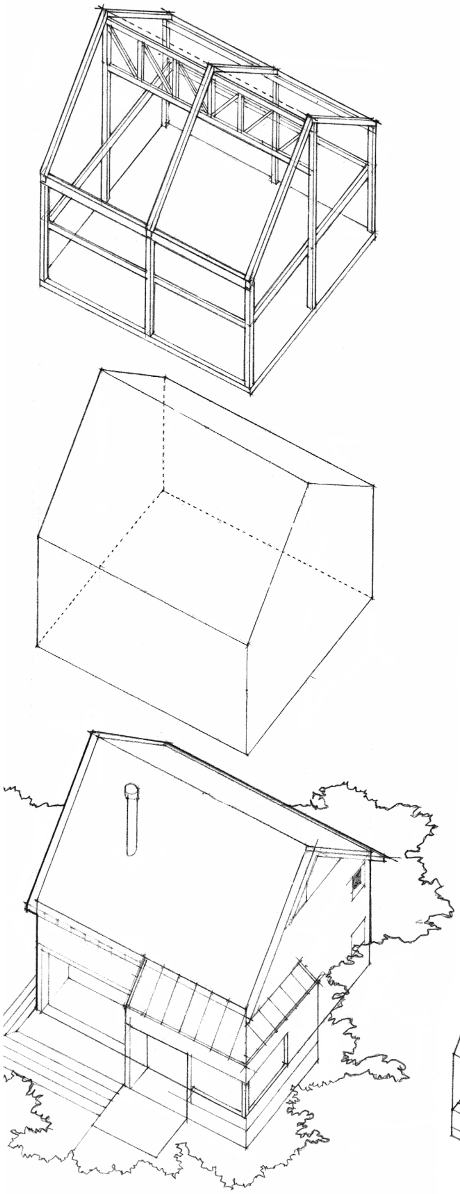
## New Wall Openings




Structural support is required along edges of new floor and roof openings.

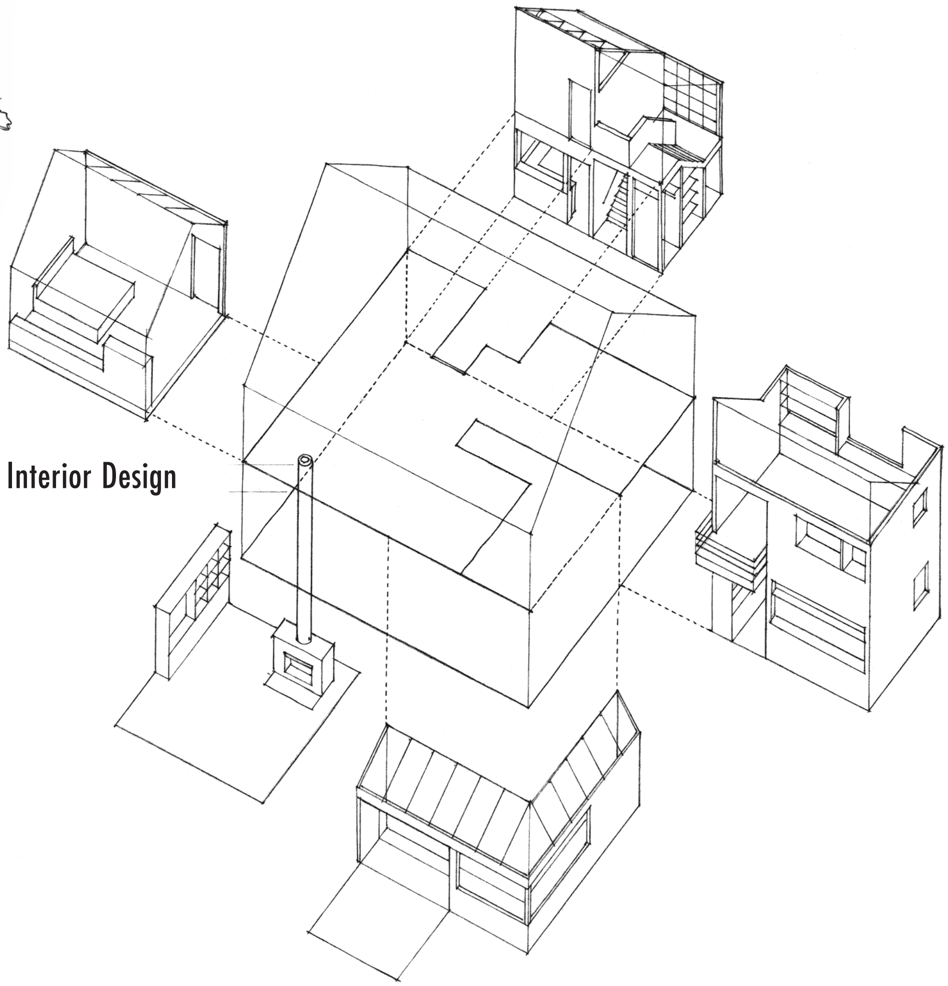


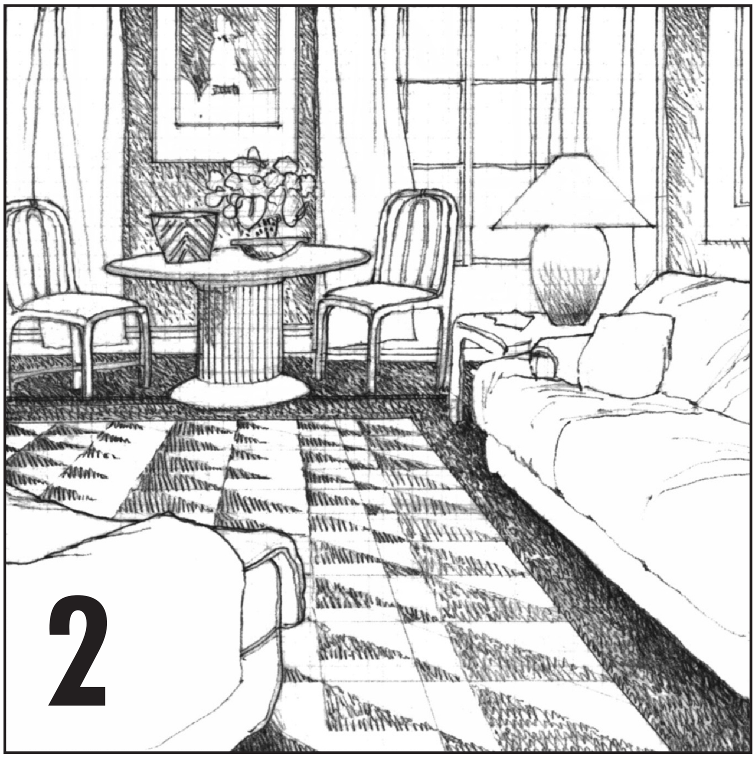

## Vertical Expansion



Even as we deal with specific design issues and with different aspects of a building's interior spaces, we should be mindful of the overall structure and patterns of the architecture. In particular, any changes in the physical boundaries of a space must be carefully planned so that the structural integrity of a building is not disturbed. Major structural changes in a space, therefore, require the assistance of a professional engineer or architect.

Interior spaces can be modified and enhanced with nonstructural alterations, however. While structural changes alter the physical boundaries of space, nonstructural alterations are based on how we perceive, use, and inhabit space. These are the types of changes commonly planned and executed by interior designers.





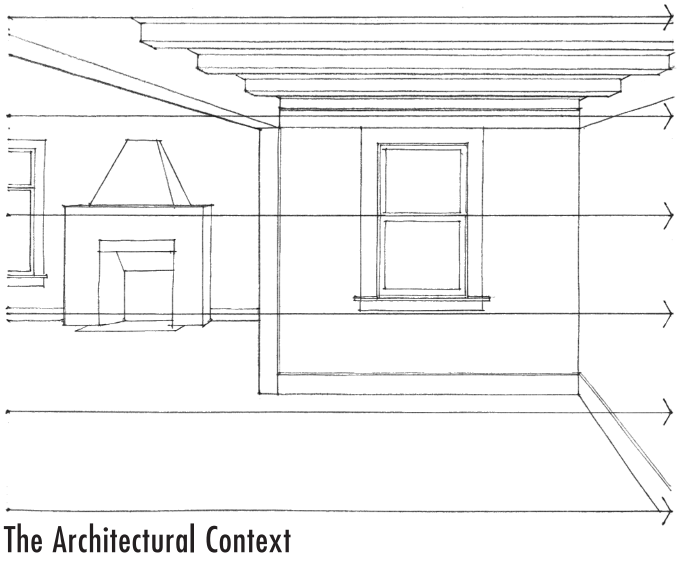
# 2 Interior Design

Interior design is the planning, layout, and design of the interior spaces within buildings. These physical settings satisfy our basic need for shelter and protection, set the stage for and influence the shape of our activities, nurture our aspirations, express the ideas that accompany our actions, and affect our outlook, mood, and personality. The purpose of interior design, therefore, is the functional improvement, aesthetic enrichment, and psychological enhancement of the quality of life in interior spaces. Increasingly, educational institutions are using the term interior architecture for their programs that focus creative design processes on the needs of people using buildings, rather than on the buildings as objects.

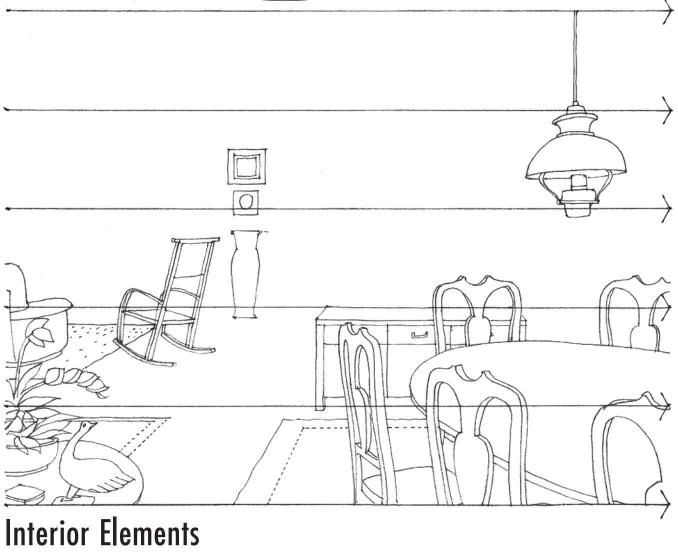
Many projects today involve the interior design of existing buildings, and the design of spatial, technical, cultural, and functional needs from the inside out. When designing new structures, the designer can consider future transformations. Other large concepts, such as sustainability and resiliency, also must be included from the start of the project. This increases the complexity of the interior designer's role, but also creates greater opportunities. Interior designers need to make maximum use of what they already have and build new only what they absolutely require.

Historic preservation has moved to the forefront for many American cities, becoming highly desirable today. Technological advantages unheard of in the past, such as ground-penetrating radar, infrared thermography, and drones with their cameras, open new frontiers for documentation of existing construction. New materials can conserve buildings by sealing masonry and concrete against water penetration, coat active cracks without themselves cracking, and protect iron materials from corrosion. Older buildings can be mathematically modeled in three dimensions to determine their strengths and weaknesses. Some of the repair methods, in opposition to the Secretary of the Interior's Standards, are so extensive as to be irreversible.

Current trends include working with local artisans in developing countries to produce unique furnishings that combine local materials with modern themes. These efforts create employment for artisans as well as helping local people start their own businesses, often with micro-savings programs.



The Architectural Context



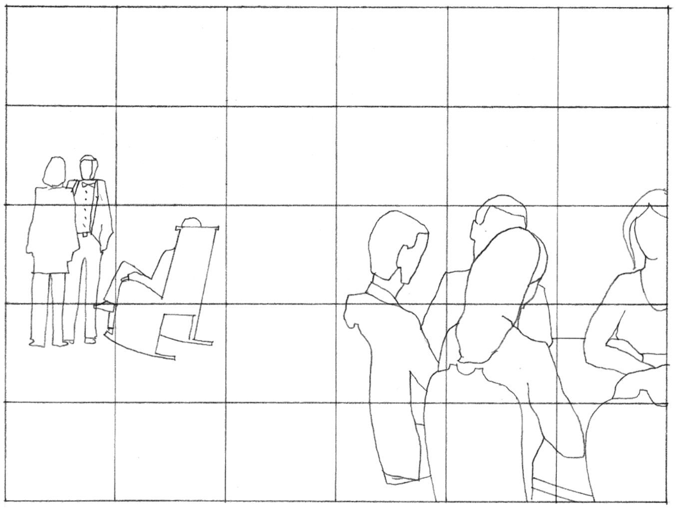
Interior Elements

Resiliency is the ability of an organization, a place, or a family to weather a catastrophic event—climate, social unrest, and the crisis in affordable housing, for instance—and to come back better than it was before. A resilient system is one designed to evolve and adapt to changing conditions over time. Experts have suggested that interior designer's contributions to post-disaster shelter design could include culturally appropriate color palettes and geographically appropriate interior finishes, along with layouts and programming that promote social cohesion, which can lead to successful recovery after a disaster. The Perkins + Will report, *Weathering the Storm: Mental Health and Resilient Design*, identified the following design strategies to address major crisis events:

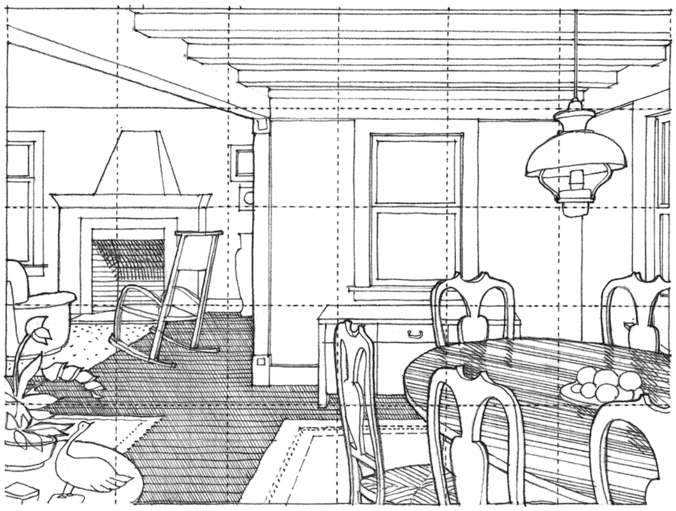
- Green roofs as outdoor refuge spaces and food production
- On-site renewable energy
- Building elements above a flood plain
- Transportation for building occupants, including public transportation, bicycles, and inflatable rafts
- On-site storage of emergency supplies
- Emergency communications
- Shelter in place
- Training for personnel
- Communications with occupants

Designing for an aging population increases the need for skills in universal design and design for longevity, and notably in renovations, additions, and new construction. Simple and intuitive use is supported by wireless devices, such as thermostats and security systems, home media, lighting systems, baby monitors, and wall ovens. Size and space for approach and use are accommodated by taller kitchen counters for tall residents or lower ones for children's areas. Pocket doors provide more room in tight bathrooms and closets, and oversized showers work for pets, shower chairs, or portable baby tubs. An extra room space is flexible in use over time, as children's play area, an entertainment center, home office, guest room, first floor bedroom, or private room for a live-in home health aide.

Flexible space also works well for multi-generational living. The unique perspectives of members of the millennial generation are reshaping the design and development of interior space. Bigger does not always mean better. Houses designed to age and adapt with the homeowners' changing needs are becoming more and more common. Clients are seeking homes that relate to their natural context as well as the lifestyles of their occupants, and designers are consulting clients on what makes them feel at home.



Intentions, Perception, and Use



The Interior Environment

WeWork, experts on designing for collaborative, empowering office spaces, cite five factors for coworking spaces (*Metropolis*, June 2016):

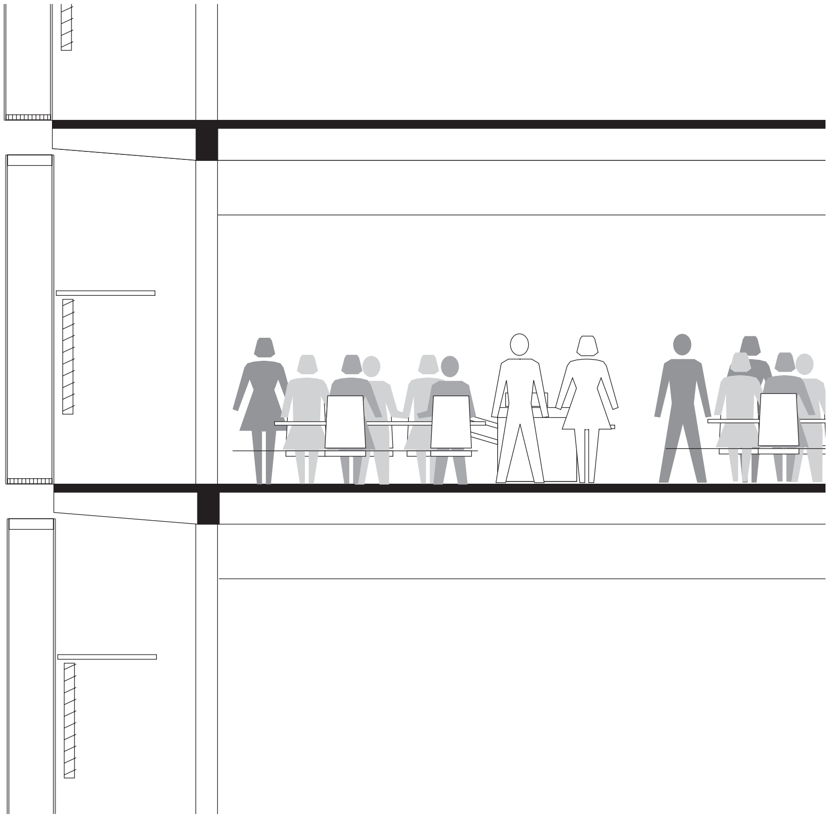
1. Warm up the lighting with connections to natural light.
2. Create a spectrum of sound by providing multiple options in terms of energy level and noise, varying with activity level and mood.
3. Feel at home with warm, inviting, and comfortable spaces with a human connection to nature and natural materials.
4. Rely on data by using concerted data analysis such as user rating of spaces.
5. Pair unexpected activities by designing amenity hubs, such as putting printers and food in one area to keep people moving in and out of the space, encouraging them to stop and chat.

Office spaces are trying to mimic the private and social spaces of residential architecture. Some spaces feel comfortable and cozy, while other are more expansive and provide views. The more minimal the private workspaces are, and the more energy is put into collaborative or unstructured spaces, the more effective the office is. Kitchens can become hearths of offices, as they have become the home away from home. Dining rooms have become workspaces, balanced by low- or no-tech zones for personal interactions.

Research into the impacts of design by sociologists and healthcare experts show us how interior spaces impact productivity and well-being. Interior designers can understand the importance of meeting with the people who will be the users and understanding from their experience how the design will meaningfully support them. Designers can act as liaisons with other professionals to bring a wider range of perspectives to the table.

Healthcare facility design today focuses on patients, with *evidence-based design* (EBD) linking patient-centered design with improved patient and worker safety, patient outcomes, environmental performance, and operational efficiency.

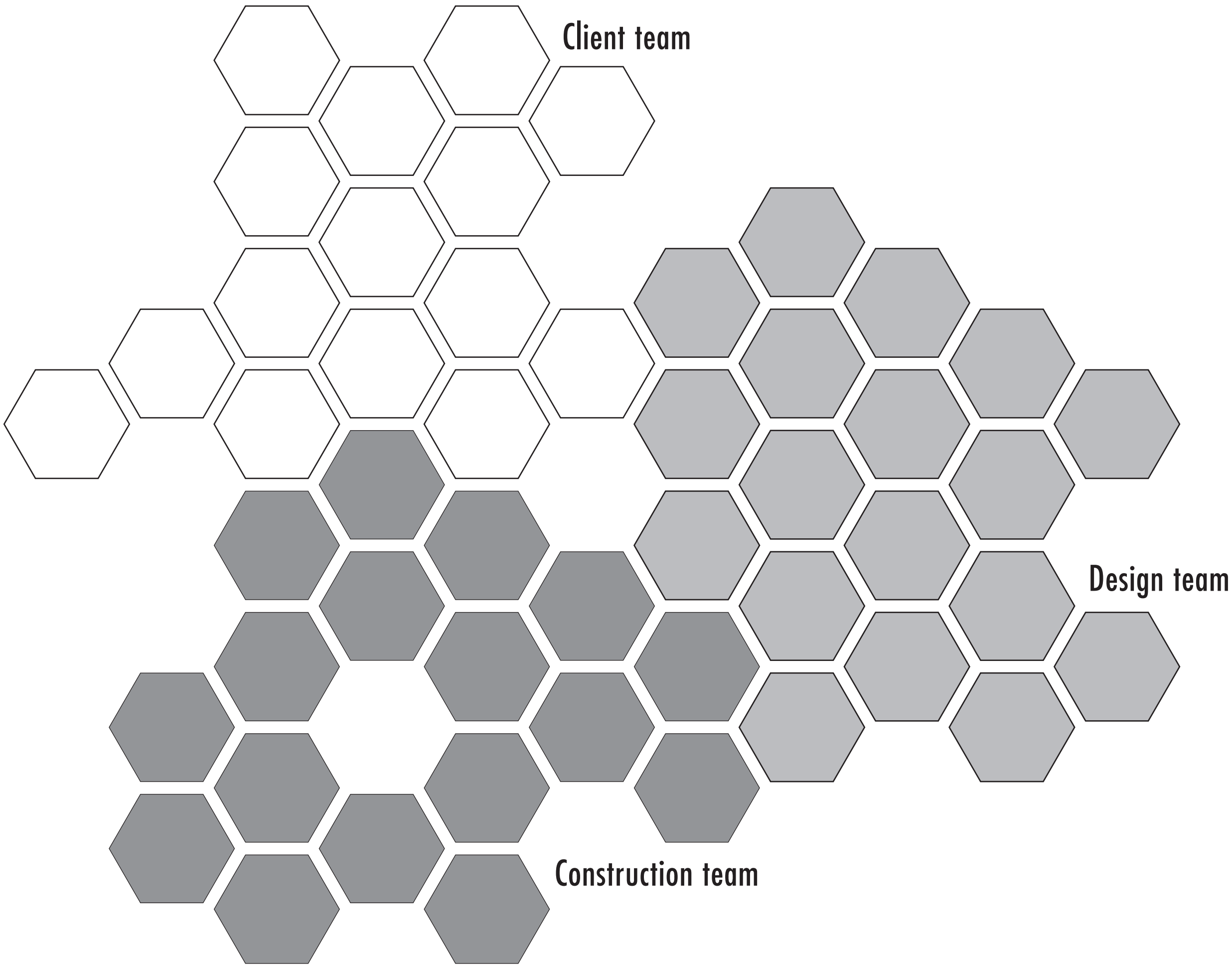
Today, everything is changing so quickly that designers need to be able to allow for movement or rearrangement, as some design ideas will remain while others will not. The question of how a person can be productive on an individual basis remains open. Acoustical problems become dominant, engendering multiple types of spaces or ways that people can work. Movement from one space to another becomes increasingly important.

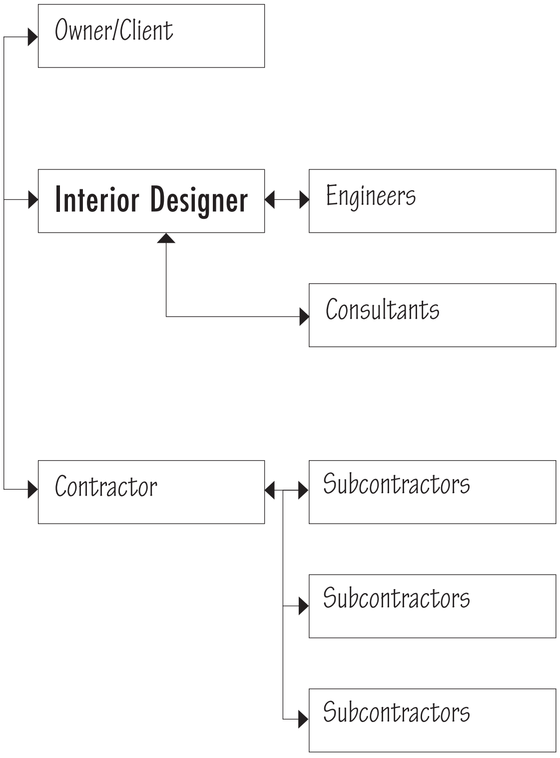


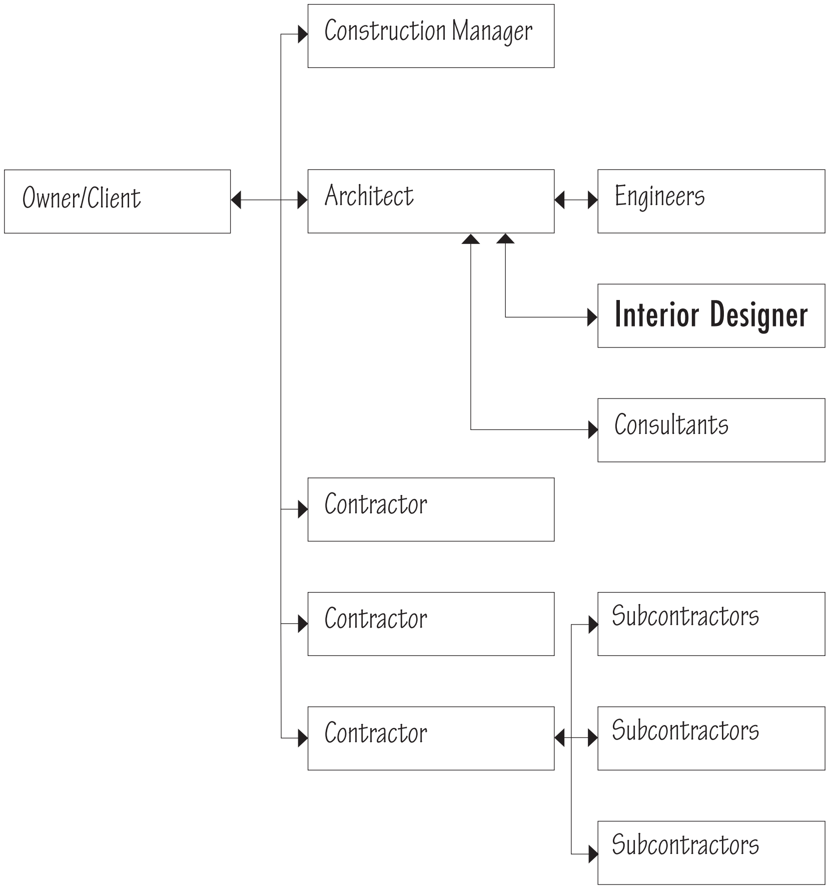
The development of architectural forms and environmental systems for any building has implications for the interior designer, just as the information the interior designer collects about the client, the space, and the intended activities has implications for the work of the other members of the design team.

The interior designer may be working as a sole practitioner; collaborating with other designers, architects, and design specialists in a larger design firm; or serving as a consultant to an architectural firm. In any case, the interior designer is likely to have contact with architects, engineers, and other consultants in other firms. In addition, the interior designer will work with client representatives, including facilities managers, administrators, and end users.

The interior designer is often the liaison between the client and the sources for finishes or furnishings. The user (for example, a hotel's housekeeping staff) often sees critical elements that professional designers may miss. During construction, the interior designer is also in contact with contractors and suppliers. All of these members of the design and construction team should strive to maintain an atmosphere of communication, cooperation, and mutual respect. The coordination among design professionals throughout the building design process allows the expertise of each design field to be tapped to produce creative solutions to design problems as they arise.






The need to create spaces that work for today's changes and remain relevant tomorrow makes an interdisciplinary approach that includes designers, architects, engineers, and facility managers increasingly important. It is necessary to look at a building as an interconnected, interactive whole rather than as separate components belonging to a single profession. Complex challenges require technical knowledge from a variety of disciplines, including architecture and interior design, graphic and landscape design, structural, industrial, mechanical, acoustical, electrical and systems engineering, and other fields including psychology, sociology, and anthropology.

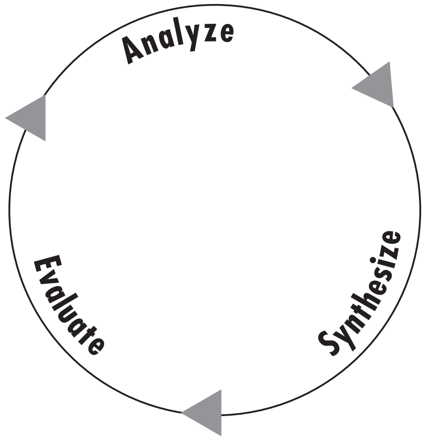
At the time of writing this book, architecture is still a male-dominated profession. The diversity of solutions, connections, and ideas we need requires more diversity in the industry's ranks.

The design team includes both in-house talent and specialized consultants, preferably from the beginning of the design process. Unfortunately, this often doesn't happen because of tight timelines and tight budgets. Often, when it does happen, the interior designer may be the one to pull the disciplines together.

Interior designers may be uniquely able to facilitate multidisciplinary collaborations. They are knowledge seekers both within their own profession and with other professions. In practice, interior designers rarely work alone, but rather bring together the people and abilities that deliver success for their clients by devising the best possible solutions.

The awareness of cultural differences can be aided by multidisciplinary teams. This has an obvious role in projects for affluent clients or in other countries, but is also important in the U.S. when designing to combat homelessness. Programs include consideration of human dignities, such as cleanliness, good food, safety, employment, and community for people on the street. From their student days onward, they collaborate face-to-face and online, and graduate ready to contribute to a team. They realize that architecture and interior design work best when considered as one.

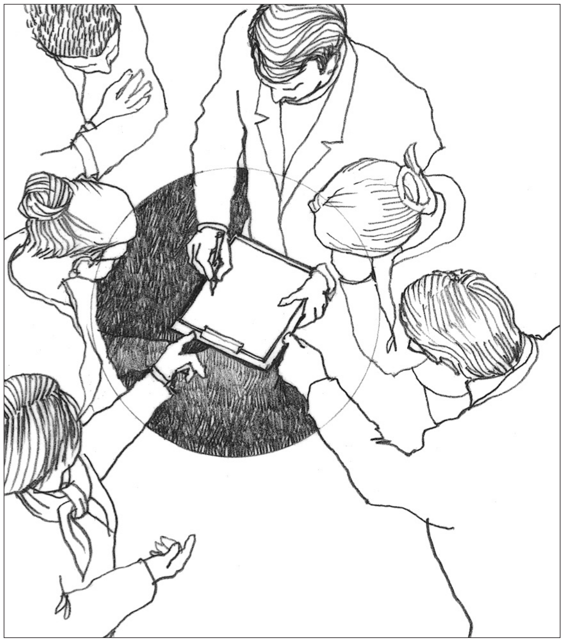
Interior designers determine which elements to use and how to arrange them into patterns through the process of design. Although presented as a linear series of steps, the design process is more often a cyclical, iterative one in which a sequence of careful analysis, synthesis, and evaluation of available information, insights, and possible solutions is repeated until a successful fit between what exists and what is desired is achieved.




### Steps in the Design Process

- Define Problem
- Formulate Program
- Develop Concept
- Assess Alternatives
- Make Design Decisions
- Develop and Refine Design
- Implement Design
- Reevaluate Completed Design

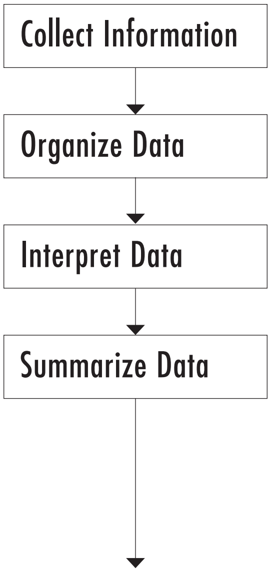
The design problem is first defined. The ability to define and understand the nature of the design problem is an essential part of the solution. This definition should specify how the design solution should perform and what goals and objectives will be met.



### Define Problem

[ ] **Identify client needs.**
- Who, what, when, where, how, why?

[ ] **Set preliminary goals.**
- Functional requirements.
- Aesthetic image and style.
- Psychological stimulus and meaning.




An analysis of the problem requires that it be broken down into parts, that issues be clarified, and that values be assigned to the various aspects of the problem. Analysis also involves gathering relevant information that would help us to understand the nature of the problem and develop appropriate responses. From the outset, it is worthwhile to know the limitations that will help shape the design solution. Any givens—what can change and what cannot be altered—should be determined. Any financial, legal, or technical constraints that will impinge on the design solution should be noted.

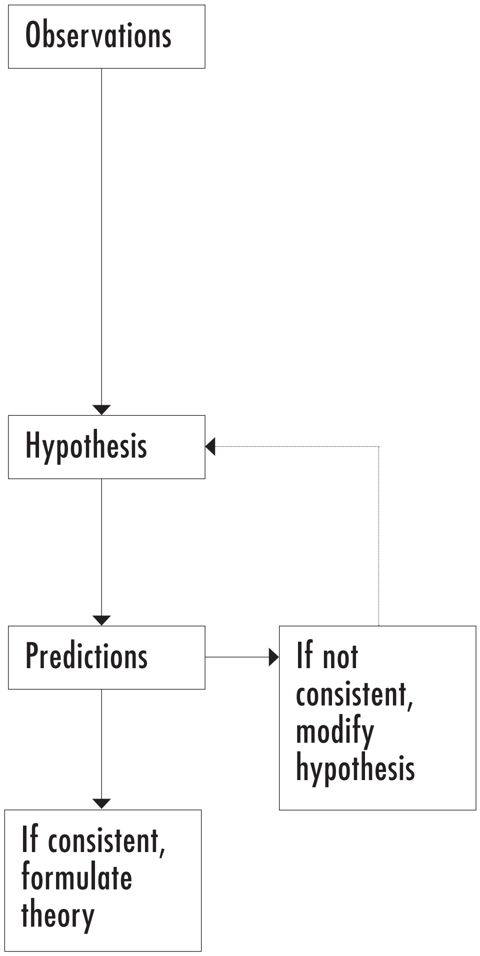
Through the design process, a clearer understanding of the problem should emerge. New information may develop that could alter our perception of the problem and its solution. The analysis of a problem, therefore, often continues throughout the design process.

## Formulate Program

[ ] **What exists?**
- Collect and analyze relevant information.
- Document physical/cultural context.
- Describe existing elements.

[ ] **What is desired?**
- Identify user needs and preferences.
- Clarify goals.
- Develop matrices, charts, and adjacency diagrams.

[ ] **What is possible?**
- What can be altered . . . what cannot?
- What can be controlled . . . what cannot?
- What is allowed . . . what is prohibited?
- Define limits: time, economic, legal, and technical.

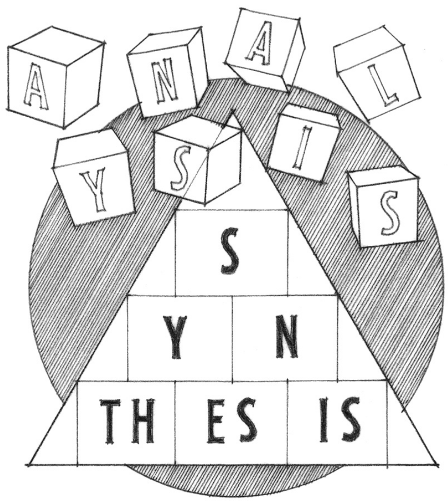


From the analysis of the problem and its parts, we can begin to formulate possible solutions. This requires synthesizing—bringing together and integrating—responses to the various issues and aspects of the problem into coherent solutions. Design requires rational thought based on knowledge and arrived at through experience and research. *Evidence-based design* seeks to create better design outcomes by basing decisions on credible research. Also playing important roles in the design process are intuition and imagination, which add the creative dimension to the otherwise rational design process.

University-sponsored incubators, which are spaces that are high on collaboration and low on structure and intended to spur new ideas, view design as an invitation to connect. These spaces avoid formalizing design so much that people cannot easily connect. This involves 24/7 operating hours, perfectly functioning wireless connectivity, and a fun atmosphere. Finishes and design are kept flexible and functional, able to change with needs. Academic incubators cultivate ideas in a controlled—but not restricted—environment.

There are several approaches one can take to generate ideas and synthesize possible design solutions, including:

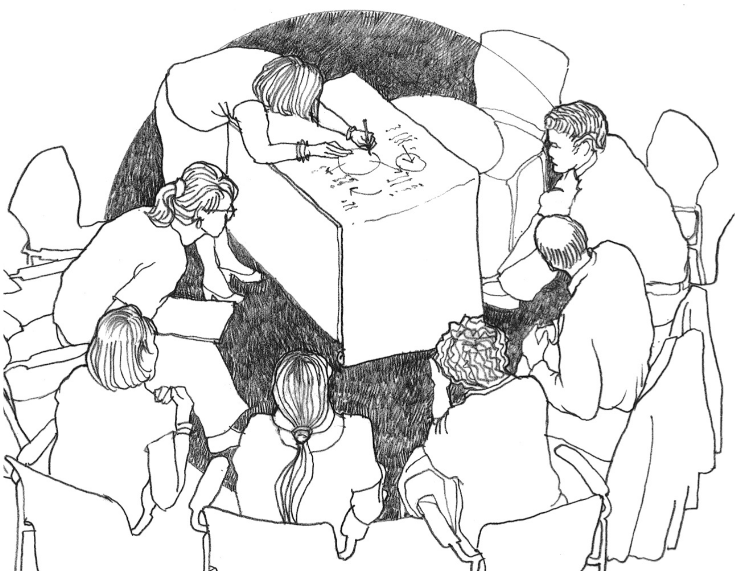
- Isolate one or more key issues of value or importance, and develop solutions around them.
- Study analogous situations that could serve as models for developing possible solutions.
- Develop ideal solutions for parts of the problem, which could be integrated into whole solutions and tempered by the reality of what exists.




As described by Rosanne Somerson in the May 2016 issue of *Metropolis*, students required to sit and draw through free association for more than about 45 minutes tend to become uncomfortable. When instructed to push through this discomfort, they often entered a whole new direction for their work—a surprising response to their boredom. Being creative is often uncomfortable, even painful. For designers and artists, it is often the result of driving an inquiry down a new path and stumbling into the unknown. They discover new ways to conceptualize ideas in expansive, nonlinear forms that go beyond traditional perceptual and cognitive divisions. When an idea fails, the materials and processes can suggest alternate paths. This push can result in a moment of insight that teaches how to sustain and encourage creative breakthroughs.

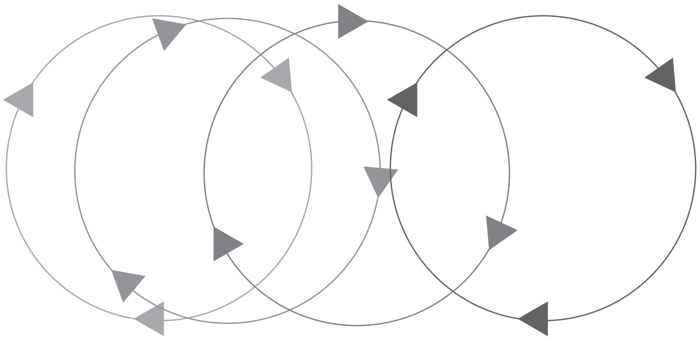
## Develop Concept

[ ] **Brainstorm ideas.**
- Diagram major functional and spatial relationships.
- Assign values to key issues or elements.
- Search for ways to combine several good ideas into a single better one.
- Manipulate the parts to see how a change might affect the whole.
- Look at the situation from different points of view.



[ ] **Draft a concept statement.**
- Verbalize the principal design ideas in a concise manner.

[ ] **Develop schematic designs.**
- Establish major functional and spatial relationships.
- Show relative sizes and shapes of important features.
- Develop several alternatives for comparative study.



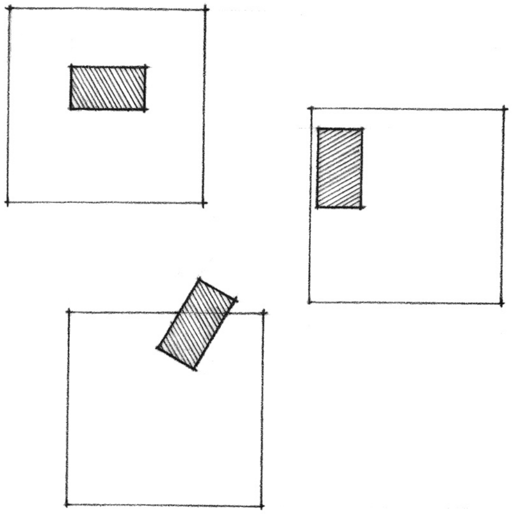
Design requires a critical view of alternatives and careful weighing of the strengths and weaknesses of each proposal until the best possible fit between problem and solution is achieved. Within a range of possible solutions, each must be evaluated according to the criteria set forth in the problem statement and further clarified in the problem analysis. Successive explorations of the problem and the evaluation of alternative solutions should help narrow the choices for design development. While the initial stages of the design process encourage divergent thinking about the problem, the design development phase requires a convergent focus on a specific design solution.

## Assess Alternatives

[ ] **Compare each alternative with design goals.**

[ ] **Weigh the benefits and strengths of each alternative against the costs and liabilities.**

[ ] **Rank alternatives in terms of suitability and effectiveness.**



## Make Design Decisions

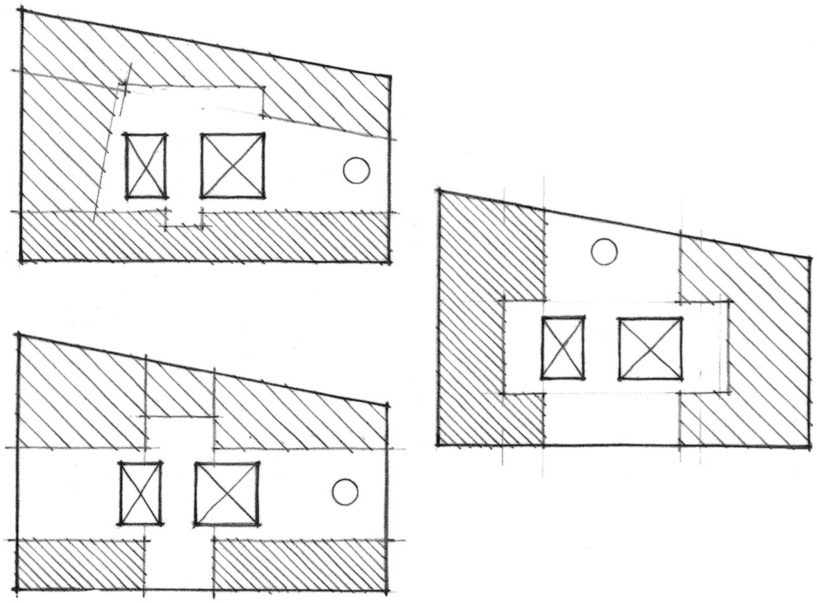
[ ] **Combine the best design elements into the final design.**
- Draw preliminary plans.
- Construct scale drawings.
- Show important interior architectural details (e.g., walls, windows, built-in elements).
- Show furniture if appropriate.
- Computer design software may combine these steps.

[ ] **Make preliminary material selections.**
- Develop alternative color and finish schemes.
- Collect material samples.

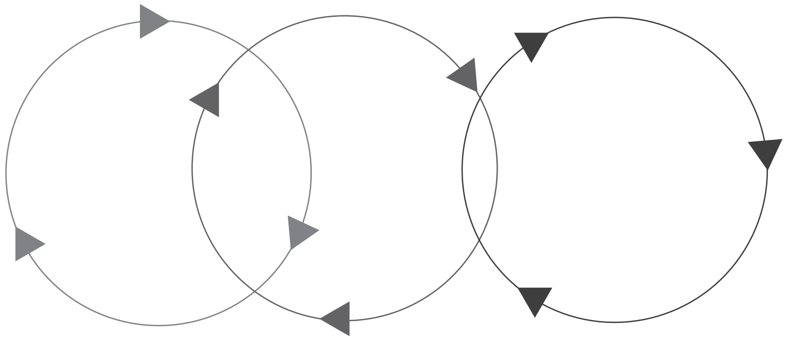
[ ] **Make preliminary furniture and lighting selections.**

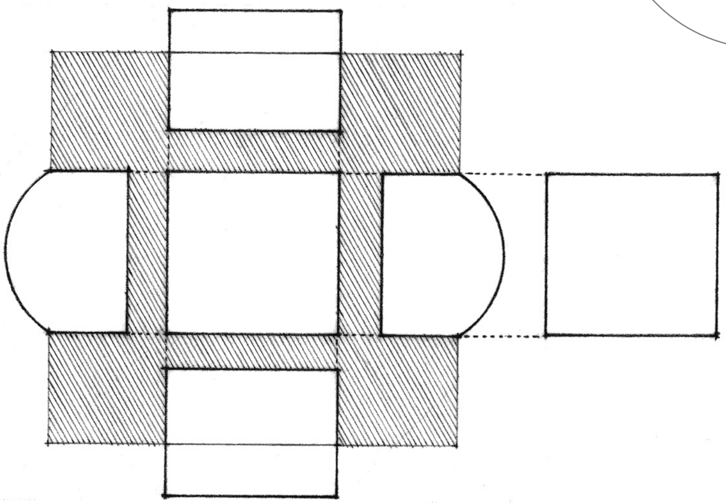
[ ] **Prepare a presentation to the client for feedback and preliminary approval.**

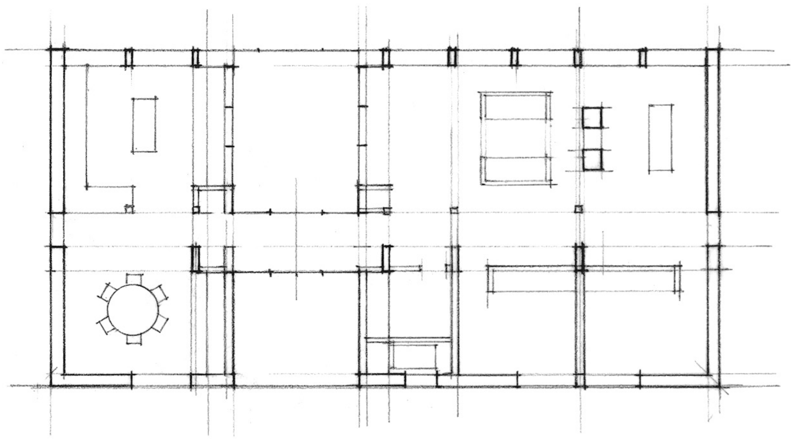
## Test and Refine Ideas



Once a final decision has been made, the design proposal is developed, refined, and prepared for implementation. This includes the production of construction drawings and specifications and other services related to purchasing, construction, and supervision.







## Develop and Refine Design

[ ] Develop plans, elevations, sections, and details.

[ ] Develop three-dimensional computer models of interior spaces, including walk-throughs.

[ ] Develop specifications for interior finish materials, furnishings, and lighting.

## Implement Design

[ ] Prepare construction drawings.

[ ] Finalize specifications for interior finish materials, furnishings, and lighting.

## Reevaluate Completed Design

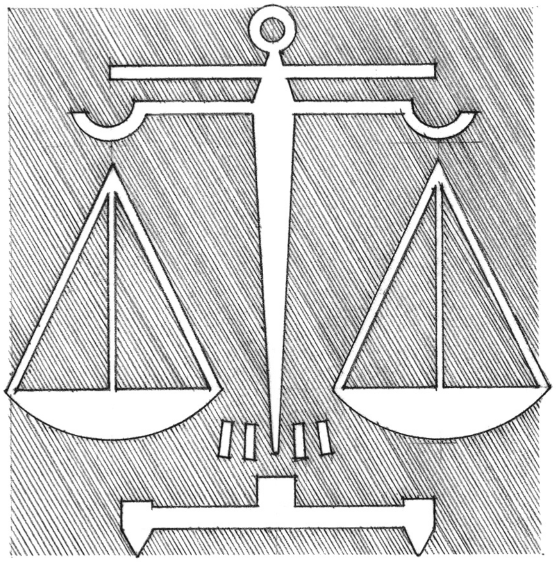
[ ] Perform design reviews.

[ ] Coordinate with architect, engineers, and consultants.

[ ] Solicit client feedback.

[ ] Perform post-occupancy evaluation.

No design process is complete until a design solution that has been implemented is evaluated for its effectiveness in solving a given problem. This critical appraisal of a completed design can build up our knowledge base, sharpen our intuition, and provide valuable lessons that may be applied in future work.



One of the idiosyncrasies of the design process is that it does not always lead simply and inevitably to a single, obvious, correct answer. In fact, there is often more than one solution to a design problem. How then can we judge whether a design is good or bad?

A design may be good in the judgment of the designer, the client, or the people who experience and use the design for any of several reasons:

- Because it functions well—it works.
- Because it is affordable—it is economical, efficient, and durable.
- Because it looks good—it is aesthetically pleasing.
- Because it is sustainable and accessible.
- Because it recreates a feeling remembered from another time and place—it carries meaning.

At times, we may judge a design to be good because we feel it follows current design trends or because of the impression it will make on others—it is in fashion, or it enhances our status.

As these reasons suggest, there are several meanings that can be conveyed by a design. Some operate at a level widely understood and accepted by the general public. Others are more readily discerned by specific groups of people. Successful designs usually operate at more than one level of meaning and thus appeal to a wide range of people.

A good design, therefore, should be understandable to its audience. Knowing why something was done helps to make a design comprehensible. If a design does not express an idea, communicate a meaning, or elicit a response, either it will be ignored or it will appear to be a bad design.

In defining and analyzing a design problem, one also develops goals and criteria by which the effectiveness of a solution can be measured. Regardless of the nature of the interior design problem being addressed, there are several criteria with which we should be concerned.

## Function and Purpose

First, the design must satisfy its intended function and fulfill its purpose.

## Utility, Economy, and Sustainability

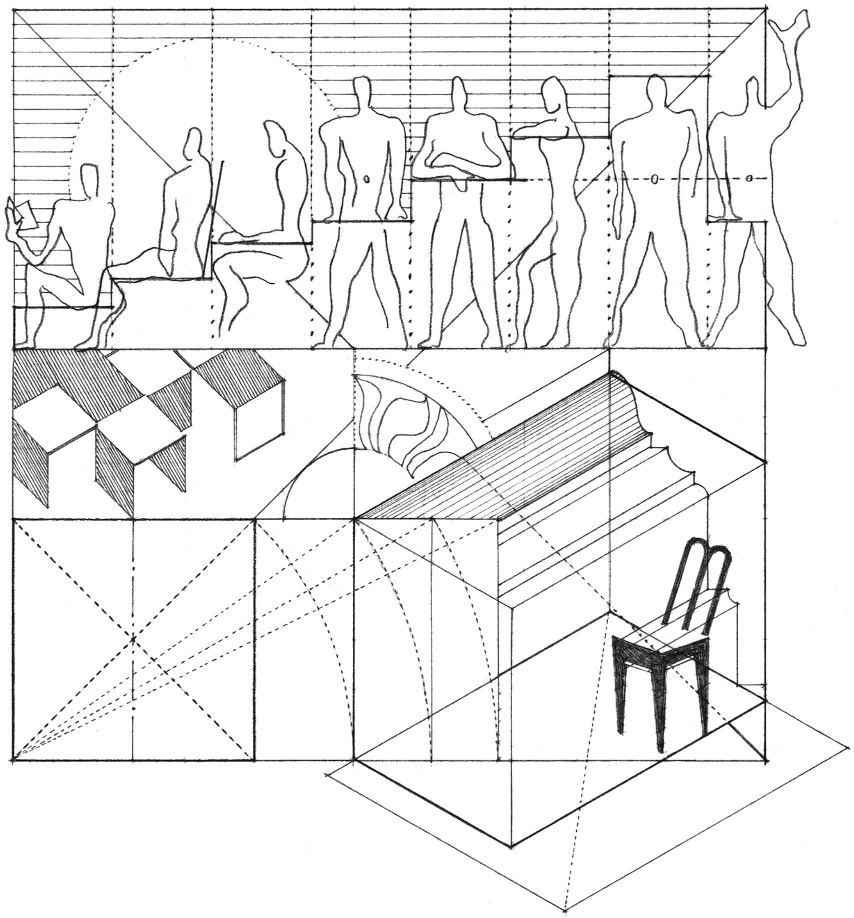
Second, a design should exhibit utility, honesty, economy, and sustainability in its selection and use of materials.

## Form and Style

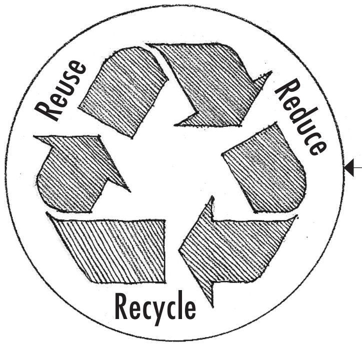
Third, the design should be aesthetically pleasing to the eye and our other senses.

## Image and Meaning

Fourth, the design should project an image and promote associations that carry meaning for the people who use and experience it. Although technology has made the visual aspect incredibly easy, designers need to focus more on narrative storytelling. As humans, we need contact. An agile workforce can work anywhere not because of the agility of the technology, but because of the needs of creative humans using it.

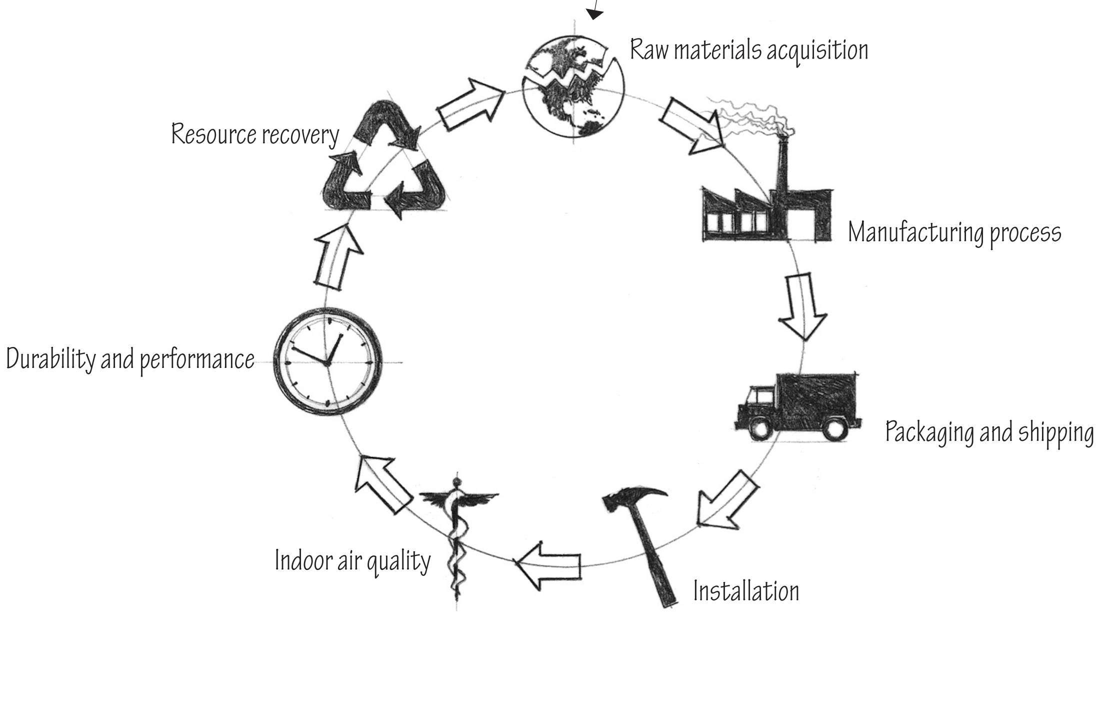


Buildings use large amounts of materials and energy for their construction and operation. Sustainable design seeks to produce buildings that use energy and natural resources efficiently throughout their lives. Sustainable architecture strives to find architectural solutions that protect both the natural environment and the myriad forms of life on earth. Simply put, sustainable design strategies for building interiors include the following:

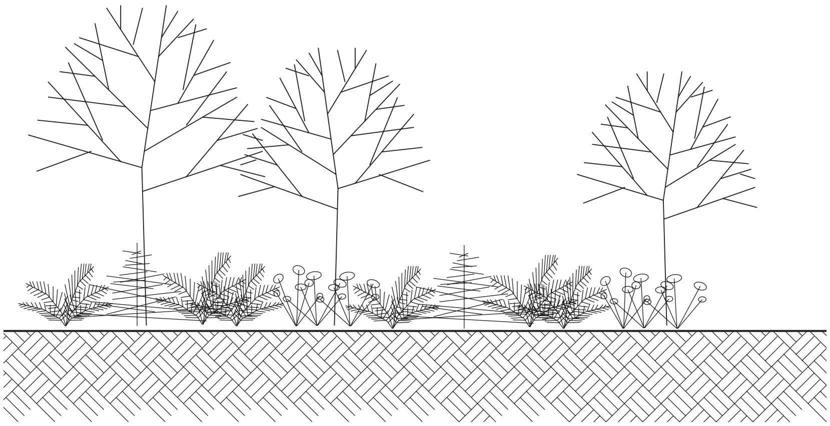



- Reduce, reuse, and recycle materials.
- Evaluate environmental and health impacts, from acquisition of raw materials through end-of-use recovery.
- Design for energy- and water-use efficiency.
- Access to fresh air, natural light, nontoxic materials, and green public spaces that invite exercise and social contact.

Research shows that the presence of plants in the workspace contributes to workers being happier in their jobs. In addition, some plants are able to mitigate indoor pollutants, and some of the most efficient air cleaners are also easy to take care of. The combination of effects makes indoor plants a good choice for a sustainable environment.



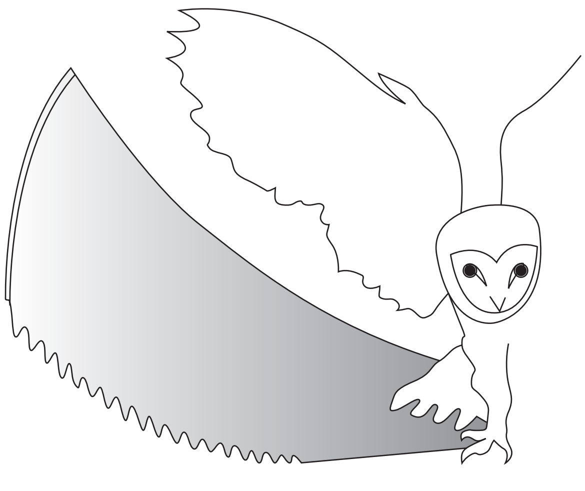
Since 1984, research has shown that hospital patients with a view of nature had better hospital healing experiences than those without such views. Influential studies have supported biologist E. O. Wilson's hypothesis in *Biophilia* that human beings have an innate connection with the natural world. These studies have shown that the presence of water, natural light, and a view to the outdoors can reduce stress, lower blood pressure, improve cognitive function, and enhance memory. Our often visual connection to the natural world is also auditory, olfactory, and tactile.



After extensively studying the characteristics and behavior of plants and animals, Janine Benyus developed a thesis based on her observations about how life works. Her 1997 book *Biomimicry*, which included new research as well as material from five field guides she published by 1990, chronicles her search for new ways in which the design community can create innovations that are inspired by nature and put into human-made products. Her approach to problem solving thrives on changes in how people see the natural world.

In 2014, sustainability strategist Bill Browning co-authored *14 Patterns of Biophilic Design: Improving Health and Well-Being in the Built Environment*, which grouped the 14 patterns into three broad categories:

1. Nature in the Space: "the direct, physical, and ephemeral presence of nature in an environment."
2. Natural Analogues: "Nonliving and indirect evocations of nature such as objects, materials, colors, shapes, sequences, and patterns."
3. Nature of the Space: "Spatial configurations in nature."



German manufacturer Ziehl-Abegg recently introduced a fan blade modeled on the serrated edges of the owl's wing, significantly enhancing its aerodynamic properties and reducing noise and energy use.

## Sustainable Design Rating Systems and Standards

In 2000, the U.S. Green Building Council (USGBC) launched LEED—Leadership in Energy and Environmental Design—a benchmarking system that has driven the global demand for green buildings. To meet LEED's stringent criteria, the architectural design, engineering, and construction professions have had to learn to work together to deliver buildings with a highly integrated design approach.

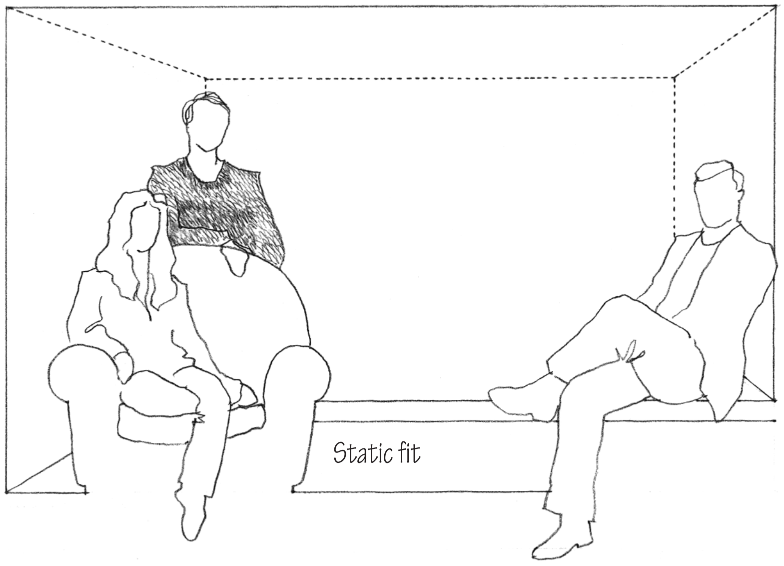
There are a variety of sustainable design rating systems and standards, including updates of LEED:

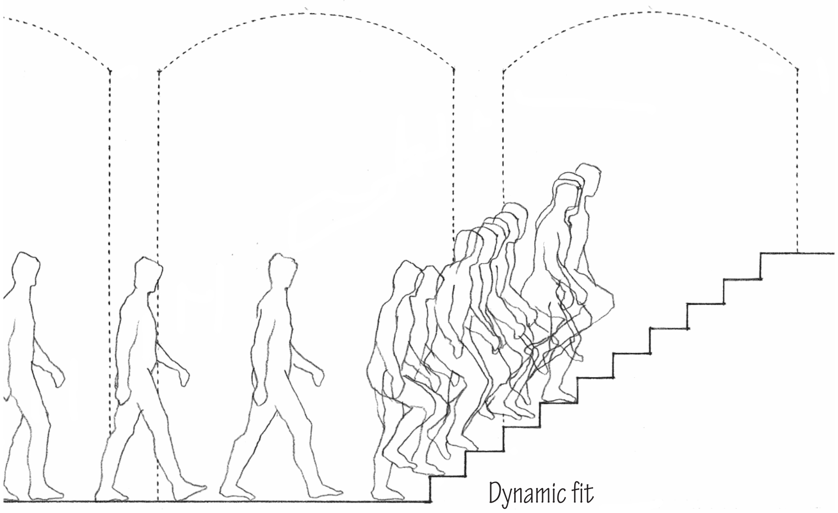
- The USGBC's LEED v4 system increases the technical stringency from earlier requirements and has developed new requirements for project types such as data centers, warehouse and distribution centers, hotels/motels, existing schools, existing retail, and mid-rise residential. In addition, LEED v4 will ask manufacturers to disclose the contents of products, and engage in life-cycle thinking. Clients are demanding a higher level of transparency; the process may be messy, but it appears that its time has come.
- WELL Building Standard, administered by the International WELL Building Institute, sets performance standards for buildings in seven categories related to human health—air, water, nourishment, light, fitness, comfort, and mind—seeking to improve people's moods, sleep quality, nutrition, physical fitness, and work performance.
- Green Building Initiatives' Green Globes is an online assessment protocol, rating system, and guidance for green building design, operation, and management. It is interactive, flexible, and affordable, and provides market recognition of a building's environmental attributes through third-party verification.
- International Living Future Institute's Living Product Challenge requires manufacturers and suppliers to develop products using processes powered only by renewable energy and within the water balance of the places they are made. The Living Product Challenge addresses design and construction methods and draws on the ideas of biomimicry and biophilia.
- Living Building Challenge (LBC) defines the most advanced measure of sustainability possible in the current built environment. LBC requires close adherence to some of the most stringent building performance standards in the world. Certification requires meeting all the program requirements over a full 12-month period of continued operations and full occupancy.
- Health Product Declaration (HPD) Collaborative is a free and public tool for objective and accurate reporting of product contents and how each ingredient relates to the bigger picture for ecological health. It is moving manufacturers toward full product transparency.
- Environmental Product Declaration (EPD): A standardized report outlining the results of data collected in a life cycle assessment (LCA) that transparently present the environmental impacts of a product from cradle to grave, across the entire value chain, qualifying everything that goes in (energy, water, materials) and everything that comes out (emissions to land, air, and water). Completing the EPD helps pinpoint where materials and processes have the most environmental impact. The report provides a common language and measurement about life-cycle environmental impact of products. It is primarily used for business-to-business (not consumer) communication.


**Typical categories of green building provisions**

Interior designers can support sustainable design in the following ways:

- Reduce energy use by specifying efficient lighting and equipment.
- Design to facilitate daylight, views, and fresh air.
- Design for disassembly, so that materials can be taken apart and recycled.
- Limit the use of *potable* (drinkable) water in toilets and sinks.
- Select interior finishes and materials made from rapidly renewable, salvaged, refurbished, or recycled materials from local sources.
- Choose low *volatile organic compound* (VOC)-emitting products and installation materials.
- Specify products from manufacturers who minimize energy, water, and raw material consumption.
- Avoid waste in manufacturing, packaging, and installation.


Static fit

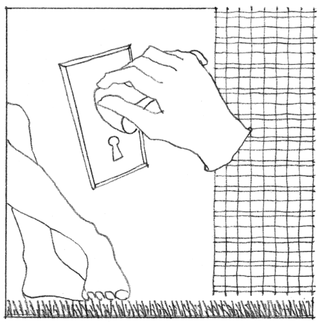

Dynamic fit

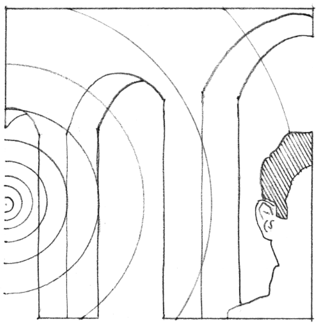
The interior spaces of buildings are designed as places for human movement, activity, and repose. There should be, therefore, a fit between the form and dimensions of interior space and our own body dimensions. This fit can be a static one, as when we sit in a chair, lean against a railing, or nestle within an alcove.

There can also be a dynamic fit, as when we enter a building's foyer, walk up a stairway, or move through the rooms and halls of a building. How a space encourages or inhibits movement has an important influence on the well-being of its users. When we sit, our metabolism decreases, good cholesterol drops, the muscles in the lower half of our bodies turn off, and some of the insulin in our bodies is produced less efficiently, contributing to heart disease and diabetes. It becomes really important to get up every 30 minutes, even for a short time. We sit all day because of the way our environments have been set up for us. Physical activity has been shown to stimulate mental activity, and designing spaces for different functions has both a physical and mental impact. The design of clean, well-lighted stairways as connectors that encourage movement between spaces has become an important feature. Height-adjustable furniture that easily adjusts between sitting and standing levels is increasingly popular.

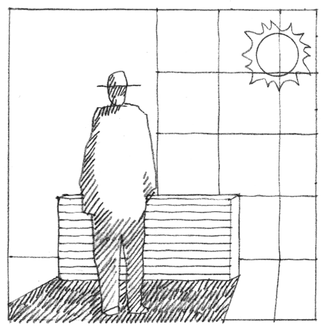
A third type of fit is the way space accommodates our need to maintain appropriate social distances and to control our personal space.

In addition to these physical and psychological dimensions, space also has tactile, auditory, olfactory, and thermal characteristics that influence how we feel and what we do within it.


Touch

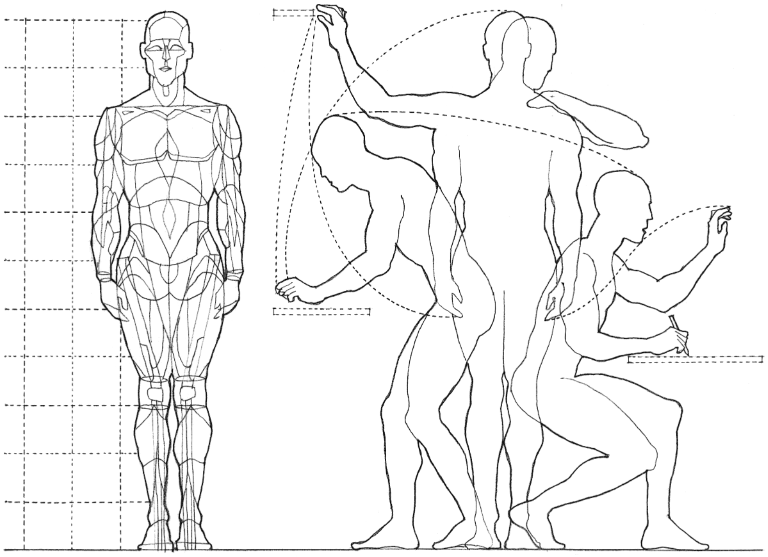

Hearing


Smell


Temperature

Our body dimensions, and the way we move through and perceive space, are prime determinants of architectural and interior design. In the following section, basic human dimensions are illustrated for standing, sitting, and reaching. Dimensional guidelines are also given for group activities, such as dining or conversing.

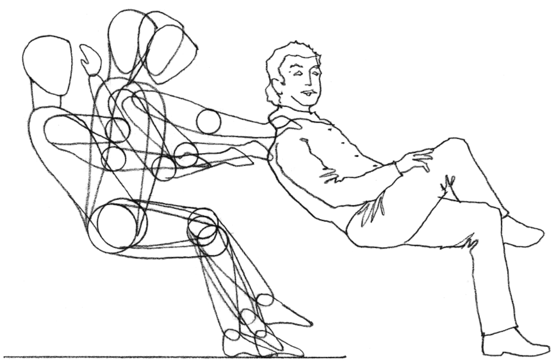
There is a difference between the structural dimensions of our bodies and those dimensional requirements that result from the way we reach for something on a shelf, sit down at a table, walk down a set of stairs, or interact with other people. These are functional dimensions that vary according to the nature of the activity engaged in and the social situation.

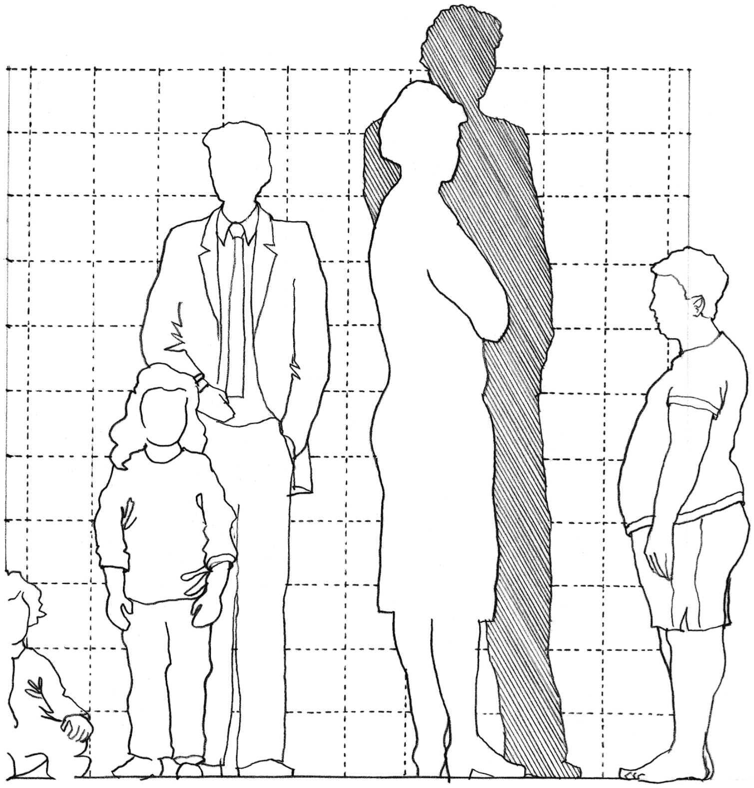


Structural dimensions Functional dimensions

Always exercise caution when you use any set of dimensional tables or illustrations such as those on the following pages. These are based on typical or average measurements that may have to be modified to satisfy specific user needs. Variations from the norm will always exist as a result of the differences between men and women, among various age and genetic groups, and from one individual to the next.

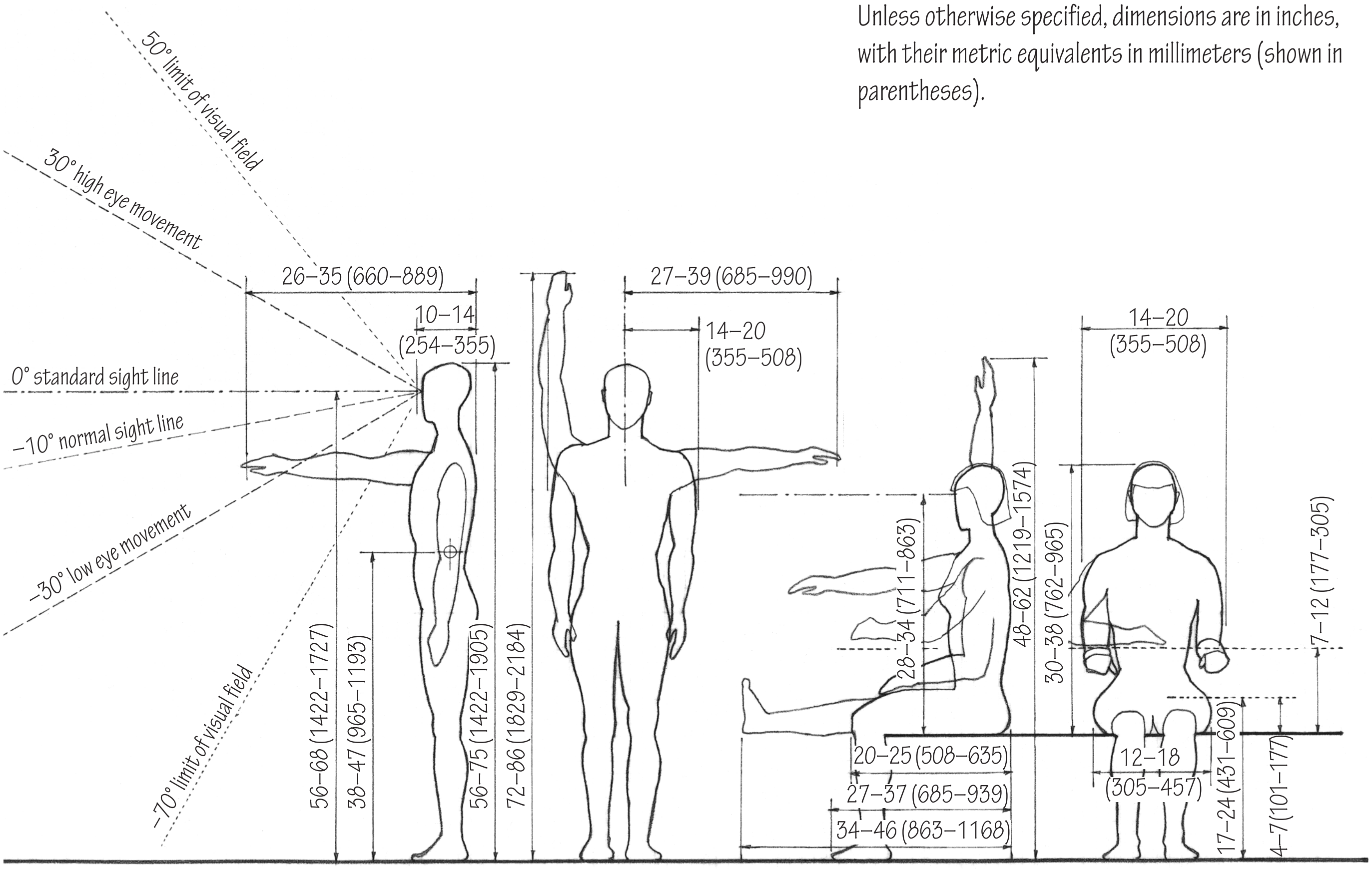
Most people will experience different physical ranges and abilities as they grow and age, and with changes in weight, height, and physical fitness. These changes over time affect how an interior environment will fit or accommodate the user. *Bariatric* design and design for aging-in-place are two ways that interiors can accommodate these conditions.

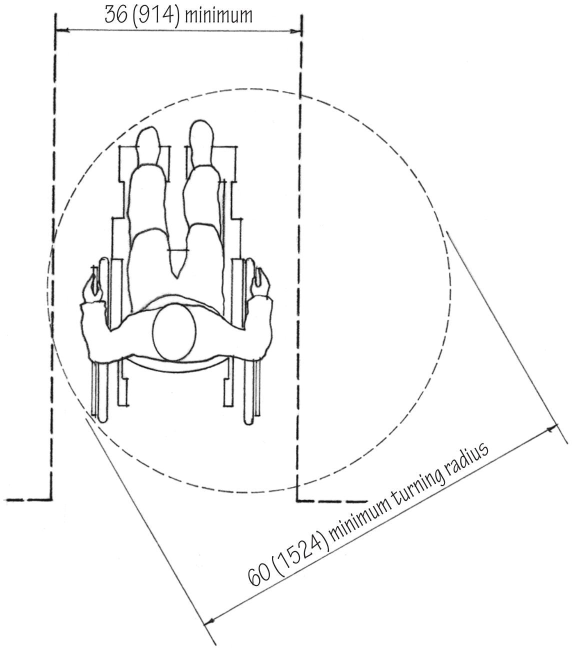


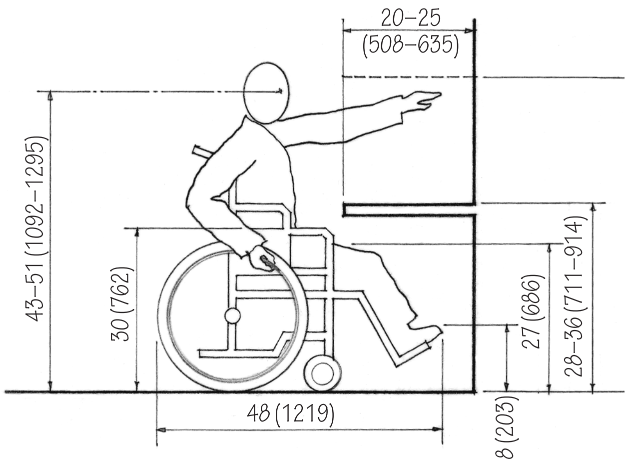


Individual variations and abilities

Unless otherwise specified, dimensions are in inches, with their metric equivalents in millimeters (shown in parentheses).



## Designing for Longevity

By United Nations standards, the populations of Japan, Italy, Germany, Finland, and Greece will be considered super-aged, with over 20 percent of their citizens over 65. According to the U.S. Census Bureau, in 2050 the U.S. population aged 65 and over is projected to be 83.7 million, which is almost double the previously estimated population of 43.1 million in 2012. Approximately one in five adults in the U.S. will be over the age of 65.

As fewer and fewer people move into institutional care, more people with disabilities are living in everyday settings that, in the past, were designed for people with levels of agility and ability that they do not have. States such as Oregon have already passed legislation to encourage voluntary age-friendly design in both new construction and remodeling projects.

Interior designers will need to meet these changes with designs renovations and new construction of quality housing. According to the American Society of Interior Designers (ASID):

- Restaurants, hotels, and motels will need to be accessible.
- Offices, retail stores, and other workspaces will need adequate lighting, seating, technology, task areas, and quiet places for older workers.
- There will be an increased need for outpatient and in-home healthcare, and accommodation for caretakers and caregivers.
- Retail stores will need to be accessible and accommodate users of assistive devices.
- There will be a growing demand for multihousing/multiuse livable communities and urban complexes with easy access to healthcare, entertainment, and shopping.

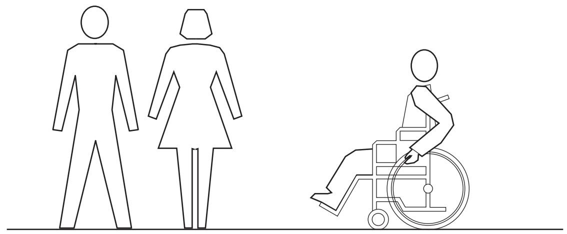
Other trends include looking at how design is about networks, where authorship of a design is less high profile and there is a sense of people working together, reacting to being constantly connected, and exploring things that shape the way we deal with a longer life span. For instance, a move away from digital media to print, or to the spirit of hands-on crafting of interior items, can bring us closer to some of the qualities that define what it is to be human.

## Designing for Children's Healthcare

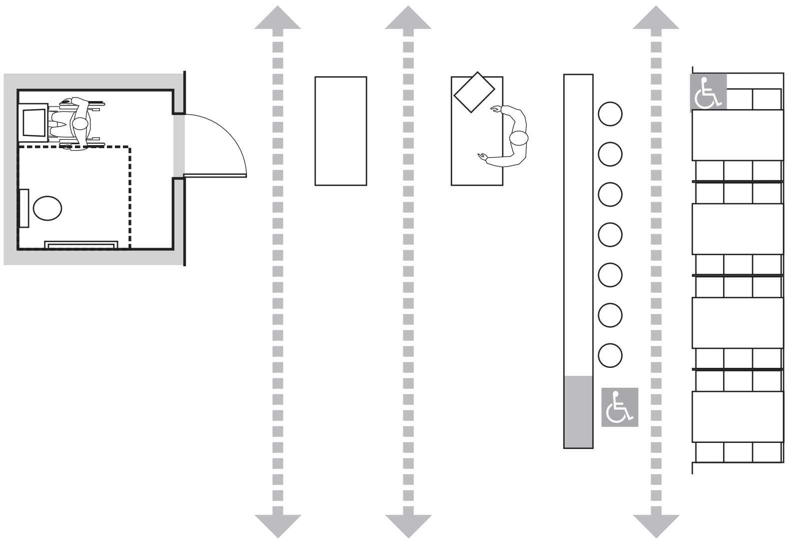
Healthcare facilities have taken the lead in creating playful research-based environments that support, distract, and heal children. These spaces strive to be:

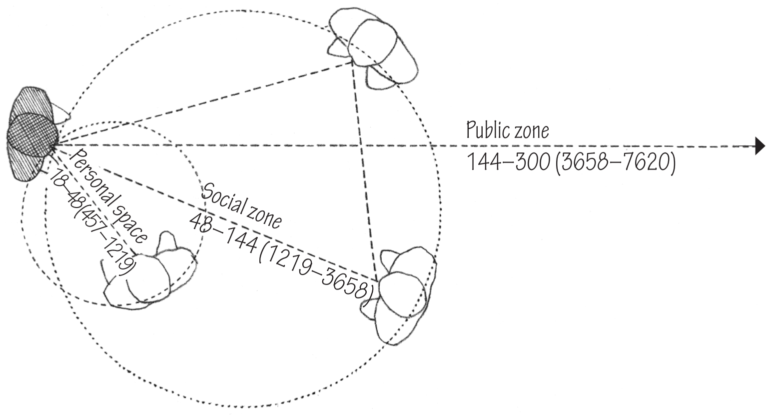
- Empowering, giving patients ownership of their treatment journey
- Familiar, welcoming, and friendly
- Dependable, building trust between patients and the institution
- Shared experiences that unite patients, their families, and staff

Positive patient distraction reduces stress for parents and allows the staff to perform their jobs more effectively.



Equal access to facilities






Human beings share with animals a perception of the appropriate uses of the space around their bodies, which varies between various groups and cultures and among individuals within a group. This is a person's territorial space. Others are allowed to penetrate these areas only for short periods of time. The presence of other people, objects, and the immediate environment can expand or contract our sense of personal space. The invasion of an individual's personal space can affect the person's feelings and reactions to everything around him or her.

## Intimate Zone

Allows physical contact; invasion by a stranger can result in discomfort.

## Personal Space

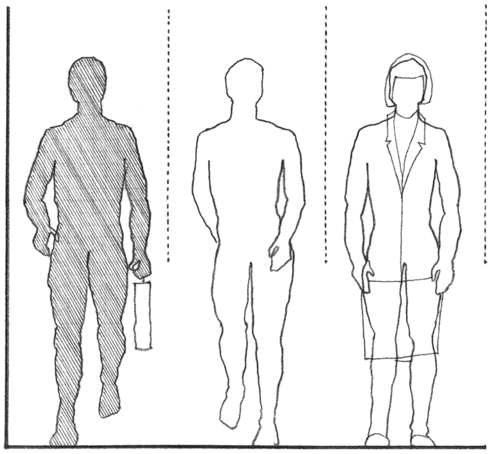
Allows friends to come close and possibly penetrate inner limit briefly; conversation at low voice levels is possible.

## Social Zone

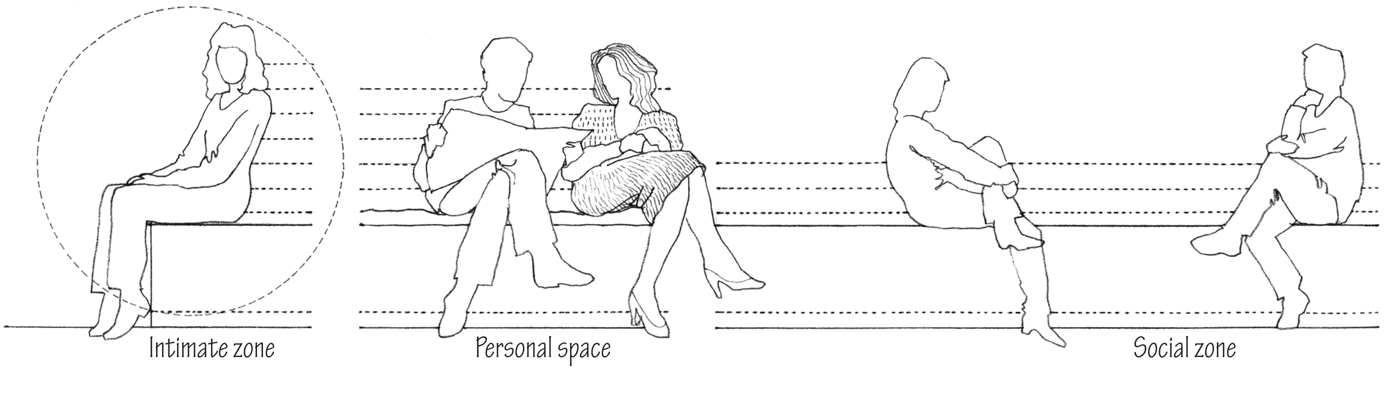
Appropriate for informal, social, and business transactions; conversation occurs at normal to raised voice levels.

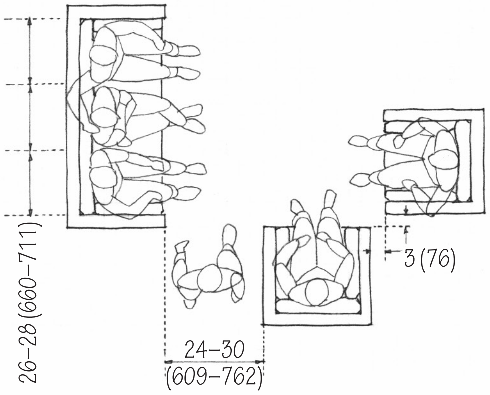
## Public Zone

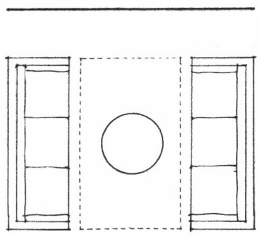
Acceptable for formal behavior and hierarchical relationships; louder voice levels with clearer enunciation are required for communication.

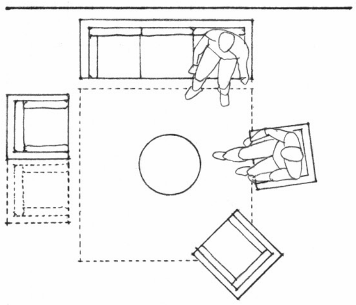


Space for movement varies from 30–36 (762–914) for a single person to 72–96 (1829–2438) for three people walking abreast.



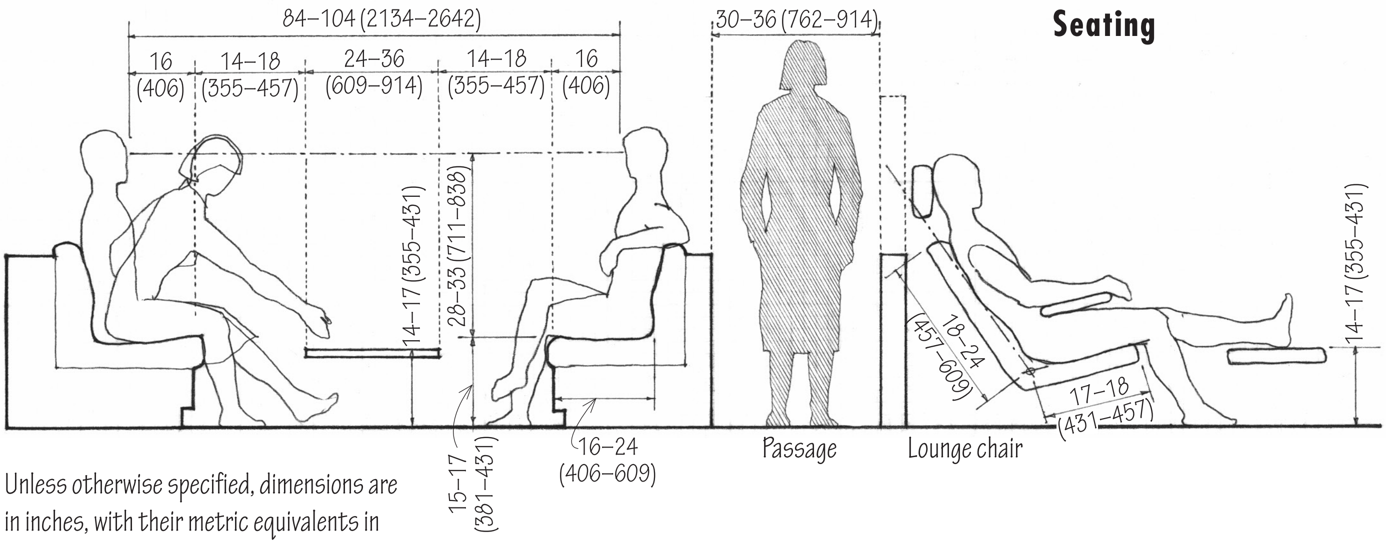


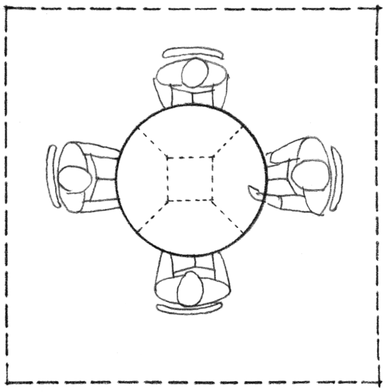


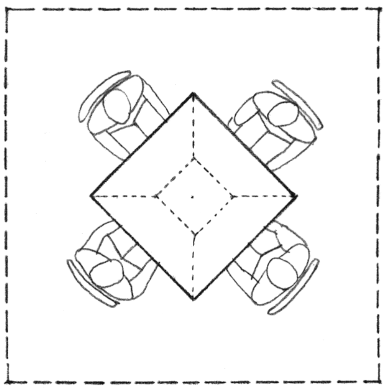
Plan arrangements for seating

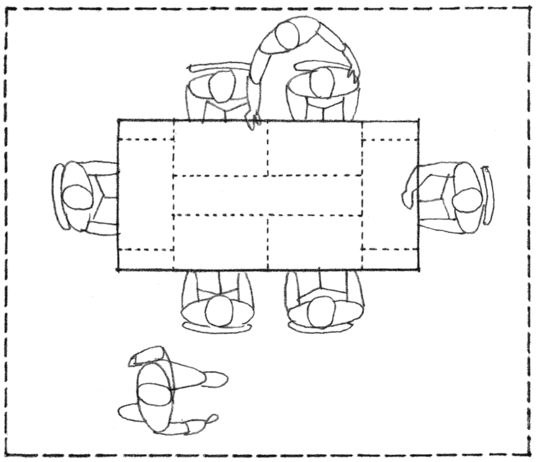
## Seating



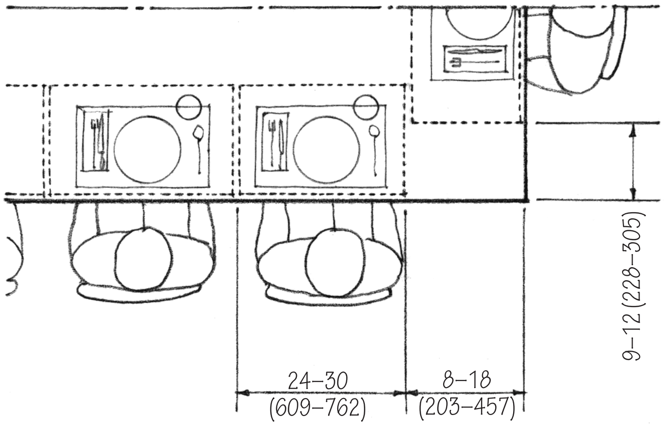

Unless otherwise specified, dimensions are in inches, with their metric equivalents in millimeters (shown in parentheses).

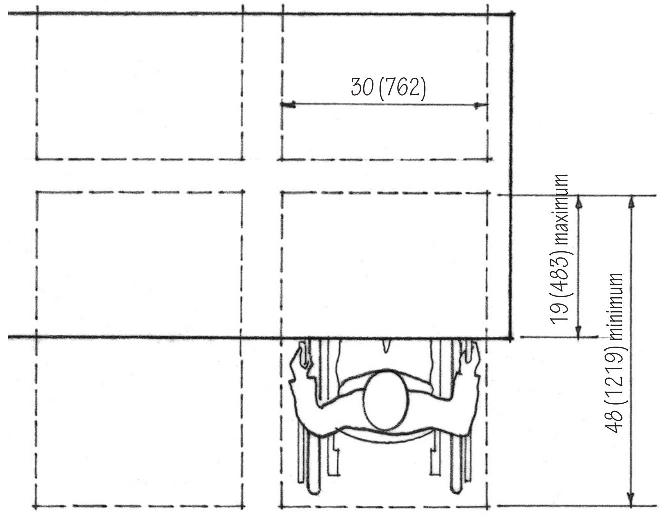






Plan arrangements for dining tables

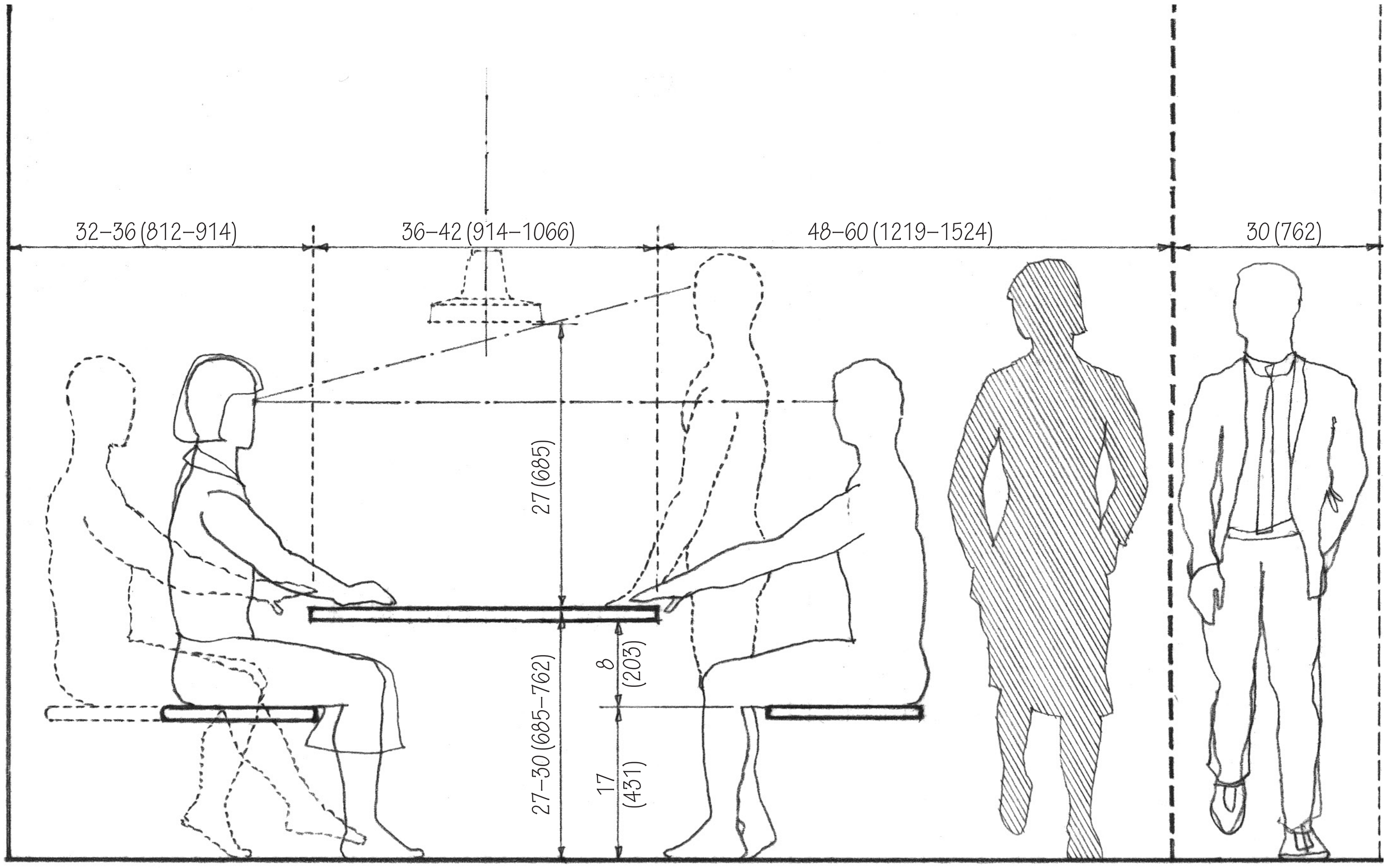


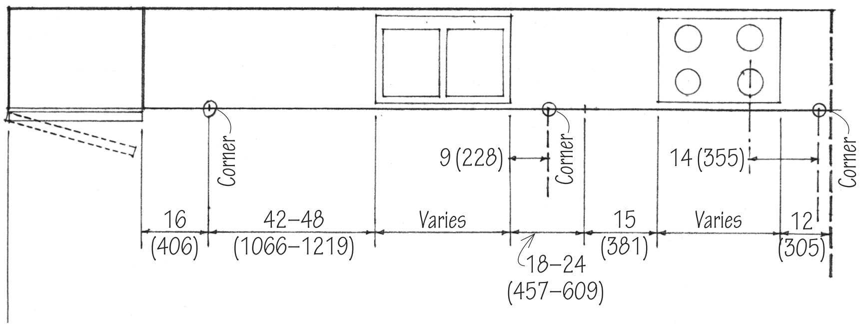



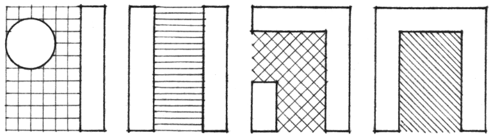

Accessible seating at tables

## Dining

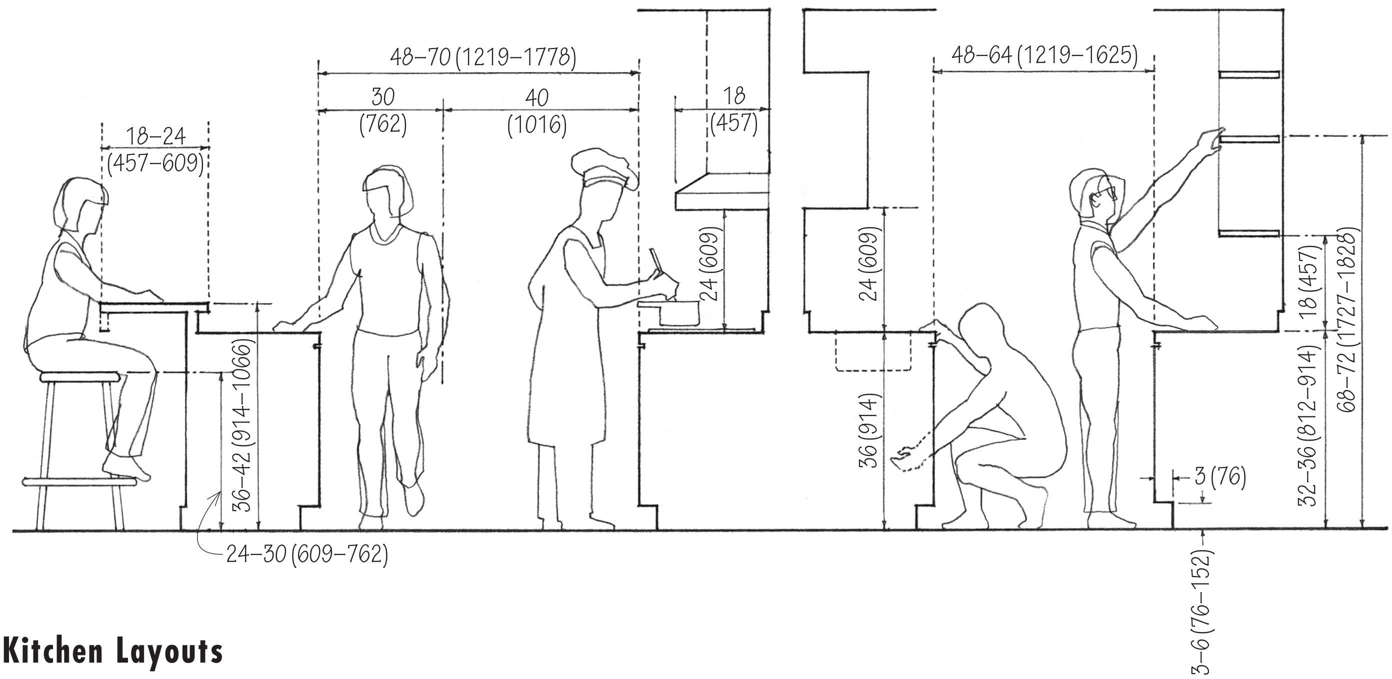
Unless otherwise specified, dimensions are in inches, with their metric equivalents in millimeters (shown in parentheses).



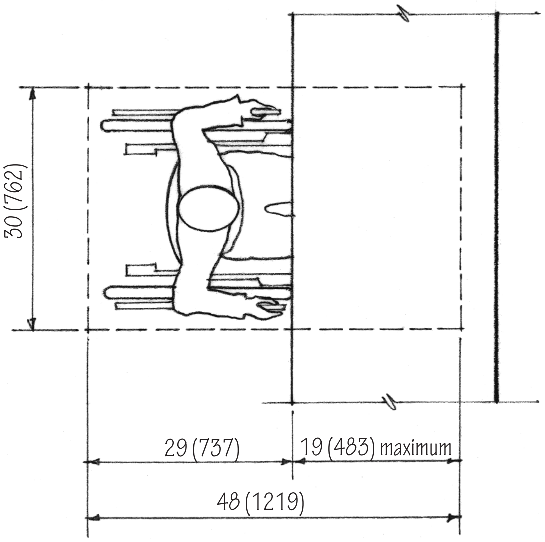


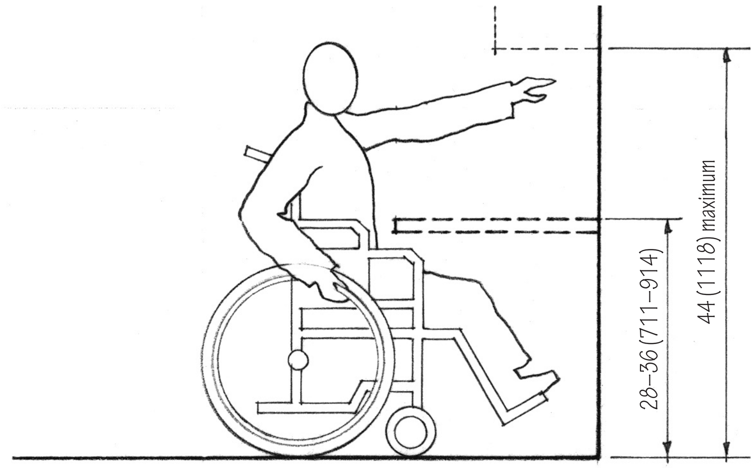



Countertop configurations

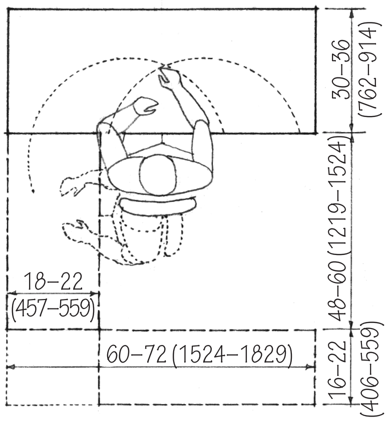


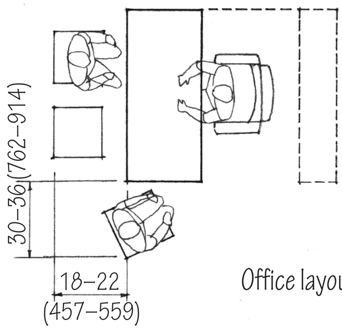

## Kitchen Layouts



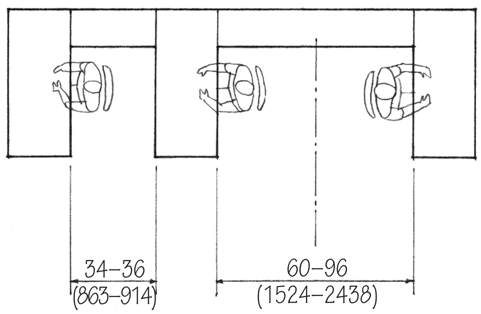




Accessible reach at counters




Office layouts



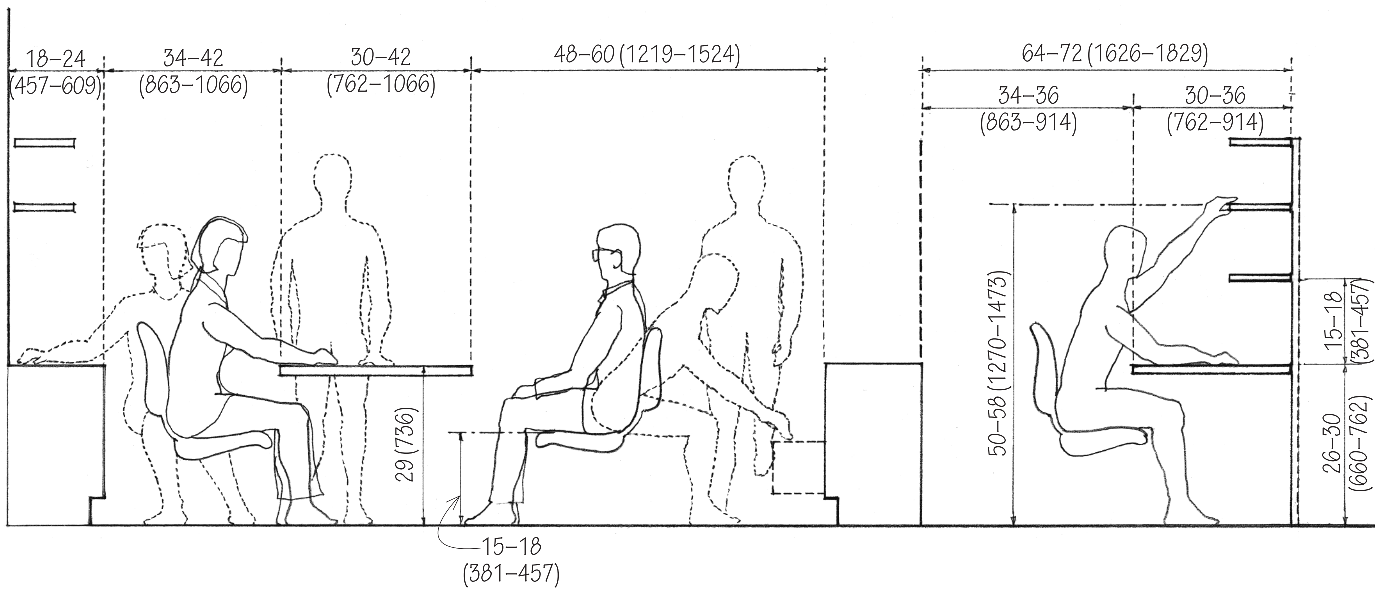

## Workstations

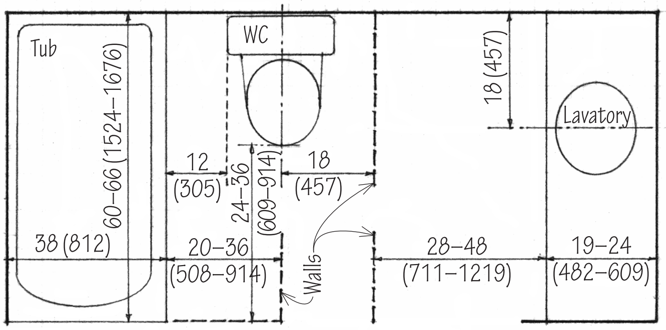
Workspaces are changing rapidly, with new requirements. Some of the new functions in creative workspaces include:

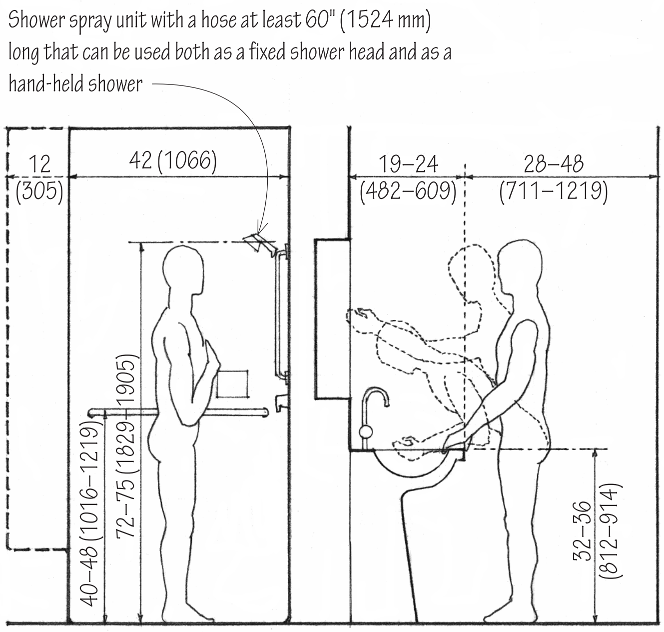
- Spaces where people can play
- Spaces where people can come together informally
- Spaces where people can find a private space when they need it

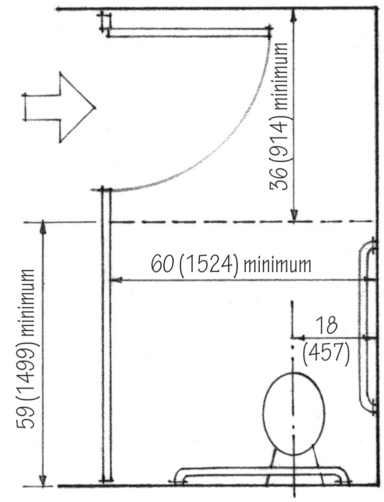
Good acoustics can make spaces more versatile and able to accommodate more people. Creative spaces are never about money first; rather they are about what can be done for clients that is creative and unique. The space can allow people to work at an individual scale, but also as part of daily operating units, and of a larger community.

Offices increasingly are being designed with a kitchen, café, or lounge at the center to facilitate collaboration and mobility. These spaces are often designed with strategies from the hospitality industry, and can offer comfortable sofas, overstuffed chairs, banquette seating, or booths, as well as bar-height countertops or communal tables. A rising demand is occurring for amenities like green space, open stairwells, and lactation rooms.

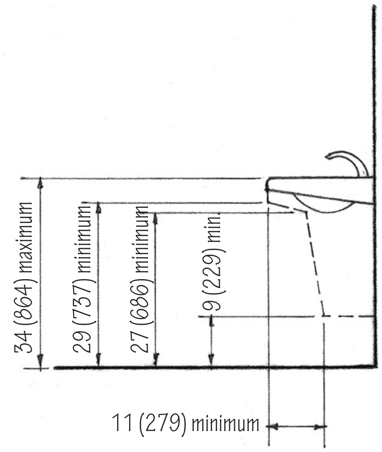




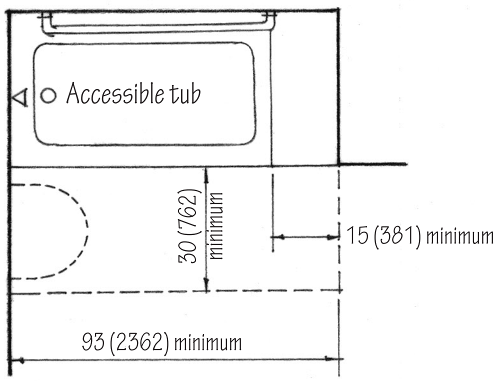



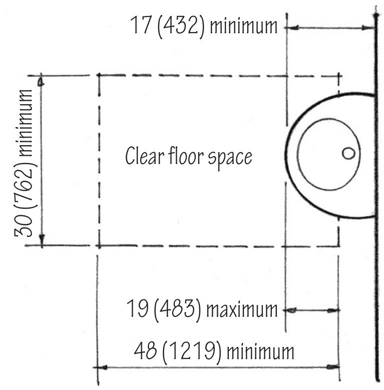

Accessible toilet stall




Accessible lavatory

## Bathing

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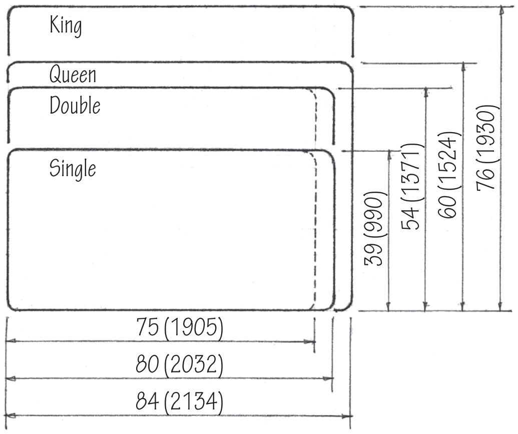
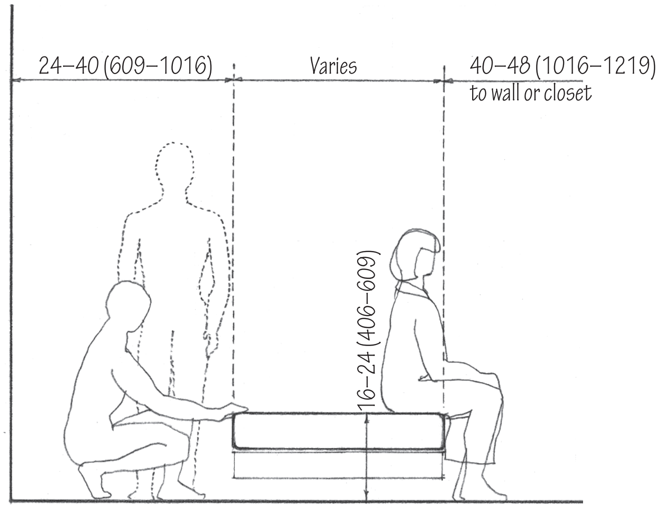
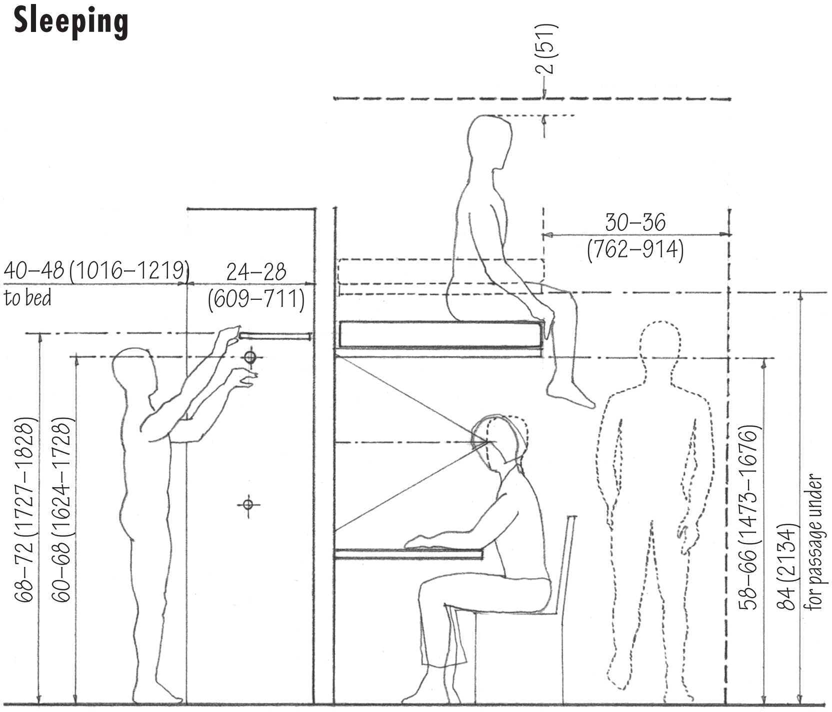
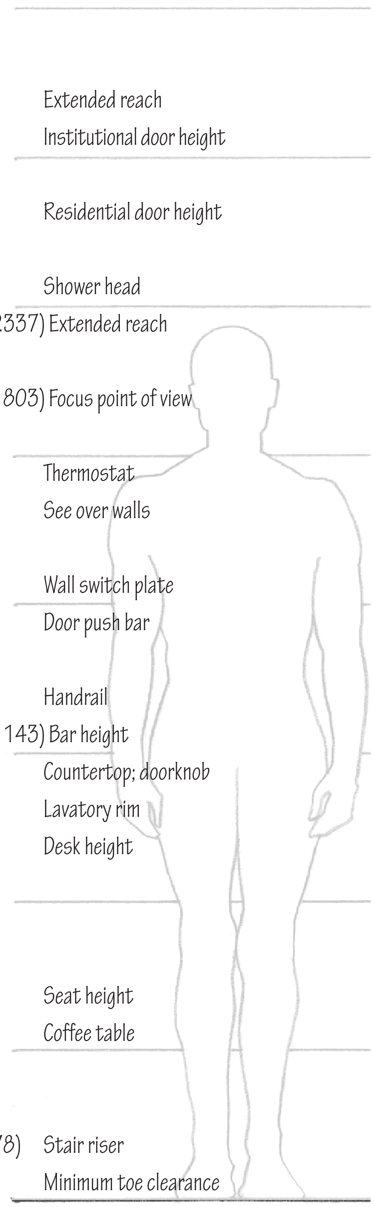



## Sleeping




| | | |
|---|---|---|
| 89 | (2261) | Extended reach |
| 84 | (2134) | Institutional door height |
| 80 | (2032) | Residential door height |
| 75 | (1905) | Shower head |
| 70–92 | (1778–2337) | Extended reach |
| 54–71 | (1372–1803) | Focus point of view |
| 58 | (1473) | Thermostat |
| 55 | (1397) | See over walls |
| 48 | (1219) | Wall switch plate |
| 45 | (1143) | Door push bar |
| 42 | (1067) | Handrail |
| 42–45 | (1067–1143) | Bar height |
| 36 | (914) | Countertop; doorknob |
| 31 | (787) | Lavatory rim |
| 29 | (736) | Desk height |
| 17 | (431) | Seat height |
| 14 | (355) | Coffee table |
| 4–7 | (102–178) | Stair riser |
| 3 | (76) | Minimum toe clearance |



## Heights

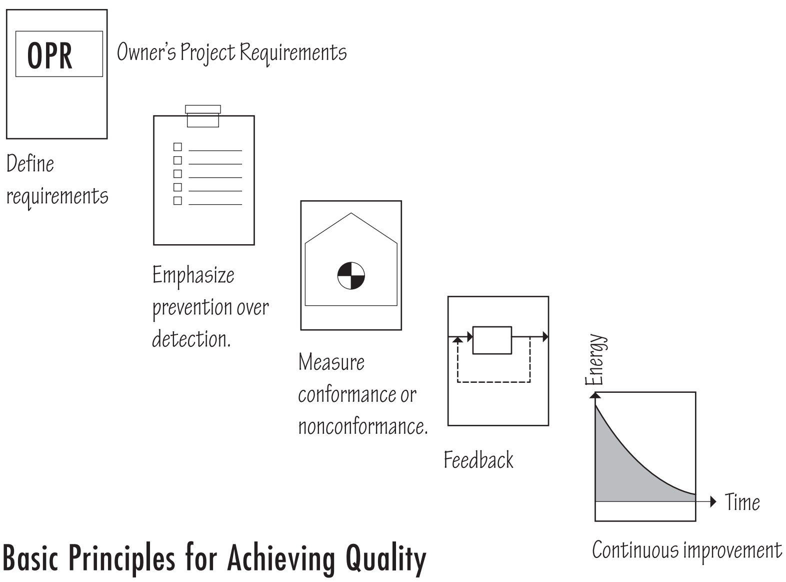
Today's workers, including both knowledge workers and digital natives, are looking for authentic experiences at work that feel like a natural part of their lifestyle, their interests, and their life goals—the essence of an authentic workplace, the vital characteristic of which is a combination of space typologies, with space redistributed for different environments, experiences, and postures. Today's workspaces must support all work styles and lifestyles, offering a sense of having a choice in how, when, and where a person does his or her best work. This diversity also promotes a sense of community and collaboration, sparks imagination and creativity, and offers a focus on employee health and happiness.

The programming process begins with trying to understand what is known, then to understand that everything will evolve and change, even in just a few years. Building in efficiencies, economies, and sustainability early allows a project to grow.

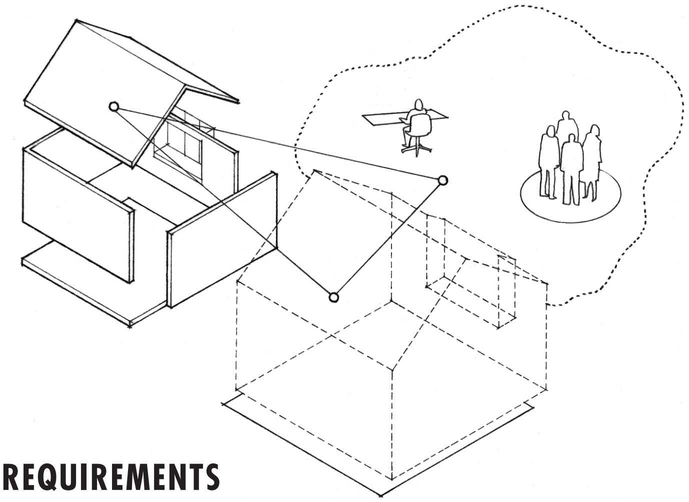
There are multiple methods to follow for programming a variety of types of buildings. One process—the functional programming process—is defined in the Facility Guidelines Institute's (FGI) guidelines for hospitals, outpatient, and residential long-term care settings. It begins by gathering management and administration, along with all other disciplines together to discuss the goals of the project. Design professionals must understand an organization's mission and core values in order to evaluate options. Sustainability goals are evaluated through the organization's mission and core values. The selection of a building rating system such as LEED or Green Globes combines building performance with patient/resident and staff outcomes and provides for continual improvement.

Universal (also called inclusive) design needs to be incorporated into a building's program from the beginning. The costs for upgrading an existing building are affected by space and structural constraints, working during off-hours to limit the impact on active spaces, modifications that disturb existing finishes and expose existing hazardous material such as lead paint and asbestos, and the need to update the building to current code requirements.

Both natural and manmade disasters have made resilience a concern for design professionals and others including regulators, government agencies, and liability insurance carriers. Understanding potential climate change impacts on a site should be considered from the beginning. Research into the current emphasis on individual devices that learn personal patterns of behavior may be somewhat misguided. Alternatively, increased quality and discipline around collaboration may pay huge dividends in transforming the way we work.




**Basic Principles for Achieving Quality**



A prime criterion for judging the success of an interior design is whether or not it is functional. Function is the most fundamental level of design. We design to improve the functioning of interior spaces and make the tasks and activities performed within them more convenient, comfortable, and pleasurable. The proper functioning of a design is, of course, directly related to the purposes of those who inhabit and use it, as well as to their physical dimensions and abilities.

To understand, and ultimately to fulfill, the function and purpose of an interior space, it is necessary for the designer to carefully analyze the user and activity requirements for that space. The following outline can help the designer program these requirements, translate these needs into forms and patterns, and integrate them into the spatial context.

## USER REQUIREMENTS

[ ] **Identify users.**
- Individuals
- User groups
- User characteristics
- Working parents
- Age groups: older users may be more active than in past
- Digital natives and their need for fast production processes
- Circadian rhythms

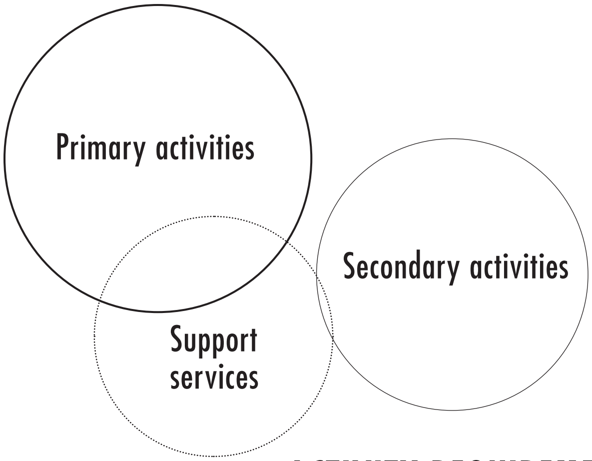
[ ] **Identify needs.**
- Specific individual needs and abilities
- Group needs and abilities
- Universal design

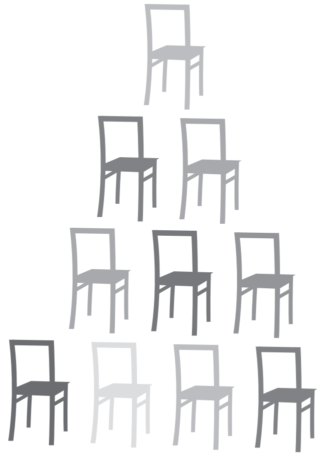
[ ] **Establish territorial requirements.**
- Personal space
- Privacy
- Interaction
- Digital communications
- Access
- Security
- Blurring boundaries between interior and exterior spaces

[ ] **Determine preferences.**
- Favored objects
- Favorite colors
- Special places
- Special interests

[ ] **Research code requirements.**
- Prevailing U.S. building energy codes:
  1. International Energy Conservation Code (IECC): by International Code Council
  2. Standard 90.1: by the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)
- National Fire Protection Association (NFPA): fire safety codes, Life Safety Code
- Institute of Electrical and Electronics Engineers (IEEE): electrical code standards

[ ] **Research environmental concerns.**
- Energy efficiency
- Daylight, views, and fresh air
- Reduce, reuse, recycle
- Water conservation
- Sustainable materials and manufacturing processes
- Non-toxic materials
- Decreased waste

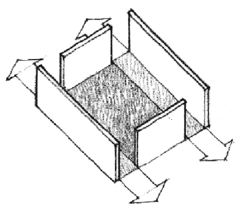


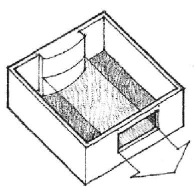



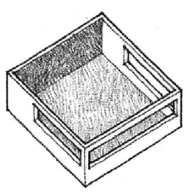
## ACTIVITY REQUIREMENTS

[ ] **Identify primary and secondary activities.**
- Name and function of primary activity
- Names and functions of secondary or related activities

[ ] **Analyze nature of the activities.**
- Active or passive
- Noisy or quiet
- Public, small group, or private
- Compatibility of activities if space is to be used for more than one activity
- Frequency of use
- Times of day or night use







[ ] **Determine requirements.**
- Privacy and enclosure
- Access
- Accessibility
- Communication
- Flexibility
- Light
- Acoustic quality
- Security
- Maintenance and durability

## FURNISHING REQUIREMENTS

[ ] **Determine furnishings and equipment for each activity.**
Number, type, and style of:
- Seating
- Tables
- Work surfaces
- Storage and display units
- Accessories

[ ] **Identify other special equipment required.**
- Lighting
- Electrical
- Mechanical
- Plumbing
- Data and communications
- Security
- Fire safety
- Acoustical

[ ] **Establish quality requirements of furnishings.**
- Comfort
- Safety
- Variety
- Flexibility
- Style
- Durability and maintenance
- Sustainability

[ ] **Develop possible arrangements.**
- Functional groupings
- Tailored arrangements
- Flexible arrangements

## Space Planning

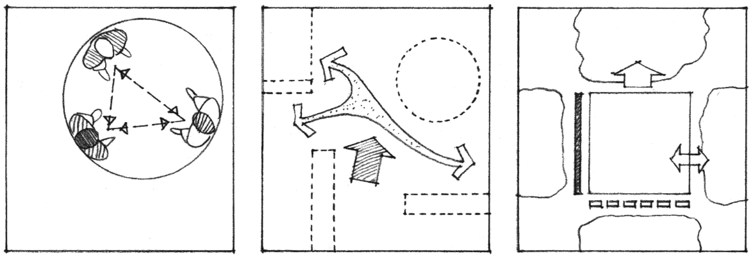
The form of a building's structure and enclosure affects the character of the spaces within. Space planning involves the efficient and productive use of these spaces, fitting living patterns to the architectural patterns of the space.

The term "space planning" is often used to refer to the specific task of planning and designing large-scale spaces for commercial and retail businesses. In this narrow sense, space planners program client needs, study user activities, and analyze spatial requirements. The results of such planning are then used in the architectural design of new construction or for negotiating the leasing of existing commercial spaces.

## SPACE ANALYSIS

[ ] **Document existing or proposed space.**
- Measure and draw base plans, *sections*, and *interior elevations*.
- Photograph existing space.
- Laser measure space if applicable.

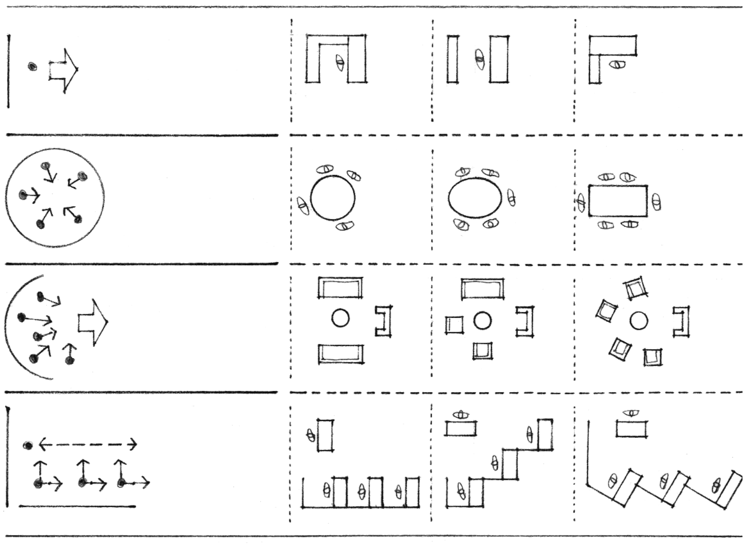
[ ] **Analyze space.**
- Orientation and site conditions of space
- Form, scale, and proportion of space
- Doorway locations, points of access, and the circulation paths they suggest
- Windows and the light, views, and ventilation they afford
- Wall, floor, and ceiling materials
- Significant architectural details
- Location of plumbing, electrical, and mechanical fixtures and outlets
- Possible architectural modifications
- Elements for possible reuse, including finishes and furnishings



Communication Movement Adjacencies

## DIMENSIONAL REQUIREMENTS

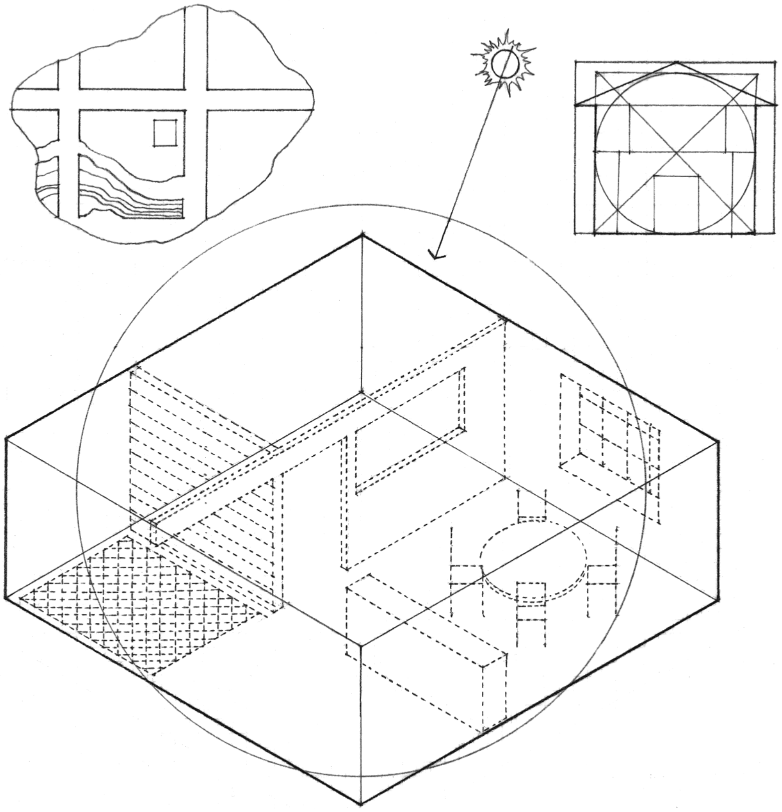
[ ] **Determine required dimensions for space and furniture groupings.**
- Each functional grouping of furniture
- Access to and movement within and between activity areas
- Number of people served
- Appropriate social distances and interaction



Furniture requirements and arrangements

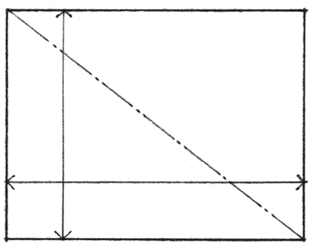
In a broader sense, all interior designers are involved in the planning and layout of interior spaces, whether small or large, residential or commercial. Once a design program has been outlined and developed from an analysis of the client's or users' needs, the design task is to allocate the available or desired interior spaces properly for the various required activities.

Area requirements can be estimated from an analysis of the number of people served, the furnishings and equipment they require, and the nature of the activity that will go on in each space. These area requirements can then be translated into rough blocks of space and related to each other and to the architectural context in a functional and aesthetic manner.

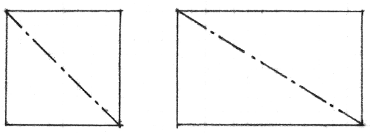


Space utilization

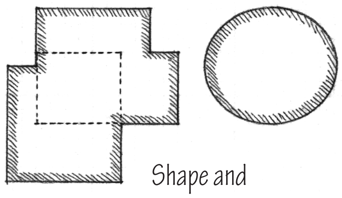
## Analysis of User Requirements + Existing or Proposed Spaces…Integration



Dimensions



Proportions



Shape and significant features

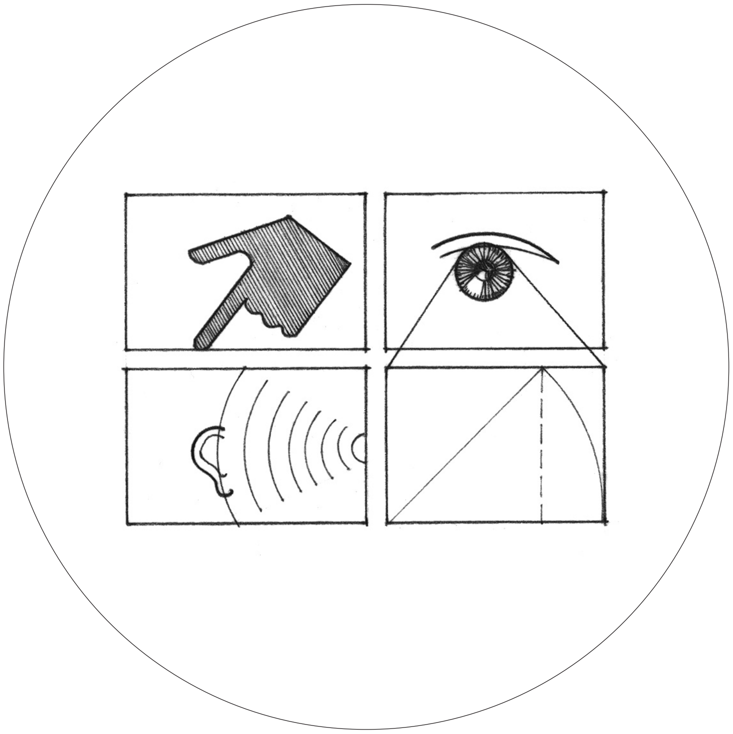
## DESIRED QUALITIES

[ ] **Determine appropriate spatial qualities compatible with client's or users' needs or wishes.**
- Feeling, mood, or atmosphere
- Image and style
- Degree of spatial enclosure
- Comfort and security
- Quality of light
- Focus and orientation of space
- Color and tone
- Textures
- Acoustical environment
- Thermal environment
- Flexibility and projected length of use
- Encouragment of physical movement

## DESIRED RELATIONSHIPS

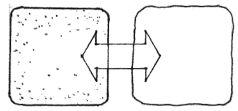
[ ] **Determine desired relationships between:**
- Related activity areas
- Activity areas and space for movement
- Room and adjacent spaces
- Room and the outside

[ ] **Determine desired zoning of activities.**
- Organization of activities into groups or sets according to compatibility and use

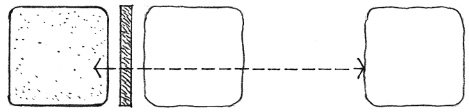


Whether collaborating on the design of a new building or planning the remodeling of an existing structure, the interior designer strives for a proper fit between the demands of activities and the architectural nature of the spaces that house them.

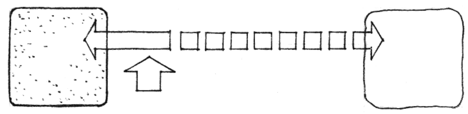
Certain activities may need to be closely related or adjacent to each other, while others may be more distant or isolated for privacy. Some activities may require easy access, while others may need controlled entries and exits. Daylighting, view, and natural ventilation may be priorities for some areas, while others may not need to be located near exterior windows. Some activities may have specific spatial requirements, while others may be more flexible or be able to share a common space.



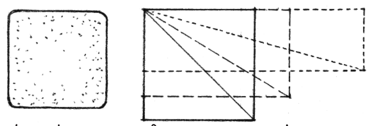
Which activities should be closely related?



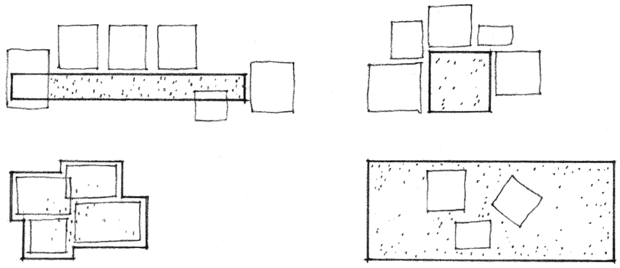
Which activities can be isolated by enclosure or distance?



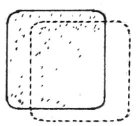
What degree of accessibility is required?



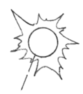
Are there specific proportional requirements?

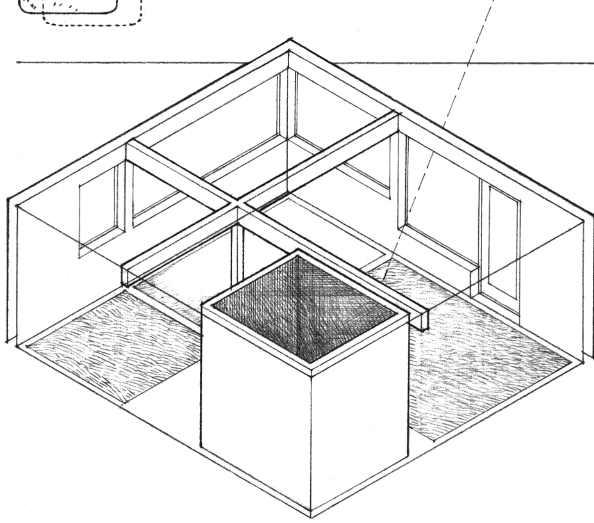


Do activity relationships suggest a spatial pattern?

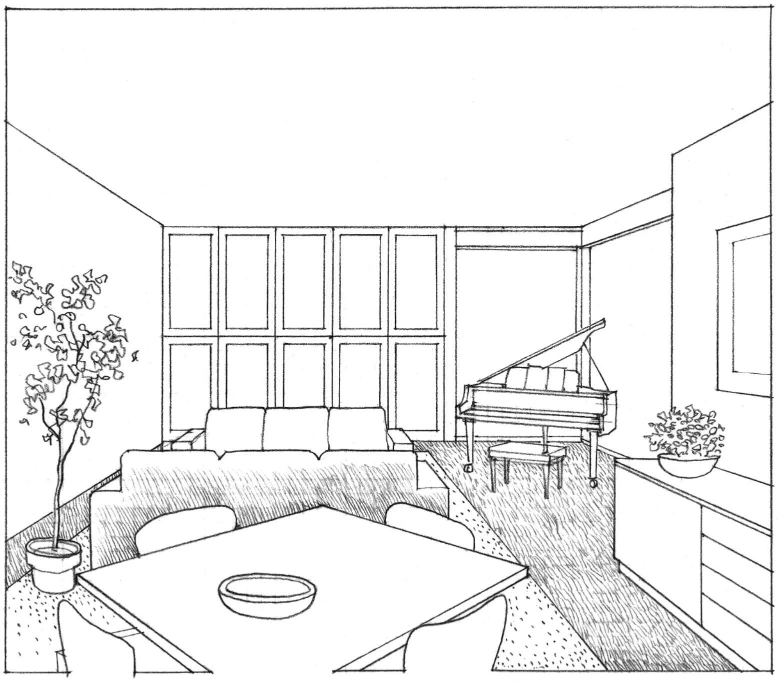


Can any activities share the same space?



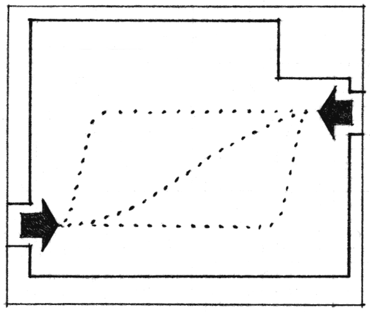


Which activities require daylighting and ventilation?

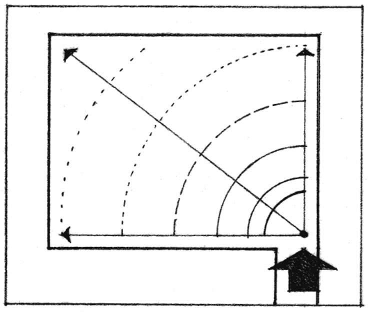


The architect will begin to develop the shape and form of a new building as interior areas are organized on the basis of considerations developed during programming, along with considerations of the building site and adjacent structures.

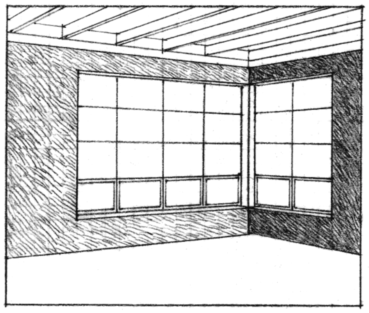
Whether a space is situated within an existing structure or is contemplated in a newly designed building, it usually provides clues for the interior designer as to how it can best be utilized. The entries into a space may define a pattern of movement that divides the area into certain zones. Some zones may be more easily accessed than others. Some may be large enough to accommodate group activities, while others are not. Some may have access to exterior windows or skylights for daylighting or ventilation; others may be internally focused. Some may include a natural center of interest, such as a view window or a fireplace.



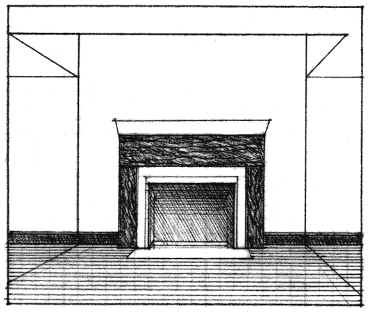
Possible paths of movement



Accessibility of zones

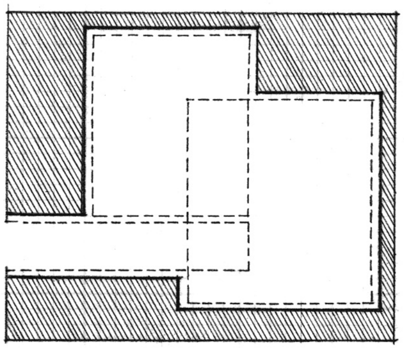


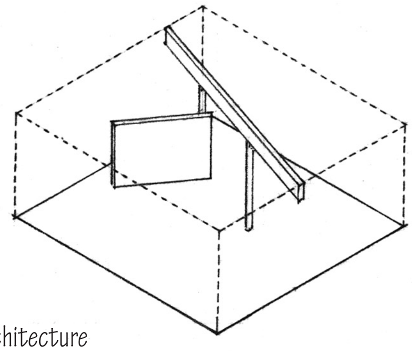
External outlook



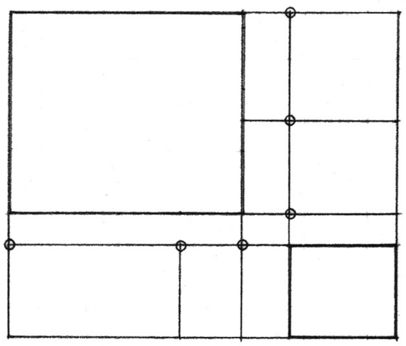
Internal focus

The zoning of a space may be suggested by the shape of its enclosure or by the architecture. Doorways suggest paths of movement and establish access to certain zones. The daylighting afforded by windows or skylights should influence the placement of activities. An external outlook or an internal focus might suggest how a space could be organized.

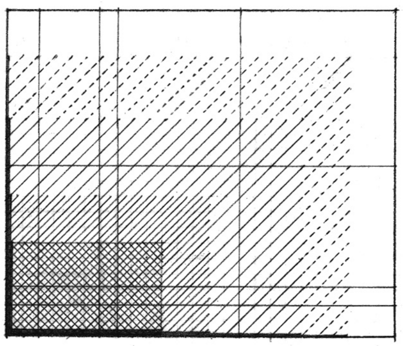




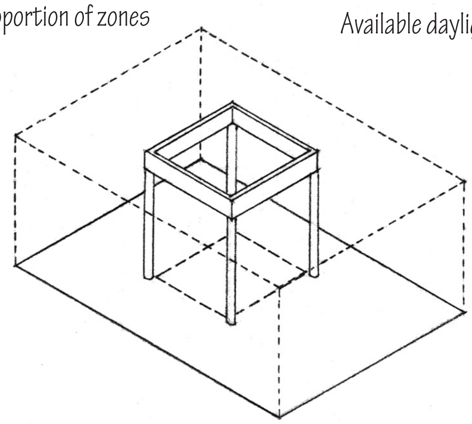
Divisions suggested by room shape or by the architecture

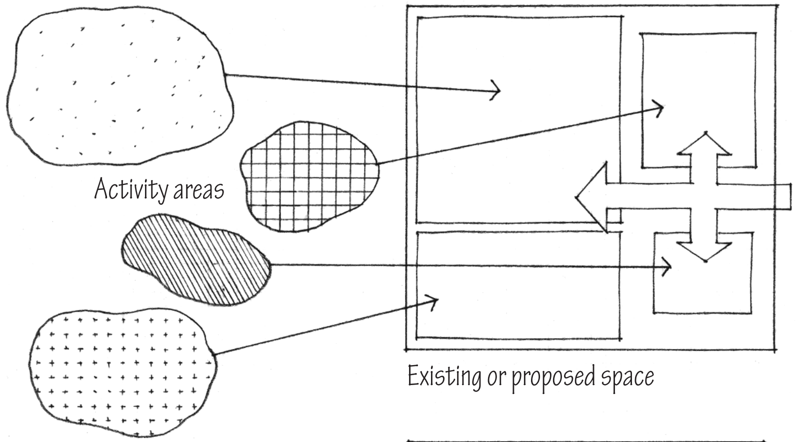


Size and proportion of zones



Available daylight



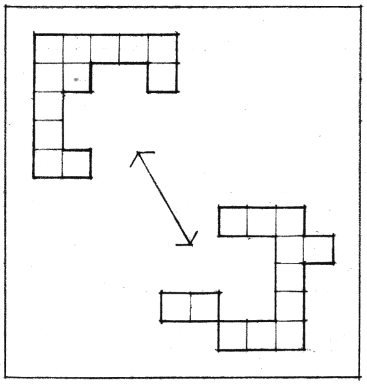


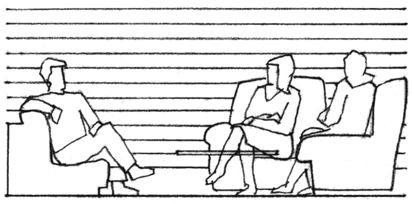
Existing or proposed space

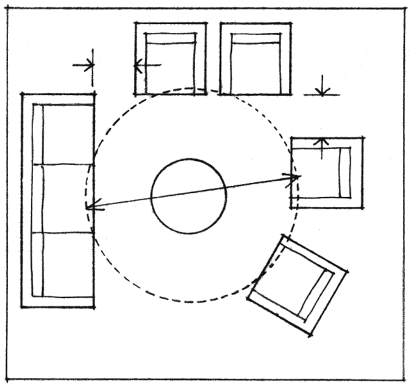
From the preceding activity and space analyses, one can begin to match the space requirements of each activity to the characteristics of the available spaces. The design task then shifts to selecting furnishings, finishes, and lighting, and to arranging them into three-dimensional patterns within the given spatial boundaries. These arrangements of shapes and forms in space should respond both to functional and aesthetic criteria.

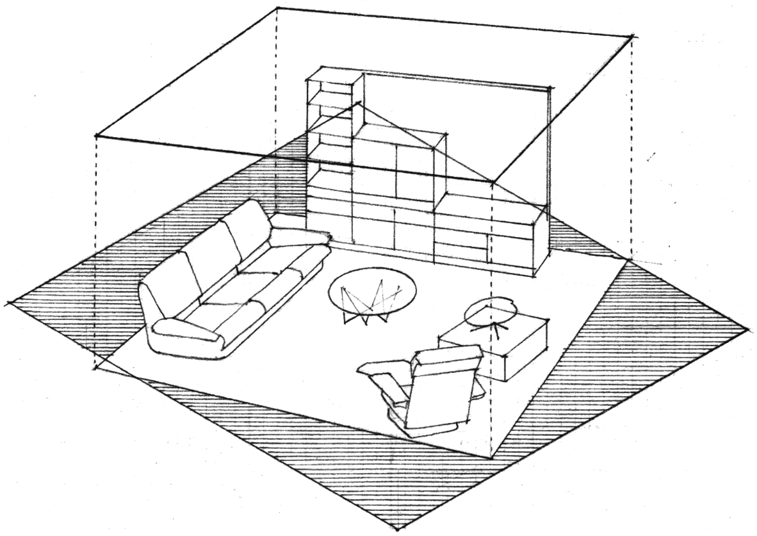
## Function

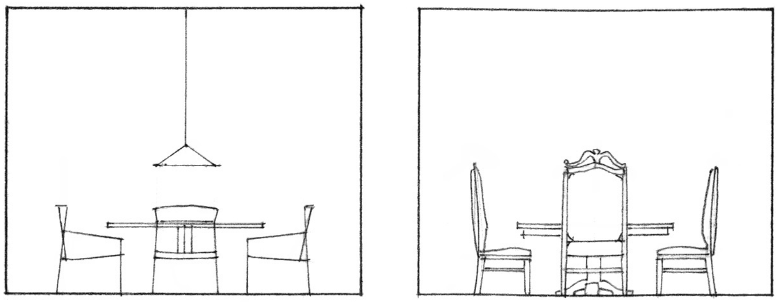
- Activity-specific grouping of furniture
- Workable dimensions and clearances
- Appropriate social distances
- Suitable visual and acoustical privacy
- Adequate flexibility or adaptability
- Appropriate lighting and other building services


Flexibility


Functional groupings


Dimensions and distances

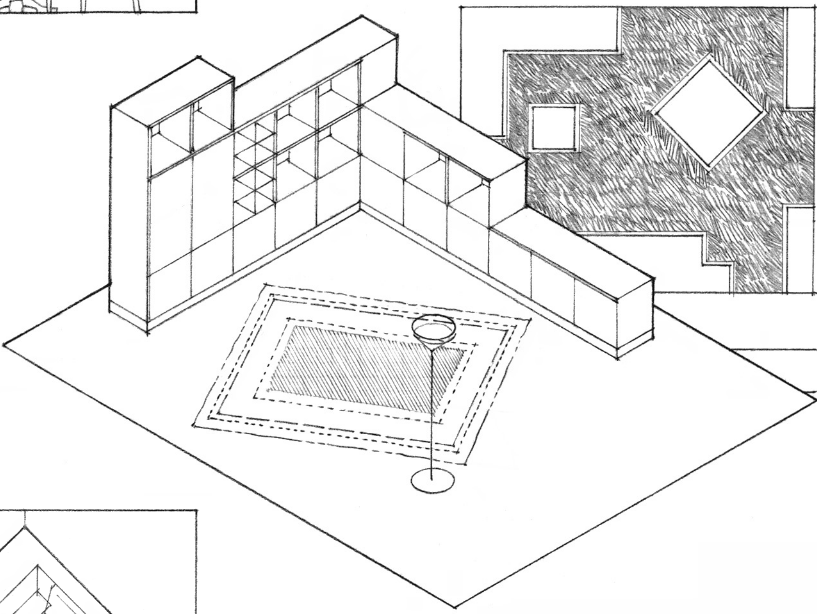

Spatial definition and privacy



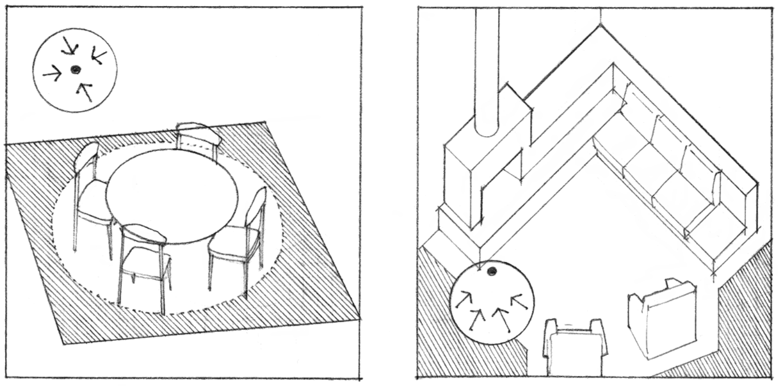
Scalar relationship to space

## Aesthetics

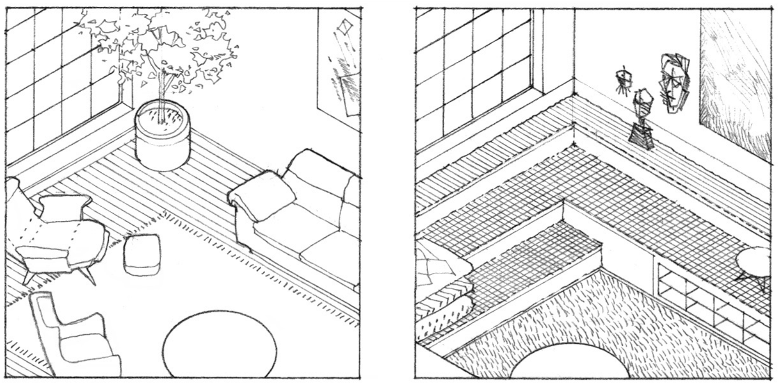
- Appropriate scale to space function
- Visual grouping: unity with variety
- Figure–ground reading
- Three-dimensional composition: rhythm, harmony, balance
- Appropriate orientation toward light, view, or an internal focus
- Shape, color, texture, and pattern



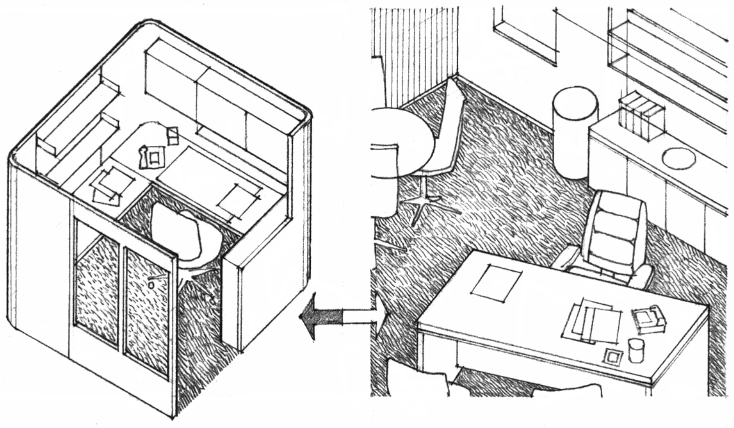
Figure–ground patterns



Grouping and orientation

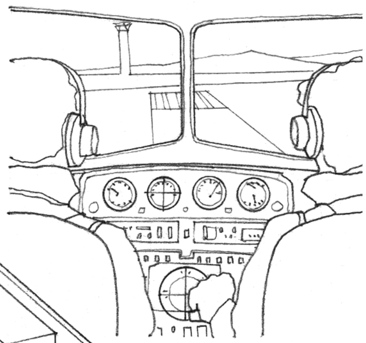


Objects in space or merging with space

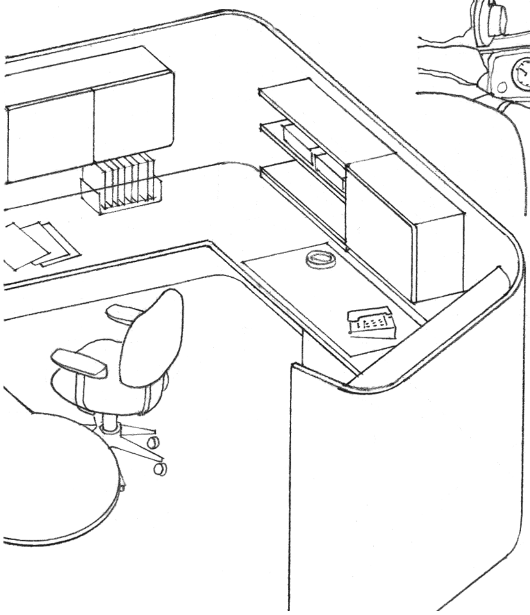


## Tight Fit

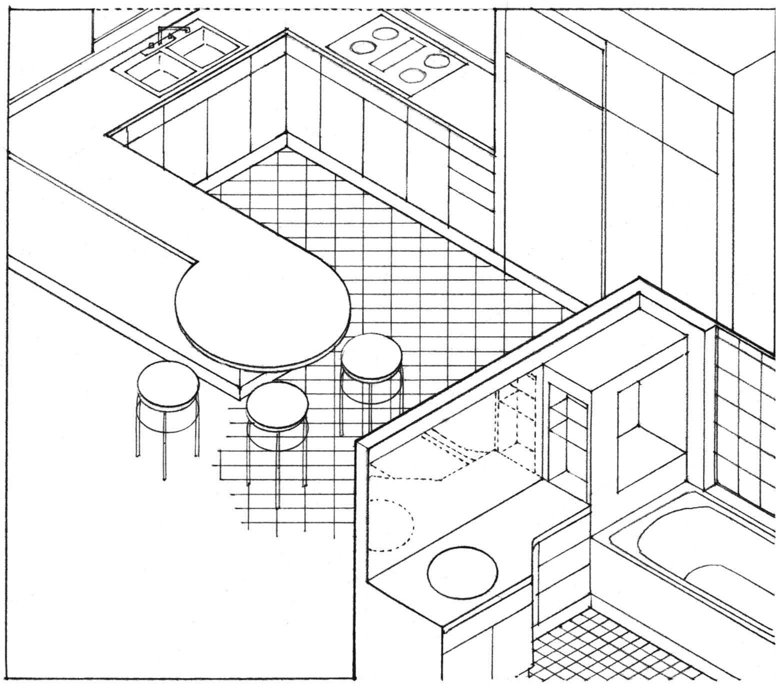
Plan arrangements can be generally classified into two broad categories—tight fit and loose fit—according to how each uses the available space. The first exhibits a close correspondence between furniture and equipment. This may be particularly appropriate when space is at a premium or when functional efficiency is important. A tight-fit arrangement must be laid out with great care for its intended use; however, it may not be readily adaptable to other uses.



A tight-fit arrangement usually employs modular or unit furniture components that can be combined in a number of ways to form integrated and often multifunctional assemblies. Such assemblies utilize space efficiently and leave a maximum amount of floor area around them. A tailored arrangement of modular furniture can also be used to define a space within a larger volume for greater privacy or intimacy.



Carried to an extreme, a tight-fit arrangement can be built in place and become a permanent extension of a room's architecture. Like modular and unit arrangements, built-in furniture utilizes space efficiently, conveys an orderly and unified appearance, and mitigates visual clutter in a space.

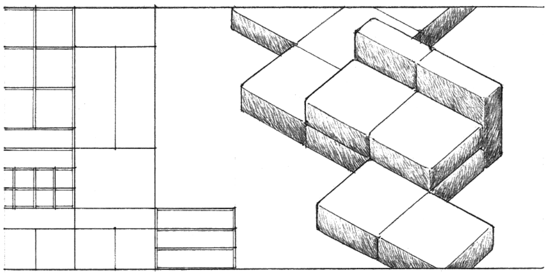


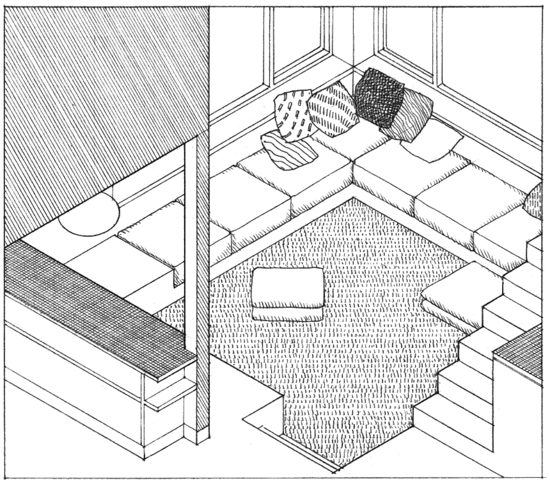
Tight-fit or tailored arrangements require careful study and analysis of functional relationships.

## Loose Fit

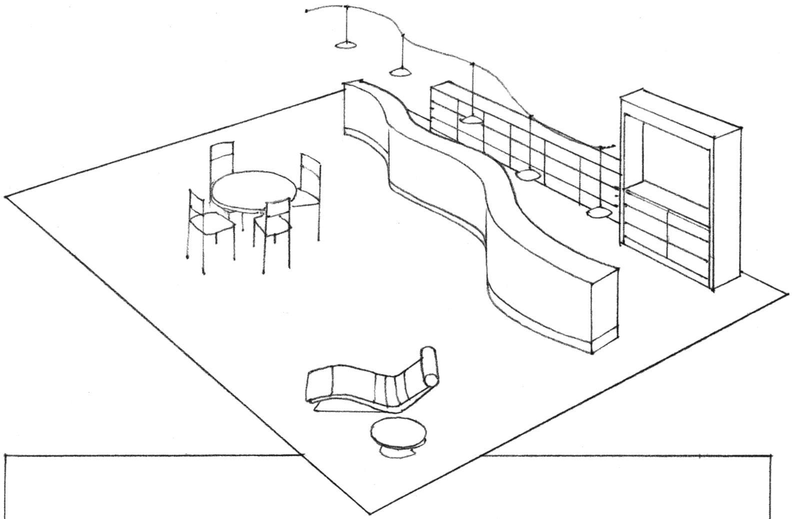
A second, more common type of plan arrangement exhibits a looser fit between function and space. Loose-fit arrangements are desirable for the flexibility and diversity they afford.

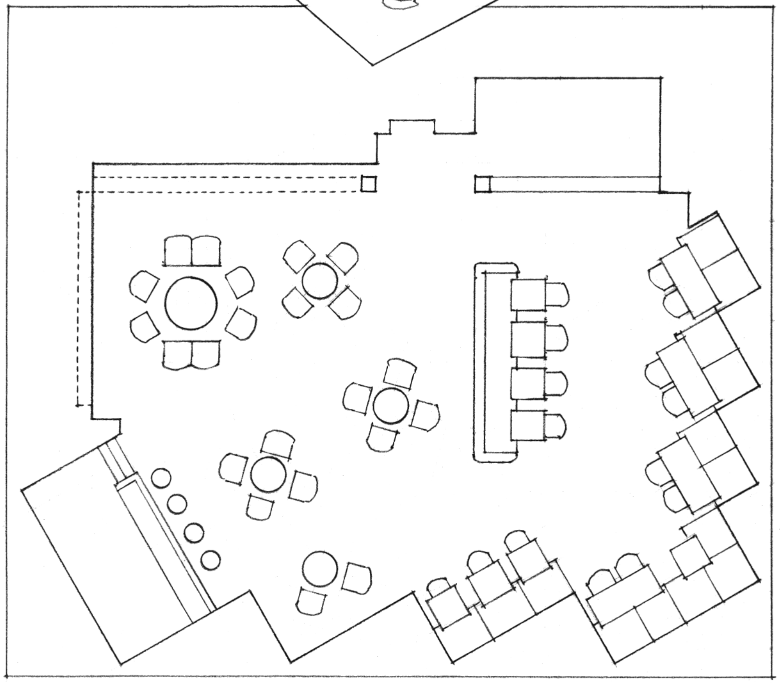
Most rooms with a loose-fit arrangement can accommodate a variety of uses, especially if the furniture used can be easily moved and rearranged. This inherent flexibility in adapting to changes in use or circumstance makes a loose-fit arrangement the more common method for laying out furniture in a space. It also offers the opportunity for a greater mix of furniture types, sizes, and styles to be selected over time to suit almost any design situation.

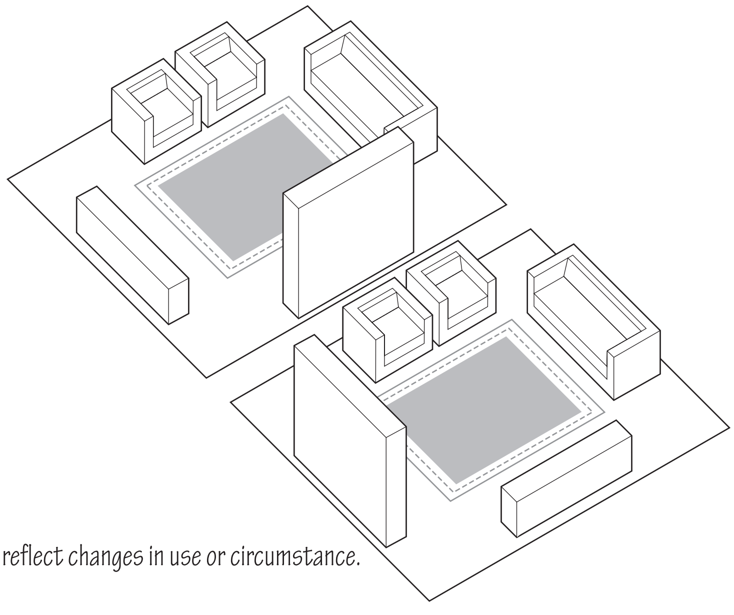




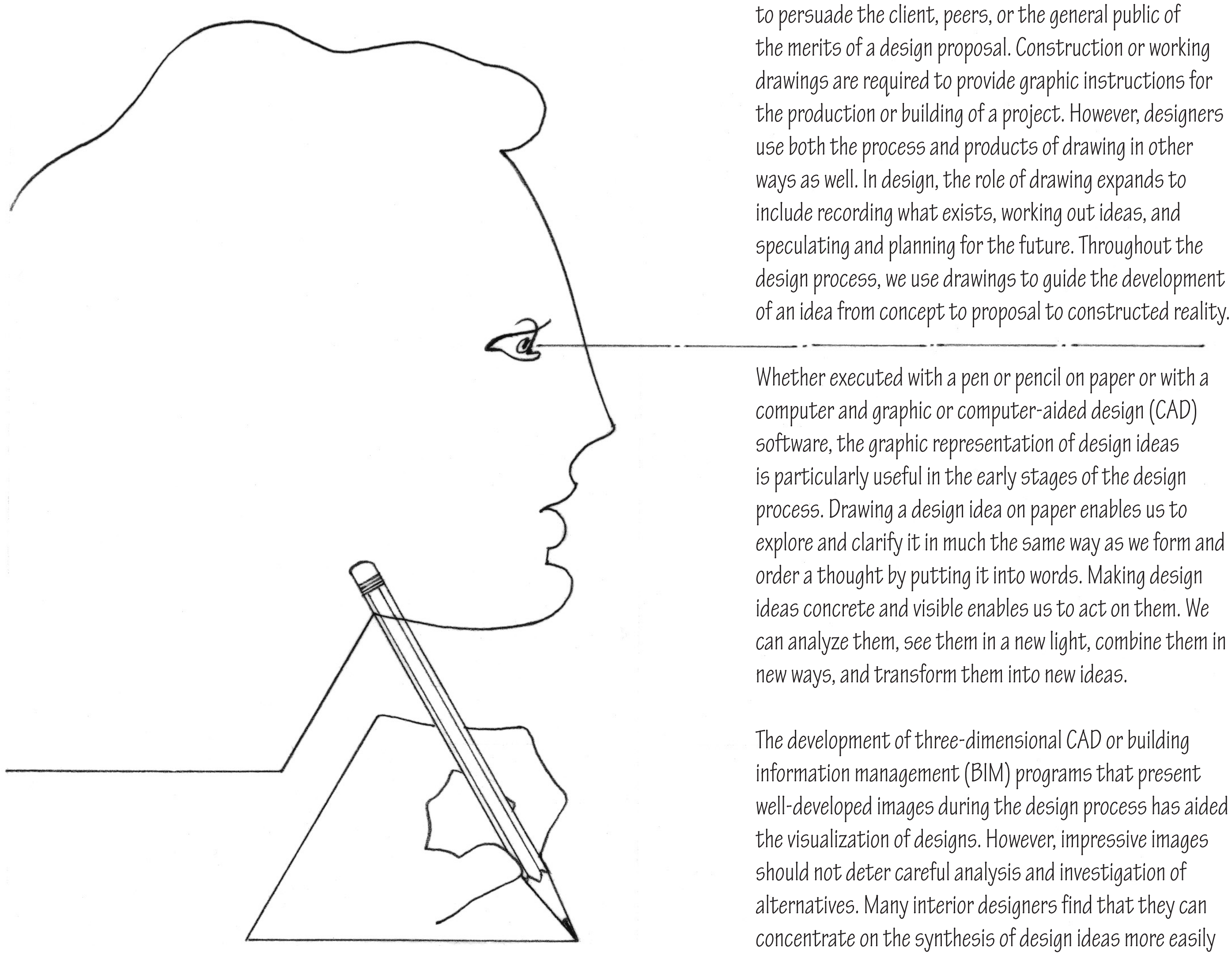
Modular furnishings are flexible and utilize space efficiently.







Loose-fit arrangements can reflect changes in use or circumstance.

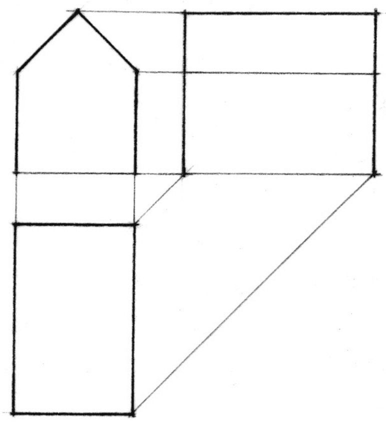


Designers use drawings in many ways. The presentation drawings executed at the end of a design project are used to persuade the client, peers, or the general public of the merits of a design proposal. Construction or working drawings are required to provide graphic instructions for the production or building of a project. However, designers use both the process and products of drawing in other ways as well. In design, the role of drawing expands to include recording what exists, working out ideas, and speculating and planning for the future. Throughout the design process, we use drawings to guide the development of an idea from concept to proposal to constructed reality.

Whether executed with a pen or pencil on paper or with a computer and graphic or computer-aided design (CAD) software, the graphic representation of design ideas is particularly useful in the early stages of the design process. Drawing a design idea on paper enables us to explore and clarify it in much the same way as we form and order a thought by putting it into words. Making design ideas concrete and visible enables us to act on them. We can analyze them, see them in a new light, combine them in new ways, and transform them into new ideas.

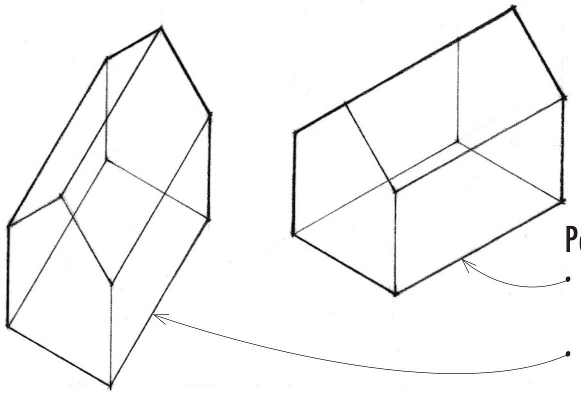
The development of three-dimensional CAD or building information management (BIM) programs that present well-developed images during the design process has aided the visualization of designs. However, impressive images should not deter careful analysis and investigation of alternatives. Many interior designers find that they can concentrate on the synthesis of design ideas more easily with paper and a pen or pencil, without the distraction and restraints of operating the computer software. Loose sketches can evolve into explorations of alternative design schemes. Analyze ideas, synthesize the good ones, and evaluate the results. Then refine them into preliminary designs for further evaluation and development.

The central task of architectural drawing is representing three-dimensional forms, constructions, and spatial environments on a two-dimensional surface. Three distinct types of drawing systems have evolved over time to accomplish this mission: *multiview*, *paraline*, and *perspective* drawings. These visual systems of representation constitute a formal graphic language that is governed by a consistent set of principles.



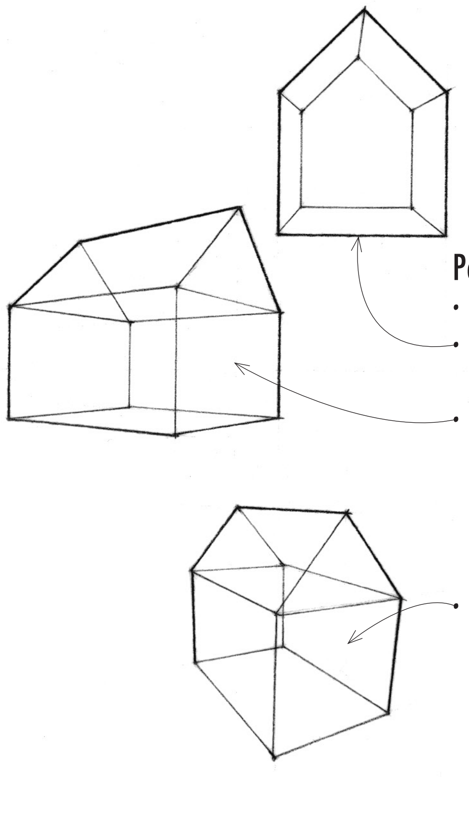
## Multiview Drawings

- Plans, sections, and elevations
- A related series of *orthographic projections*



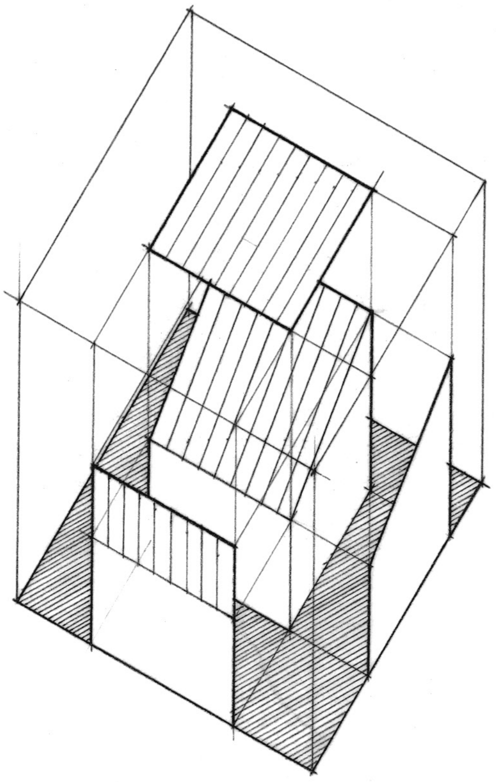
## Paraline Drawings

- *Axonometric projections*
- *Oblique projections*, including elevation obliques and plan obliques



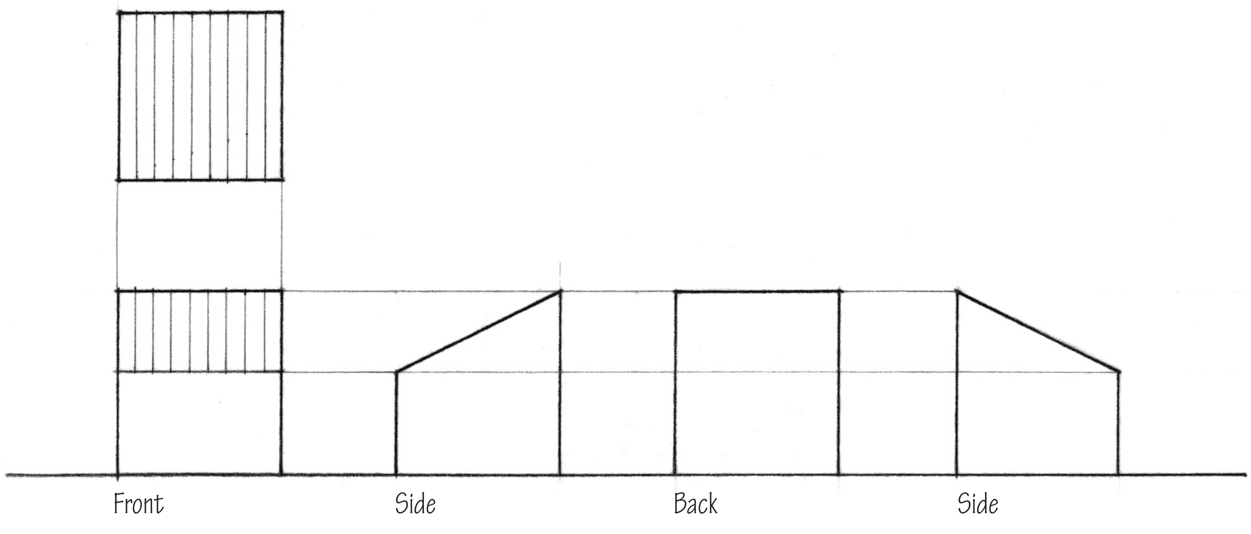
## Perspective Drawings

- Perspective projections
- One-point perspective
- Two-point perspective
- Three-point perspective

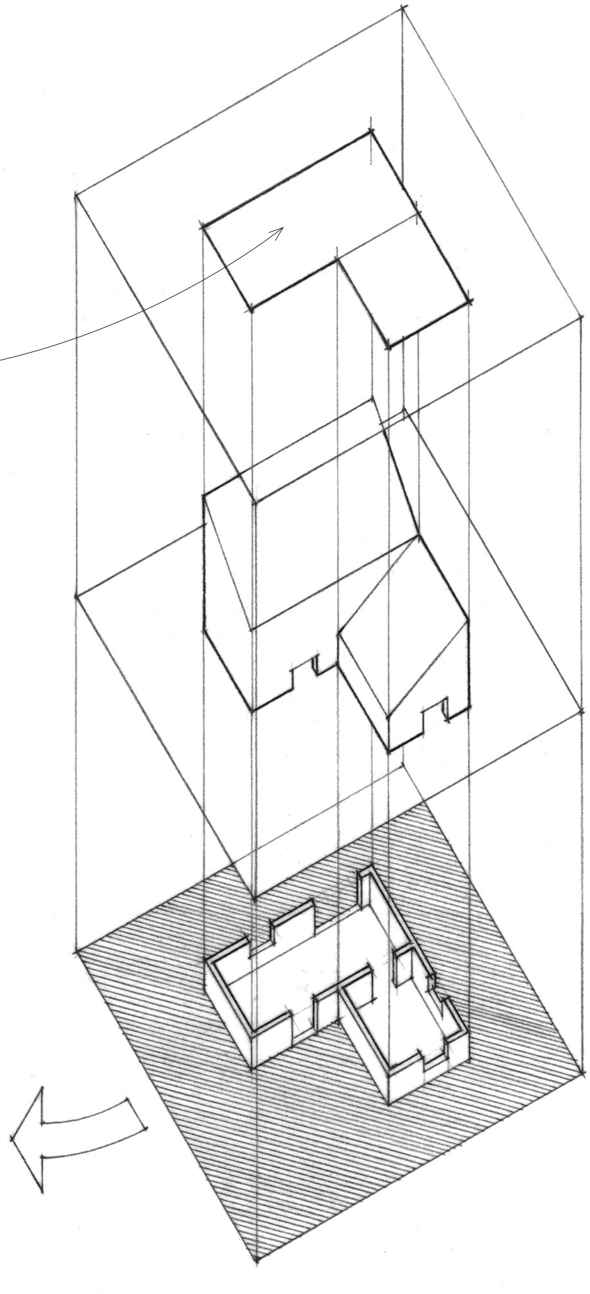


Multiview drawings comprise the drawing types we know as plans, elevations, and sections. Each is an orthographic projection of a particular aspect of an object or construction. In orthographic projection, parallel projectors meet the picture plane at right angles. Therefore, the orthographic projection of any feature or element that is parallel to the picture plane remains true in size, shape, and configuration. This gives rise to the principal advantage of multiview drawings—the ability to locate points precisely, gauge the length and slope of lines, and describe the shape and extent of planes.

A single multiview drawing can reveal only partial information about an object or construction. There is an inherent ambiguity of depth because the third dimension is flattened onto the picture plane. Whatever depth we read in a solitary plan, section, or elevation must be inferred from such graphic depth cues as hierarchical line weights and contrasting tonal values. Although a sense of depth can be inferred, it can be known with certainty only by looking at additional views. We, therefore, require a series of distinct but related views to describe fully the three-dimensional nature of a form or composition—hence the term "multiview."

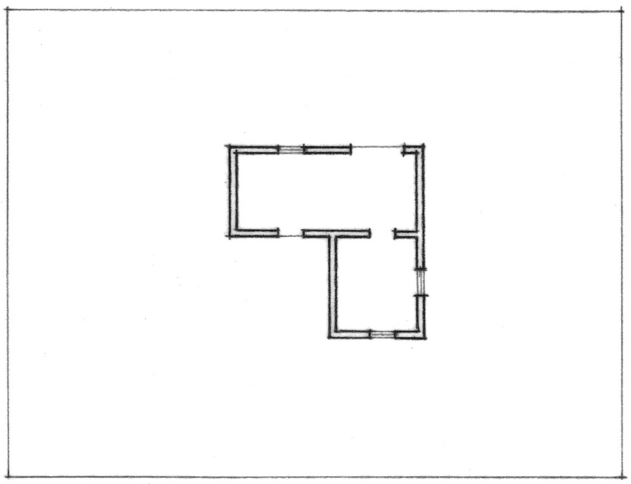


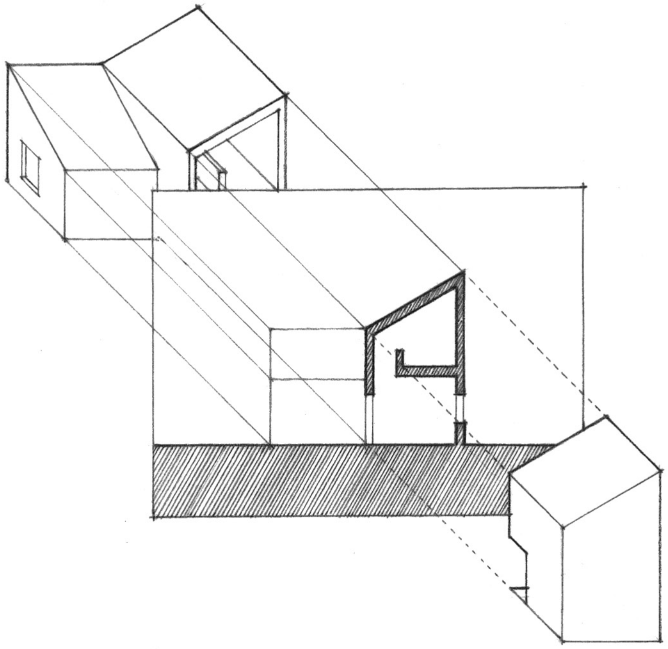
A plan is an orthographic projection of an object, structure, or composition on a horizontal plane.



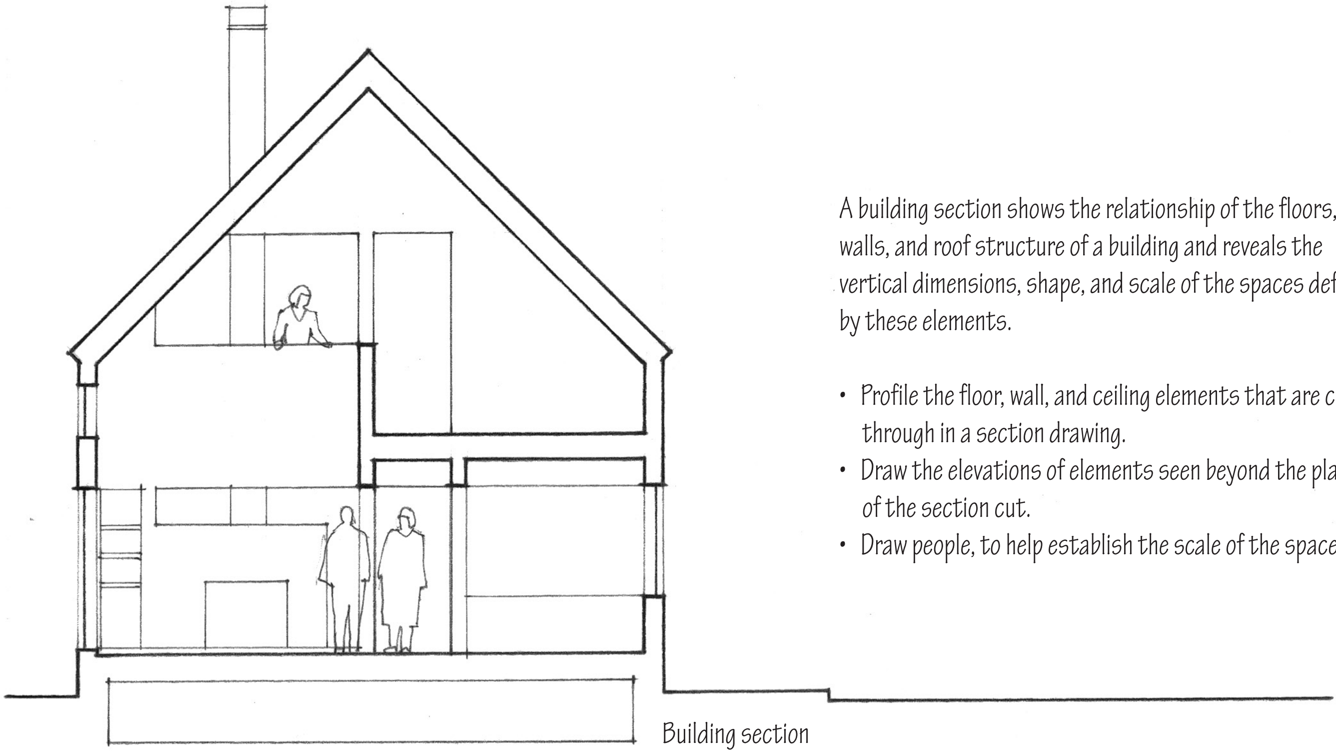
A *floor plan* represents a section through a building or portion of a building after a horizontal slice is made, usually at about 4 feet (about 1.2 m) above the floor, and the upper part is removed.

- Profile the thicknesses of walls and columns that are cut through.
- Note the locations and sizes of doors and windows.





A *section* is an orthographic projection of an object or structure as it would appear if cut through by a vertical plane to show its internal configuration.

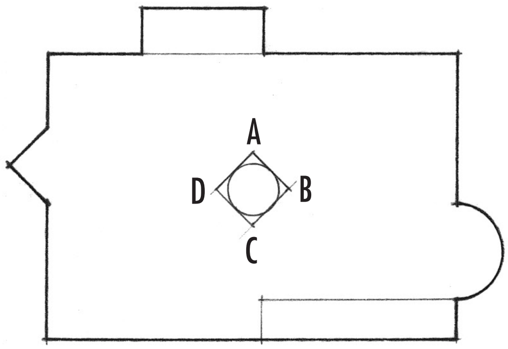


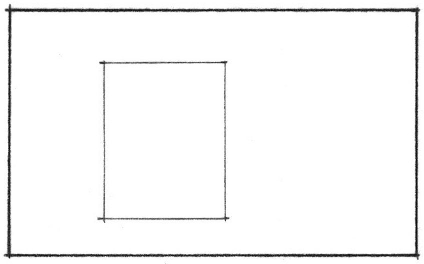
A building section shows the relationship of the floors, walls, and roof structure of a building and reveals the vertical dimensions, shape, and scale of the spaces defined by these elements.

- Profile the floor, wall, and ceiling elements that are cut through in a section drawing.
- Draw the elevations of elements seen beyond the plane of the section cut.
- Draw people, to help establish the scale of the space.

Building section

*Interior elevations* are orthographic projections of the significant interior walls of a building. While normally included in the drawing of building sections, they may stand alone to study and present highly detailed spaces, such as kitchens, bathrooms, and stairways. In this case, instead of profiling the section cut, we emphasize the boundary line of the interior wall surfaces.

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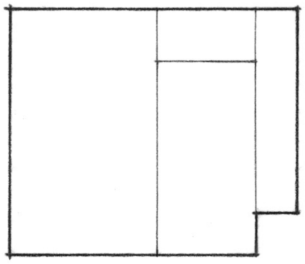
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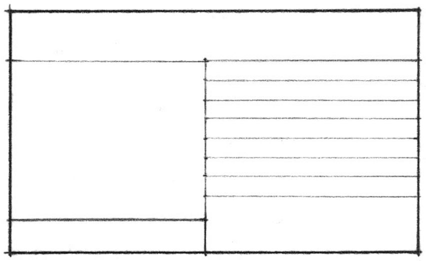
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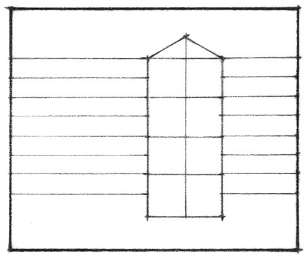
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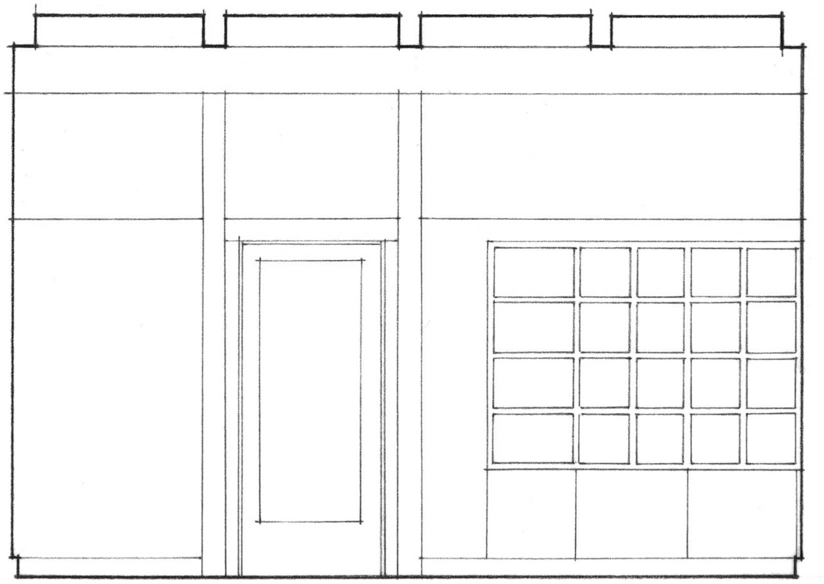
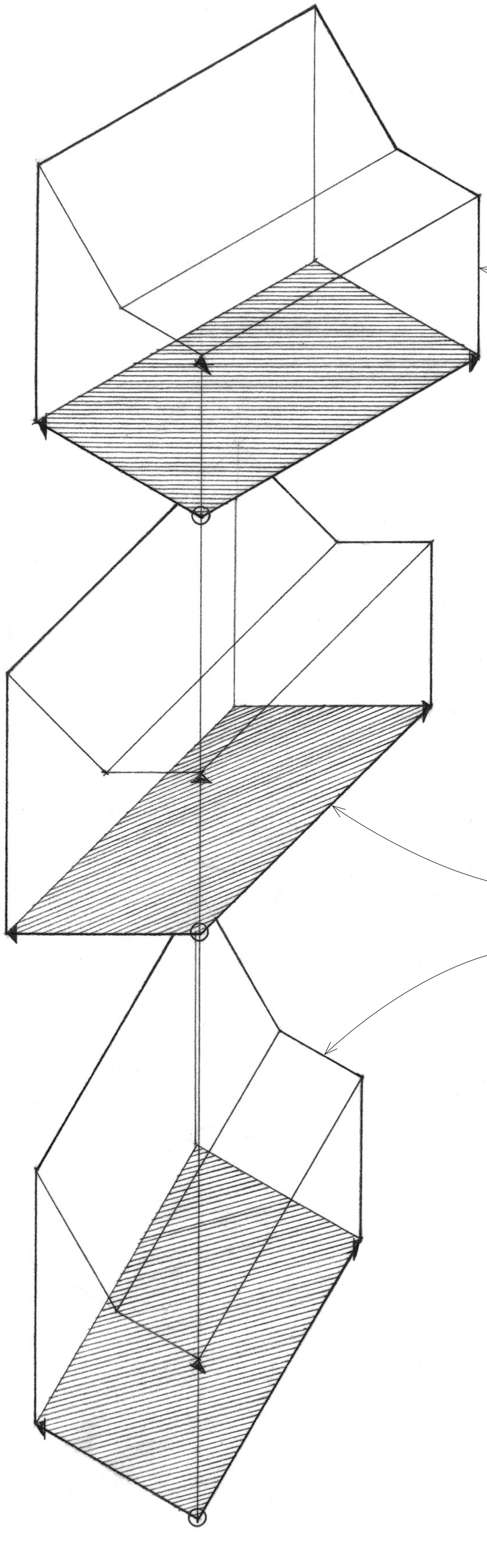

Interior elevation



Paraline drawings convey the three-dimensional nature of a form or construction in a single pictorial view. They include axonometric projections—a subset of orthographic projections, the most common of which is isometric projection—as well as the entire class of oblique projections.

## Axonometric Projections

- Isometrics—The three principal axes make equal angles with the picture plane.
- Dimetrics—Two of the three principal axes make equal angles with the picture plane.
- Trimetrics—The three principal axes make unequal angles with the picture plane.

## Oblique Projections

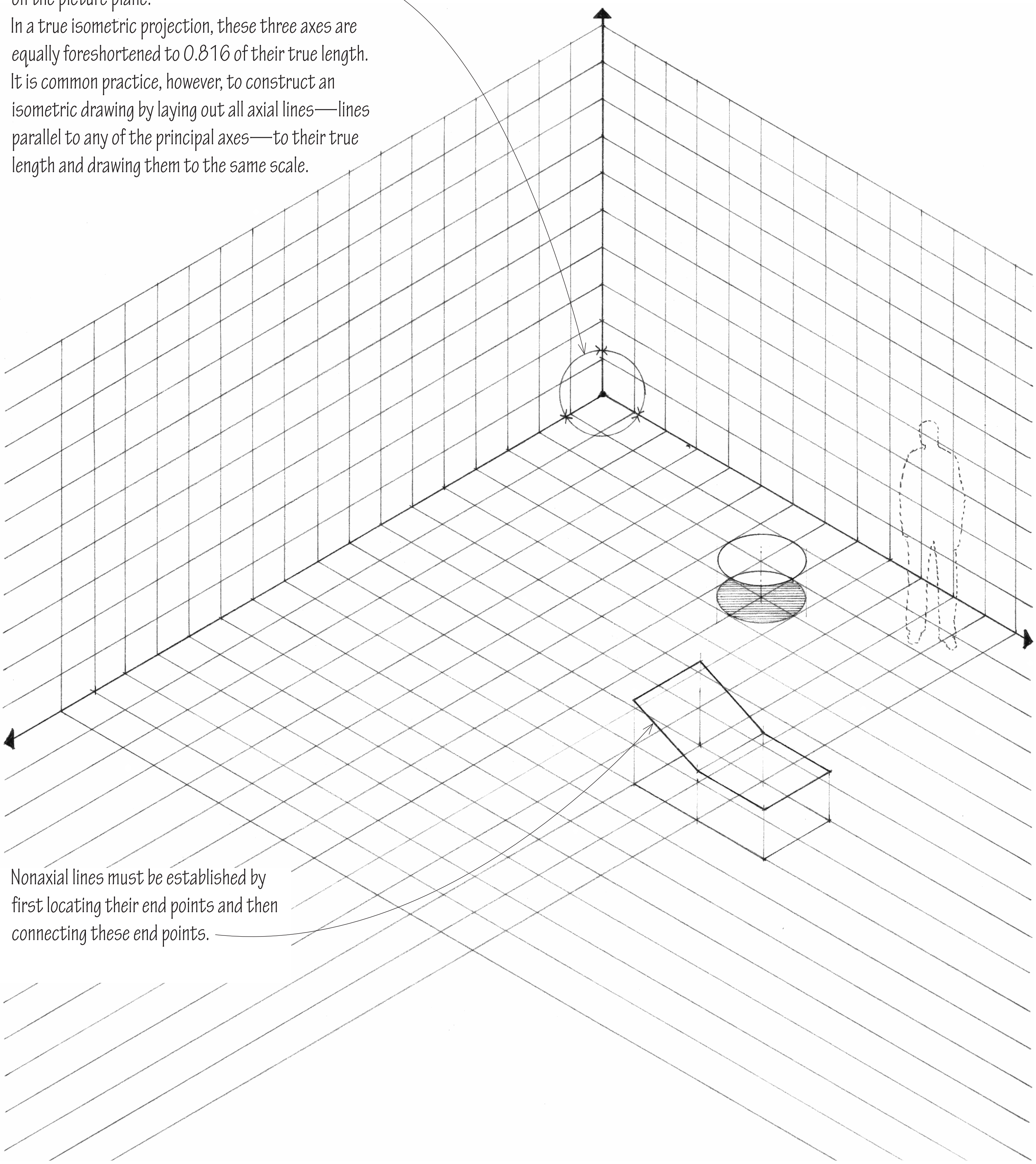
- Elevation obliques—A principal vertical face is oriented parallel to the picture plane.
- Plan obliques—A principal horizontal face is oriented parallel to the picture plane.

In all paraline drawings—both axonometrics and obliques:

- Parallel lines in the subject remain parallel in the drawn view.
- All dimensions parallel to any of the three principal axes can be measured and drawn to scale.

Isometrics are axonometric projections of objects or structures inclined to the picture plane in such a way that the three principal axes are equally foreshortened.

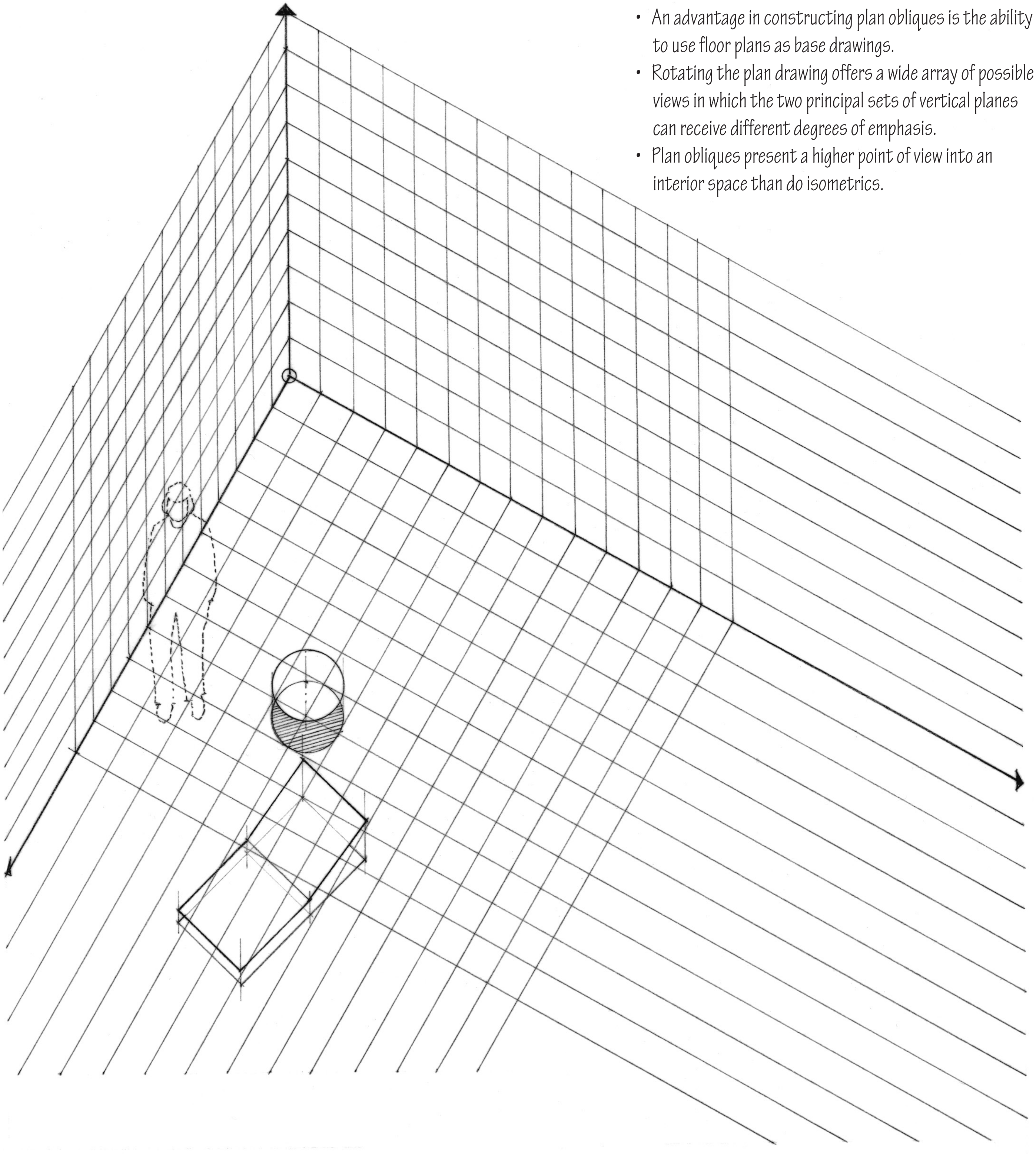
- The three principal axes appear 120° apart on the picture plane.
- In a true isometric projection, these three axes are equally foreshortened to 0.816 of their true length.
- It is common practice, however, to construct an isometric drawing by laying out all axial lines—lines parallel to any of the principal axes—to their true length and drawing them to the same scale.



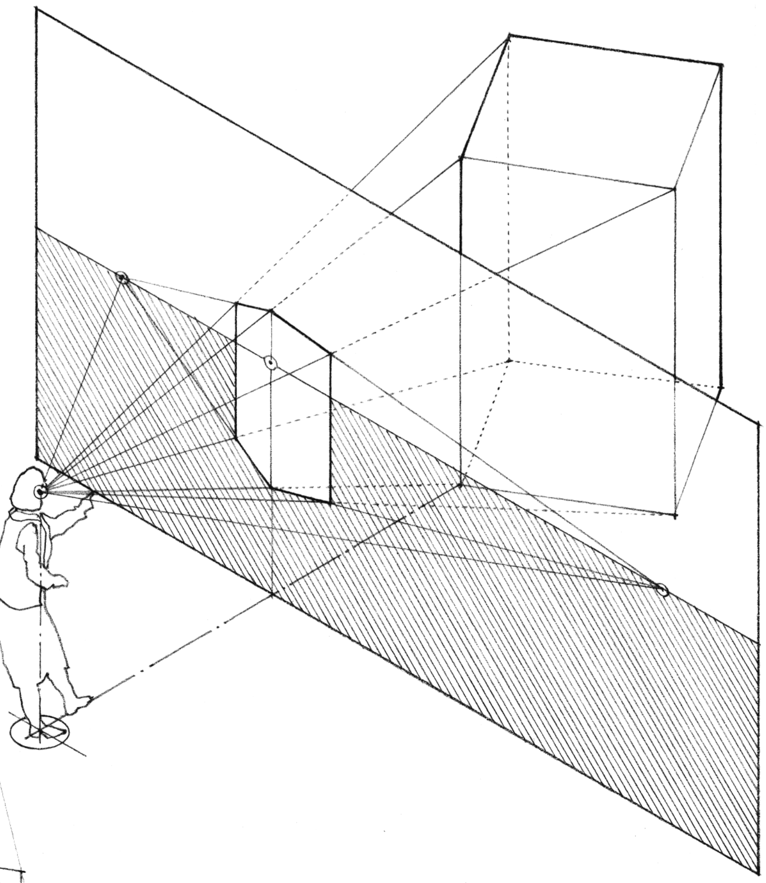
- Nonaxial lines must be established by first locating their end points and then connecting these end points.

Plan obliques orient the horizontal planes of the subject parallel to the picture plane. These horizontal planes therefore reveal their true size and shape, while the two prime sets of vertical planes are foreshortened.

- An advantage in constructing plan obliques is the ability to use floor plans as base drawings.
- Rotating the plan drawing offers a wide array of possible views in which the two principal sets of vertical planes can receive different degrees of emphasis.
- Plan obliques present a higher point of view into an interior space than do isometrics.



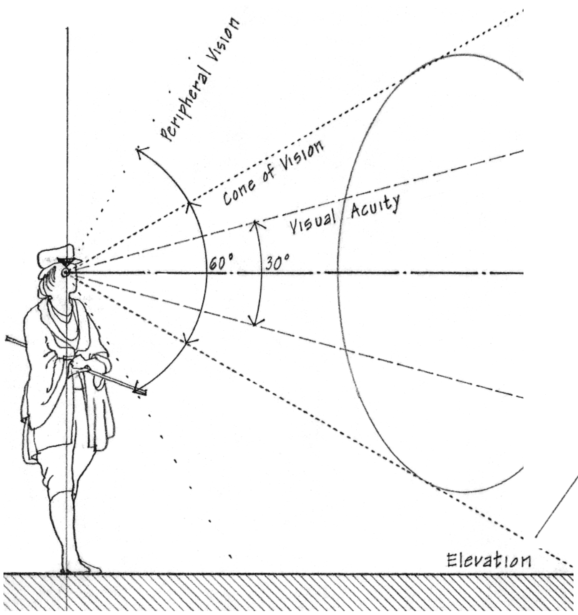
Perspective projection portrays a three-dimensional form or construction by projecting all of its points to a picture plane (PP) through the use of straight lines that converge at a fixed point representing a single eye of the observer. While we normally see through both eyes in what is termed binocular vision, perspective projection assumes that we view a three-dimensional subject or scene through a single eye, which we call the station point (SP).

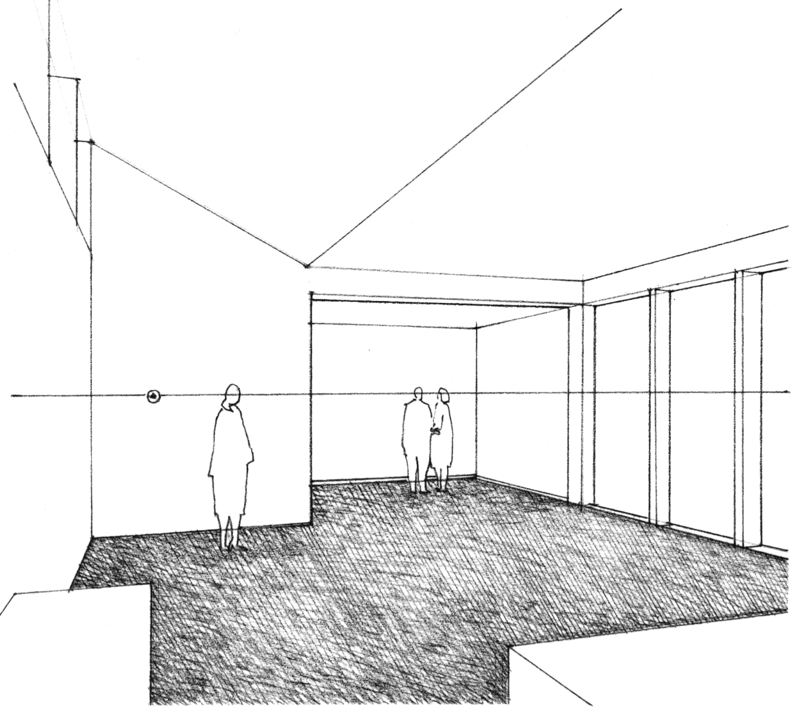


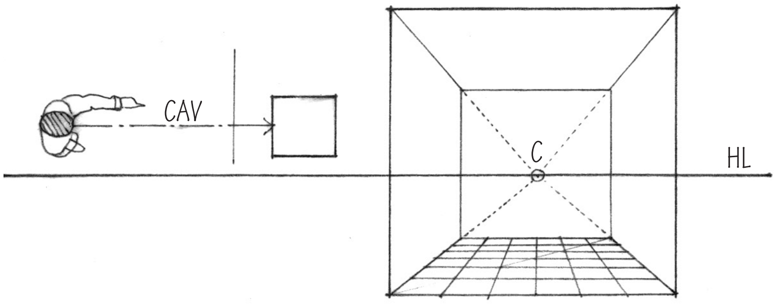
Multiview and paraline drawings utilize parallel projectors, and the projected size of an element remains the same regardless of its distance from the picture plane. The converging projectors or sightlines in a perspective drawing, however, alter the apparent size of a line or plane according to its distance from the picture plane and the observer. In other words, converging sightlines reduce the size of distant objects.

The primary use of perspective drawings in design is to convey an experiential view of space and spatial relationships.

3D computer modeling programs, while following the mathematical principles of perspective, can easily create distorted perspective views. Keeping the central portion of a subject or scene within a reasonable 60° cone of vision avoids such distortion. This problem can be resolved in Autodesk Revit by manipulating the focal length.

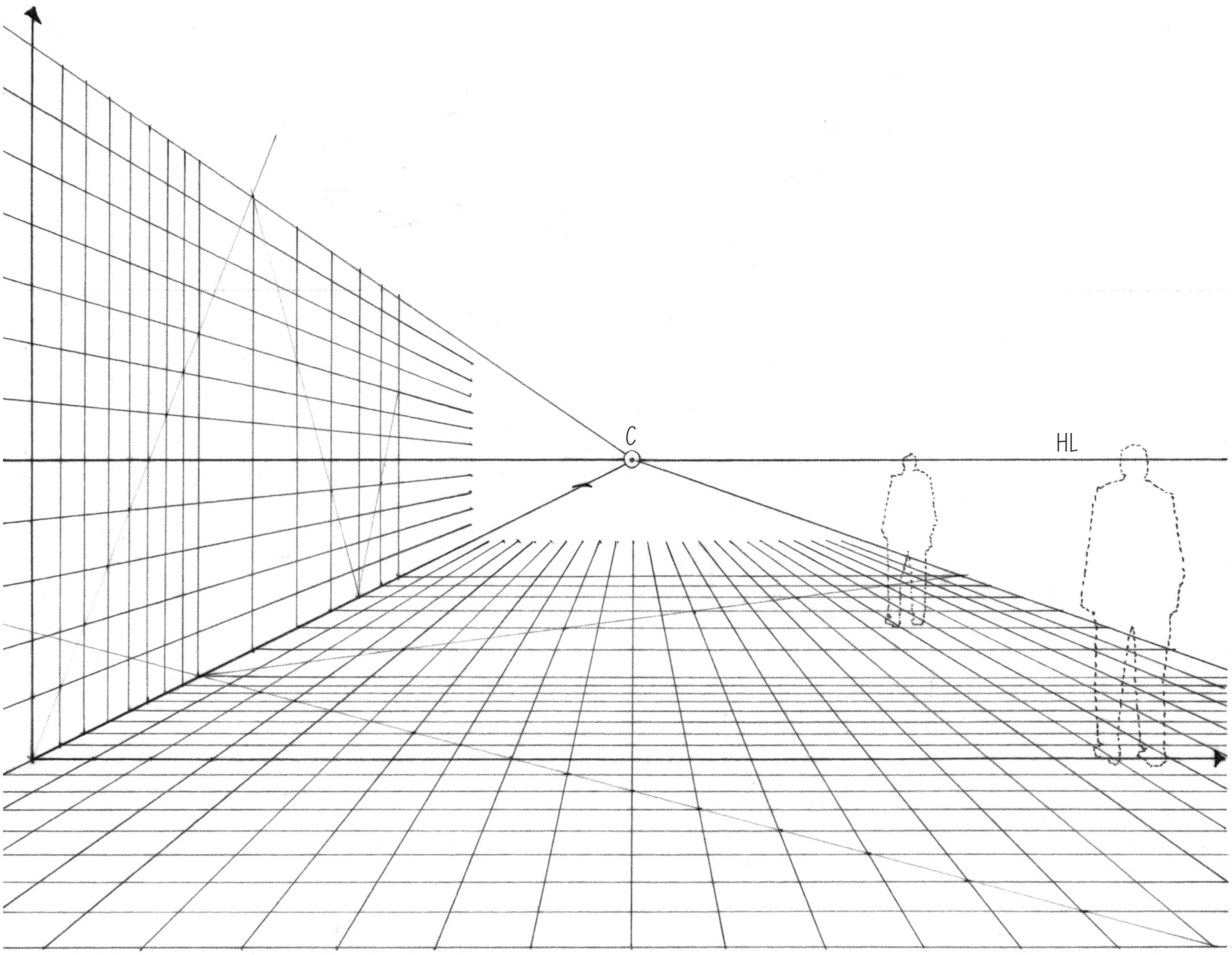


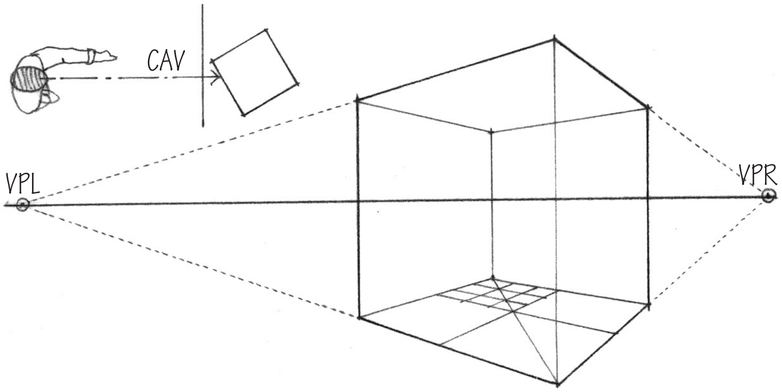



If we view a cube with our central axis of vision (CAV) perpendicular to one of its faces, all of the cube's vertical lines are parallel with the picture plane and remain vertical. Horizontal lines that are parallel to the PP and perpendicular to the CAV remain horizontal. Lines parallel to the CAV, however, will appear to converge at a single point on the horizon line (HL), the center of vision (C).

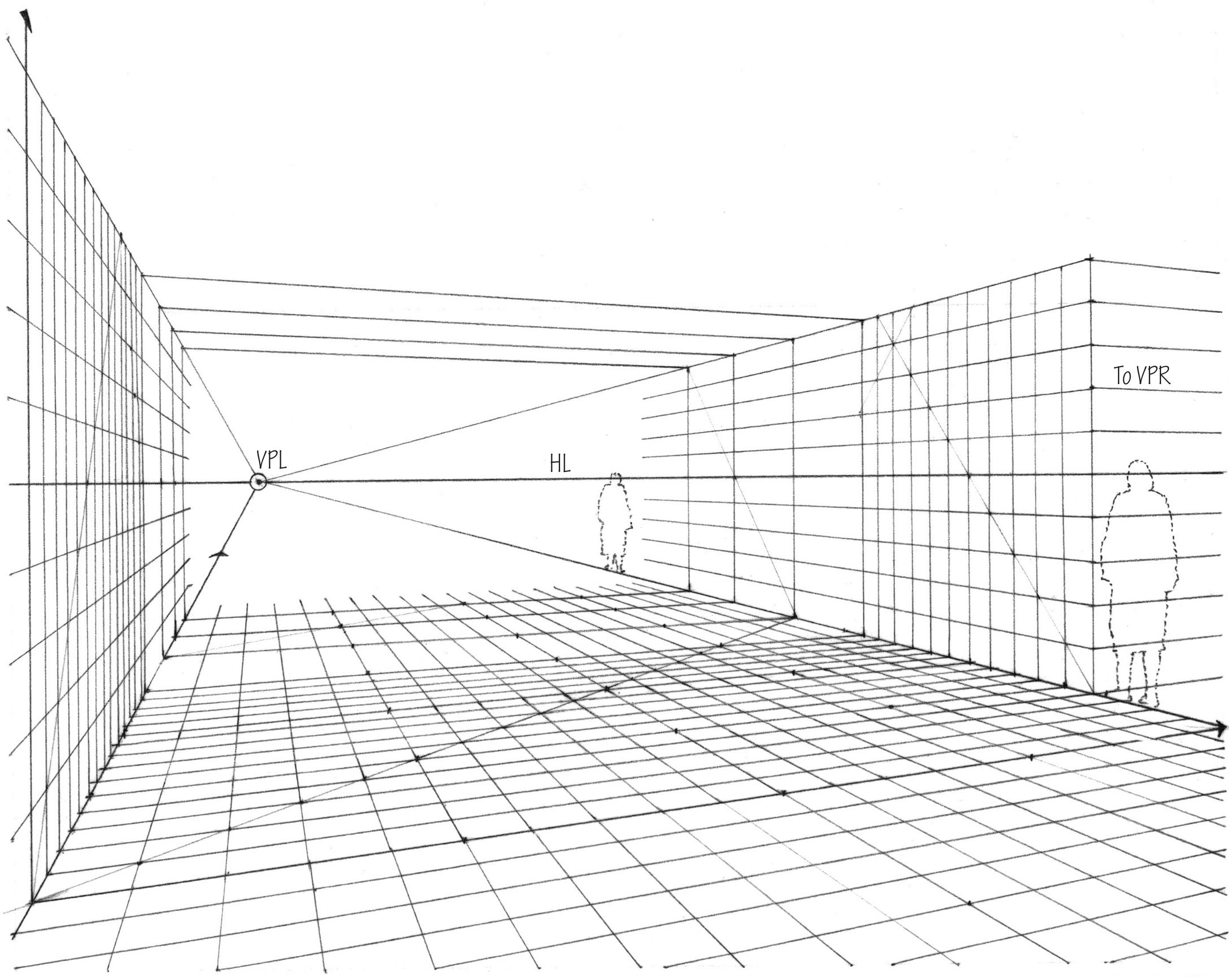
One-point perspectives are particularly effective in depicting interior spaces because the display of three bounding faces provides a clear sense of enclosure. The converging lines parallel to the CAV provide a sense of depth. By moving the CAV left or right, attention can be drawn to the vertical walls on either side.

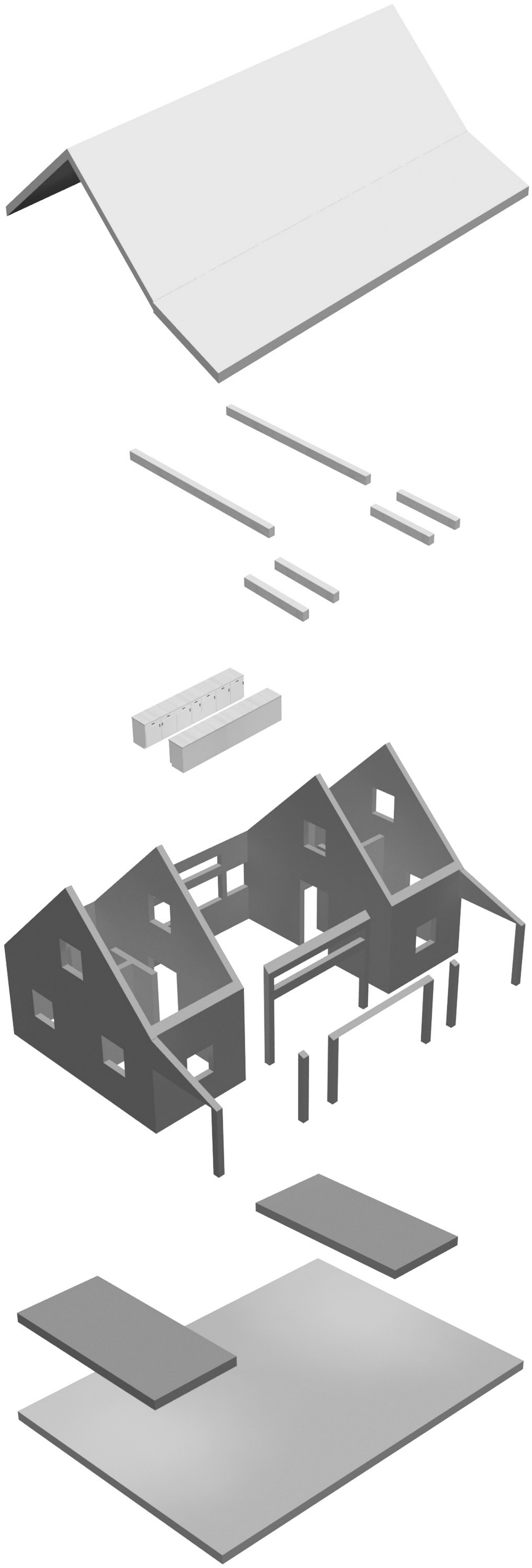


If we shift our view of a cube so that we view it obliquely, but keep our CAV horizontal, then the cube's vertical lines will remain vertical. The two sets of horizontal lines, however, are now oblique to the PP and will appear to converge, one set to a left vanishing point (VPL) and the other to a right vanishing point (VPR). These are the two points referred to in two-point perspective.




The pictorial effect of a two-point perspective varies with the observer's angle of view. In depicting interior spaces, a two-point perspective is most effective when the angle of view approaches that of a one-point perspective. Any perspective view that displays three bounding faces of a spatial volume provides the clear sense of enclosure inherent in interior spaces.





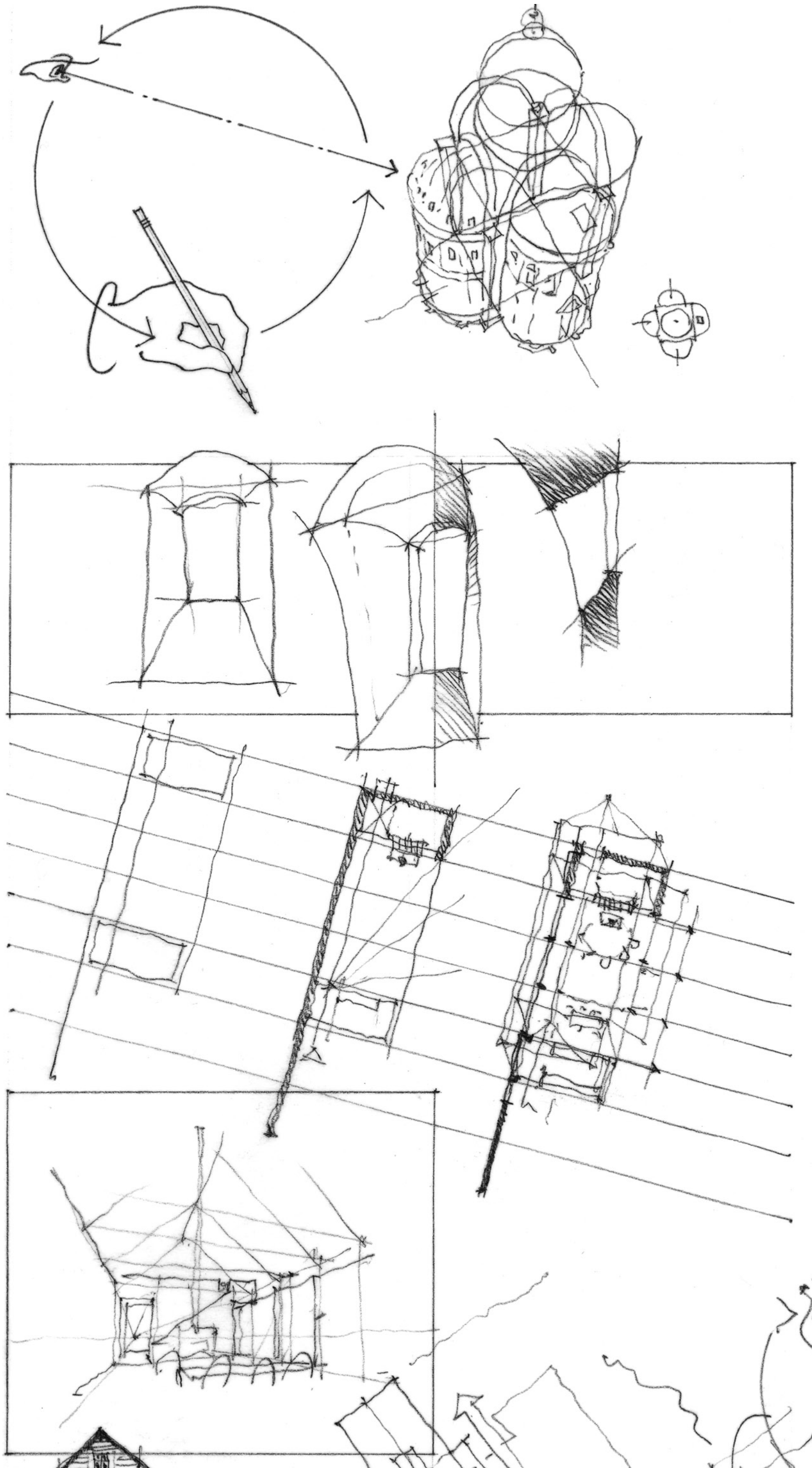
## Three-Dimensional Printing

The advent of three-dimensional printing may revolutionize the work of interior designers and students by saving time with the production of models and materials at at accelerated rate, while reducing the output of scraps. The growth of available materials that can be used with a 3D printer and of the number of students familiar with rapid prototyping joining the design professions will probably lead to many future innovations.

## Virtual Reality

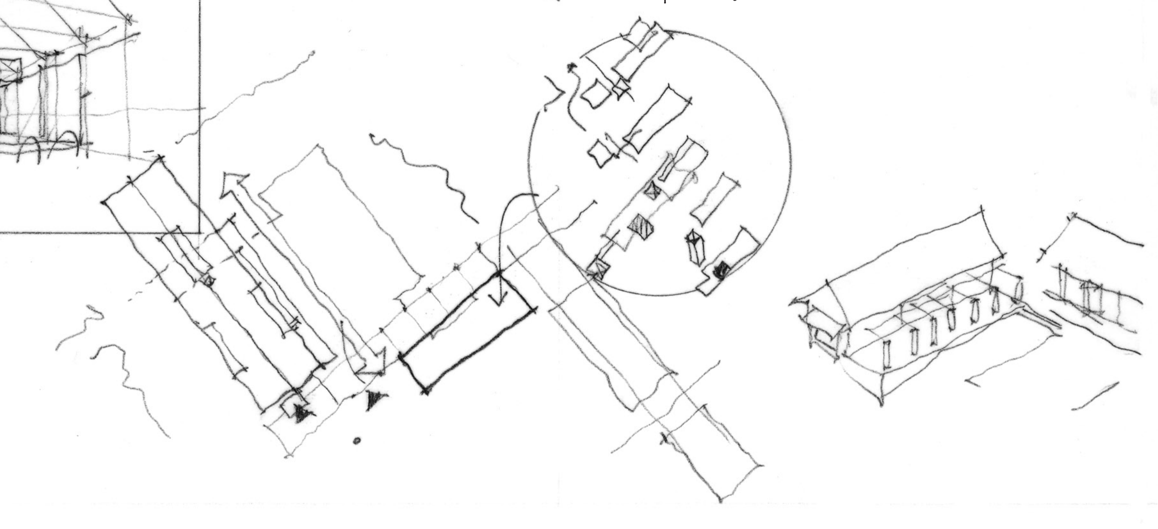
Virtual reality (VR) technology continues to become more usable, accessible, and ubiquitous. It is already a common and valuable tool for designing, marketing, and collaborating with clients from the beginning of the design process. VR is changing the way architects and designers go about projects with their clients, transforming design practice. Today VR helps in making key decisions, and in understanding a design proposal in three dimensions. VR gives clients a comfort level they may not have had before. Consensus is growing that the best way to use VR in the design process is in managing client communications and expectations.

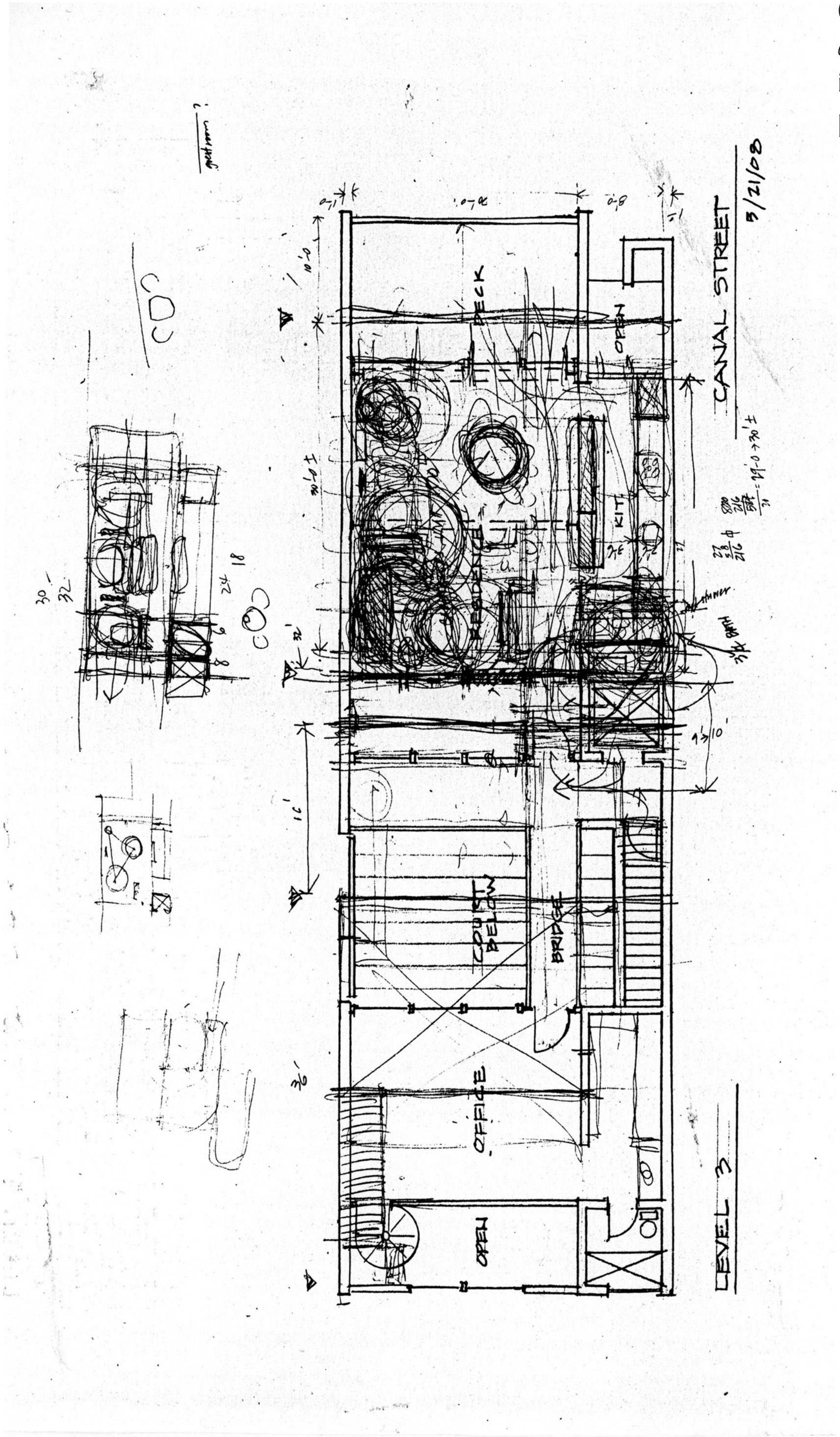
The use of virtual reality is spreading, especially in larger architectural firms, and will undoubtedly continue to spread as the technology improves. VR enables clients to experience a design intuitively, rather than in the abstract, expressing scale better than even the best renderings. Architects around the world are beginning to be able to meet virtually, standing together inside models of projects they are designing. In the near future, avatars will use real-time data and track the movements of actual building users. Eventually, VR technology may create the true melding of virtual and physical space.



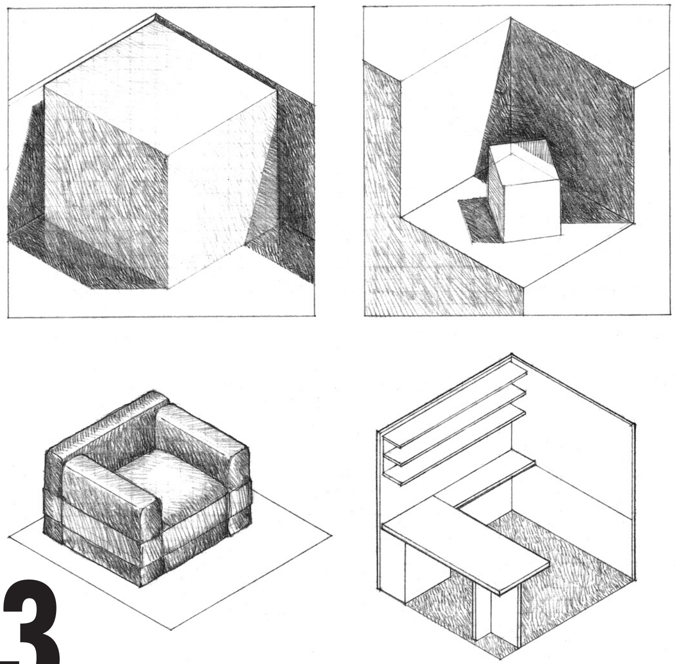
Despite advances in digital imaging technology that make it possible to sketch designs with a computer, for many people drawing with a free hand holding a pen or pencil remains the most intuitive means we have for graphically recording observations, thoughts, and experiences. Many things cannot be readily discovered by mere looking. The tactile, kinesthetic response to sensory phenomena that drawing requires sharpens our awareness in the present and enables us to collect memories of the past. Sketching in this manner also allows us to initiate and freely work through ideas of a possible future that we imagine in the mind's eye.

- The process for drawing from observation is to look, respond, and record.
- Freehand sketches may consist purely of lines or be a combination of lines and tones.
- Freehand drawing of diagrams during the design process allows us to explore these ideas further and develop them into workable concepts.
- Digital diagramming technology generally accepts and processes information in a precise and accurate manner. We should not allow this capacity for precision to limit our exploration in the early stages of the design process. As more intuitive CAD systems are developed, our ability to freely visualize with them should continue to improve.
- Freehand drawing of places and objects allows one to look closely, to think visually, and to investigate what works and what could work better.
- One can feel free to alter details, colors, and volumes while drawing, and to return to earlier sketches repeatedly.



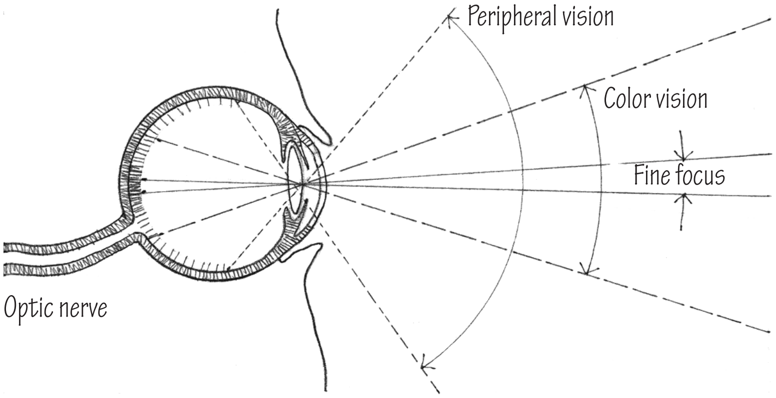



In her advice to young designers in the July/August 2016 edition of *Metropolis*, the Los Angeles–based designer Geere Kavanaugh says: "Looking and reading open the doors of imagination. You never know where your next idea is going to come from. . . . Also, please use a real wood pencil to draw on a big sheet of paper. It's magic."



# 3

# A Design Vocabulary




**A Design Vocabulary**

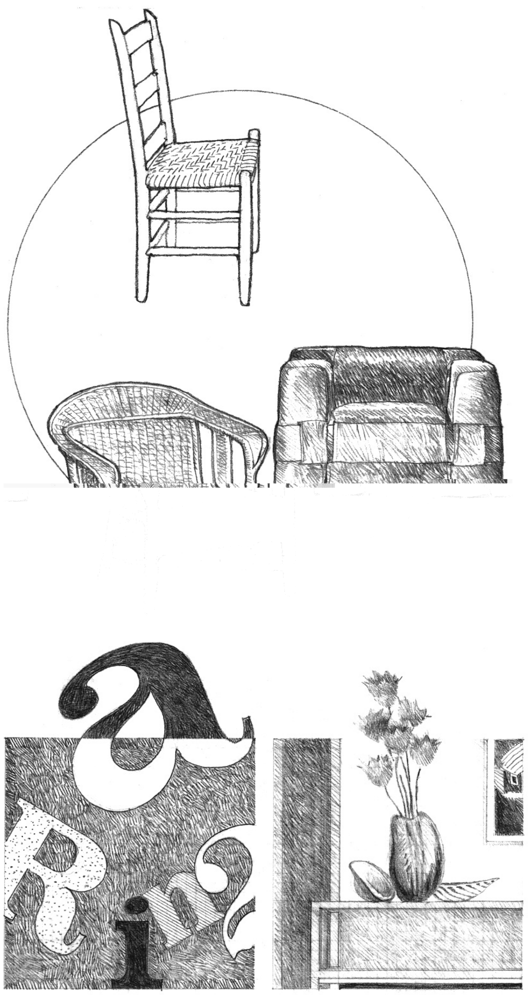
- Form
- Shape
- Color
- Texture
- Light
- Proportion
- Scale
- Balance
- Harmony
- Unity and Variety
- Rhythm
- Emphasis

Our ability to focus on and perceive detail is restricted to a fairly narrow cone of vision. In surveying our visual field, our eyes continually move, scan, focus, and refocus to discover visual information. To make sense of what we see, the brain interprets the visual data gathered by our eyes and assembles the information into visual patterns that we can recognize and understand.

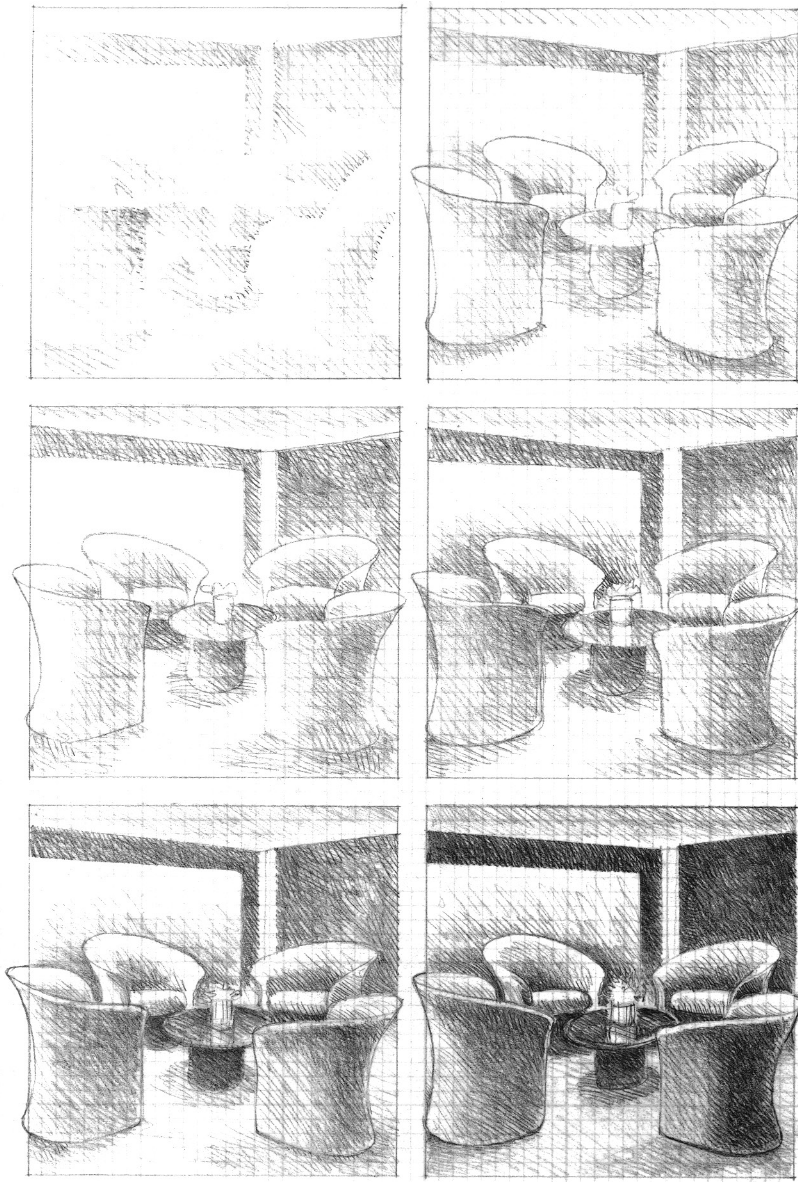
The normal process of perception is utilitarian and geared toward recognition. When we see a chair, we recognize it to be a chair if its form and configuration fit a pattern established by chairs we have seen and used in the past. If we look carefully, however, we will also be able to perceive the chair's specific shape, size, proportion, color, texture, and material. This ability to see beyond recognition and utility is extremely important to designers. We must continually strive to see and be conscious of the specific visual characteristics of things and how they relate to and interact with each other to form the aesthetic quality of our visual environments.

Traditionally, two types of photoreceptors in the mammalian retina were accepted by scientists: rods (which saw in black and white) and cones (which perceived in color). In 2002, the Brown University scientist David Berson identified an entirely new class of photoreceptor, the ipRGC, which is sensitive to short-wavelength (blue) light. The ipRGC is the main conduit of light signals from the retina to the brain, and receives processed input from rods and cones. Its discovery radically changed how lighting is measured, manufactured, specified, and applied. It has led to a proposal for a model of human circadian phototransduction—the means by which the retina converts light signals into neural signals for the circadian system—to quantify circadian-effective light. A new way of quantifying light's impact on the circadian system called circadian stimulus (CS) allows predictions of how spectral power distributions and light levels will suppress the hormone melatonin at night. CS has impacts on sleep quality and quantity, performance, fatigue, mood, and behavior in people including older adults with Alzheimer's disease, office workers, and cancer patients; this obviously affects the design of interior spaces. (*Architectural Lighting*, Nov./Dec. 2016).

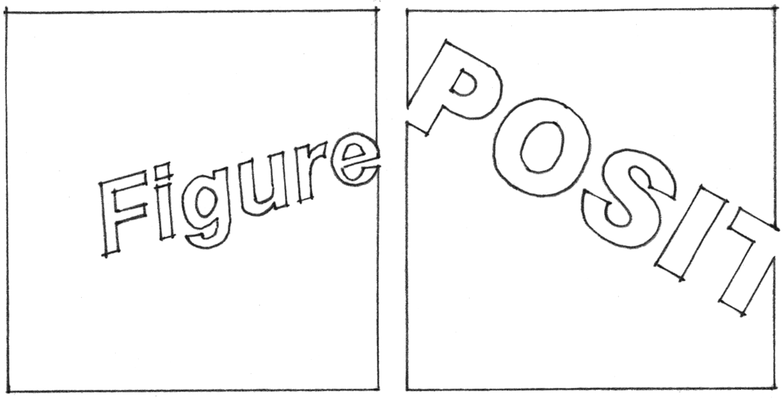
Our perception of the visual shape, size, color, and texture of things is affected by the optical environment in which we see them and the relationships we can discern between them and their visual setting. If our visual field were undifferentiated, we would be unable to identify anything. As a perceptible change in tonal *value*, color, and texture occurred, however, we would begin to discern an object or figure as differentiated from its background. To read the lines, shapes, and forms of objects in our field of vision, therefore, we must first perceive contrast between them and their background.

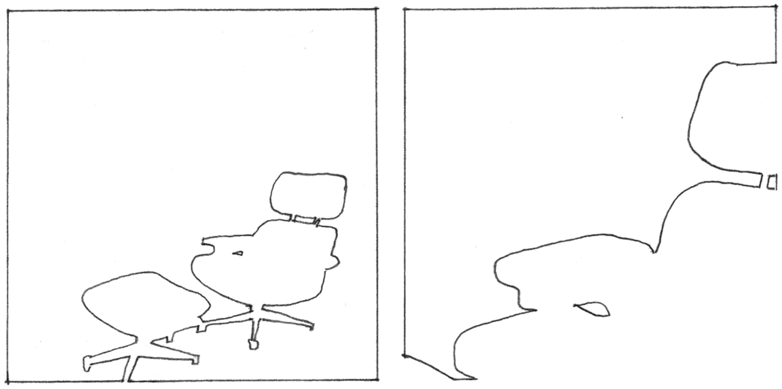


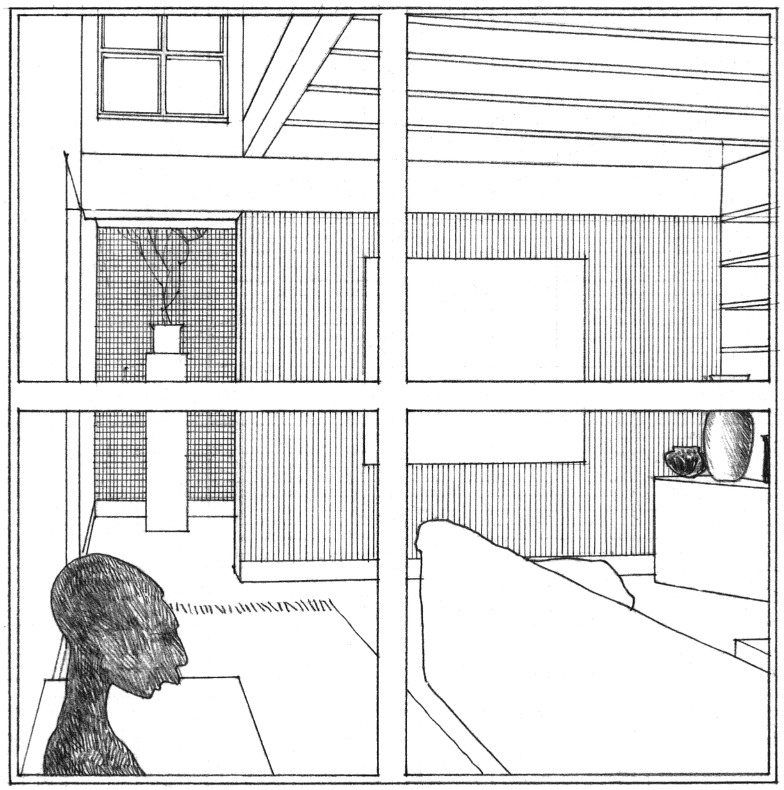
Figure–ground relationships



Visual contrast



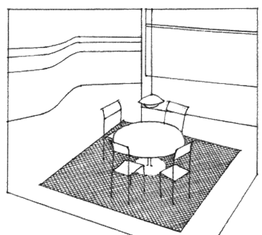



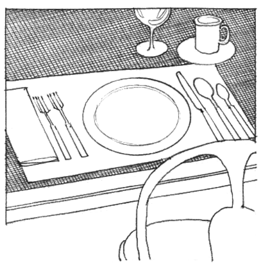


Those elements that appear to stand out from or in front of their background are called figures. In addition to tonal value contrast, what distinguishes a figure from its background is its shape and size relative to its field. While a figure shares a common border with its background, it has a more distinct and recognizable shape that makes it appear as an object. Figures are sometimes referred to as positive elements—having a positive shape—while backgrounds are described as negative or neutral elements—lacking a clear or discernible shape.

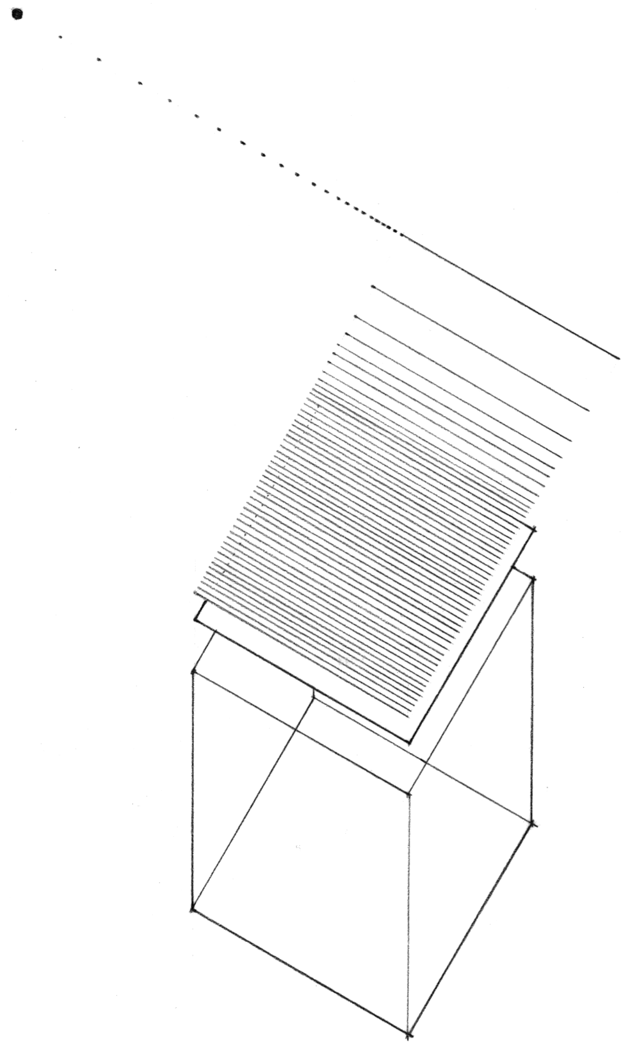
Figures are most discernible when surrounded by a generous amount of space or background. When the size of a figure is such that it crowds its background, the background can develop its own distinct shape and interact with the shape of the figure. At times, an ambiguous *figure–ground relationship* can occur wherein elements in a composition can be seen alternately, but not simultaneously, as both figure and ground.

Our visual world is, in reality, a composite image constructed from a continuous array of figure–ground relationships. In interior design, these relationships can be seen to exist at several scales, depending on one's point of view.





*Form* refers to the shape and structure of something, as distinguished from its substance or material. The *point* is the generator of all form. As a point moves, it leaves a trace of a *line*—the first dimension. As the line shifts in direction, it defines a *plane*—a two-dimensional element. The plane, extended in a direction oblique or perpendicular to its surface, forms a three-dimensional *volume*.



Point, line, plane, and volume—these are the primary elements of form. All visible forms are, in reality, three-dimensional. In describing form, these primary elements differ according to their relative dimensions of length, width, and depth—a matter of *proportion* and *scale*.

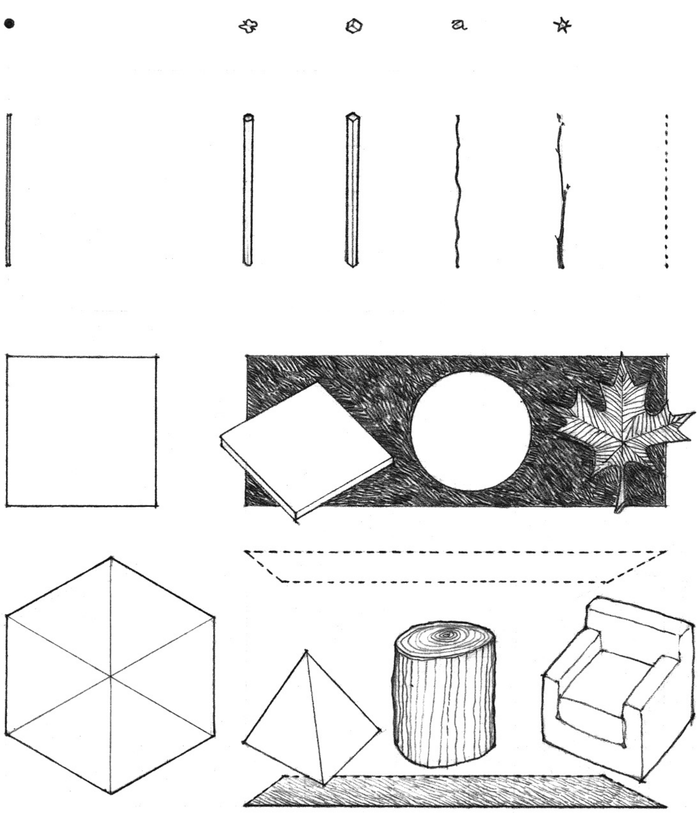
Many existing buildings have forms that are organized for particular uses, often with low ceilings, many walls, and windows that precisely correspond to interior arrangements, making them difficult to adapt and reuse. Other buildings are built as sustainable shells, with generous floor-to-ceiling heights, open floor plans, long structural spans with high load-bearing capacities, and large mechanical and circulation areas. These buildings combine a durable, flexible building type with a development model that will function in both the short and long term.

**Point**

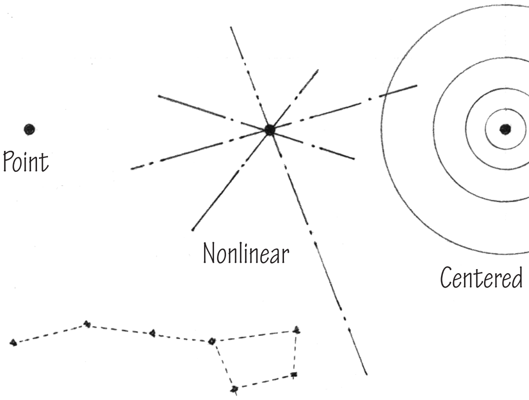
**Line**

**Plane**

**Volume**



## POINT



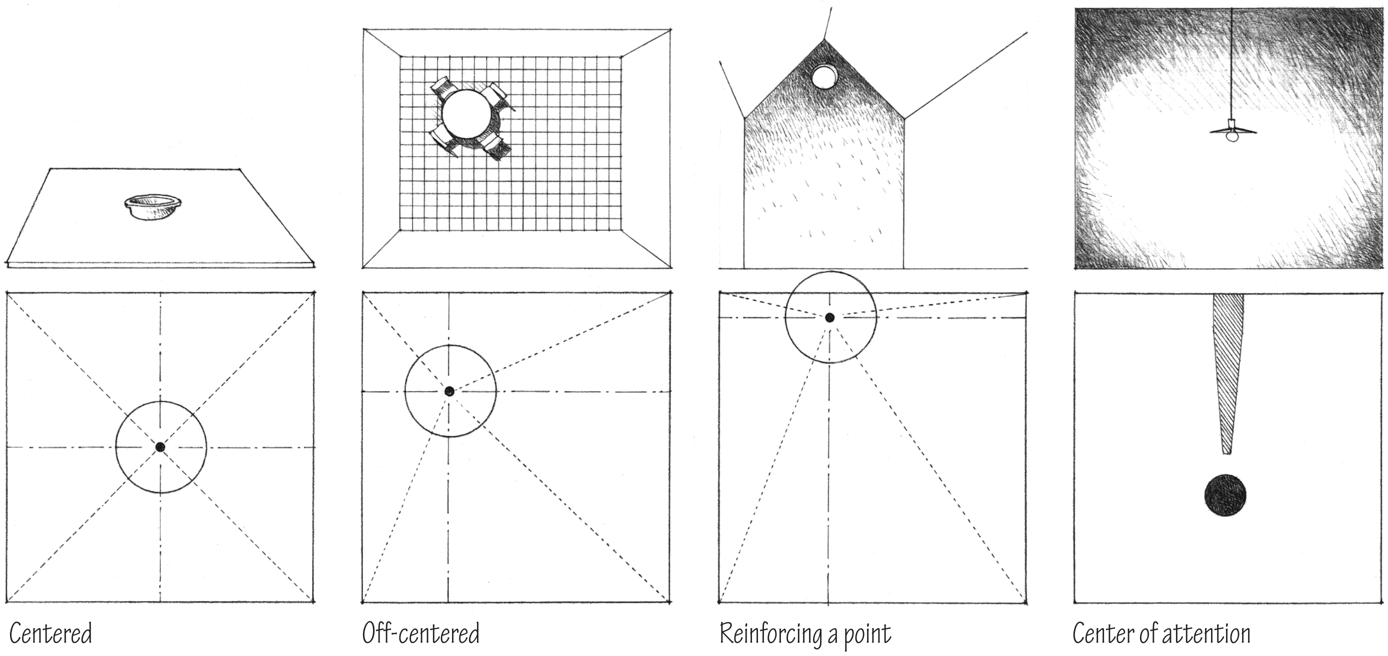

Multiple points define lines and shapes.

Relatively small shapes can read as points.

A point marks a location in space. Conceptually, it has no length, width, or depth. It is, therefore, static and directionless. As the prime generator of form, a point can mark the end of a line, the intersection of two lines, or the corner where the lines of a plane or volume meet.

As a visible form, a point is most commonly manifested as a dot, a circular shape that is small relative to its field. Other shapes can also be seen as point forms if sufficiently small, compact, and nondirectional.

When at the center of a field or space, a point is stable and at rest, and capable of organizing other elements about itself. When moved off-center, it retains its self-centering quality but becomes more dynamic. Visual tension is created between the point and its field. Point-generated forms, such as the circle and the sphere, share this self-centering quality of the point.

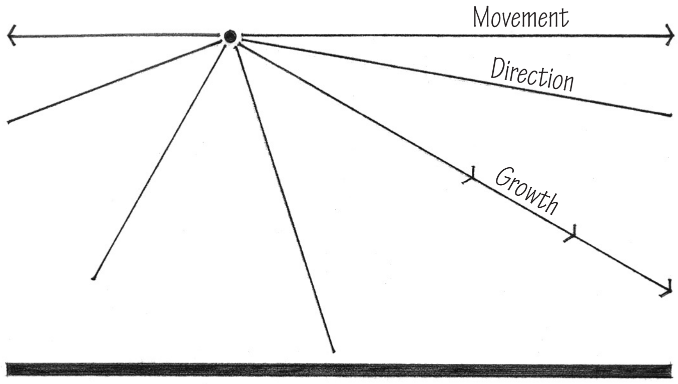


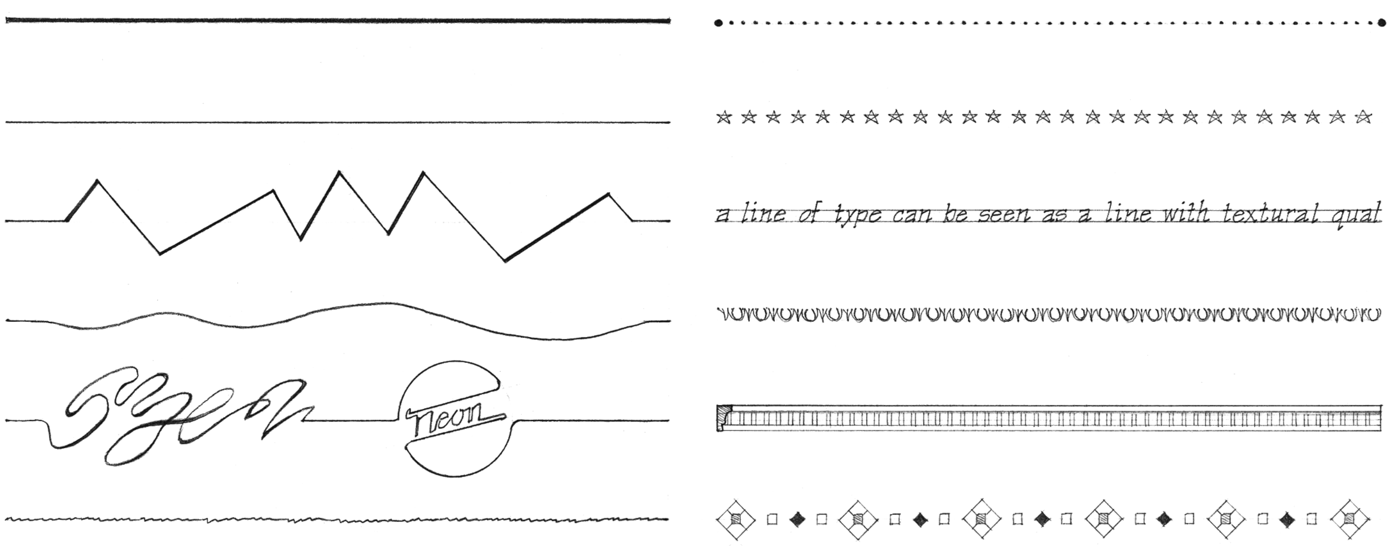

Point-generated forms, such as the circle and the sphere, are self-centering.

A point extended becomes a line. Conceptually, a line has only one dimension, length. In reality, a line's length visually dominates whatever thickness it must have to be visible. Unlike a point, which is static and directionless, a line is capable of expressing movement, direction, and growth.

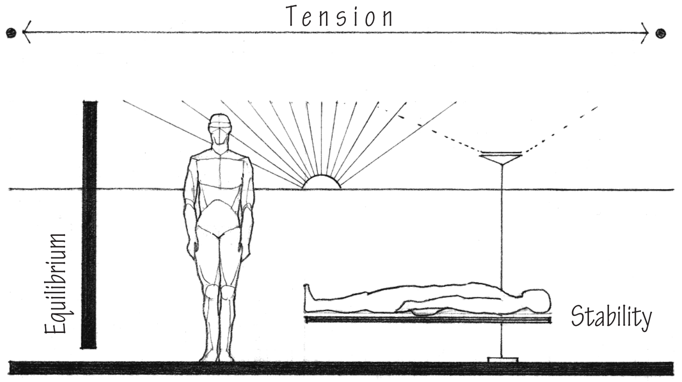
As visible forms, lines may vary in weight and character. Whether bold or delicate, taut or limp, graceful or jagged, a line's visual character is due to our perception of its length-to-width ratio, its contour, and its degree of continuity.

A line can also be implied by two points. Carried further, the simple repetition of similar elements, if continuous enough, can define a line with significant textural qualities.



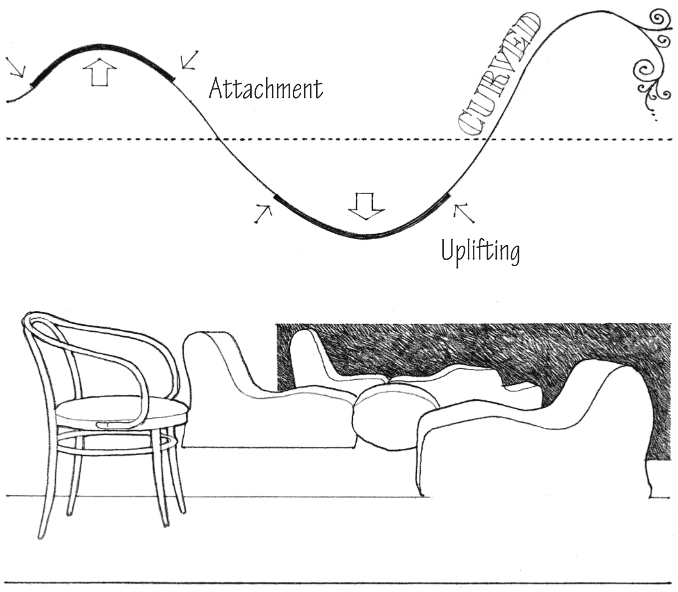

Lines can vary in weight, contour, and texture.

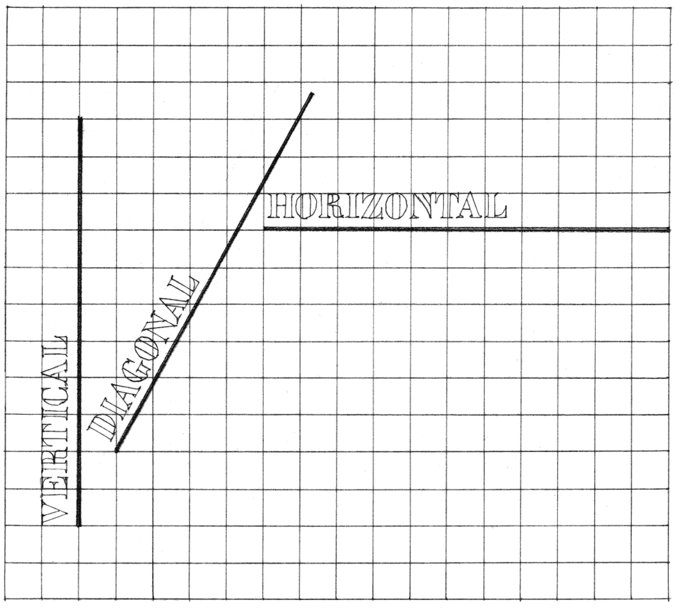



A straight line represents the tension that exists between two points. An important characteristic of a straight line is its direction. A horizontal line can represent stability, repose, or the plane upon which we stand or move. In contrast to this, a vertical line can express a state of equilibrium with the force of gravity.

Diagonal lines, deviations from the horizontal and the vertical, can be seen as rising or falling. In either case, they imply movement and are visually active and dynamic.

A curved line represents movement deflected by lateral forces. Curved lines tend to express gentle movement. Depending on their orientation, they can be uplifting or represent solidity and attachment to the earth. Small curves can express playfulness, energy, or patterns of biological growth.

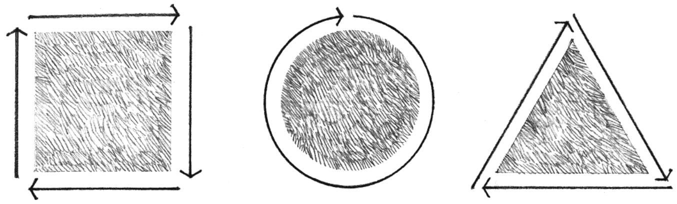


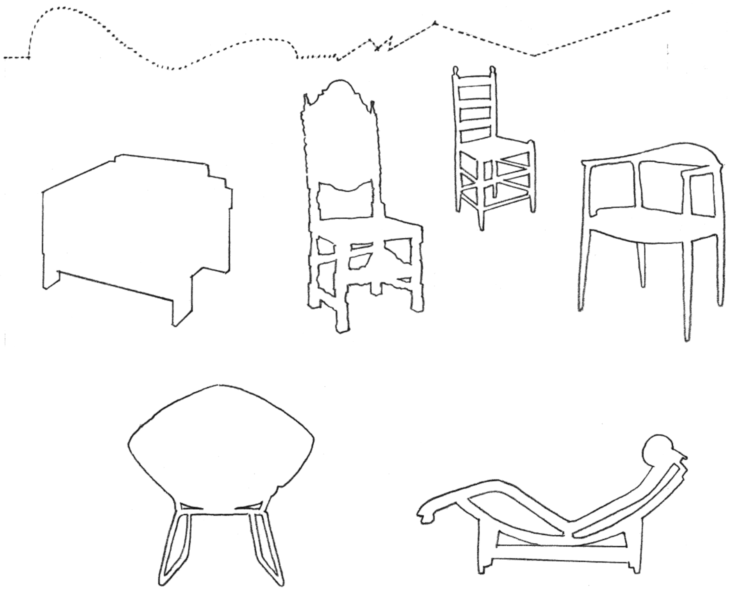
Line is an essential element in the formation of any visual construction. Without lines, we would not be able to define *shape*—that characteristic by which we generally recognize things. Lines describe the edges of shape and separate it from the space around it. In addition, the contours of these lines imbue the shape with their expressive qualities.

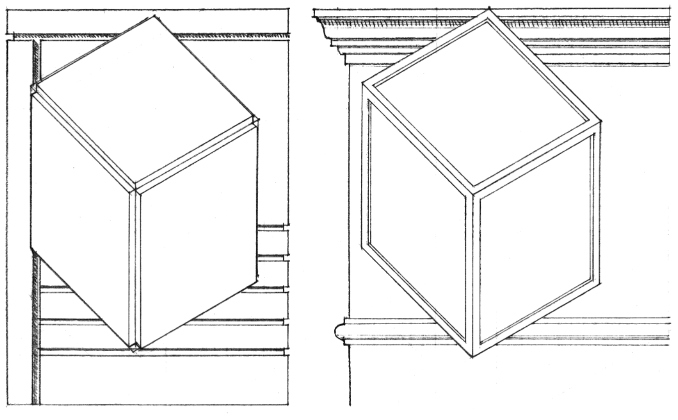
In addition to describing shape, lines can articulate the edges of planes and the corners of volumes. These lines can be expressed either by the absence of material—*reveals* and recessed joints—or by the application of trim.

Lines can also be used to create texture and *patterns* on the surfaces of forms.

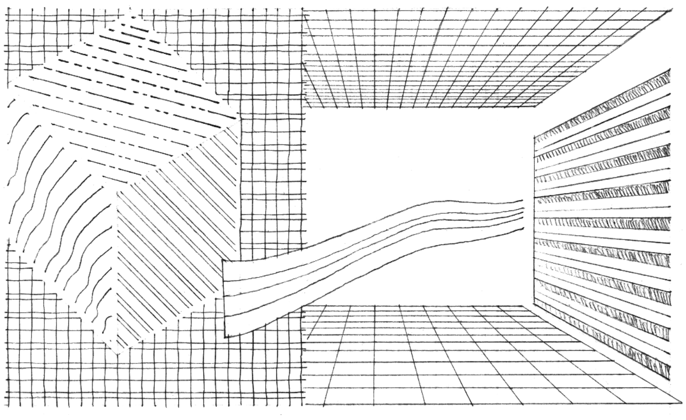


Lines defining shapes





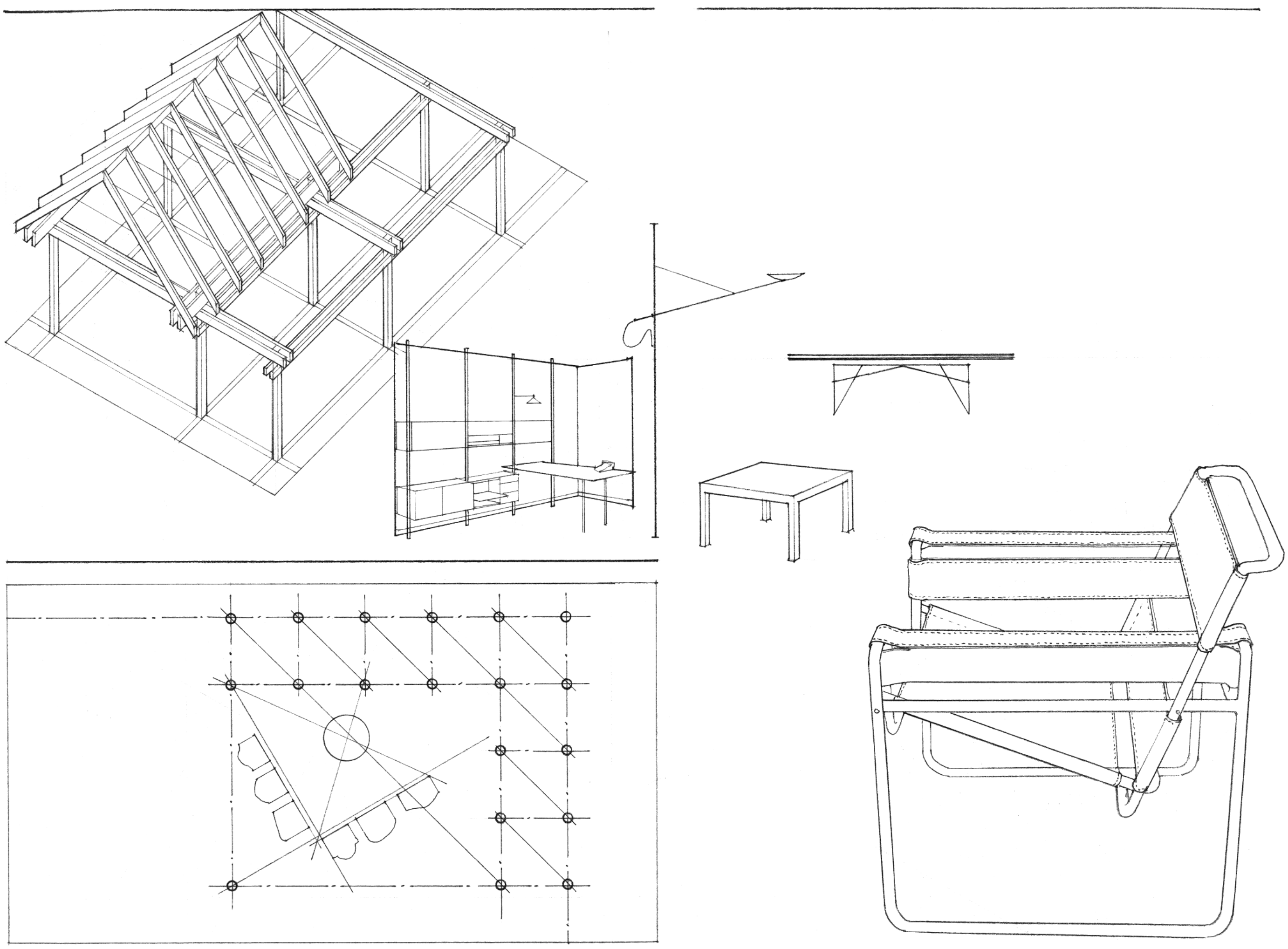
Lines articulating edges



Lines creating textures and patterns

Linear forms have traditionally been used to provide vertical support, to span and express movement across space, and to define the edges of spatial volumes. This structural role of linear elements can be seen at the scale of architecture and interior space, and in furnishings.

Within the design process itself, lines are used as regulating devices to express relationships and establish patterns among design elements.



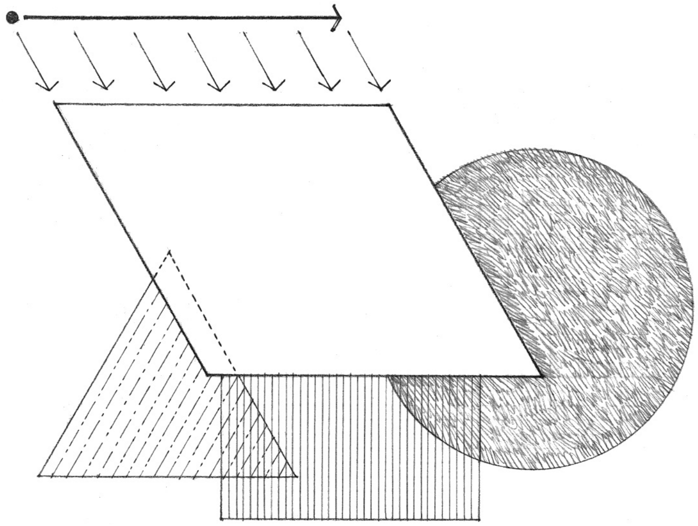
We often use lines to regulate relationships in drawing and design.

A line shifted in a direction other than its intrinsic direction defines a plane. Conceptually, a plane has two dimensions—width and length—but no depth. In reality, a plane's width and length dominate whatever thickness it must have to be visible.

Shape is the primary characteristic of a plane. It is described by the contour of the lines defining the edges of the plane. Since our perceptions of a plane's shape can be distorted by perspective, we see the true shape of a plane only when we view it frontally.

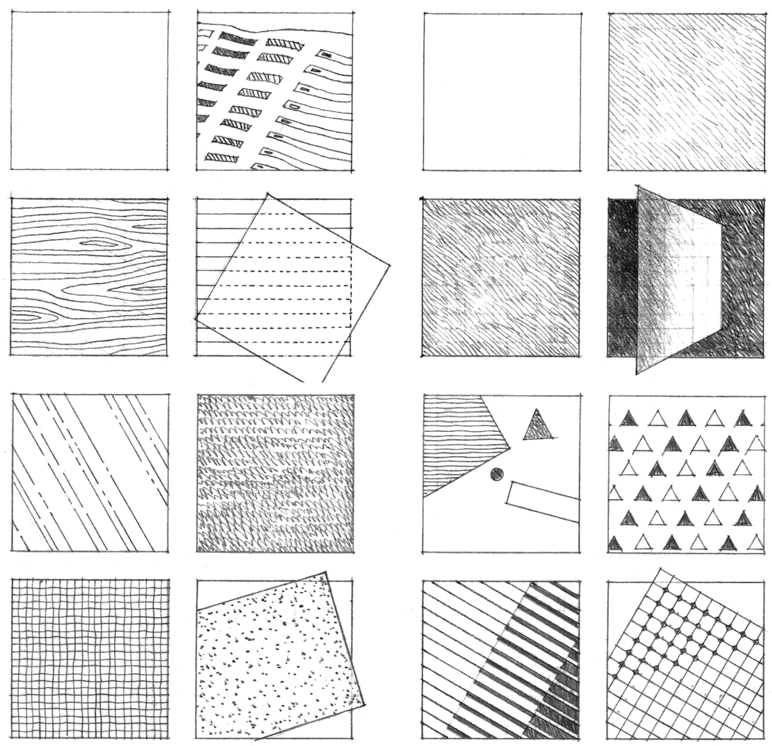
In addition to shape, planar forms have significant surface qualities of material, color, texture, and pattern. These visual characteristics affect the qualities of a plane:

- Visual weight and stability
- Perceived size, proportion, and position in space
- Light reflectivity
- Tactile characteristics
- Acoustic properties



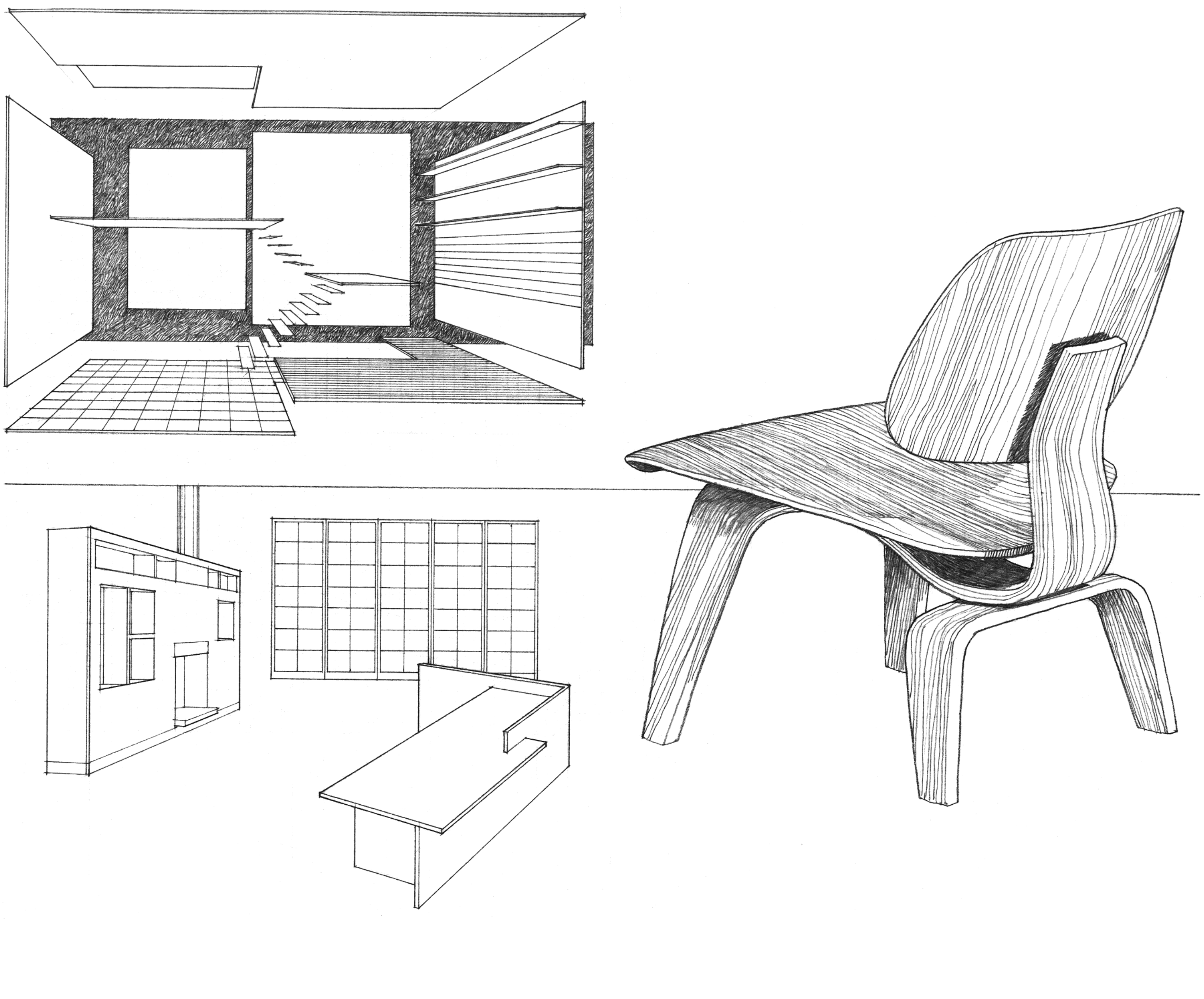
Material and color

Texture and pattern



Planar elements have surface characteristics of material, color, texture, and pattern.

Planar forms are fundamental elements of architecture and interior design. Floor, wall, and ceiling or roof planes serve to enclose and define three-dimensional volumes of space. Their specific visual characteristics and their relationships in space determine the form and character of the space they define. Within these spaces, furnishings and other interior design elements can also be seen to consist of planar forms.

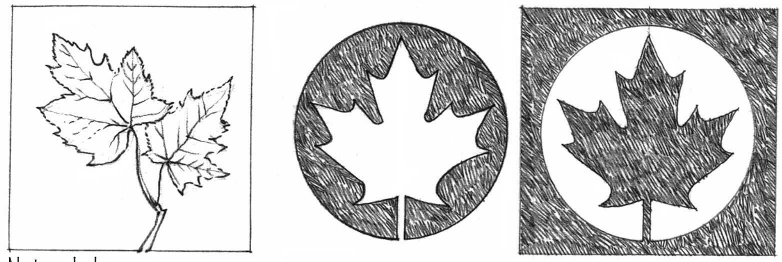


Shape is the primary means by which we distinguish one form from another. It may refer to the contour of a line, the outline of a plane, or the boundary of a three-dimensional mass. In each case, shape is defined by the specific configuration of the lines or planes that separates a form from its background or surrounding space.

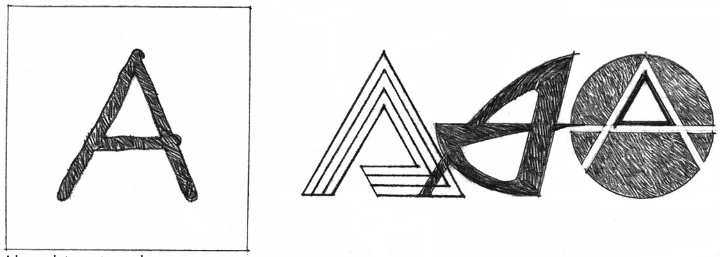
There are several broad categories of shapes. Natural shapes represent the images and forms of our natural world. These shapes may be abstracted, usually through a process of simplification, and still retain the essential characteristics of their natural sources.

Nonobjective shapes make no obvious reference to a specific object or to a particular subject matter. Some nonobjective shapes may result from a process, such as calligraphy, and carry meaning as symbols. Others may be geometric and elicit responses based on their purely visual qualities.

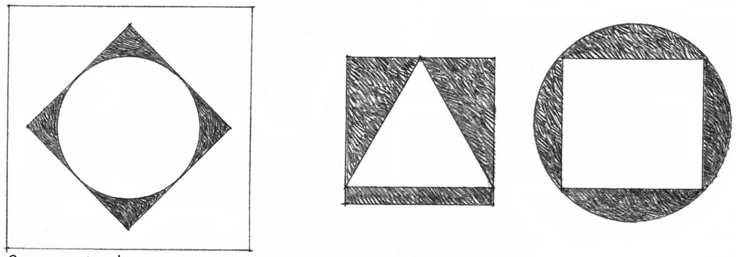
Geometric shapes dominate the built environment of both architecture and interior deign. There are two separate and distinct types of geometric shapes—rectilinear and curvilinear. In their most regular form, curvilinear shapes are circular, while rectilinear shapes include the series of polygons that can be inscribed within a circle. Of these, the most significant geometric shapes are the circle, the triangle, and the square. Extended into the third dimension, these primary shapes generate the sphere, the cylinder, the cone, the pyramid, and the cube.



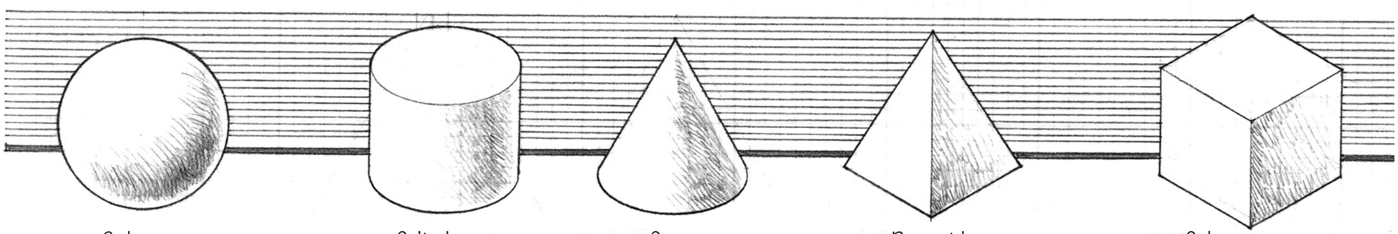
Natural shapes

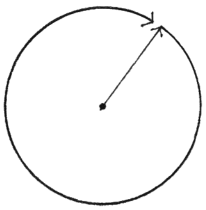


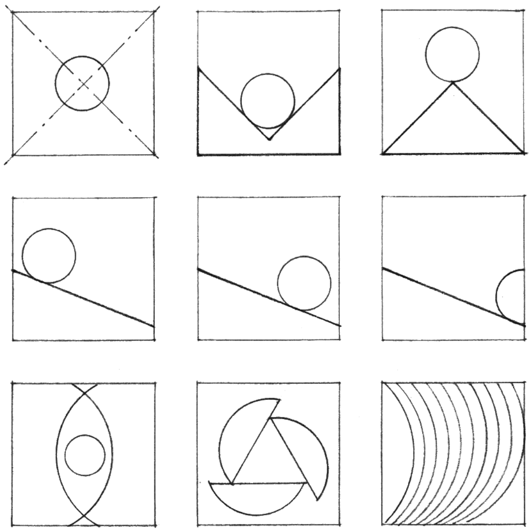
Nonobjective shapes



Geometric shapes



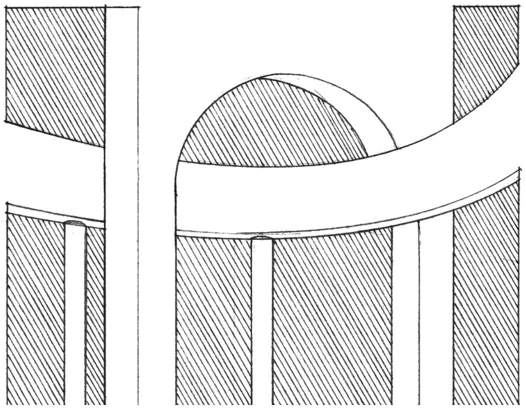


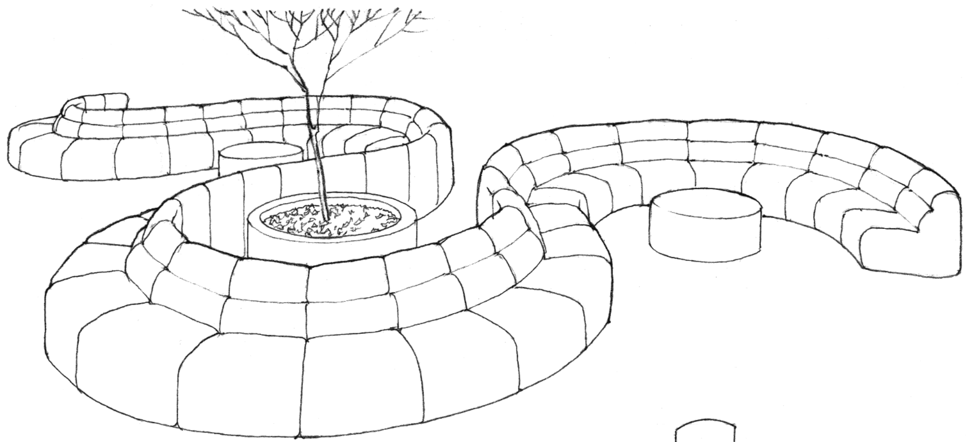


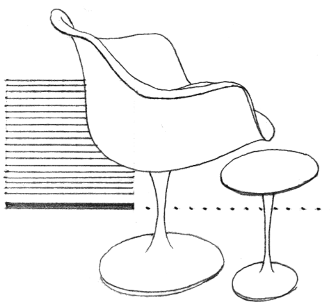
The circle is a compact, introverted shape that has its center point as its natural focus. It represents unity, continuity, and economy of form.

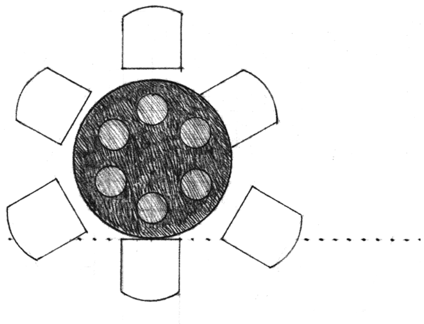
A circular shape is normally stable and self-centering in its environment. When associated with other lines and shapes, however, a circle can appear to have motion.

Other curvilinear lines and shapes can be seen to be fragments or combinations of circular shapes. Whether regular or irregular, curvilinear shapes are capable of expressing softness of form, fluidity of movement, or the nature of biological growth.





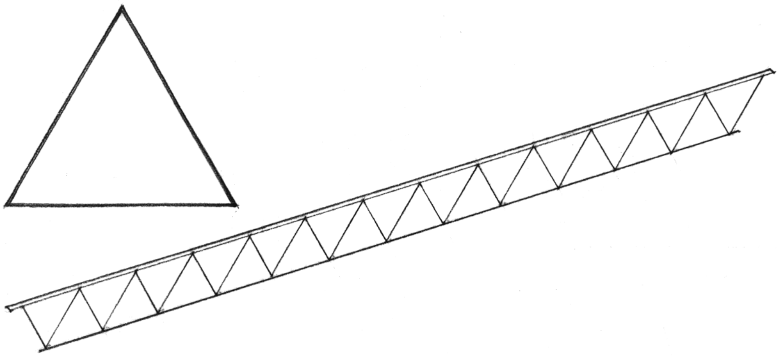


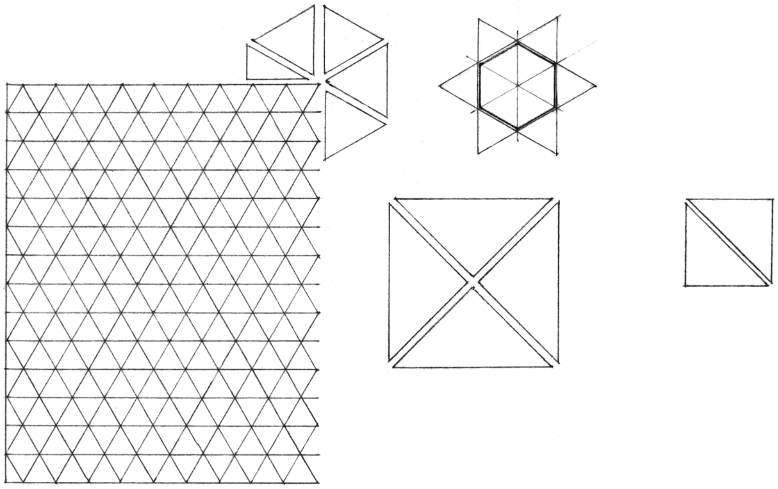


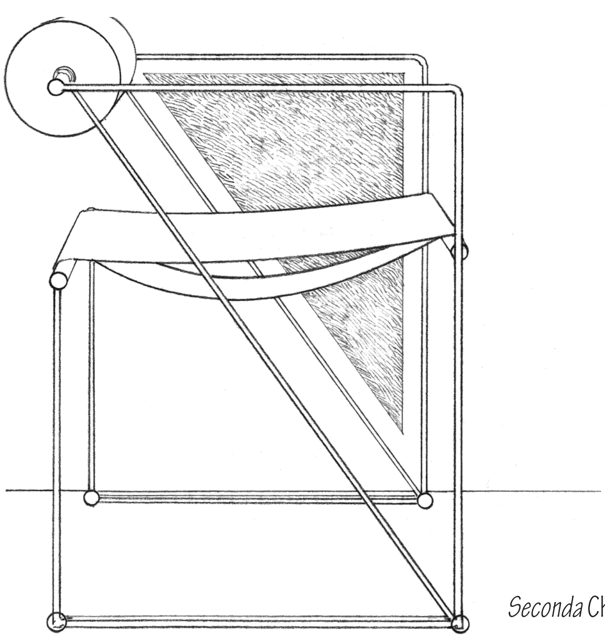
The triangle represents stability. Triangular shapes and patterns are often used in structural systems, since their configuration cannot be altered without bending or breaking one of their sides.

From a purely visual point of view, a triangular shape is perceived as stable when resting on one of its sides. When tipped to stand on one of its points, however, the triangular shape becomes dynamic. It can exist in a precarious state of balance or imply motion, as it tends to fall over onto one of its sides.

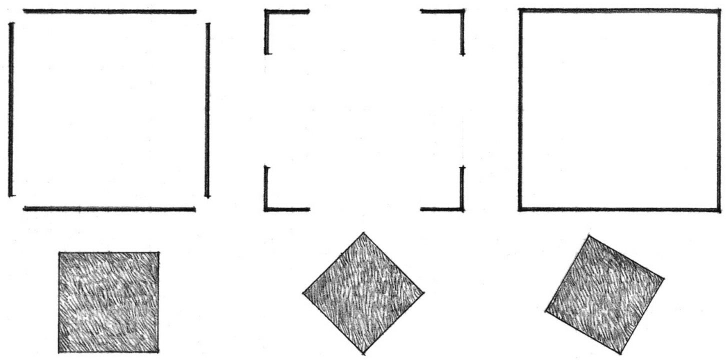
The dynamic quality of a triangular shape is also due to the angular relationships of its three sides. Because these angles can vary, triangles are more flexible than squares and rectangles. In addition, triangles can be conveniently combined to form any number of square, rectangular, and other polygonal shapes.

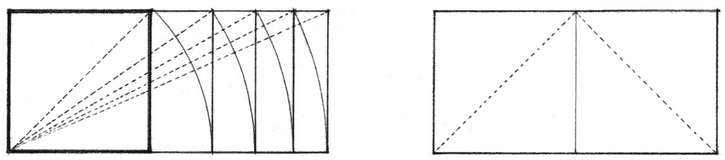






*Seconda* Chair, 1982: Mario Botta

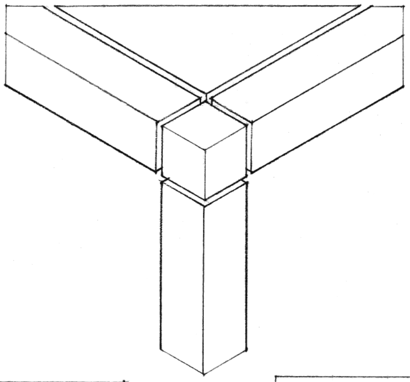


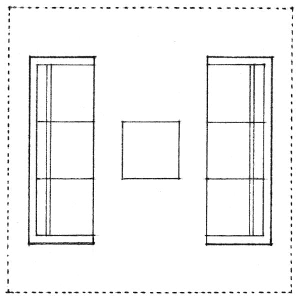


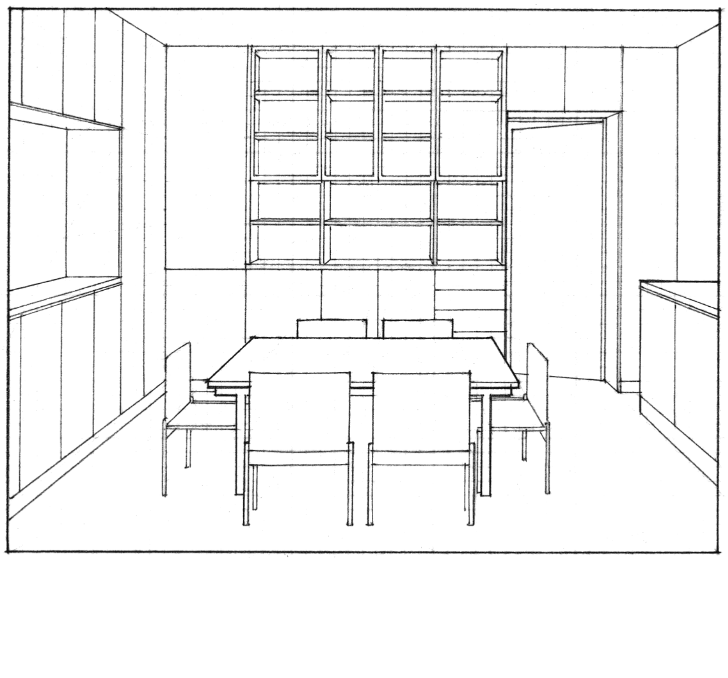
The square represents the pure and the rational. The equality of its four sides and its four right angles contributes to its regularity and visual clarity.

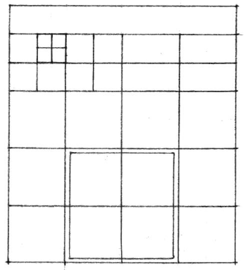
A square shape has no preferred or dominant direction. Like the triangle, the square is a stable, tranquil figure when resting on one of its sides, but becomes dynamic when standing on one of its corners.

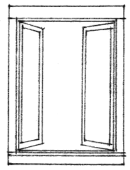
All other rectangles can be considered to be variations of the square with the addition of width or length. While the clarity and stability of rectangular shapes can lead to visual monotony, variety can be introduced by varying their size, proportion, color, texture, placement, or orientation.









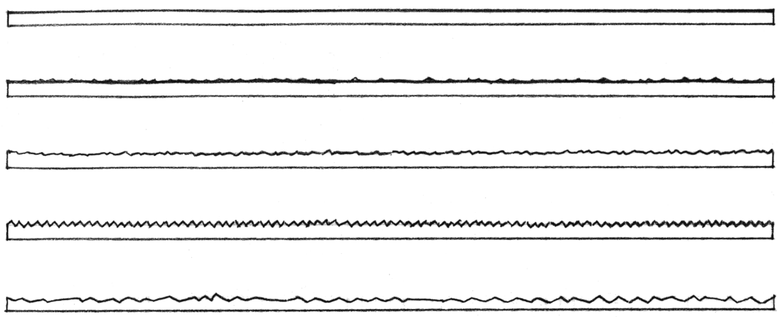


Texture is the specific quality of a surface that results from its three-dimensional structure. Texture is most often used to describe the relative smoothness or roughness of a surface. It can also be used to describe the characteristic surface qualities of familiar materials, such as the roughness of stone, the grain of wood, and the weave of a fabric.

There are two basic types of texture. Tactile texture is real and can be felt by touch; visual texture is seen by the eye. All tactile textures provide visual texture as well. Visual texture, on the other hand, may be illusory or real.

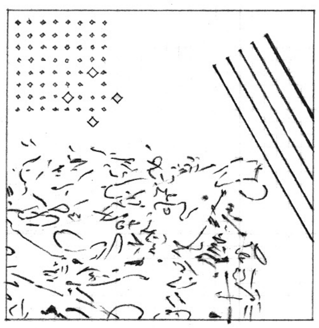
Our senses of sight and touch are closely intertwined. As our eyes read the visual texture of a surface, we often respond to its apparent tactile quality without actually touching it. We base these physical reactions to the textural qualities of surfaces on previous associations with similar materials.

Digitally dazed individuals are looking for real textures they can touch. Shoppers form stronger impressions about products with which they can physically interact. Touch is very closely related to emotional feelings.



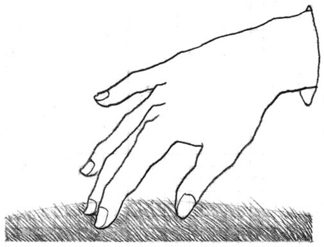
Texture refers to the three-dimensional structure of a surface.

Physical texture

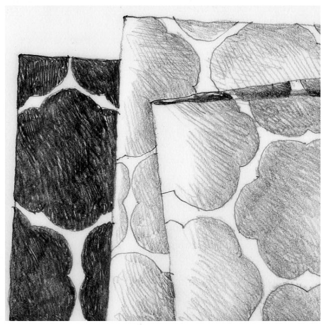


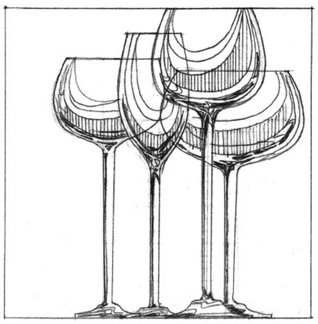
Visual texture

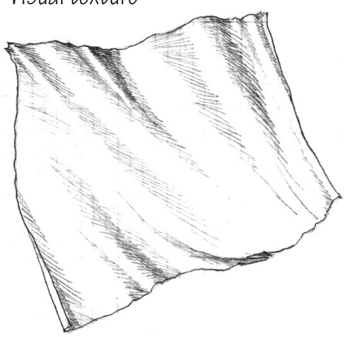
Texture is intertwined with our senses of sight and touch.

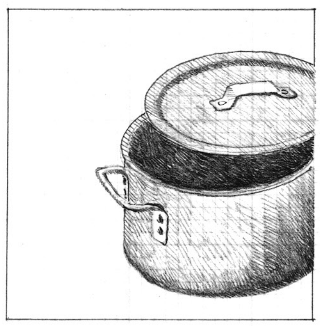


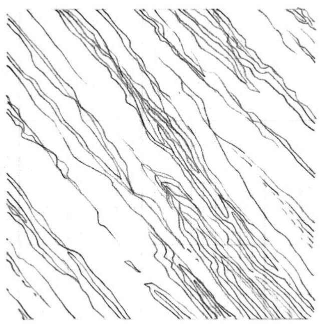
Material texture







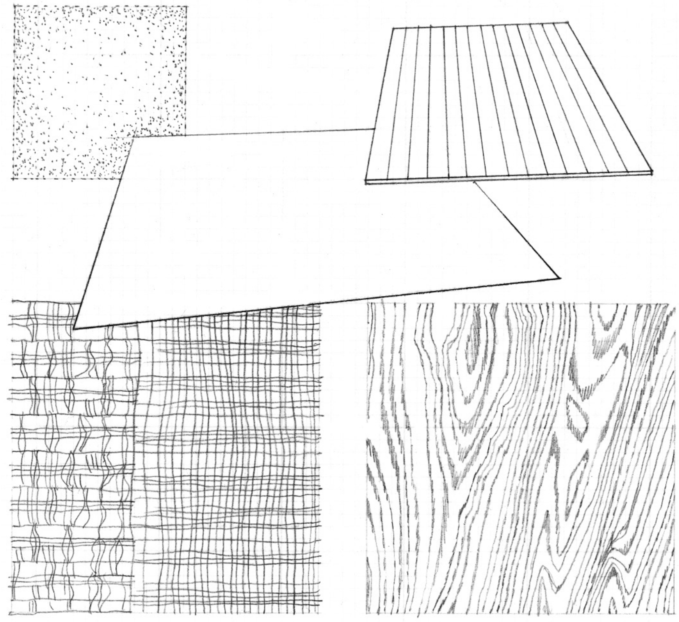


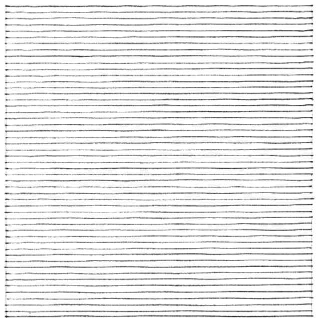


Scale, viewing distance, and light are important modifying factors in our perception of textures and the surfaces they articulate.

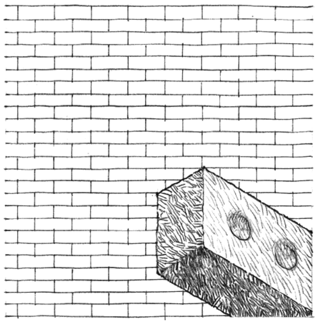
All materials have some degree of texture, but the finer the scale of a textural pattern is, the smoother it will appear to be. Even coarse textures, when seen from a distance, can appear to be relatively smooth. Only upon closer viewing will the texture's coarseness become evident.

The relative scale of a texture can affect the apparent shape and position of a plane in space. Textures with a directional grain can accentuate a plane's length or width. Coarse textures can make a plane appear closer, reduce its scale, and increase its visual weight. In general, textures tend to fill the space in which they exist visually.

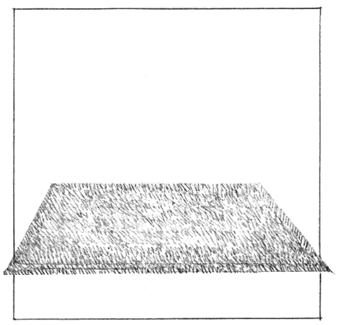




Far



Near



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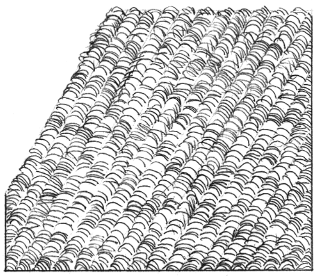
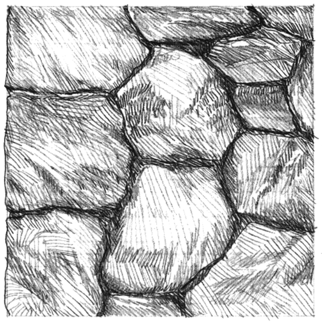


Near

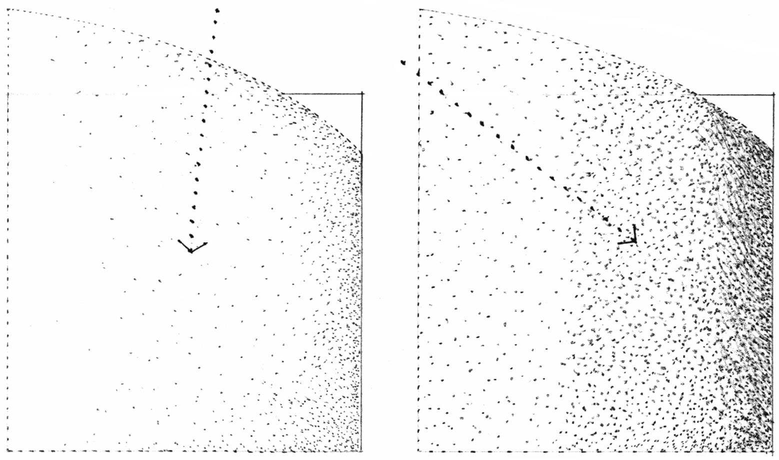
Far



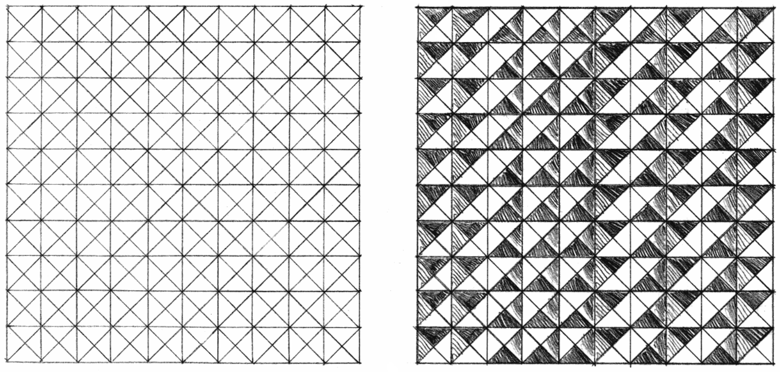
Near

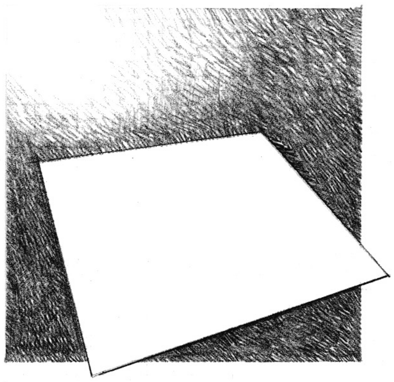
Light influences our perception of texture and, in turn, is affected by the texture it illuminates. Direct light falling across a surface with physical texture will enhance its visual texture. Diffused lighting deemphasizes physical texture and can even obscure its three-dimensional structure.

Smooth, shiny surfaces reflect light brilliantly, appear sharply in focus, and attract our attention. Surfaces with a matte or medium-rough texture absorb and diffuse light unevenly and, therefore, appear less bright than similarly colored but smoother surfaces. Very rough surfaces, when illuminated with direct lighting, cast distinct shadow patterns of light and dark.

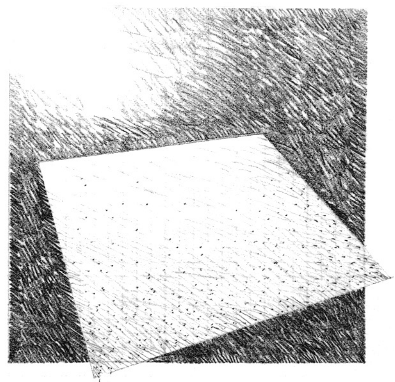


Lighting direction affects our reading of texture.

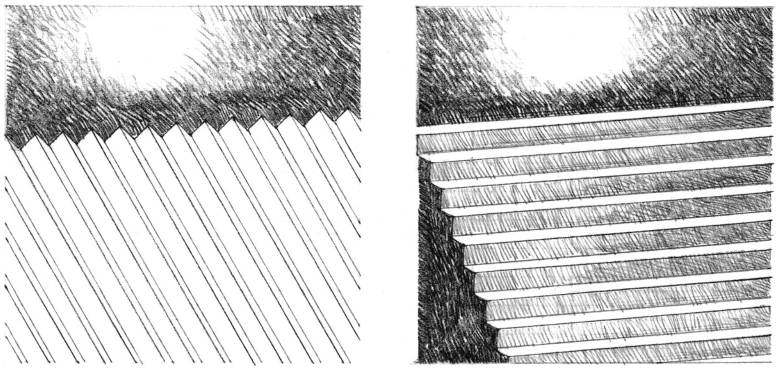


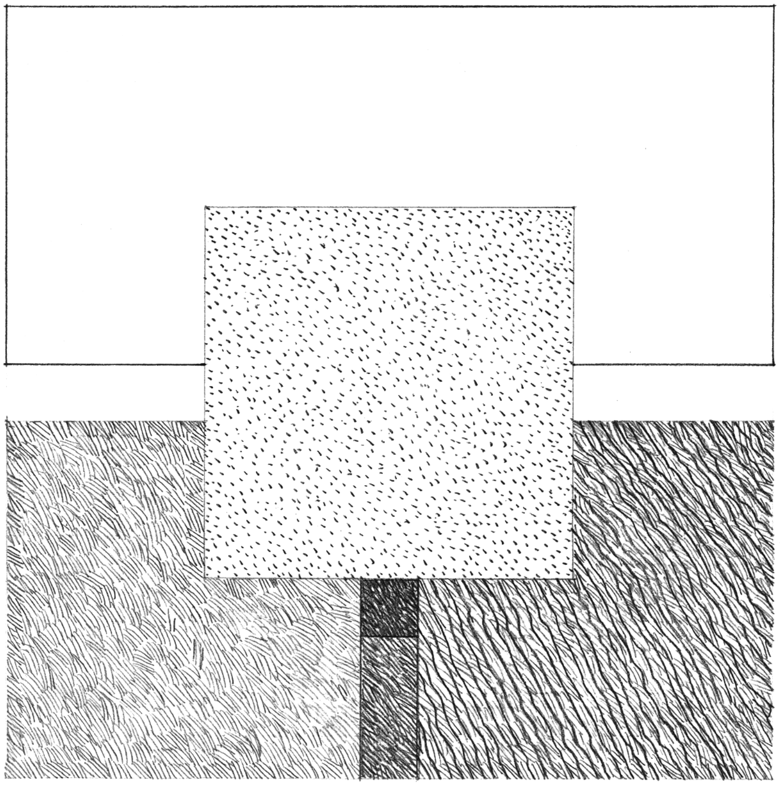


Shiny surfaces reflect.



Matte surfaces diffuse.

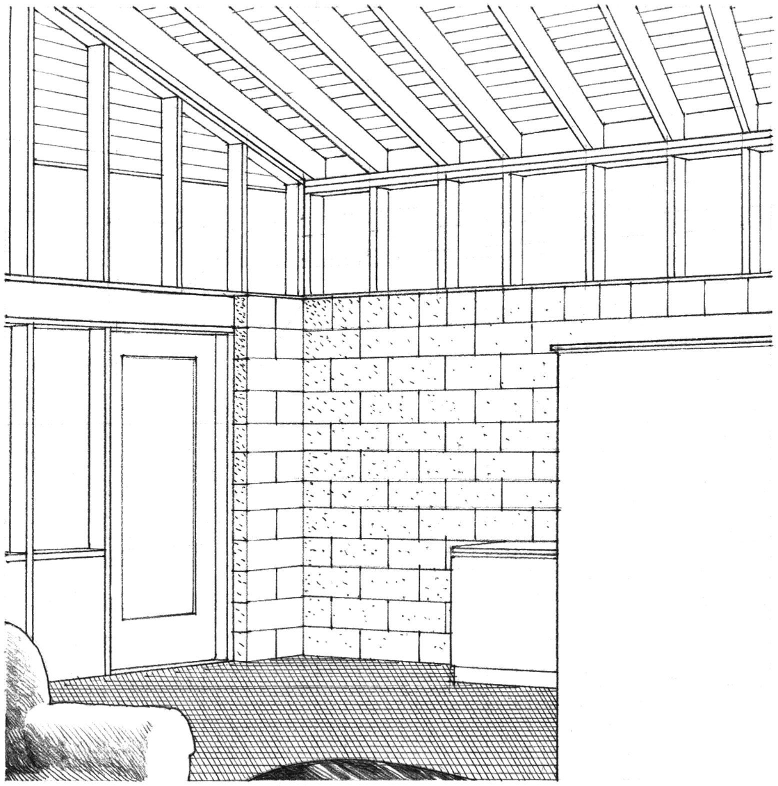




Contrast affects the apparent strength or subtlety of adjacent textures.

Contrast influences how strong or subtle a texture will appear to be. A texture seen against a uniformly smooth background will appear more obvious than when placed in juxtaposition with a similar texture. When seen against a coarser background, the texture will appear to be finer and reduced in scale.

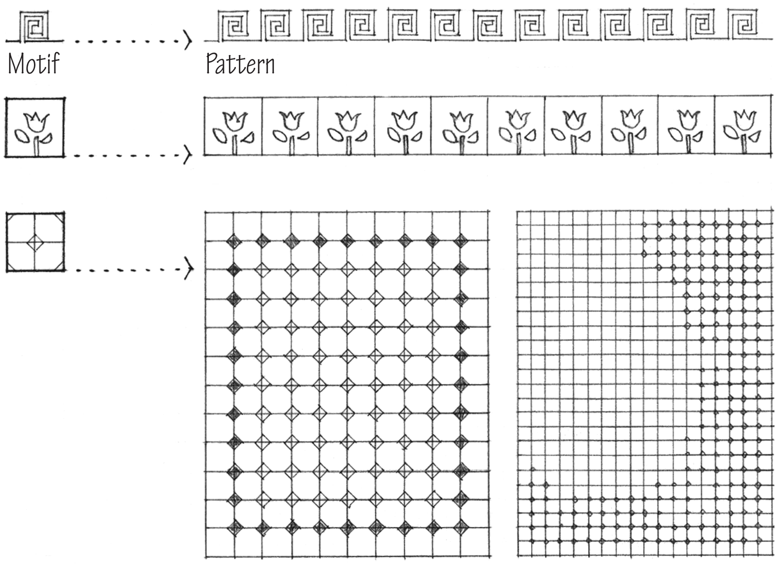
Finally, texture is a factor in the maintenance of the materials and surfaces of a space. Smooth surfaces show dirt and wear but are relatively easy to clean, while rough surfaces may conceal dirt but may also be more difficult to maintain.



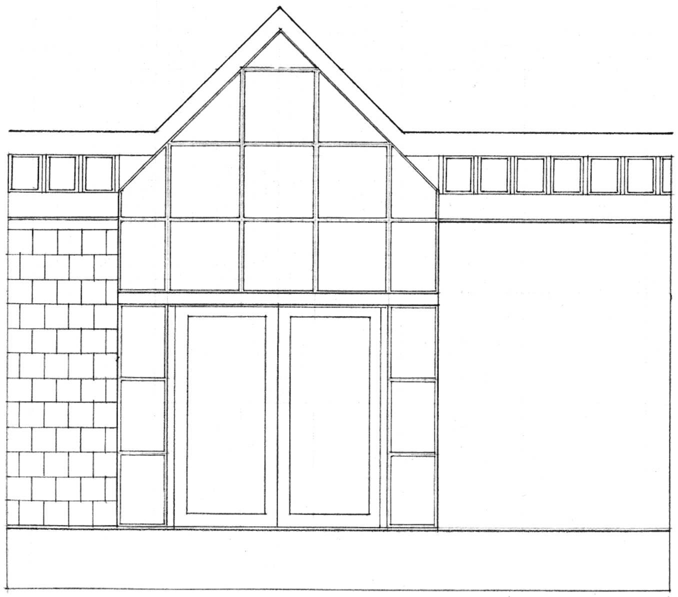
Texture can also result from the manner in which materials are assembled in construction.

Texture and pattern are closely related design elements. Pattern is the decorative design or ornamentation of a surface that is almost always based on the repetition of a *motif*—a distinctive and recurring shape, form, or color in a design. The repetitive nature of a pattern often gives the ornamented surface a textural quality as well. When the elements that create a pattern become so small that they lose their individual identity and blend together, they become more texture than pattern.

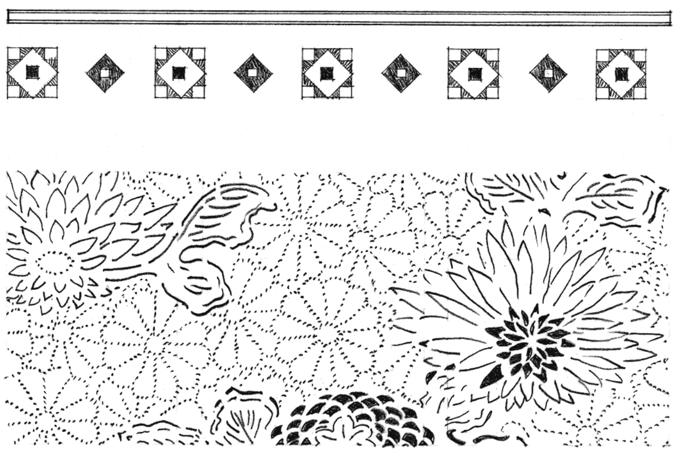
A pattern may be integral or applied. An integral pattern results from the intrinsic nature of a material and the way it is processed, fabricated, or assembled. An applied pattern is added to a surface after it is fabricated or built.



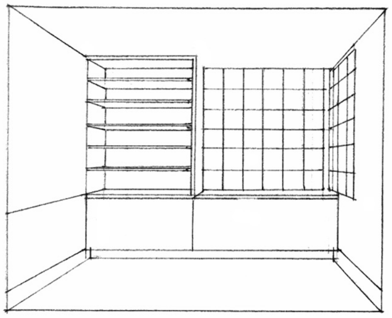

A pattern reduced in scale becomes texture.



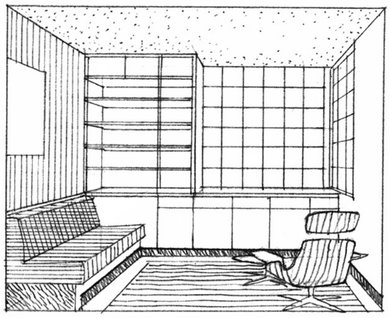
Integral patterns



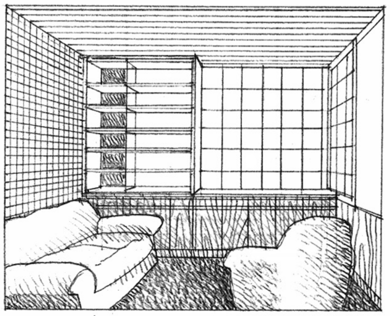
Applied patterns



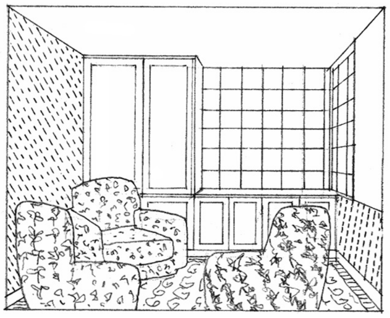
Minimal texture



Textured



Texture filling space

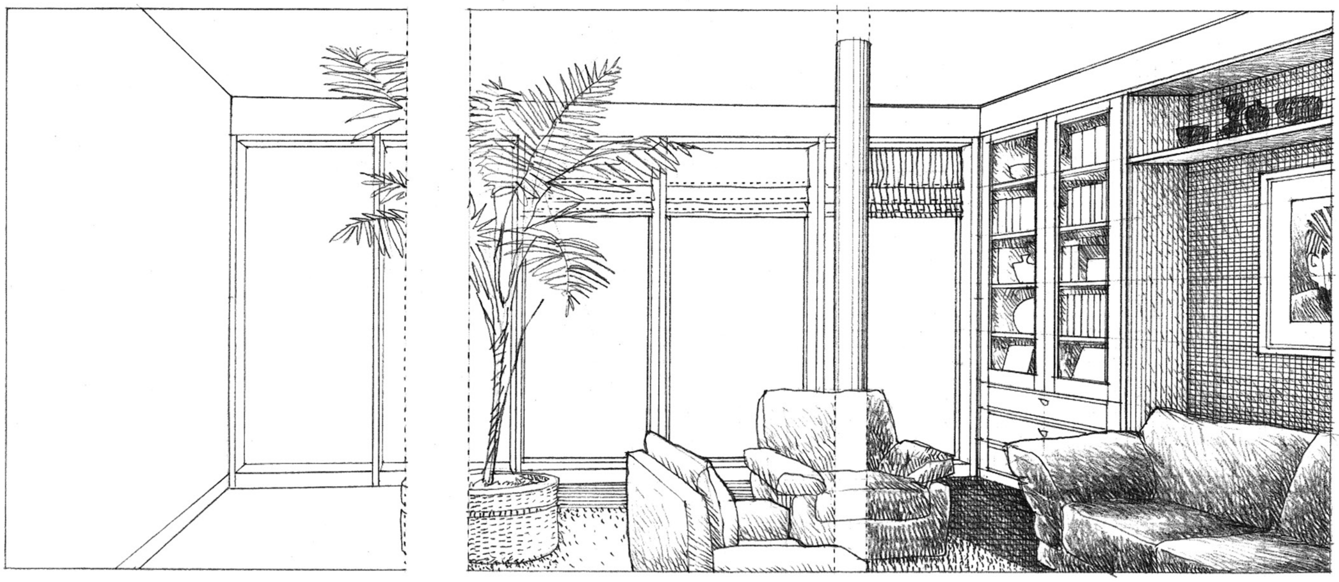


Competing textures

Texture is an intrinsic characteristic of the materials we use to define, furnish, and embellish interior space. How we combine and compose differing textures is just as important as the composition of color and light, and should suit the desired character and use of a space.

The scale of a textural pattern should be related to the scale of a space and its major surfaces, as well as to the size of secondary elements within the space. Since texture tends to visually fill space, any textures used in a small room should be subtle or used sparingly. In a large room, texture can be used to reduce the scale of the space or to define a more intimate area within it.

A room with little textural variation can be bland. Combinations of hard and soft, even and uneven, and shiny and dull textures can be used to create variety and interest. In the selection and distribution of textures, moderation should be exercised and attention paid to their ordering and sequence. Harmony among contrasting textures can be sustained if they share a common trait, such as degree of light reflectance or visual weight.

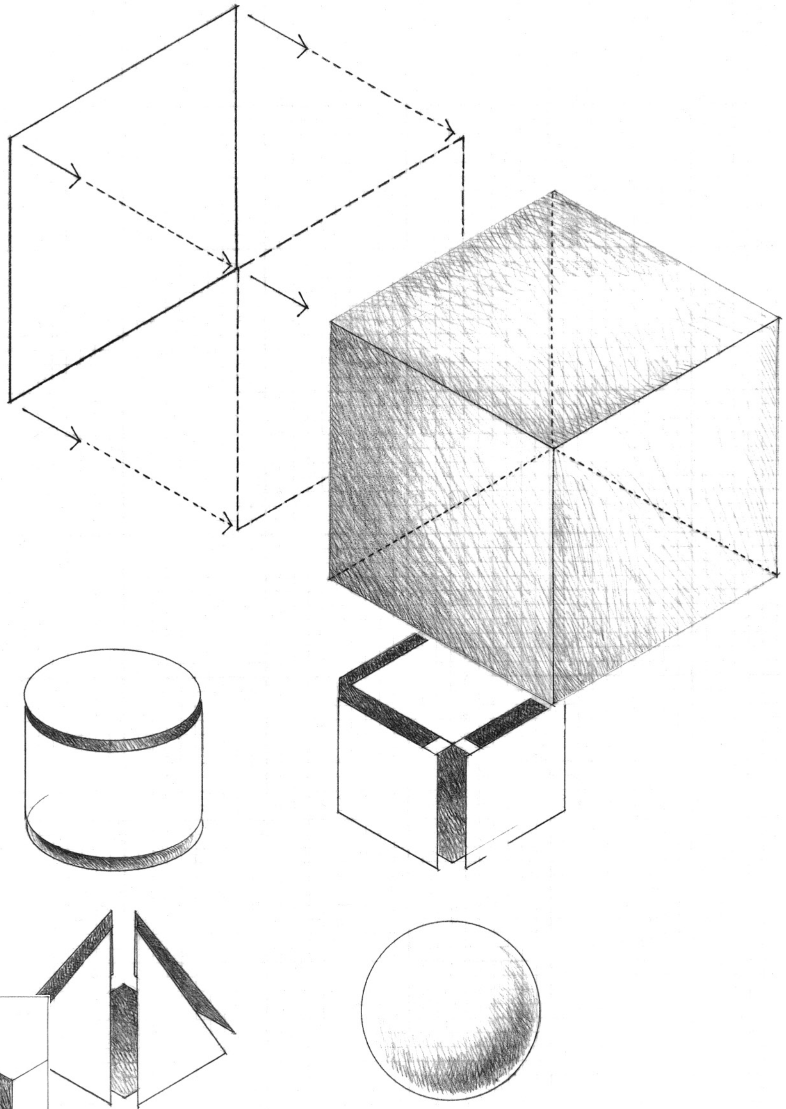


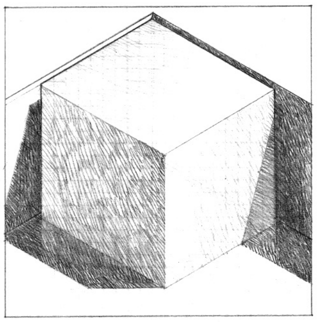
Increasing textures in a room from left to right

A plane extended in a direction other than along its surface forms a volume. Conceptually and in reality, a volume exists in three dimensions.

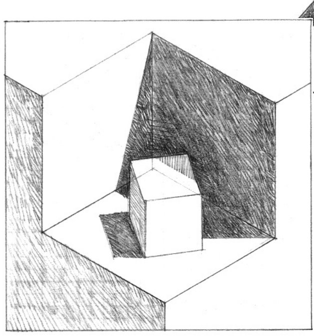
*Form* is the term we use to describe the contour and overall structure of a volume. The specific form of a volume is determined by the shapes and interrelationships of the lines and planes that describe its boundaries.

As the three-dimensional element of architectural and interior design, a volume can be either a solid (space displaced by the mass of a building or building element) or a void (space contained and defined by wall, floor, and ceiling or roof planes). It is important to perceive this duality of containment versus displacement, especially when reading orthographic plans, elevations, and sections.

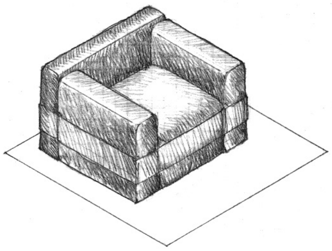




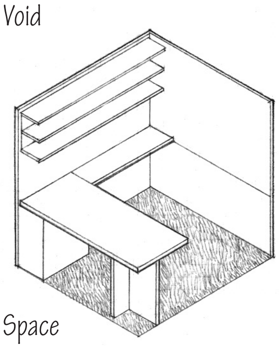
Solid



Void

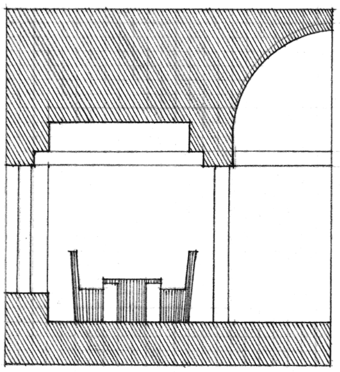


Mass

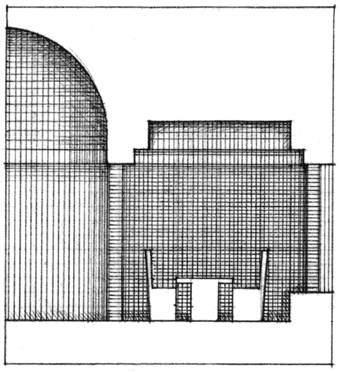


Space

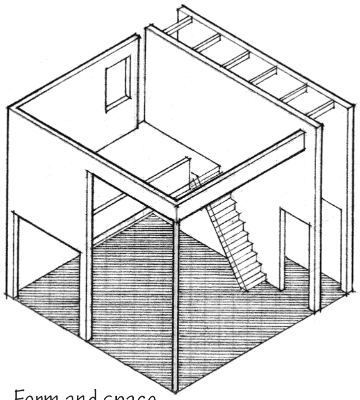
The duality of solid forms and spatial voids represents the essential unity of opposites that shapes the reality of architecture and interior design. Visible forms give space dimension, scale, color, and texture, while space reveals the forms. This symbiotic relationship between form and space can be seen at several scales in interior design.



Form

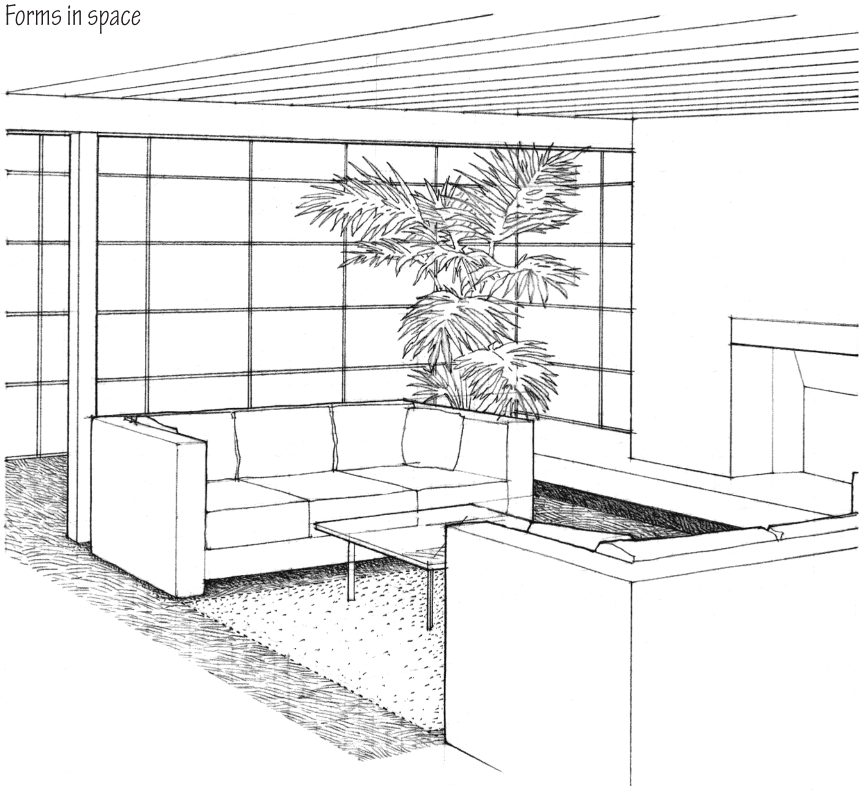


Space



Form and space

Forms in space



Color, like shape and texture, is an inherent visual property of all form. We are surrounded by color in our environmental settings. The colors we attribute to objects find their source in the light that illuminates and reveals form and space. Without light, color does not exist.

The science of physics deals with color as a property of light. Within the visible spectrum of light, color is determined by wavelength. Starting at the longest wavelength with red, we proceed through the spectrum of orange, yellow, green, blue, and violet to arrive at the shortest visible wavelengths. When these colored lights are present in a light source in approximately equal quantities, they combine to produce white light—light that is apparently colorless.

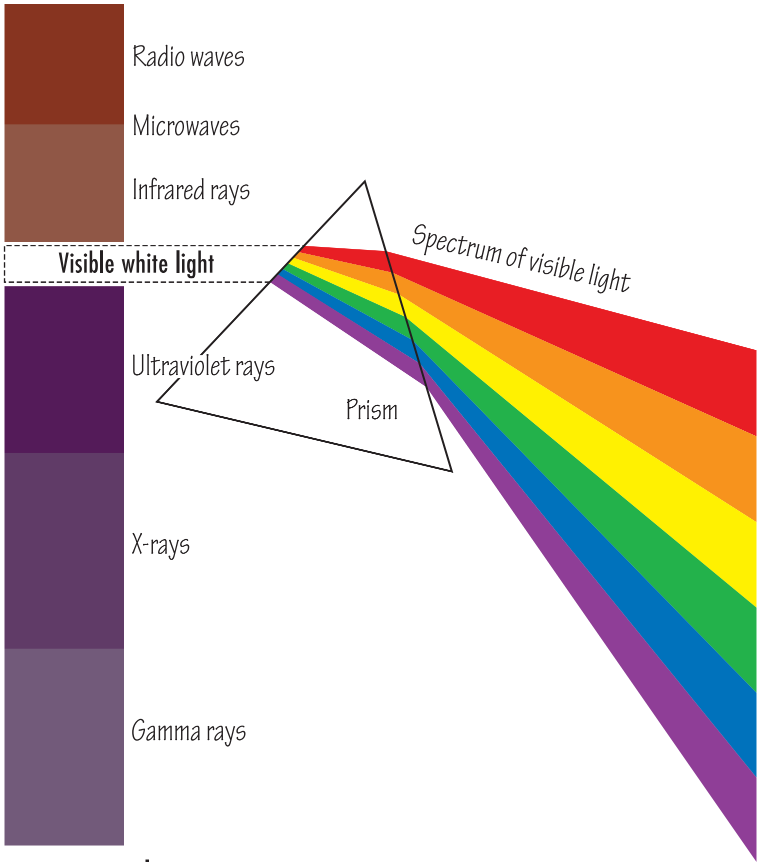
Research suggests that humans exposed to the same colors tend to see colors in similar ways. This may allow people with very different eyes to see colors in similar ways. It can also result in people in very different environments perceiving colors differently.

As people age, the lens of the eye becomes more yellow. By age 70, most people see the world through a lens roughly the color of ginger ale, especially when distinguishing between blues and purples. Using rich, saturated colors and plentiful lighting helps. Aging may also increase the incidence of cataracts, which causes the eye's lens to turn cloudy with a yellowish, brownish tint; macular degeneration, which blurs central vision and makes objects less bright; and the effects of glaucoma or dementia.

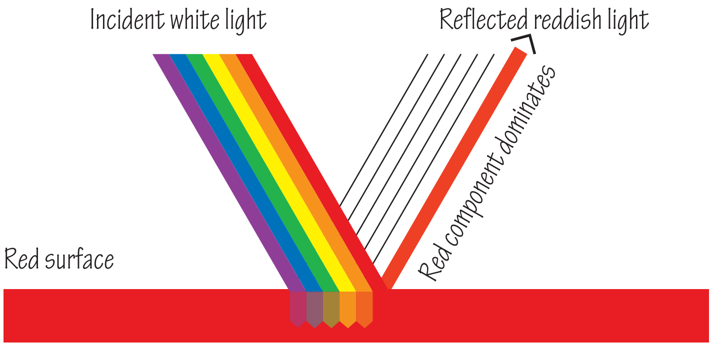
Avoiding contrast on surfaces like walls and floors helps clients avoid seeing them as holes that could cause a misstep or fall. Yellow color schemes may be avoided because of the effects of cataracts. Rather than avoiding specific colors, designing with the whole spectrum of the outdoors may be a better choice.

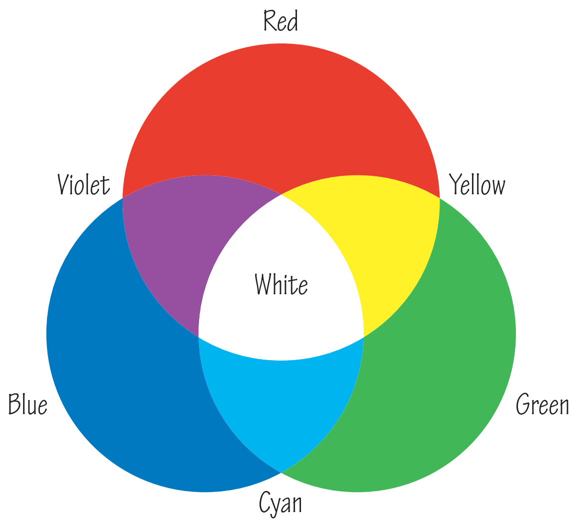
Sensitivity to glare appears to increase as we age, so a matte or lower sheen may be a better approach than a high gloss. And, as is usually the case, testing a potential color with a variety of natural and artificial light sources is a good idea.

In northern climates, the red and orange end of full-spectrum daylight is partially blocked, while the blue end passes through, making some paint colors appear greenish.

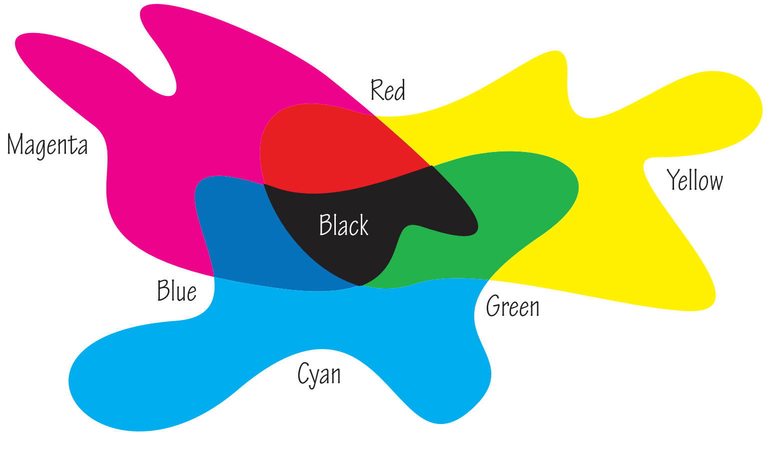



Electromagnetic Spectrum




Colored lights combine by additive mixing.




Pigment colors combine by subtractive mixing.

When white light falls on an opaque object, selective absorption occurs. The surface of the object absorbs certain wavelengths of light and reflects others. Our eyes apprehend the color of the reflected light as the color of the object.

White light is composed of the entire spectrum of colored lights. Some light sources—such as some electric lamps or light reflected off a colored wall—may not be well balanced and thus lack part of the spectrum. This lack of certain colors will make a surface illuminated by such light appear to lack those colors.

Artificial lighting has its own color bias. LED light tends to be whiter and more neutral than other sources, but can be programmed for different wavelengths and intensity. Fluorescent bulbs produce a cool blue light, while incandescent bulbs shift light color toward a warm orange.

Which wavelengths or bands of light are absorbed and which are reflected as object color is determined by the pigmentation of a surface. A red surface appears red because it absorbs most of the blue and green light falling on it and reflects the red part of the spectrum; a blue surface absorbs the reds. Similarly, a black surface absorbs the entire spectrum; a white surface reflects all of it.

A surface has the natural pigmentation of its material. This coloration can be altered with the application of paints, stains, or dyes that contain color *pigments*. While colored light is additive in nature, color pigments are subtractive. Each pigment absorbs certain proportions of white light. When pigments are mixed, their absorptions combine to subtract various colors of the spectrum. The colors that remain determine the *hue*, value, and intensity of the mixed pigment.

It is important for interior designers to remember that the colors they see on their computer screens are colored light, while colors in printed materials and samples are pigments. For accuracy, they should rely on physical color samples viewed in the light in which they will be used.

Color has three dimensions:

### Hue

The attribute by which we recognize and describe a color, such as red or yellow.

### Value

The degree of lightness or darkness of a color in relation to white and black.

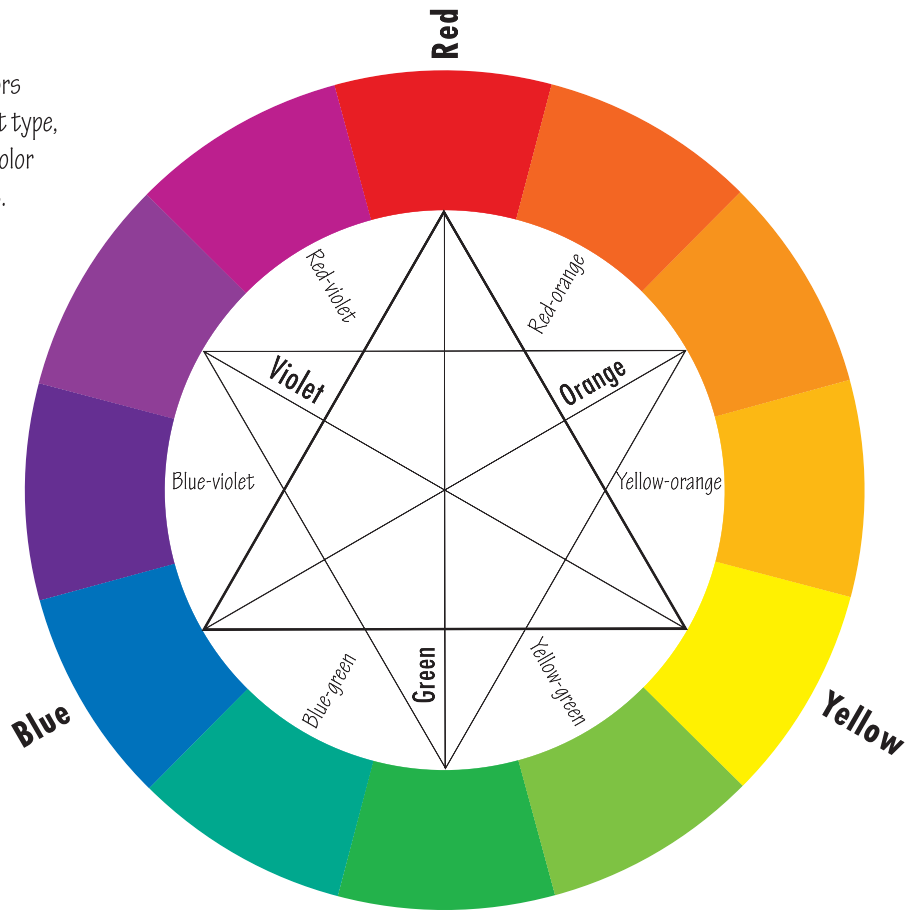
### Saturation

The brilliance or dullness of a color; this depends on the amount of hue in a color.

All of these attributes of color are interrelated. Each principal hue has a normal value. Pure yellow, for example, is lighter in value than pure blue. If white, black, or a complementary hue is added to a color to lighten or darken its value, its *saturation* will be diminished as well. It is difficult to adjust one attribute of a color without simultaneously altering the other two.

A number of color systems attempt to organize colors and their attributes into a visible order. The simplest type, such as the Brewster/Prang color wheel, organizes color pigments into primary, secondary, and tertiary hues.

The primary hues are red, yellow, and blue. The secondary hues are orange, green, and violet. The tertiary hues are red-orange, yellow-orange, yellow-green, blue-green, blue-violet, and red-violet.



A more comprehensive system for the accurate specification and description of color is the Munsell system, developed by Albert H. Munsell. The system arranges colors into three orderly scales of uniform visual steps, according to their attributes of hue, value, and *chroma* (intensity).

The Munsell system is based on five principal hues and five intermediate hues. These ten major hues are arranged horizontally in a circle.

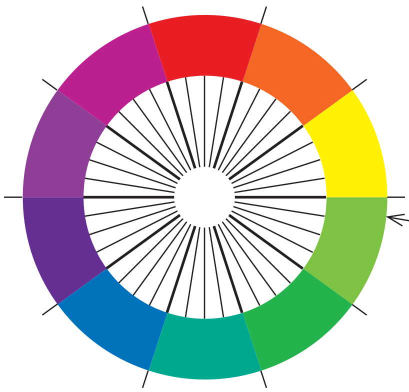
Extending vertically through the center of the hue circle is a scale of neutral gray values, graded in ten equal visual steps from black to white.

Radiating out from the vertical scale of values are equal steps of chroma, or intensity. The number of steps will vary according to the attainable saturation of each color's hue and value.

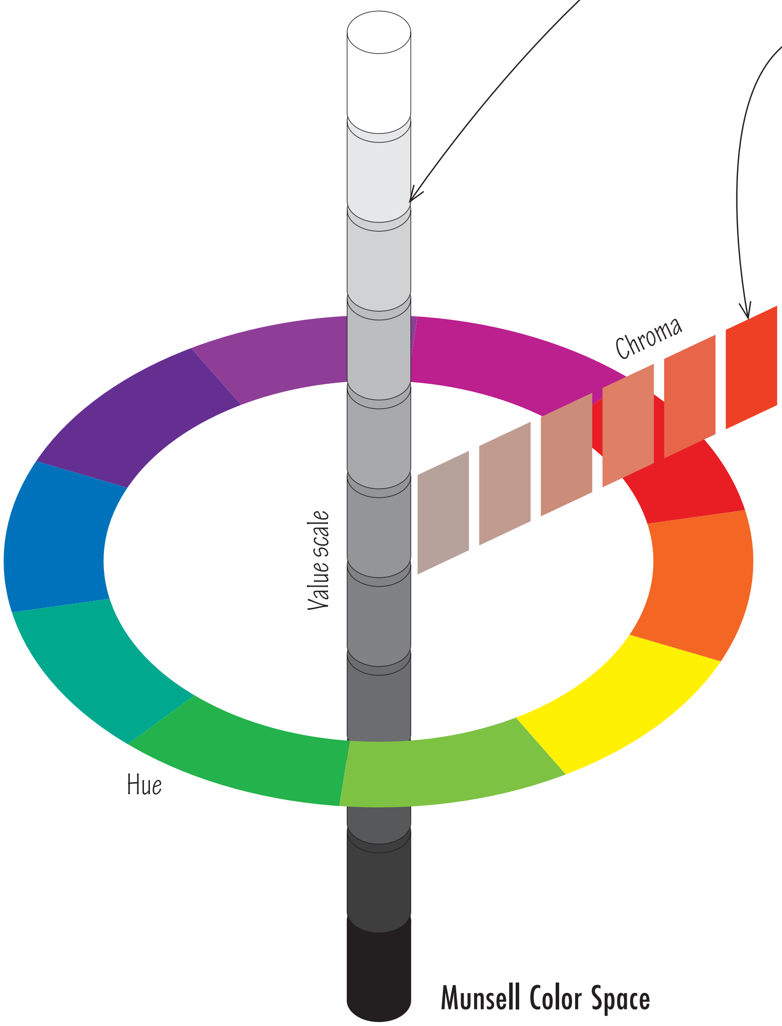
With this system, a specific color can be identified with the following notation: Hue Value/Chroma, or H V/C. For example, 5R 5/14 would indicate a pure red at middle value and maximum chroma.

Another color system by the Dutch designer Hella Jongerius uses a series of color palettes based on the legacy of designs and designers for the Swiss furniture company Vitra. These have had an idiosyncratic but rejuvenating effect on the brand (*Metropolis*, April 2016).

Although the ability to accurately communicate the hue, value, and intensity of a specific color without an actual sample is important in science, commerce, and industry, color names and notations cannot adequately describe the visual sensation of color. Actual color samples, seen in the light in which they will be used, are essential in the design of a color scheme.



Munsell Color Wheel




Munsell Color Space

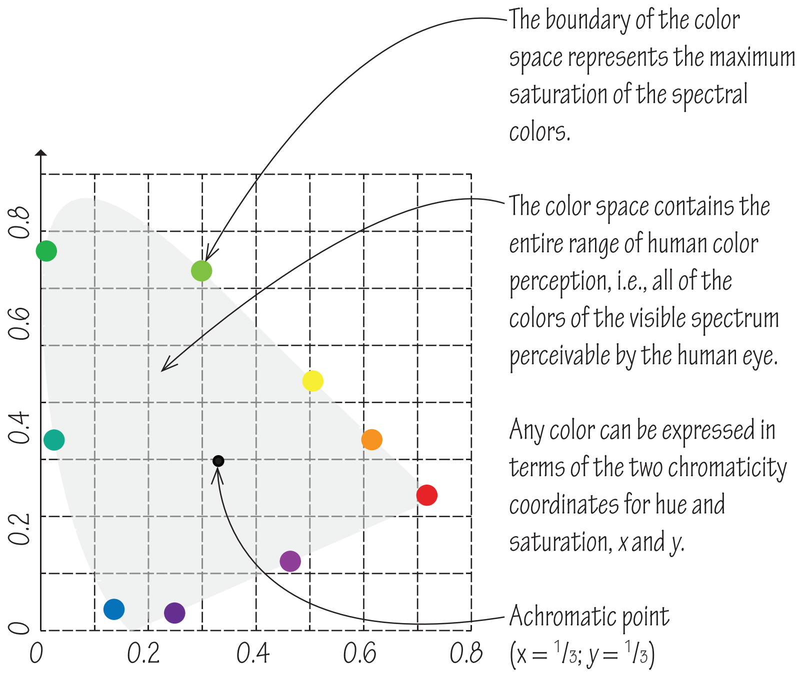
With the advent of color computer monitors and printers, the need for a universal language of color communication has become even more pressing. Interior designers often must indicate a color to be used uniformly in paints, textiles, graphic design materials, and other media.

Commission Internationale de l'Eclairage (CIE) standards are based on the precise measurement of light waves reflected by a surface, factored by sensitivity curves that have been measured for the human eye. Although cumbersome to use, CIE standards are specified by most U.S. furniture manufacturers.

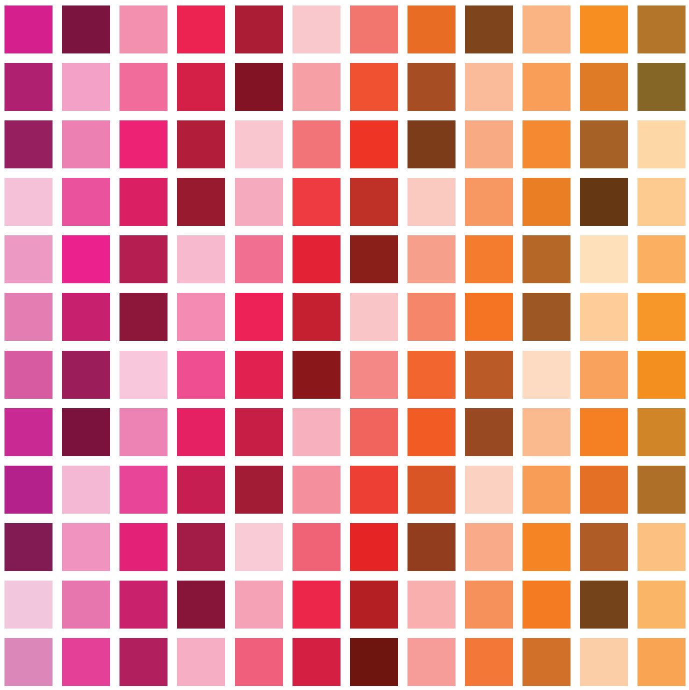
Color maps, such as the color space developed by Munsell and described earlier, allow color communication between any two individuals with the same map.

Systems such as Pantone® for architecture and interiors provide the interior designer with a way to specify, communicate, and manage color choices for a wide variety of materials, both online and offline.

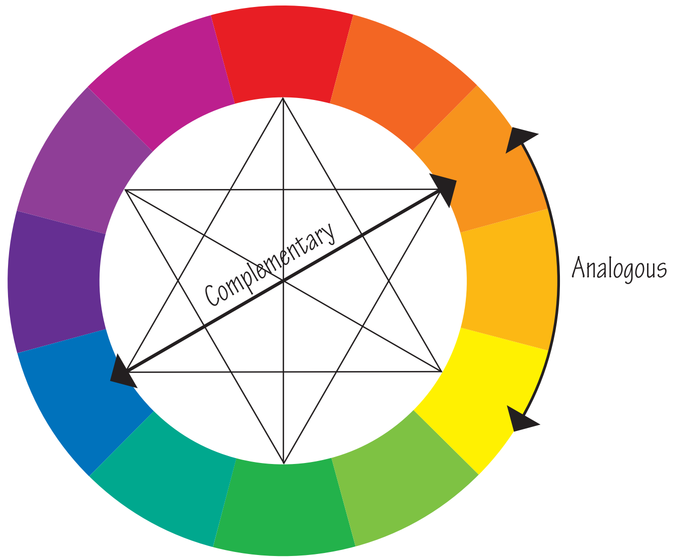
Other available tools are electronic color analyzers, which identify color data from samples, and color viewing lights, which simulate varied lighting conditions. Electronic color analysis is commonly used for paint matching. Color may be mixed at the point of sale to match almost any color sample.




CIE Chromaticity Diagram



A Sampling of Pantone® Color Swatches

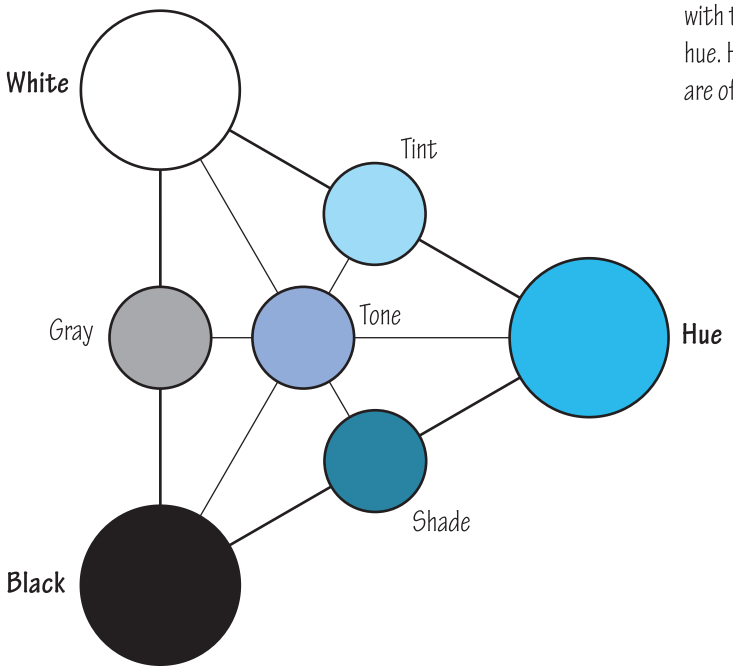



Object colorants, such as paints and dyes, are means to modify the color of the illuminating light, changing what we interpret to be the color of the object. In mixing the pigments of paints and dyes, each of the attributes of color can be altered.

The hue of a color can be changed by mixing it with other hues. When neighboring or analogous hues on the color wheel are mixed, harmonious and closely related hues are created. In contrast to this, mixing *complementary hues*, those hues directly opposite each other on the color wheel, produces neutral hues.

The value of a color can be raised by adding white and lowered by adding black. Lightening a hue's normal value by adding white creates a *tint* of that hue; darkening the hue's normal value with black creates a *shade* of the hue. A normally high-value color, such as yellow, is capable of more shades than tints, while a low-value color, such a red, is able to have more tints than shades.

The intensity of a color can be strengthened by adding more of the dominant hue. It can be lowered by mixing gray with the color or by adding to the color its complementary hue. Hues that are grayed or neutralized in this manner are often called *tones*.



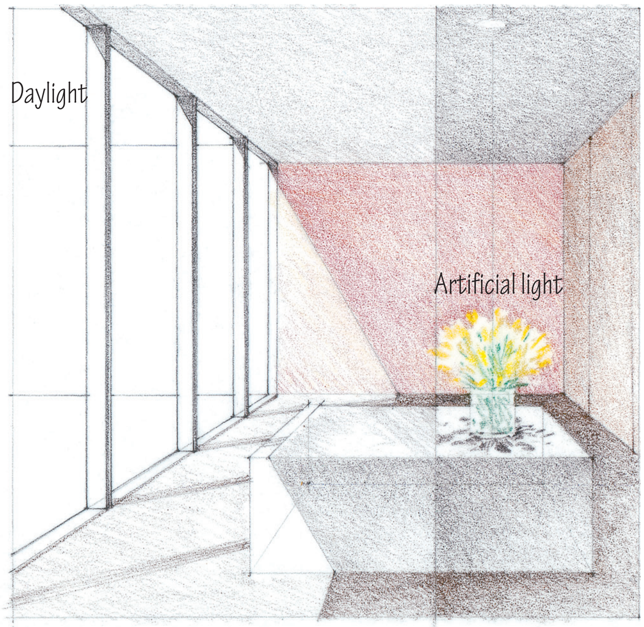
Apparent changes in an object's color can result from the effects of light and from the juxtaposition of surrounding or background colors. These factors are especially important to the interior designer, who must carefully consider how the colors of elements in an interior space interact and how they are rendered by the light illuminating them.

Light of a particular hue, other than white, is rarely used for general illumination. However, not all sources of what we consider white light are spectrally well balanced. Incandescent bulbs cast a warm glow, while some fluorescents cast a cool light. Even the color of a large reflecting surface can alter the light within an interior space. The current widening use of LED light encourages the use of colored light in interiors. It is important to be aware that colored light changes the color of the object it is reflected from. For example, an appealing red apple can become a very unappealing gray one. It requires foresight and care to avoid negative effects when using colored light. Observing color firsthand, taking into account the sun's angle and direction along with the amount and quality of artificial light, is the surest way to verify what a color will actually look like.

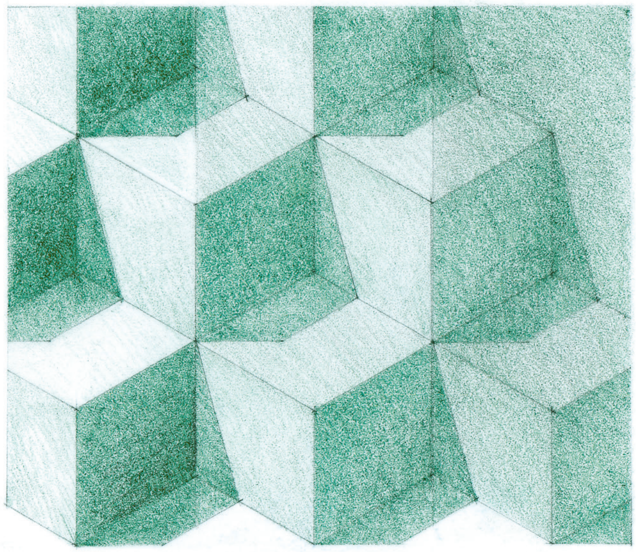
Daylight, too, can be warm or cool, depending on the time of day and the direction from which it comes. The color of sunlight throughout the day changes color perception. Human eyes have evolved to see better during the day than night, and our brains adjust to figure out what color we are really observing (our chromatic bias). Morning and evening have an orange bias, and midday light under a clear sky has a blue bias. Our brains automatically shift by subtracting the prevailing bias as the quality and angle of light changes. Rapid changes in light during transition periods from dawn to early morning and from twilight and dusk to dark can throw off this adjustment. These times of day are the worst times to make color decisions and should be avoided when choosing colors indoors. However, our brains do take prior experience into consideration. Observing what happens when window blinds are opened and closed also helps. Warm light tends to accentuate warm colors and neutralize cool hues, while cool light intensifies cool colors and weakens warm hues. If light is altered with a particular hue, it will raise the intensity of colors of that hue and neutralize colors of a complementary hue.

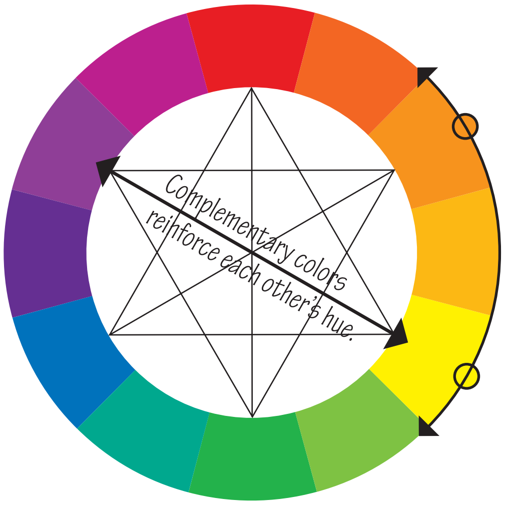
The apparent value of a color can also be altered by the amount of light used to illuminate it. Lowering the amount of illumination will darken a color's value and neutralize its hue. Raising the lighting level will lighten the color's value and enhance its intensity. However, high levels of illumination can also tend to make colors appear less saturated, or washed out.

The natural fluctuations of light in an interior setting can alter colors in subtle ways. A color may also look different depending on its angle to the viewer. It is always best to test colors in the environment in which they are to be viewed, under both daylight and nighttime conditions.



Conditions affecting the rendition of colors in an interior space


Strong illumination Medium illumination Low illumination




Although mixing two complementary color pigments results in a neutralized or grayed hue, placing them next to each other can produce the opposite effect. In the phenomenon known as simultaneous contrast, the eye tends to generate a color's complementary hue and project it as an afterimage on adjacent colors. Thus, two complementary colors placed side by side tend to heighten each other's saturation and brilliance without an apparent change in hue.

When the two colors are not complementary, each will alter the other with its own complement and shift it toward that hue. The result is that the two colors are pushed farther apart in hue.

Simultaneous contrast in hue is most easily perceived when two colors are fairly uniform in value. If one color is much lighter or darker than the other, the effects of contrasting values become more noticeable.

## Simultaneous Contrast

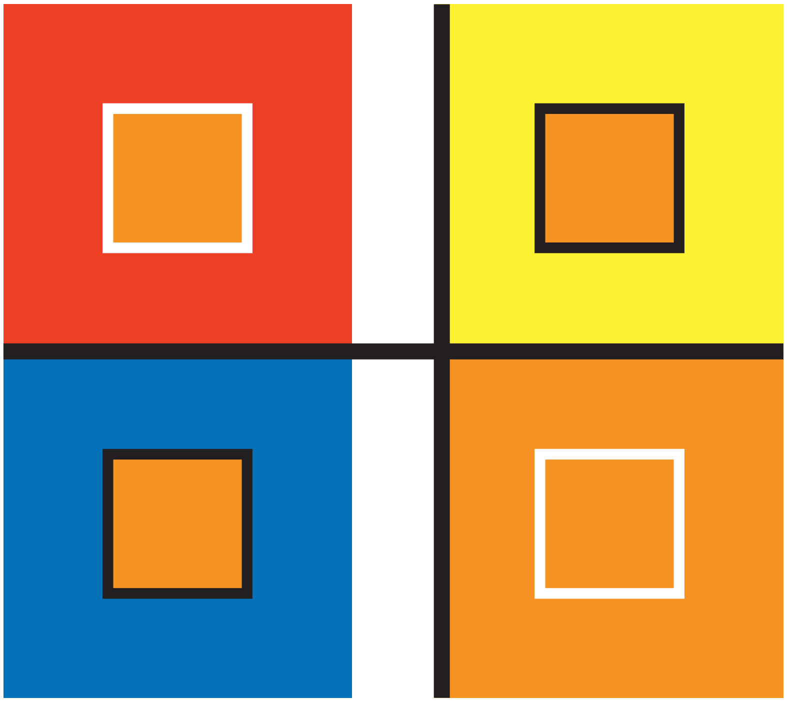
Complementary colors | Analogous colors; contrasting values | Analogous colors; similar values

Simultaneous contrast also affects the apparent value of a color, which can be made to appear lighter or darker according to the value of its background color. A light color will tend to deepen a dark color, while a dark color will tend to brighten a light color.

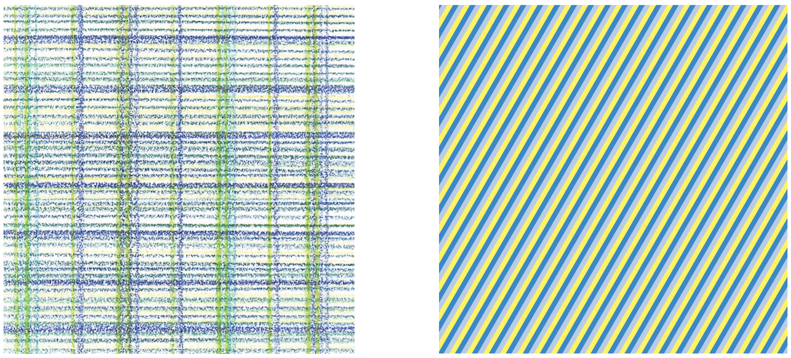
Both black and white have a visible effect on colors brought into contact with them. Surrounding colors with black tends to make them richer and more vibrant, while outlining with white often has the opposite effect. A large area of white will reflect light onto adjacent colors, while thin white lines tend to spread and alter the hues they separate.

The effects of contrasting hues and values depend on areas large enough to be perceived as separate colors. If the areas are small and closely spaced, the eye does not have enough time to adjust to their differences and mixes the colors optically. The effects of optical mixing are often used in the weaving of textiles to create an impression of many hues and values with a limited number of colored yarns or threads.

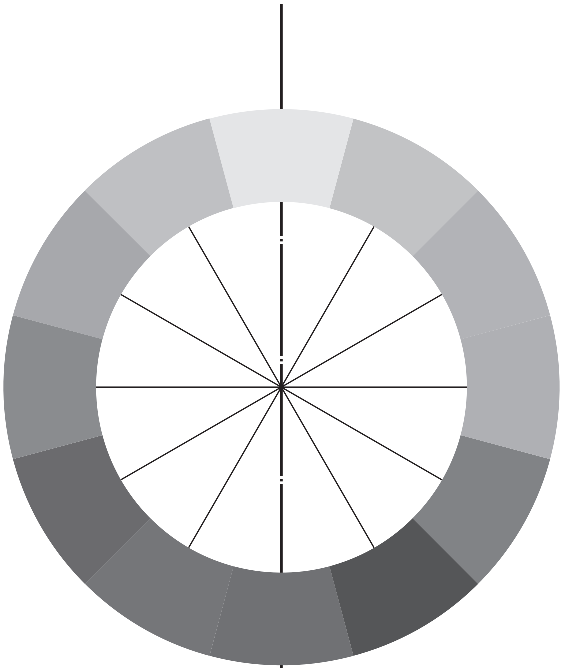
Contrasting values alter perceived values.



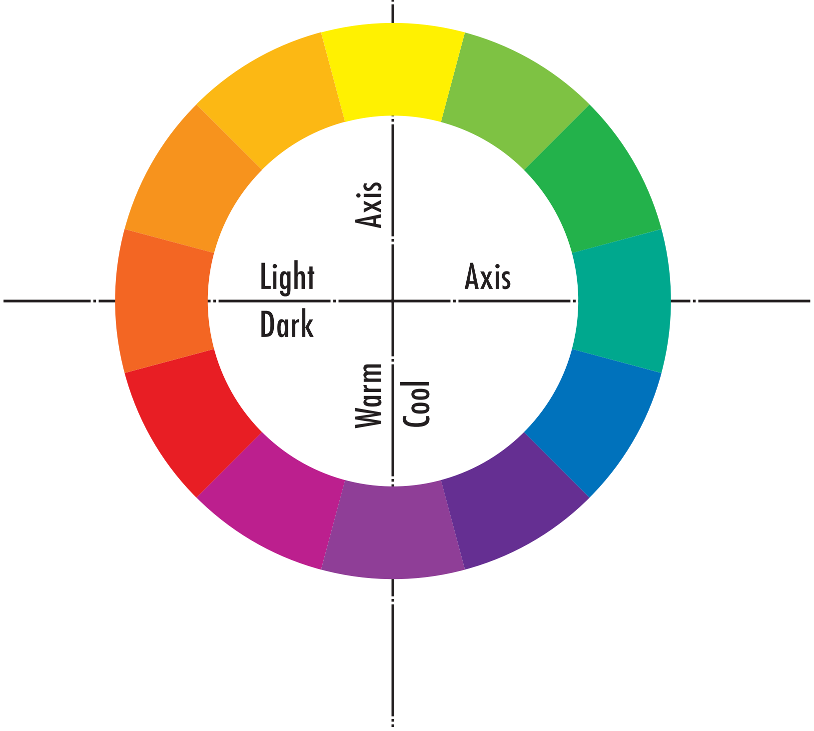
Effect of outlining colors with white or black



Optical mixing occurs when dots or strokes of colors merge to produce more blended hues.



Normal values of hues in standard color wheel



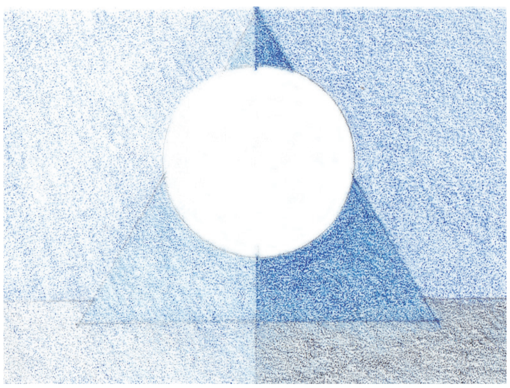

In addition to understanding how colors interact and alter one another's attributes, the interior designer must consider how color affects our perception of form and the dimensions and qualities of interior space.

Colors are often divided into warm and cool categories. Reds, oranges, and yellows are considered to be warm colors that advance. Blues, greens, and violets are considered cooler and tend to recede. Neutrals, such as grays and off-whites, may be either warm (brownish) or cool (bluish).

The warmth or coolness of a color's hue, along with its relative value and degree of saturation, determines the visual force with which it attracts our attention, brings an object into focus, and creates a sense of space. The following generalizations summarize some of these effects of color.

Warm hues and high intensities are said to be visually active and stimulating, while cool hues and low intensities are more subdued and relaxing. Light values tend to be cheerful, middle values undemanding, and dark values somber.

Bright, saturated colors and any strong contrasts attract our attention. Grayed hues and middle values are less forceful. Contrasting values, in particular, make us aware of shapes and forms. Contrasting hues and saturations can also define shape, but if they are too similar in value, the definition they afford will be less distinct.



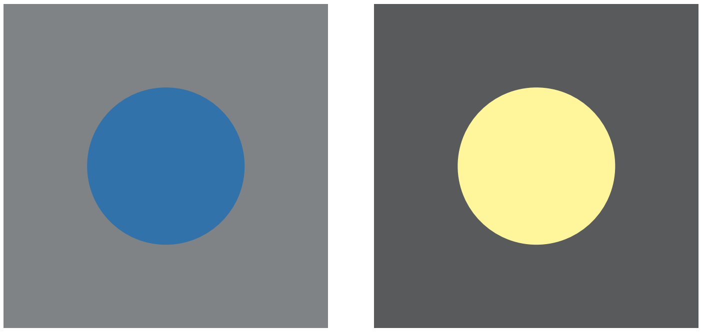
Value contrast aids in our perception of shape.

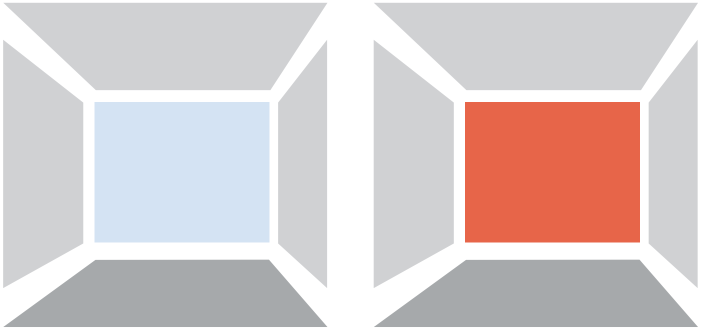
Deep, cool colors appear to contract. Light, warm colors tend to expand and increase the apparent size of an object, especially when seen against a dark background.

When used on an enclosing plane of a space, light values, cool hues, and grayed colors appear to recede and increase apparent distance. They can therefore be used to enhance the spaciousness of a room and increase its apparent width, length, or ceiling height.

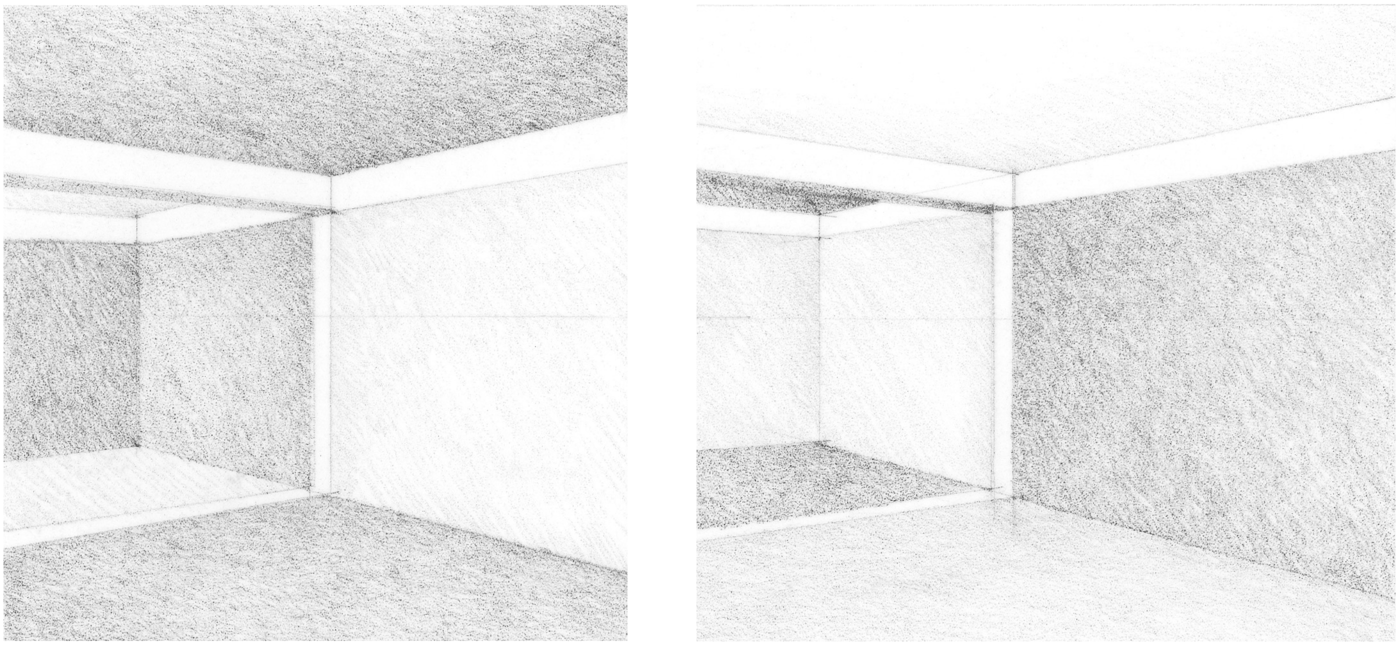
Warm hues appear to advance. Dark values and saturated colors suggest nearness. These traits can be used to diminish the scale of a space or, in an illusory way, shorten one of a room's dimensions. These color generalizations have complex interrelationships. For example, although blue is considered cool and red warm, a vibrant electric blue may not strike us as cooler than a soft rose. Our emotional reactions to color vary with our personal experiences and cultural associations. In addition, favored color combinations are subject to fashion trends, with certain color palettes closely tied to specific times or places.

Research into the effects of color in workspaces has shown that white, although crisp and clean, does not aid productivity. Red aids detail-oriented workers, and can raise blood pressure, speed up respiration and heartbeat, and increase alertness. Blue aids creativity, and green inspires innovation. Women have an extra gene that makes it possible to detect more variations in the red-orange spectrum than men. Experts recommend avoiding yellow in conference rooms as well as the suppressive impact of gray.

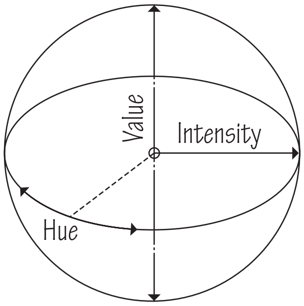


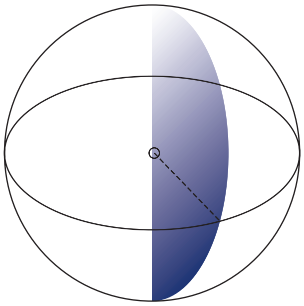


Although vibrant colors and patterns can be used to create a lively environment, too much can produce visual chaos. Instead, less obtrusive natural colors can be used in unobtrusive patterns to create a floor, for example, that echoes cobblestones or wood grains.

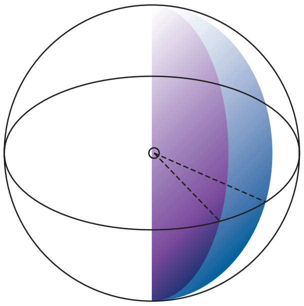


The effect of values on spatial boundaries

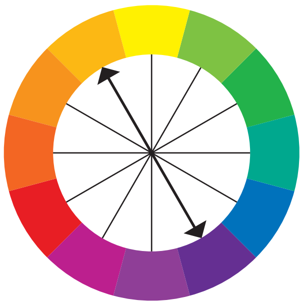


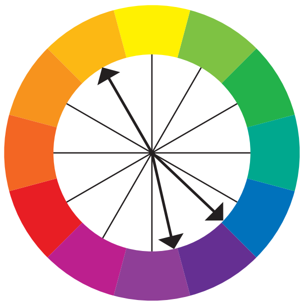
Monochromatic color schemes vary the value of a single hue.



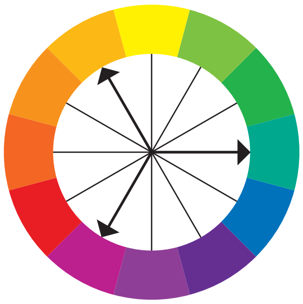
Analogous color schemes use two or more hues from the same quarter of the color wheel.



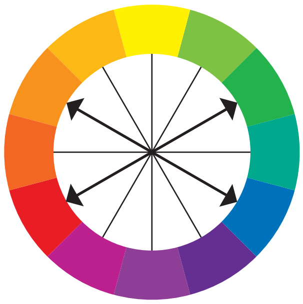
Complementary color schemes use two hues on opposite sides of the color wheel.



Split complementary color schemes combine one hue with the two hues adjacent to its complement.



Triadic color schemes use colors located at three equidistant points on the color wheel.



Contrasting hue schemes are based on complementary or triadic color combinations.

Although each of us may have favorite colors and a distinct dislike of others, there is no such thing as a good or bad color. Some colors are simply in or out of fashion at a given time; others may be appropriate or inappropriate given a specific color scheme. The suitability of a color depends ultimately on how and where it is used and how it fits into the palette of a color scheme.

Digital mobile color scanning tools are now available that aid in the management, organization, and sharing of a color specification. In addition, videoconferencing systems using wireless projection allow seamless video communication across any device with a screen via cloud-based service, saving money and equipment. With an Internet connection available, everyone can contribute to the conversation from wherever they are.

Manufacturers design color series for paints that suggest compatible color selections. These series may be scientifically built on gradations of pigments; based on references to nature, fabrics, or other materials; or developed to reflect emotional, historic, or similar associations.

If colors are like the notes of a musical scale, then color schemes are like musical chords, structuring color groups according to certain visual relationships among their attributes of hue, value, and intensity. The color schemes shown here are based on the hue relationships within a color group.

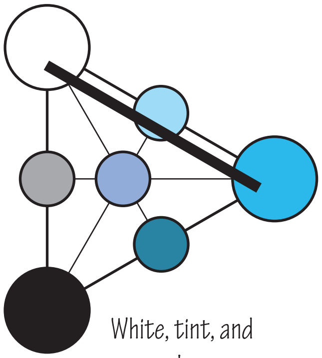
There are two broad categories of hue schemes, related and contrasting. Related hue schemes, based on either a single hue or a series of analogous hues, promote harmony and unity. Variety can be introduced by varying value and intensity, by including small amounts of other hues as accents, or by bringing shape, form, and texture into play.

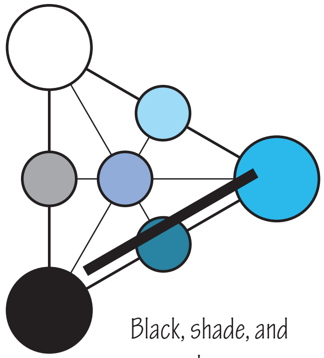
Contrasting hue schemes, based on complementary or triadic color combinations, are inherently more rich and varied, since they always include both warm and cool hues.

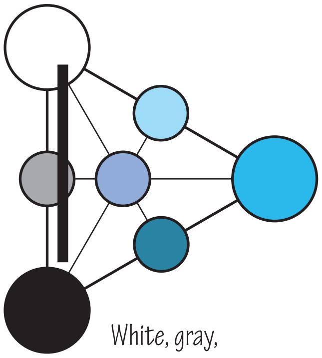
Hue schemes merely outline the approaches one can take in organizing a combination of hues. In designing a color scheme, other color relationships must also be considered.

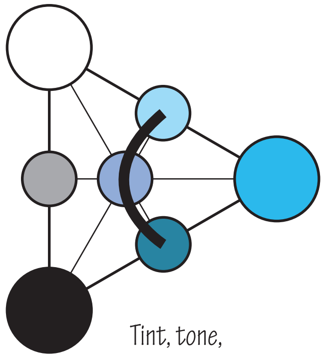
The color triangle developed by Faber Birren illustrates how modified colors—tints, tones, and shades—may be related in a harmonious sequence. The triangle is based on the three basic elements: pure color, white, and black. They combine to create the secondary forms of tint, shade, gray, and tone. Any of the bold-line paths illustrated here define a harmonious sequence, since each involves a series of visually related elements.

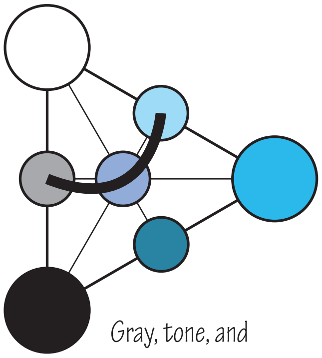
Ultimately, whether a color scheme is lively and exuberant or restful and quiet will depend on the chromatic and tonal values of the hues chosen. Large intervals between the colors and values will create lively contrasts and dramatic effects. Small intervals will result in more subtle contrasts and patterns.

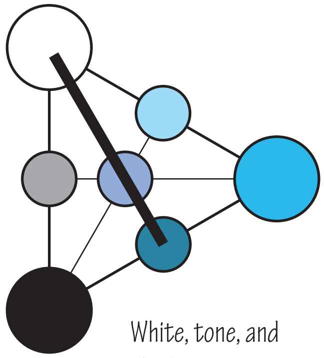

White, tint, and pure color

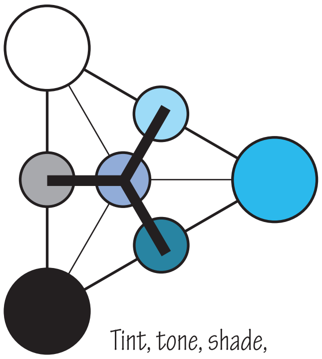

Black, shade, and pure color

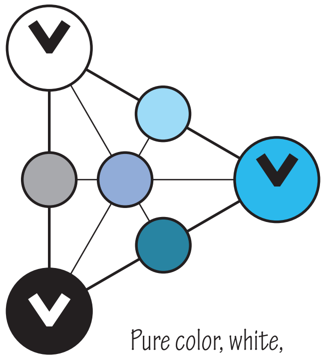

White, gray, and black

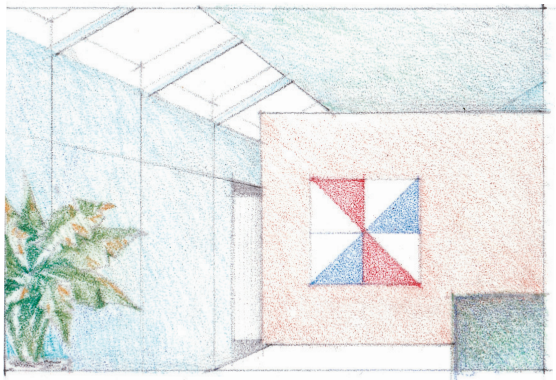

Tint, tone, and shade

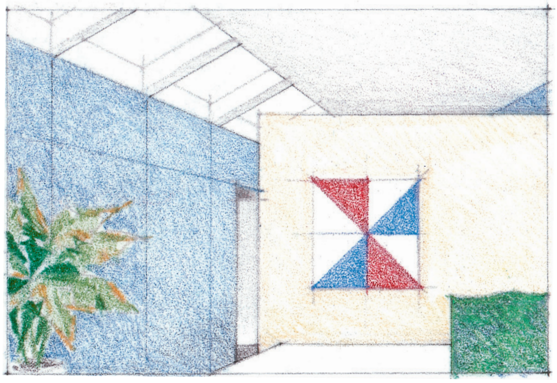

Gray, tone, and tint

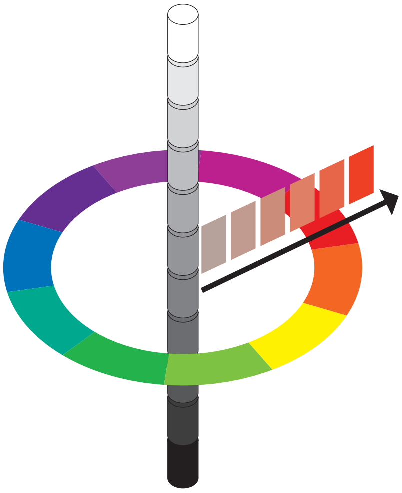

White, tone, and shade


Tint, tone, shade, and gray


Pure color, white, and black


Small intervals


Large intervals

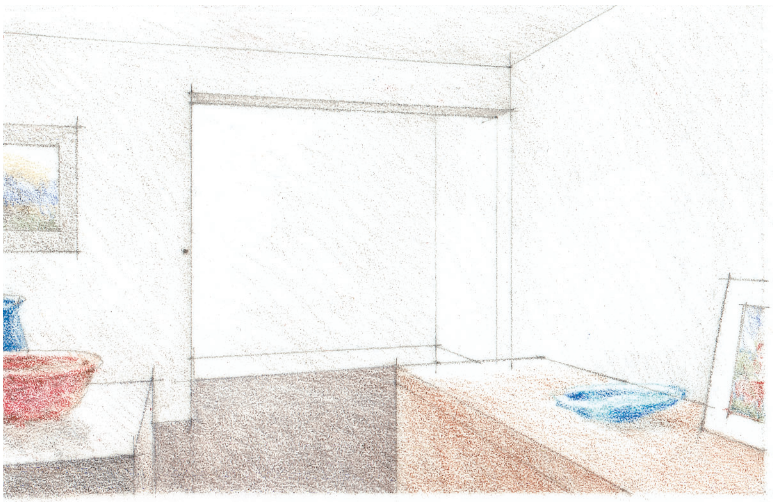


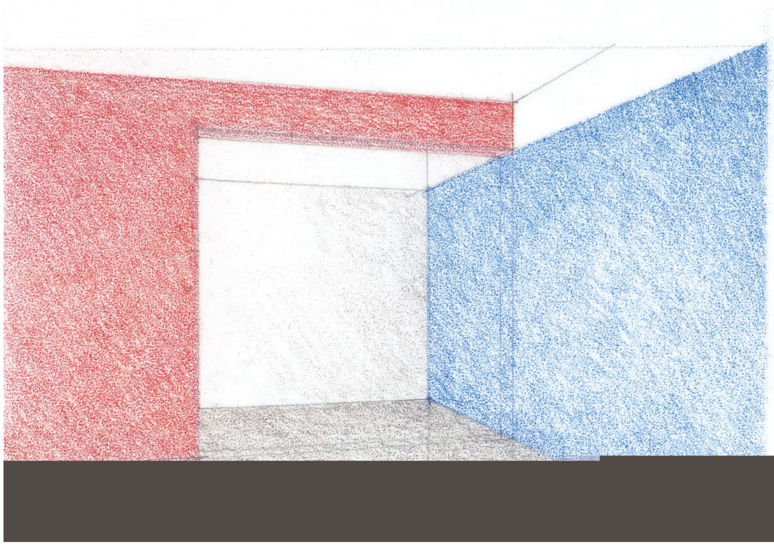
In developing a color scheme for an interior space, one must consider carefully the chromatic and tonal key to be established and the distribution of the colors. The scheme must not only satisfy the purpose and use of the space but also take into account its architectural character.

Decisions must be made regarding the major planes of an interior space and how color might be used to modify their apparent size, shape, scale, and distance. Which elements will form the background, middle ground, and foreground? Are there architectural or structural features that should be accentuated, or undesirable elements to be minimized?

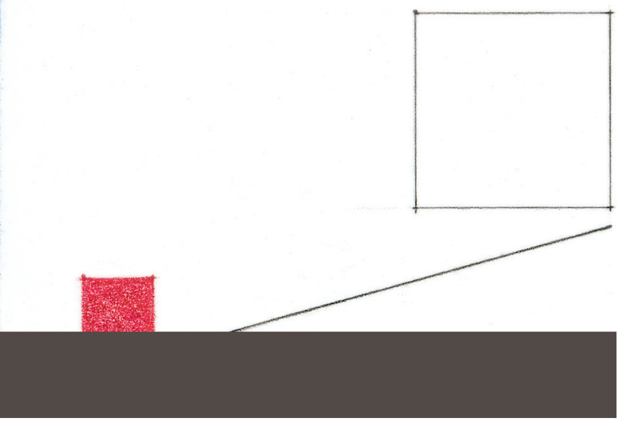
Usually, the largest surfaces of a room—its floor, walls, and ceiling—have the most neutral values. Against this background, secondary elements such as large pieces of furniture or area rugs can have greater chromatic intensity. Finally, accent pieces, accessories, and other small-scale elements can have the strongest chroma for balance and to create interest.

Neutral color schemes are the most flexible. For a more dramatic effect, the main areas of a room can be given the more intense values, while secondary elements have lesser intensity. Large areas of intense color should be used with caution, particularly in a small room. They reduce the apparent distance and can be visually demanding.



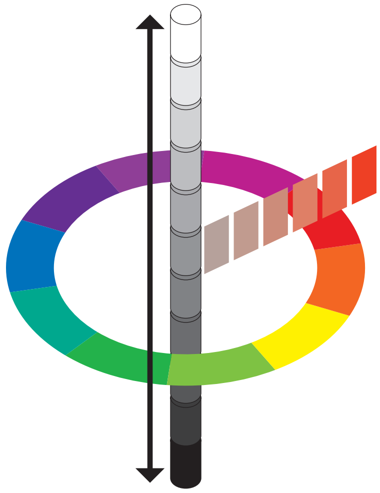


Large areas of intense color can be both dramatic and visually demanding.

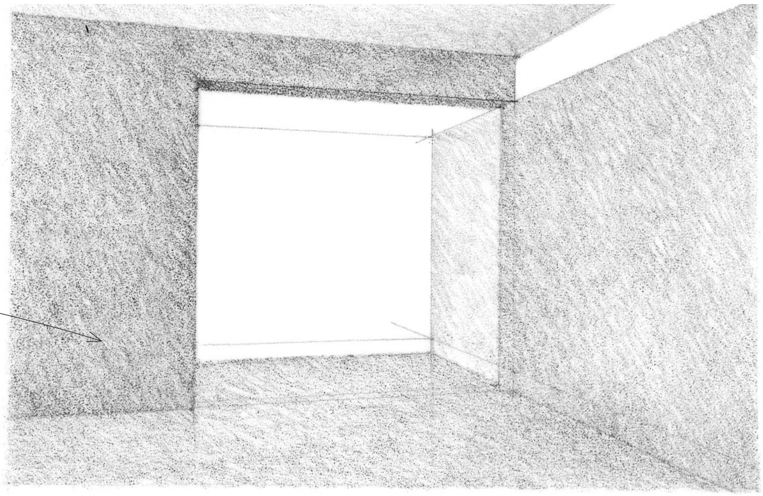


Balance large neutral areas with smaller areas of stronger intensity.

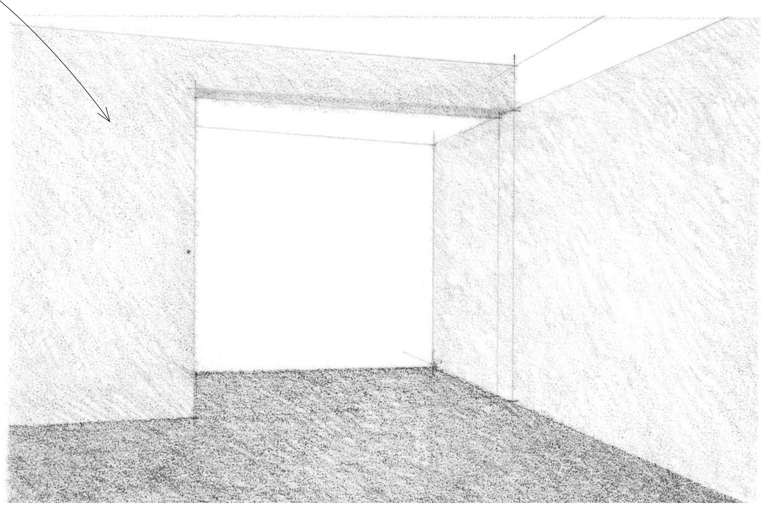
Of equal importance to chromatic distribution is tonal distribution, the pattern of lights and darks in a space. It is generally best to use varying amounts of light and dark values with a range of middle values to serve as transitional tones. Avoid using equal amounts of light and dark unless a fragmented effect is desired.



Typically, large areas of light value are offset by smaller areas of medium and dark values. This use of light values is particularly appropriate when the efficient use of available light is important. Dark color schemes can absorb much of the light within a space, resulting in a significant loss of illumination and an increase in energy use for lighting.



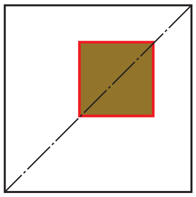
Another way of distributing values is to follow the pattern of nature. In this tonal sequence, the floor plane has the darkest value, surrounding walls are in the middle to light range, and the ceiling is fairly light.

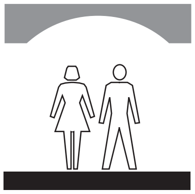


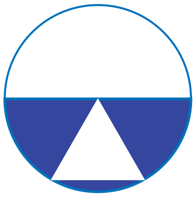
Of course, the distribution of values and their degree of contrast will also depend on the size, shape, and scale of the space. Because light values tend to recede while dark values advance, their placement can modify our perception of these spatial dimensions.

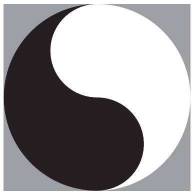
Interior design involves the selection of interior design elements and their arrangement within a spatial enclosure to satisfy functional and aesthetic requirements. This arrangement of elements in a space involves pattern making. No one single part or element in a space stands alone. In a design pattern, all of the parts, elements, or pieces depend on one another for their visual impact, function, and meaning.

The visual relationships established among the interior design elements in a space are ordered by proportion, scale, balance, harmony, unity and variety, rhythm, and emphasis. These design principles are not intended to be hard and fast rules, but rather guidelines to the possible ways design elements can be arranged into recognizable patterns. Ultimately, we must learn to judge the appropriateness of a pattern, its visual role in a space, and its meaning to the users of the space. These principles, however, can help develop and maintain a sense of visual order among the design elements of a space, while accommodating their intended use and function.


Proportion

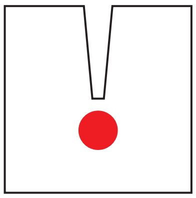

Scale


Balance

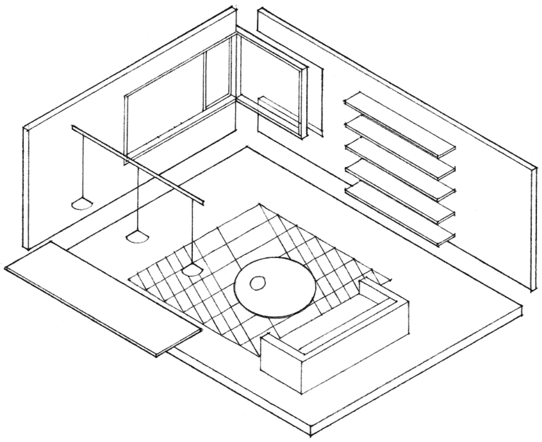

Harmony


Unity and Variety

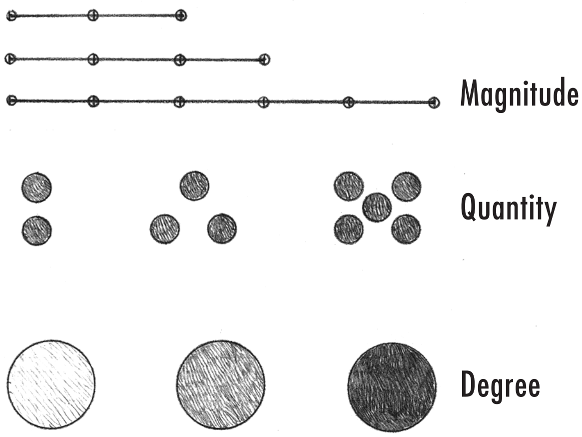

Rhythm

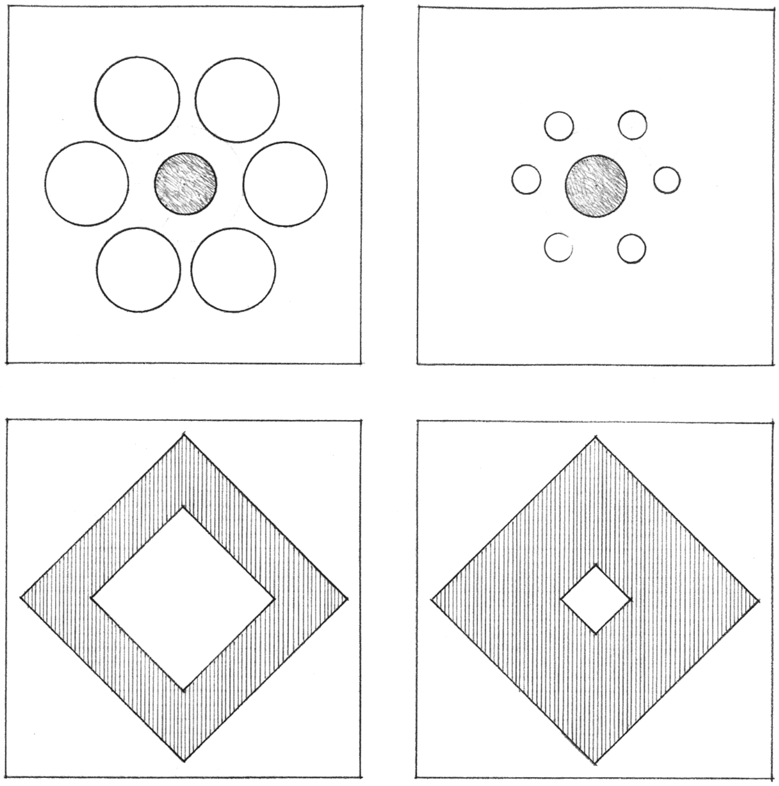

Emphasis

Arranging Design Patterns

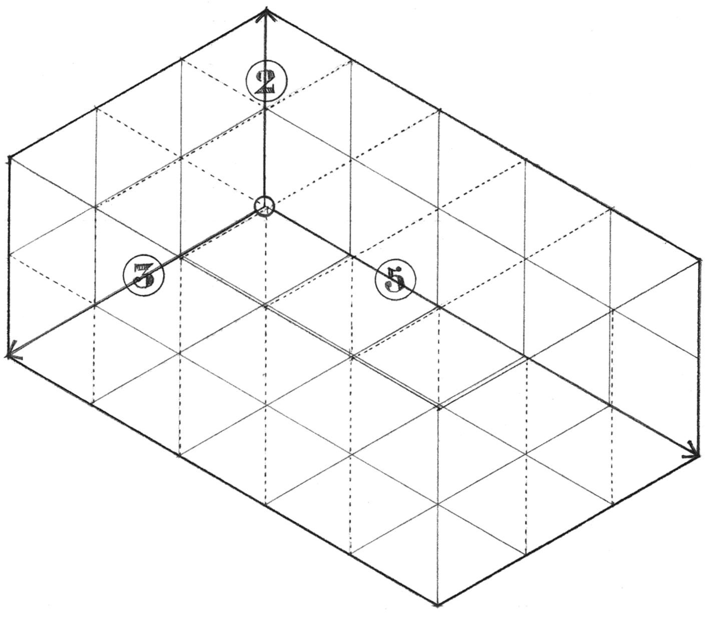


Proportion refers to the relationship of one part to another or to the whole, or between one object and another. This relationship may be one of magnitude, quantity, or degree.



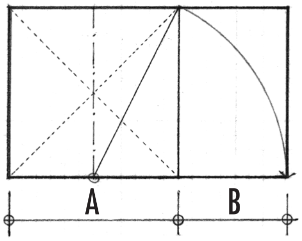
The apparent size of an object is influenced by the relative sizes of other objects in its environment.



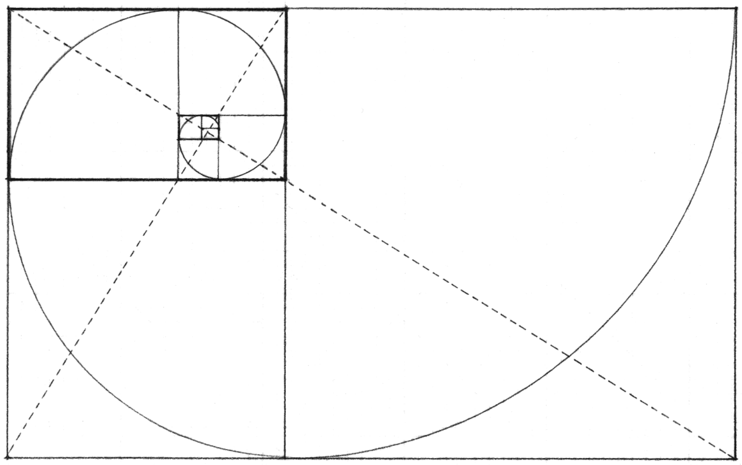

When dealing with forms in space, one must consider proportion in three dimensions.

Ratio A:B A/B

Proportion A:B:C A/B = B/C



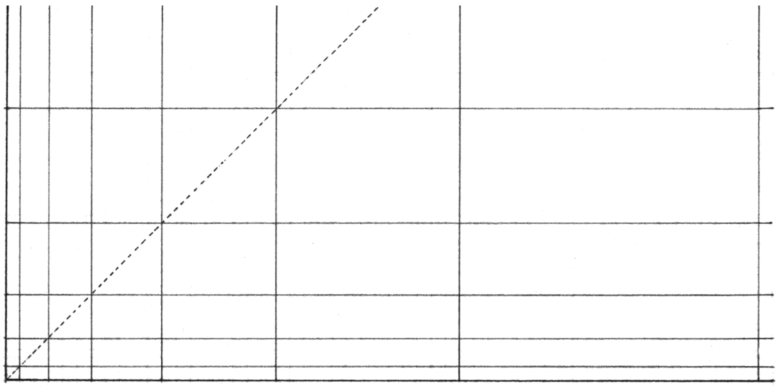

Golden Section: B/A = A/(A+B)



In the course of history, a number of mathematical or geometric methods have been developed to determine the ideal proportion of things. These proportioning systems go beyond functional and technical determinants in an attempt to establish a measure of beauty—an aesthetic rationale for the dimensional relationships among the parts and elements of a visual construction.

According to the ancient Greek mathematician Euclid, a ratio refers to the quantitative comparison of two similar things, while proportion refers to the equality of ratios. Underlying any proportioning system, therefore, is a characteristic ratio, a permanent quality that is transmitted from one proportion to another.

Perhaps the most familiar proportioning system is the *golden section* established by the ancient Greeks. It defines the unique relationship between two unequal parts of a whole in which the ratio between the smaller and greater parts is equal to the ratio between the greater part and the whole.

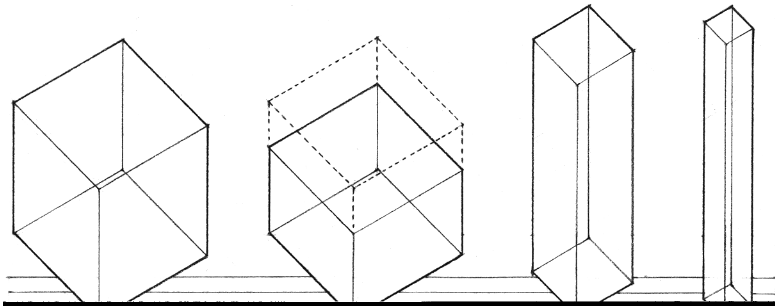


1,1,2,3,5,8,13,21,34,55…

The Fibonacci series is a progression of whole numbers wherein each term is the sum of the preceding two. The ratio between two consecutive terms approximates the golden section.

Although often defined in mathematical terms, a proportioning system establishes a consistent set of visual relationships among the parts of a composition. It can be a useful design tool for promoting unity and harmony. However, our perception of the physical dimensions of things is often imprecise. The foreshortening of perspective, viewing distance, or even cultural bias can distort our perception.

The matter of proportion is primarily one of critical visual judgment. In this respect, significant differences in the relative dimensions of things are important. Ultimately, a proportion will appear to be correct for a given situation when we sense that neither too little nor too much of an element or characteristic is present.



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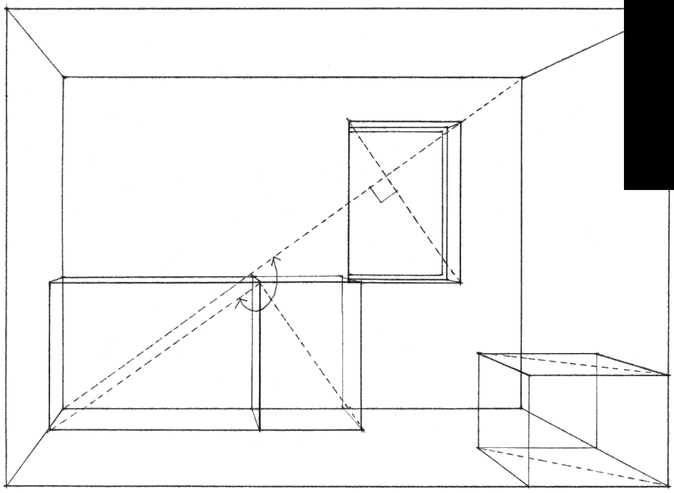
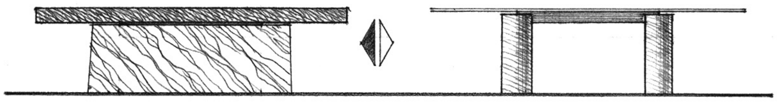
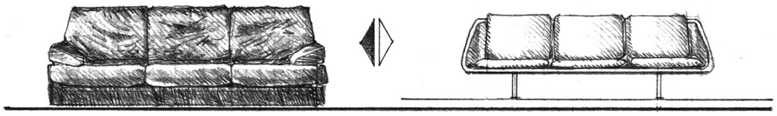


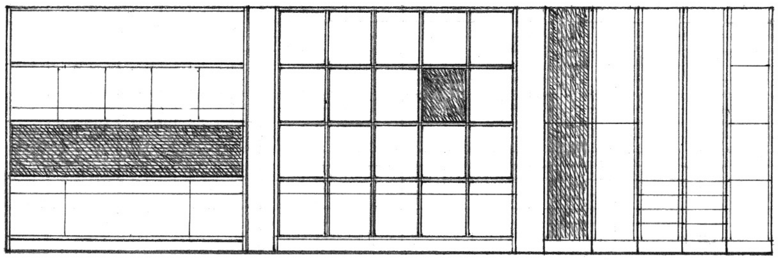
Diagonals that are parallel or perpendicular to each other indicate that the rectangles they bisect have similar proportions.



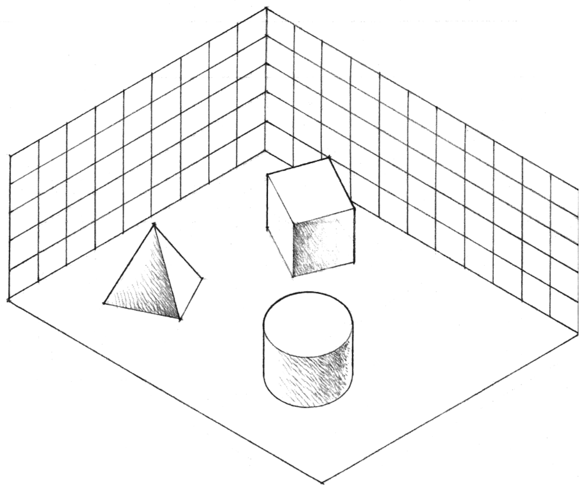
In interior design, we are concerned with the proportional relationships between the parts of a design element, between several design elements, and between the elements and the spatial form and enclosure.

## Proportional differences

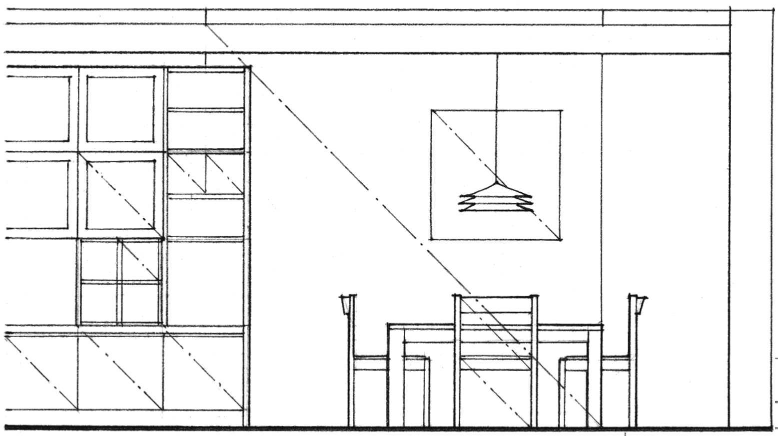




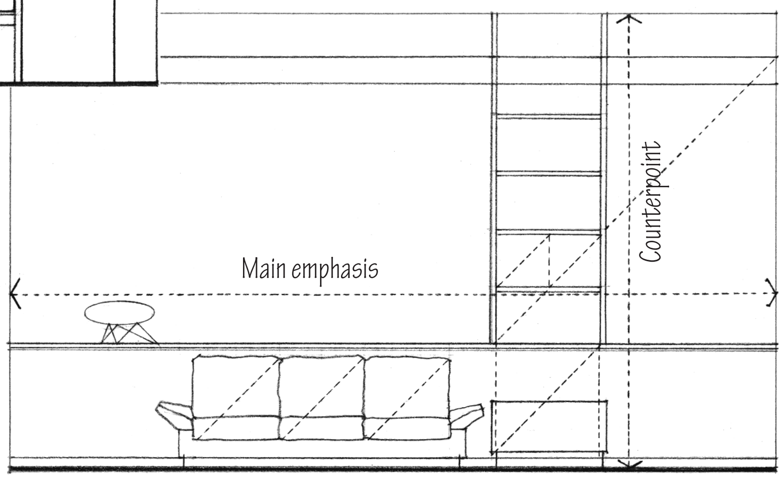
Between parts of an element



Between elements and the spatial enclosure

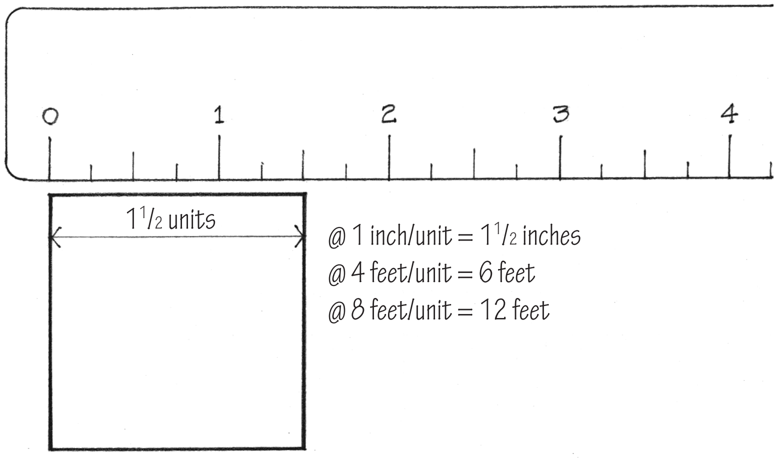


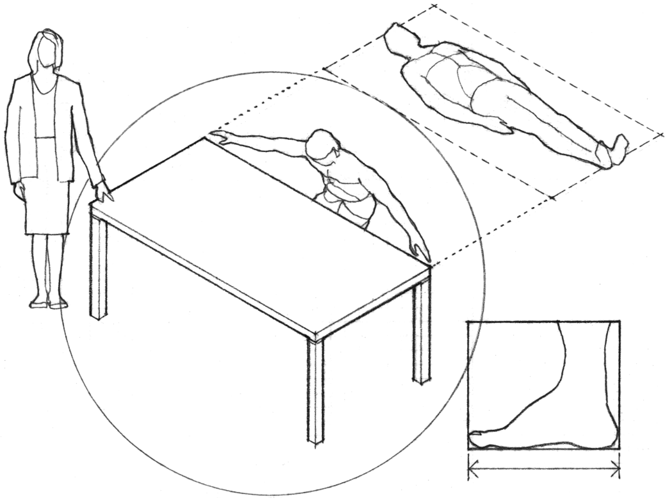
Between elements



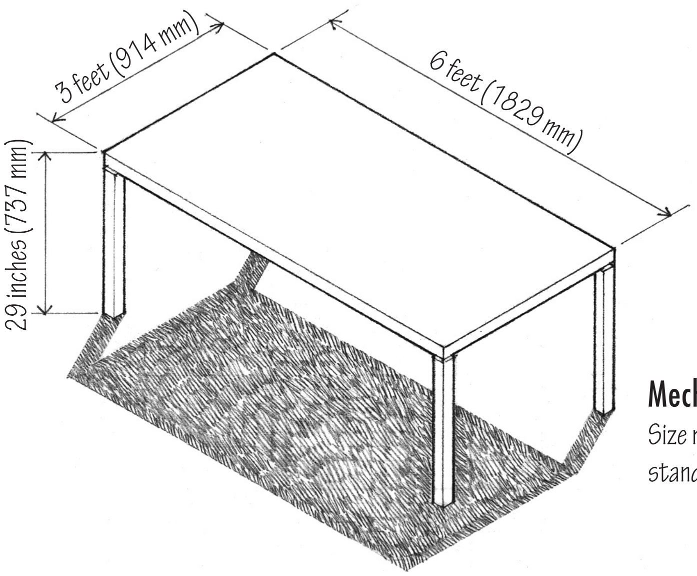
The design principle of scale is related to proportion. Both proportion and scale deal with the relative sizes of things. If there is a difference, proportion pertains to the relationships between the parts of a composition, while scale refers specifically to the size of something, relative to some known standard or recognized constant.

Mechanical scale is the calculation of something's physical size according to a standard system of measurement. For example, we can say that a table is, according to the U.S. Customary System, 3 feet wide, 6 feet long, and 29 inches high. If we are familiar with this system and with objects of similar size, we can visualize how big the table is. Using the International System of Units (the metric system), the same table would measure 914 mm wide, 1829 mm long, and 737 mm high.



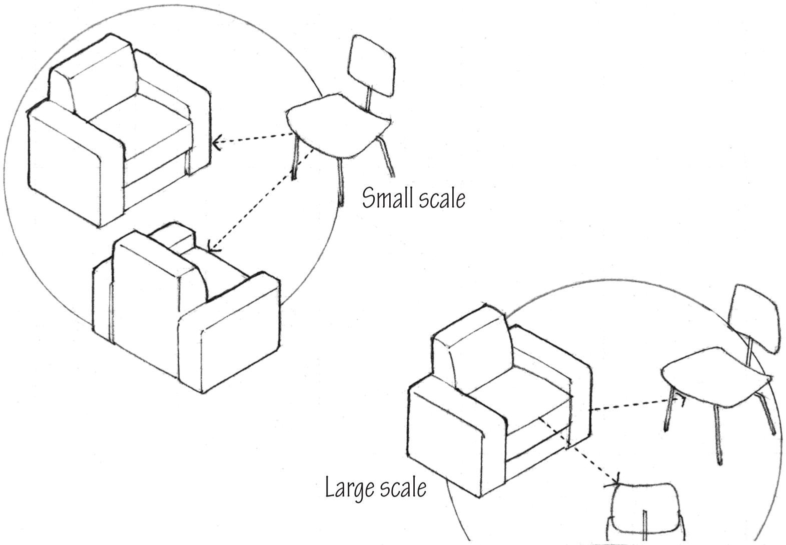
Our bodies can serve as a system of measurement.

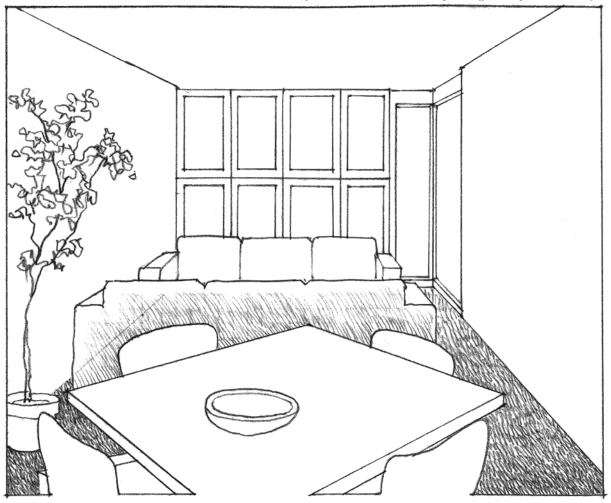



**Mechanical Scale**
Size relative to an accepted standard of measurement

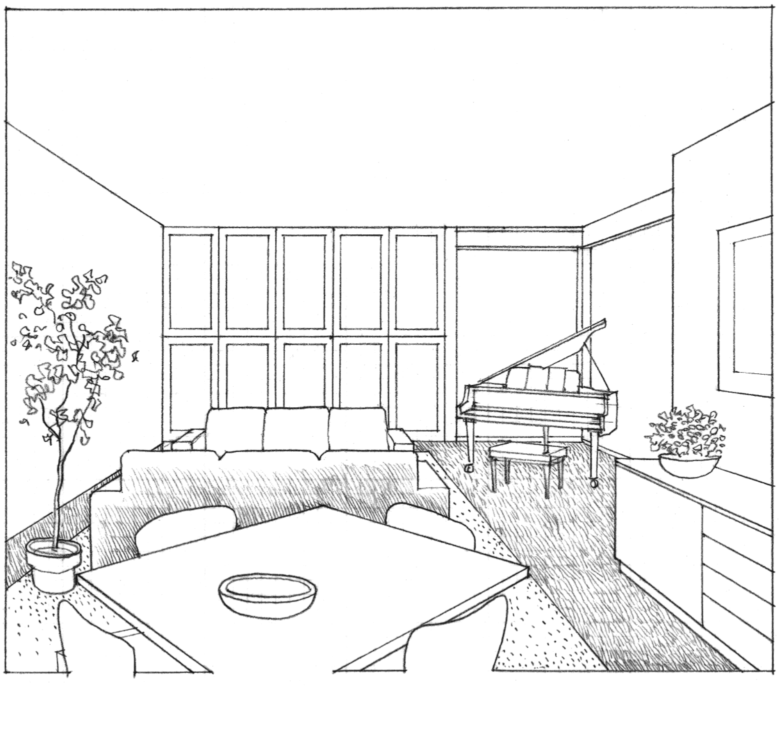
Visual scale refers to the size something appears to have when measured against other things around it. Thus, an object's scale is often a judgment we make based on the relative or known sizes of nearby or surrounding elements. For example, the aforementioned table can appear to be in scale or out of scale with a room, depending on the relative size and proportions of the space.

We can refer to something as being small scale if we are measuring it against other things that are generally much larger. Similarly, an object can be considered to be large scale if it is grouped with relatively small items, or if it appears to be larger than what is considered normal or average.



Small-scale space or large-scale furniture

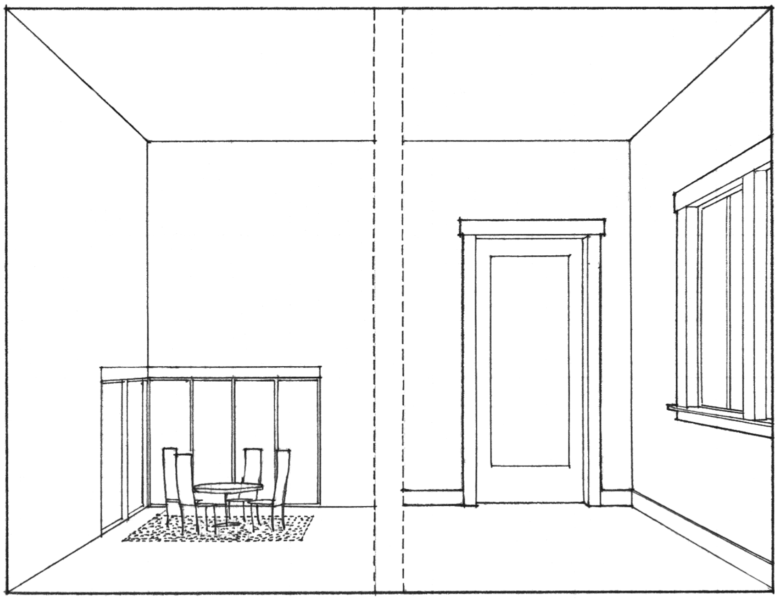


**Visual Scale**
Size relative to other objects in the environment or to the surounding space

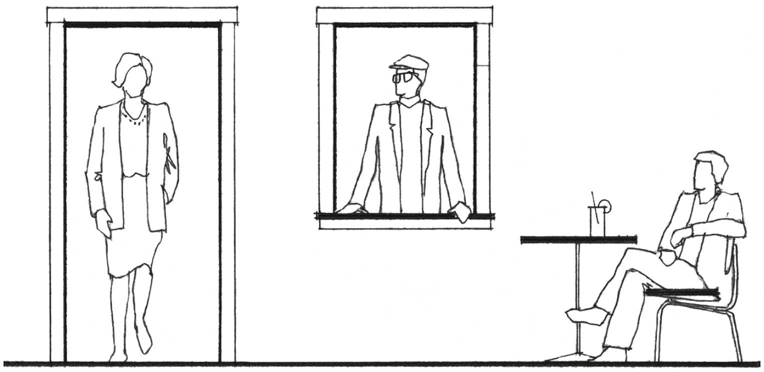
Human scale refers to the feeling of bigness something gives us. If the dimensions of an interior space or the sizes of elements within it make us feel small, we can say they lack human scale. If, on the other hand, the space does not dwarf us, or if the elements offer a comfortable fit with our dimensional requirements of reach, clearance, or movement, we can say they are human in scale.

Most of the elements we use to ascertain human scale are those whose dimensions we have become accustomed to through contact and use. These include doorways, stairs, tables, counters, and various types of seating. These elements can be used to humanize a space that would otherwise lack human scale.

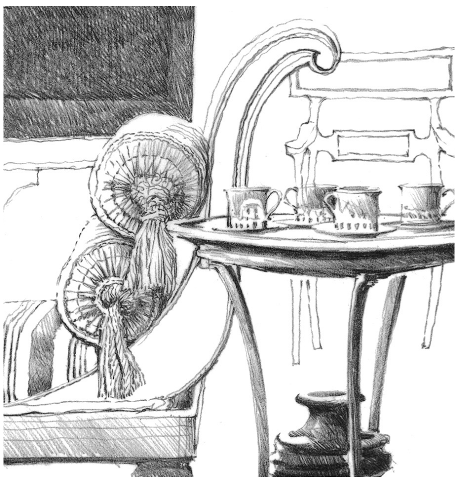
Interior details near eye level can be used to bring the scale of an architectural space down to human size. For example, a chair rail along a wall creates a visual line at roughly hand height. Similarly, moderately scaled artwork and accessories can help make an imposing space feel more comfortable.

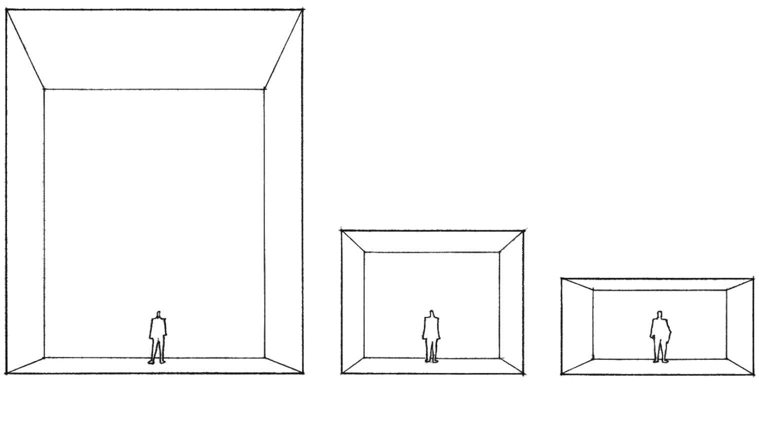


We can judge the scale of a space by the relative size of the interior elements within it.



We often use doorways, windowsills, tables, and chairs to discern human scale because we have become accustomed to their dimensions.

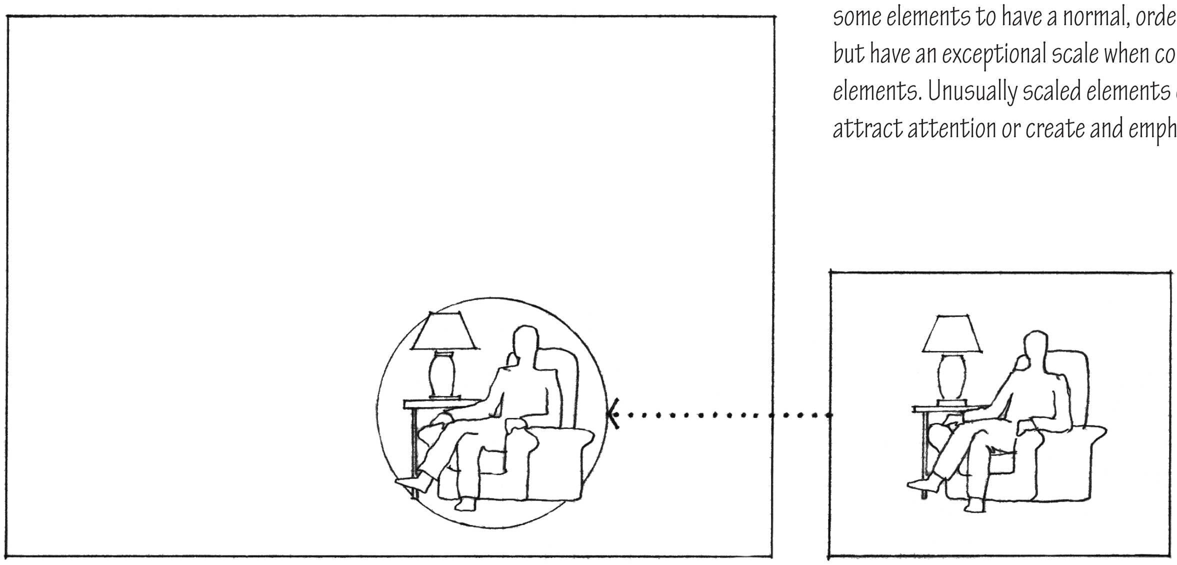




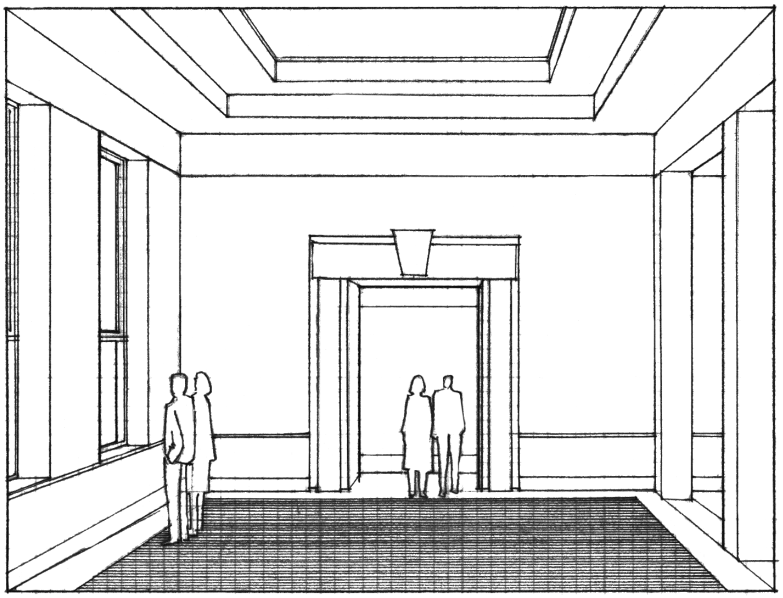
**Human Scale**

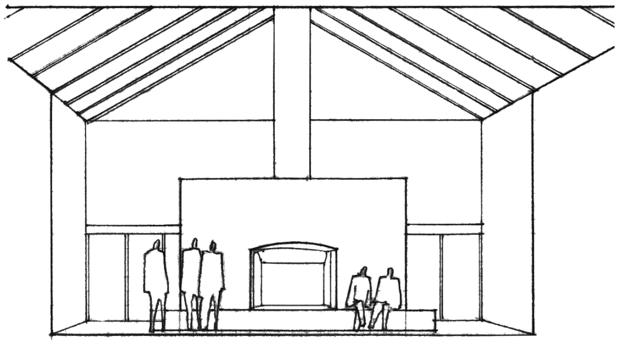
The feeling of smallness or bigness a space or an interior element gives us.

The issue of scale in an interior space is not limited to one set of relationships. Interior elements can be related simultaneously to the whole space, to each other, and to those people who use the space. It is not unusual for some elements to have a normal, orderly scale relationship but have an exceptional scale when compared to other elements. Unusually scaled elements can be used to attract attention or create and emphasize a focal point.



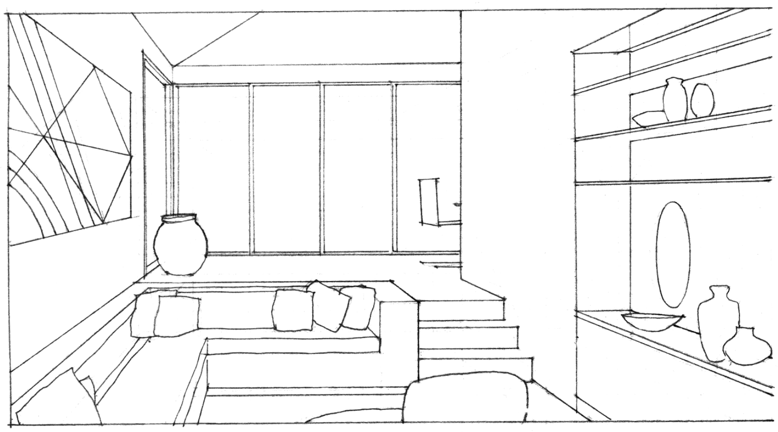
A set of scale relationships can exist within a larger context.



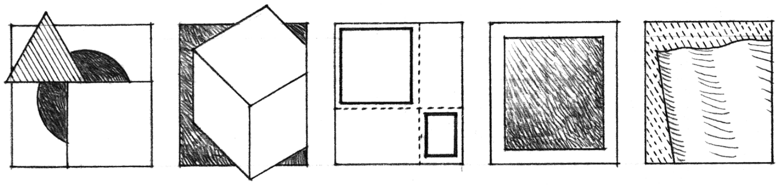


Doorways and windows may be scaled to the dimensions of a space while sill heights and wainscots retain a human scale.

Interior spaces—and their elements of enclosure, furnishings, lighting, and accessories—often include a mix of shapes, sizes, colors, and textures. The organization of these elements is a response to functional needs and aesthetic desires. At the same time, these elements should be arranged to achieve visual balance—a state of equilibrium among the visual forces projected by the elements.



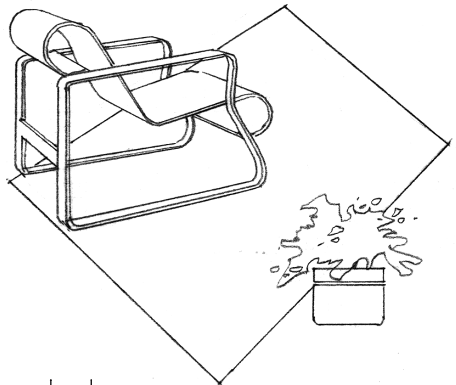
Each element in the ensemble of interior space has specific characteristics of shape, form, size, color, and texture. These characteristics, along with the factors of location and orientation, determine the visual weight of each element and how much attention each will attract in the overall pattern of space.

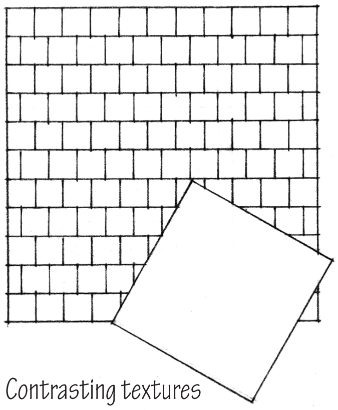


Interiors: A mix of shapes, colors, and textures

Characteristics that will enhance or increase the visual weight of an element—and attract our attention—include:

- Irregular or contrasting shapes
- Bright colors and contrasting textures
- Large dimensions and unusual proportions
- Elaborate details

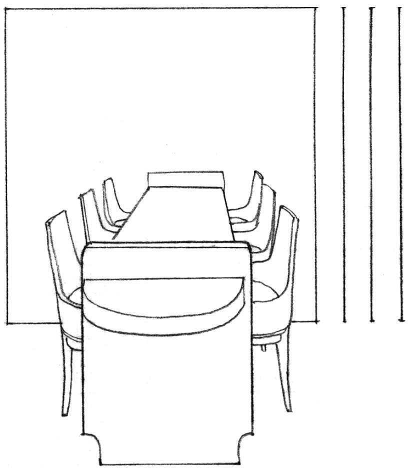




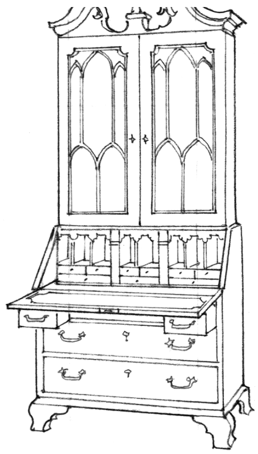
Attracting attention with . . .

Irregular shapes

Contrasting textures

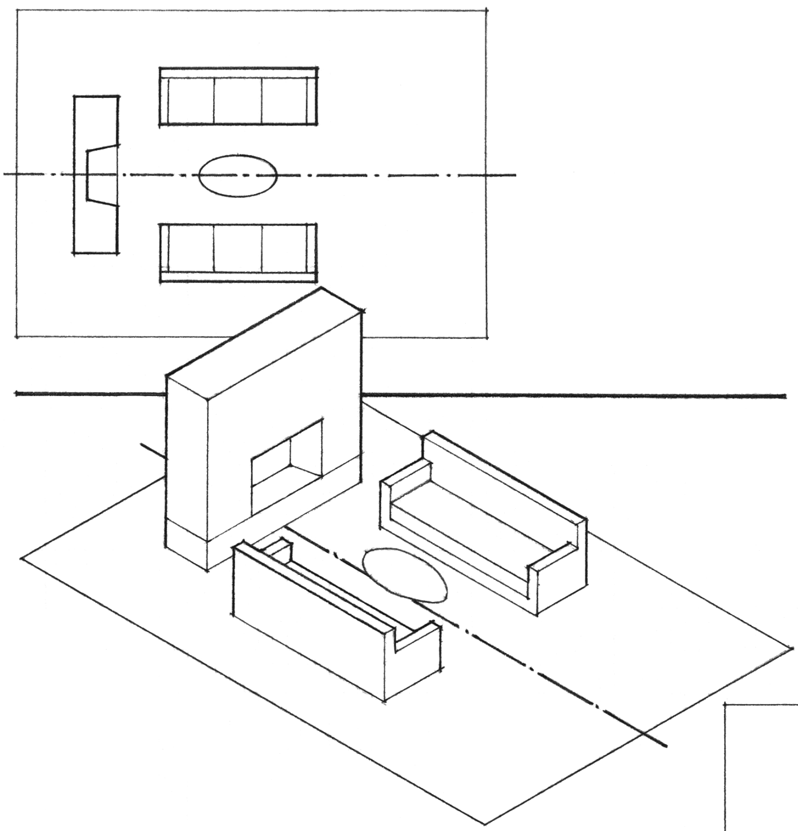


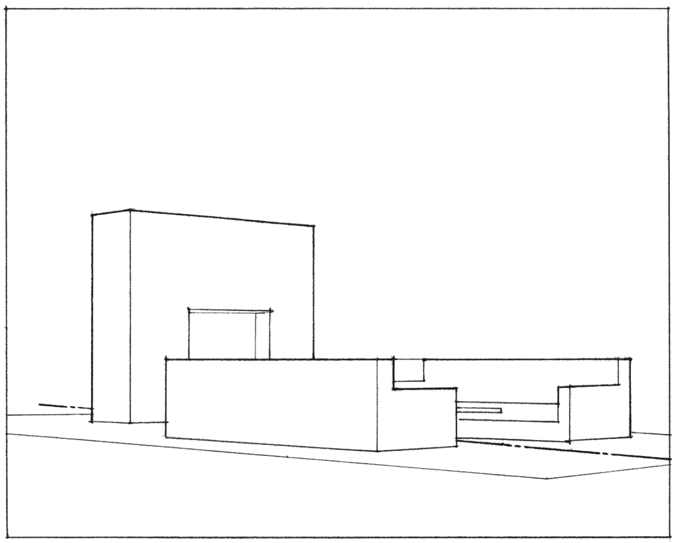
Unusual proportions

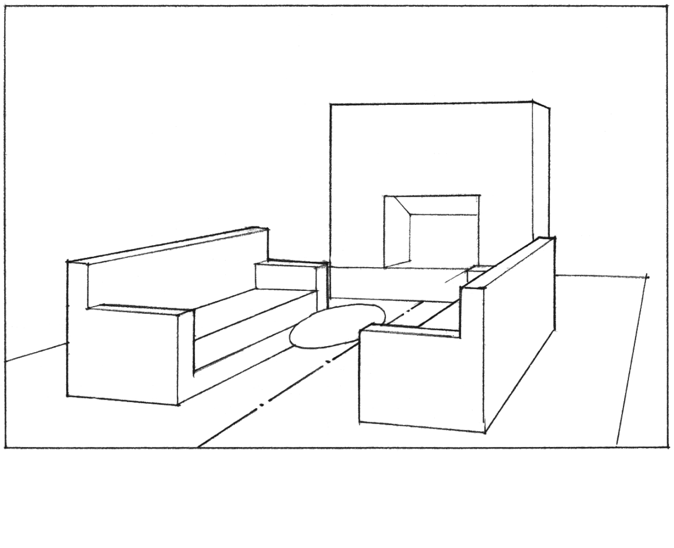


Elaborate details

Our perception of a room, and the composition of its elements, is altered as we use it and move through its space. Our perspective varies as our point of view shifts from here to there. A room also undergoes changes as it is illuminated by the light of day and by lighting fixtures at night, occupied by people and paraphernalia, and modified over time. The visual balance among the elements in a space should therefore be considered in three dimensions and be strong enough to withstand the changes brought about through time and use.



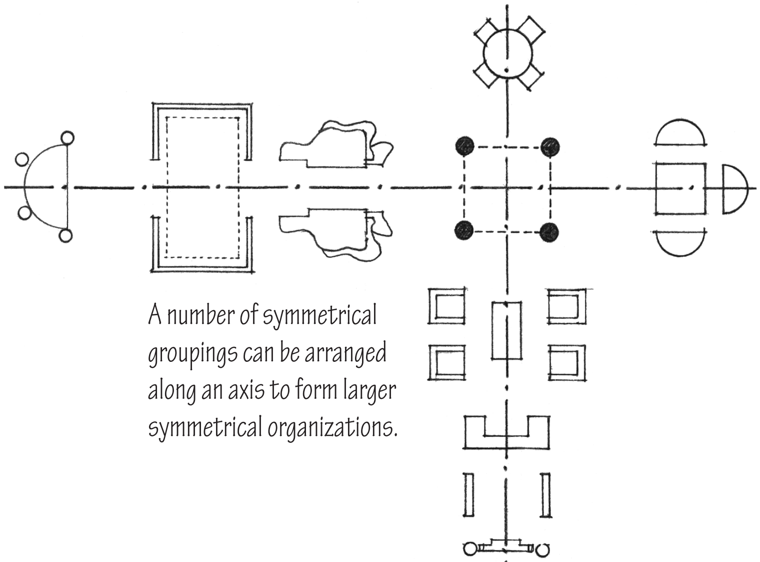




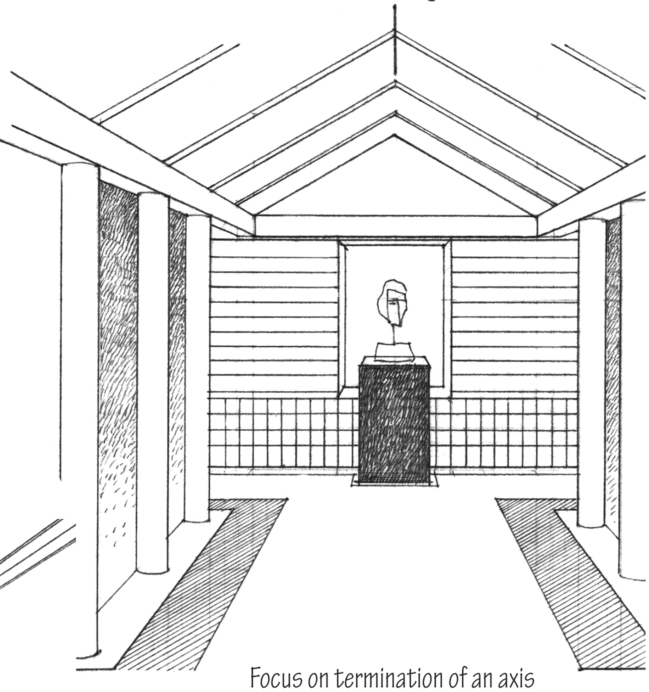
Visual balance must be considered in three dimensions.

There are three types of visual balance: symmetrical, radial, and asymmetrical. Symmetrical balance results from the arrangement of identical elements, corresponding in shape, size, and relative position, about a common line or axis. It is also known as axial or bilateral symmetry.

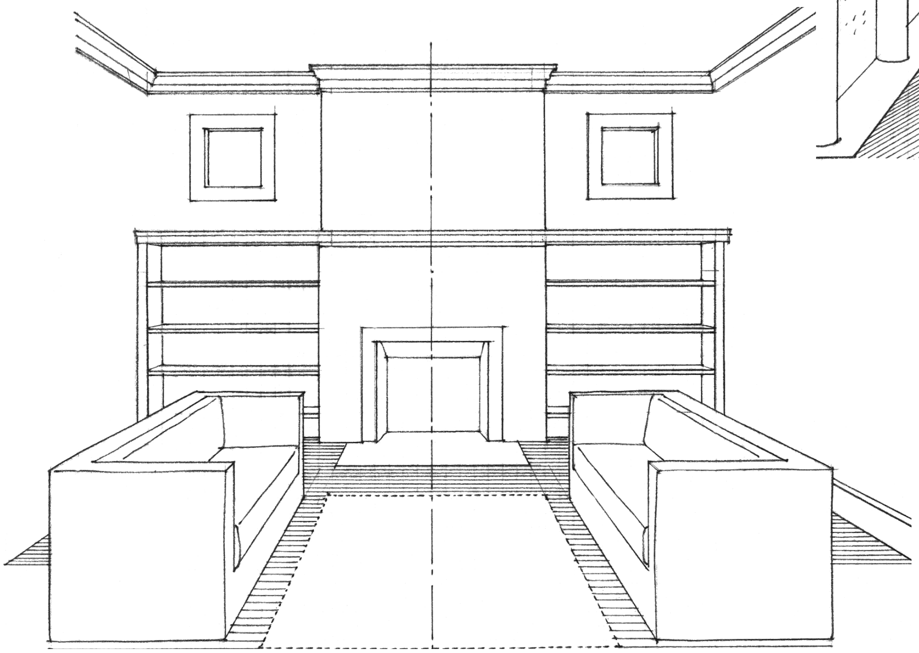
Symmetrical balance most often results in a quiet, restful, and stable equilibrium that is readily apparent, especially when oriented on a vertical plane. Depending on its spatial relationships, a symmetrical arrangement can either emphasize its central area or focus attention on the terminations of its axis.



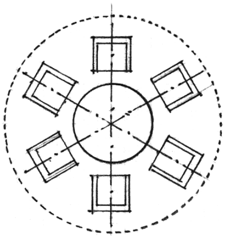
A number of symmetrical groupings can be arranged along an axis to form larger symmetrical organizations.

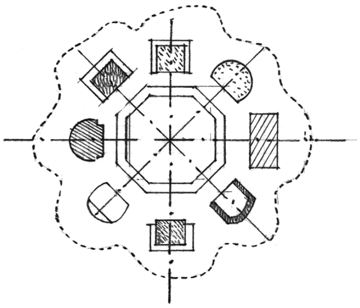


Focus on termination of an axis



Focus on the middle ground.

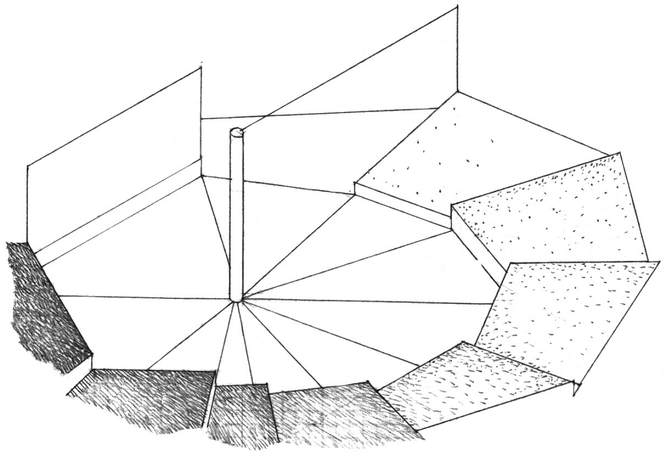


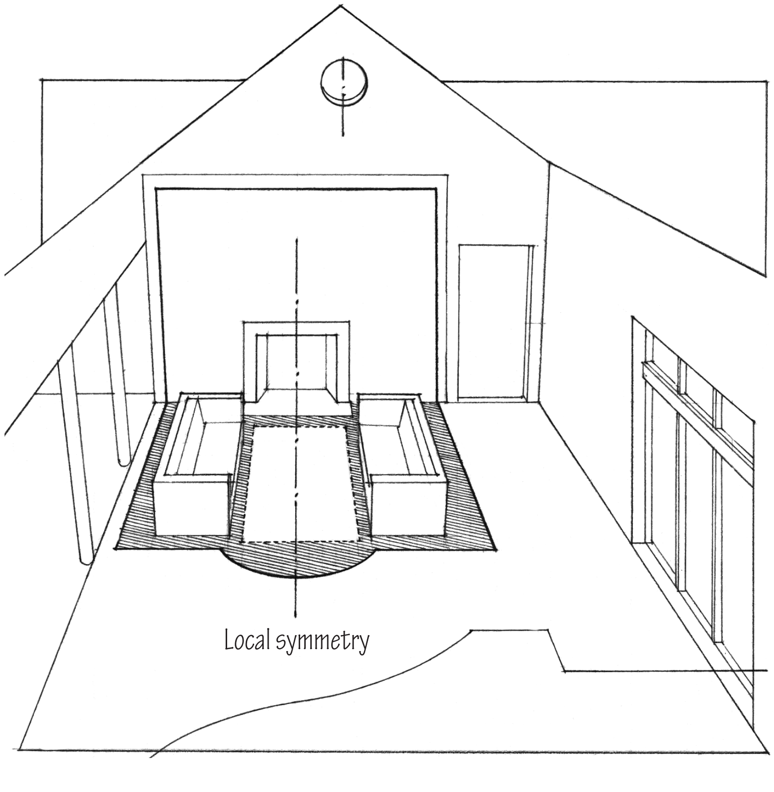


Symmetry is a simple yet powerful device to establish visual order. If carried far enough, it can impose a strict formality on an interior space. Total symmetry, however, is often undesirable or difficult to achieve because of function or circumstance.

It is often possible or desirable to arrange one or more parts of a space in a symmetrical manner and produce local symmetry. Symmetrical groupings within a space are easily recognized and have a quality of wholeness that can serve to simplify or organize the room's composition.

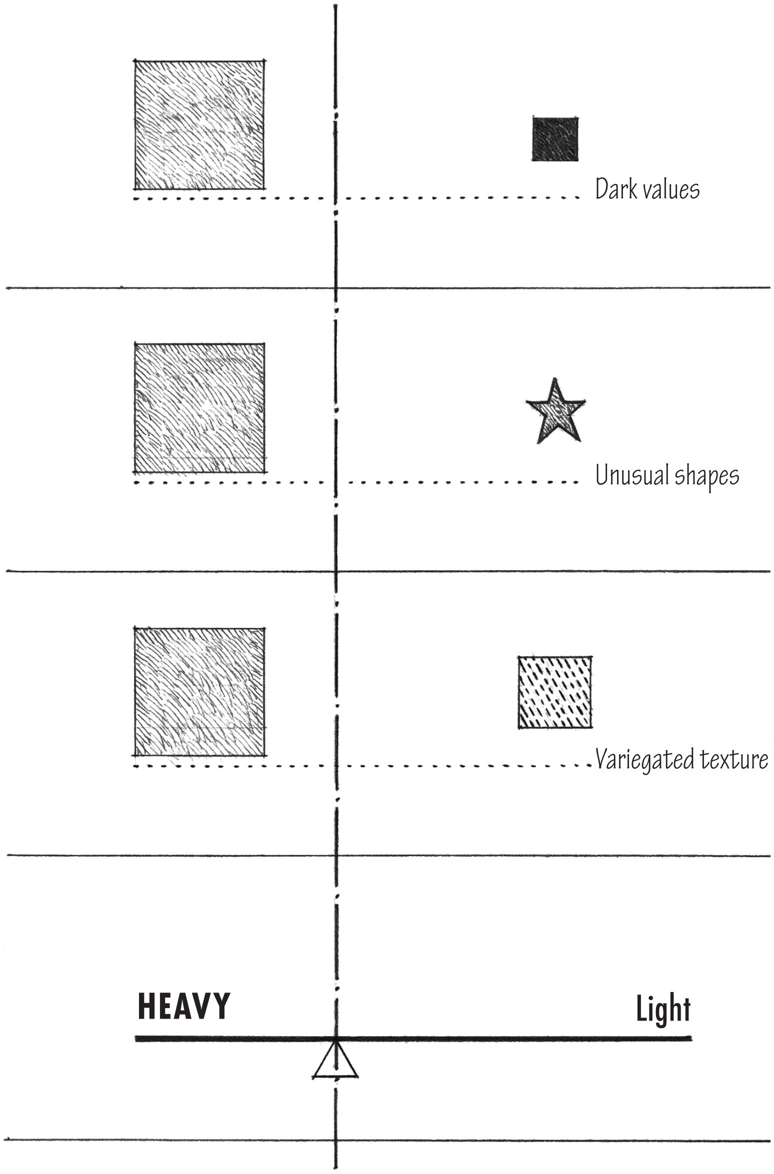
The second type of balance, radial balance, results from the arrangement of elements about a center point. It produces a centralized composition that stresses the middle ground as a focal point. The elements can focus inward toward the center, face outward from the center, or simply be placed about a central element.

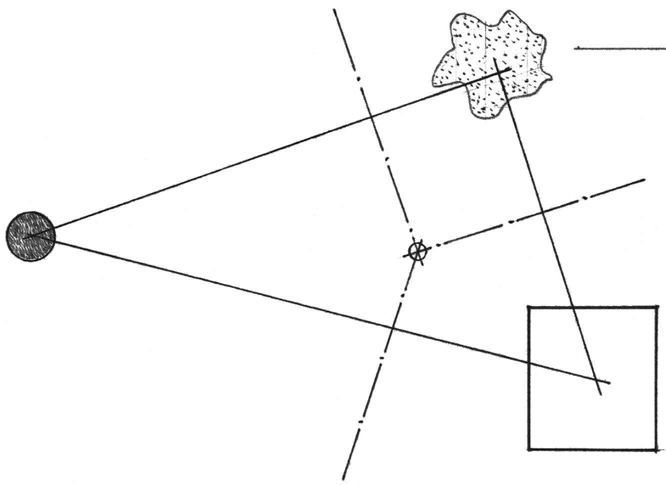




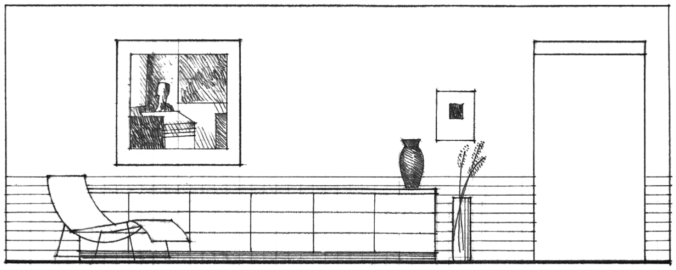
Asymmetry is recognized as the lack of correspondence in size, shape, color, or relative position among the elements of a composition. While a symmetrical composition requires the use of pairs of identical elements, an asymmetrical composition incorporates dissimilar elements.

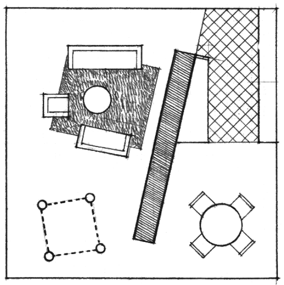
To achieve an occult or optical balance, an asymmetrical composition must take into account the visual weight or force of each of its elements and employ the principle of leverage in their arrangement. Elements that are visually forceful and attract our attention—unusual shapes, bright colors, dark values, variegated textures—must be counterbalanced by less forceful elements that are larger or placed farther away from the center of the composition.

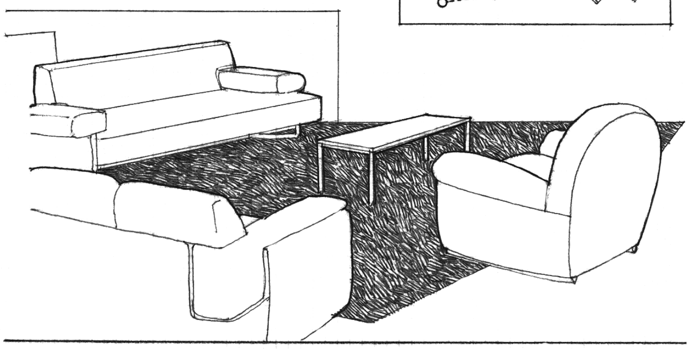


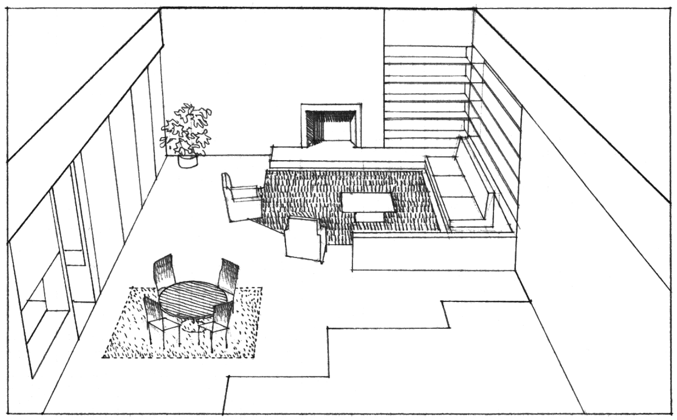



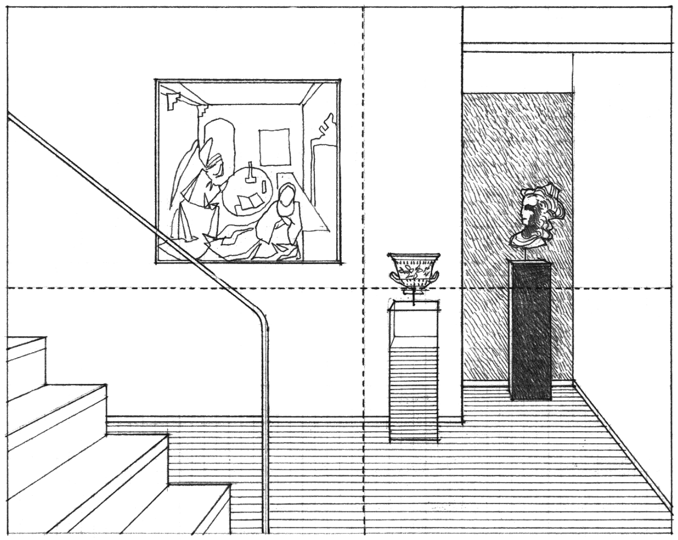
Asymmetrical balance is not as obvious as symmetry and is often more visually active and dynamic. It is capable of expressing movement, change, even exuberance. It is also more flexible than symmetry and can adapt more readily to varying conditions of function, space, and circumstance.





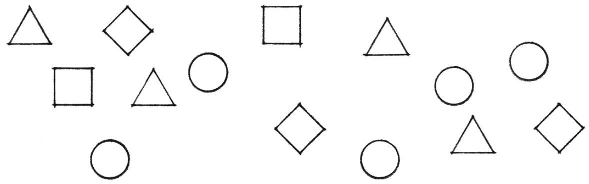




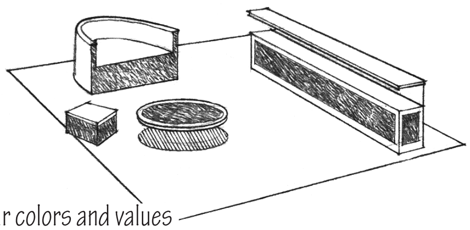


*Harmony* can be defined as consonance, or the pleasing agreement of parts or combination of parts in a composition. While balance achieves unity through the careful arrangement of both similar and dissimilar elements, the principle of harmony involves the careful selection of elements that share a common trait or characteristic, such as shape, color, texture, or material. It is the repetition of a common trait that produces unity and visual harmony among the elements in an interior setting.

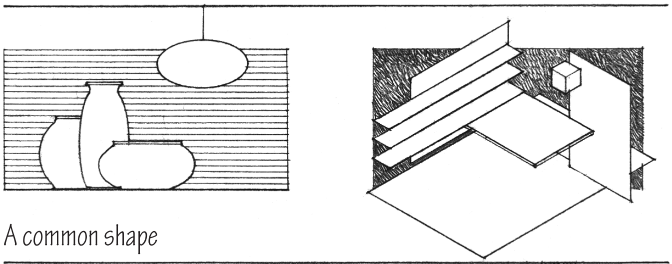
## Sharing a Common Trait



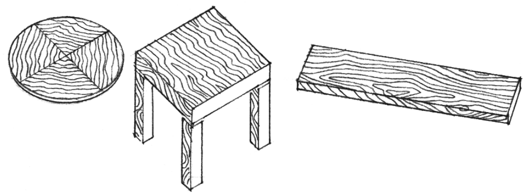
A common size



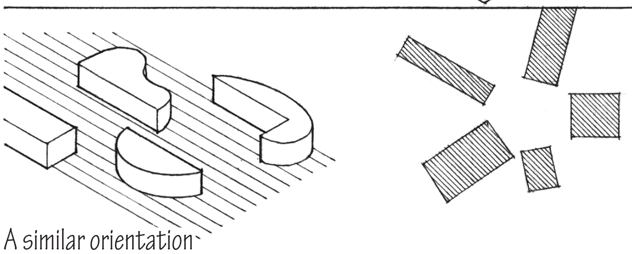
Similar colors and values



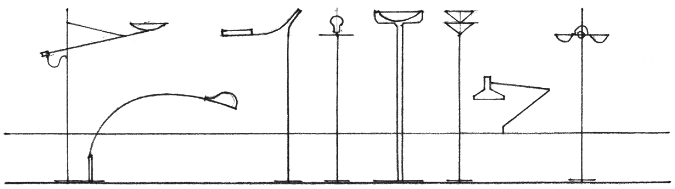
A common shape



Similar materials



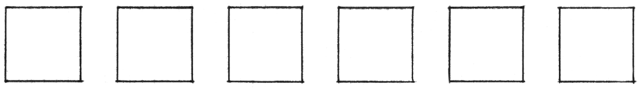
A similar orientation



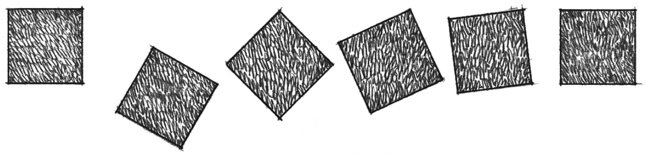
Similar detail characteristics

Harmony, when carried too far in the use of elements with similar traits, can result in a unified but uninteresting composition. Variety, on the other hand, when carried to an extreme for the sake of interest, can result in visual chaos. It is the careful and artistic tension between order and disorder—between unity and variety—that enlivens harmony and creates interest in an interior setting.

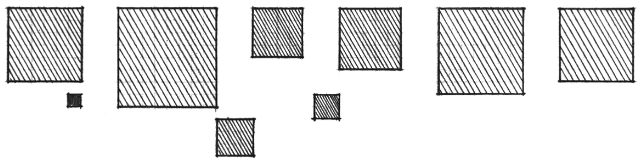
## Introducing Variety



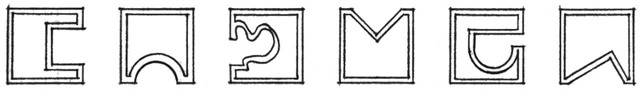
Given a set of identical shapes, variety can be introduced by:



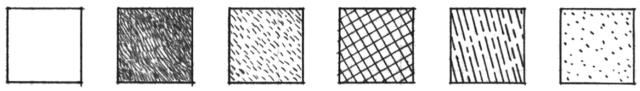
Varying orientation



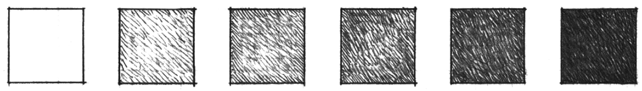
Varying size



Varying detail characteristics



Varying texture

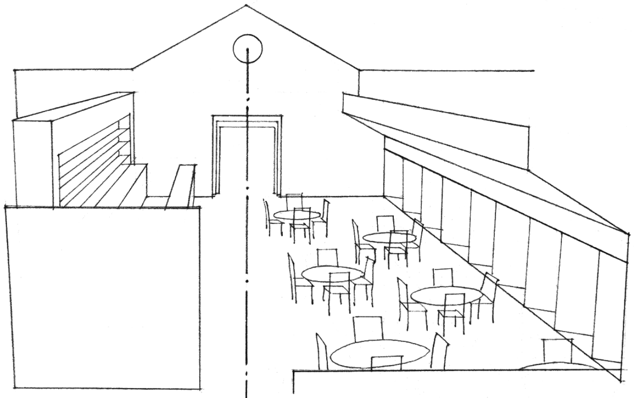


Varying color

It is important to note that the principles of balance and harmony, in promoting unity, do not exclude the pursuit of variety and interest. Rather, the means for achieving balance and harmony are intended to include in their patterns the presence of dissimilar elements and characteristics.

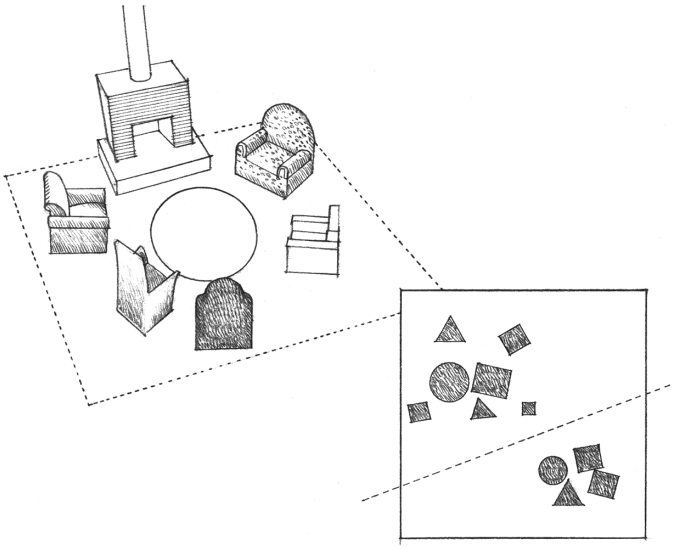
For example, asymmetrical balance produces equilibrium among elements that differ in size, shape, color, or texture. The harmony produced by elements that share a common characteristic permits the same elements to also have a variety of unique, individual traits.

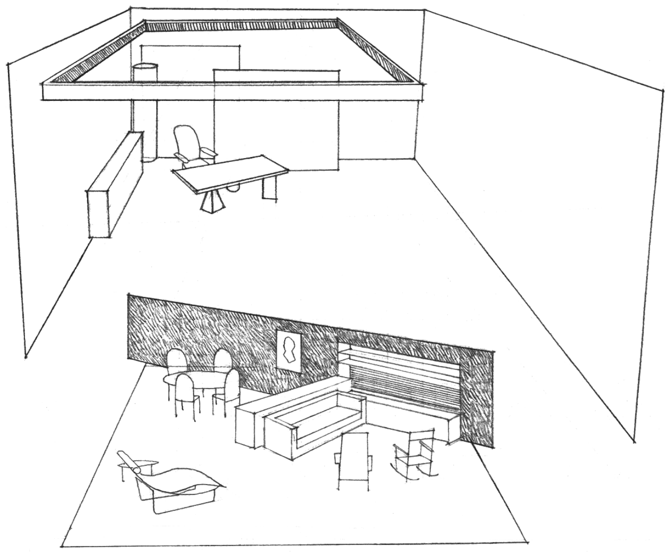
Another method for organizing a number of dissimilar elements is to arrange them in close proximity to one another. We tend to read such a grouping as an entity, to the exclusion of other elements farther away. To further reinforce the visual unity of the composition, continuity of line or contour can be established among the elements' shapes.



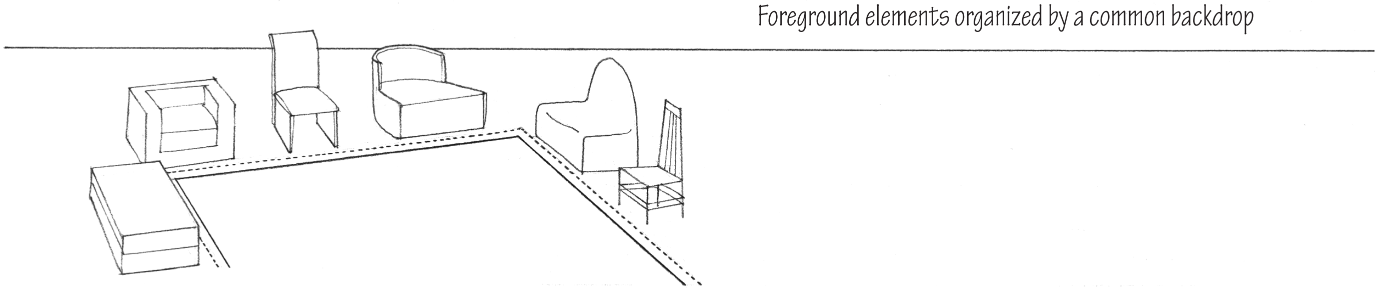
Asymmetrical schemes can organize a variety of shapes, colors, and textures into their layouts.

Grouping related to an overhead plane

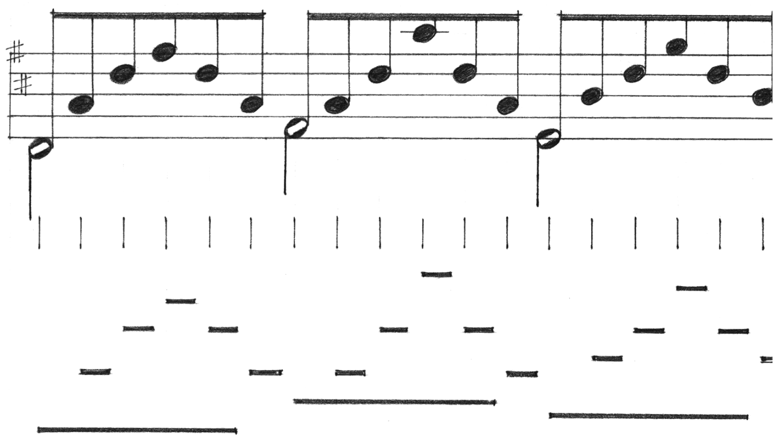




Foreground elements organized by a common backdrop

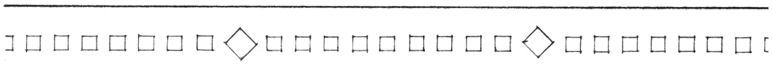


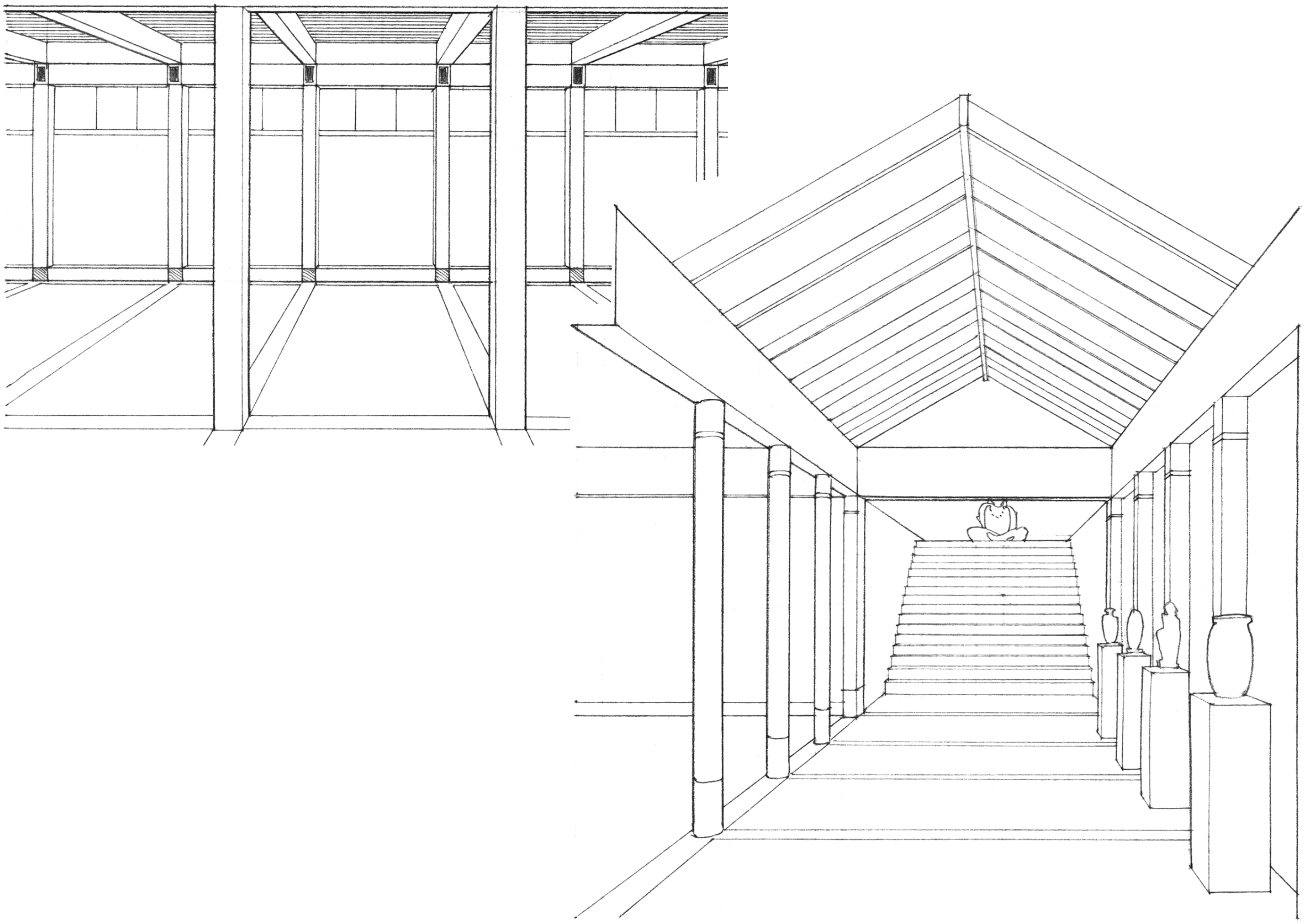
Dissimilar elements can be organized by grouping them in close proximity or by relating them to a common line or plane.



The design principle of *rhythm* is based on the repetition of elements in space and time. This repetition not only creates visual unity but also induces a recurring continuity of movement that a viewer's eyes and mind can follow along a path, within a composition, or around a space.

The simplest form of repetition consists of the regular spacing of identical elements along a linear path. Although this pattern can be quite monotonous, it can also be useful in establishing a background rhythm for foreground elements or in defining a textured line, border, or trim.



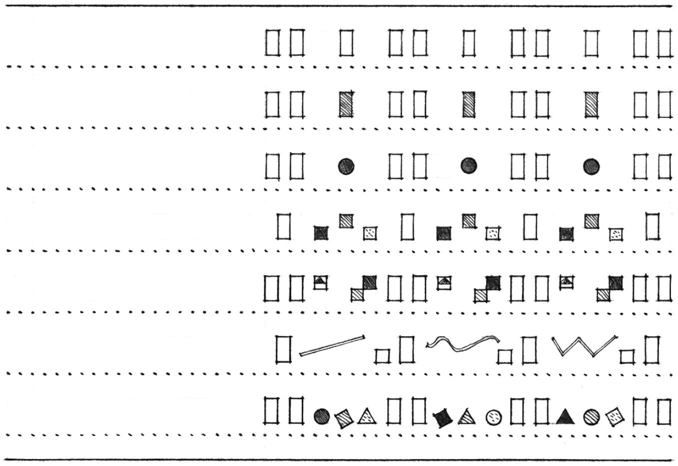


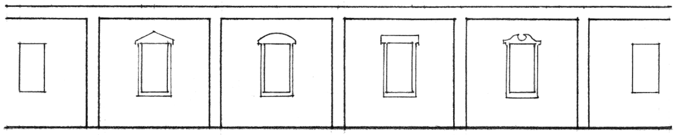
The repetitive nature of structural elements creates a natural rhythm in three dimensions.

More intricate patterns of rhythm can be produced by taking into account the tendency for elements to be visually related by their proximity to one another or their sharing of a common trait.

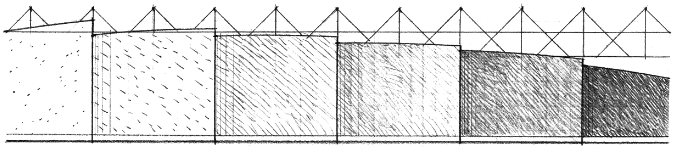
The spacing of the recurring elements, and thus the pace of the visual rhythm, can be varied to create sets and subsets and to emphasize certain points in the pattern. The resulting rhythm may be graceful and flowing or crisp and sharp. The contour of the rhythmic pattern and the shape of the individual elements can further reinforce the nature of the sequence.

Although the recurring elements must, for continuity, share a common trait, they can vary in shape, detail, color, or texture. These differences, whether subtle or distinct, create visual interest and can introduce other levels of complexity. An alternating rhythm can be superimposed over a more regular one, or the variations can be progressively graded in size or color value to give a direction to the sequence.

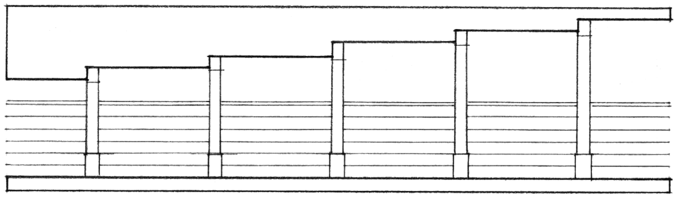




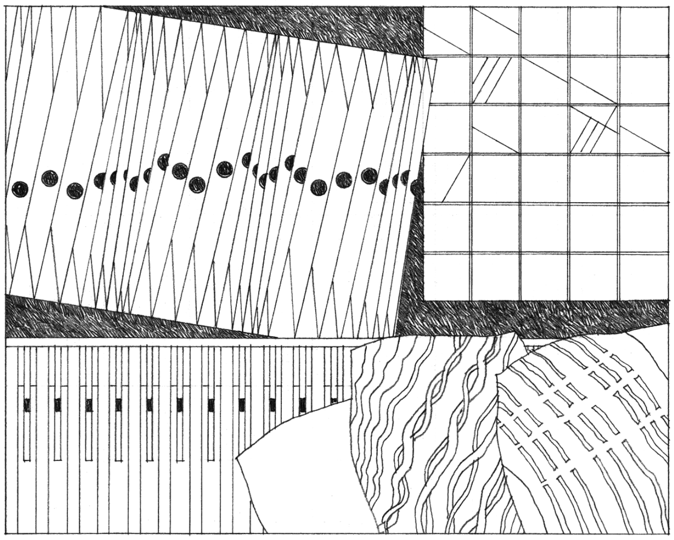
Detail variations in rhythm



Gradation in value or color

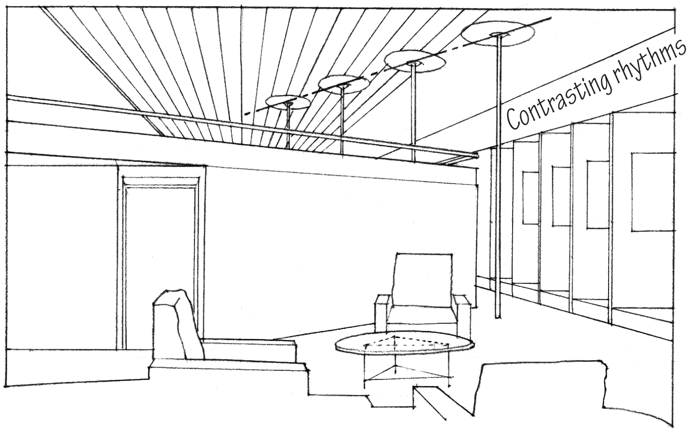


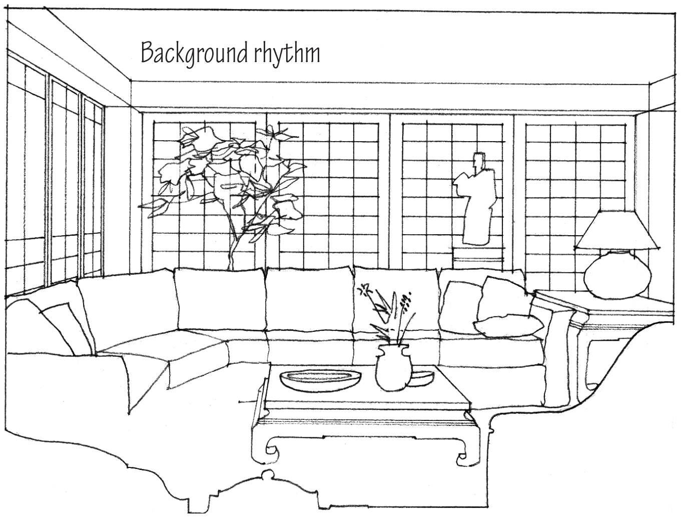
Gradation in size

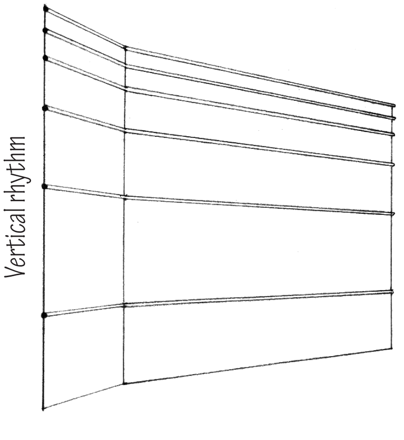


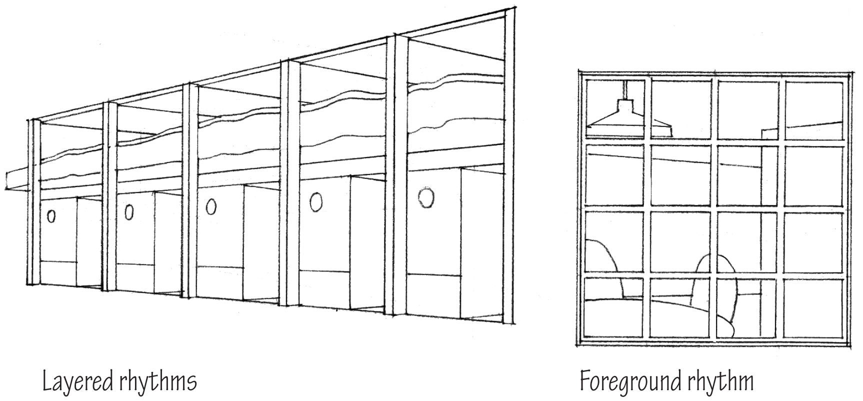
Rhythm existing at the detail level

Visual rhythm is most easily recognized when the repetition forms a linear pattern. Within an interior space, however, nonlinear sequences of shape, color, and texture can provide subtler rhythms that may not be immediately obvious to the eye.



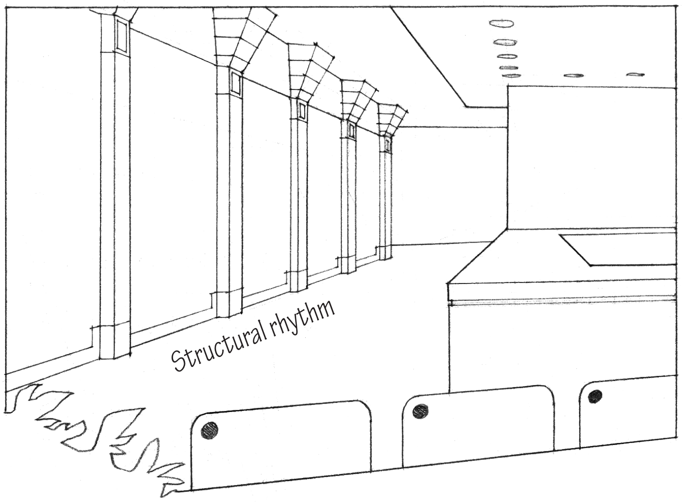



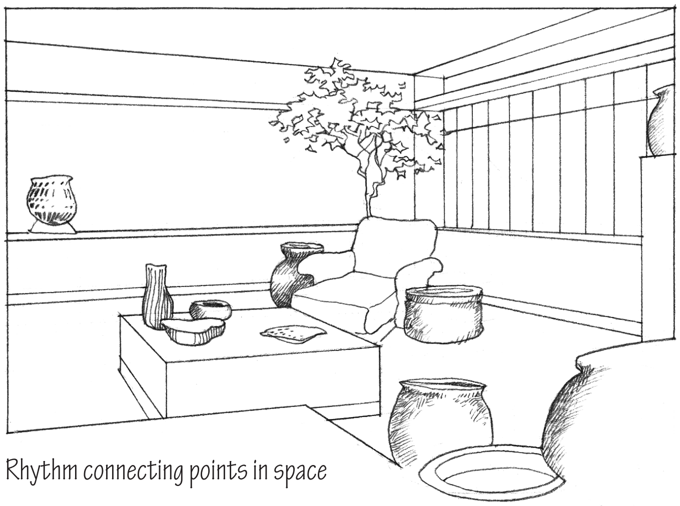
Layered rhythms

Foreground rhythm

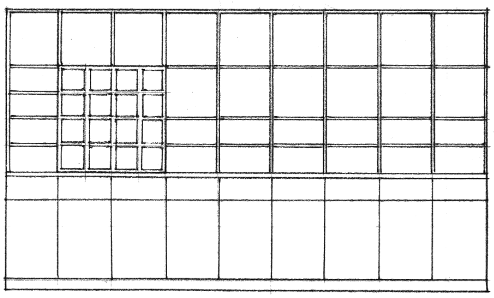
Rhythm may refer to the movement of our bodies as we advance through a sequence of spaces. Rhythm incorporates the fundamental notion of repetition as a device to organize forms and spaces in architecture. Beams and columns repeat themselves to form repetitive structural bays and modules of space. Spaces often recur to accommodate similar or repetitive functional requirements in the building program.



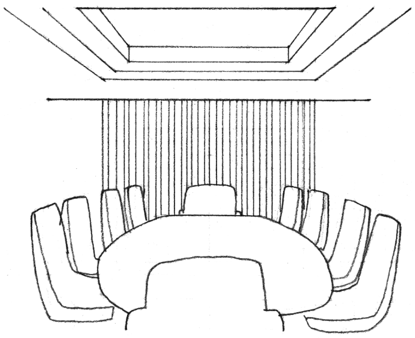
Structural rhythm

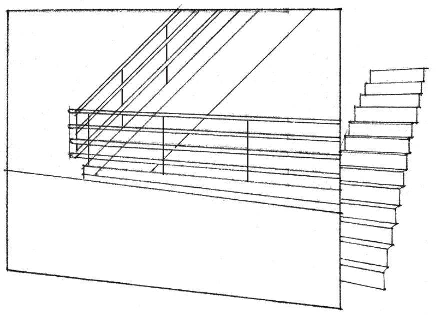


Rhythm connecting points in space

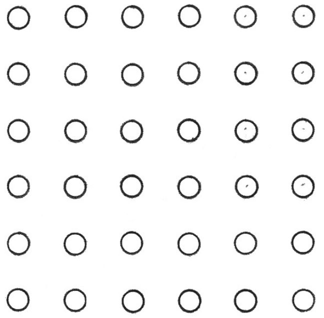


Vertical and horizontal rhythms

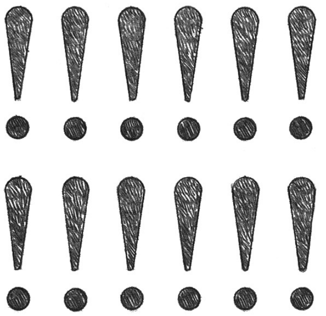




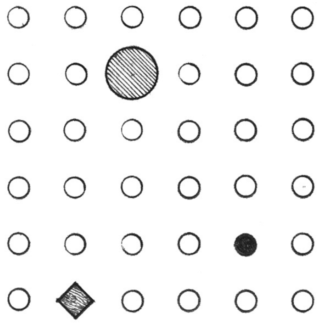
The manner in which stairways and railings express movement naturally results in rhythmic patterns.



No dominant elements . . .
no emphasis



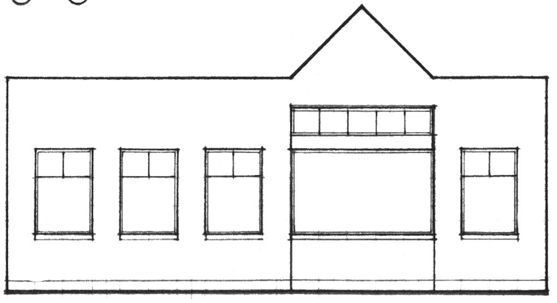
Too many dominant elements . . .
no emphasis



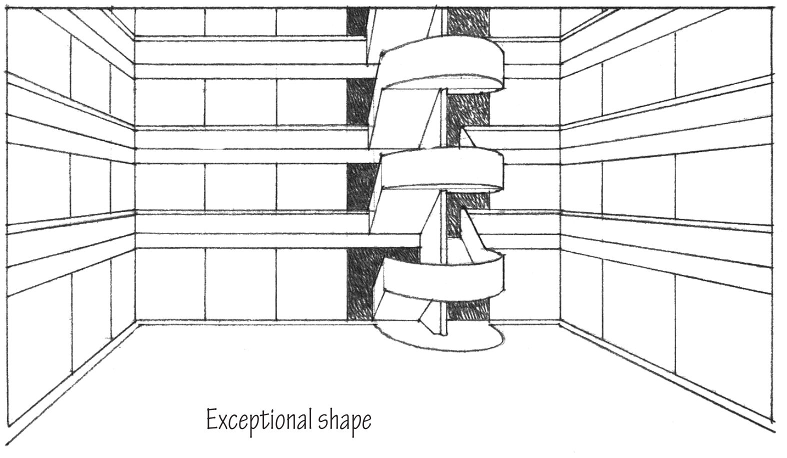
Points of emphasis can be created by a perceptible contrast in size, shape, color, or tonal value.

The principle of *emphasis* assumes the coexistence of dominant and subordinate elements in the composition of an interior setting. A design without any dominant elements would be bland and monotonous. If there are too many assertive elements, the design will be cluttered and chaotic, detracting from what may be important. Each part of a design should be given proper significance according to its degree of importance in the overall scheme.

An important element or feature can be given visual emphasis by endowing it with significant size, a unique shape, or a contrasting color, value, or texture. In each case, a discernible contrast must be established between the dominant element or feature and the subordinate aspects of the space. Such contrast will attract our attention by interrupting the normal pattern of the composition.



Exceptional size



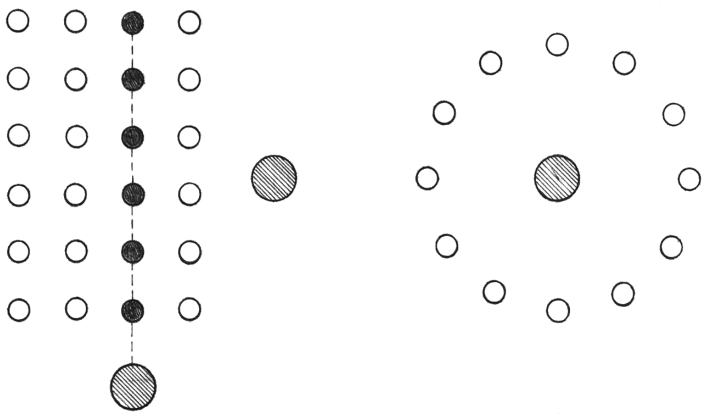
Exceptional shape

An element or feature can also be visually emphasized by its strategic position and orientation in a space. It can be centered within the space or serve as the centerpiece of a symmetrical organization. In an asymmetric composition, it can be offset or isolated from the rest of the elements. It can be the termination of a linear sequence or a path of movement.

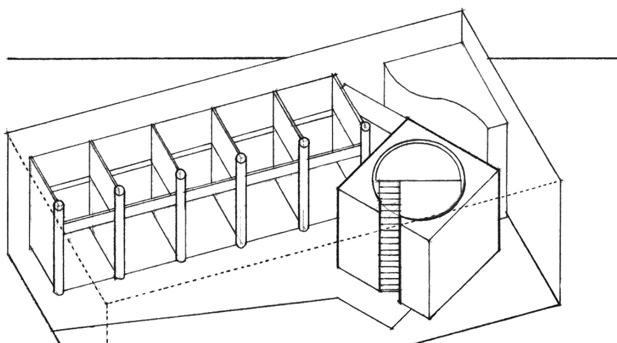
To further enhance its visual importance, an element can be oriented to contrast with the normal geometry of the space and the other elements within it. It can be illuminated in a special manner. The lines of secondary and subordinate elements can be arranged to focus our attention on the significant element or feature.

Some strategies for creating emphasis when using lighting and color together include:

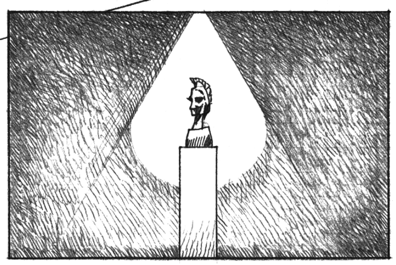
- String rope lighting in or around a ceiling to add dimension and lighten darker hues.
- Suspend eye-catching pieces in a tall, colorful lobby to emphasize its height.
- Use smaller, separate light fixtures to create individual spaces.



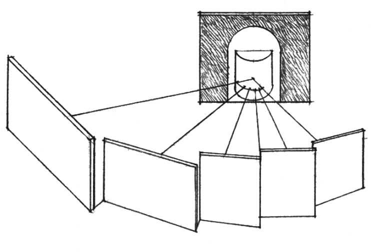
Points of emphasis can be created by the strategic positioning of important elements.



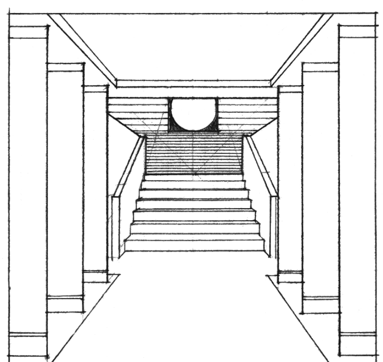
Shift in geometry



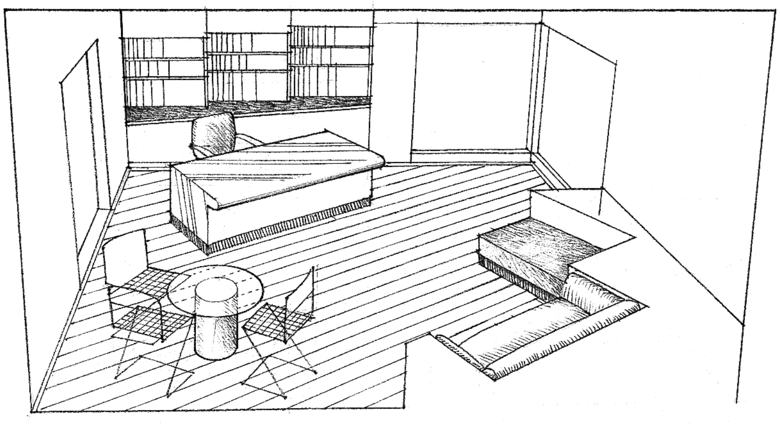
Spotlighted



Center of focus

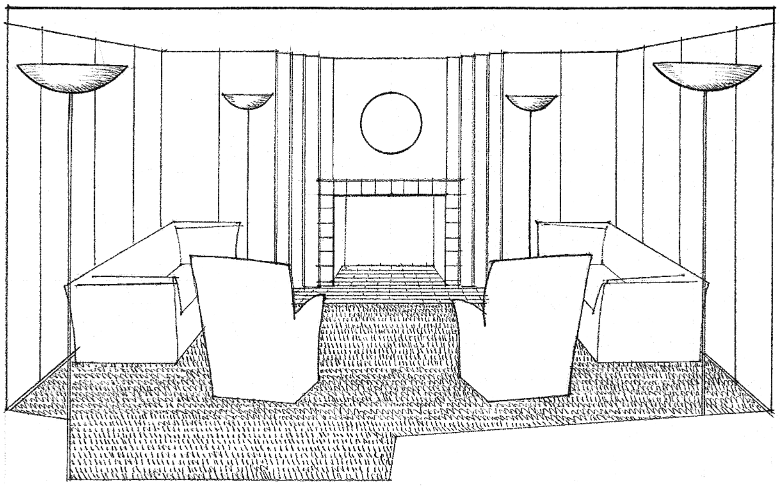


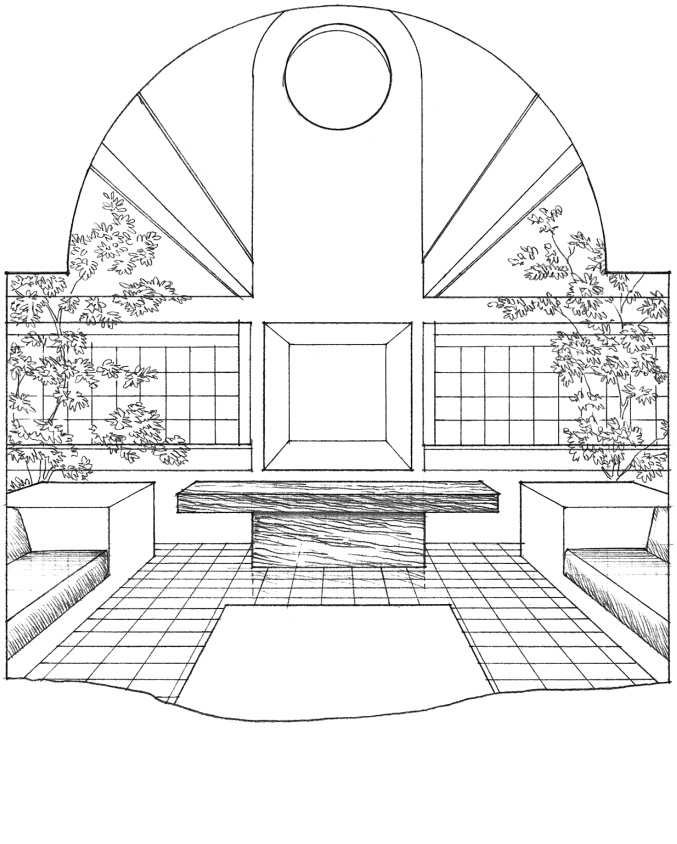
Termination of axis

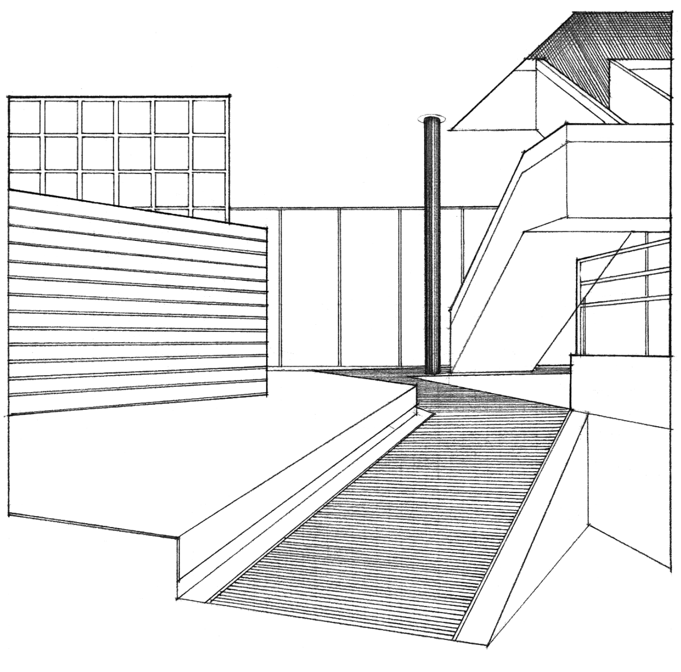


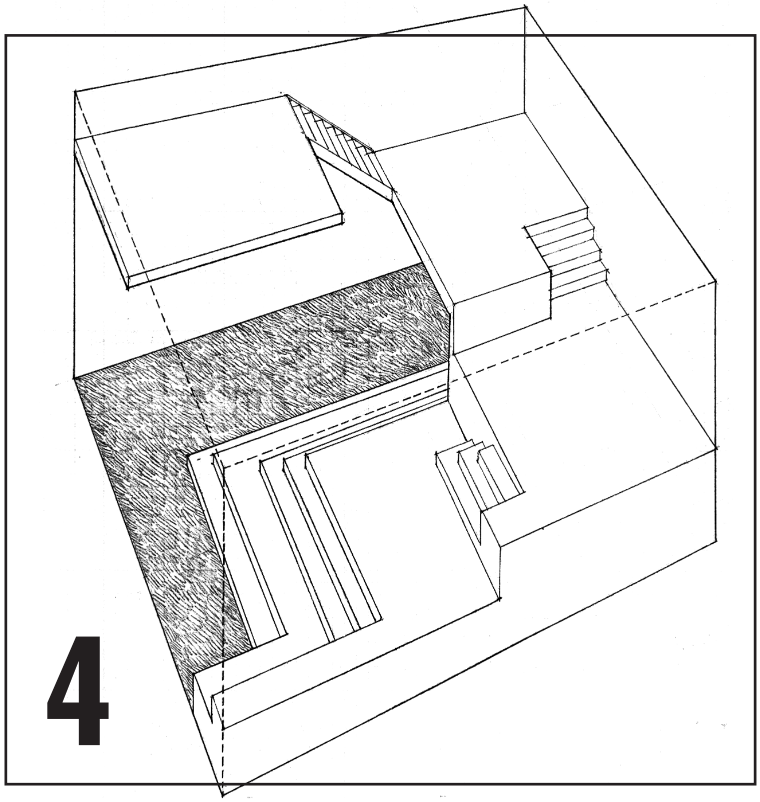
Just as there may be varying degrees of importance among the elements in an interior setting, there can also be varying degrees of emphasis. Once the significant elements or features are established, a strategy for orchestrating the subordinate elements must be devised to enhance the dominant ones.

A room's focal points should be created with some subtlety and restraint. They should not be so visually dominant that they cease to be integral parts of the overall design. Secondary points of emphasis—visual accents—can often help knit together dominant and subordinate elements. Following the principle of harmony, related shapes, colors, and values can also help retain unity of design.





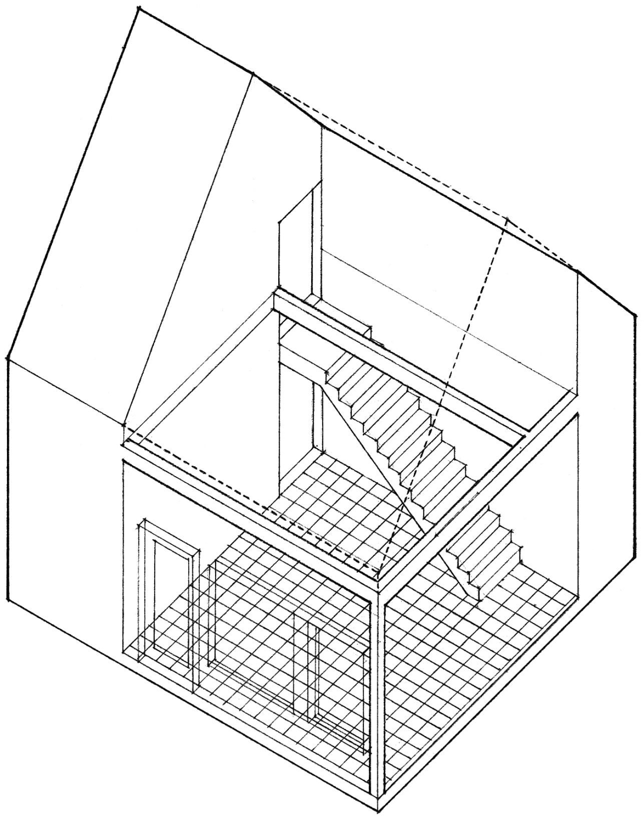




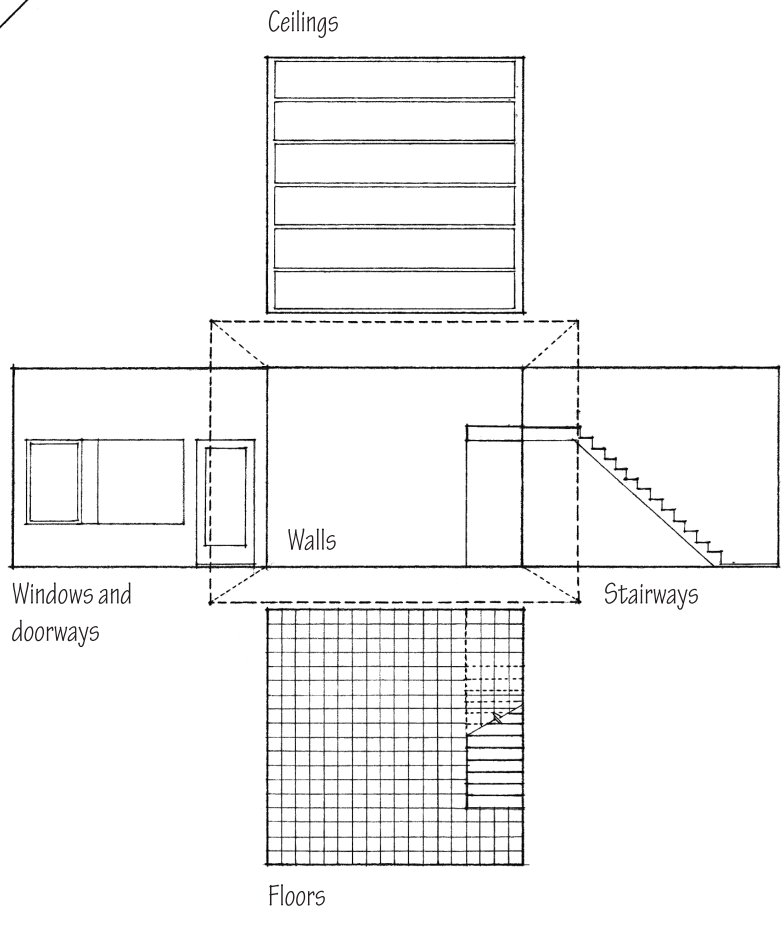
# 4

# Interior Building Elements

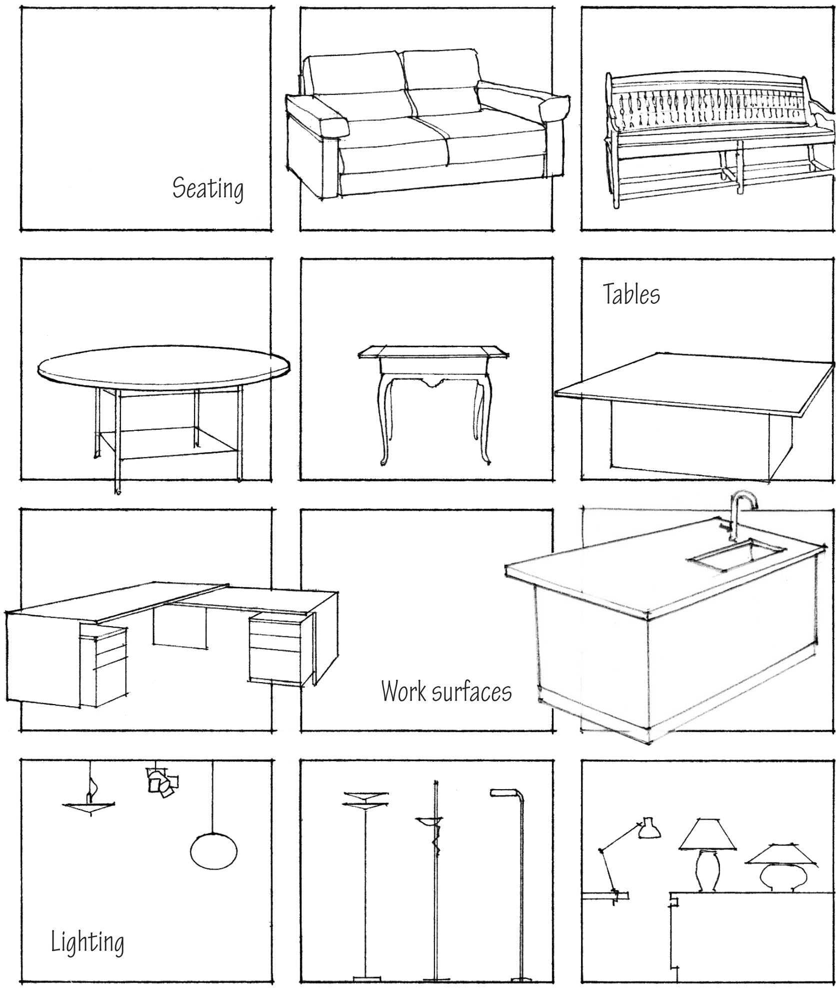
Interior spaces within buildings are defined by the architectural elements of structure and enclosure, such as columns, walls, floors, and roofs. These elements give a building its form, carve out a portion of infinite space, and set up a pattern of interior spaces. This chapter outlines the major elements of interior design with which we develop, modify, and enhance these interior spaces and make them habitable—that is, functionally fit, aesthetically pleasing, and psychologically satisfying for our activities.

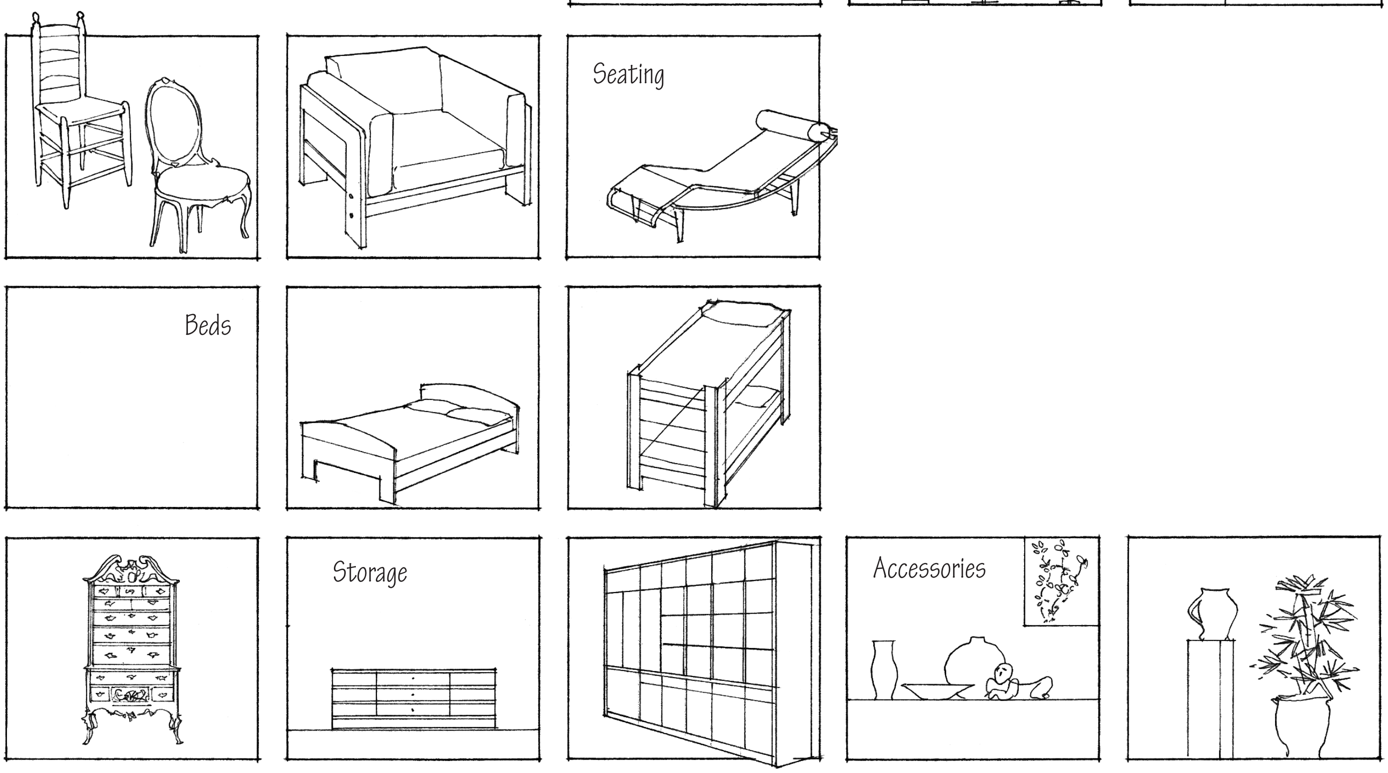


Interior Building Elements

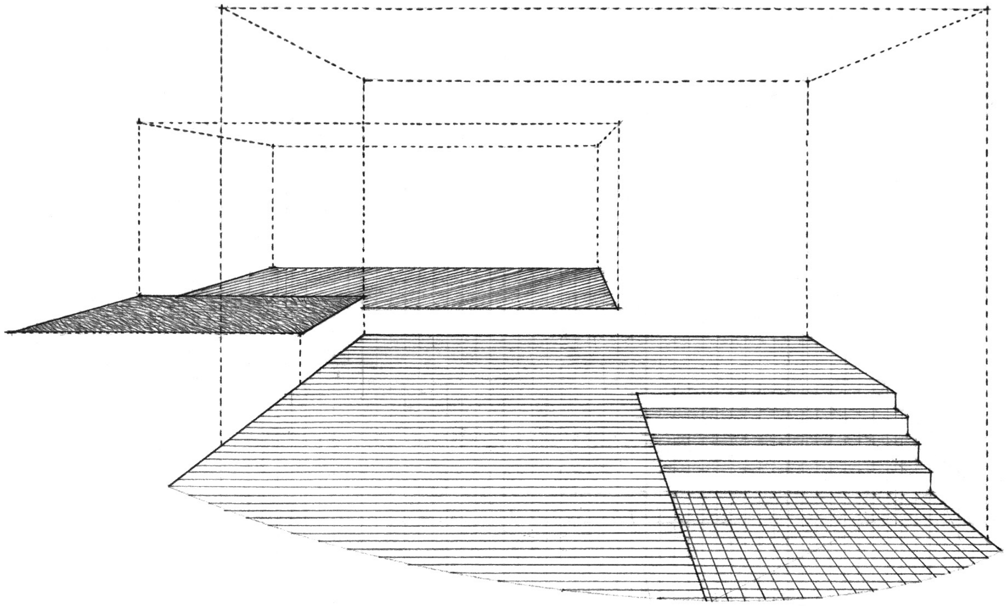


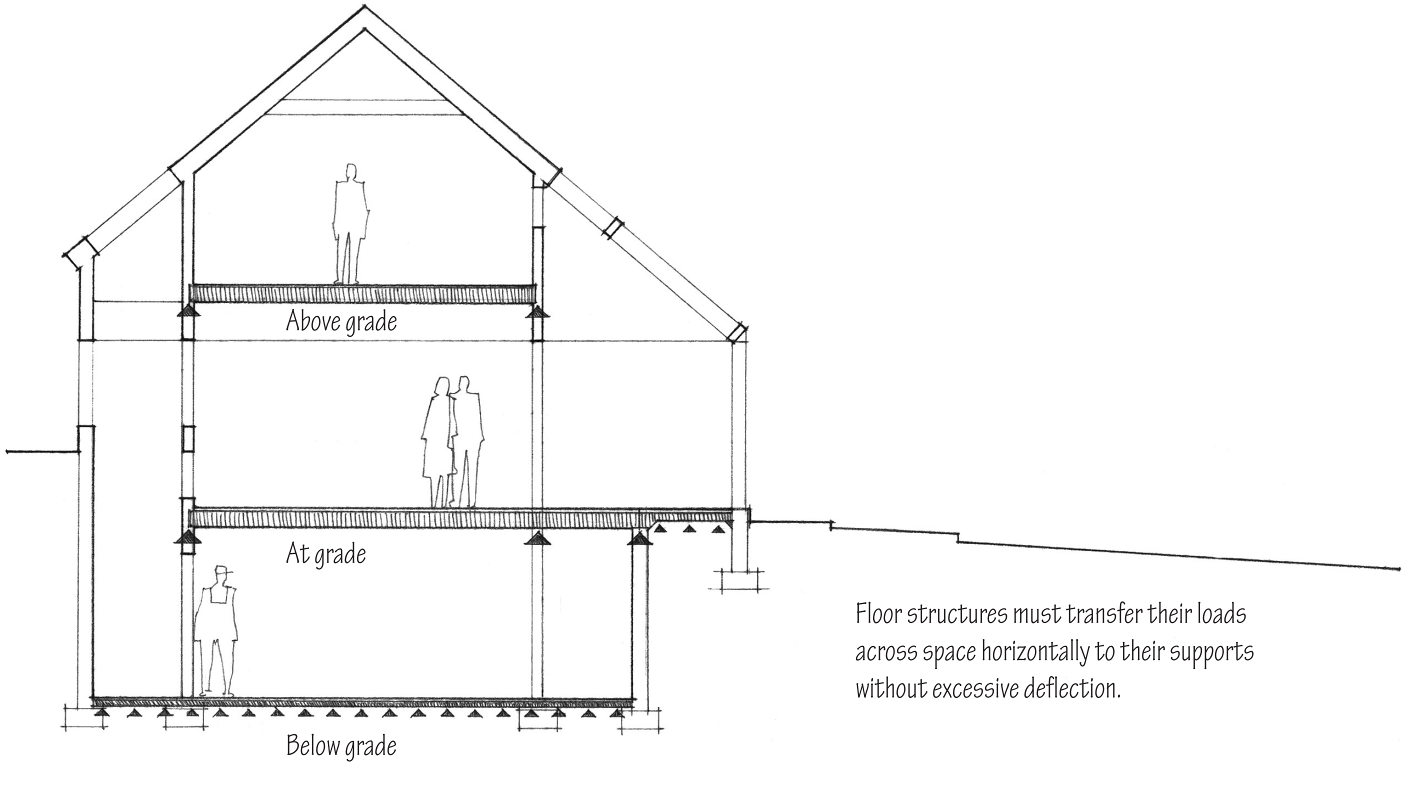
These design elements, and the choices they represent, are the interior designer's palette. The manner in which we select and manipulate these elements into a spatial, visual, and sensory pattern will affect not only the function and use of a space but also its expressive qualities of form and style.



Floors are the flat, level base planes of interior space. As the platforms that support our interior activities and furnishings, they must be structured to carry the resulting loads safely. Their surfaces must be durable enough to withstand continual use and wear.



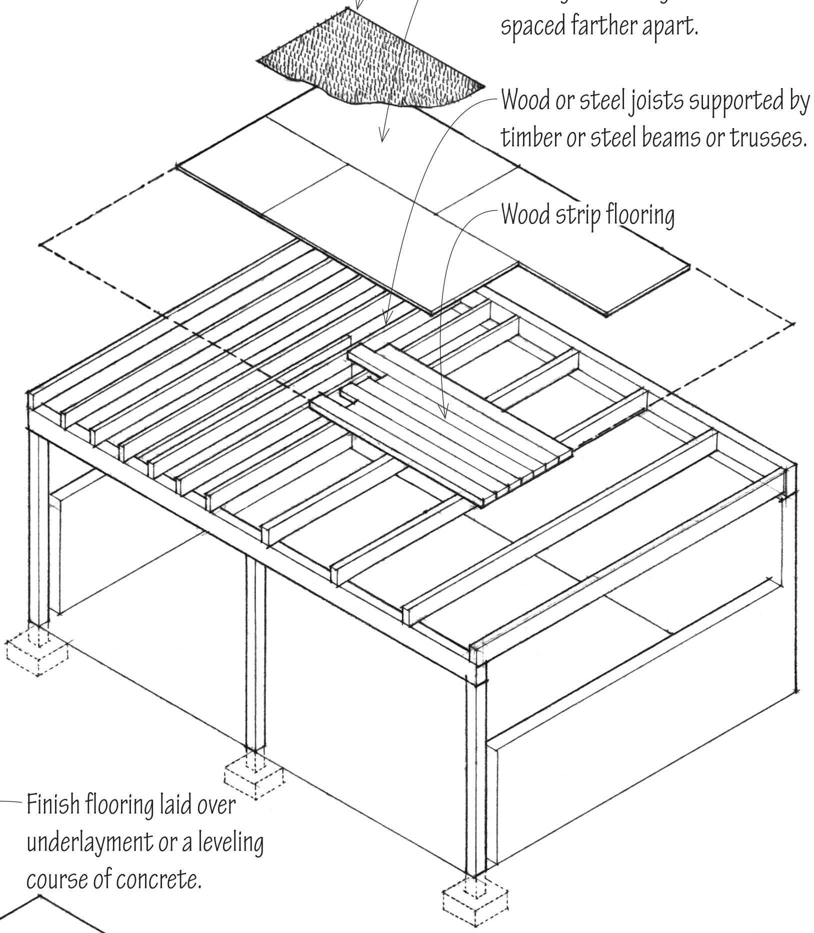


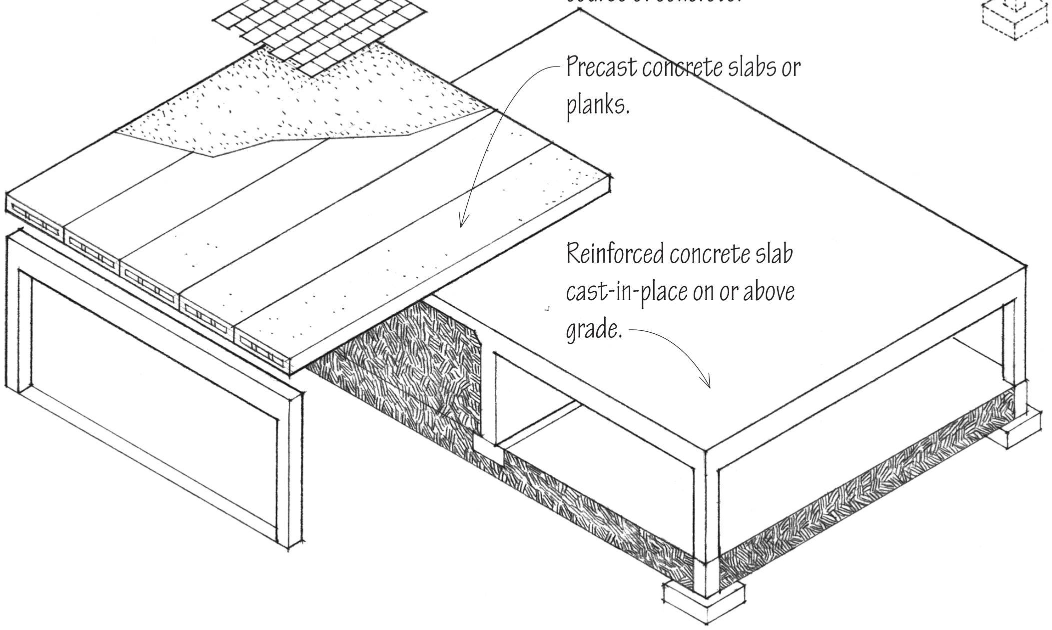

Floor structures must transfer their loads across space horizontally to their supports without excessive deflection.

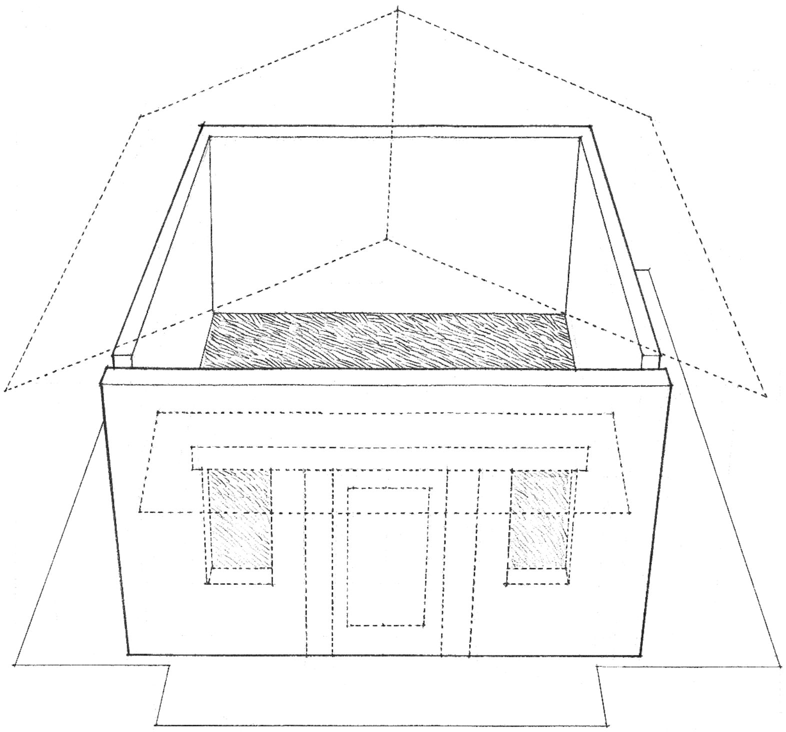
A floor may be constructed of a series of parallel beams or joists overlaid with a subfloor—a structural material such as plywood sheathing, concrete planks, or steel decking capable of spanning the beams or joists. The subfloor and beams or joists are secured so that they act together as a structural unit in resisting stresses and transferring loads to their supports.

A floor may also consist of a monolithic, steel-reinforced concrete slab capable of extending in one or two directions. The form of a slab's underside often reflects the manner in which it extends across space and transfers its loads. Instead of being cast monolithically in place, a slab can also be precast as planks.

Whether a floor structure is a monolithic slab or a framed assembly, its surface must be smooth, level, and dense enough to receive the finished flooring material. To compensate for any roughness or unevenness, a layer of underlayment or a cement topping may be required for some flooring materials.





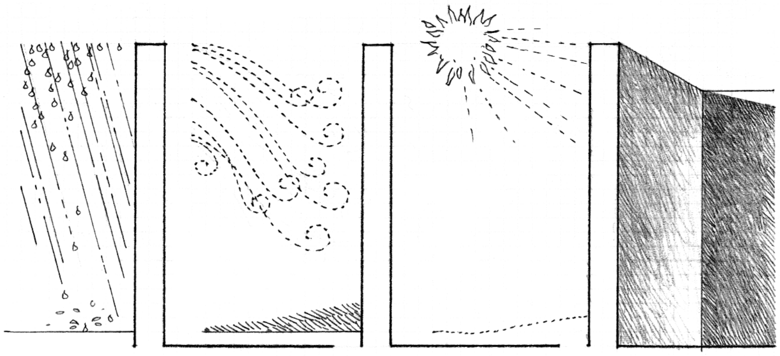
Walls are essential architectural elements of any building. They have traditionally served as structural supports for above-grade floors, ceilings, and roofs. They form the facades of buildings. They enclose, separate, and protect the interior spaces they create.

The exterior walls of a building must control the passage of air, heat, moisture, water vapor, and sound. The exterior skin, whether applied or integral to the wall structure, must also be able to withstand the effects of sun, wind, snow, and rain.

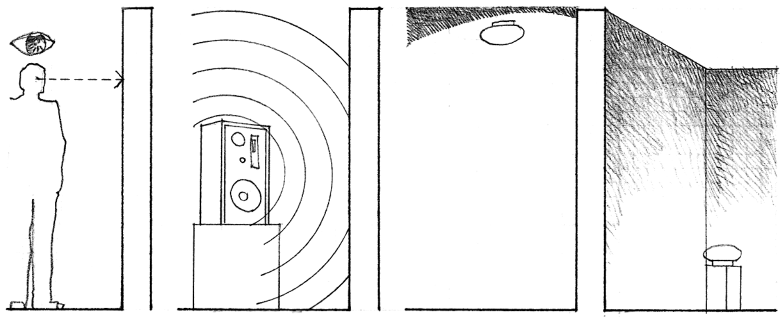
Interior walls subdivide the interior spaces of a building, provide privacy for these spaces, and control the passage of sound, heat, and light from one space to the next. An interior wall dividing a room or part of a building into separate areas is referred to as a partition.

Both exterior and interior walls may be load-bearing structures of homogeneous or composite construction designed to support imposed loads from floors and roofs. They may also consist of a framework of columns and beams, with nonstructural panels attached to or filling in between them.

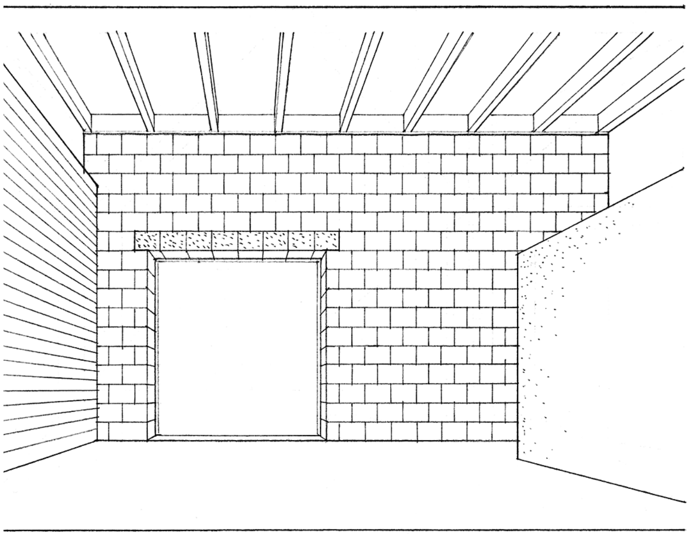
Architectural and mechanical system elements must meet code requirements for *seismic* design that focus on protecting people from falling objects and preserving egress routes. Seismic design affects the heights, reinforcement, and connections of interior and exterior walls.



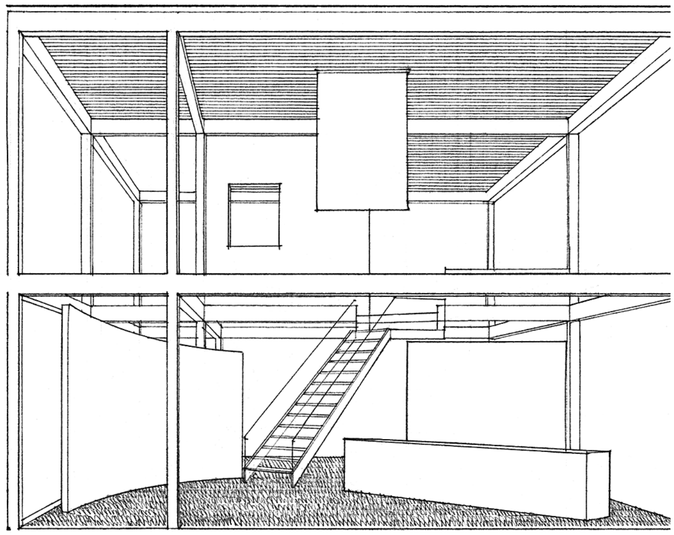
Exterior walls control the passage of air, heat, moisture, water vapor, and sound.



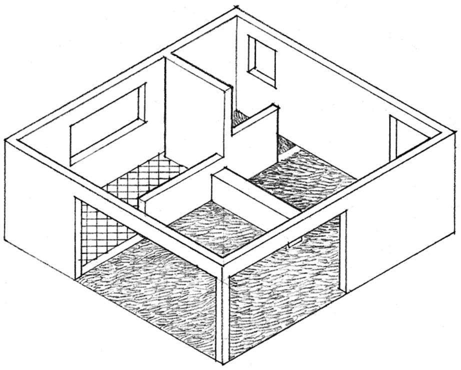
Interior walls control the passage of vision, sound, heat, and light.



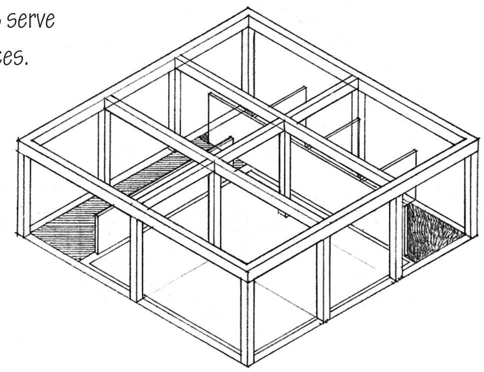
Load-bearing walls define the boundaries of space.

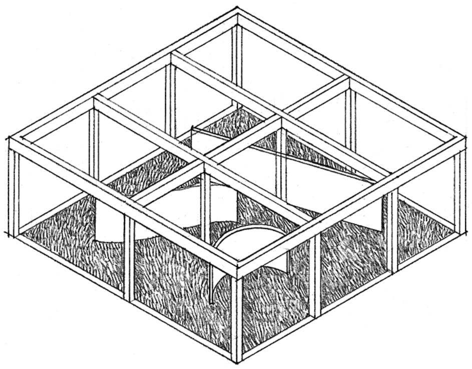


Columns and beams imply the edges of interior space.

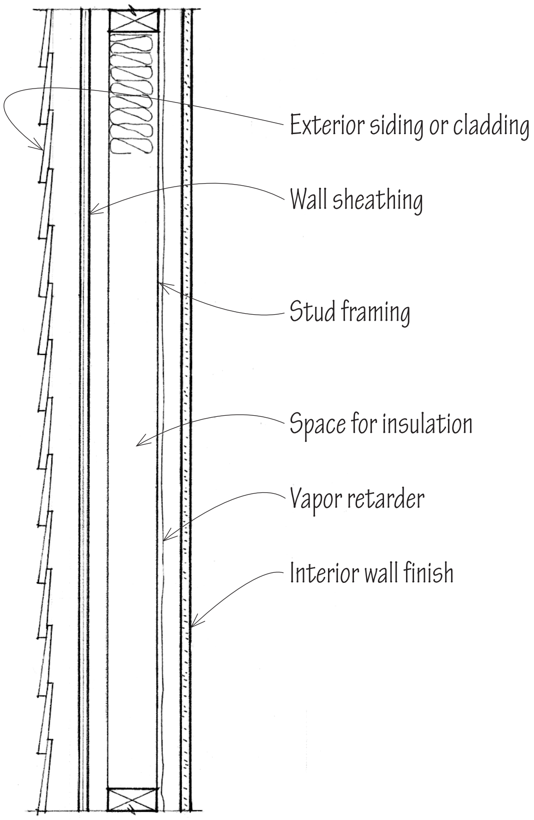


Nonbearing walls and partitions serve to subdivide larger interior spaces.





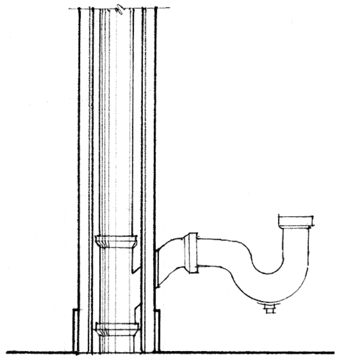
A structural framework of columns and beams establishes a grid of interconnected spaces. Within this grid, partitions can define spaces as required.



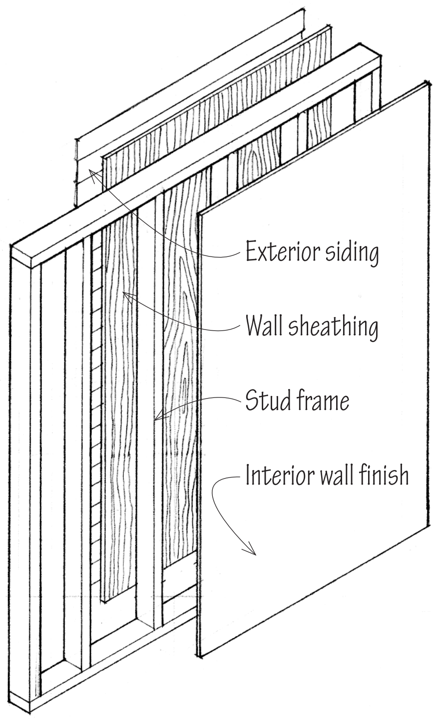

Stud-framed walls may be constructed of wood or metal studs tied together by sole (bottom) and top plates. Onto this frame are laid one or more layers of a sheet material, such as plywood or gypsum board, which stiffens the plane of the wall.

The sheet material may serve as the finish of interior walls, but more often it serves as a support for a separate layer of finish material. Exterior cladding of siding, shingles, or stucco must be weather resistant. Interior wall surfaces do not have to withstand climatic elements and therefore can be selected from a wider range of materials.

Stud-framed walls are flexible in form because of the workability of the relatively small pieces and the variety of means of fastening available.



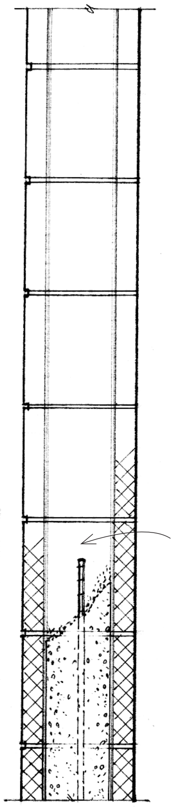
The cavities formed by the stud frame can accommodate thermal and acoustic insulation, vapor retarders, and the distribution of mechanical and electrical services and outlets.

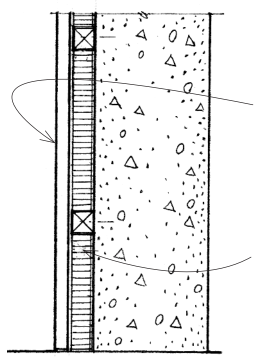


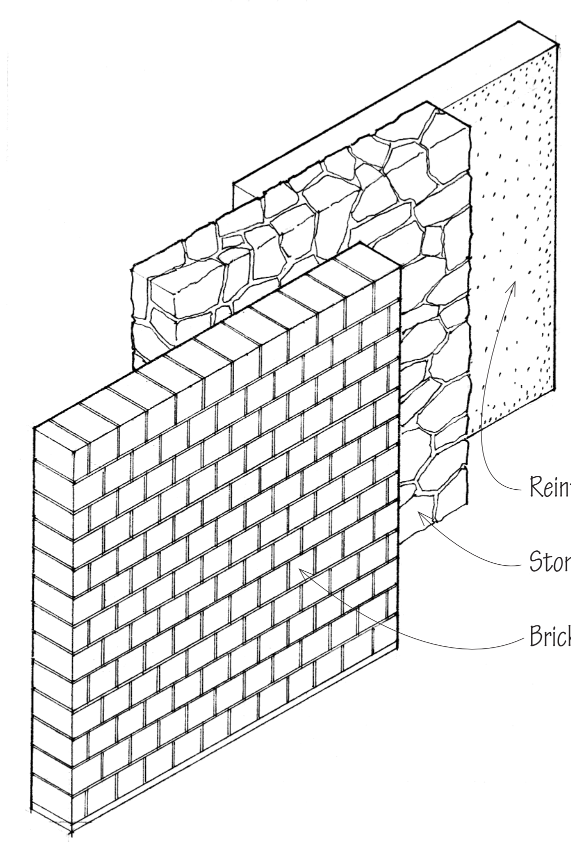
Concrete and masonry walls are typically load-bearing and qualify as noncombustible construction. They forcefully define the physical boundaries of space and are more difficult to alter than framed walls.

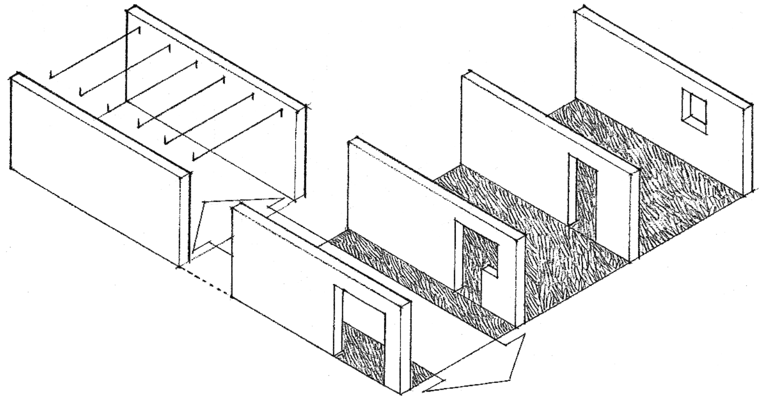
Concrete and masonry walls are usually thicker than stud-framed walls because they depend on their mass for their strength and stability. Cavities between wythes (vertical sections one unit in thickness) of masonry deter the passage of moisture and water vapor, and are often used to accommodate thermal insulation.

Concrete and masonry walls may be left exposed. Because of their attractive color and texture, stone and brick are almost always left exposed as the finish wall surface. Concrete and concrete masonry walls can be constructed with attractive colors and textures. If a separate finish is desired, an intermediate layer of supporting *lath* or *furring* may be required.



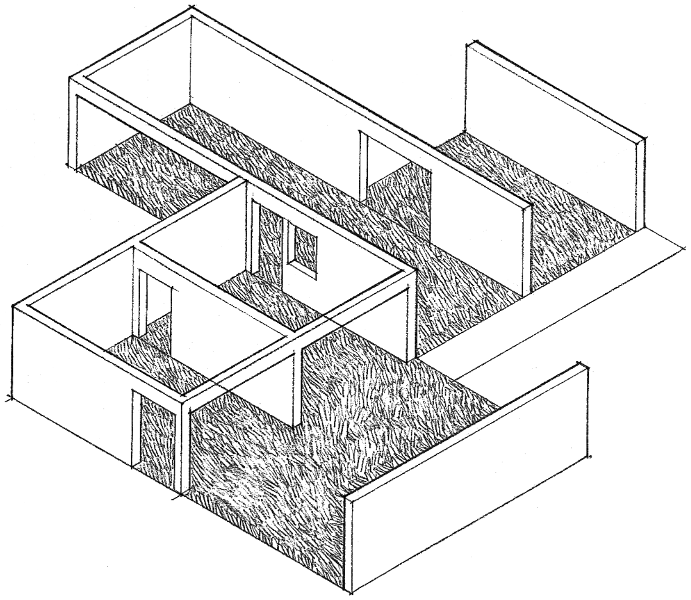





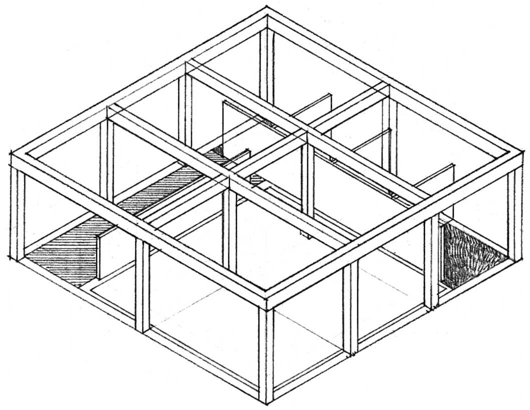
It makes sense to lay out load-bearing walls in a parallel series to support one-way floor and roof structures.

The pattern of load-bearing walls should be coordinated with the spans of the floor and roof structures they support. This structure will begin to dictate the possible sizes, shapes, and layouts of interior spaces.

When the size and shape requirements of interior spaces and the activities they house do not correspond well with a firm pattern of structural walls, a structural framework of columns and beams can be used. Nonstructural walls and partitions can then freely define and enclose interior spaces as required. This is often done in commercial, multistory, and other buildings where flexibility in the layout of spaces is desirable.

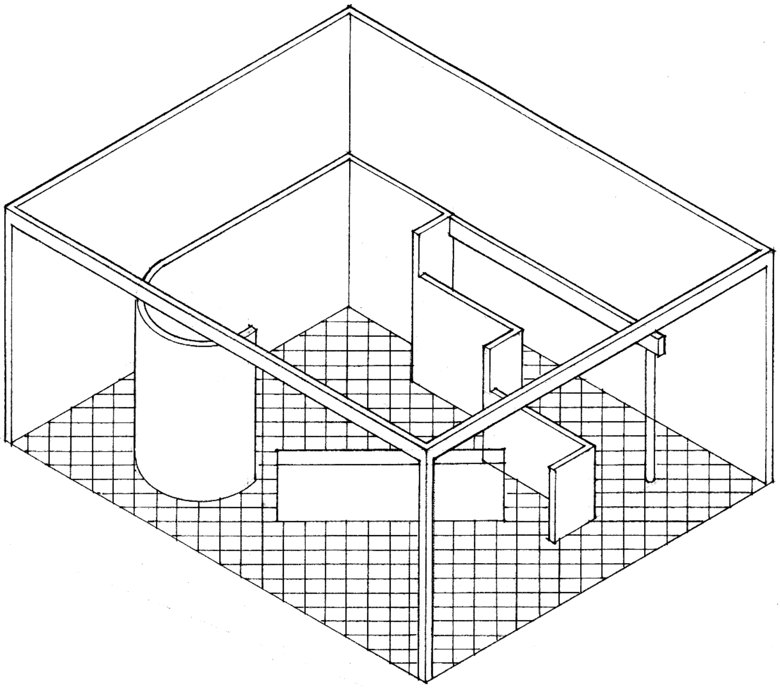


Changing the direction of the floor and roof spans, or using two-way systems, can lead to more complex spatial relationships.

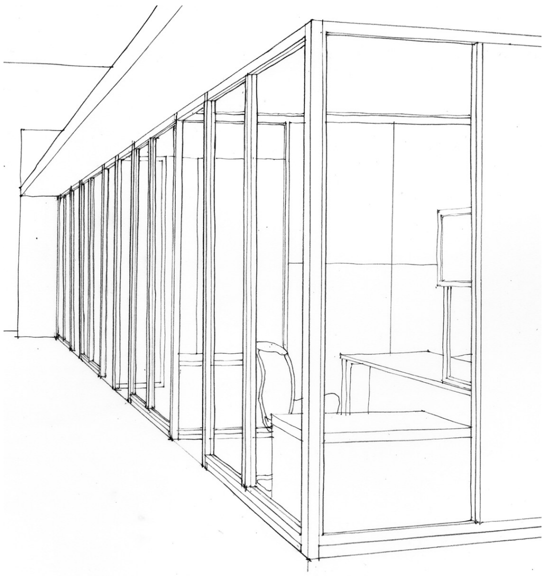


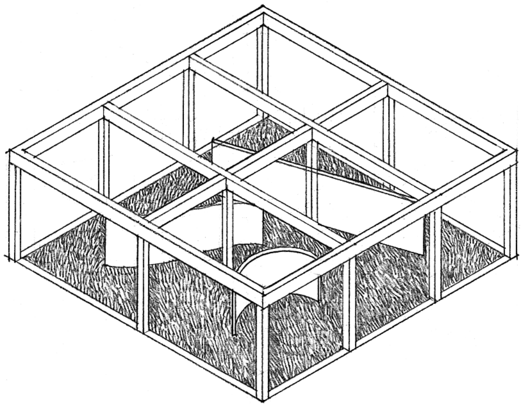
Although a column-and-beam system suggests a succession of interconnected volumes, the spaces themselves can be organized in harmony with or as a counterpoint to the grid of the structural framework.

Nonstructural walls need to support only themselves and any attachments. They therefore offer more possibilities than do load-bearing walls in shaping and enclosing space.

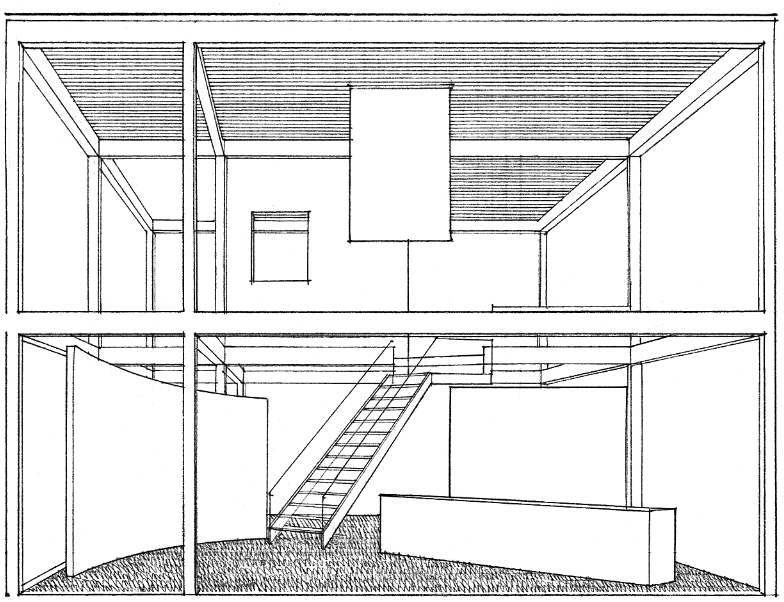


A nonstructural wall can stop short of the ceiling or adjacent walls and allow the flow of air and light from one space to the next. Spatial continuity between two areas can be reinforced, while some degree of visual—but not necessarily acoustical—privacy is maintained. Acoustically rated glass wall systems are now available, as are curving molded foam panels covered with fabric.





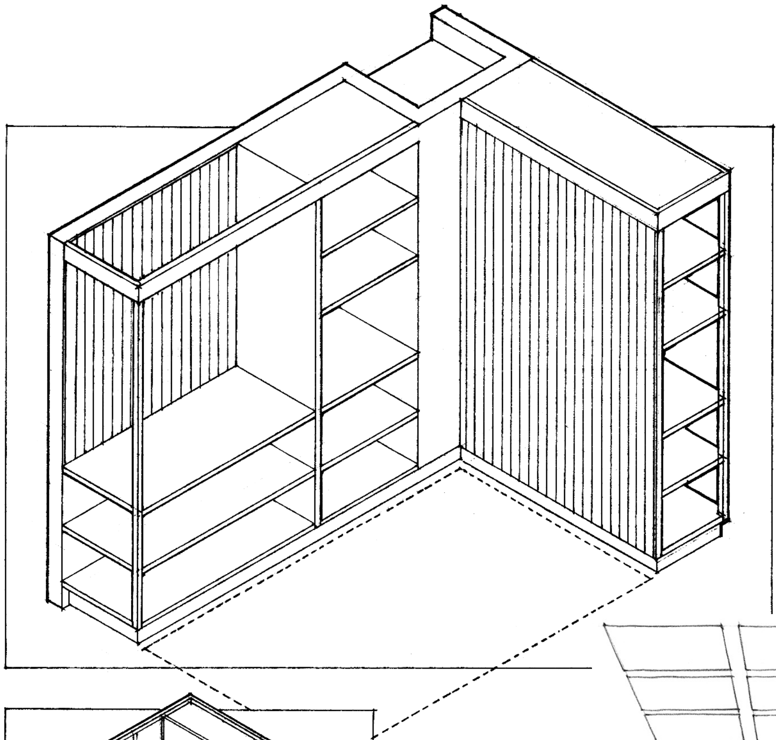
Nonbearing walls or partitions most commonly are supported by the floor system. They can also be secured to columns or bearing-wall structures, or they can be hung from the ceiling or roof structure. Whether freestanding on the floor or hung from above, nonbearing walls should be stabilized against lateral forces.

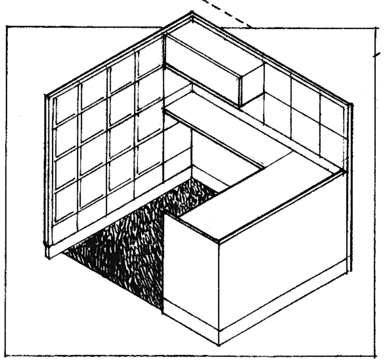


Nonbearing partitions may be attached to or fill in the spaces in the structural frame. The metal or glass curtainwall systems often used in commercial and institutional buildings are examples of exterior non-load-bearing walls.

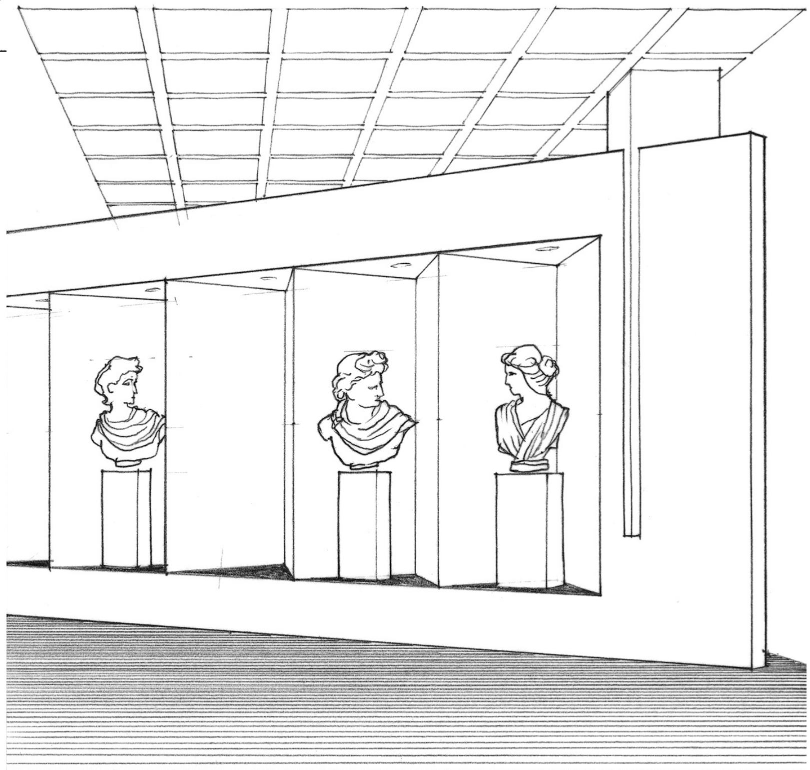
Freestanding walls that stop short of the ceiling and do not connect to adjacent walls on either end require support for lateral stability. Stability may be achieved by utilizing L- and U-shaped configurations or by tying the walls to the structure of the ceiling or adjacent walls.

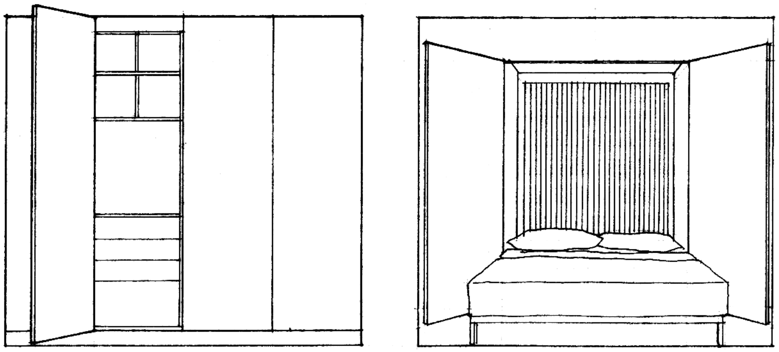
Instead of being strictly a background element in interior space, a wall can also be structured to support furnishing elements, such as seating, shelving, work surfaces, and lighting. A wall can also incorporate these elements into its thickness and become itself a piece of furniture.





Vertically oriented furniture elements can function as walls if they are freestanding and are double-sided or have finished backs.

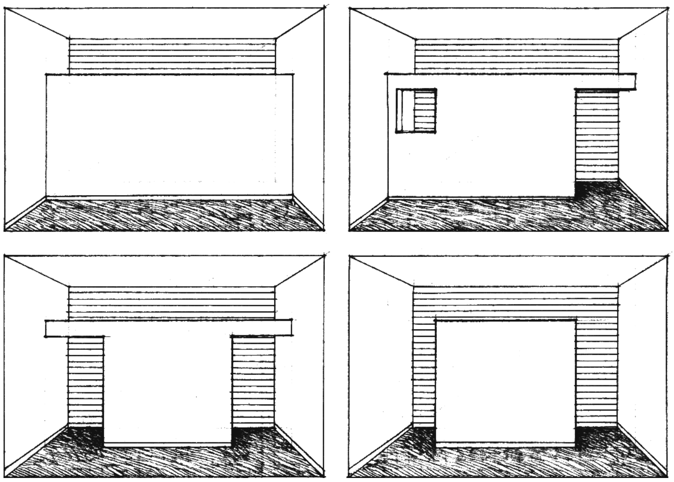


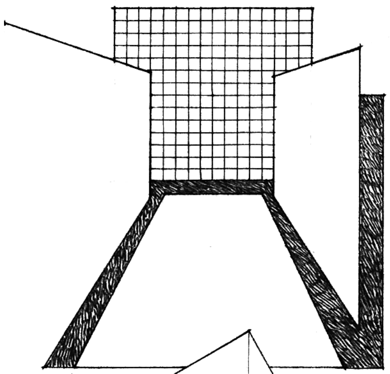


Freestanding walls may be made deep to incorporate spaces within their thickness.

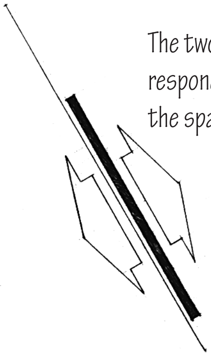
Walls are the primary elements with which we define interior space. Together with the floor and ceiling planes that complete the enclosure, walls govern the size and shape of a room. They can also be seen as barriers that limit our movement. They separate one space from the next and provide the occupants of a space with visual and acoustical privacy.

Rectilinear space defined by flat, rectangular walls is clearly the norm. Wall planes can also be curved, with the amount of curvature being determined in part by the materials and method of construction. The concave aspect of a curved wall encloses, while its convex side expands space.

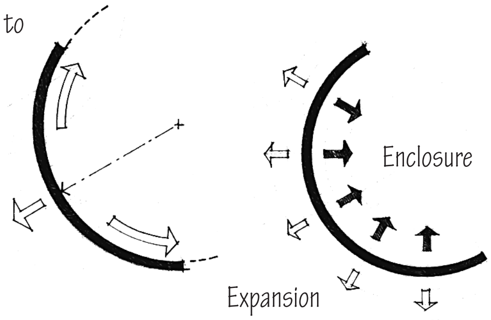


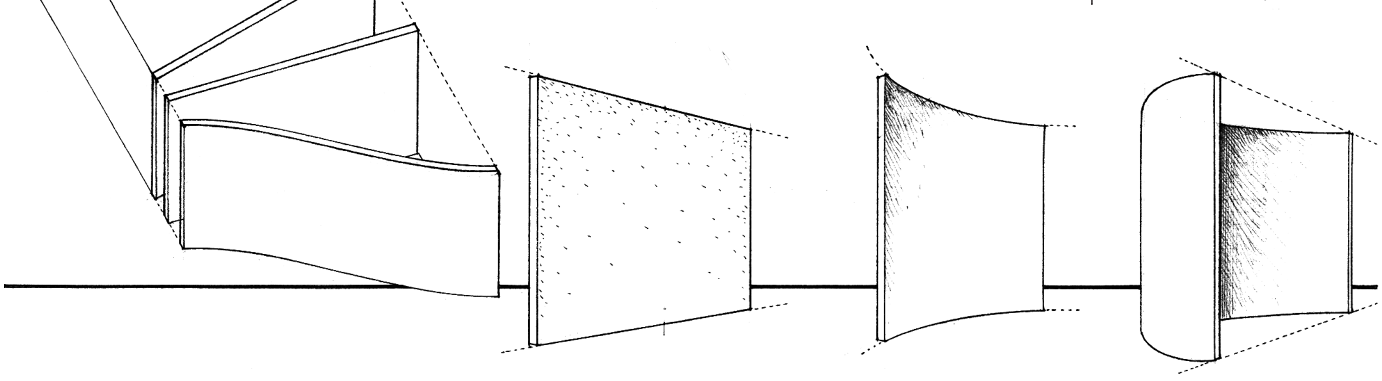


Walls enclose space and restrict views and movement.

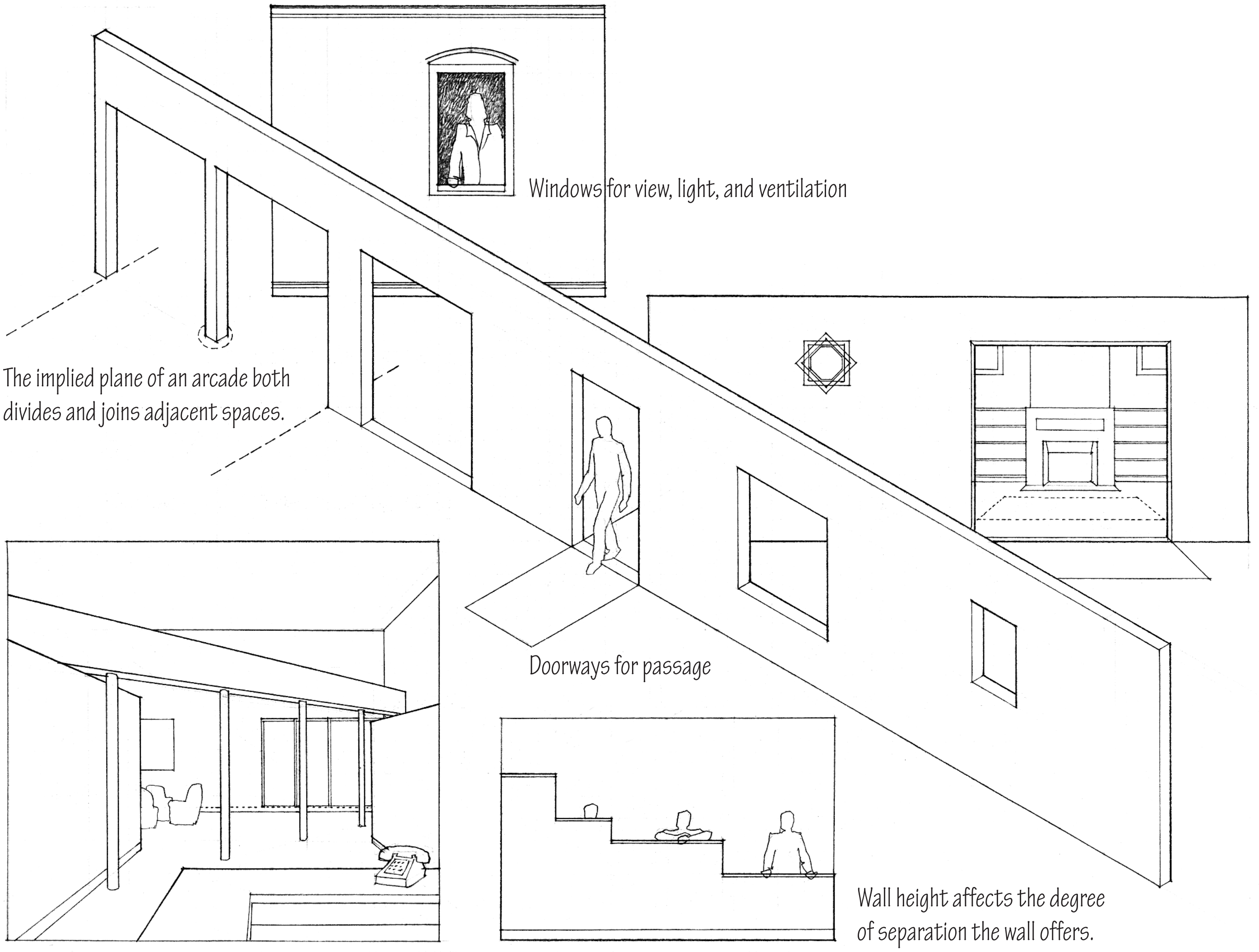


The two sides of a wall can respond in different ways to the spaces they address.



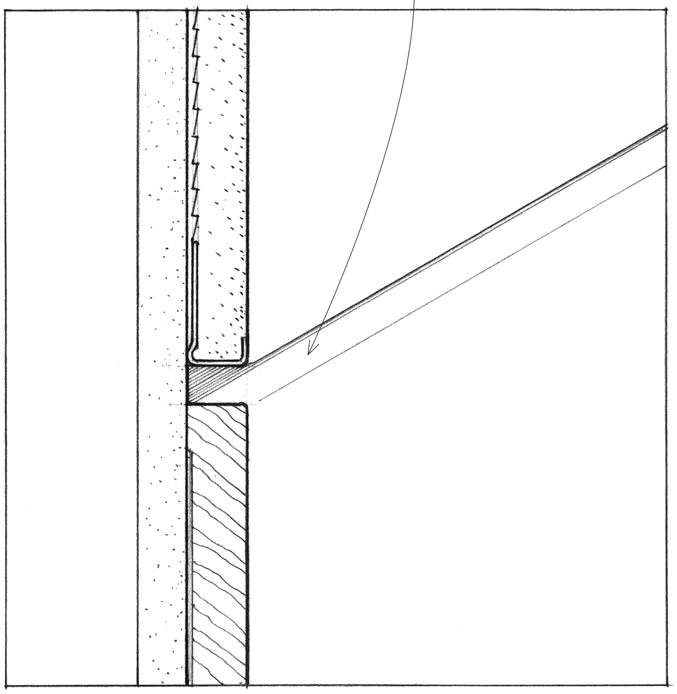
Openings within or between wall planes facilitate continuity and physical movement between spaces, as well as the passage of light, heat, and sound. As they increase in size, the openings begin to erode the sense of enclosure the walls provide and visually expand the space to include adjacent spaces. Views seen through the openings become part of the enclosed space. Enlarging the openings further will result ultimately in an implied separation of space defined by a framework of columns and beams.

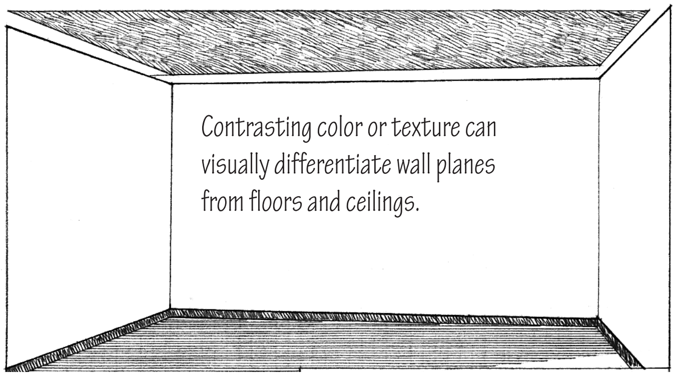


A wall can be visually differentiated from either the adjoining wall or ceiling plane by a change of color, texture, or material. The distinction can be made clearer with either trimwork or a reveal.

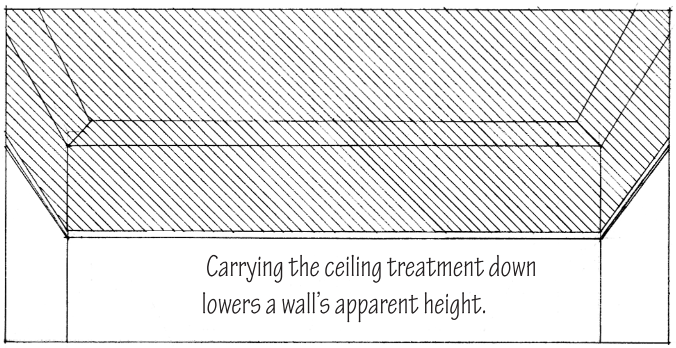
Trimwork, such as base and crown moldings, serves to conceal the unfinished construction joints and gaps between materials and to embellish architectural surfaces. Trim moldings can be simple or complex, depending on their profile and finish. Much of their impact depends on their scale, their color, and the shadow lines cast by their profile.

A reveal is a continuous recess that visually separates the meeting of two planes and articulates their edges by the shadow lines they create. When two planes meet in this manner, their surfaces must have finished or trimmed edges where exposed to our view.

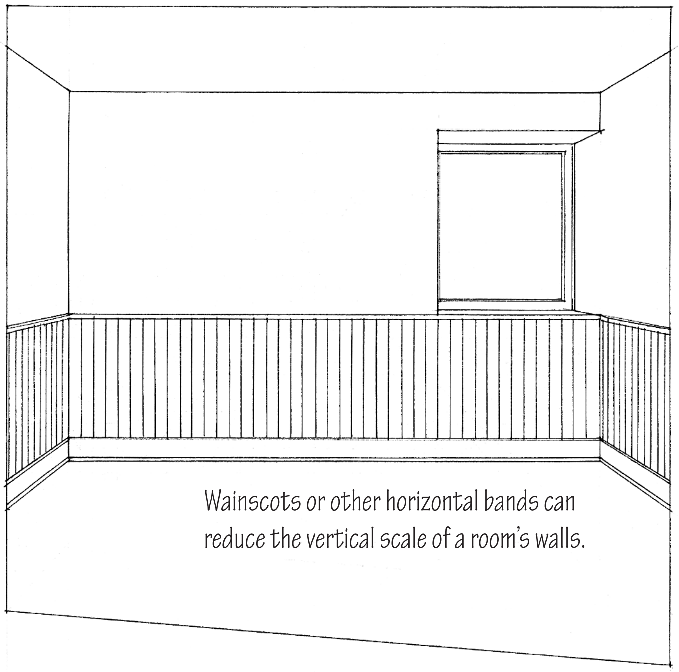




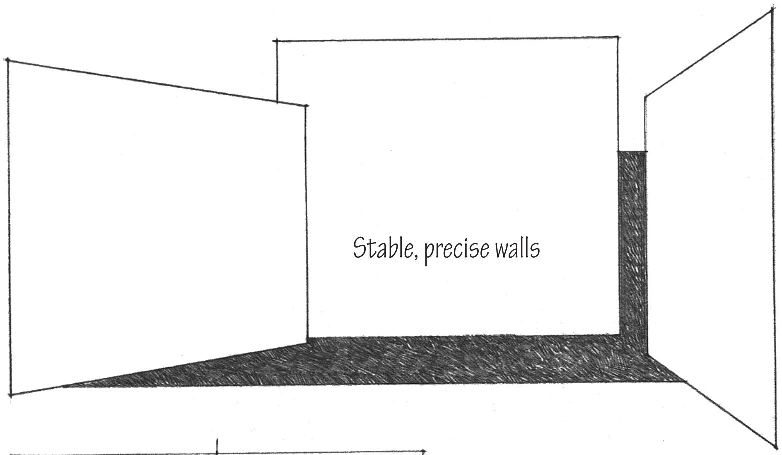
Contrasting color or texture can visually differentiate wall planes from floors and ceilings.



Carrying the ceiling treatment down lowers a wall's apparent height.



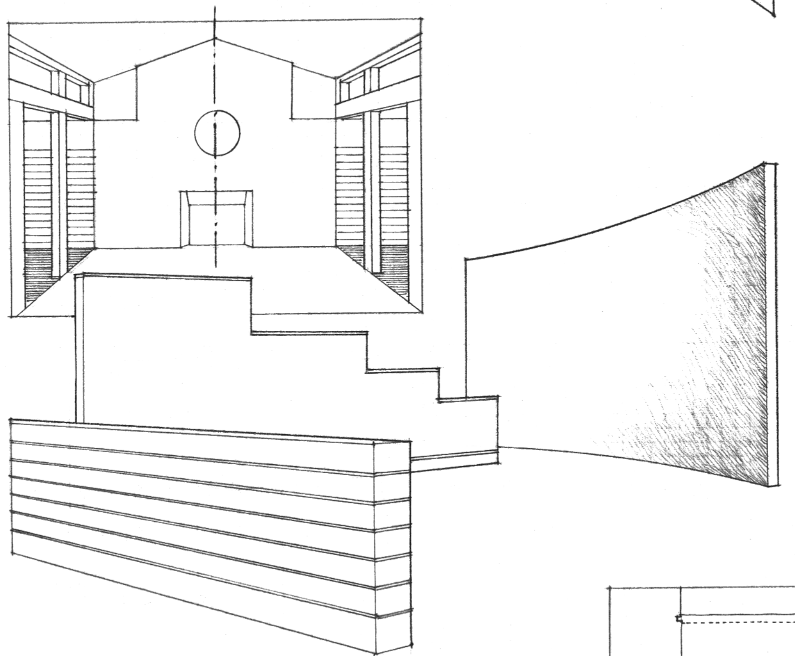
Wainscots or other horizontal bands can reduce the vertical scale of a room's walls.



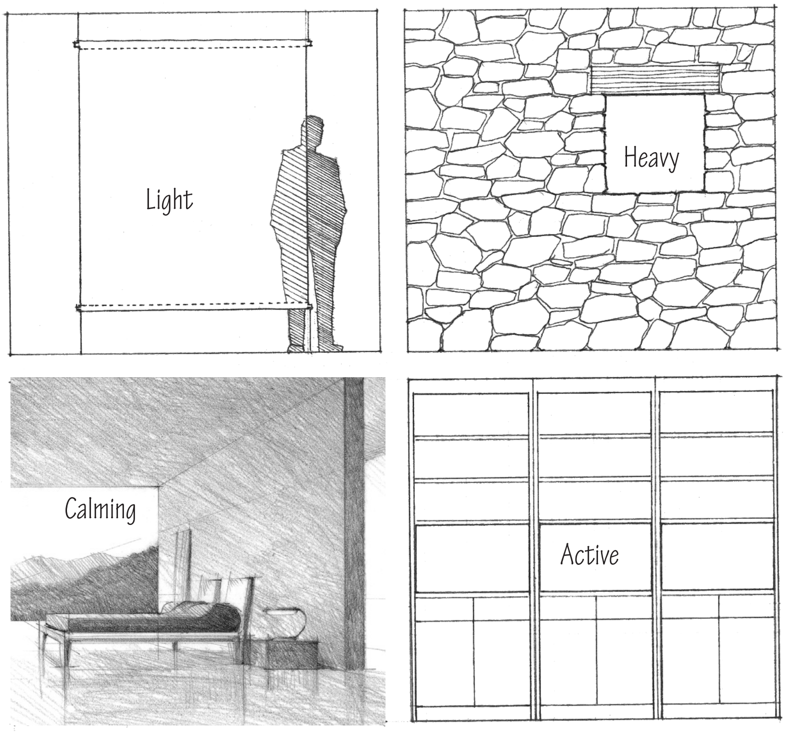

The vertical orientation of walls makes them visually active in our field of vision. In defining the boundaries of a room, they give form and shape to the space and play a major role in determining its character.

Stable, precise, symmetrical walls convey a feeling of formality that can be considerably enhanced with the use of smooth textures. Irregularly shaped walls, on the other hand, are more dynamic. When combined with a rough texture, they can impart an informal character to a space.

Walls provide a background for a room's furnishings and occupants. If smooth and neutral in color, they serve as passive backdrops for foreground elements. When irregular in shape or given texture, pattern, or vigorous color, walls become more active and compete for our attention.



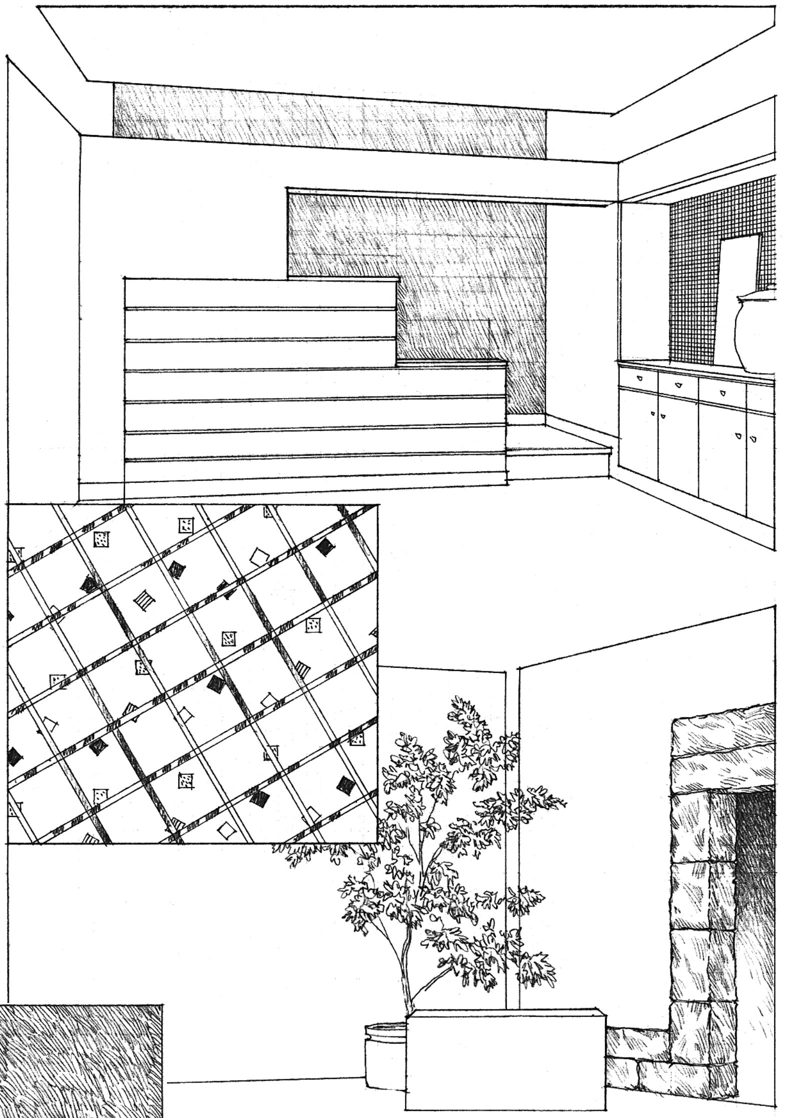
An irregular shape, coarse texture, or strong color can make a wall visually active.



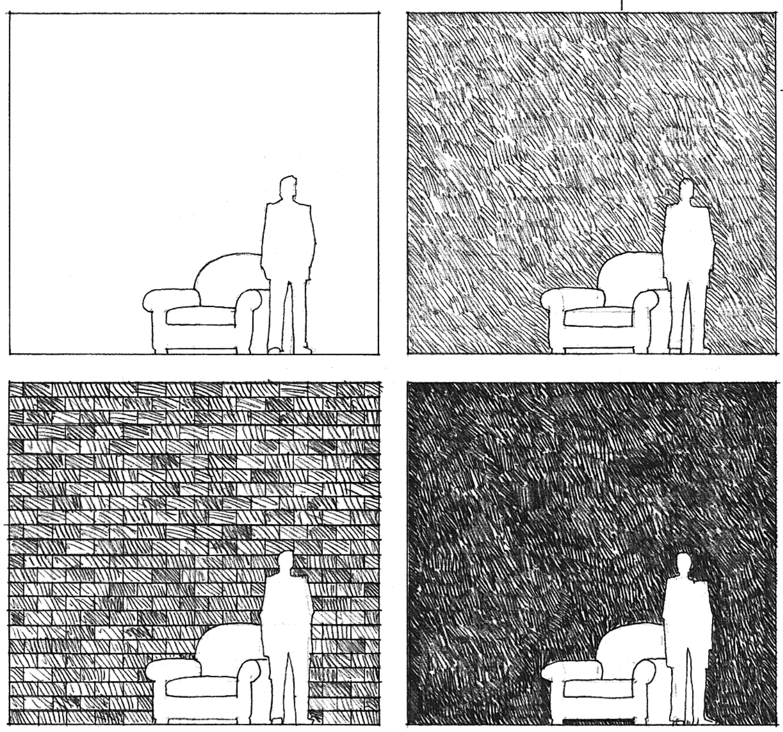
Light-colored walls reflect light effectively and serve as efficient backdrops for elements placed in front of them. Light, warm colors on a wall exude warmth, while light, cool colors increase a room's appearance of spaciousness.

Dark-colored walls absorb light, make a room more difficult to illuminate, and convey an enclosed, intimate feeling.

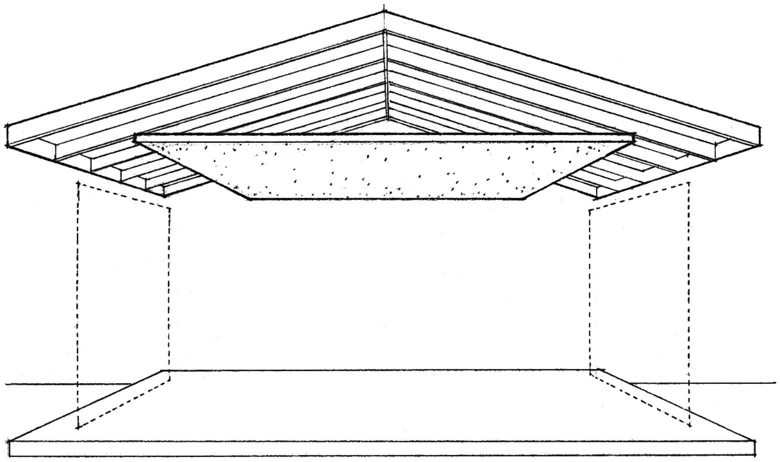
A wall's texture also affects how much light it will reflect or absorb. Smooth walls reflect more light than textured ones, which tend to diffuse the light striking their surfaces. In a similar manner, smooth, hard wall surfaces will reflect more sound back into a space than porous or soft-textured walls.



As with color, the juxtaposition of textures enhances both the coarse and the smooth.

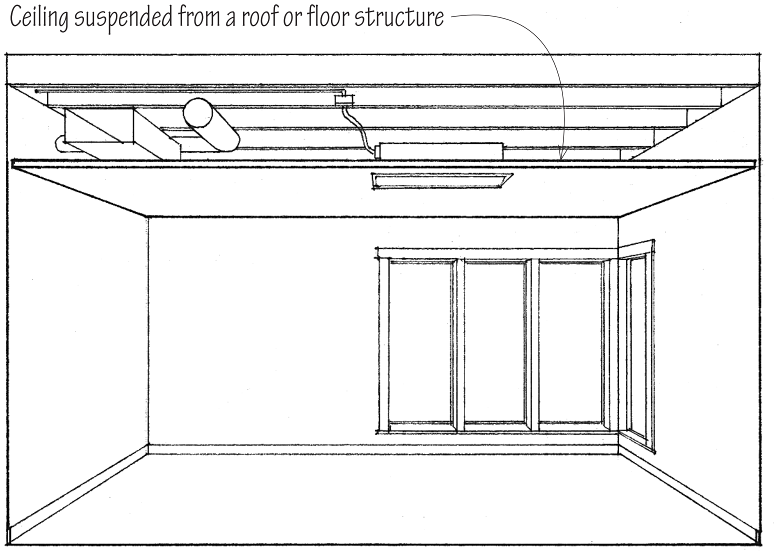


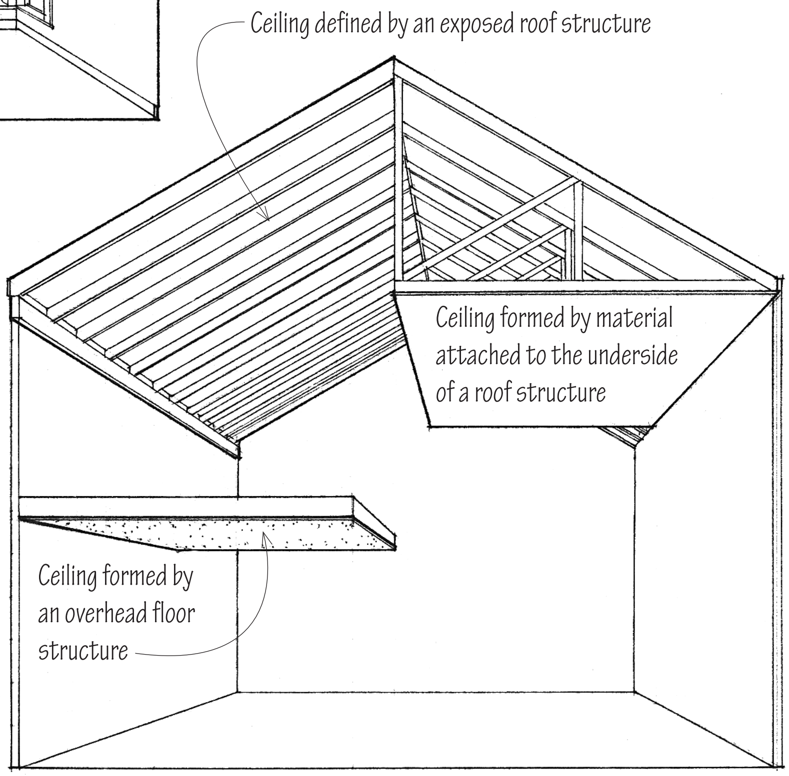
Color, texture, and pattern can be used to differentiate one wall plane from the next and to articulate the form of the space.



The third major architectural element of interior space is the ceiling. Although usually out of our reach and not used in the ways floors and walls are, the ceiling plays an important visual role in shaping interior space and limiting its vertical dimension. It is the sheltering element of interior design, offering both physical and psychological protection for those beneath its canopy.

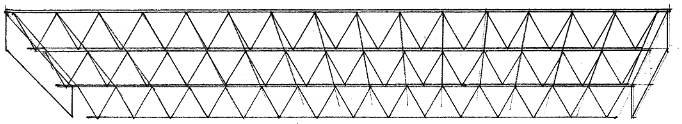
Ceilings are formed by the undersides of floor and roof structures. The ceiling material can be attached directly to the structural frame or be suspended from it. In some cases, the overhead structure can be left exposed and serve as the ceiling.



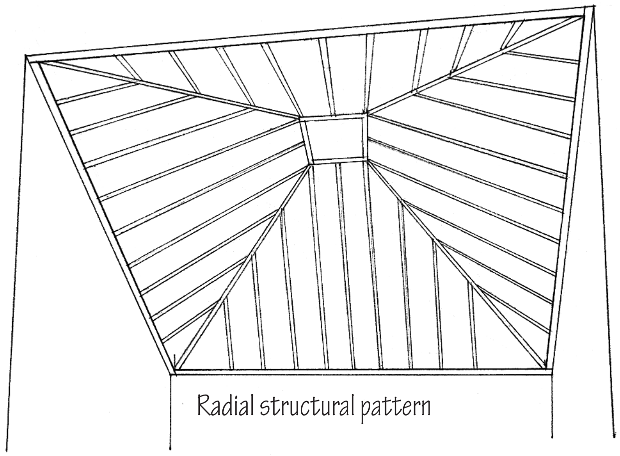



Instead of being surfaced with a smooth, planar material, a ceiling can consist of or express the structural pattern of the floor or roof above. Linear structural members or materials can create parallel, grid, or radial patterns. Any ceiling pattern will tend to attract our attention and appear to be lower than it is because of its visual weight. Since linear patterns direct the eye, they can also emphasize that dimension of space to which they are parallel.

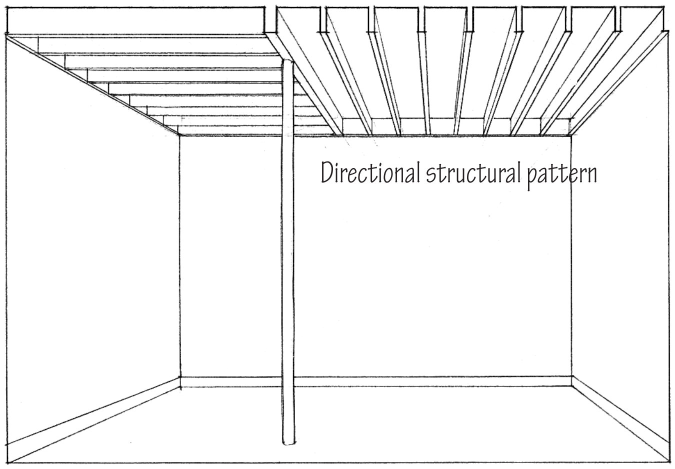
Exposed floor and roof structures provide a ceiling with texture, pattern, depth, and direction. These characteristics attract our attention and are best displayed in contrast to smoother wall planes.



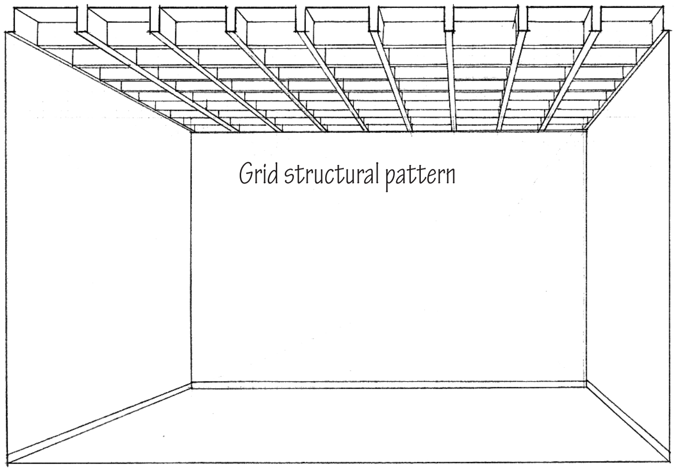
Space frame grid



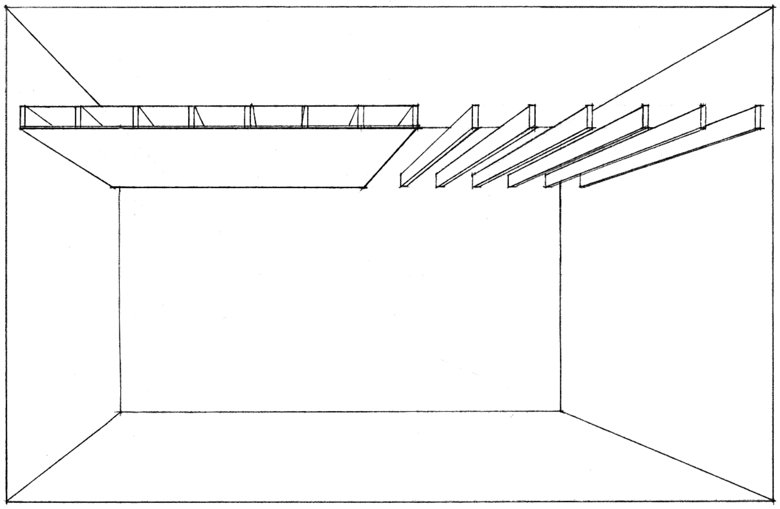
Radial structural pattern



Directional structural pattern

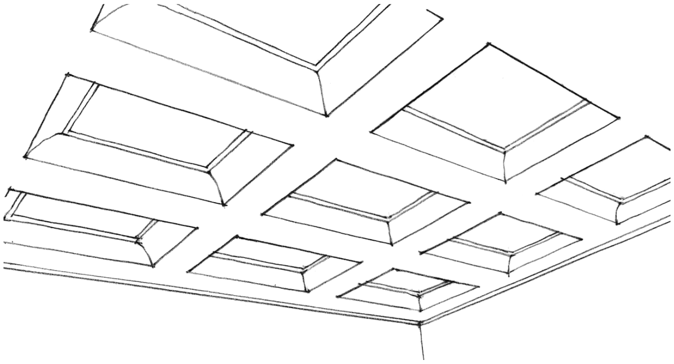


Grid structural pattern

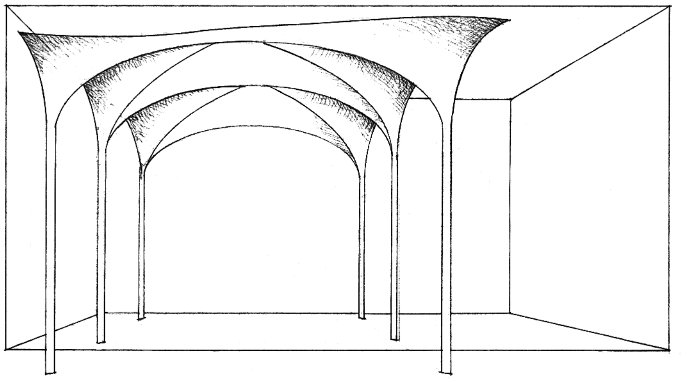


In a room with a high ceiling, all or a portion of the ceiling can be dropped, to lower the scale of the space or to differentiate an area from the space around it. Because a dropped ceiling is usually suspended from the floor or roof structure above, its form can either echo or contrast with the shape and geometry of the space.

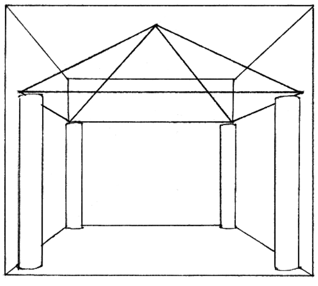
The effect of a suspended ceiling can be created with open framing or with nonstructural elements, such as fabric or a series of suspended lighting fixtures.



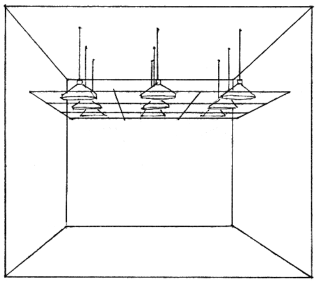
A coffered ceiling adds visual texture to a space.



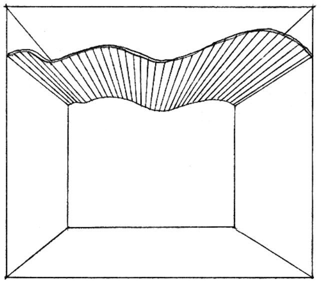
Contrasting space can be created within a larger space.



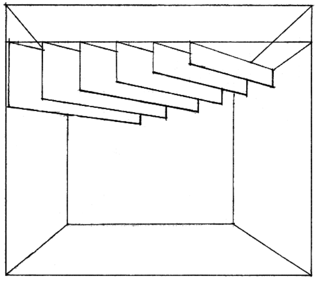
Open frame structure



Suspended light fixtures



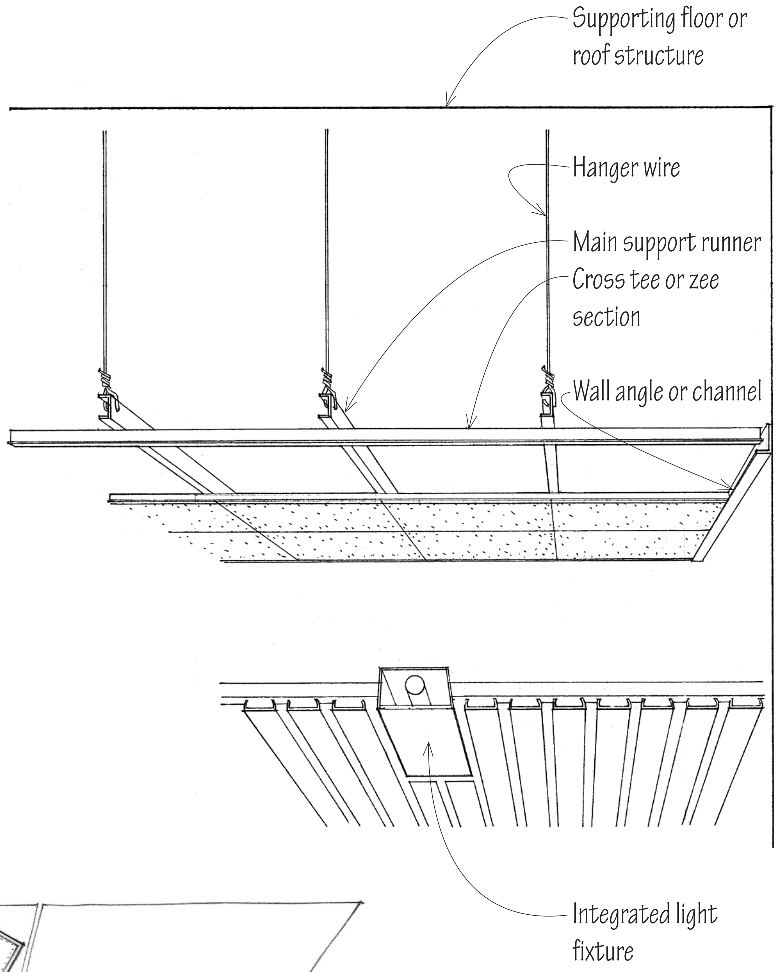
Wood or metal slats

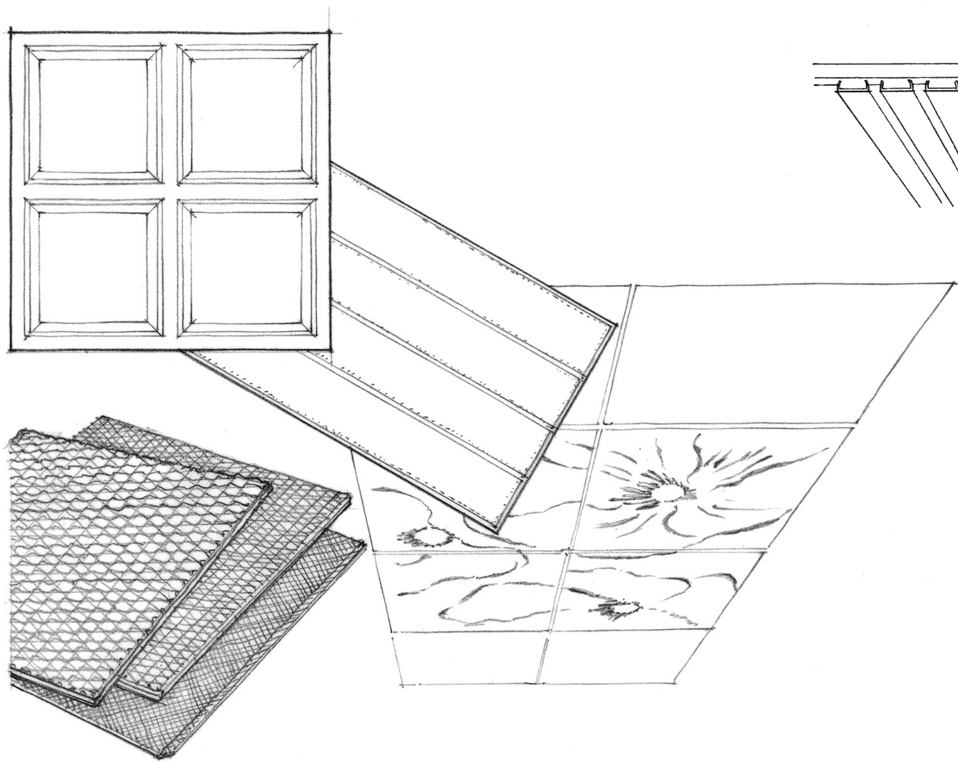


Banners or baffles

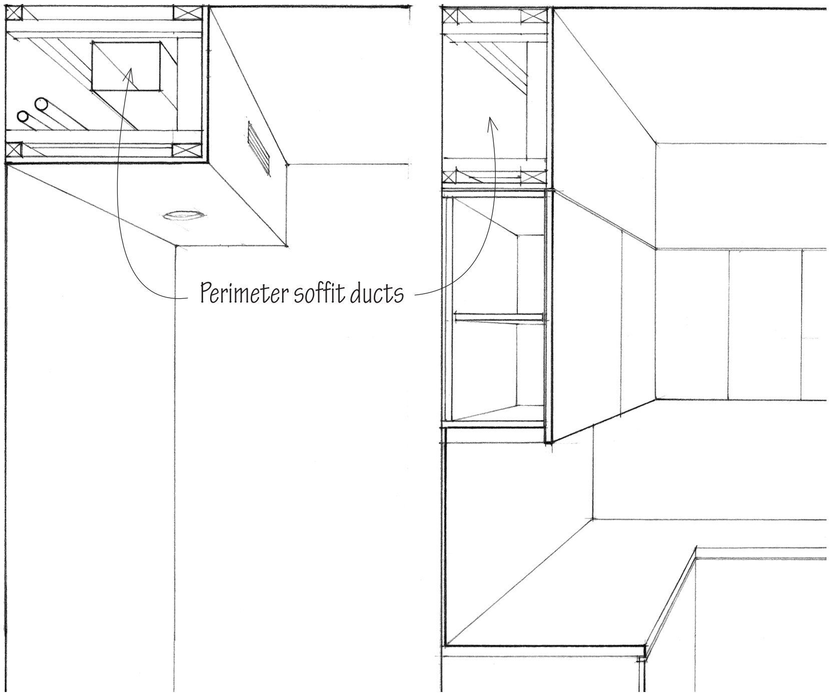
In commercial spaces, a suspended ceiling system is often used to provide a concealed space for mechanical ductwork, electrical conduit, and plumbing lines. Light fixtures, air-conditioning registers, sprinkler heads, and sound systems can be integrated with the grid of modular ceiling tiles or panels. The ceiling membrane can be fire rated and provide fire protection for the supporting overhead structure.

The typical suspended ceiling system consists of modular acoustical tiles supported by a metal grid suspended from the overhead floor or roof structure. The grid may be *exposed*, using lay-in tiles, or be concealed, using tiles with tongue-and-groove or *kerfed* edges.



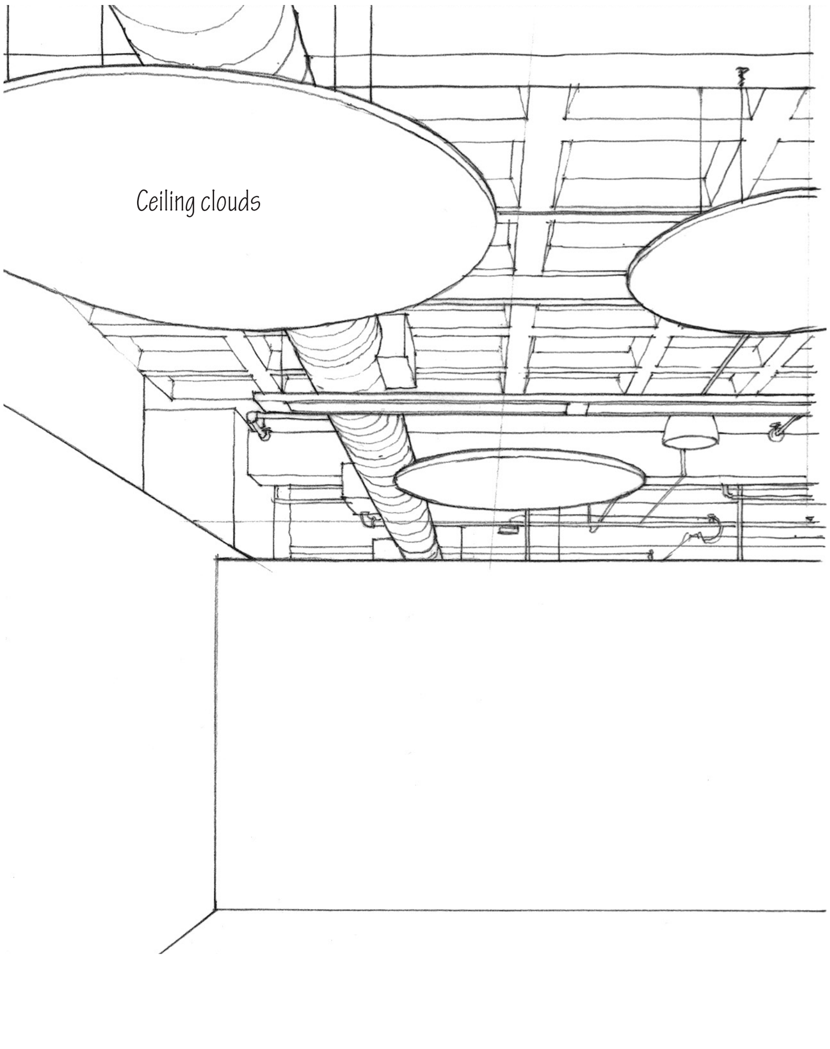
Acoustical tiles are modular units of mineral or glass fiber. Some have wood, vinyl, aluminum, or ceramic faces. The tiles are usually removable for access to the ceiling space above.

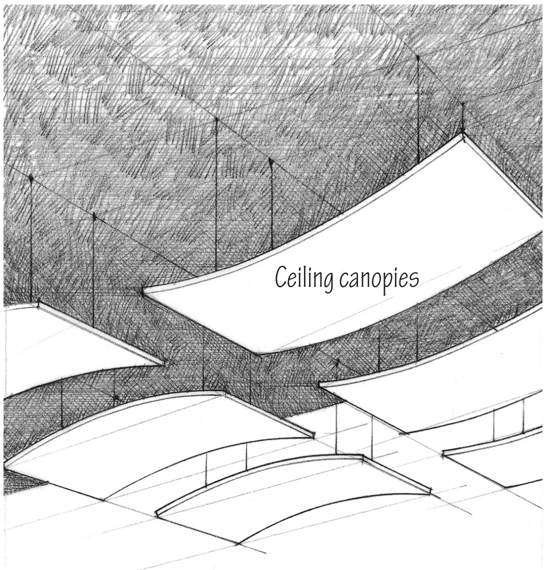



Lowering part of a ceiling adds variety to a room and shelters more intimate spaces. Lowered ceiling sections can be treated with acoustical finishes to absorb sound over noisy areas. Soffits built down from ceilings can hide ductwork and other mechanical equipment of a room, or fill spaces above wall cabinets or shelving.

Ceiling canopies and clouds can be made of fabric, acoustical tile, metal, translucent plastic, or other materials. They allow ceilings to be dropped over small areas, even below other ceiling finish materials. Canopies and clouds are suspended from pendants or wires, and usually allow access to equipment on the ceiling above. Clouds tend to have more structured framing systems, and are usually made of acoustic materials, sometimes with a perforated metal finish.

Stretched ceiling systems consist of a lightweight track with vinyl or other lightweight fabric stretched across and clipped to it. Stretched ceilings can be made in almost any shape.



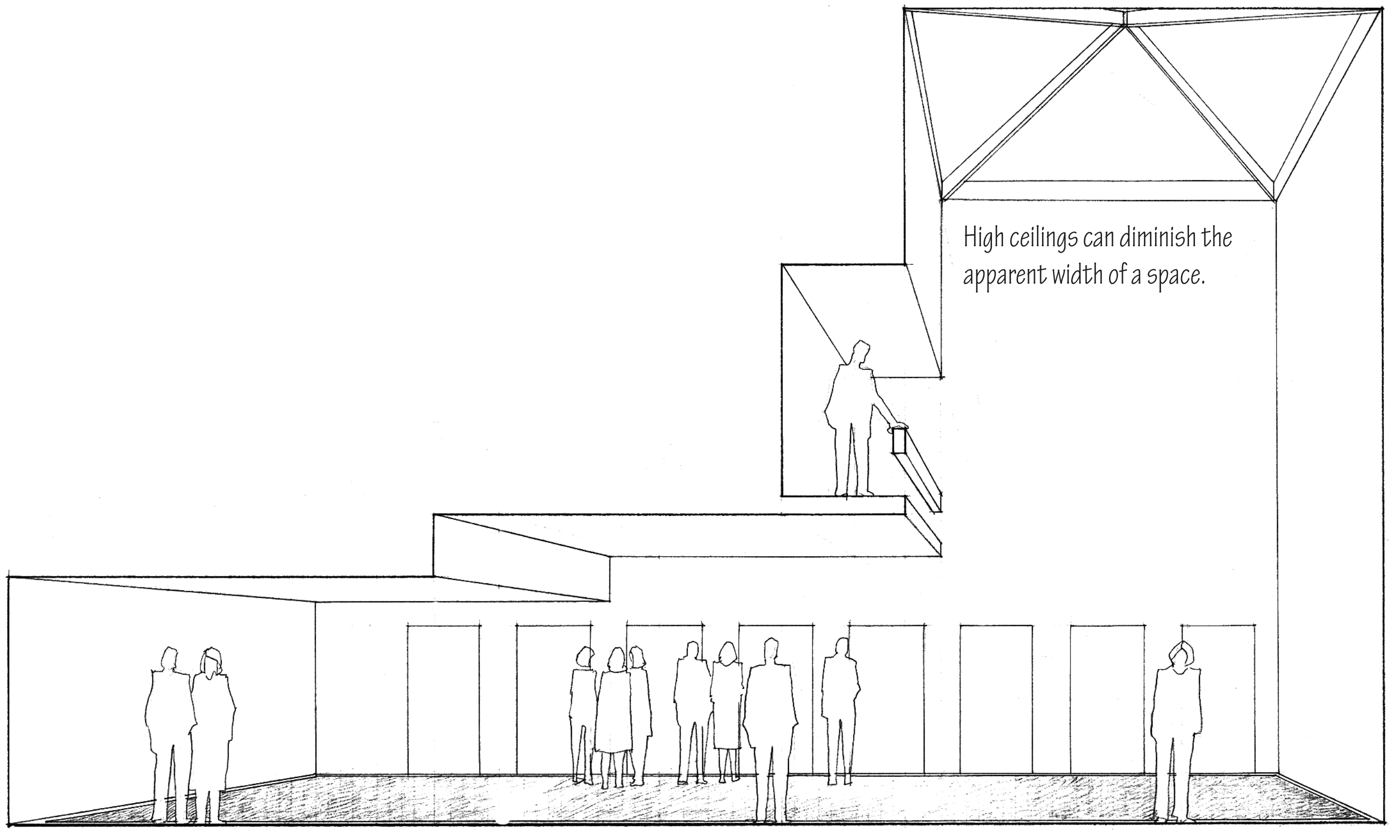



The height of a ceiling has a major impact on the scale of a space. While a ceiling's height should be considered relative to a room's other dimensions and to its occupancy and use, some generalizations can still be made about the vertical dimension of a space.

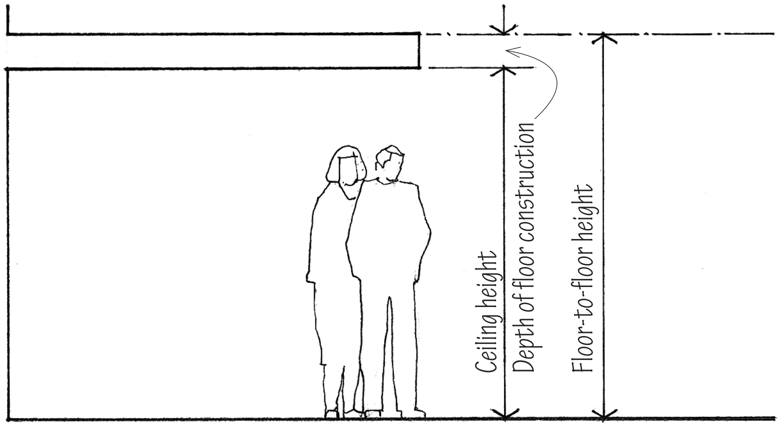
High ceilings tend to give a space an open, airy, lofty feeling. They can also provide an air of dignity or formality, especially when regular in shape and form. Instead of merely hovering over a space, they can soar.

Low ceilings, on the other hand, emphasize their sheltering quality and tend to create intimate, cozy spaces. Low ceilings over large areas may feel oppressive.

Changing the ceiling height within a space, or from one space to the next, helps to define spatial boundaries and to differentiate between adjacent areas. Each ceiling height emphasizes, by contrast, the lowness or height of the other.




The normal height of a ceiling should be in proportion to a room's horizontal dimensions and to its use.

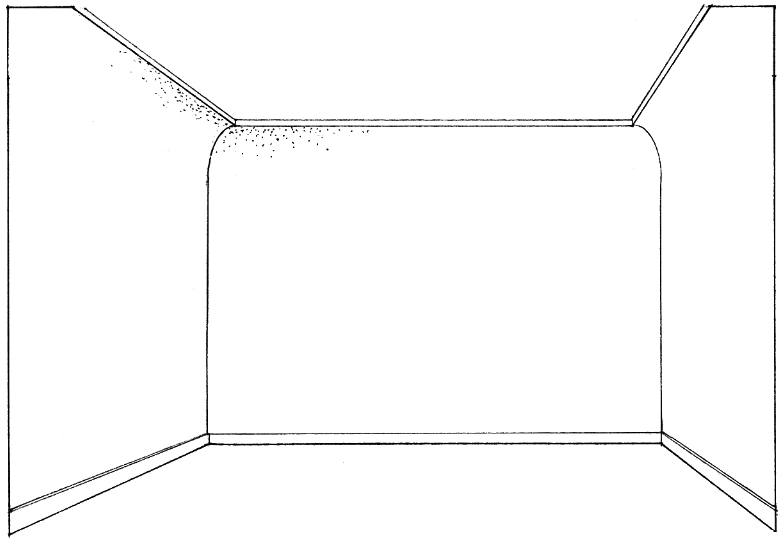



When a floor above forms a flat ceiling, the ceiling height is fixed by the floor-to-floor height and the depth of the floor construction. Given this fixed dimension, the apparent height of a ceiling can be altered in several ways.

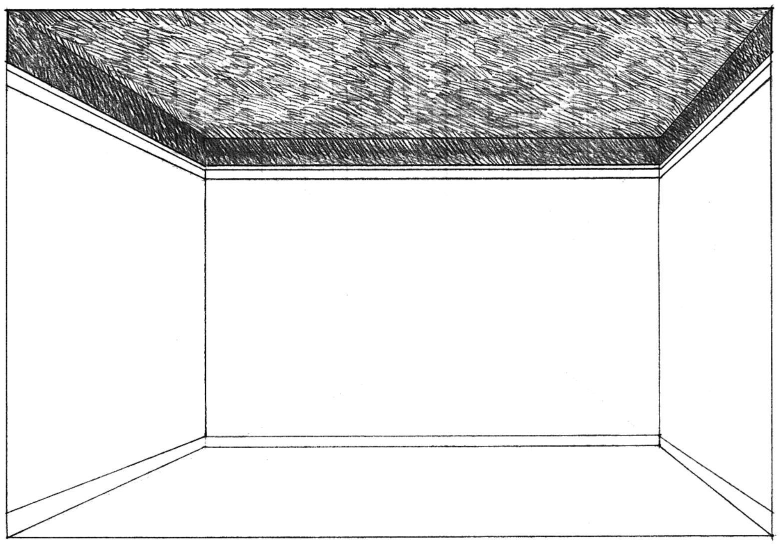
Because light values appear to recede, smooth, light-colored ceilings that reflect light convey a feeling of spaciousness. Carrying the wall material or finish onto the ceiling plane can make a ceiling appear higher than it is, especially when a cove is used to make the transition between wall and ceiling.

The apparent height of a ceiling can be lowered by using a dark and/or bright color that contrasts with the wall color, or by carrying the ceiling material or finish down onto the walls.

Warm air rises, while cooler air descends. A high ceiling allows the warmer air in a room to rise and cooler air to settle at floor level. This pattern of air movement makes a high-ceilinged space more comfortable in warm weather but more difficult to heat in cold weather. Conversely, a low-ceilinged space traps warm air and is easier to heat in cold weather, but can be uncomfortably warm in hot weather.



Ceiling coves smooth the transition between wall and ceiling.



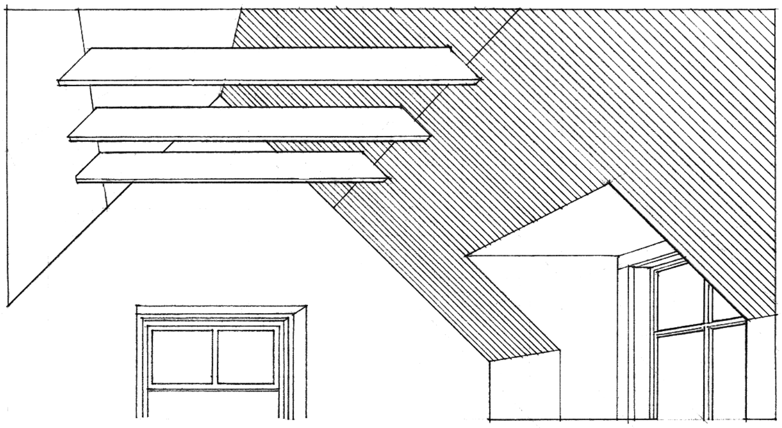
A dark ceiling color carried down onto the walls lowers the apparent ceiling height.

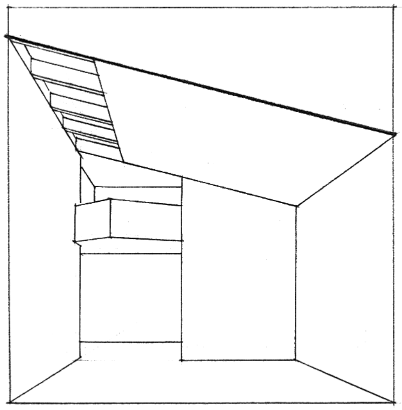
Ceilings supported by a floor structure above are normally flat. When created by a roof structure, however, a ceiling can take on other forms that reflect the shape of the structure, add visual interest, and give direction to the space.

A single-slope or *shed-roof* form may lead the eye up toward the ridge or down toward the eave line, depending on the location of the daylighting sources within the room.

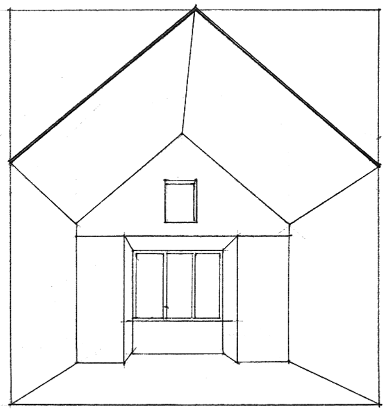
Gabled ceilings expand space upward toward the ridgeline. Depending on the direction of any exposed structural elements, the gabled form may direct our attention to the height of the ridge or to its length.

A pyramid ceiling directs the eye upward to its peak, a focus that can be accentuated further with an illuminating skylight.

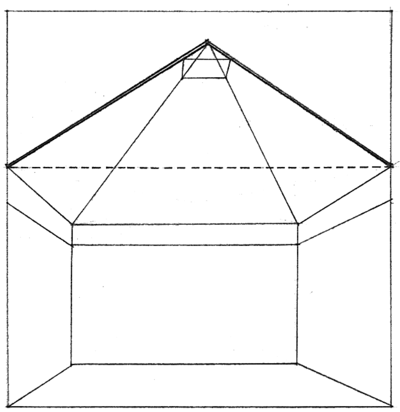




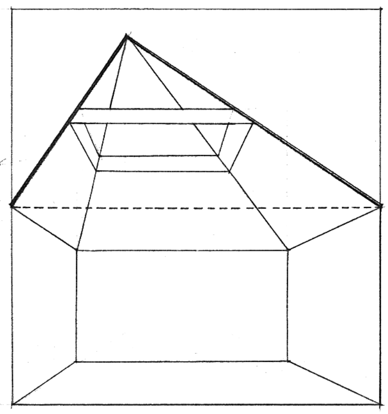
Single-slope ceiling



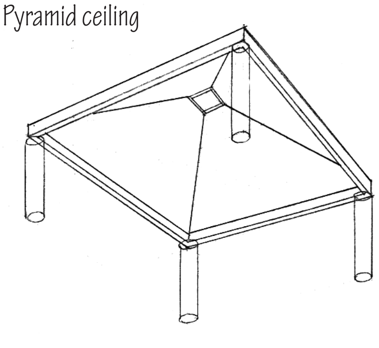
Gabled ceiling

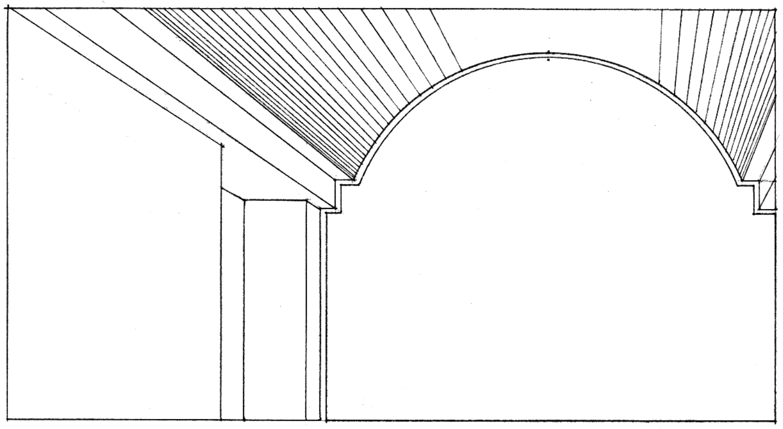


Pyramid ceiling



Off-center pyramid

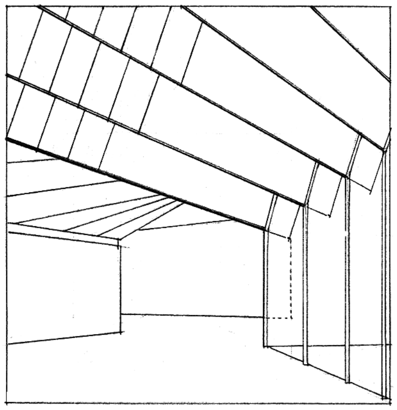




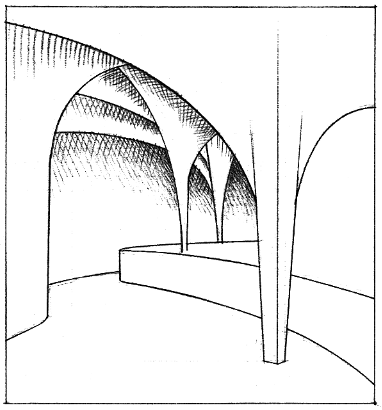
A coved ceiling uses a curved surface to soften its meeting with the surrounding wall planes. The resulting merger of vertical and horizontal surfaces gives the enclosed space a plastic, moldable quality.

Increasing the scale of the cove leads to vaulted and domed ceiling forms. A vaulted ceiling directs our eyes upward and along its length. A dome is a centralized form that expands space upward and focuses our attention on the space beneath its center.

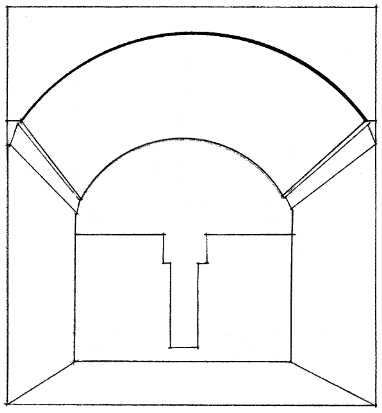
Freeform ceilings contrast with the planar quality of walls and floors and, therefore, attract our attention. Whether curvilinear or angular in nature, they are decorative and can dominate the other elements of interior space.



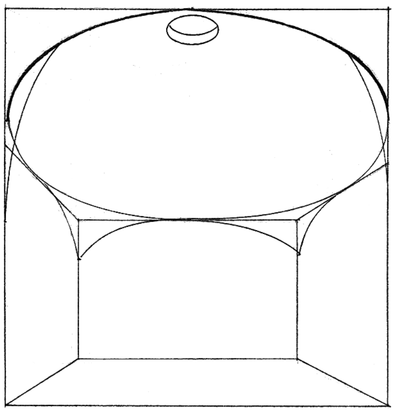
Angular freeform ceiling



Curving freeform ceiling



Vaulted ceiling



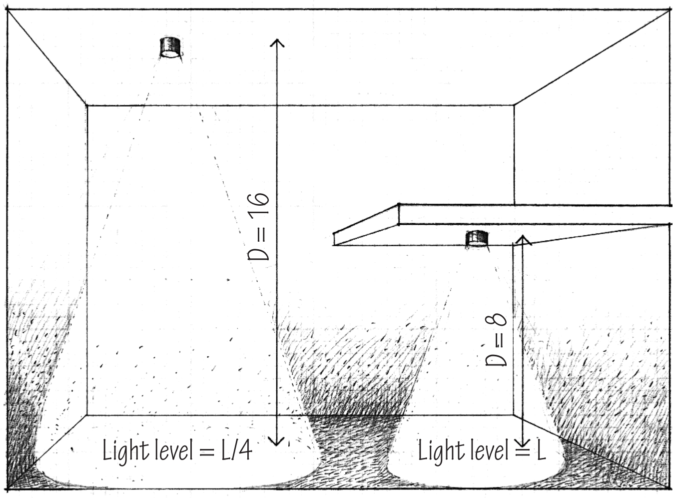
Domed ceiling

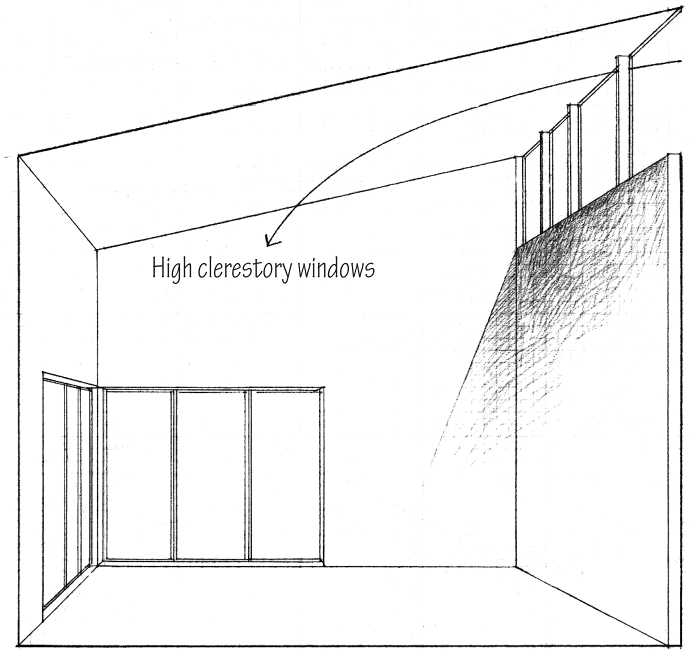
As a functional element, a ceiling affects the illumination of a space, its acoustical quality, and the amount of energy it requires to heat or cool it.

The height and surface qualities of a ceiling affect the light level within a space. Fixtures mounted on a high ceiling must cast their light a greater distance to achieve the same level of illumination as fewer fixtures suspended below the ceiling.

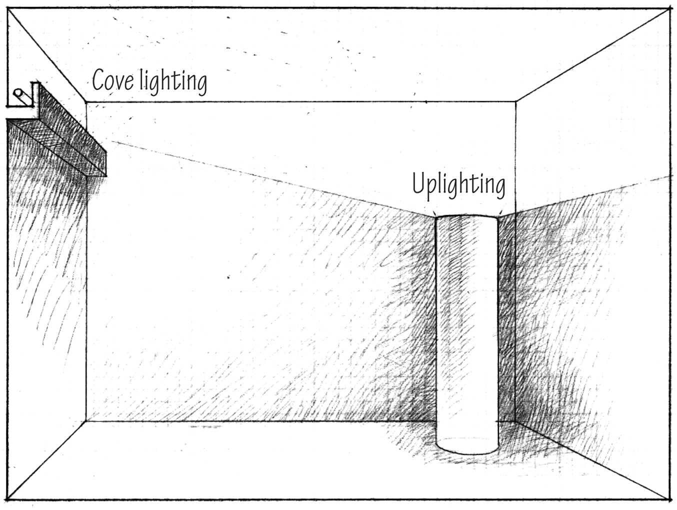
Because it is not usually encumbered with elements that can block the illumination from light sources, a smooth and light-colored ceiling plane can be an efficient reflector of light. When directly lit from below or the side, the ceiling surface itself can become a broad surface of soft illumination.

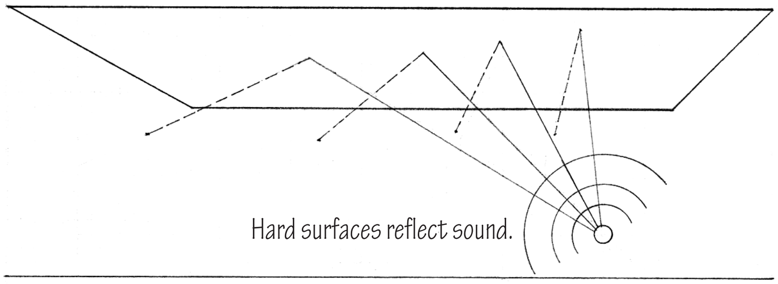
The intensity of light diminishes according to the square of the distance from its source.



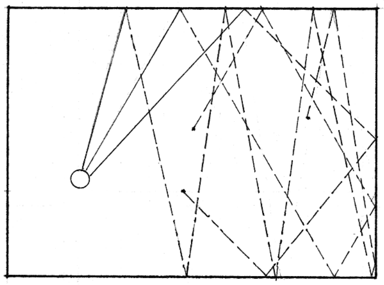

Light-colored ceilings can become sources of illumination when lit by broad sources of light.

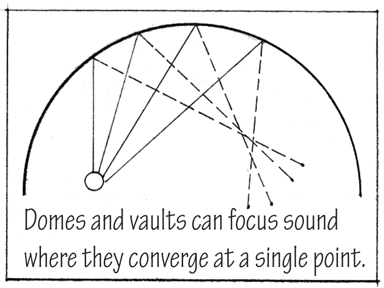


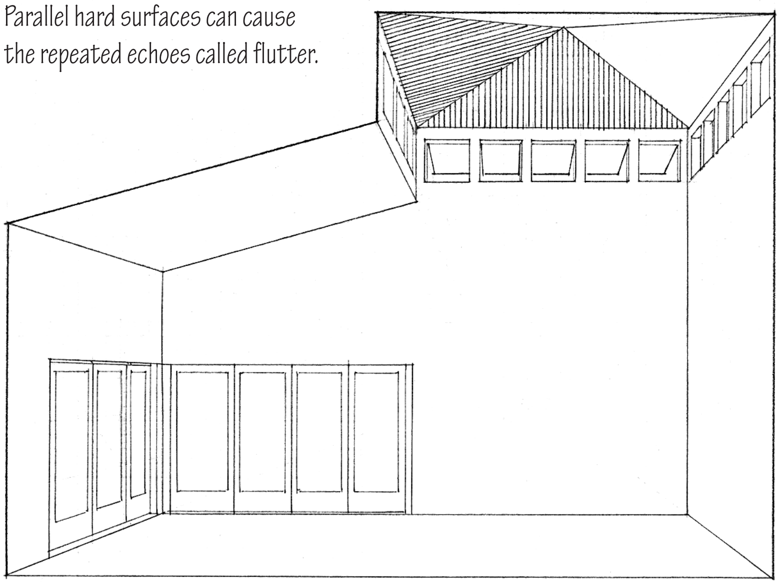

Hard surfaces reflect sound.

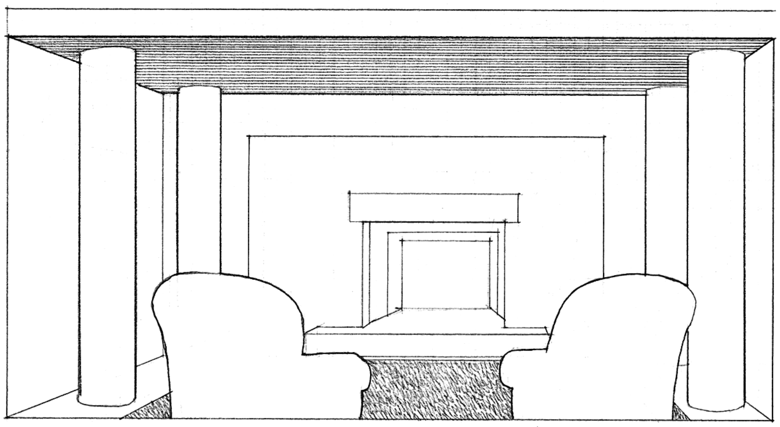
Because the ceiling represents the largest unoccupied surface of a room, its form and texture can have a significant impact on the room's acoustics. Smooth, hard ceiling materials reflect airborne sound within a space. In some situations, this is acceptable since other elements and surfaces in a space can employ sound-absorbing materials. In offices, stores, and restaurants, where additional sound-absorbing surfaces may be required to reduce the reflection of noise from numerous sources, acoustical ceilings can be employed.

Undesirable *flutter* within a space results when rapidly repeated echoes traverse back and forth between two nonabsorbing parallel flat or concave planes, such as a shallow dome opposite a hard-surfaced floor. A remedy for flutter is to add absorbing surfaces. Another is to slope the ceiling plane or use one with a multifaceted surface.


Parallel hard surfaces can cause the repeated echoes called flutter.


Domes and vaults can focus sound where they converge at a single point.



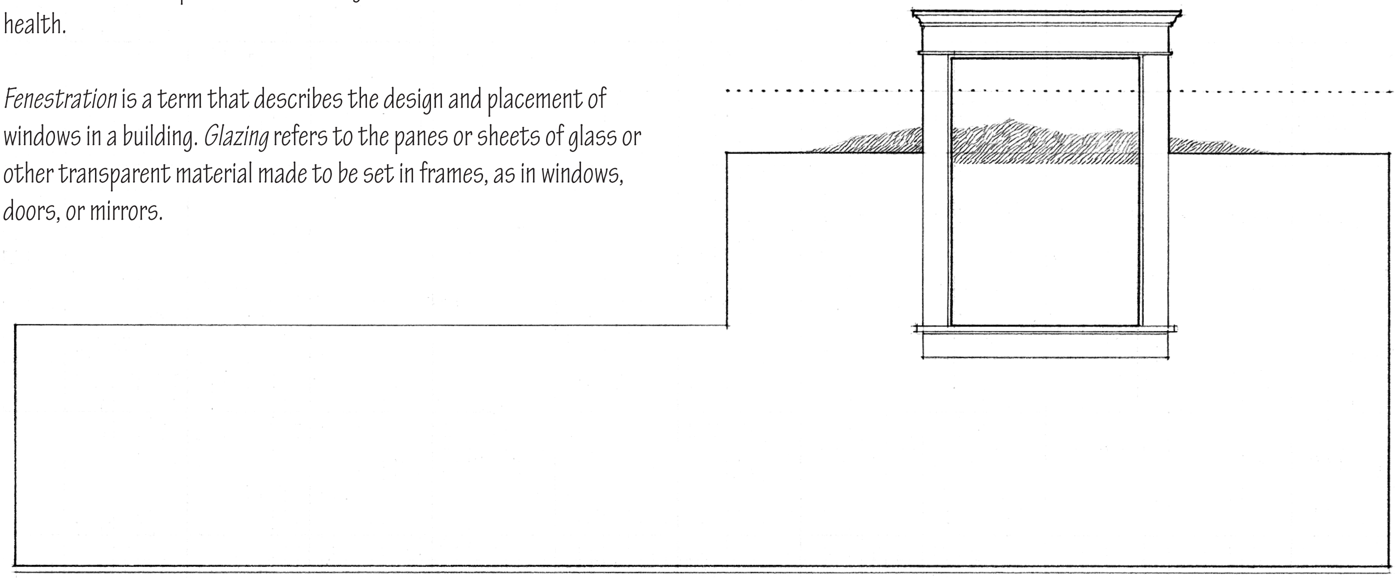


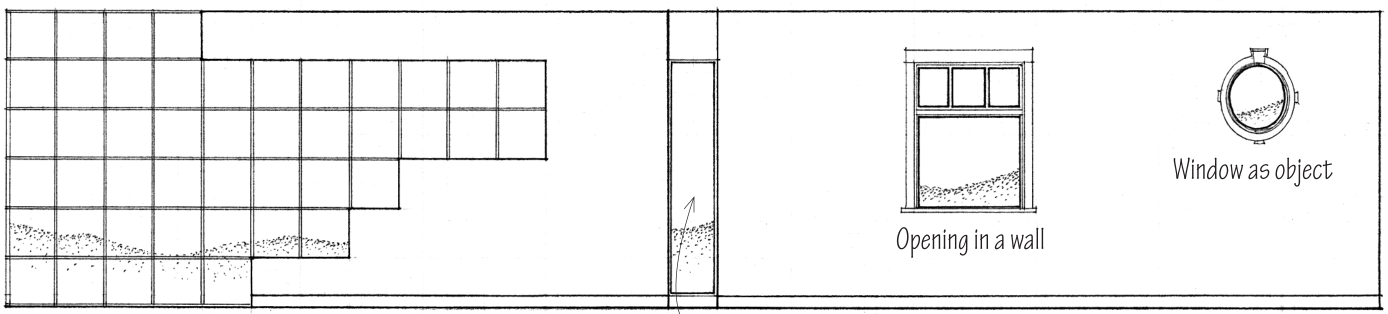
Windows and doorways interrupt the wall planes that give a building its form and give interior spaces their definition. They are transitional elements of architectural and interior design that link one space to another and join inside to outside, both visually and physically.

The size, shape, and placement of windows affect the visual integrity of a wall surface and the sense of enclosure it provides. A window can be seen as a bright area within a wall or a dark plane at night, an opening framed by a wall, or a void separating two wall planes. It can also be enlarged to the point where it becomes the physical wall plane—a transparent window wall that visually unites an interior space with the outdoors or an adjacent interior space.

Studies have shown that humans who view photographs of natural landscapes display higher cognitive performance compared with those who see photos of an urban environment. Humans also relate positively to shapes and arrangements that occur in nature. However, experts warn that products that mimic nature while destroying nature itself in the process can work against holistic views of human health.

*Fenestration* is a term that describes the design and placement of windows in a building. *Glazing* refers to the panes or sheets of glass or other transparent material made to be set in frames, as in windows, doors, or mirrors.



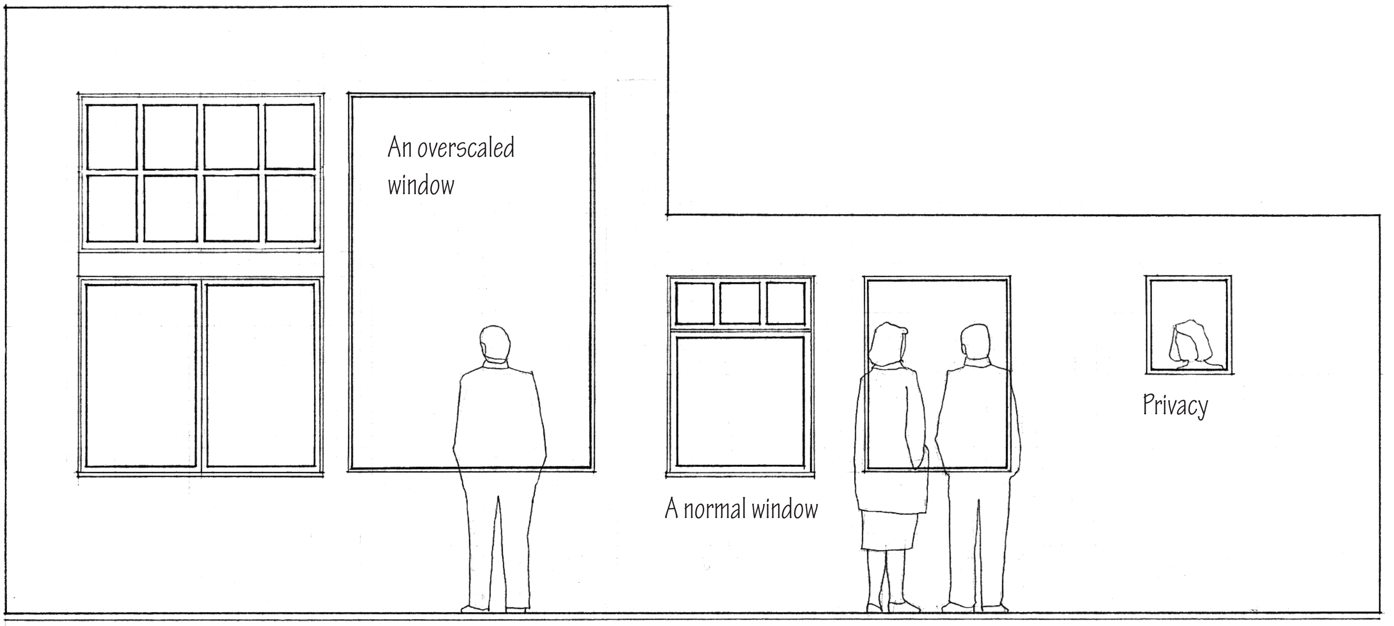



Window framing a view beyond

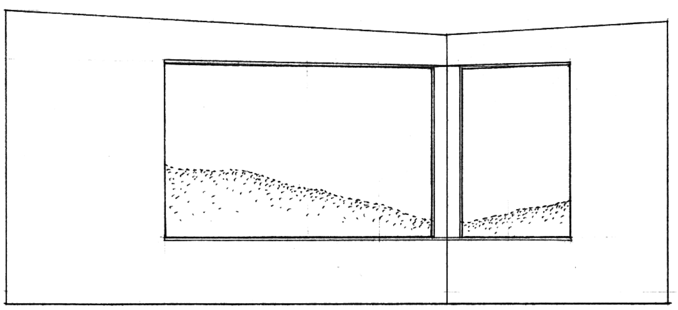
Window separating two planes

The scale of a window is related not only to the surrounding wall plane but also to human dimensions. We are accustomed to a window head height slightly above our height and to a sill height that corresponds to our waistline. When a large window is used to expand a space visually, broaden its outlook, or complement its scale, the window can be subdivided into smaller units to maintain a human scale.

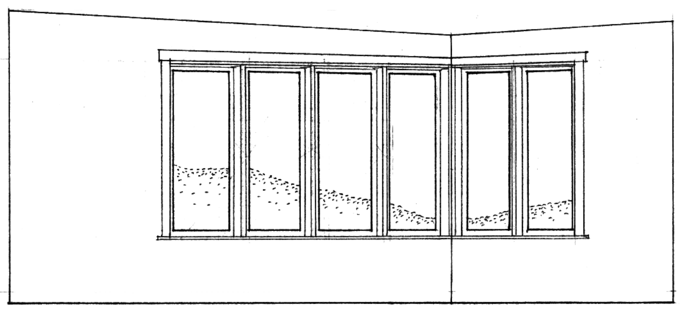
Motorized blinds, shades, and drapes are becoming more affordable and accessible. Child safety guidelines to guard against window cord strangulation are a major concern, especially where older products have not been updated in schools, daycare centers, and military housing.




Varying the scale of window openings



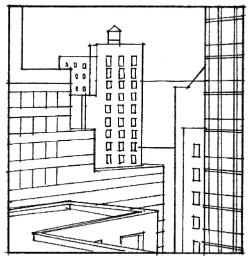
The design and placement of windows in a building is called fenestration.

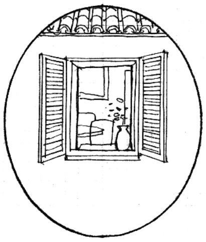


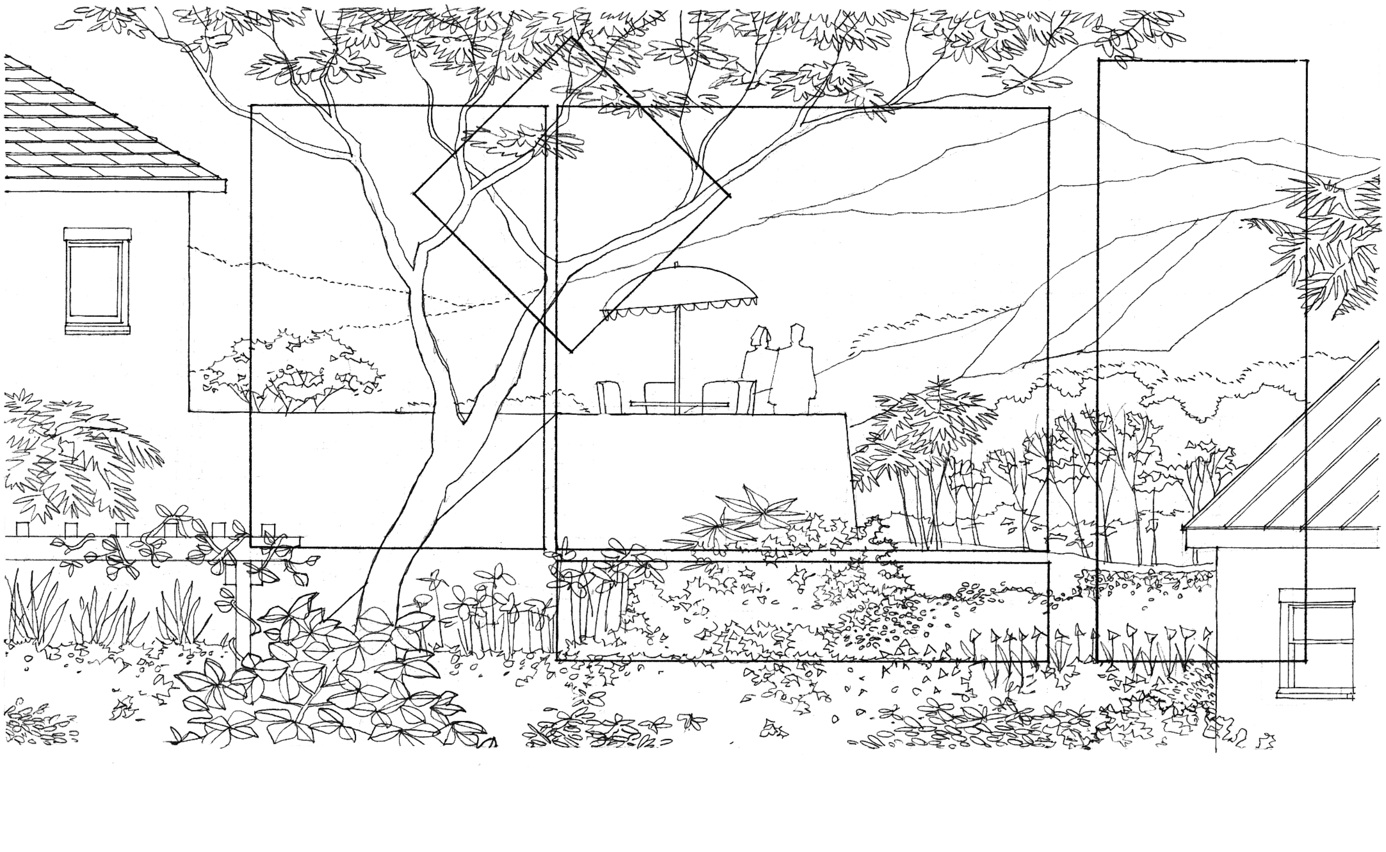
The fenestration pattern and window trim details affect the sense of enclosure provided by the walls of a room.

Views from windows become an integral part of the fabric of interior space. They not only provide an outward focus from within a room but also convey visual information to us about where we are. They form a connection between inside and outside.

In determining the size, shape, and placement of windows in a room, consideration should be given to what can be seen through the window openings (both from inside and outside), how these views are framed, and how the visual scenes shift as we move about the room.

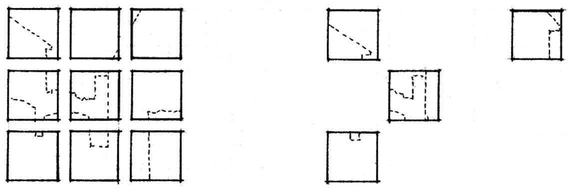




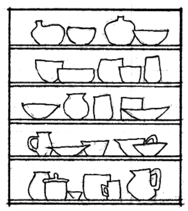


Windows do more than simply frame views; they also aid in daylighting a space and providing for its ventilation. Daylight and access to outdoor views are considered important components of sustainable design.

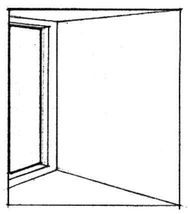
However, a window may expose a less than desirable view. In such a case, the treatment of a window can fragment, filter, or divert our view. Exterior landscaping can also aid in shielding an interior space from an undesirable view or even create a pleasant outlook where none existed. Translucent window glazing and sheer fabric casements can obscure views while allowing some daylight to pass.



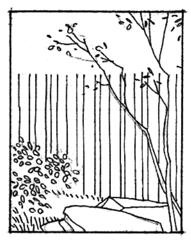
Fragment the view with a grouping of small windows.



Filter the view by setting a collection of objects within the window opening.



Divert attention away from the view.



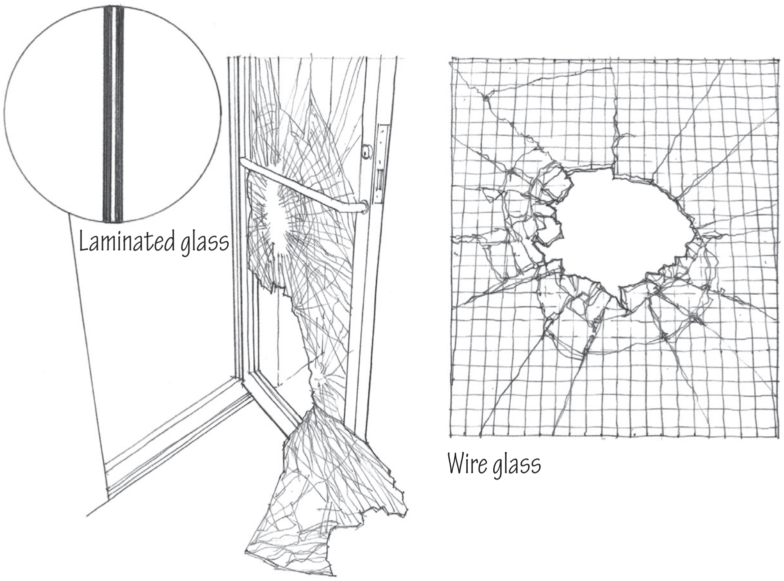
Where no view exists, create a garden or courtyard view.

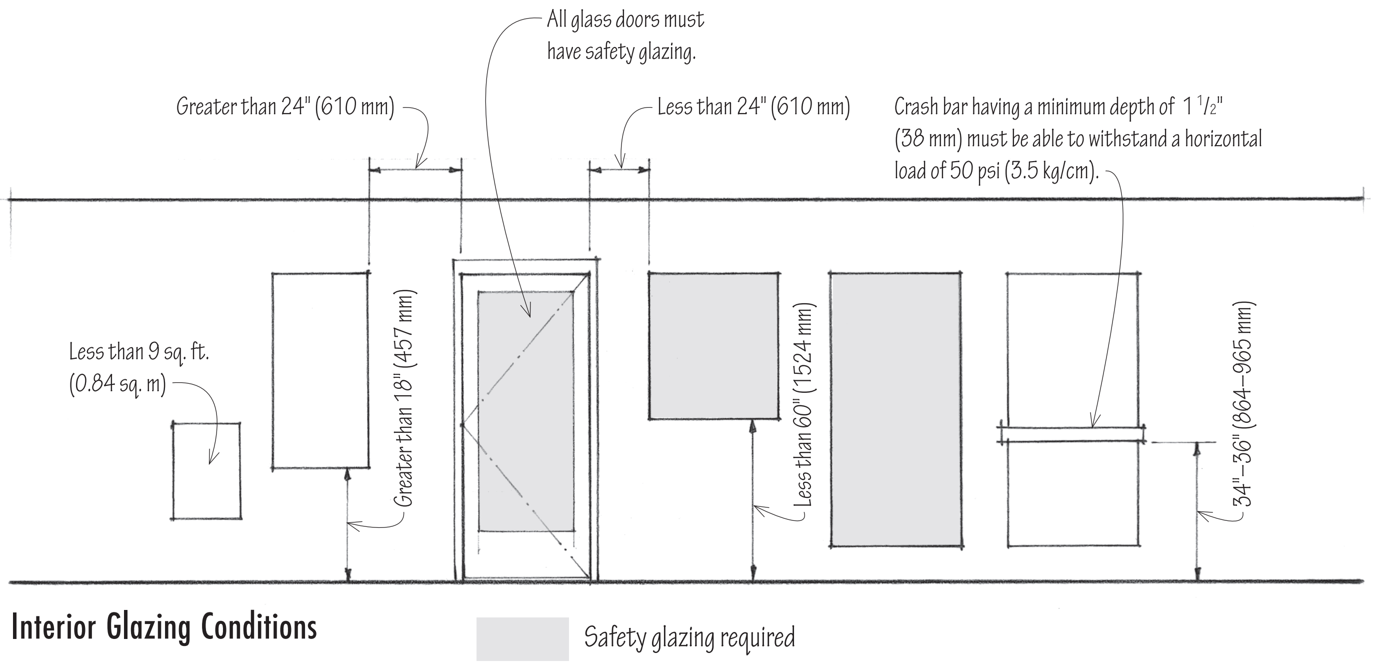
## Ways to Deal with an Unsightly View

Interior glazing allows light to pass through the building from outside and from one space to another. It opens up and visually connects spaces. Glazed walls and vision panels make it possible to see if an adjoining space is occupied; translucent glazing can be used so that movement can be detected while preserving some privacy.

*Safety glazing* is required in locations that could be subject to human impact, such as in glass doors, shower and bath enclosures, and glass sidelights in partitions. Generally, *tempered glass* and *laminated glass* are considered safety glazing. Building codes set requirements for the use of glazing in fire-resistance-rated assemblies, including some corridors.

*Wire glass* has wire mesh or parallel wires rolled into the center of the glass sheet. If breakage occurs, the wire helps to hold the glass fragments in the opening, reducing personal injuries. The use of wire glass has been limited in some locations due to concern about injuries when it is broken by a hand.

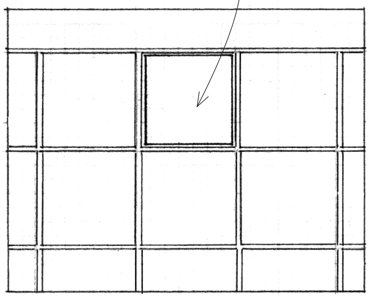
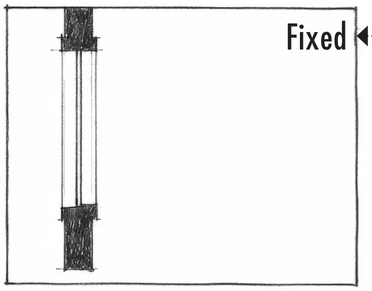



Interior Glazing Conditions

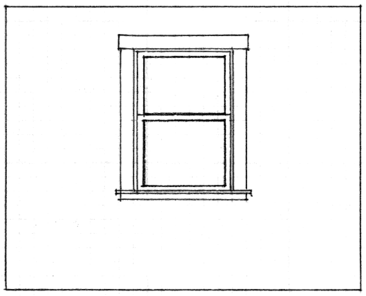
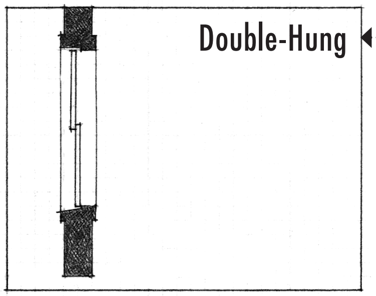
Windows can be categorized into two major groups: fixed and ventilating. Fixed windows cannot be opened and are sometimes used in interiors. Both groups provide interior spaces with light and views, but fixed windows do not allow for the passage of air, as do ventilating windows, which can be opened and closed.

Glazing refers to the panes or sheets of glass set in the frame of a window.

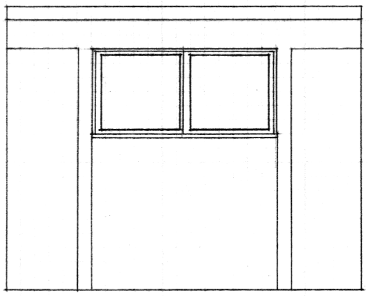
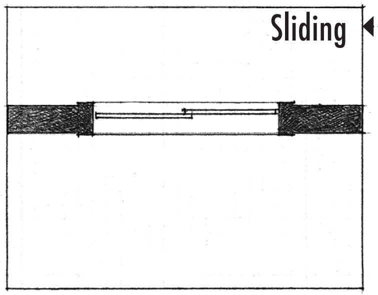
**Fixed**

- Frame and glazed sash are stationary.
- No ventilation is possible.
- Hardware or screens are not required.
- Varied sizes and shapes are possible.

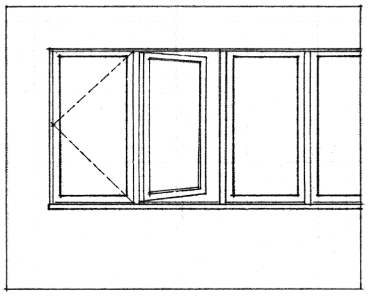
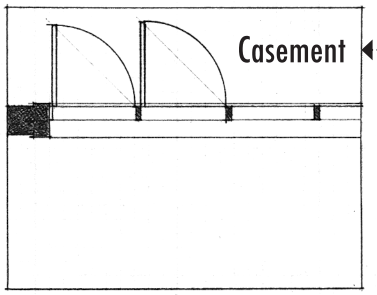
**Double-Hung**

- Two sashes travel vertically in separate tracks or grooves and are held in the desired position by friction or a balancing device.
- No rain protection is provided.
- Can be weatherproofed effectively.
- May be screened on outside.
- Provide maximum 50 percent ventilation.
- Difficult to paint and clean without pivoting sash.

**Sliding**

- May consist of either two sashes, of which one slides horizontally (50 percent ventilation), or three sashes, of which the middle is fixed while the other two slide (66 percent ventilation).
- No rain protection is provided.
- Screened on exterior.
- Sliding patio doors are similar to large sliding windows.

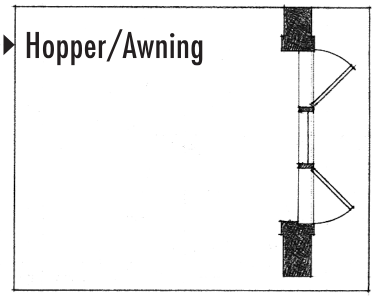
**Casement**

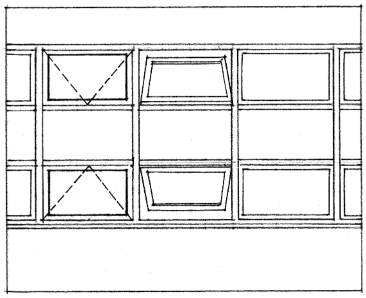
- Operating sash is side-hinged and usually swings outward.
- Provide 100 percent ventilation; can direct or deflect breezes.
- No rain protection.
- Projecting sash can be an obstruction.

Building codes regulate the minimum size of window openings that provide natural lighting and ventilation for habitable spaces, as well as the size of operable windows that serve as emergency exits from residential sleeping spaces.

- Similar to casements but hinged at bottom (hopper) or top (awning).
- Provide 100 percent draft-free ventilation.
- Awning windows provide some rain protection.
- May be difficult to weatherproof.
- Require space for swing of sash.

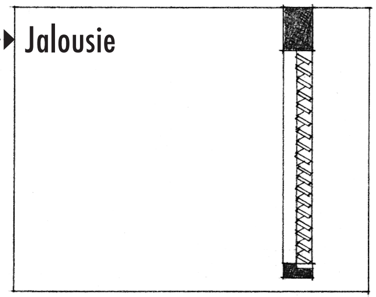
**Hopper/Awning**

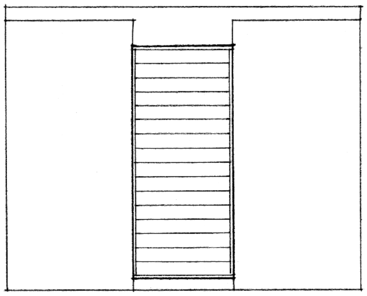




- Similar to awning windows, but with a series of narrow opaque or translucent strips.
- Able to direct flow of incoming air.
- Difficult to clean and weatherproof.
- Used for ventilation along with privacy.

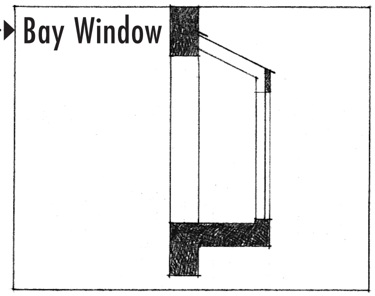
**Jalousie**

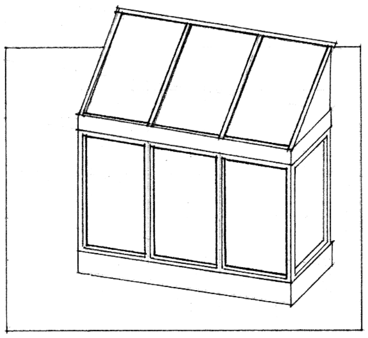




- Use a combination of fixed and operable windows and skylights.
- Project a portion of interior space outward into the surrounding landscape.

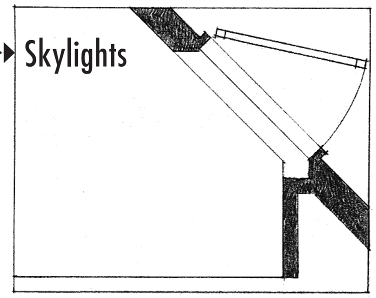
**Bay Window**

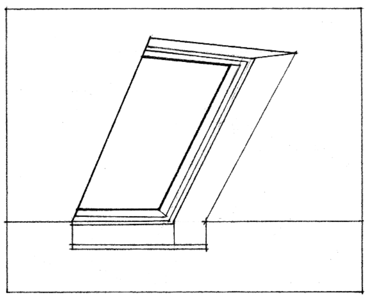




- May consist of fixed or ventilating units.
- Safety glazing is required.
- Provide daylighting.
- Ventilating skylights allow rising hot air to escape in warm weather.

**Skylights**

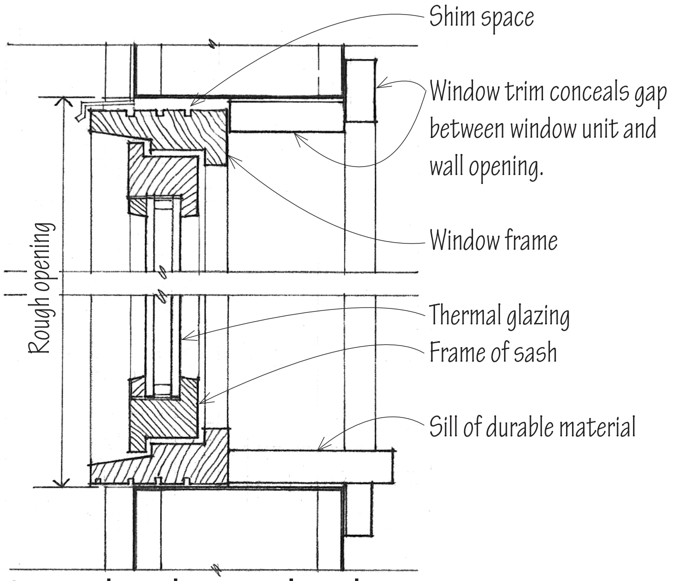




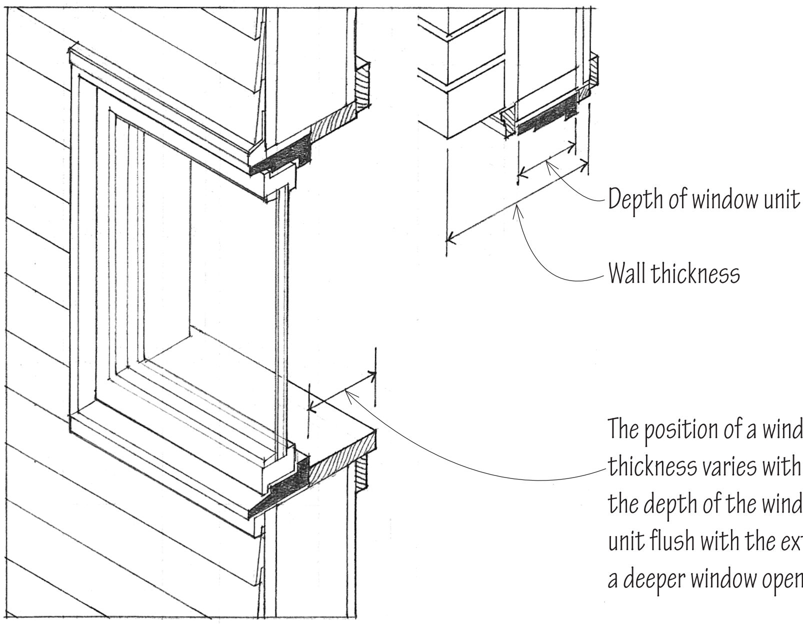
Factory-manufactured windows come in stock sizes, but these vary with each manufacturer. Custom sizes and shapes are available, but often at additional cost.

Rough openings in wall construction usually allow 1/2 to 3/4 inch (13 to 19 mm) on each side and along the top for leveling and plumbing of the window units. Flashing and caulking on the exterior side of the frames help to make the joints weathertight and minimize the infiltration of air, a major source of building heat loss.

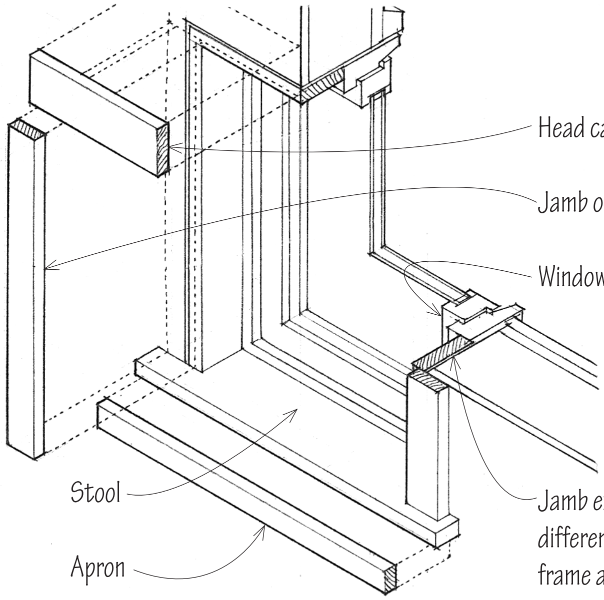
Casing and trimwork are used to conceal and finish the gaps between a window unit and its rough opening. The type of interior trim used contributes significantly to the character of a space.

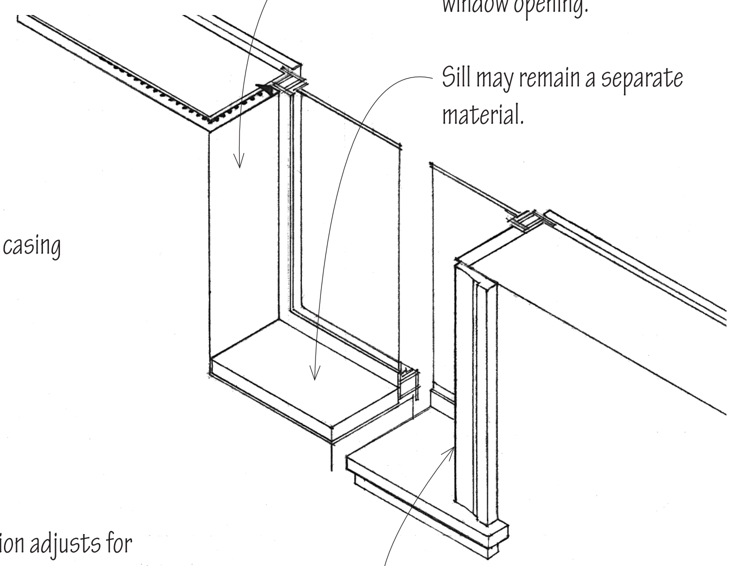



**Section through a Typical Window**

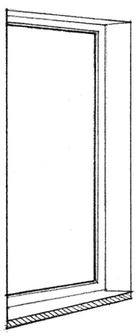



The position of a window unit within a wall's thickness varies with the wall construction and the depth of the window frame. Setting a window unit flush with the exterior face of a wall provides a deeper window opening in the interior.

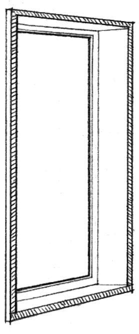


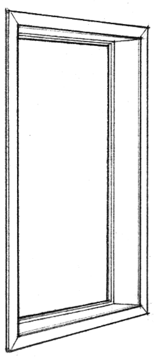

## Interior Window Trim



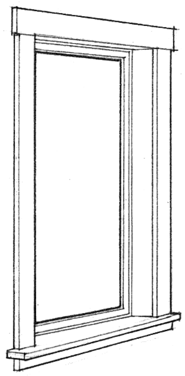
Minimal Trim:
Wall material wraps around corner of window opening.



Light Trim:
Only edge thickness of window trim is exposed.

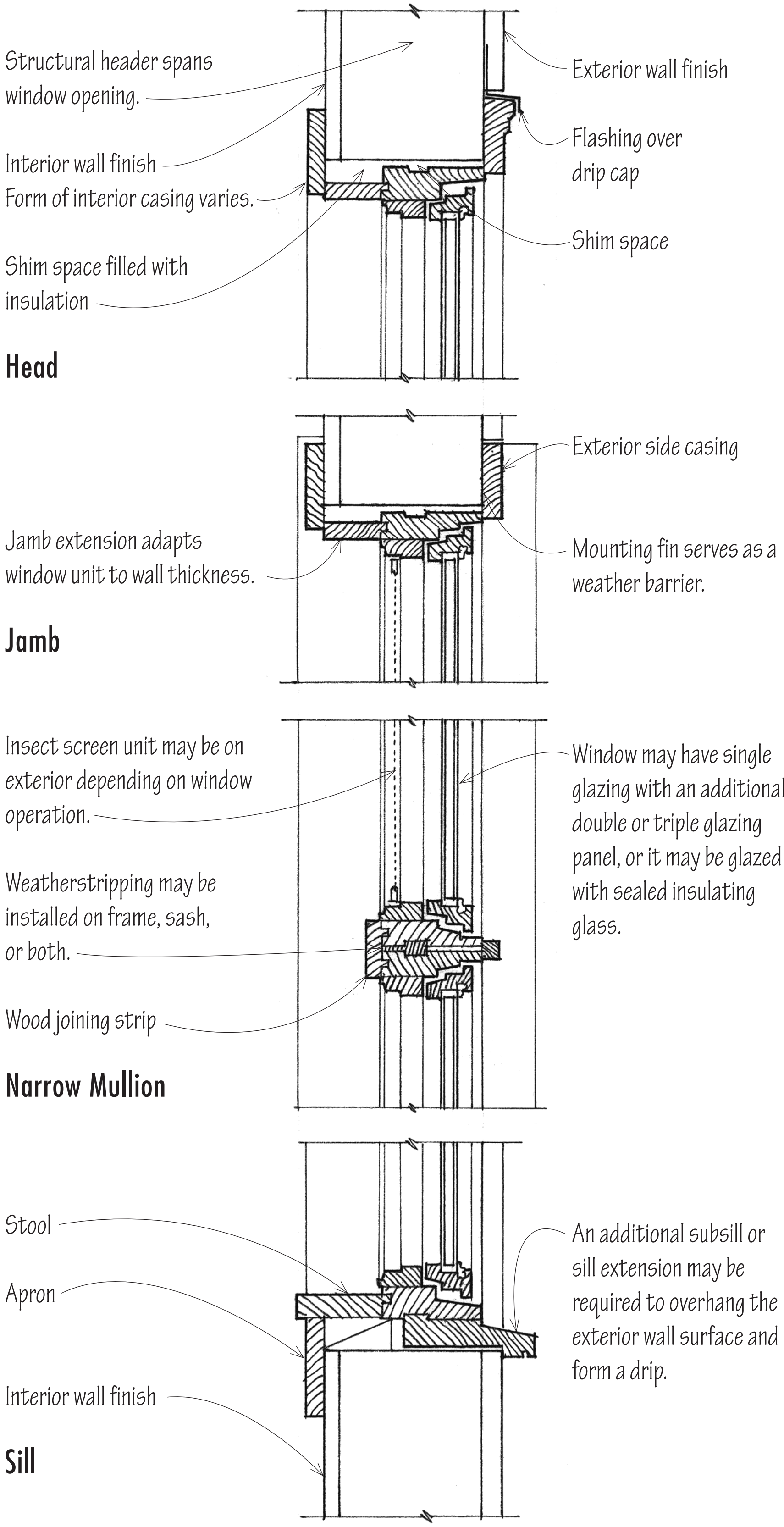


Medium Trim:
Narrow casing trim wraps around entire window opening.



Heavy Trim:
Head, jamb, and sill are differentiated.

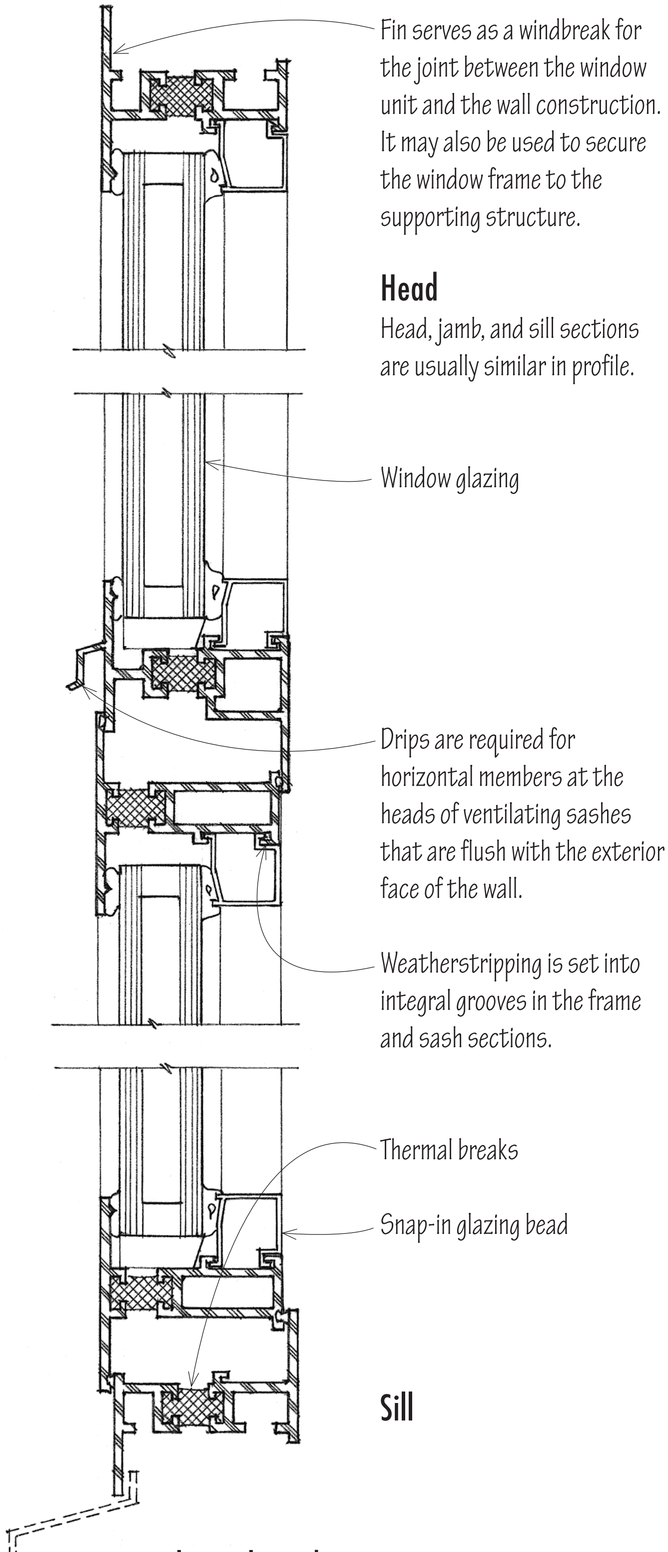
Most windows used today are prefabricated units with frames of wood or metal. Wood frames are generally constructed of kiln-dried, clear, straight-grain wood. They are usually treated in the factory with water-repellant preservatives. The exterior of the frame may be ordered unfinished, stained, primed for painting, or clad with vinyl or with acrylic-coated aluminum for reduced maintenance. The interior of the frame may be ordered unfinished, vinyl clad, or primed for painting.




Typical Wood Window

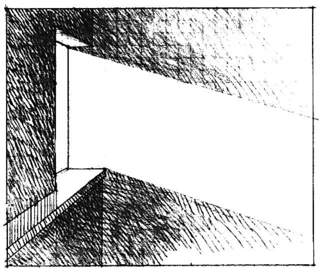
Metal frames are stronger, and therefore usually thinner in profile, than wood frames. Aluminum and steel are the most common types, although stainless steel and bronze window frames are also available. Aluminum frames may have a natural mill finish, or be anodized for additional protection and color. Because aluminum is an efficient conductor of heat, moisture can condense on the inner face of metal sashes in cold weather unless a thermal break is built into their construction. Steel window frames must be galvanized or primed and painted for corrosion resistance.

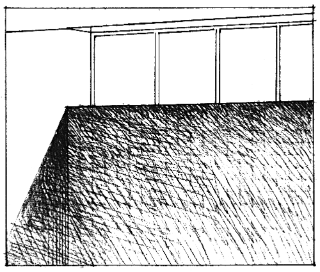
Because aluminum is susceptible to *galvanic corrosion*, anchoring materials and flashing should be aluminum or a material compatible with aluminum, such as stainless steel or galvanized steel. Dissimilar materials, such as copper, should be insulated from direct contact with the aluminum by a waterproof, nonconductive material, such as neoprene or coated felt.

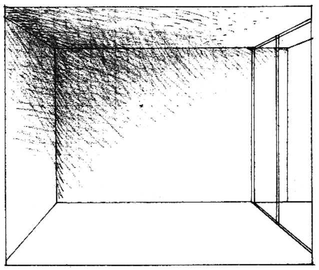


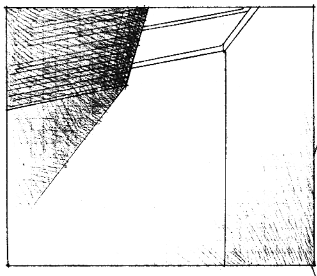

Typical Metal Window

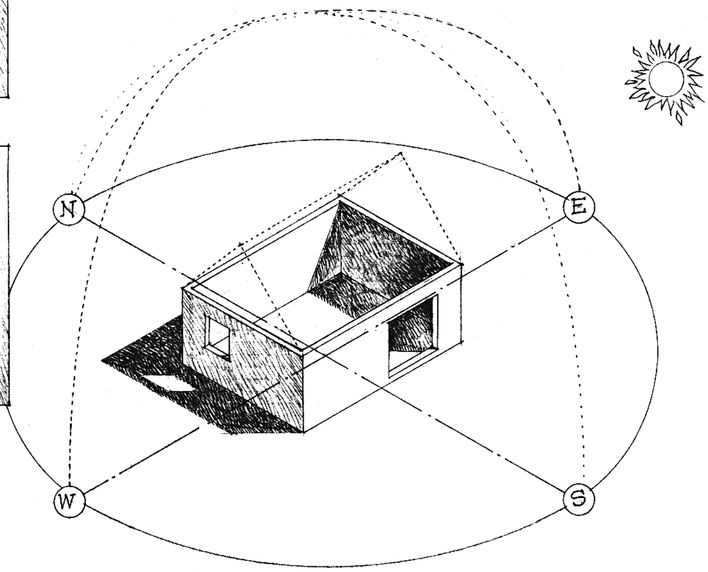
The size and orientation of windows and skylights control the quantity and quality of natural light that penetrates and illuminates an interior space. Window size is obviously related to quantity of light. The quality of light—its intensity and color—is determined by a window's orientation and placement in a room.

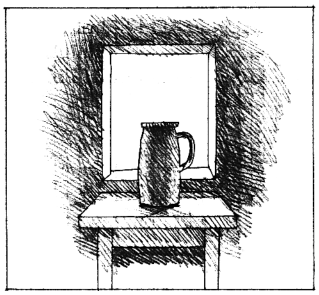

Window

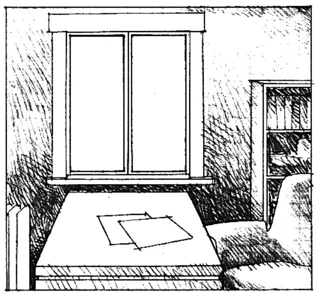

Clerestory

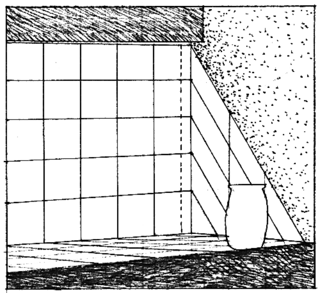

Window wall

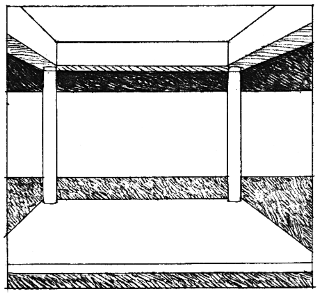

Skylight





Bright areas of light attract attention.

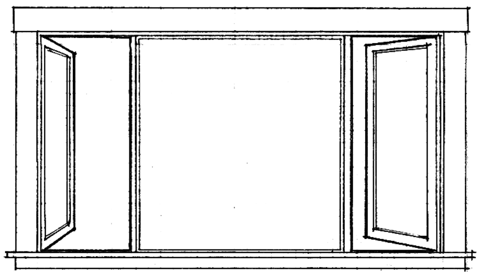

Indirect daylight can be used effectively as task lighting.


Changing patterns of light and shadow animate space.

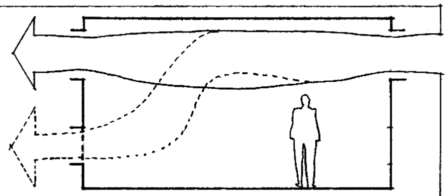

Light can be used to define space.

Natural ventilation relies on the natural movement of air rather than mechanical means, and is an important component of sustainable design. Wind velocity, temperature, and direction are important site considerations in locating windows in all climatic regions. During hot periods, wind-induced ventilation is desirable for cooling by evaporation or conduction. In cold weather, wind should be avoided or screened from windows to minimize the infiltration of cold air into a building. At all times, some degree of ventilation is desirable for good health and the removal of stale air and odors from interior spaces.

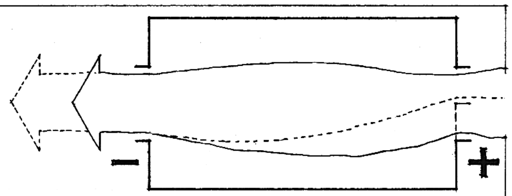
Natural ventilation in interior spaces is generated by differences in air pressure as well as temperature. Airflow patterns induced by these forces are affected more by building geometry than air speed.



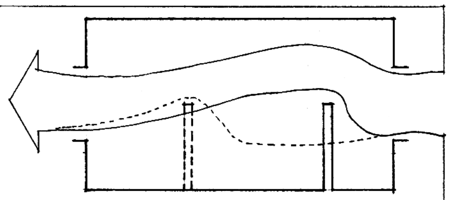
Natural ventilation requires the use of operable windows.



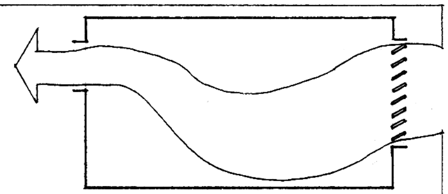
High inlets and outlets produce air movement above our body level. Lowering the outlets does not ameliorate this condition.



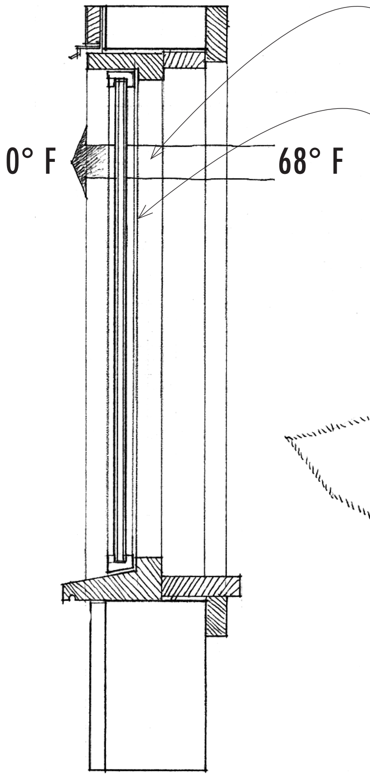
Air flows from higher to lower pressure zones. Air flow is accelerated when inlets are smaller than outlets.



Interior partitions and tall furnishings can adversely affect the pattern of air flow.



Louvers can help direct air flow.

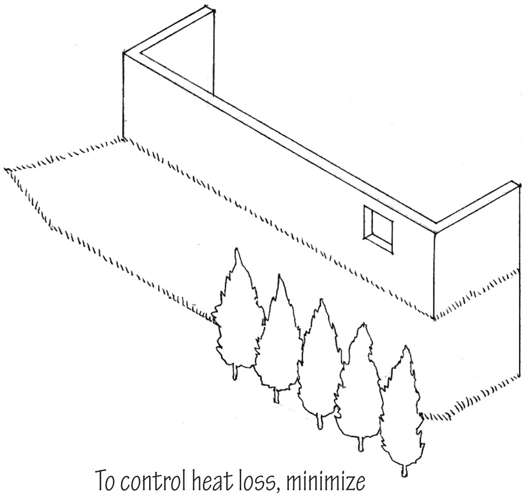



Heat flows from warmer to cooler zones.

Double- or triple-glazing traps air space to increase a window's thermal insulation value.

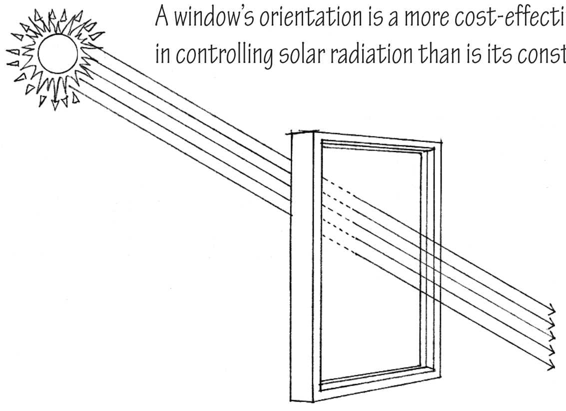
Even when closed, windows are sources of building heat gain and loss. Heat gain helps save heating energy in cold weather but increases cooling energy use in hot weather. Heat gain is due to solar radiation passing through a window's glazing. Heat loss through a window wastes energy in cold weather as a result of the temperature differential between a heated interior space and the colder outside air.

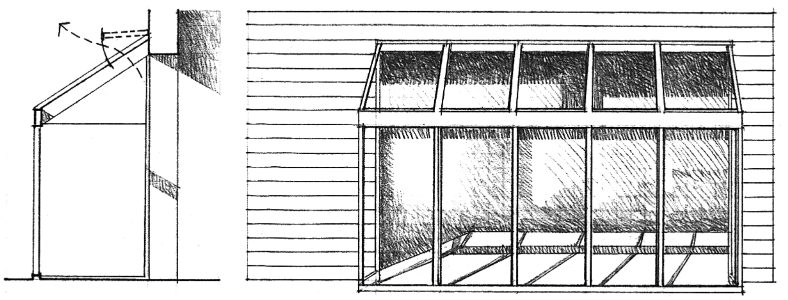
Glass is a poor thermal insulator. To increase its resistance to heat flow, a window can be double- or triple-glazed, so that the trapped air space between the glass panes can be used as insulation. The air space can be filled with an insulating gas, usually argon or krypton, to reduce heat transfer further. For improved thermal efficiency, tinted, reflective, or low-emissivity (low-e) glazing can also be used.



To control heat loss, minimize window openings that face cold winter winds, or buffer them with landscaping elements.

A window's orientation is a more cost-effective factor in controlling solar radiation than is its construction.





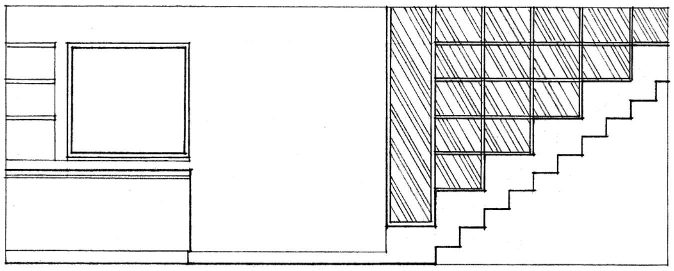
A sunspace is a glazed area oriented to admit large amounts of sunlight. Massive materials store thermal energy for later release. Some operable glazing is necessary to ventilate the space in warm weather.

In addition to their aesthetic impact on the interior environment, windows influence the physical arrangement of furnishings within a room. Their brightness during daylight hours and the views they offer attract our attention and encourage us to orient a furniture grouping toward them.

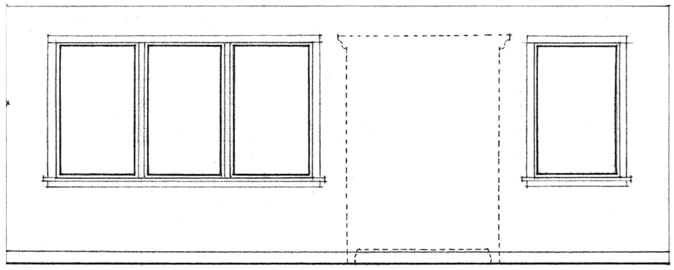
When locating windows, the designer should consider whether the size and proportion of wall segments between them can accommodate the desired furnishings. If wall space is at a premium, clerestory windows and skylights can be considered as alternatives.

The sill height of a window affects what can be placed below it. A low sill height may dictate that the floor area in front of the window be left open, thereby reducing the amount of usable floor space in a room. This is especially pertinent when window walls extend down to the floor to promote visual continuity between interior and exterior space.

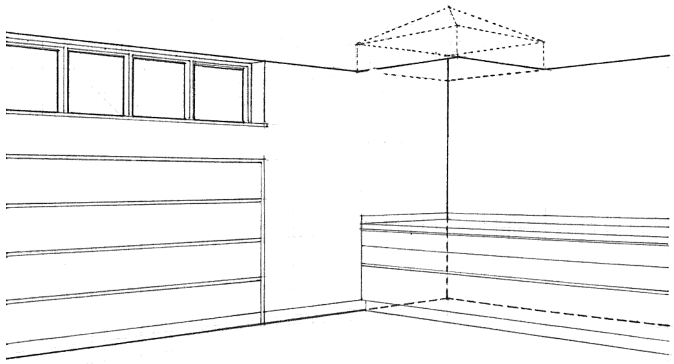
Other considerations in the placement of furnishings near windows include the adverse effect the heat and glare of direct sunlight can have on a room's occupants, and the possible fading and deterioration of its carpet and other furnishings.



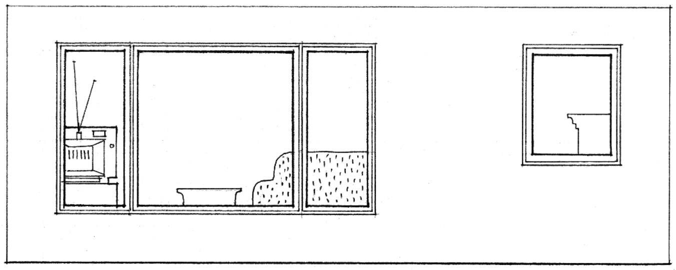
Windows should be coordinated with built-in elements, such as countertops and stairways.



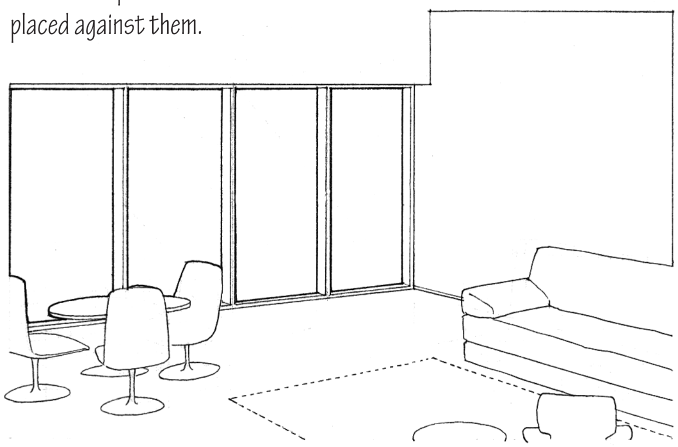
Position windows to consolidate wall space.



Clerestory windows and skylights provide daylight while conserving wall space.

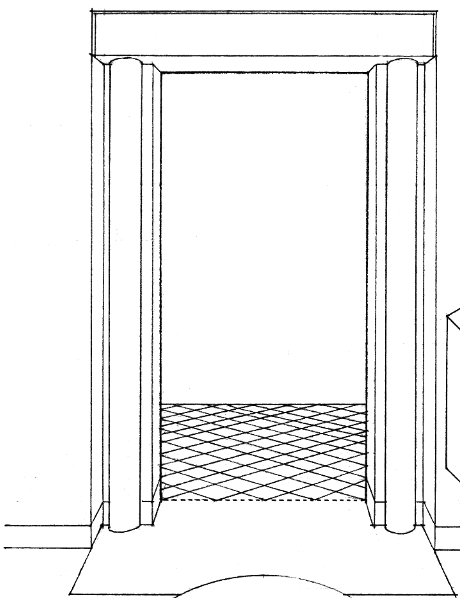


Windows expose the backs of furniture placed against them.

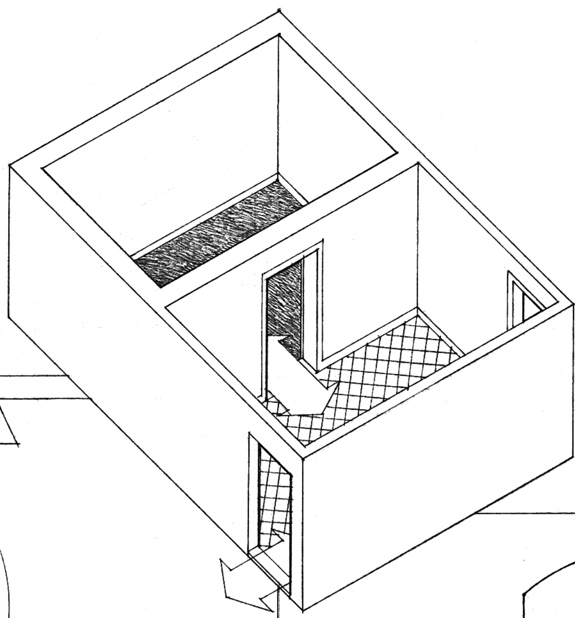


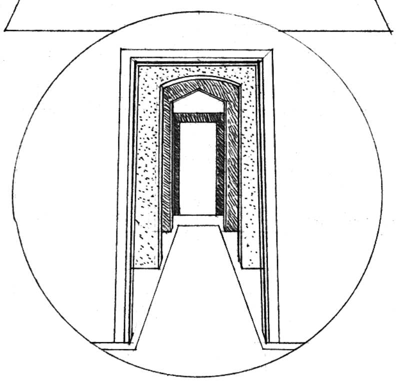
Window walls that extend to the floor inhibit the placement of furniture against them.

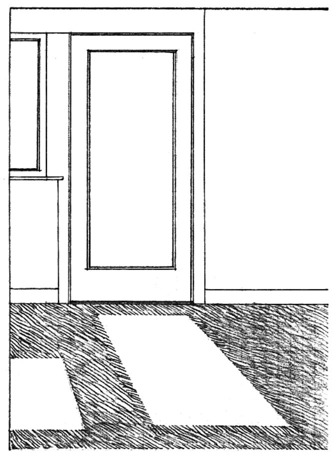
Doors and doorways allow physical access in and out of a building, and from room to room, for ourselves, our furnishings, and our goods. Through their design, construction, and location, doors and windows can control the use of a room, the views from one space to the next, and the passage of light, sound, warmth, and air.



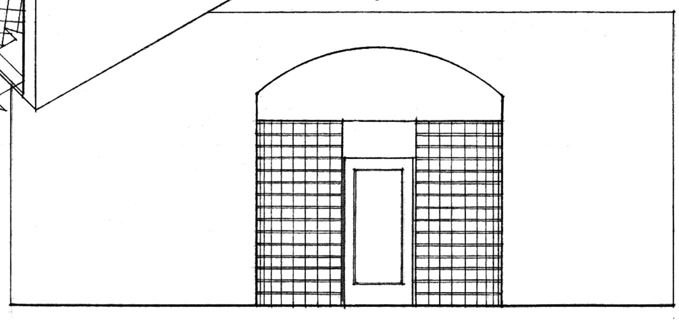
A doorway provides passage from one space to another . . .







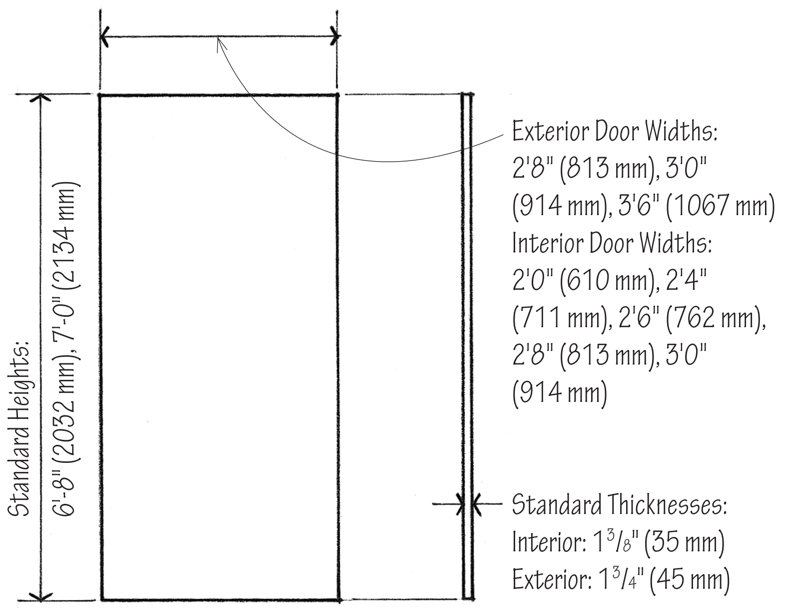
. . . and controls the transmission of light, vision, sound, heat, and cold.



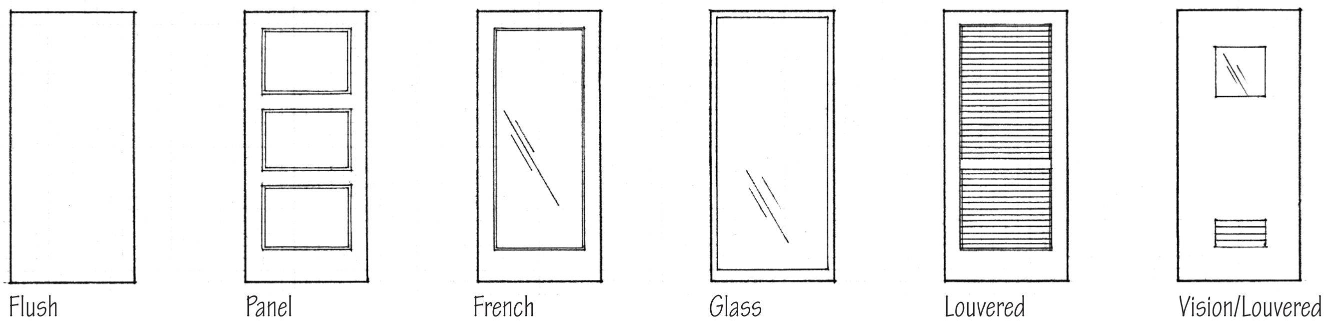
Doors may have wood or metal frames. Doorframes may be prepainted, factory-primed for painting, or clad in various materials. They may be glazed for transparency, or contain louvers for ventilation. It is possible to construct frameless doors for one-hour fire-rated walls.

Glass doors are generally constructed of 1/2- or 3/4-inch (13- or 19-mm) tempered glass, with fittings to hold pivots and other hardware. Jamb frames are not necessary, and the door can be butted directly against the wall or partition.

Special doors include those constructed to have a fire-resistance rating, an acoustical rating, or a thermal insulation value, among others.

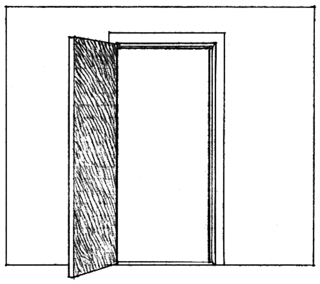


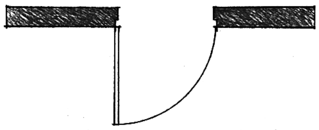

Door Sizes




Door Designs

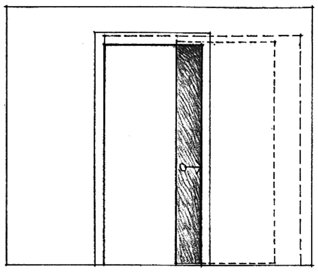
In addition to their design and construction, doors may be categorized according to the way they operate.

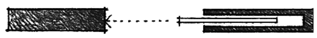




### Swinging

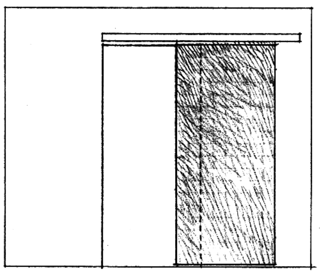
- Hinged on side jamb.
- Heavy or wide doors may pivot at head and sill. Patented pivot technology mortised into the door itself is available.
- Most convenient for our entry and passage.
- Most effective type for isolating sound and for weather tightness.
- For exterior and interior use.
- Requires space for swing.

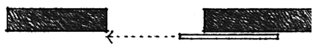




### Pocket Sliding

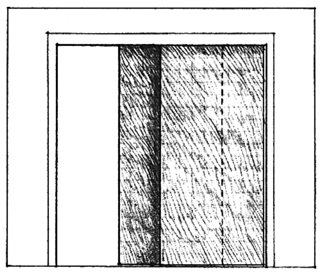
- Door is hung on track, and slides into pocket within width of wall.
- Used where normal door swing would interfere with use of space.
- Presents a finished appearance when open.
- For interior use only.

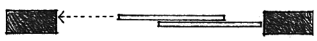




### Surface Sliding

- Similar to pocket door, except that door is surface-hung from an exposed overhead track.
- Also called "barn door" hardware.
- Primarily for interior use.
- Difficult to weatherproof.



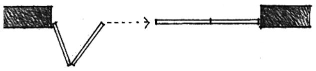


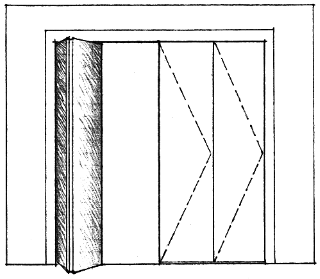
### Bypass Sliding

- Doors slide along an overhead track and along guides or a track on the floor.
- Opens only to 50 percent of doorway.
- Used indoors primarily for visual screening.
- Used on the exterior as sliding glass doors.

### Bifold

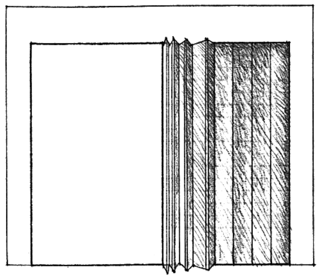
- Consists of hinged door panels that slide on an overhead track.
- For interior use only.
- Commonly used as a visual screen to close off storage and closet spaces.





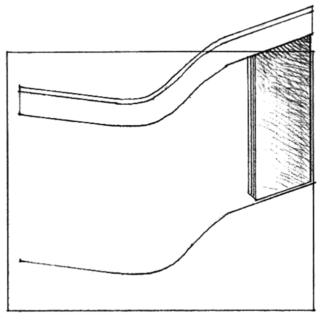
### Accordion Folding

- Similar to bifold doors, except that panels are smaller.
- For interior use only.
- Used to subdivide large spaces into smaller rooms.



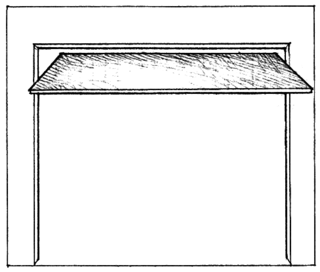
### Special Folding

- Door panels slide on overhead tracks.
- Tracks can be configured to follow a curvilinear path.
- Panels can be stored in pocket or recess.
- For interior use.
- Exterior folding glass doors are available.

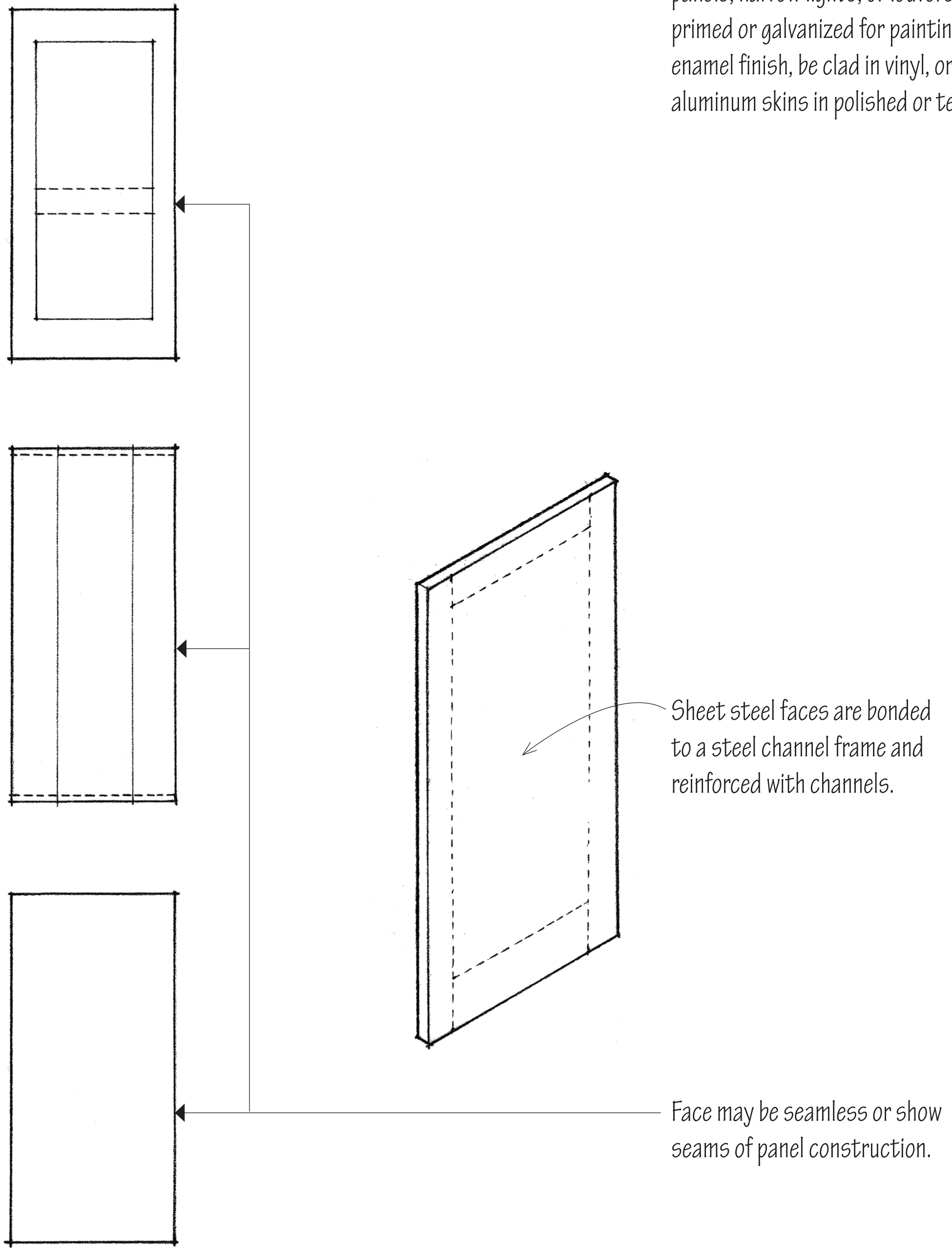


### Overhead Doors

- Consist of hinged door sections that roll upward on an overhead track.
- Capable of closing off unusually tall or wide openings for exterior or interior use.
- Not for frequent use.



Hollow metal doors have steel face sheets bonded to a steel channel frame and reinforced with channels. They may have a kraft paper honeycomb, steel-stiffened, mineral, or rigid plastic-foam core. Hollow metal doors are available as flush doors and with full glass, small vision panels, narrow lights, or louvers. Metal doors may be primed or galvanized for painting. They may have a baked enamel finish, be clad in vinyl, or have stainless steel or aluminum skins in polished or textured finishes.

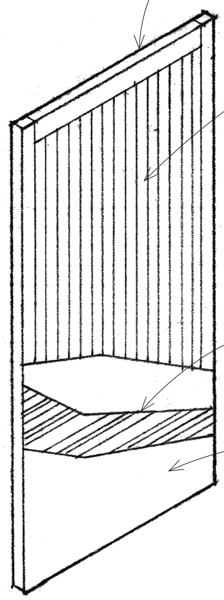



## Hollow Metal Doors

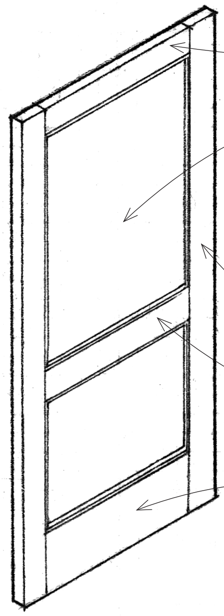
Wood flush doors may have glass inserts or louvers. Hollow core doors have a framework encasing a corrugated fiberboard core or a grid of wood strips. They are lightweight but have little inherent thermal or acoustic insulation value. They are intended primarily for interior use.

Solid core doors typically have a core of bonded lumber blocks, particleboard, or a mineral composition. Solid core doors are used primarily as exterior doors, but they may also be used wherever increased fire resistance, sound insulation, or dimensional stability is desired.

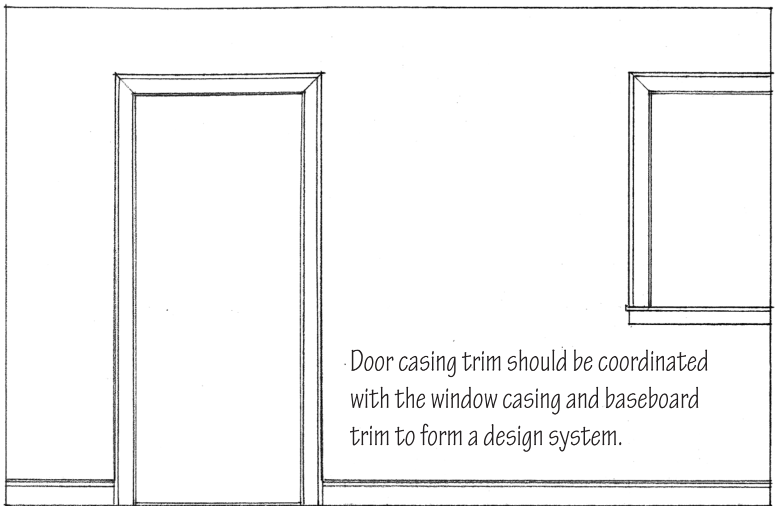
Wood stile-and-rail doors consist of a framework of vertical stiles and horizontal rails that hold solid wood or plywood panels, glass lights, or louvers in place. Various panel designs are available, as well as full-louvered and French door styles.




**Wood Flush Doors**




**Wood Panel Doors**




Most doors are manufactured in a number of standard sizes and styles. The treatment of the opening and the design of the casing trim are the areas where the designer can most readily manipulate the scale and character of a doorway.

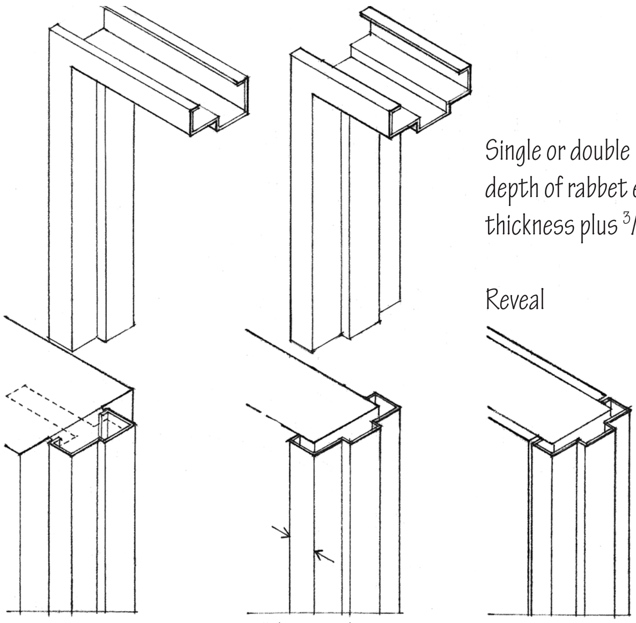
Like doors, doorframes are standard items. Hollow metal doors are hung in hollow metal frames. These may have single or double *rabbets* and may either butt up against or wrap around the wall thickness. In addition to the standard flat face, various styles of trim molding are available.

Wood doors use wood or hollow metal frames. Exterior doorframes usually have integral *stops*, while interior frames may have applied stops. Casing trim is used to conceal the gap between the doorframe and the wall surface. Casing trim can be omitted if the wall material can be finished neatly and butts up against the doorframe.

Door casing trim, through its form and color, can accentuate a doorway and articulate the door as a distinct visual element in a space. The doorway opening itself can be enlarged physically with sidelights and a transom above or visually with color and trimwork.

Conversely, a doorframe and trim can be minimized visually to reduce the scale of a doorway or to have it appear as a simple void in a wall.

If flush with the surrounding wall, a door can be finished to merge with and become part of the wall surface.

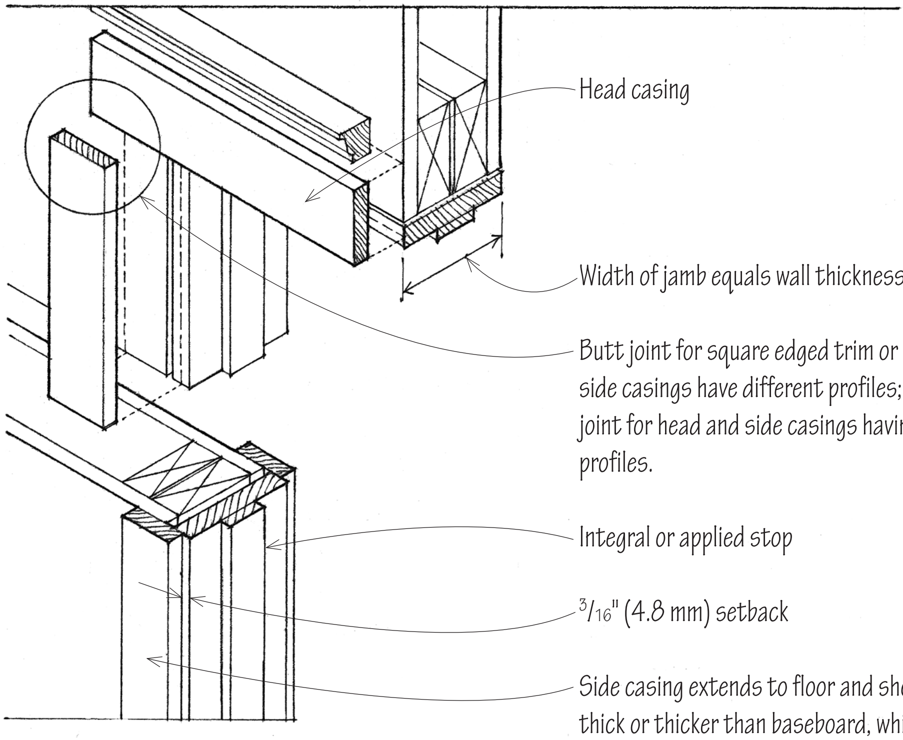



**Butt Condition at Masonry Wall**

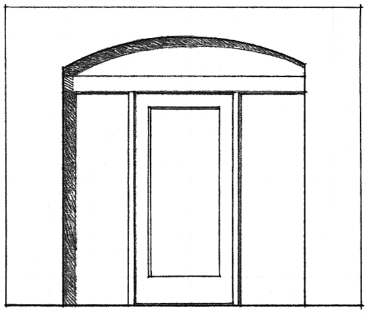
**Wrap-Around Condition**

**Flush Condition**

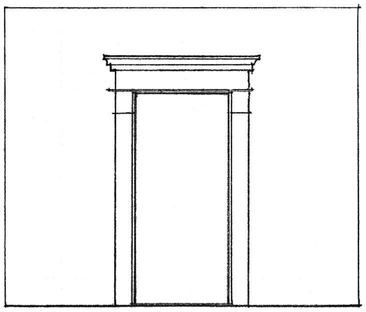
## Hollow Metal Doorframes



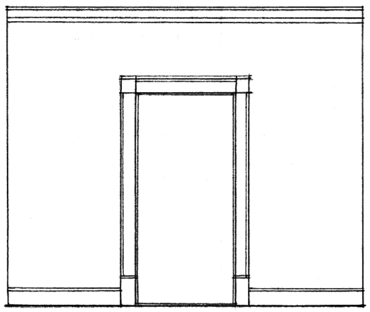

## Wood Doorframes



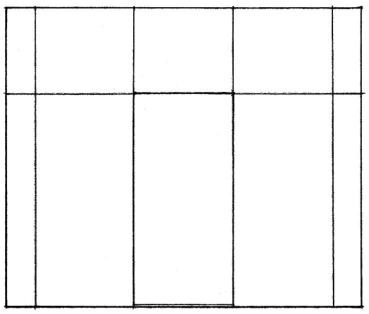
Sidelights and a transom enlarge the scale of the doorway opening.



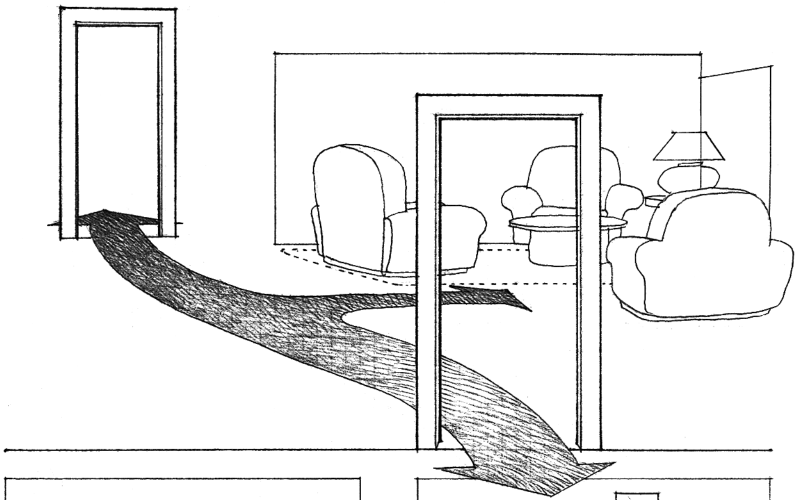
Trimwork elaborates the doorway and can give a hint as to what lies beyond.



Even simple trimwork can emphasize the opening of a doorway.

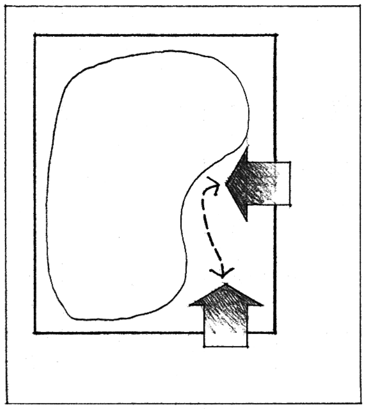


A doorway can merge with the surrounding wall surface.

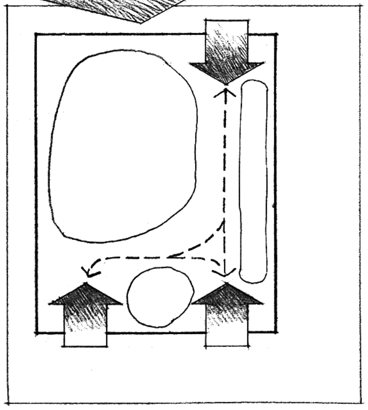


In linking the interior spaces of a building, doorways connect pathways. Their locations influence our patterns of movement from space to space, as well as within a space. The nature of these patterns should be appropriate to the uses and activities housed within the interior spaces.

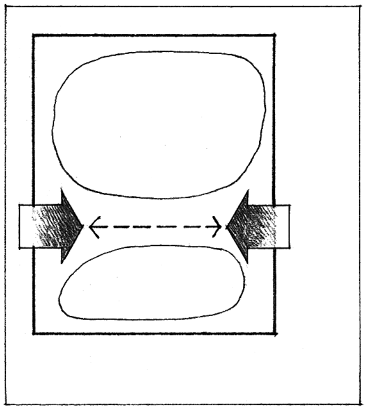
Space must be provided for our comfortable movement and the operation of doors. At the same time, there must also be sufficient and appropriately proportioned space remaining for the arrangement of furnishings and activities.



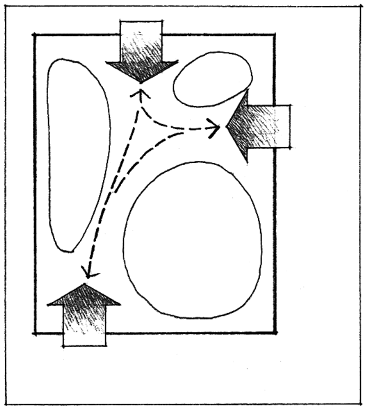
Two doorways close to each other define a short path that leaves a maximum amount of usable floor space.



Doorways situated at or near corners can define paths that run along a wall of a room. Locating the doorways away from the corners allows furnishings, such as storage units, to be placed along the wall.

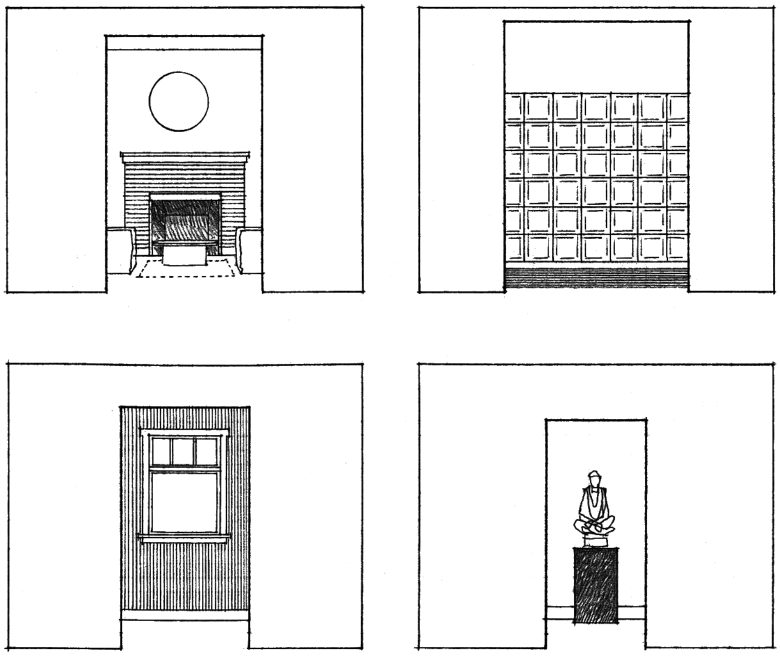


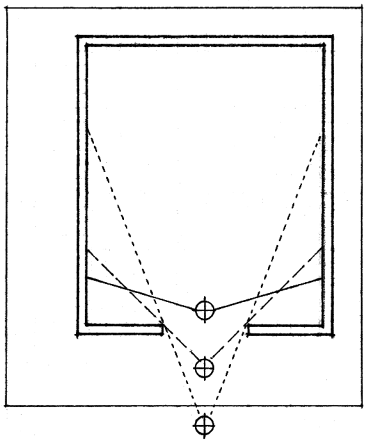
Opposing doorways define a straight path that subdivides a room into two zones.



Three doorways on three walls can present a problem if the possible pathways take up much of the floor area and leave a fragmented series of usable spaces.

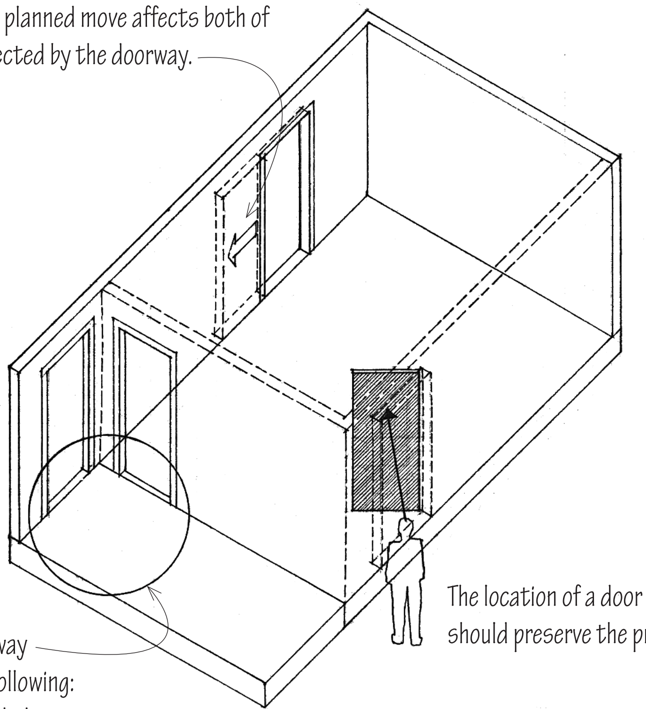
Another consideration in determining the location of a doorway is the view seen through its opening, both from the adjacent space and upon entering. When visual privacy for a room is desired, a doorway, even when open, should not permit a direct view into the private zone of the space.





Our view broadens as we approach a doorway and enter a room.

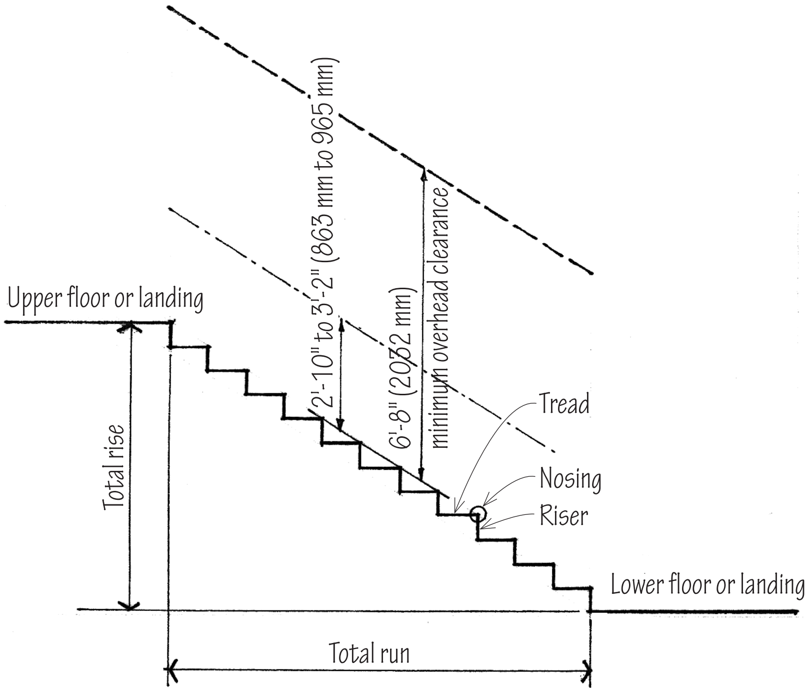
When relocating a doorway, the designer should consider how the planned move affects both of the spaces connected by the doorway.



The location of a door and the direction of its swing should preserve the privacy of a personal space.

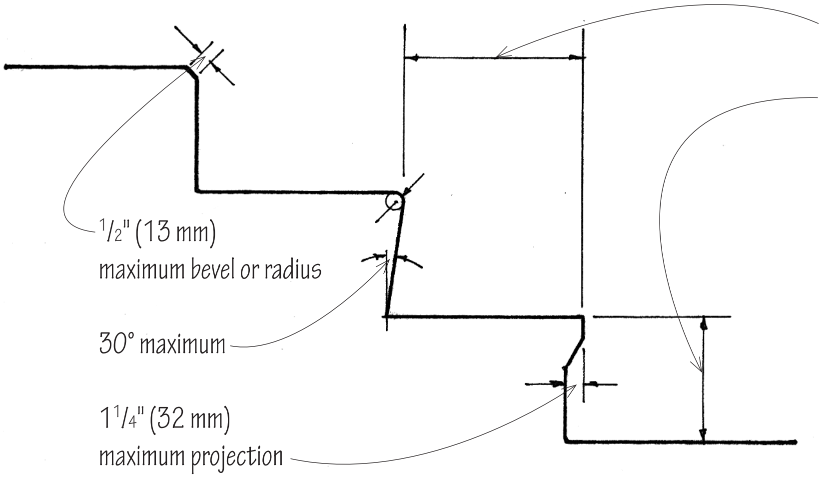
When space is tight but no doorway can be eliminated, consider the following:

- Change the swing of one or both doors.
- Change to a bifold or sliding door.
- If a door is not necessary, remove it and keep the doorway.




Stairs allow us to move vertically between the various floor levels of a building. The two most important functional criteria in the design of stairs are safety and ease of ascent and descent. The dimensions of a stair's *risers* and *treads* should be proportioned to fit our body movement. Their pitch, if steep, can make ascent physically tiring as well as psychologically forbidding, and can make descent precarious. If the pitch is shallow, a stair must have treads deep enough to fit our stride.

Building codes regulate the maximum and minimum dimensions of risers and treads. Verify dimensional requirements with applicable codes. Risers and treads should be uniform in dimension with a tolerance of $^3/_8$ inch (9.5 mm) between the smallest and the largest within any flight.

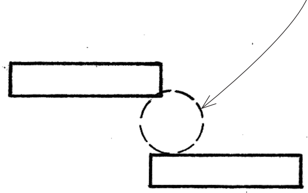



Tread depth = 11" (280 mm) minimum

Riser height = 4" (102 mm) minimum;
7" (179 mm) maximum

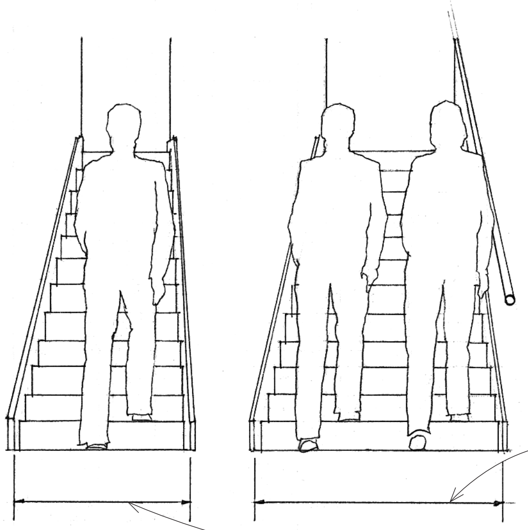
Residences may have a minimum tread depth of 10" (254 mm) and a maximum riser height of $7^3/_4$" (197 mm).

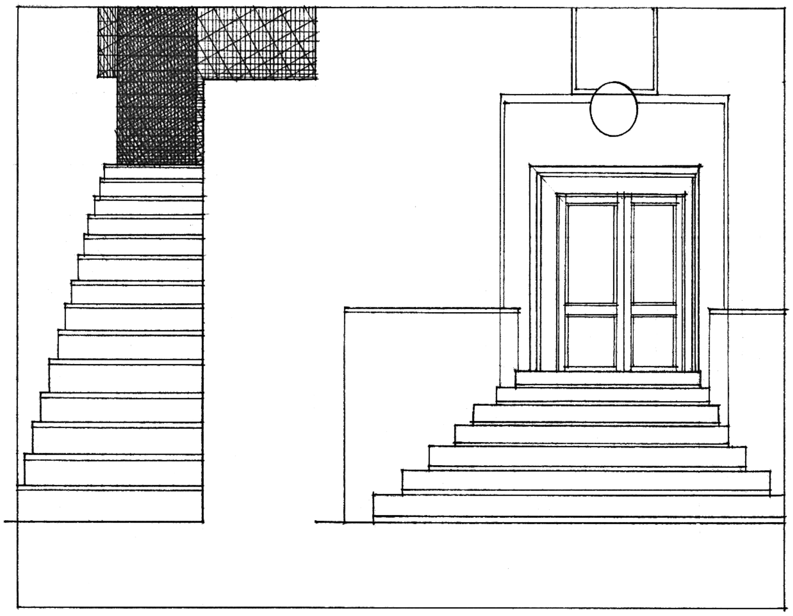
When open risers are permitted, the opening must not allow a 4" (102 mm) sphere to pass through.



## Stair Risers and Treads

A stairway should be wide enough to comfortably accommodate our passage as well as any furnishings and equipment that must be moved up or down the steps. Building codes specify minimum widths based on use and occupant loads. Verify dimensional requirements with applicable codes. Beyond these minimums, however, the width of a stairway also provides a visual clue to the public or private quality of the stairway.



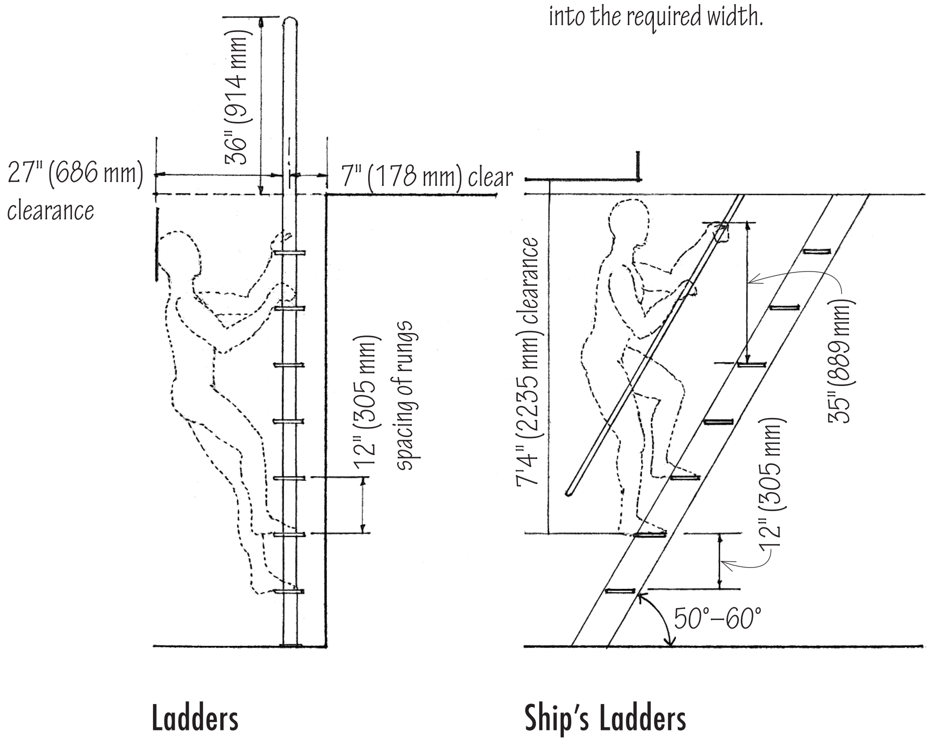


The width and angle of ascent are the variables that determine a stair's ease of use.

44" (1118 mm) minimum clear width

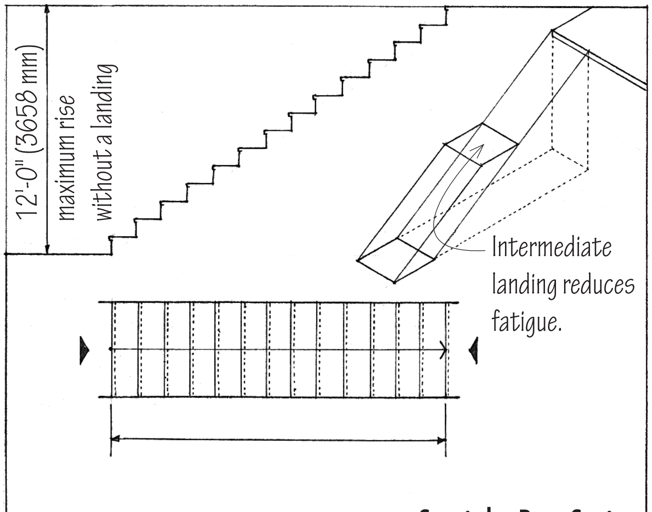
36" (914 mm) for an occupant load of 49 or less.

In general, handrails may project a maximum of 4$^{1}/_{2}$" (114 mm) into the required width.

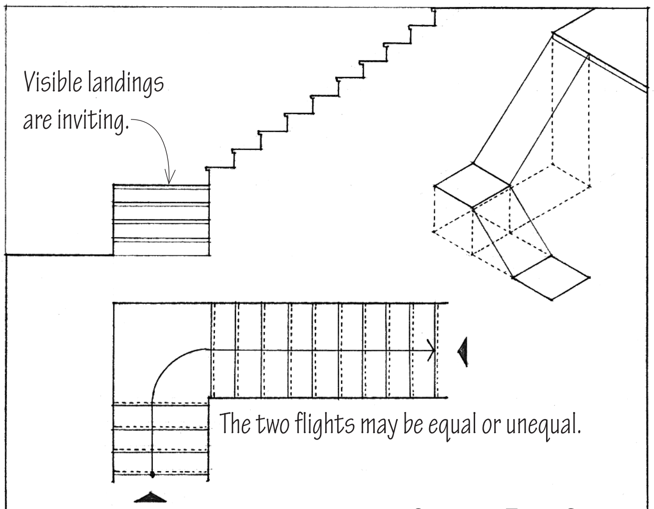



**Ladders**

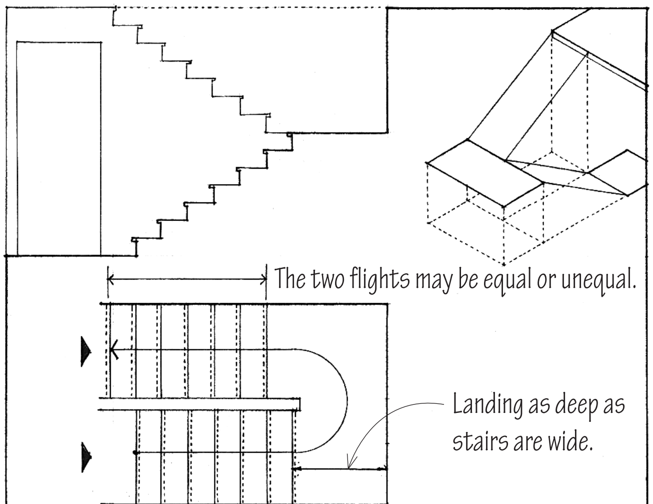
**Ship's Ladders**




Straight-Run Stairs




Quarter-Turn Stairs




Half-Turn Stairs

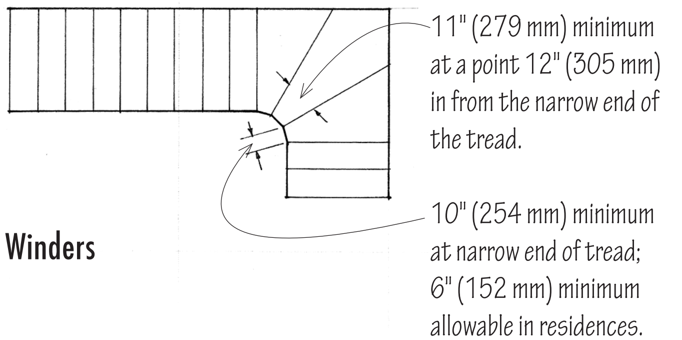
The configuration of a stairway determines the direction of our path as we ascend or descend its steps. There are several basic ways in which to configure the runs of a stairway. These variations result from the use of landings, which interrupt a stair run and enable it to change direction. Landings also provide opportunities for rest and possibilities for access to and outlook from the stairway. Together with the pitch of a stair, the locations of landings determine the rhythm of our movement up or down a stair.

An important consideration in the planning of any stairway is how it links the paths of movement at each floor level. A second consideration is the amount of space the stair requires. Each basic stair type has inherent proportions that will affect its possible location relative to other spaces around it. These proportions can be altered to some degree by adjusting the location of landings in the pattern. In each case, space should be provided at both the top and bottom of a stairway for safe and comfortable access and egress.

Landings should be at least as wide as the stairway width and have a length of at least 44 inches (1118 mm) in the direction of travel. Codes may permit landings in dwelling units to have a length of 36 inches (914 mm).

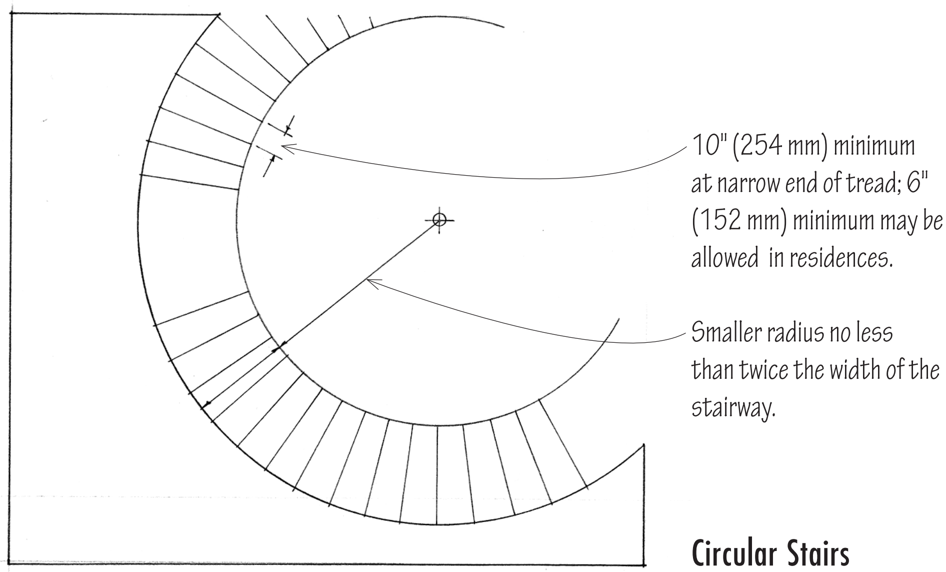
*Winders* are the tapered treads used in circular and spiral stairs. Quarter-turn and half-turn stairways may also sometimes be allowed to use winders rather than a landing to conserve space when changing directions.

Winders can be hazardous because they offer little foothold at their interior corners. Building codes generally restrict their use to private stairs within individual dwelling units.



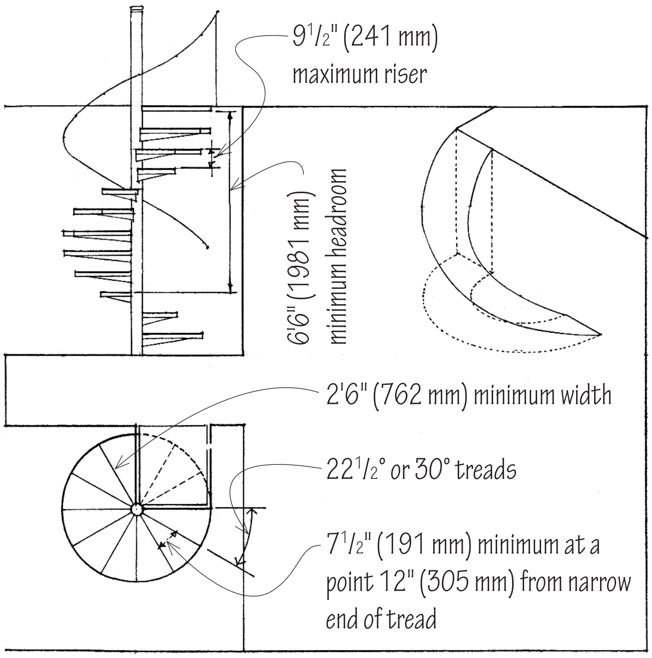

**Winders**

Circular stairs may be used for emergency egress if the inner radius is at least twice the width of the stairway; consult building codes for detailed requirements.



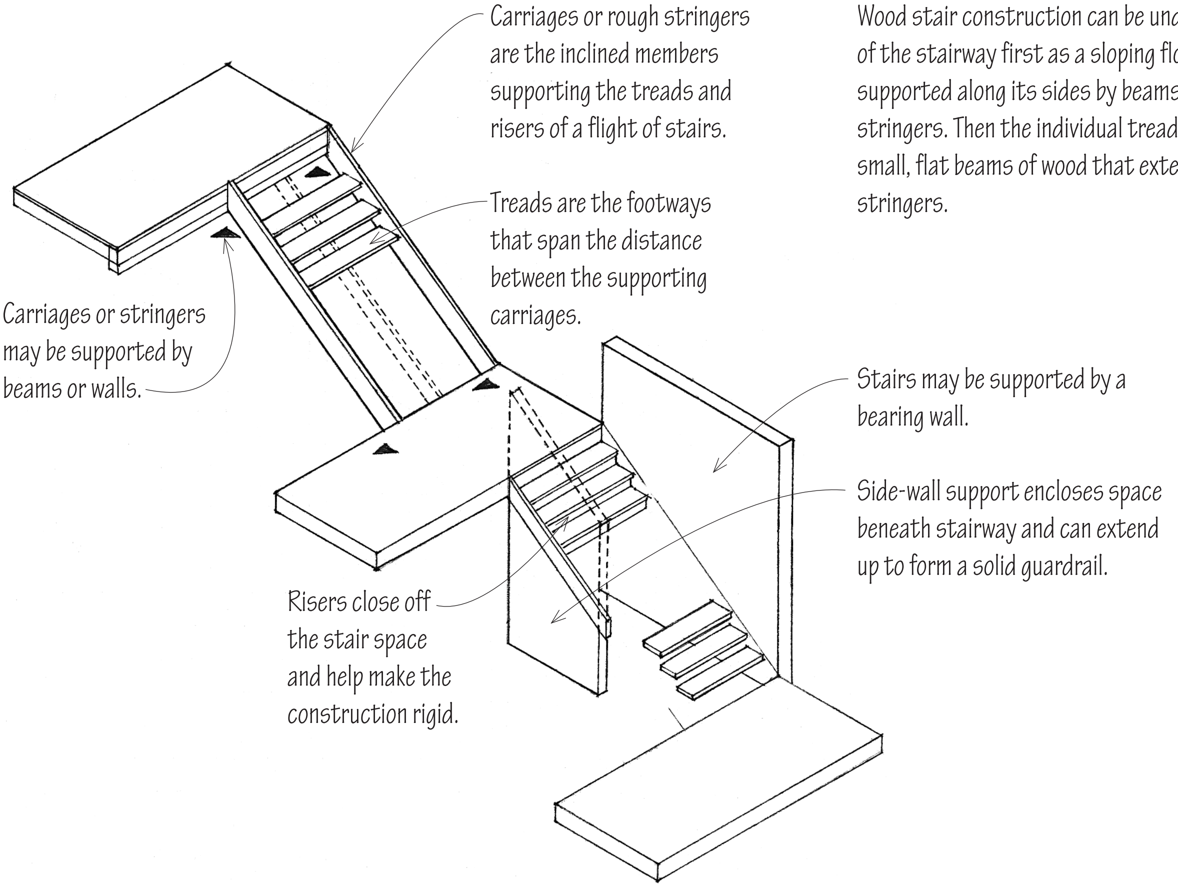

**Circular Stairs**

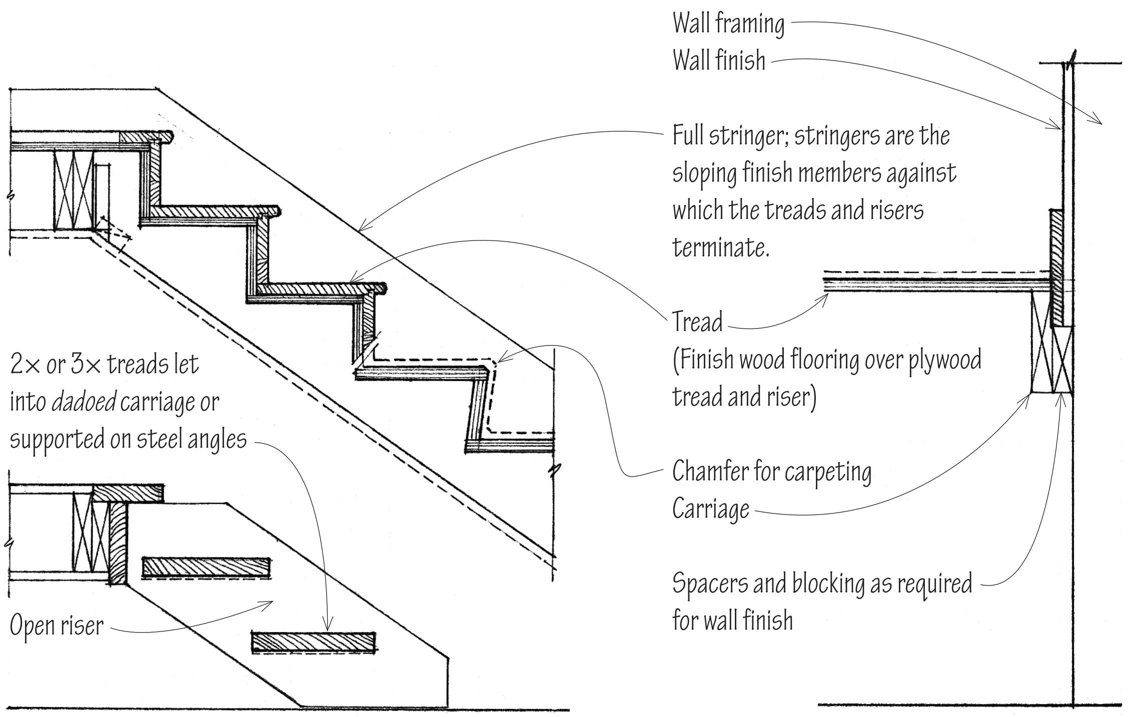
Building codes generally restrict spiral stairs to private use in individual dwelling units.




**Spiral Stairs**

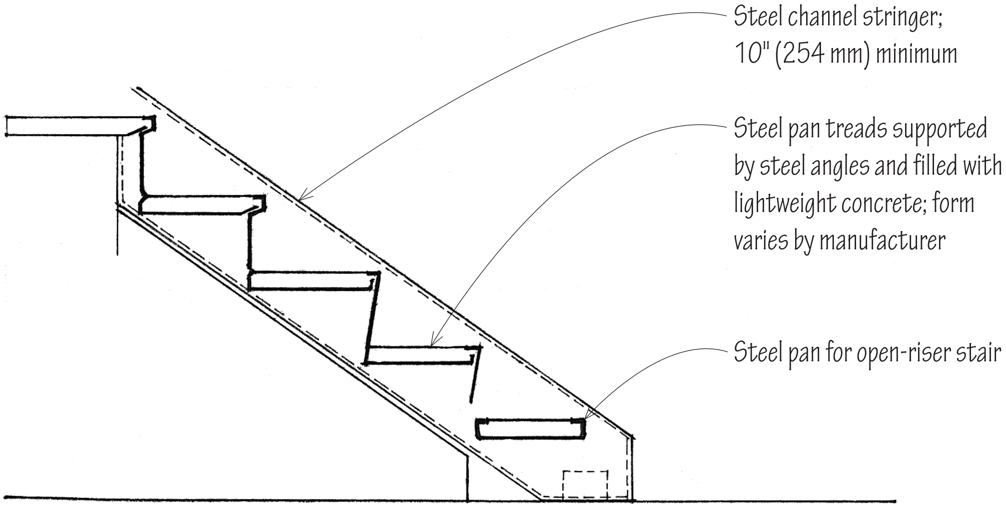
Wood stair construction can be understood by thinking of the stairway first as a sloping floor plane that is supported along its sides by beams called carriages or stringers. Then the individual treads can be thought of as small, flat beams of wood that extend between the stair stringers.



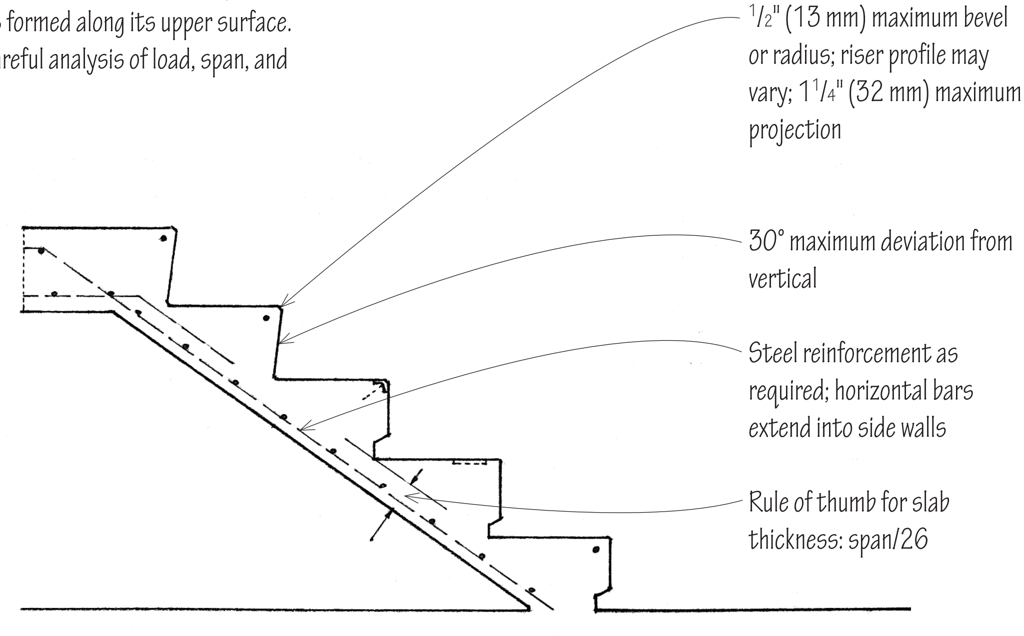

## Wood Stairs

Steel stairs are analogous in form to wood stairs. Steel channel sections serve as carriages and stringers. Stair treads span the distance between the stringers. The treads may consist of concrete-filled steel pans, bar grating, or flat plates with a textured top surface. Steel stairways are typically pre-engineered and prefabricated for a particular job.

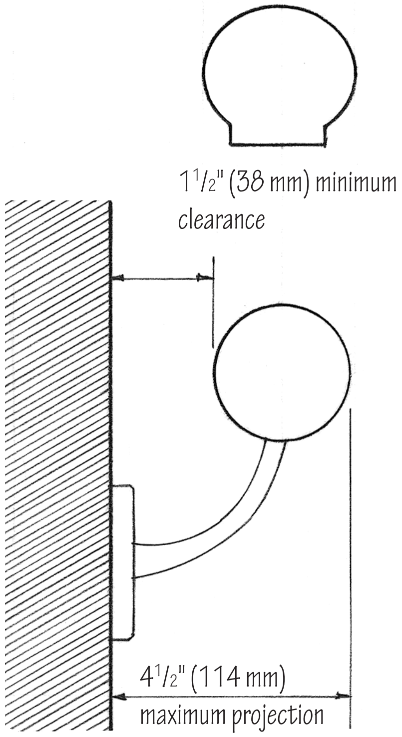



## Steel Stairs

A concrete stair is designed as an inclined, one-way reinforced slab with steps formed along its upper surface. Concrete stairs require careful analysis of load, span, and support conditions.




## Concrete Stairs

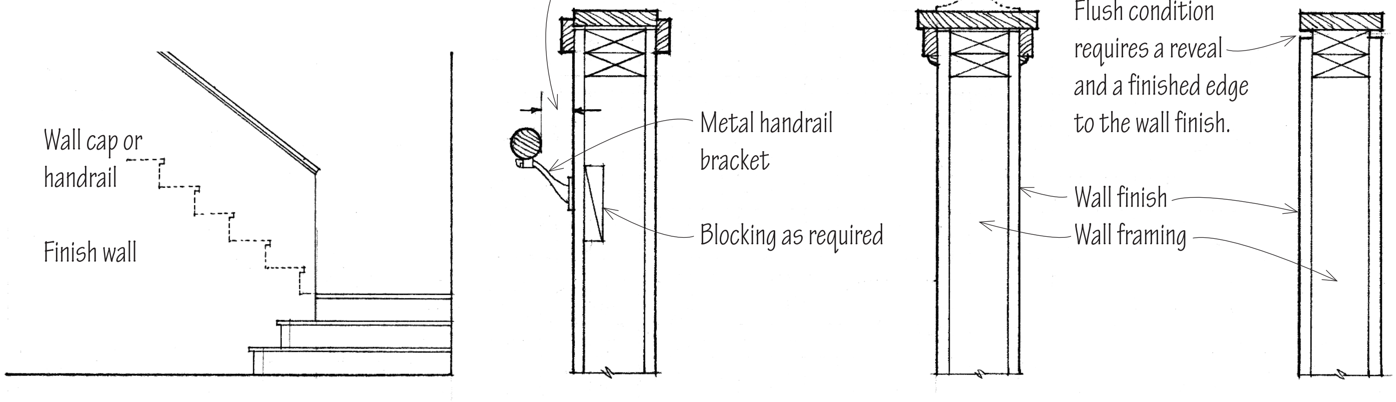



Americans with Disabilities Act (ADA) guidelines regulate the minimum and maximum dimensions and the profiles of handrails to ensure their graspability.

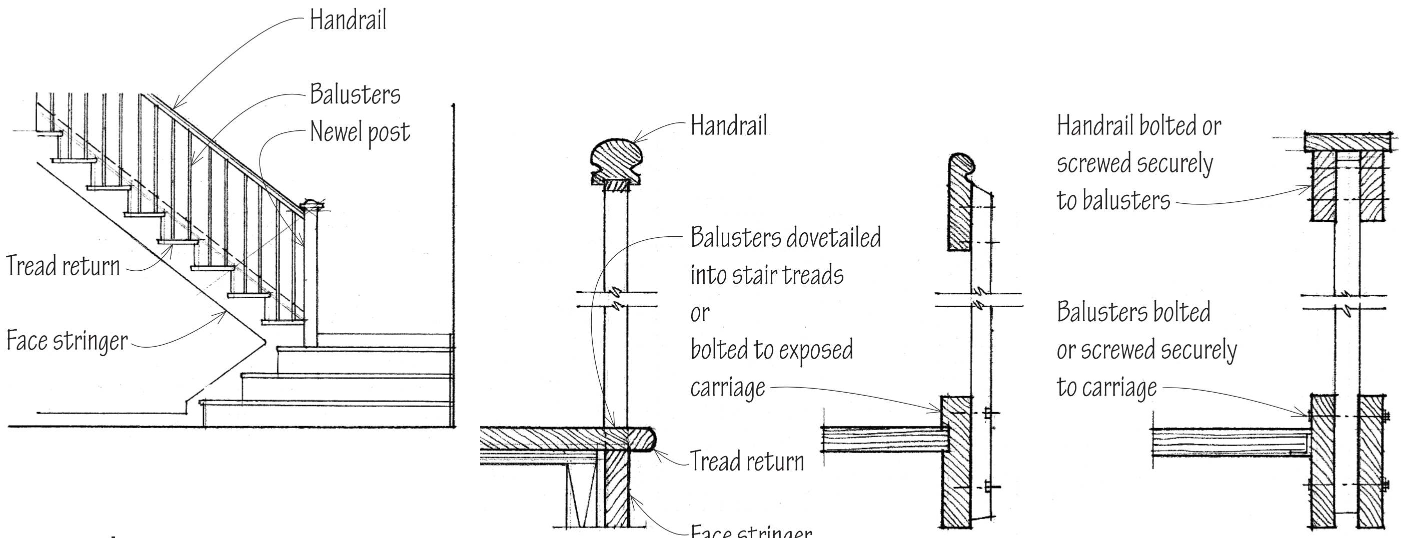
Handrails should be free of sharp or abrasive elements. They should have a circular cross section and a diameter of from $1^1/_4$ to 2 inches (32 to 51 mm); other shapes are allowable if they provide equivalent graspability and have a perimeter of from 4 to $6^1/_4$ inches (102 to 159 mm) and a maximum cross section dimension of $2^1/_4$ inches (57 mm).

Building codes and the ADA regulate the minimum height of guards and the maximum size of openings within the railings that protect the open sides of stairways, balconies, and decks.

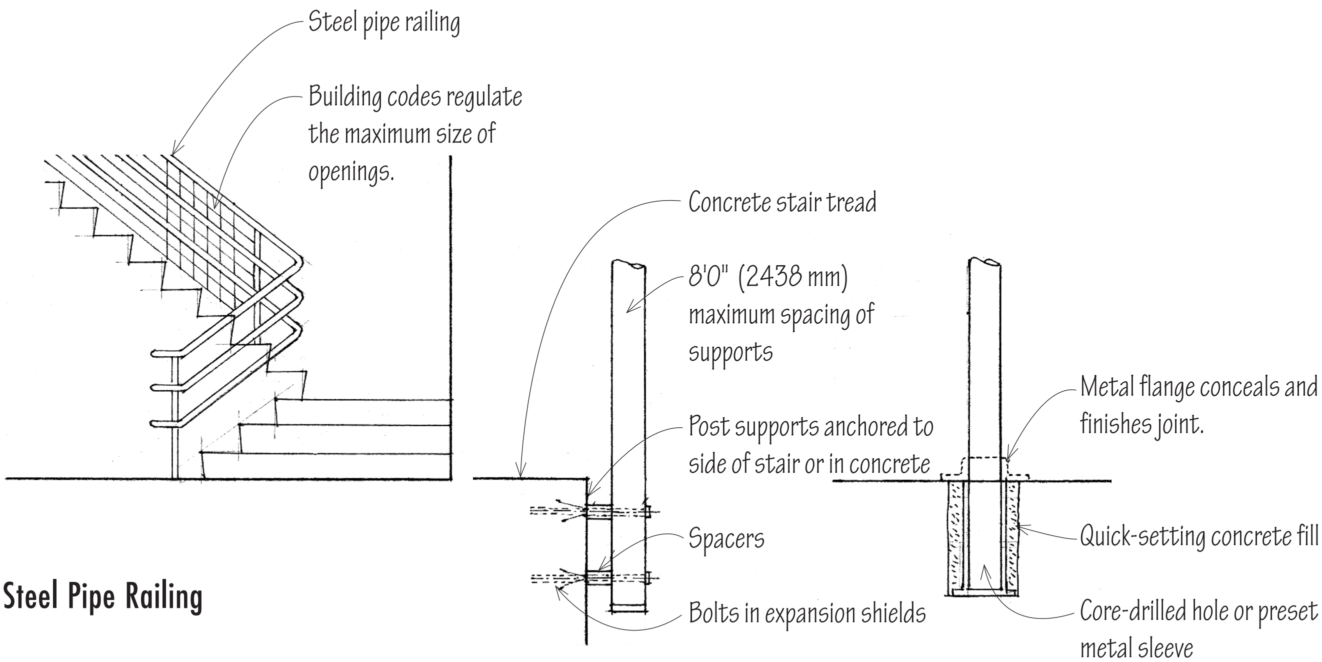
Extend handrails at least 12 inches (305 mm) horizontally beyond the top tread, and one tread width beyond the bottom tread nosing of each flight.




## Solid Rail



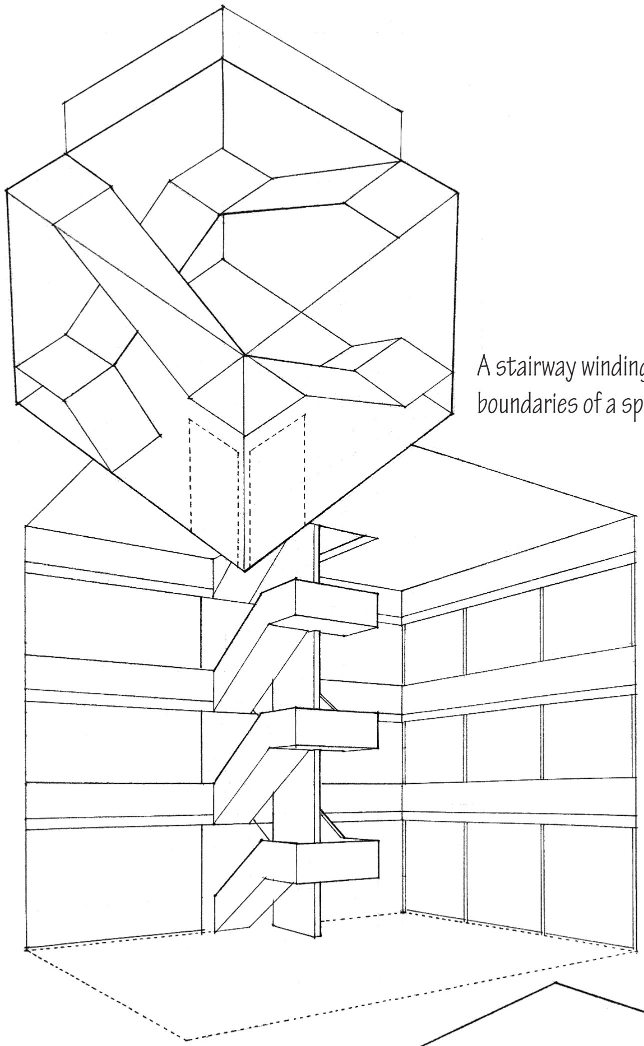

**Open Rail**




**Steel Pipe Railing**

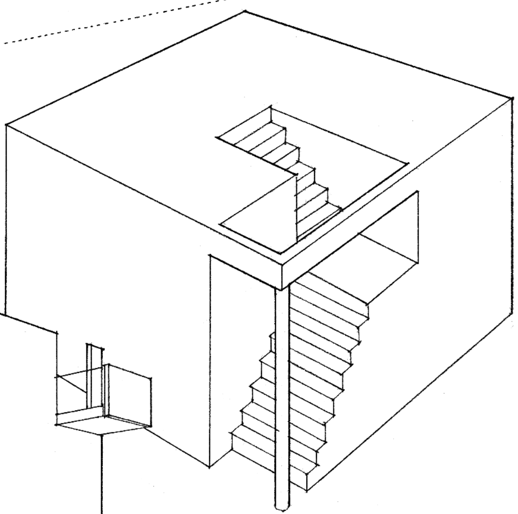
Within the guidelines for a stair's dimensions—as set forth by building codes and the mechanics of our body movement—there is ample opportunity to manipulate the form and treatment of a stairway.

Stairs are three-dimensional forms, just as moving up or down a stairway is a three-dimensional experience. Their three-dimensionality can be exploited when one treats them as sculpture—freestanding within a space or attached to a wall plane. A stairway can be treated as a volumetric solid from which space for movement as well as rest has been carved out, or as a composition of two-dimensional planes.

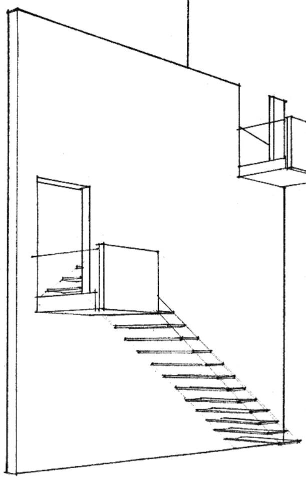


A stairway winding around the boundaries of a space

Stairways expressed as freestanding sculptural forms

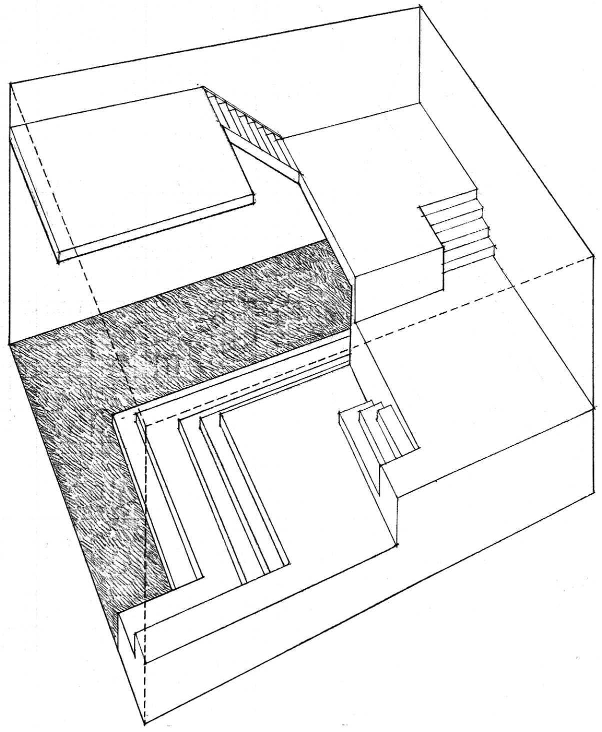


A stairway carved out of a volume

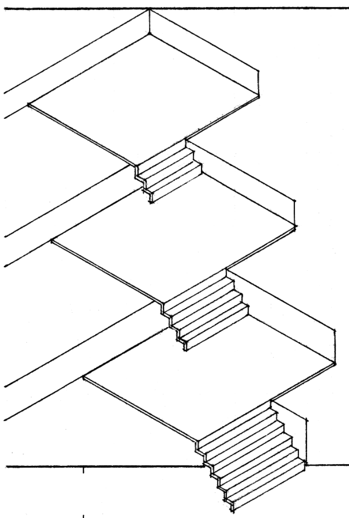


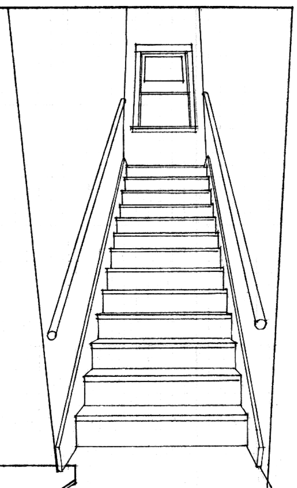
Stairs constructed from planar elements

A stair may interrupt a path or meet it at an angle. In a similar manner, the run of the stair may be parallel, perpendicular, or oblique to the path's direction.



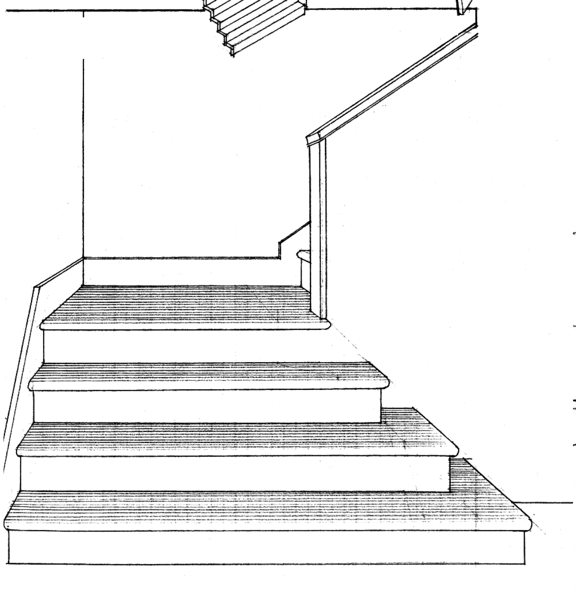
A stair can be an organizing element and knit together a series of spaces at different levels of a building.



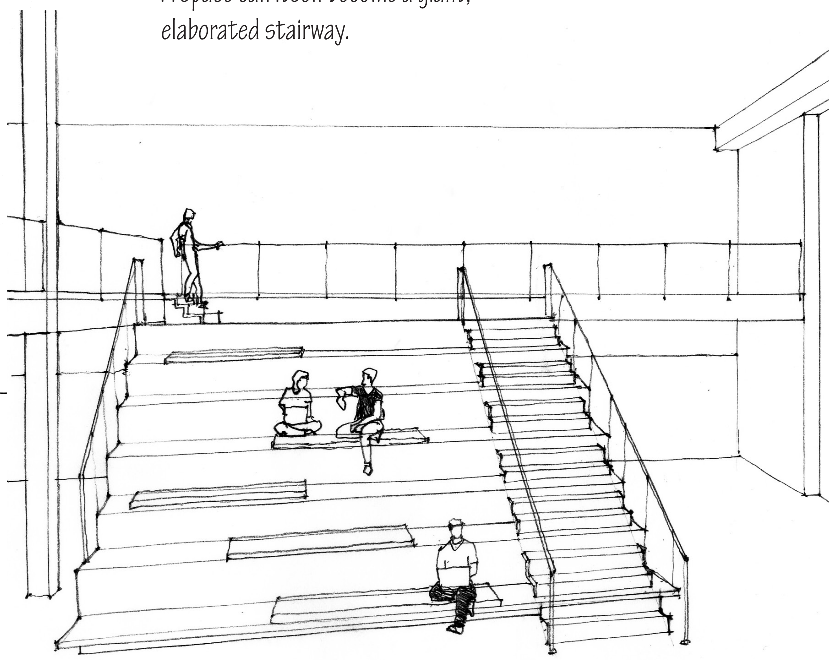


The path of a stair can rise between walls through a narrow shaft of space, or meander through and interweave among a series of spaces.

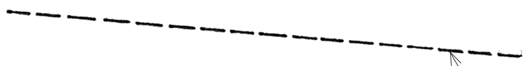
A space can itself become a giant, elaborated stairway.



Treads can spill out at the bottom of a stairway as an invitation, or be extended farther into platforms for seating or terraces for activity.



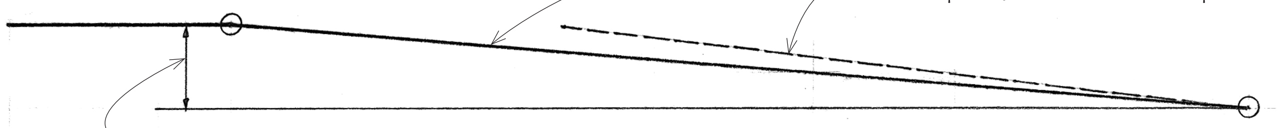
Ramps provide smooth transitions between the floor levels of a building. To have comfortably low slopes, they require relatively long runs. They are typically used to accommodate a change in level along an accessible route or to provide access for wheeled equipment. Be sure to verify requirements with current applicable building and accessibility codes.



6' 8" (2032 mm) minimum headroom

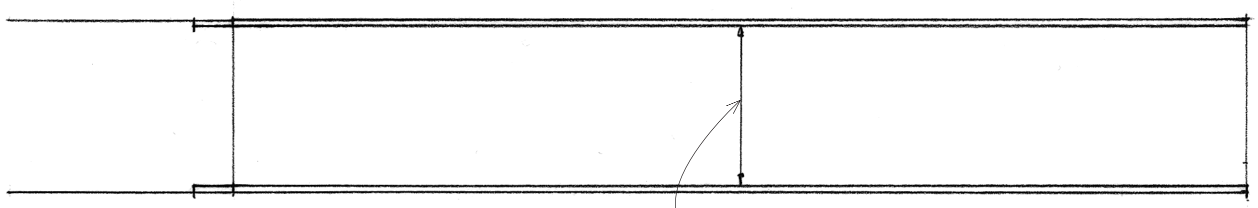
## Slope

Ramps in a means of egress may not exceed a 1:12 slope; other ramps may not exceed a 1:8 slope.



Ramps are limited to a vertical rise of 30" (762 mm) between landings.

Short, straight ramps act as beams and may be constructed as wood, steel, or concrete floor systems. Long or curvilinear ramps are usually of steel or reinforced concrete.



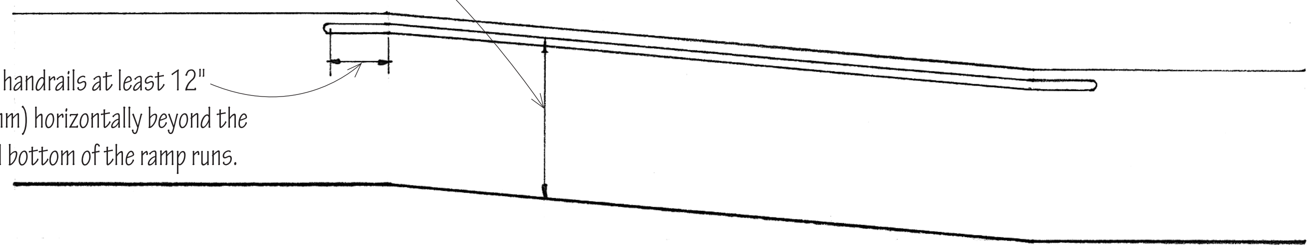
Ramps used as a means of egress should be at least 44" (1118 mm) wide; other ramps should have a minimum clear width between handrails of 36" (914 mm).

## Guards and Handrails

Ramps having a rise greater than 6" (152 mm) or a run greater than 72" (1829 mm) should have guards along both sides.

Handrails should be from 34" to 38" (864 mm to 965 mm) above the ramp surface.

Extend handrails at least 12" (305 mm) horizontally beyond the top and bottom of the ramp runs.

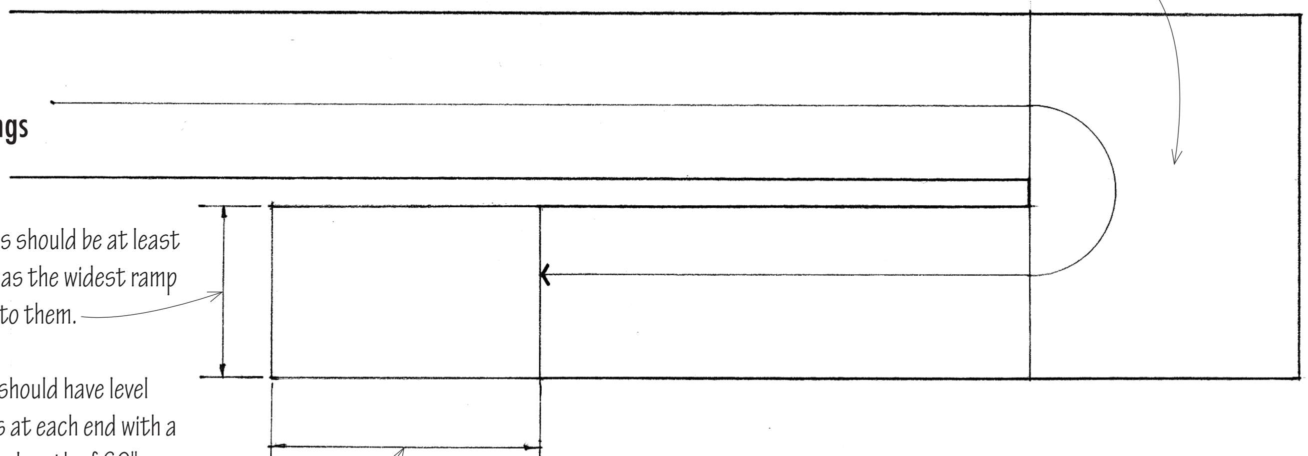


Landings that occur where a ramp changes direction should be at least 60" × 60" (1524 mm × 1524 mm).

## Landings

Landings should be at least as wide as the widest ramp leading to them.

Ramps should have level landings at each end with a minimum length of 60" (1524 mm).

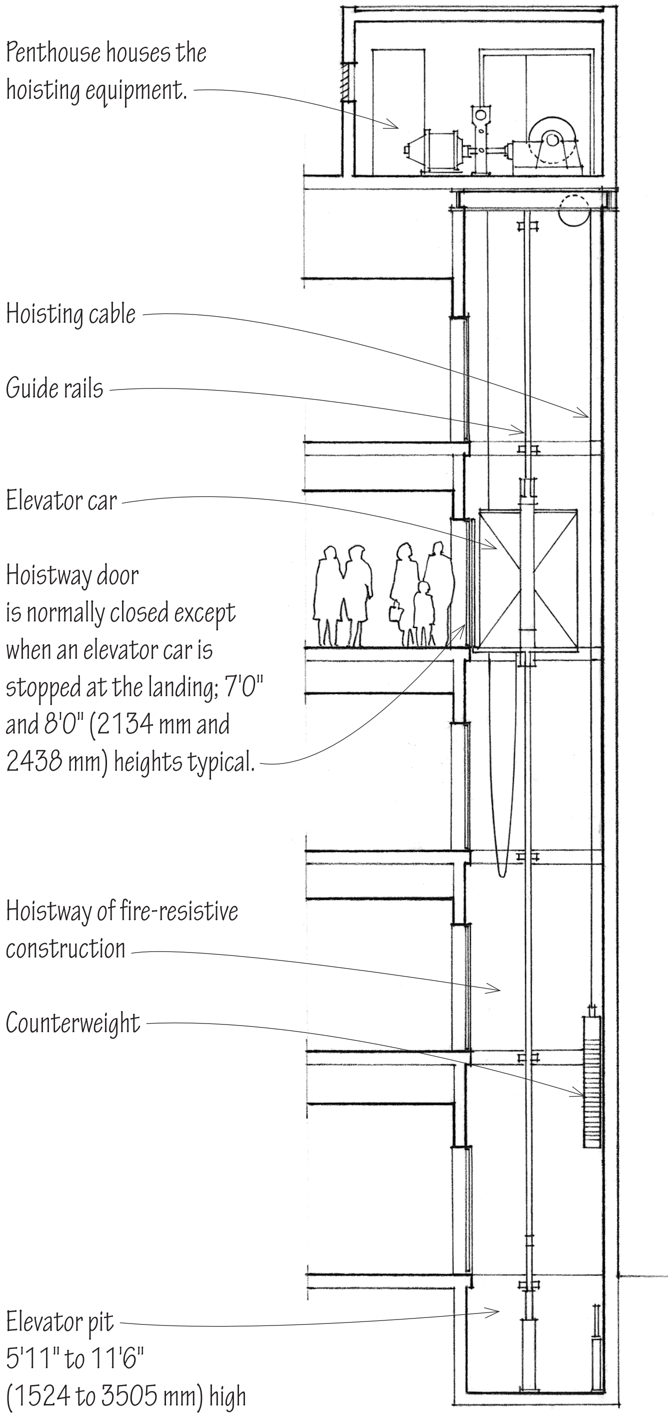


Elevators travel vertically to carry passengers, equipment, and freight from one level of a building to another. There are two basic types of commercial elevators: traction and hydraulic elevators.

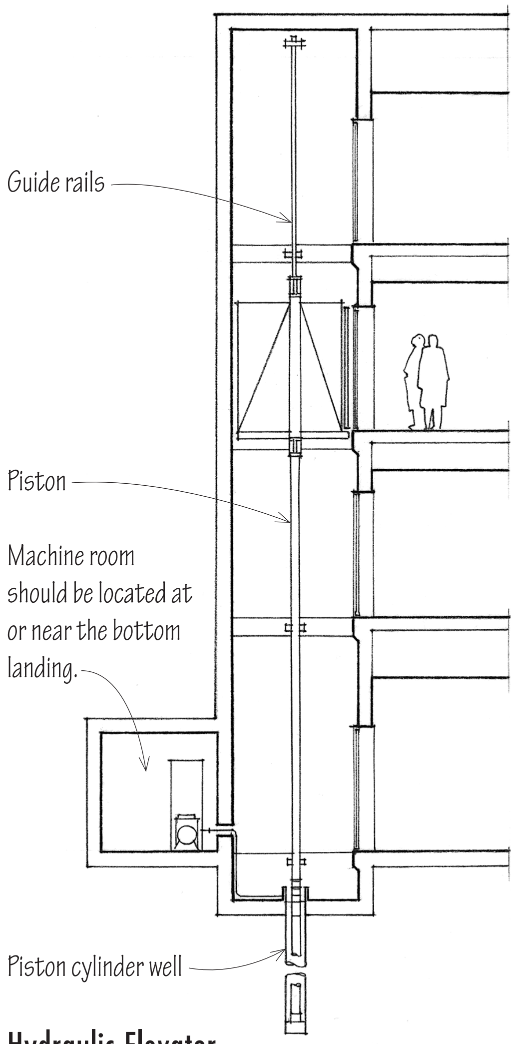
Traction elevators consist of a car that is mounted on guide rails, supported by hoisting cables, and driven by electric hoisting machinery in a penthouse. Traction elevators operate at medium to high speeds and are used in buildings of all heights.

Hydraulic elevators consist of a car supported by a piston or cylinder that is moved by or moves against a fluid under pressure. A penthouse is not required, but the hydraulic elevator's lower speed and piston length limit its use to buildings up to six stories in height.

The machine-room-less (MRL) elevator uses newer technology. It has a smaller electric motor that fits inside the elevator shaft and does not need a machine room. The more efficient motor of the MRL elevator uses the least energy of any elevator type.




**Traction Elevator**




**Hydraulic Elevator**

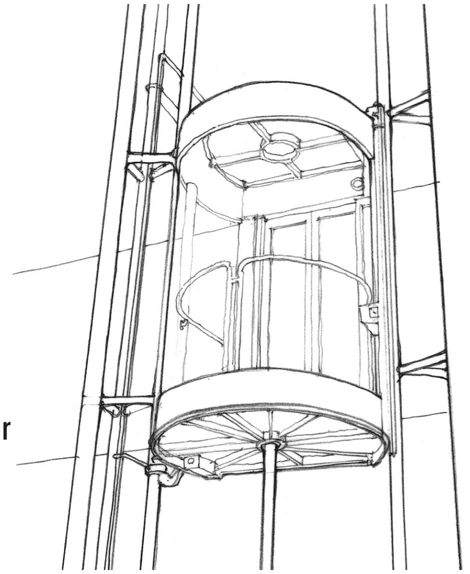
Private residential elevators can be installed only in a private residence or in a single unit in a multiple-unit dwelling. By code, they are limited in size, capacity, rise, and speed.

Fire service access elevators, sized to accommodate an ambulance stretcher, are required for some tall buildings. In addition, occupant evacuation elevators are required for use by occupants for evacuation of very tall buildings.

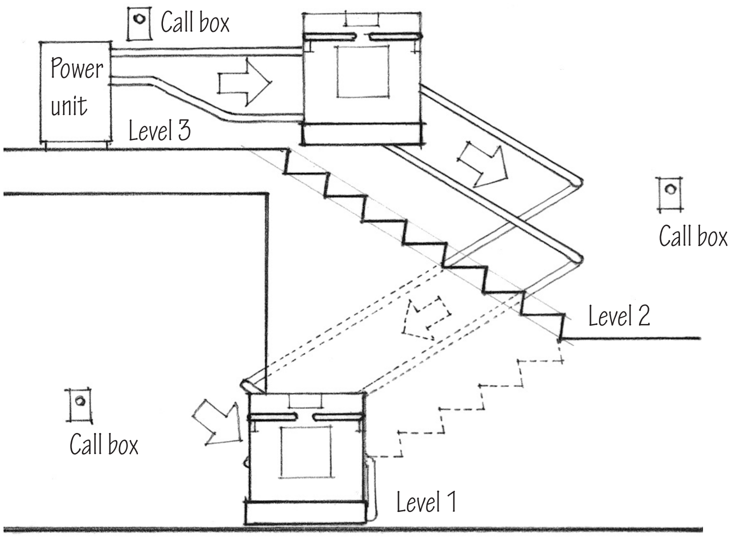
Freight elevators with either traction or hydraulic drive systems usually have vertical bipart doors and special structural support to handle heavy loads.

Observation and glass-back elevator cars travel outside of a hoistway or in a hoistway open on one side, with inconspicuous machinery and usually a decorative hoistway wall.

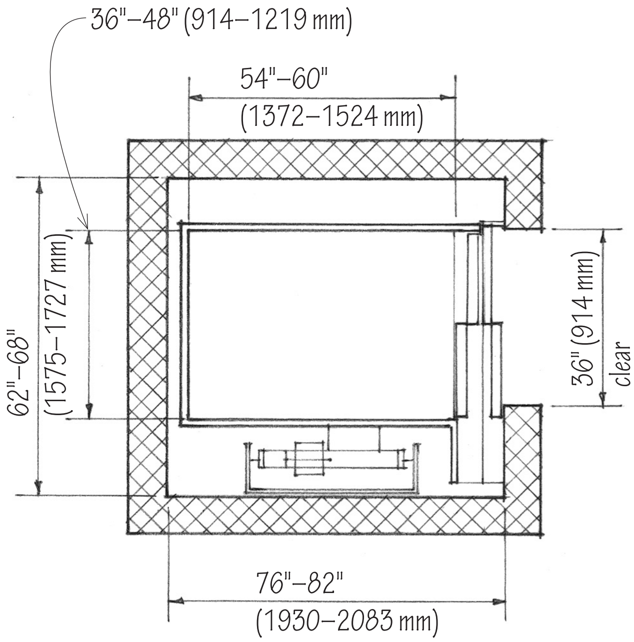
Wheelchair lifts are typically used as retrofits to existing buildings, but may not be permitted as part of an accessible route in new construction. Inclined wheelchair lifts are mounted on stairs, and include both commercial platform lifts and folding seats for residential use. Limited use/limited application (LU/LA) elevators are designed to fill the void between commercial elevators and vertical platform wheelchair lifts.



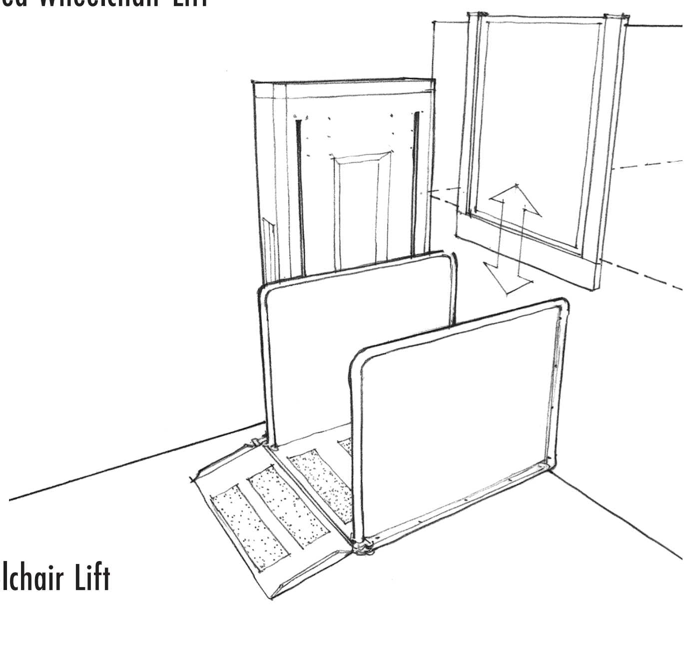
Observation Elevator Car



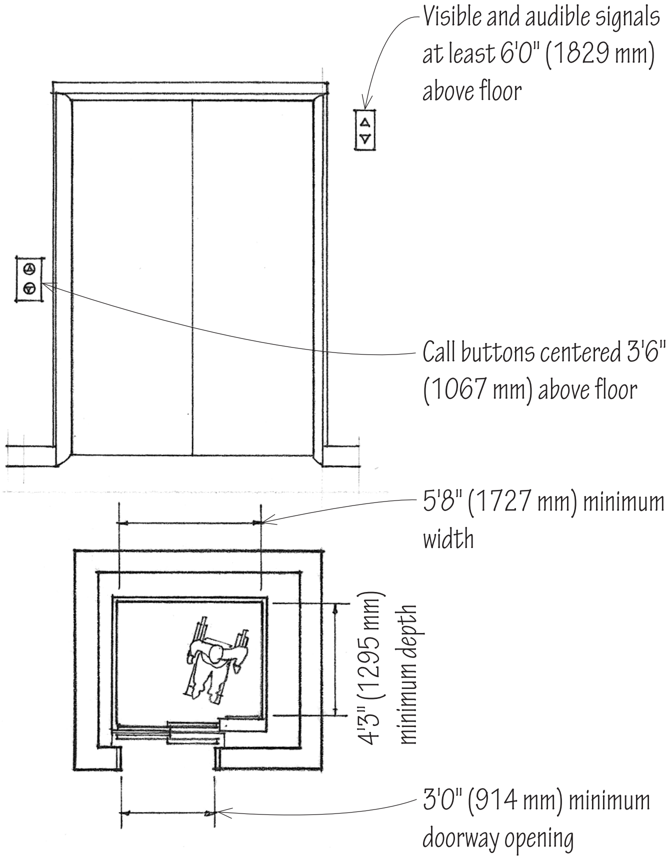

Inclined Wheelchair Lift




LU/LA Elevator



Wheelchair Lift

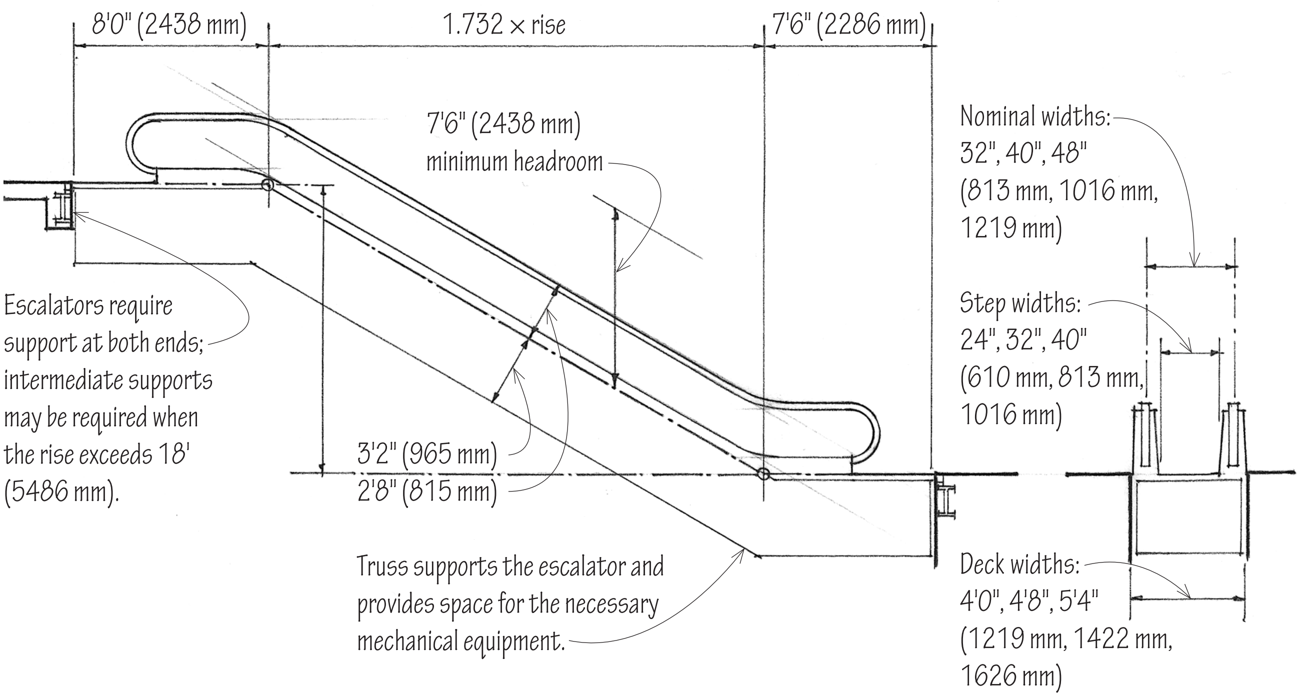



ADA accessibility guidelines for passenger elevators cover the type and location of call signals, lanterns, floor designations, call buttons, and cab controls. Elevator doors should be provided with an automatic reopening device that is activated if the door becomes obstructed by an object or person. Elevator cars should be sized to allow wheelchair users to enter the car, maneuver within reach of controls, and exit from the car.

Interior cab finishes must consider dimensions permitted by cab construction, durability, tamper resistance, and ease of maintenance. Elevator interiors should be fabricated by experienced tradespeople.

## Escalators

Escalators are power-driven stairways consisting of steps attached to a continuously circulating belt. They can move a large number of people efficiently and comfortably among a limited number of floors; six floors are a practical limit. Because escalators move at a constant speed, there is practically no waiting period, but there should be adequate queuing space at each loading and discharge point.



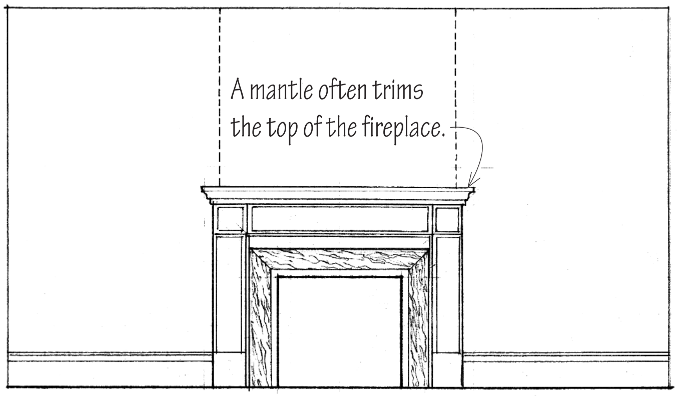
Although a traditional fireplace is not as efficient for heating an interior space as a wood stove, few would dispute the special attraction it holds for people. The warmth and flames of an open fire are like a magnet, enticing people to gather around a fireplace. Even without a fire, a fireplace can be a unique center of interest, and serve as the focal point around which a room can be arranged.

When considering the location of a fireplace, evaluate its effect on a room's proportions and the clearance required if furniture is to be arranged around it. Also consider whether heat will distribute in the desired pattern.

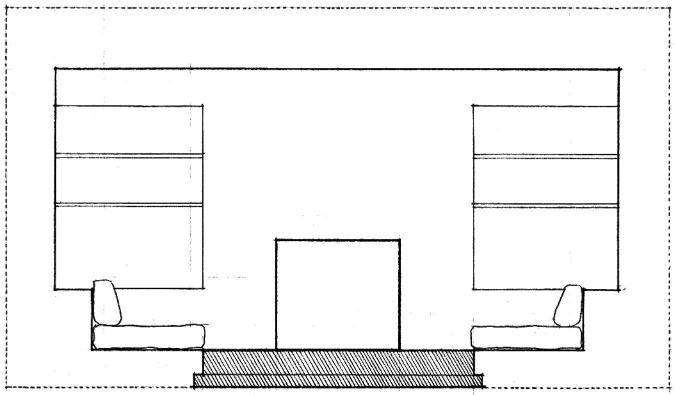
It is important for the interior designer to note the amount of space a fireplace requires and how the face—the opening, surround, and hearth—can be treated. The treatment of the surround visually enlarges the fireplace opening, enhances it as a focal point, and integrates it with the rest of a room's trimwork.

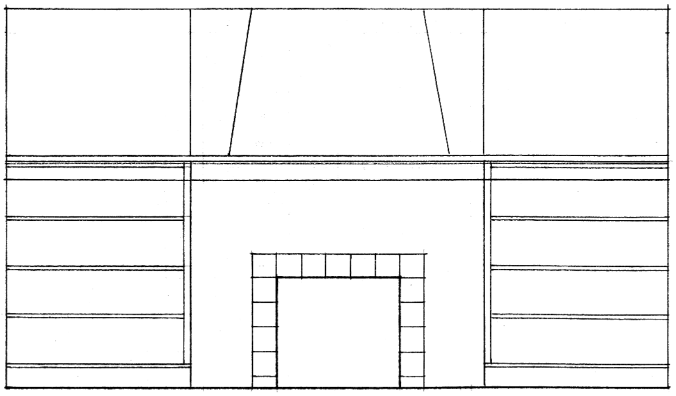
## Some Types of Fireplaces

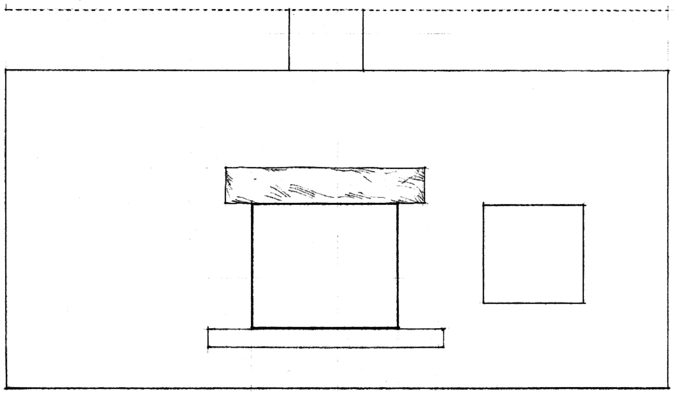
| | |
|---|---|
| Pellet stove uses electricity to burn compressed sawdust | Heat controlled by fuel feed rate |
| Traditional fireplace burning wood | 15% efficiency |
| Plug-in electric fireplace inserts | Can produce electric heat if desired |
| Ceramic log with gas burner below | Inefficient |
| Gas hot box insert sealed from room by ceramic glass | 70% to 82% efficiency |
| Freestanding sealed gas stove | 70% to 80% efficiency |



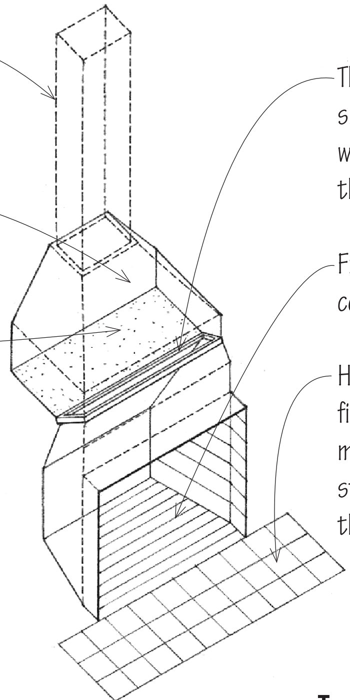
No woodwork is permitted within 6" (152 mm) of the fireplace opening.

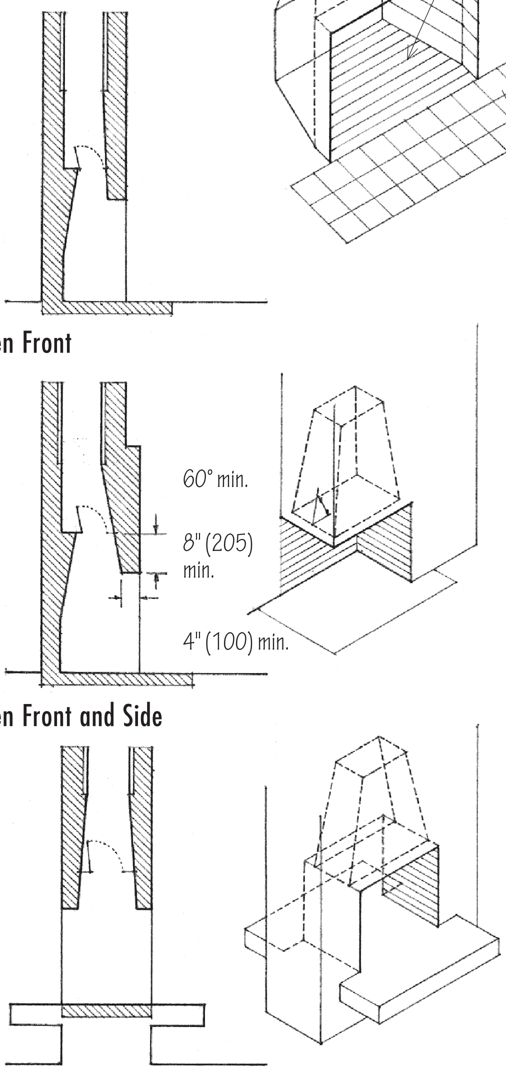

The raised hearth of a fireplace can be extended to form a platform for seating. This platform, along with the fireplace, can begin to define an alcove space.


On the wall of the room, the chimneybreast often projects a few inches into the room, forming recesses to either side that can be used for storage.


A lintel or beam that spans the fireplace opening in a masonry wall can be exposed and embellished as a visual design element.

A fireplace must be designed to draw air for combustion properly, to sustain combustion safely, and to carry smoke away efficiently. Consequently, the proportions of a fireplace and the arrangement of its components are subject to both the laws of nature and the local building code.



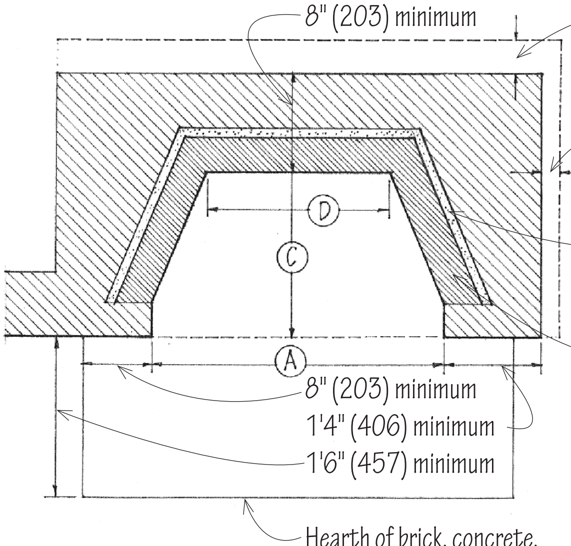

Types of Fireplaces

## Typical Fireplace Dimensions in Inches (mm)

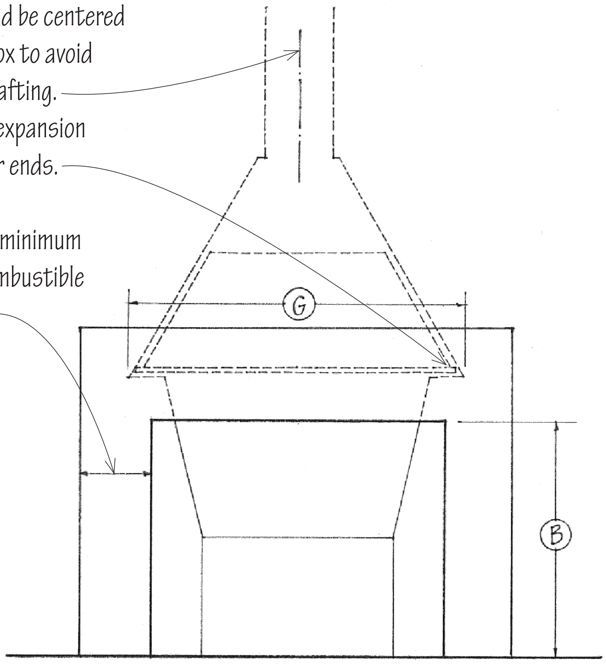
| Width (A) | Height (B) | Depth (C) | (D) | (E) | (F) | (G) |
|---|---|---|---|---|---|---|
| Open Front | | | | | | |
| 36 (914) | 29 (737) | 20 (508) | 23 (584) | 14 (356) | 23 (584) | 44 (1118) |
| 42 (1067) | 32 (813) | 20 (508) | 29 (737) | 16 (406) | 24 (610) | 50 (1270) |
| 48 (1219) | 32 (813) | 20 (508) | 33 (838) | 16 (406) | 24 (610) | 56 (1422) |
| 54 (1372) | 37 (940) | 20 (508) | 37 (940) | 16 (406) | 29 (737) | 68 (1727) |
| 60 (1524) | 40 (1016) | 22 (559) | 42 (1067) | 18 (457) | 30 (762) | 72 (1829) |
| 72 (1829) | 40 (1016) | 22 (559) | 54 (1372) | 18 (457) | 30 (762) | 84 (2134) |
| Open Front and Side | | | | | | |
| 28 (711) | 24 (610) | 16 (406) | | | | |
| 32 (813) | 28 (711) | 18 (457) | | | | |
| 36 (914) | 30 (762) | 20 (508) | | | | |
| 48 (1219) | 32 (813) | 22 (559) | | | | |
| Open Front and Back | | | | | | |
| 28 (711) | 24 (610) | 16 (406) | | | | |
| 32 (813) | 28 (711) | 16 (406) | | | | |
| 36 (914) | 30 (762) | 17 (432) | | | | |
| 48 (1219) | 32 (813) | 19 (483) | | | | |

Multifaced fireplaces are especially sensitive to drafts in a room; avoid placing their openings opposite an exterior door.

See following page for plan, section, and elevation drawings of a fireplace, showing the locations of dimensions referenced in this table.

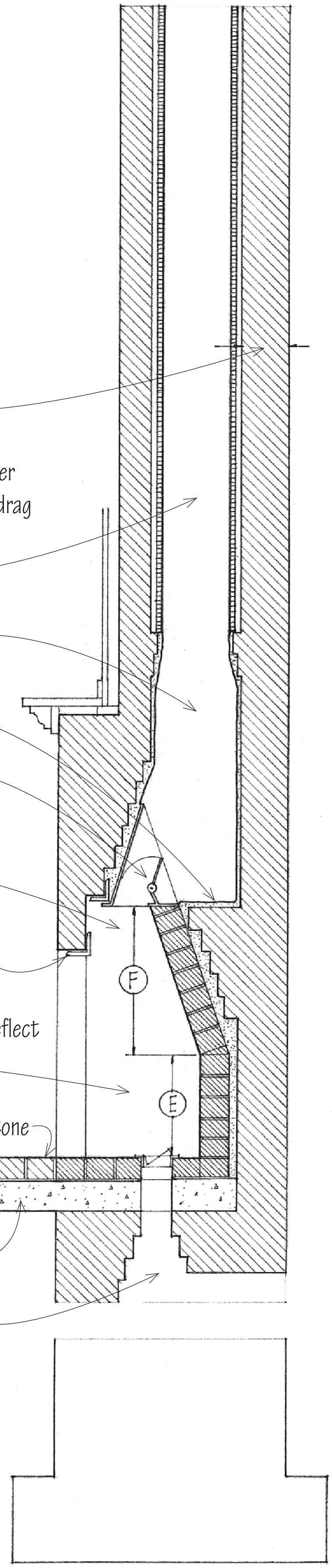



## Fireplace Plan




## Fireplace Elevation

- For typical fireplace dimensions, see table on previous page.

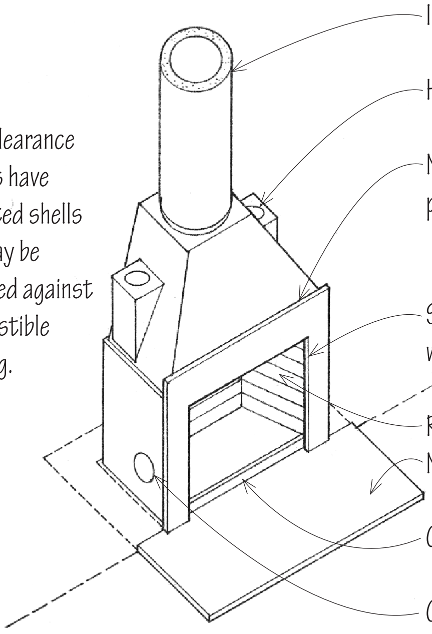



## Fireplace Section

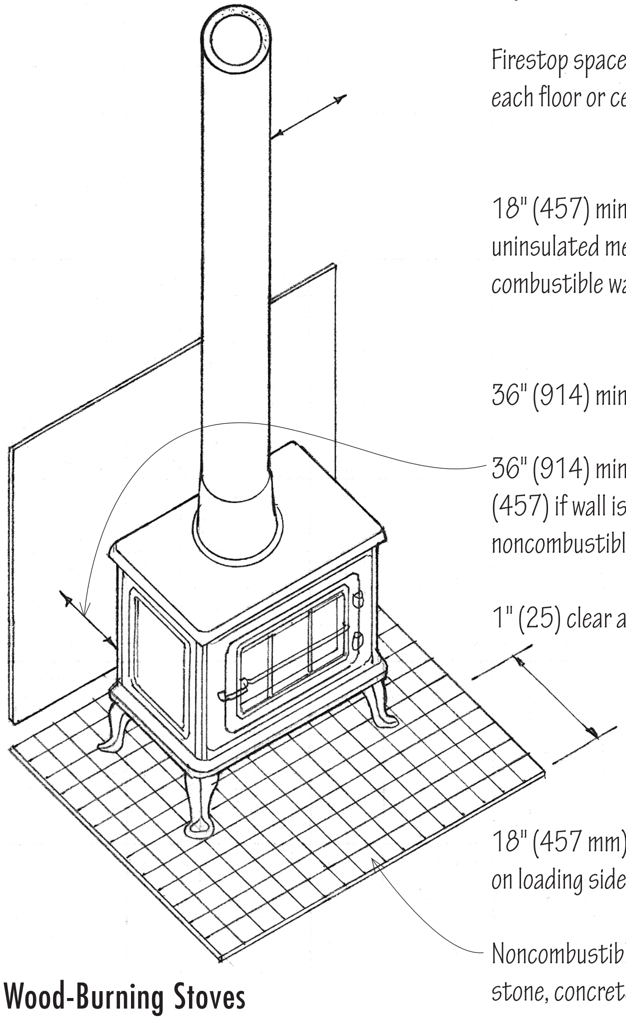
Prefabricated fireplaces and wood-burning stoves should be certified by the Environmental Protection Agency (EPA) for burning efficiency and allowable particulate emissions.

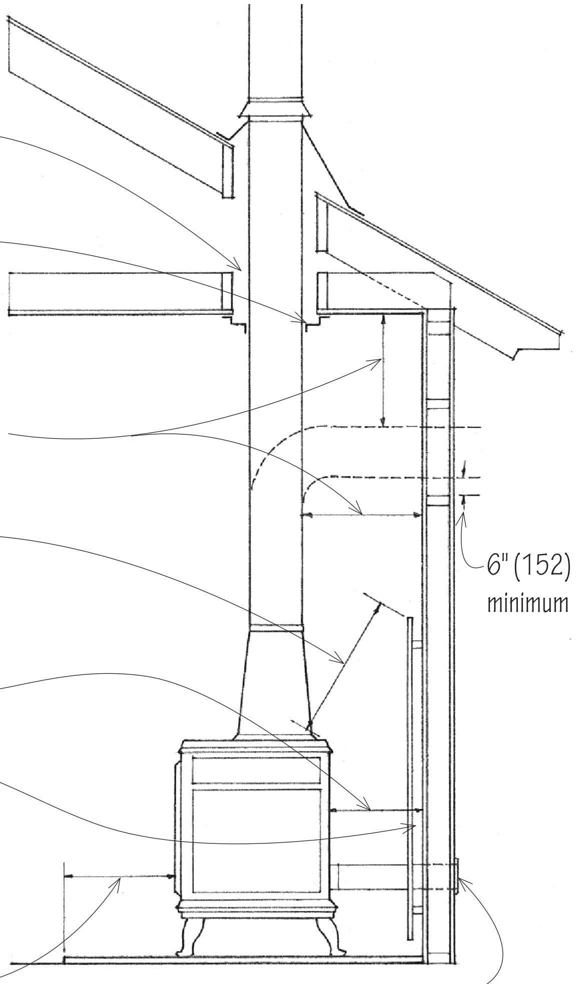
Wood-burning stoves must be located at safe distances from combustible surfaces, with noncombustible materials below and around the stove.

The stove's location affects furniture arrangements and circulation paths, with areas with a view of the stove getting most of the radiant heat.

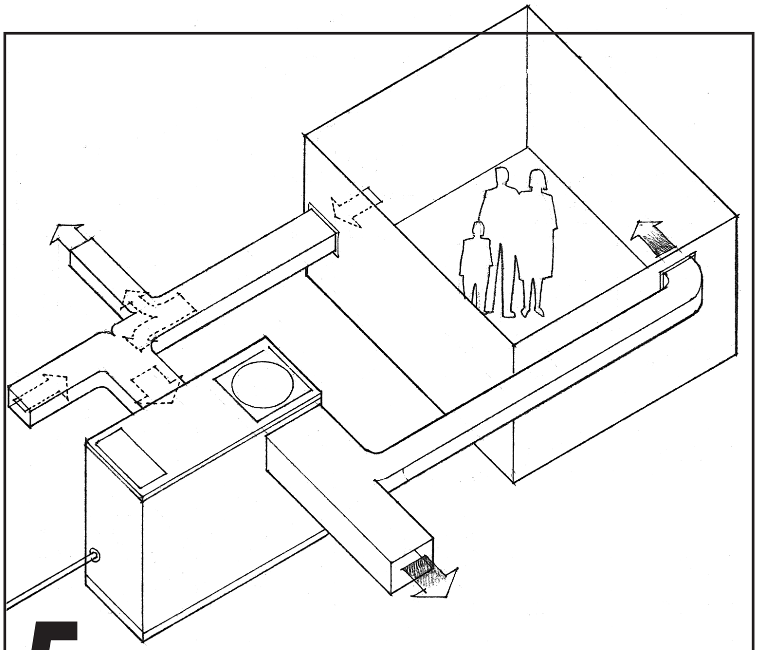



Prefabricated Fireplace



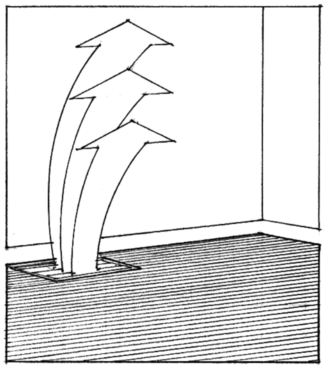



Wood-Burning Stoves

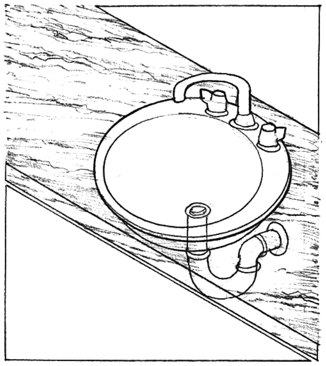


# 5

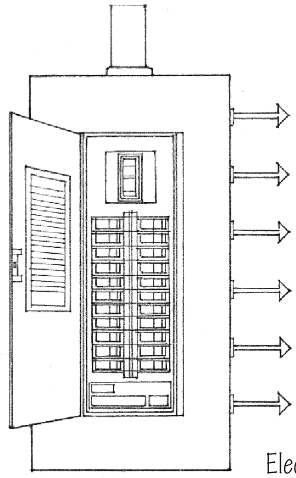
# Interior Environmental Systems



Heating, ventilating, and air-conditioning



Water supply and sanitary drainage

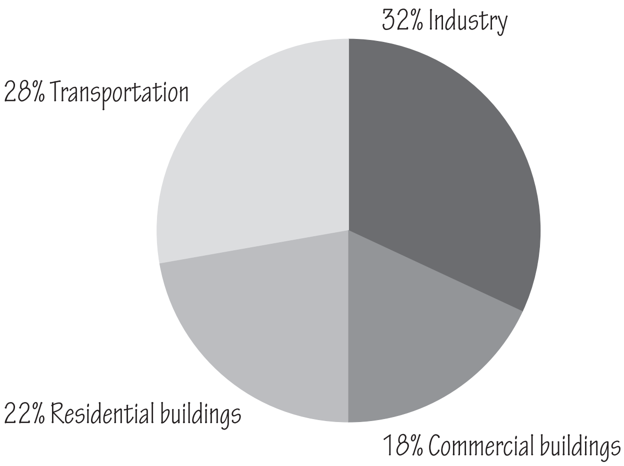


Electrical power supply and distribution

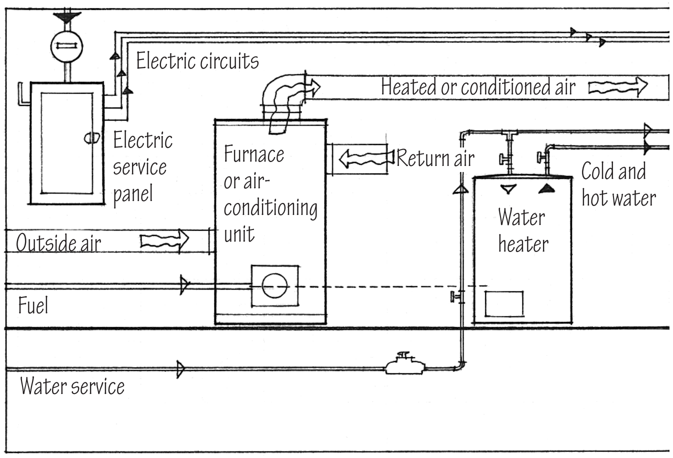
Interior environmental systems are essential components of any building. They provide the thermal, visual, auditory, and sanitary conditions necessary for the comfort and convenience of the building's occupants. These systems must be designed and laid out well to function properly. They must also be coordinated with a building's structural system. This requires the knowledge and expertise of professional engineers and architects. Nevertheless, the interior designer should be aware that these systems exist and know how they affect the quality of the interior environment. Each system has a different life span, and each is layered closely to another system inside the building's spaces, so upgrading one layer involves labor costs for installation and integration with other layers. With time, the layers become more complexly entangled.

## Interior Environmental Systems

Interior environmental systems use substantial amounts of energy. In the U.S., most of this energy (including electricity) is derived from petroleum and natural gas, with some from coal, nuclear energy, and renewable sources such as hydroelectric, wood, biofuels, biomass, wind, geothermal, and solar energy. Heating, ventilating, and air-conditioning (HVAC) equipment uses energy to maintain thermal comfort; inefficient designs allow heated and cooled air to leak out of buildings. Heat from water used for bathing and washing dishes and clothes usually ends up flushed down the drain. We often forget to shut off power to electrical devices when they are not in use, further increasing building energy use. Reducing this waste is a key factor in sustainable design.



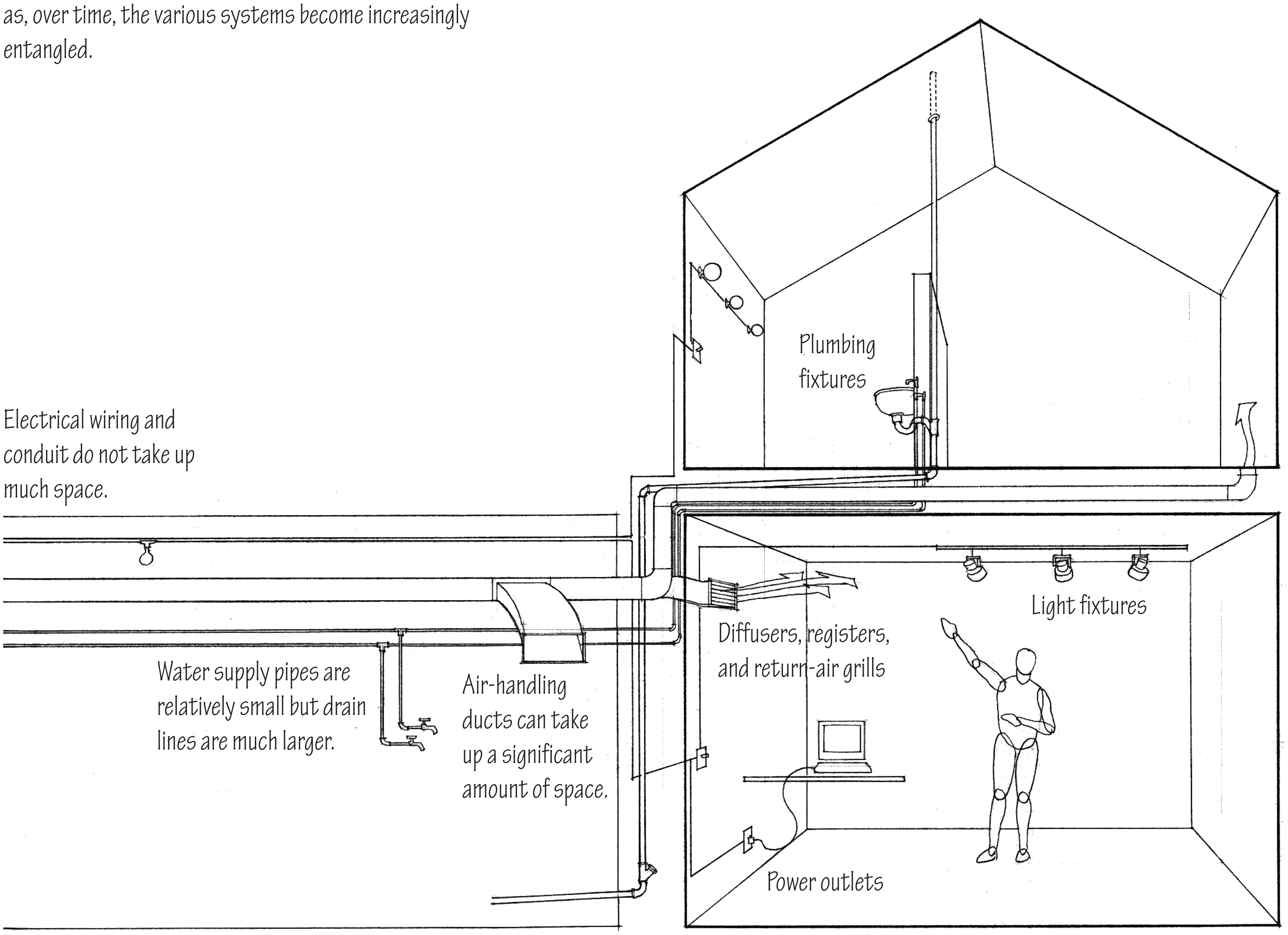

## U.S. Energy Consumption by Sector




Sources

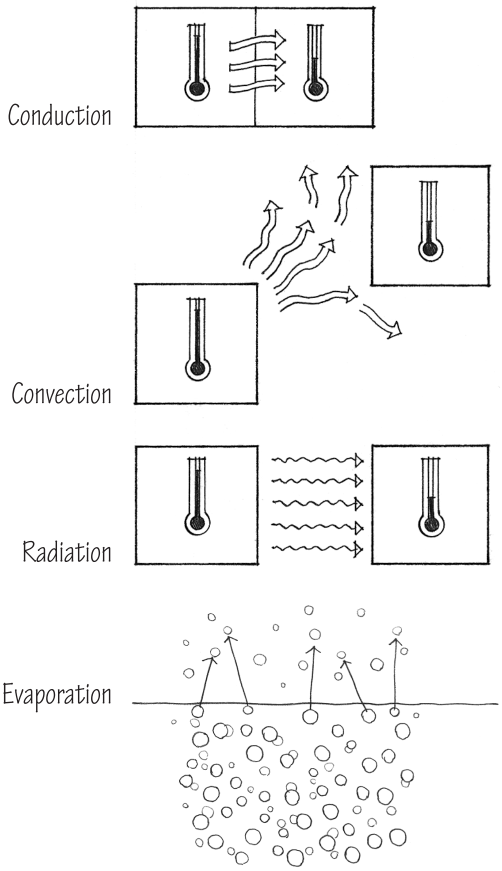
While the nature of a building's structural system can manifest itself in its interior spaces, the often complex networks of its mechanical and electrical systems are normally hidden from view. Interior designers, however, should be aware of the visible items that directly affect the interior environment, such as lighting fixtures, electrical outlets, plumbing fixtures, and air supply registers and return grilles. Also of interest are the space requirements for horizontal and vertical runs of air ducts and electrical and plumbing lines.

Although a building can last 40 years or longer, the technologies within it may need upgrades as often as every two years. These technological changes carry both financial and aesthetic costs. With each system having a different life span and being located very close to another one, their complex interrelationships add to labor costs as, over time, the various systems become increasingly entangled.




Transmission

Control and Output Devices




Thermal comfort is achieved when the human body is able to dissipate the heat and moisture it produces by metabolic action, to maintain a stable, normal body temperature.

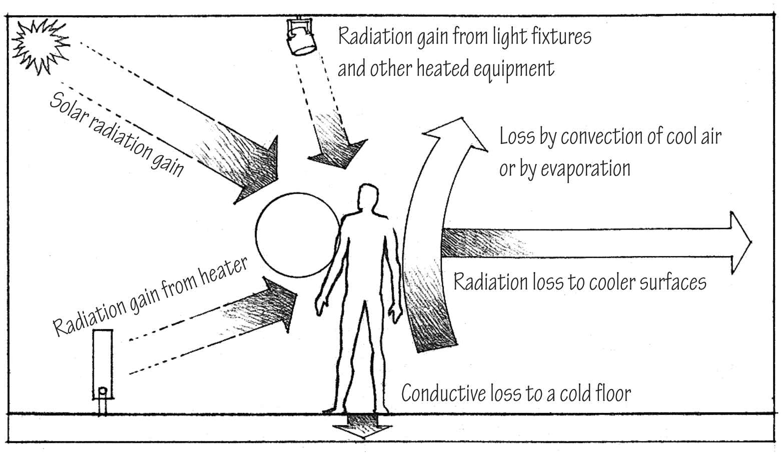
## Modes of Heat Transfer

*Radiation:* Heat energy is emitted by a warm body, transmitted through an intervening space, and absorbed by a cooler body; radiant heat is not affected by air motion or temperature.

*Convection:* Transfer is due to the circulatory motion of the heated parts of a liquid or gas.

*Conduction:* Direct transfer occurs from the warmer to the cooler particles of a medium or of two bodies in direct contact.

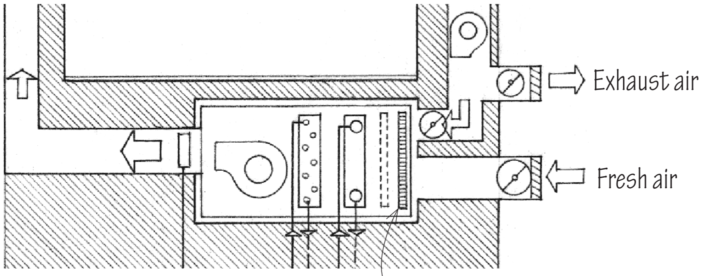
*Evaporation:* Heat loss is due to the process of converting moisture into a vapor.




Thermal comfort is dependent not only on air temperature but also on relative air humidity, the radiant temperature of surrounding surfaces, air motion, and air purity. To achieve and maintain thermal comfort, a reasonable balance must be reached among these factors.

- The higher the mean radiant temperature of a room's surfaces, the cooler the air temperature should be.
- The higher the relative humidity of a space, the lower the air temperature should be.
- The cooler the moving air stream, the less velocity it should have.

Indoor air-quality considerations affect the type of HVAC equipment chosen to control air pressure and provide fresh and conditioned air to the interior spaces of a building. Operable windows and natural ventilation can keep carbon dioxide exhaled by occupants at levels that do not cause drowsiness. Designers can help educate their clients about the building systems' attributes and how to use the space by developing welcome guides.

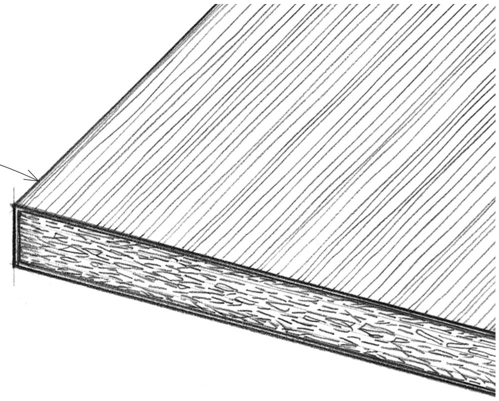


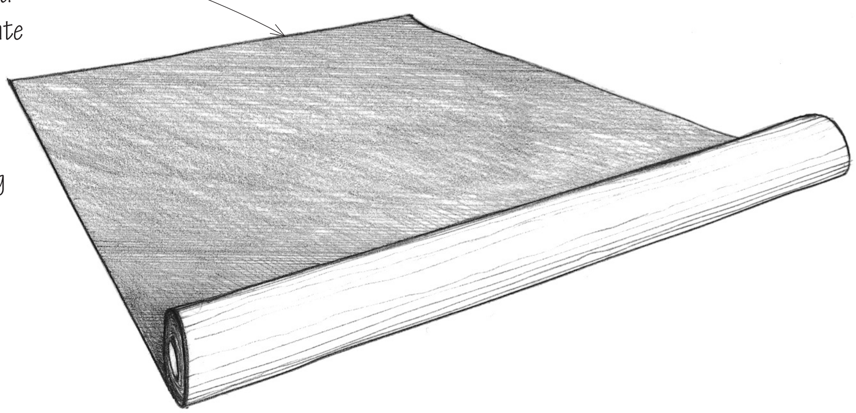

Filters remove suspended impurities from the air supply. Over half of indoor air-quality problems result from inadequate ventilation and filtration. Building codes specify the amount of ventilation required for certain uses and occupancies in air changes per hour or in cubic feet per minute per person.

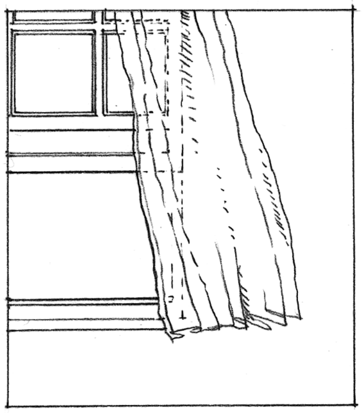
Equipment maintenance also affects the quality of air delivered, because molds and viruses thrive in warm, moist equipment. Filters must be changed often to capture particulates effectively. HEPA filters remove almost all allergens and pollutants in the air, including very small particles. Some are designed for year-round use in the home, and provide cool air in the summer as well as heat in the winter.

Some interior design materials may release volatile organic compounds (VOCs) that may irritate eyes, skin, and respiratory systems. Examples include:

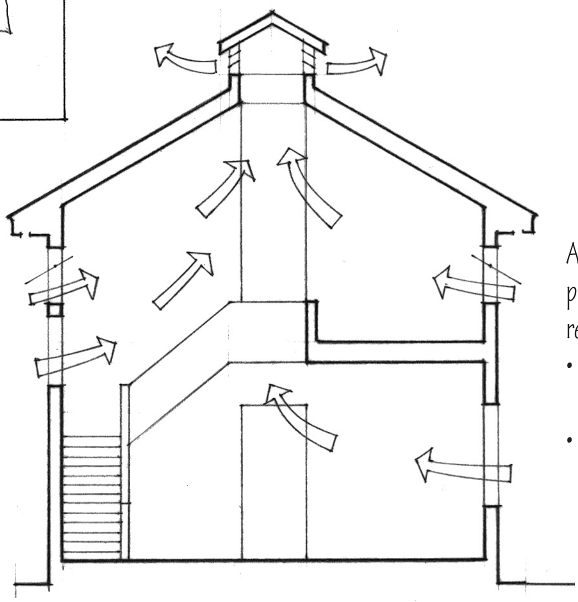
- Formaldehyde in pressed wood products such as particleboard and plywood; products are available without it. If used, seal all surfaces and edges.
- Some carpets and carpet pads and adhesives contain VOCs; select products without them, or provide an *off-gassing* period after installation.
- Vinyl sheet flooring and wall coverings owe their flexibility to petroleum-based plasticizers; seek alternative products.
- Paints, stains, and other coatings have VOC levels printed on their labels; select those with lower levels, and ventilate spaces where they are used.
- Some treated fabrics and modular office partitions contain VOC-producing chemicals; provide an off-gassing period if used.





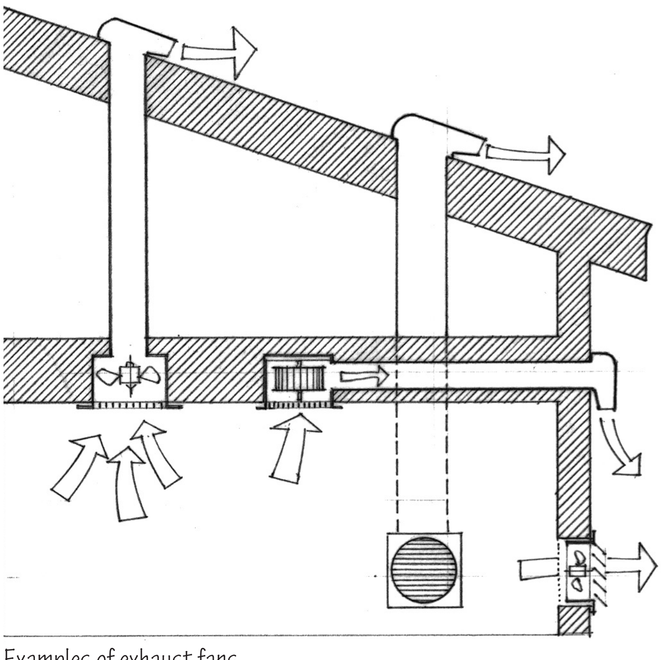


Buildings need a source of fresh air to replenish the oxygen used by the people and equipment inside and to remove carbon dioxide and other wastes from the air. Buildings designed without operable windows limit the intake of fresh air. Increasing natural ventilation and air distribution is the most energy-efficient and cost-effective way to freshen the air inside most buildings.



Air flows through a building because it moves from higher-pressure to lower-pressure areas. Natural ventilation requires:

- A source of air having an acceptable temperature, moisture content, and cleanliness.
- A force—usually wind or thermal convection—to move the air through the inhabited spaces of the building.



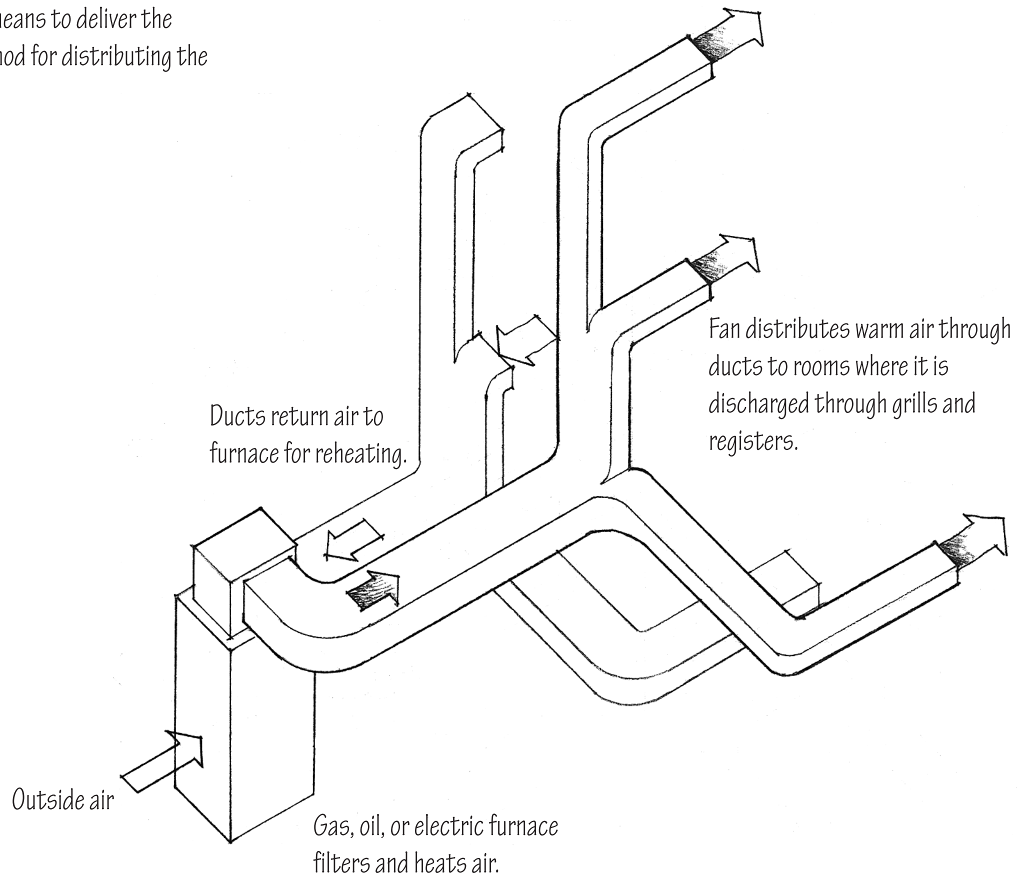
Examples of exhaust fans

Mechanical systems use fans to move air in and out of buildings, and incorporate controls for regulating the volume, velocity, and direction of airflow.

Blowers and fans move the air through ductwork that delivers it to the building's rooms. Registers control the flow of air into interior spaces. Return air grilles take in used air to be cleaned and reused or exhausted from the building.

*Infiltration* refers to the flow of outside air into an interior space through cracks around windows and doors or other openings in the envelope of a building. Although infiltration may bring fresh air into the interior, these openings can also waste energy by allowing heated or cooled air to escape.

The primary objective of a heating system is to replace the heat lost within an interior space. The basic heating system consists of a heat-producing medium, equipment to convert the medium to heat, a means to deliver the heat to a space, and, finally, a method for distributing the heat within the space.




## Forced-Air Heating

Forced-air heating is a system that uses air heated in a gas, oil, or electric furnace and distributed by a fan through ductwork to registers or diffusers in inhabited spaces.

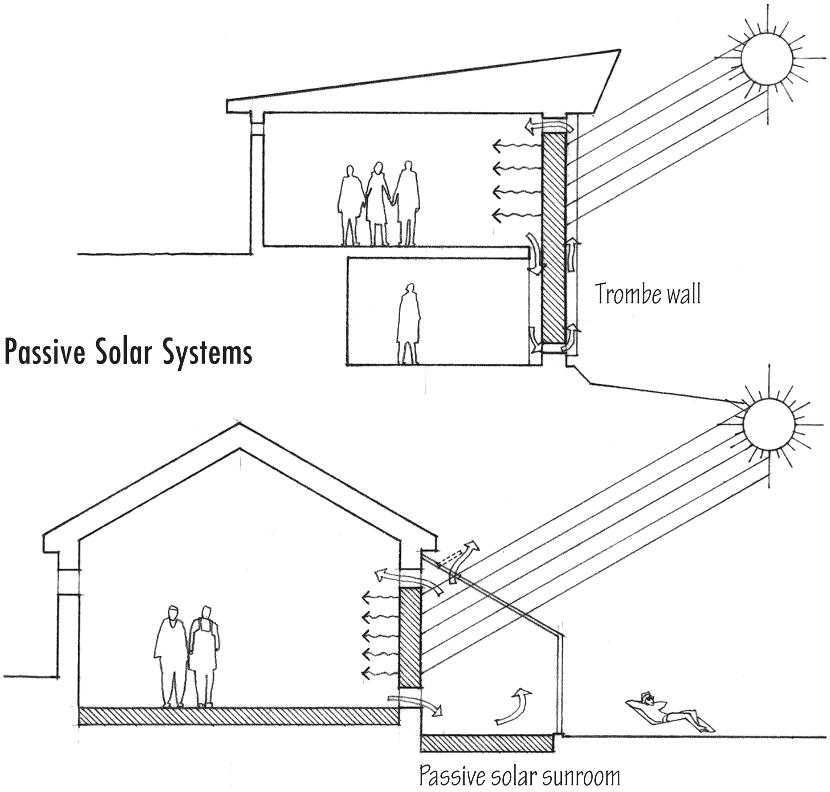
The ductwork used for forced-air heating is often concealed by a suspended ceiling; it may also be left exposed or be hidden in a soffit or other interior construction. The locations of ducts and their associated grilles and registers will affect the appearance of the ceiling, and should be coordinated with the locations of lighting fixtures, fire-suppression sprinklers, speakers, and other ceiling equipment. Interior designers should collaborate with architects and engineers to ensure a coordinated and attractive ceiling design.

## Solar Heating

The amount of sunlight falling on a building typically has enough energy to keep it comfortable throughout the year. Most solar-heating systems can accommodate 40 to 70 percent of a building's heating load.

A *passive solar-heating system* incorporates solar collection, storage, and distribution into a building's architectural design, with minimal use of pumps or fans. This is accomplished by carefully siting the building and designing the size and type of windows, as well as by using massive materials that can store thermal energy. Overhangs and shading devices are used to avoid glare and overheating.

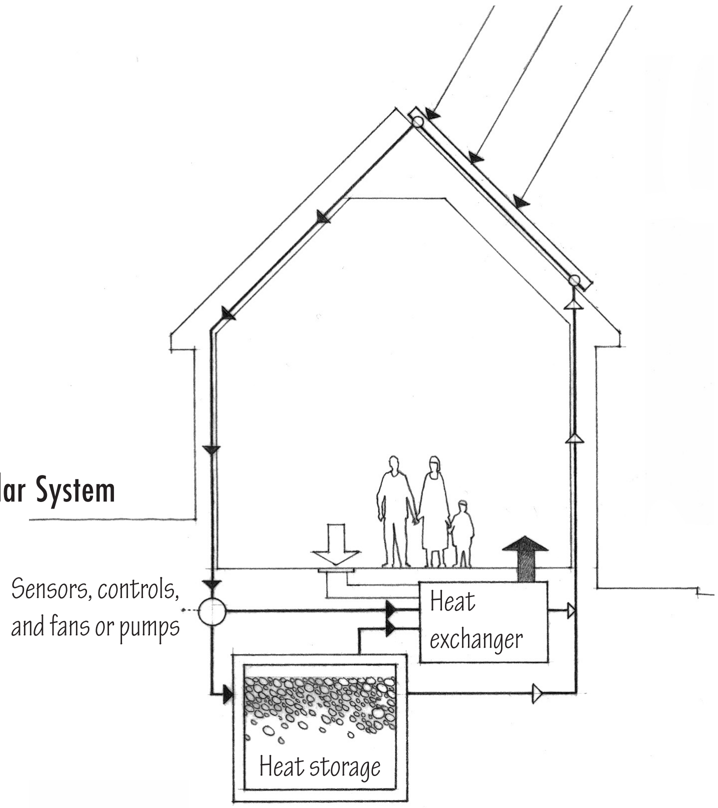
### Passive Solar Systems




*Active solar-heating systems* use pumps, fans, heat pumps, and other mechanical equipment to transmit and distribute thermal energy via air or a liquid. They offer better control of the interior environment than passive systems, and can be added onto most existing buildings. Most active systems are operated by electricity.

Many buildings use hybrid systems with passive-solar design features supplemented by electrically driven fans or pumps.

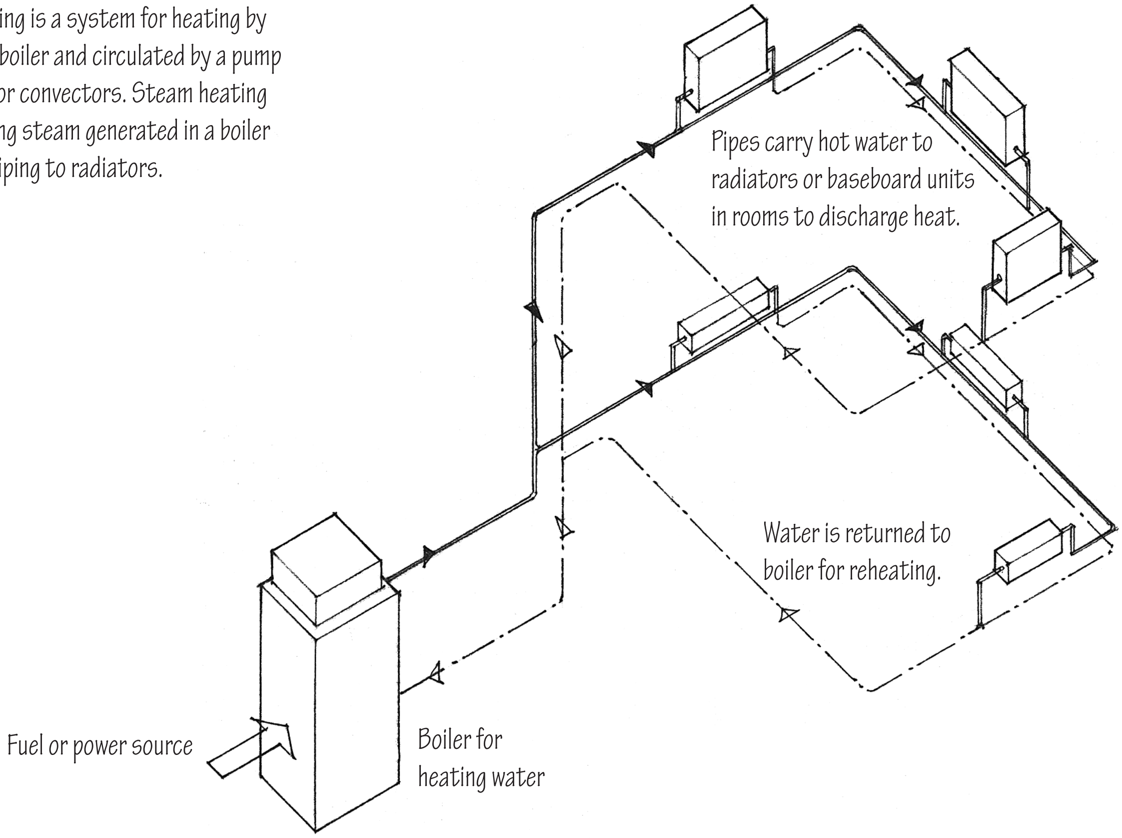
### Active Solar System




Even an interior that is not designed specifically for solar heating can take advantage of this free heat source in cold weather by absorbing the sun's warmth through windows during the day, and blocking its exit with thermal window treatments at night.

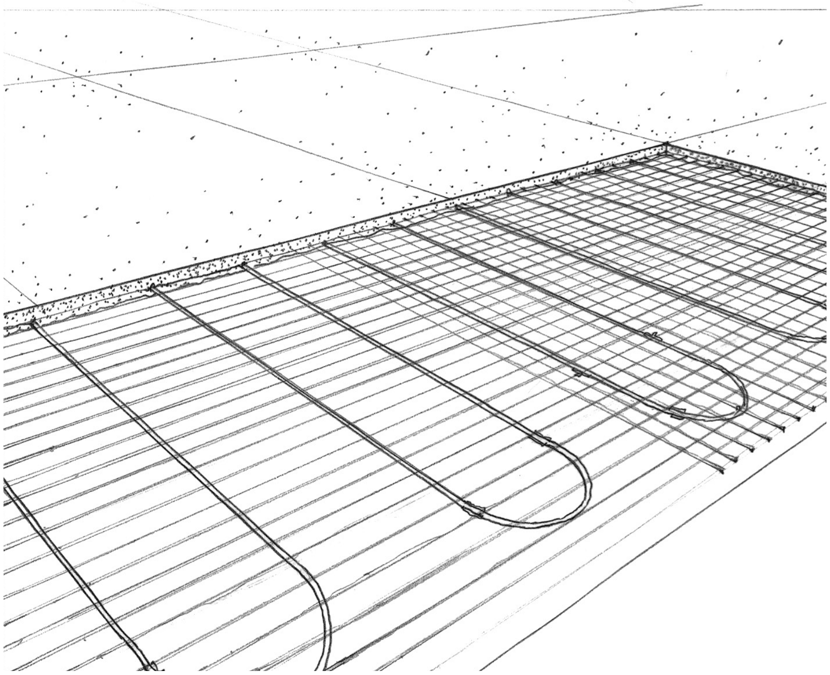
## Hot-Water Heating

Hot-water or hydronic heating is a system for heating by means of water heated in a boiler and circulated by a pump through pipes to radiators or convectors. Steam heating is similar in principle, utilizing steam generated in a boiler and circulating it through piping to radiators.




## Radiant Heating

Radiant heating systems use heated ceilings, floors, and sometimes walls as radiating surfaces. The heat source may be pipes or tubing carrying hot water, or electric-resistance heating cables embedded within the ceiling, floor, or wall construction.

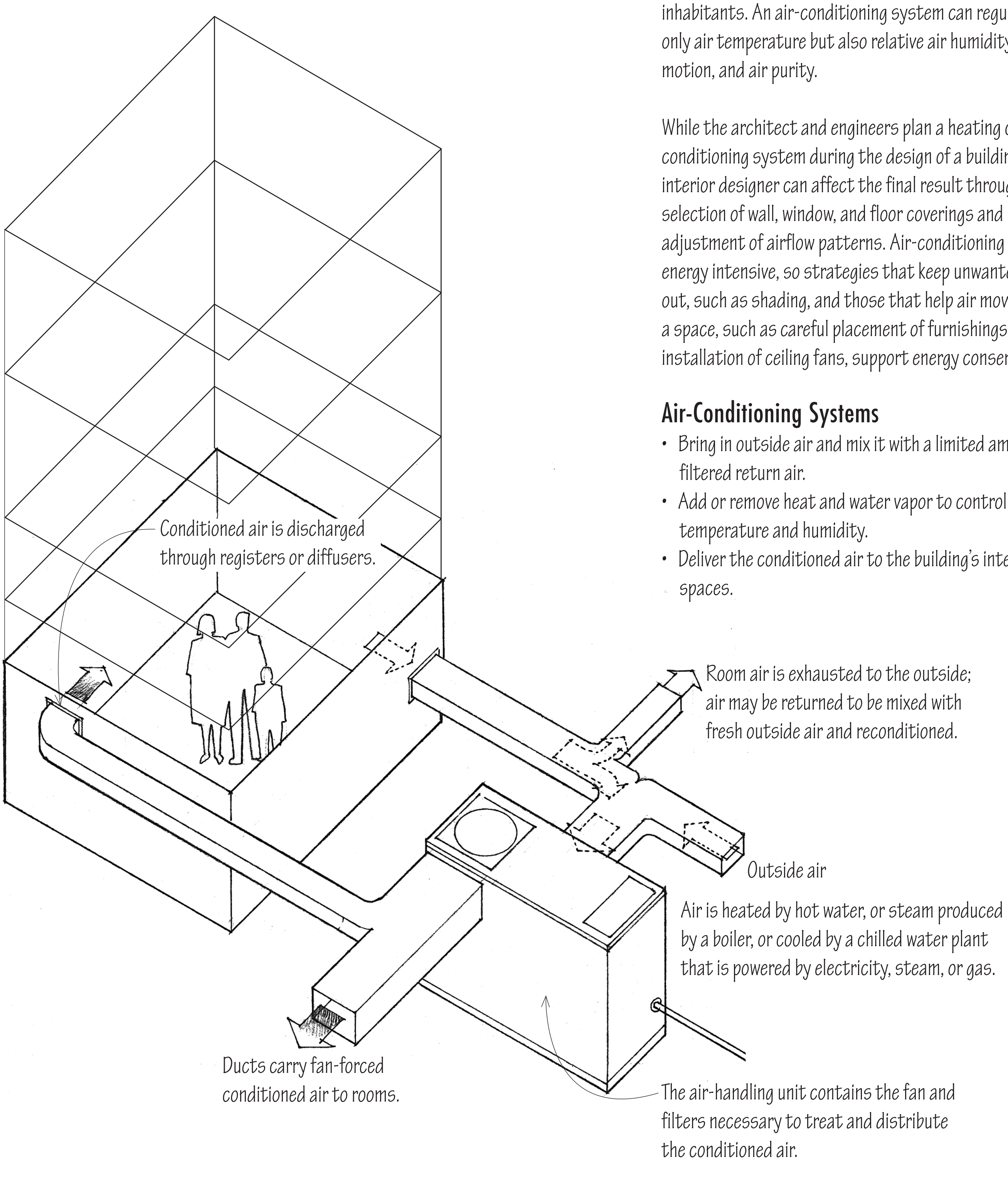


An air conditioner is usually considered to be a means for supplying cooled air. A true air-conditioning system, however, provides all-year climate control by treating air in multiple ways to ensure the thermal comfort of a building's inhabitants. An air-conditioning system can regulate not only air temperature but also relative air humidity, air motion, and air purity.

While the architect and engineers plan a heating or air-conditioning system during the design of a building, the interior designer can affect the final result through the selection of wall, window, and floor coverings and by the adjustment of airflow patterns. Air-conditioning is very energy intensive, so strategies that keep unwanted heat out, such as shading, and those that help air move through a space, such as careful placement of furnishings and the installation of ceiling fans, support energy conservation.

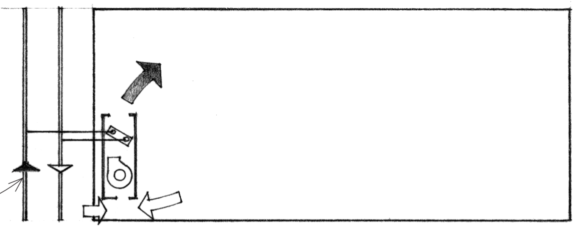
## Air-Conditioning Systems

- Bring in outside air and mix it with a limited amount of filtered return air.
- Add or remove heat and water vapor to control air temperature and humidity.
- Deliver the conditioned air to the building's interior spaces.

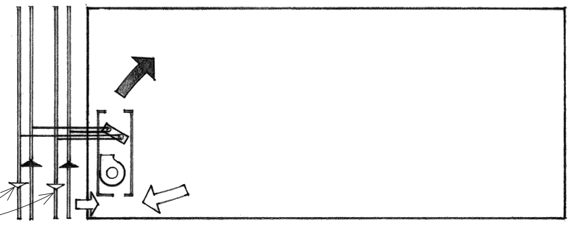


## All-Water Systems

Pipes, which require less installation space than air ducts, deliver hot or chilled water to fan-coil units in the served spaces.

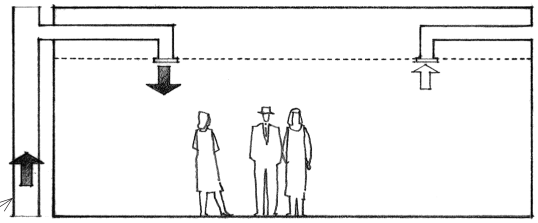


A two-pipe system uses one pipe to supply hot or chilled water to each fan-coil unit and another to return it to the boiler or chilled water plant. Fan-coil units contain an air filter and a centrifugal fan for drawing in a mixture of room air and outside air over coils of heated or chilled water and then blowing it back into the space.

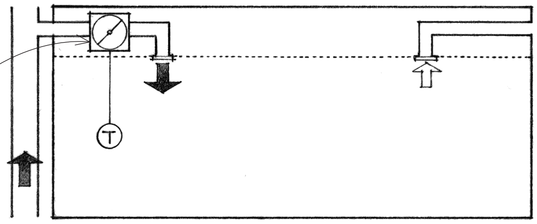


A four-pipe system uses two separate piping circuits—one for hot water and one for chilled water—to provide simultaneous heating and cooling as needed to the various zones of a building.

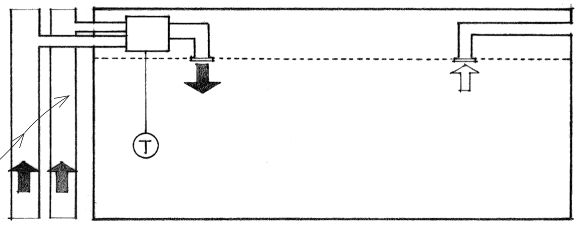
## All-Air Systems



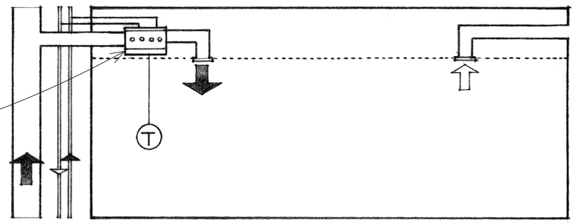
A single-duct, constant-air-volume (CAV) system delivers conditioned air at a constant temperature through a low-velocity duct system to the served spaces.




A single-duct, variable-air-volume (VAV) system uses dampers at the terminal outlets to control the flow of conditioned air according to the temperature requirements of each zone or space.

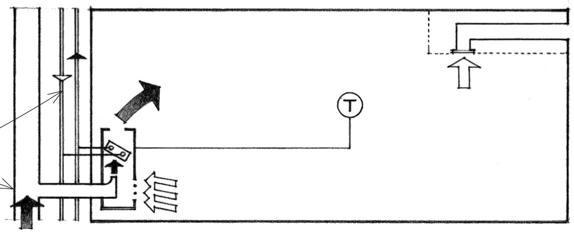



A dual-duct system uses separate ducts to deliver warm air and cool air to mixing boxes, which contain thermostatically controlled dampers. Mixing boxes proportion and blend the warm and cold air to reach the desired temperature before distributing the blended air to each zone or space. Dual duct systems take up more space and tend to cost more than other systems.

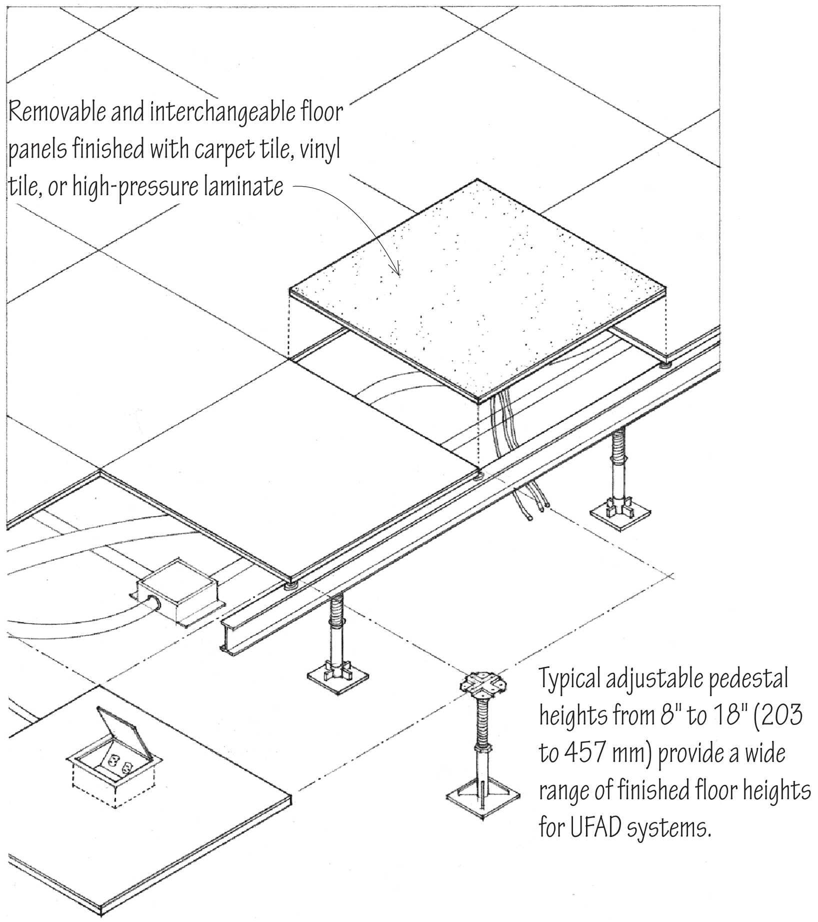



A terminal reheat system offers more flexibility in meeting changing space requirements. It supplies air at about 55°F (12°C) to terminals equipped with electric or hot-water reheat coils, which regulate the temperature of the air being furnished to each individually controlled zone or space.

## Air-Water Systems




Air-water systems use high-velocity ducts to supply conditioned primary air from a central plant to each zone or space, where it mixes with room air and is further heated or cooled in induction units.

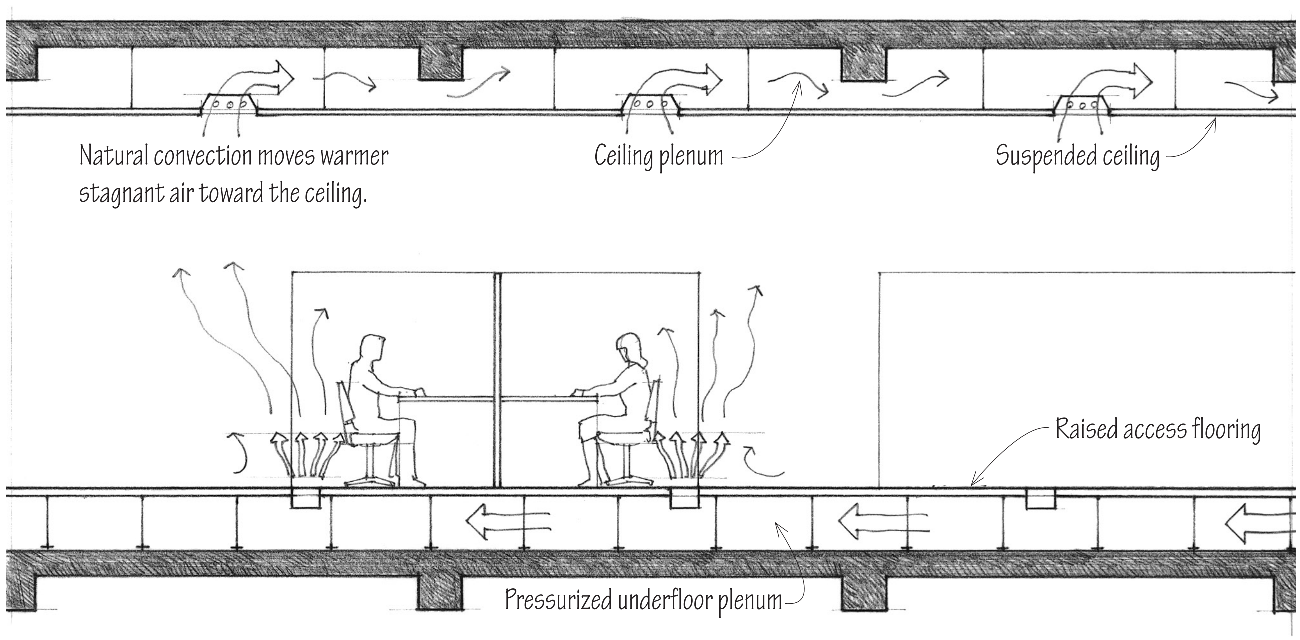



Underfloor air distribution (UFAD) systems are used with raised access flooring to distribute conditioned air in commercial buildings. They improve thermal comfort, and offer more efficient ventilation and better indoor air quality.

Raised access flooring consists of panels supported by pedestals. The *plenum* space below the panels can accommodate wiring and communications cabling, as well as air distribution and circulation.

In a UFAD system, conditioned air is typically ducted to the underfloor plenum, and then allowed to flow openly to the air supply outlets. The supply outlets are usually in the floor, but can be in partitions or at desktop level. The air is usually returned at ceiling level, where it travels through an open plenum.

The floor finish is often carpet tile, which allows easy access to equipment below the raised floor panels.

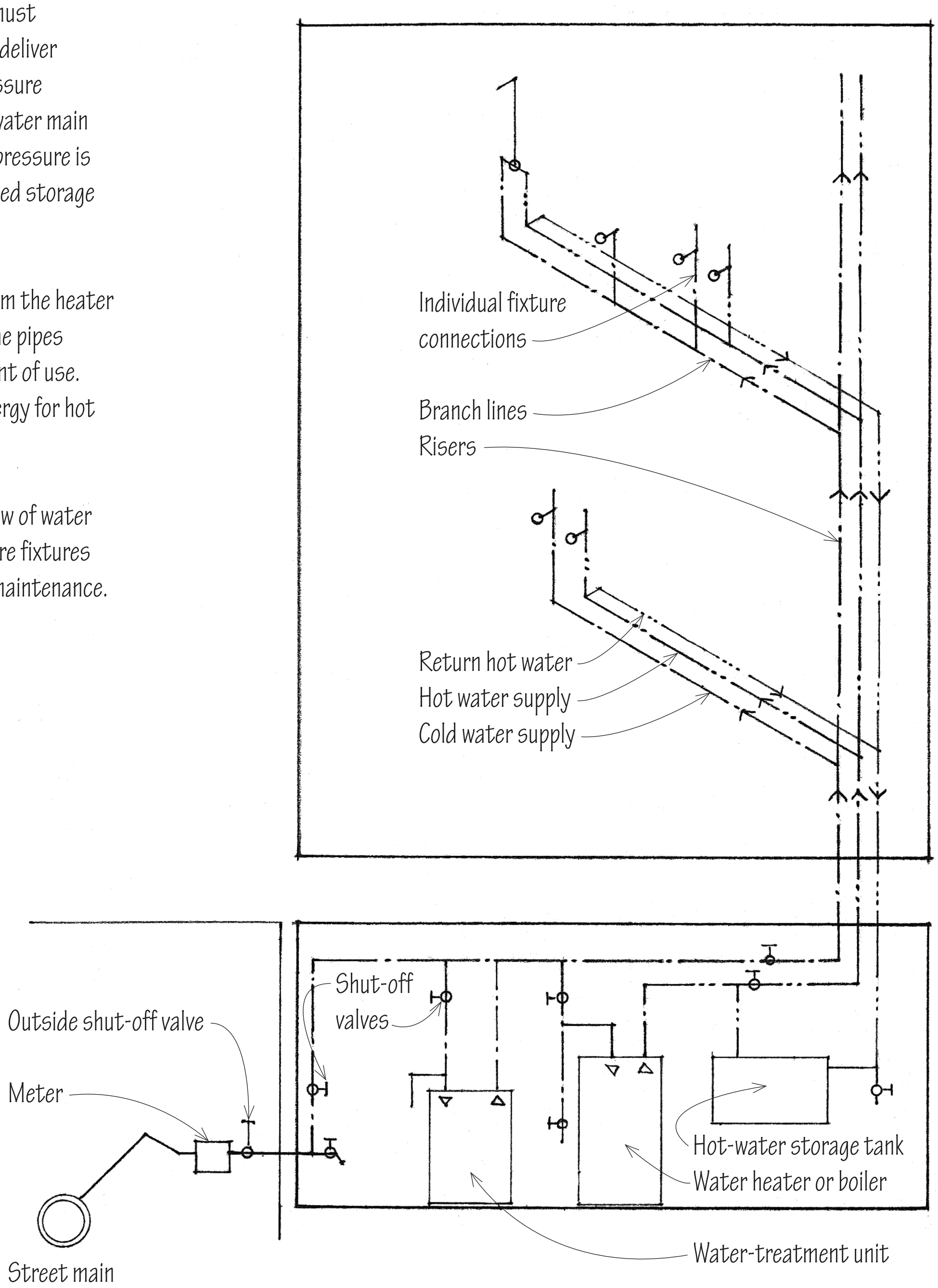


There are two separate but parallel networks in a water system. The water supply system supplies potable water for human use and consumption, as well as use by mechanical and fire protection systems. The sanitary waste system disposes of waterborne waste material once the water has been used.

Water is typically supplied to a building under pressure from a water main. The water supply system must overcome the forces of gravity and friction to deliver water up to the various points of use. The pressure required to upfeed water may come from the water main or from pumps within the building. When this pressure is insufficient, water can be pumped to an elevated storage tank for gravity downfeed.

A separate hot water supply system leads from the heater or boiler to each required fixture. Insulating the pipes conserves heat as the water travels to its point of use. A solar water heater can supply renewable energy for hot water.

A series of valves is required to control the flow of water at each fixture, as well as to isolate one or more fixtures from the water supply system for repair and maintenance.



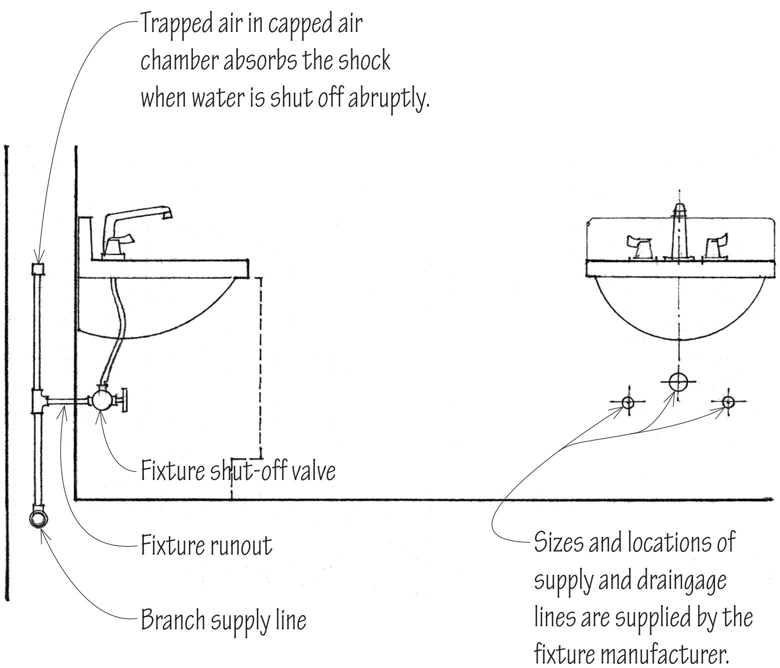
Many places in the world do not have adequate fresh water supplies, and conservation of this finite resource is an important component of sustainable design. Building codes mandate the use of water-efficient fixtures and valves in order to conserve water resources.

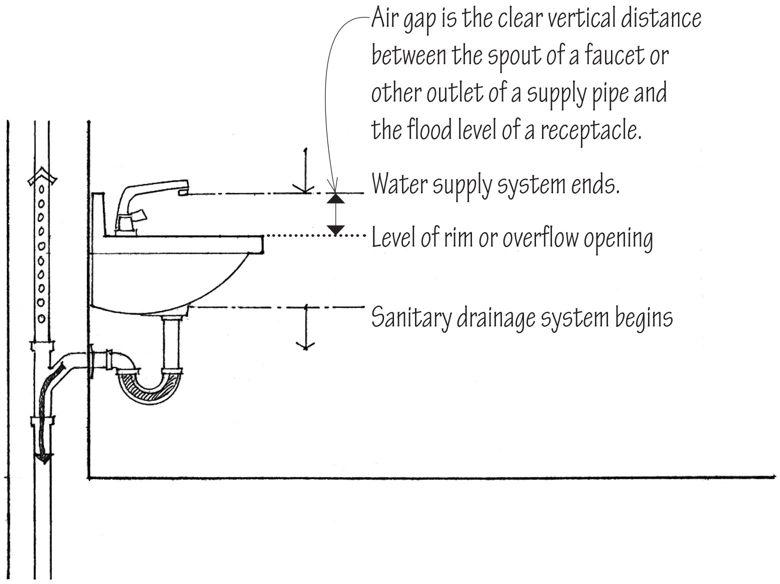
Plumbing fixtures receive water from a supply system and discharge the waste into a sanitary drainage system. The two systems are kept separate to prevent contamination. An air gap between the spout of a faucet and the flood level of a receptacle prevents used or contaminated water from being siphoned into a supply pipe.

Shut-off valves allow the water supply to be shut off for repairs or in emergencies.

Access to shut-off valves must be maintained in any interior construction.

A trap is a U-shaped or S-shaped section of a plumbing fixture's drainpipe in which wastewater remains, forming a seal that prevents the passage of sewer gas without affecting the flow of water or sewage through the pipe. In some parts of the U.S., S-shaped traps are no longer legal, as they tend to more easily siphon wastewater back into the supply system.



Commonly called a toilet, a *water closet* consists of a ceramic bowl with a detachable, hinged seat and lid and a device for flushing with water. Commercial toilet installations use larger supply pipes with flushometer valves that, when actuated by direct water pressure, supply a fixed quantity of water to flush the fixtures. Water closets have large traps that are forced to siphon rapidly during the flushing process and are refilled with fresh water to retain the seal. A water closet must have a vent located nearby to prevent accidental siphoning between flushes.

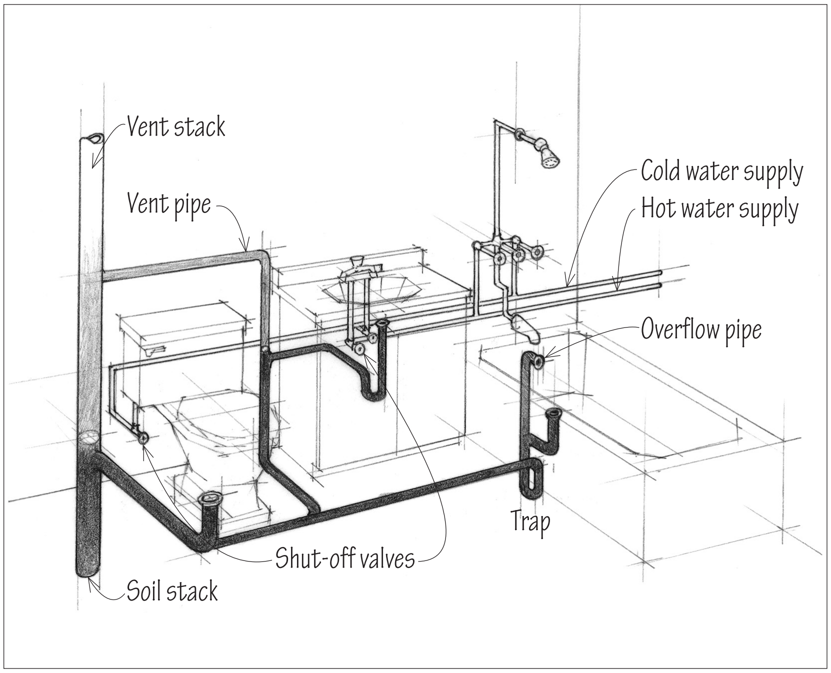
In the U.S., codes limit the amount of water used per flush to 1.6 gallons (6 liters). High-efficiency toilets (HETs) and pressure-assisted toilets are designed to function well with even less water than this. Dual-flush toilet controls allow the user to select a smaller or larger flush within these limits.

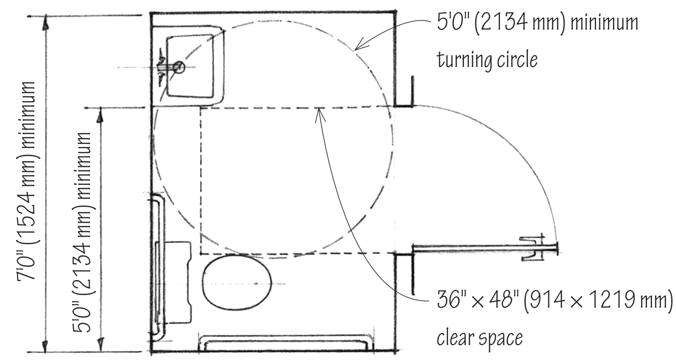
A toilet may have a round or an elongated bowl; the latter is required for accessible toilet fixtures. Toilets may be either floor- or wall-mounted. The height to the top of an accessible public toilet seat is mandated by the Americans with Disabilities Act (ADA).

Urinals may be either wall-hung or stall-type installations; the latter are more convenient for young boys and for men in wheelchairs. Waterless urinals save water by using a hygienic liquid layer that allows urine to pass while acting as a barrier to sewer gases.

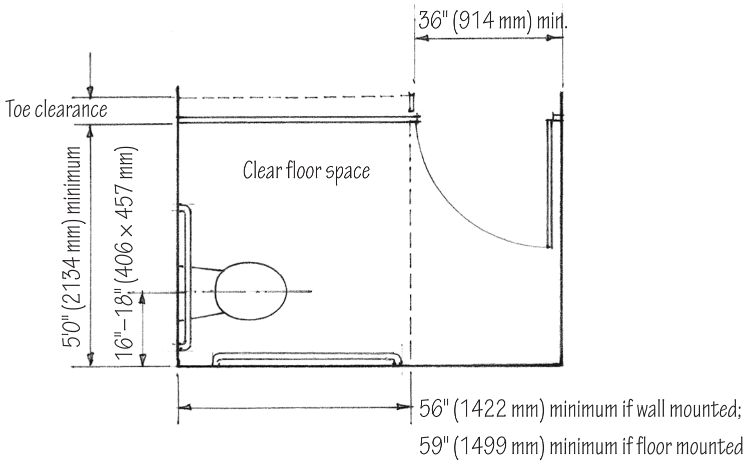
A bidet is a basinlike fixture designed to be straddled for personal cleansing. A washlet is a type of toilet seat that serves a similar purpose.

Accessibility codes detail the design of toilet stalls and rooms and set requirements for grab bars and minimum dimensions of approaches, turning radii, and clear floor spaces at toilet fixtures.



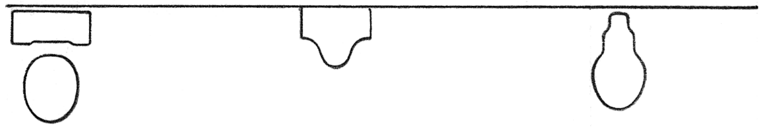

Accessible Toilet Room




Accessible End Toilet Stall

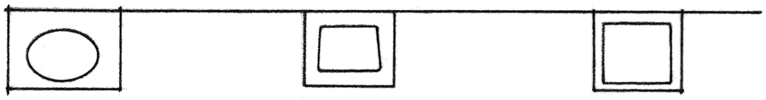
Plumbing fixtures may be made of the following materials.

- **Water closets, urinals, and bidets:**
  Vitreous china



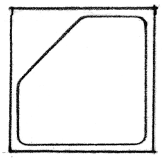
| | Water Closet | Urinal | Bidet |
|---|---|---|---|
| Width | 20"–24" (508–610 mm) | 18" (457 mm) | 14" (356 mm) |
| Depth | 22"–29" (559–737 mm) | 12"–24" (305–610 mm) | 30" (762 mm) |
| Height | 20"–28" (508–711 mm) | 24" (610 mm) | 14" (356 mm) |

- **Lavatories and utility sinks:**
  Hard, smooth, scrubbable materials, such as vitreous china, resin-based solid surfacing materials, enameled cast iron, enameled steel



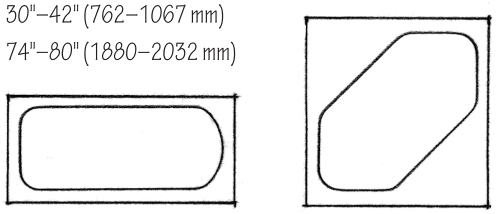
| | Lavatory | Lavatory | Lavatory |
|---|---|---|---|
| Width | 30"–36" (762 to 914 mm) | 18–24" (457–610 mm) | 18–24" (457–610 mm) |
| Depth | 21" (533 mm) | 16"–21" (406–533 mm) | 16"–21" (406–533 mm) |
| Height | 31" (787 mm) rim height | 31" (787 mm) rim height | 31" (787 mm) rim height |

- **Shower receptacles:**
  Terrazzo, enameled steel, fiberglass, acrylic plastic
- Shower enclosures:
  Enameled steel, stainless steel, ceramic tile, fiberglass, acrylic, glass



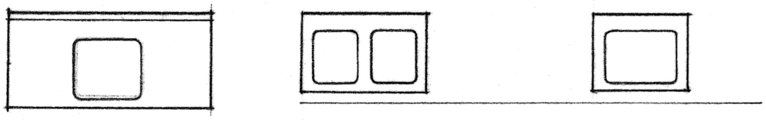
| | Shower |
|---|---|
| Width | 30"–42" (762–1067 mm) |
| Depth | 30"–42" (762–1067 mm) |
| Height | 74"–80" (1880–2032 mm) |

- **Bathtubs:**
  Acrylic, fiberglass, enameled cast iron, cultured marble



| | Bathtub | Square Bathtub |
|---|---|---|
| Width | 42"–72" (1067–1829 mm) | 44"–50" (1118–1270 mm) |
| Depth | 30"–32" (762–813 mm) | 44"–50" (1118–1270 mm) |
| Height | 12"–20" (305–508 mm) | 12"–16" (305–406 mm) |

- **Kitchen sinks:**
  Enameled cast iron, enameled steel, stainless steel



| | Sink with Drainboards | Double Bowl Sink | Utility Sink |
|---|---|---|---|
| Width | 54"–84" (1372–2134 mm) | 28"–46" (711–1168 mm) | 22"–48" (559–1219 mm) |
| Depth | 21"–25" (533–635 mm) | 16"–21" (406–533 mm) | 18"–22" (457–559 mm) |
| Height | 8" (203 mm) | 8"–10" (203–254 mm) | 27"–29" (686–737 mm) rim height |

A *lavatory* is a bowl or basin with running water for washing the face and hands. The term "sink" is used for service sinks, utility sinks, kitchen sinks, and laundry basins.

Wall-mounted lavatories require support and plumbing connections inside the wall. Countertop lavatories, including bowl-like vessel lavatories, are plumbed from below. Pedestal lavatories are freestanding, without a cabinet below. Wash fountains are designed for heavy-duty hand washing, and are available for ADA-compliant commercial restroom designs with multiple heights for broader accessibility.

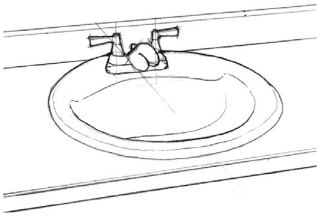
Showers may be factory-made as a complete unit, installed as a shower pan, or completely built on-site. Where there is more than one shower in a public facility, the ADA requires at least one accessible shower. There are two types of accessible showers, transfer and roll-in; the latter allows the user to remain in a wheelchair while showering.

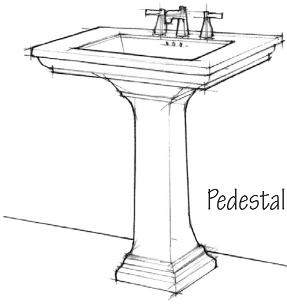
Bathtubs may be recessed into a three-walled alcove or set into a corner. Drop-in bathtubs are mounted on a platform or sunk below floor level. Freestanding bathtubs may be set on legs or installed directly onto the floor. Whirlpool tubs have motorized circulation jets, and are usually installed in a platform.

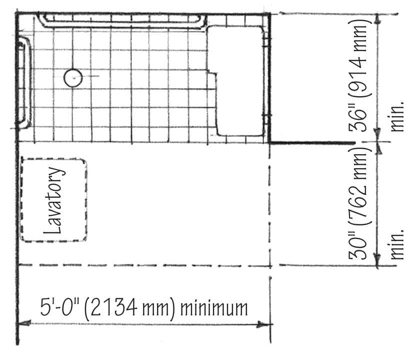
Custom-designed waterfalls are available that contain the flow of water from one height to another between layers of glass, avoiding spraying onto adjacent areas.

Faucets are now available with touchless controls for residential kitchens in a range of modern designs. The hands-free operation easily converts to manual. Residential kitchen faucets are available with foot controls as well.

Hand washing and drying can now both be provided at the sink in as little as 14 seconds, avoiding the need to move to a separate drying area to access paper towels, and thus preventing water from dripping on the floor.


Countertop lavatory

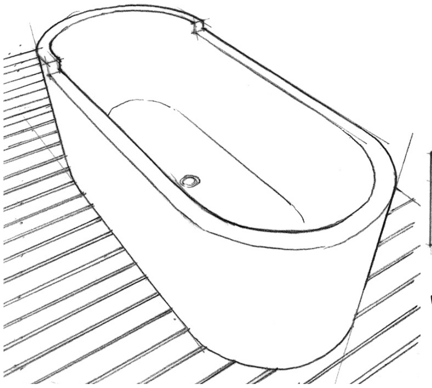

Pedestal lavatory

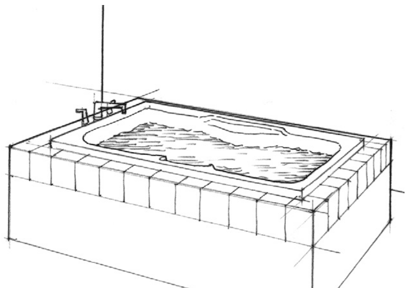


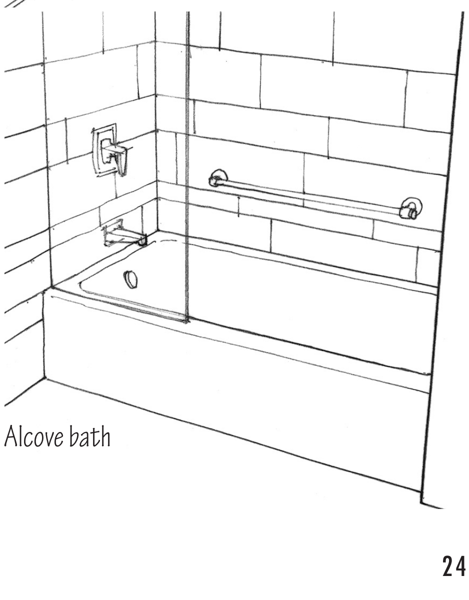
**Accessible Shower**

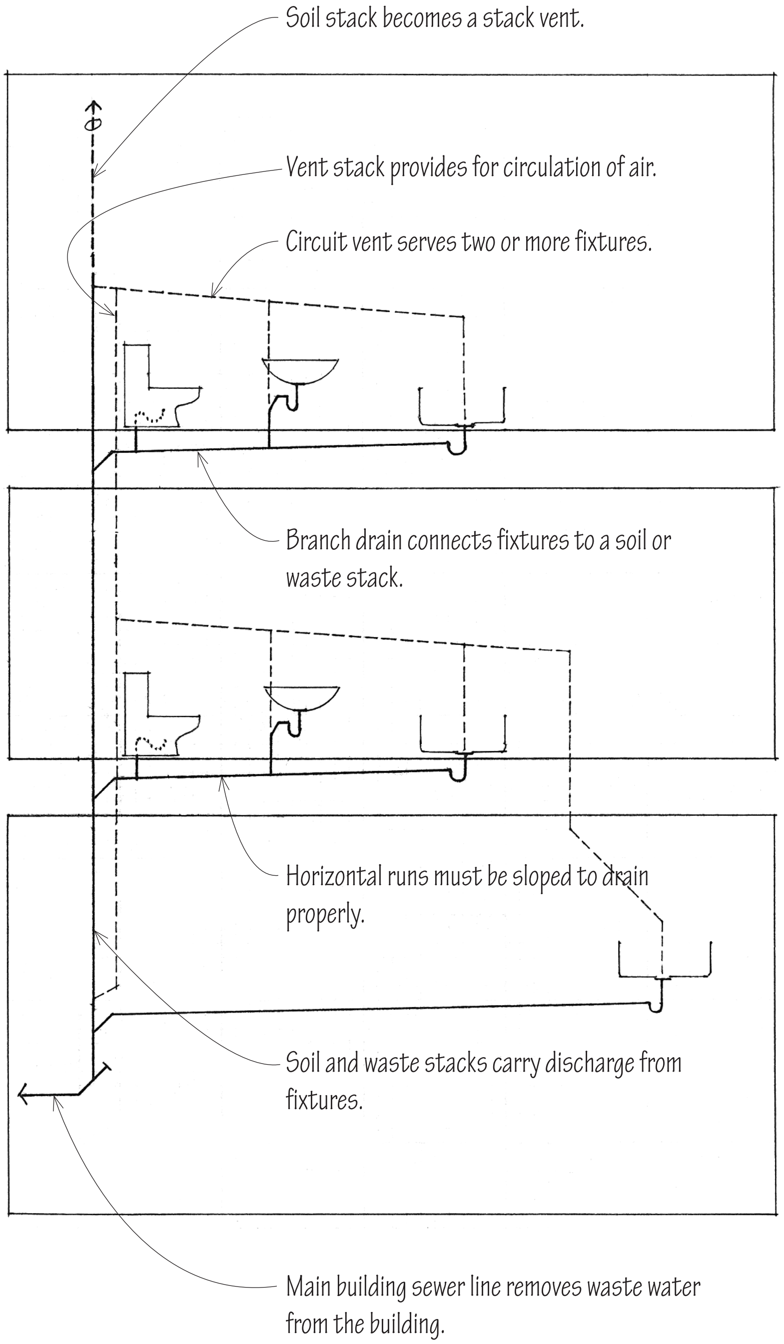

Wall-mounted lavatory


Water closet


Freestanding bathtub


Whirlpool tub


Alcove bath




The water supply system terminates at each plumbing fixture. After the water has been drawn and used, it enters the sanitary drainage system. The primary objective of this drainage system is to dispose of fluid waste and organic matter as quickly and efficiently as possible.

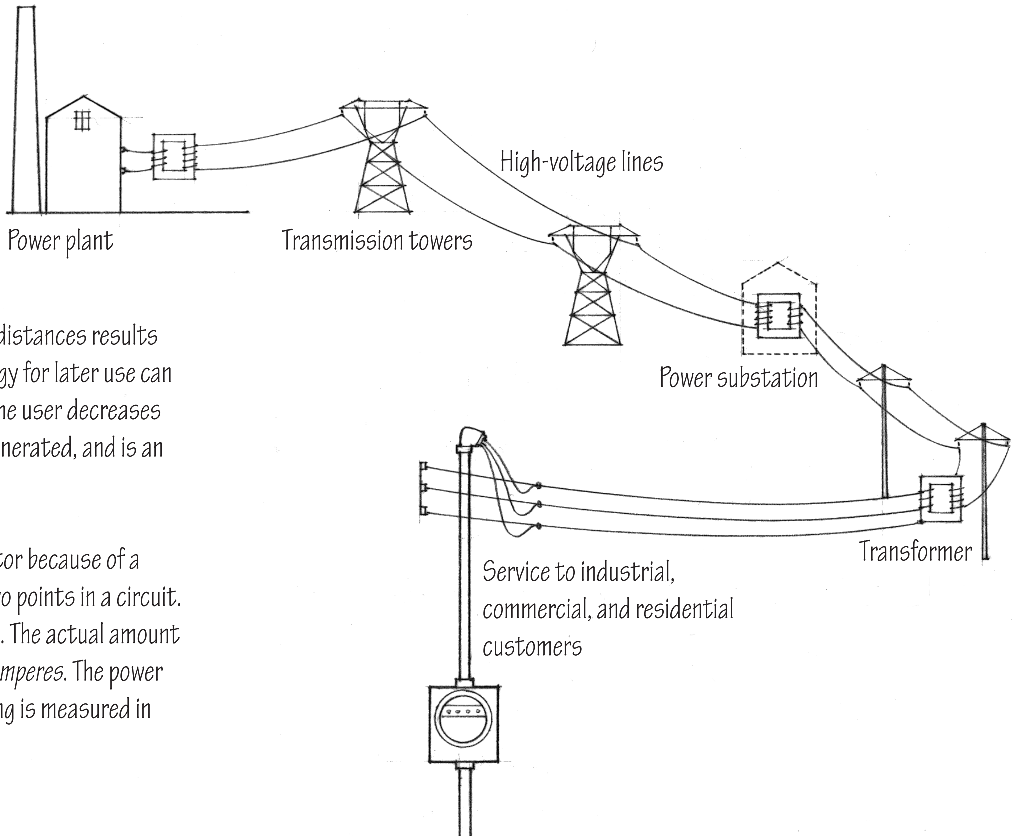
Because a sanitary drainage system relies on gravity for its discharge, its pipes are much larger than water supply lines, which are under pressure. There are restrictions on the length and slope of horizontal runs and on the types and number of turns for drainage pipes.

Gases are formed in drainage pipes by the decomposition of waste matter. To prevent these gases from entering the interior spaces of a building, traps or water seals are required at each fixture.

In addition, the entire sanitary drainage system must be vented to outside air. Venting prevents water seals in traps from being siphoned out and allows air to circulate within the system.

Floor drains are now being designed with corrosion-resistant nickel magnets replacing screws to hold the drain's strainer flush to the floor and firmly in place.

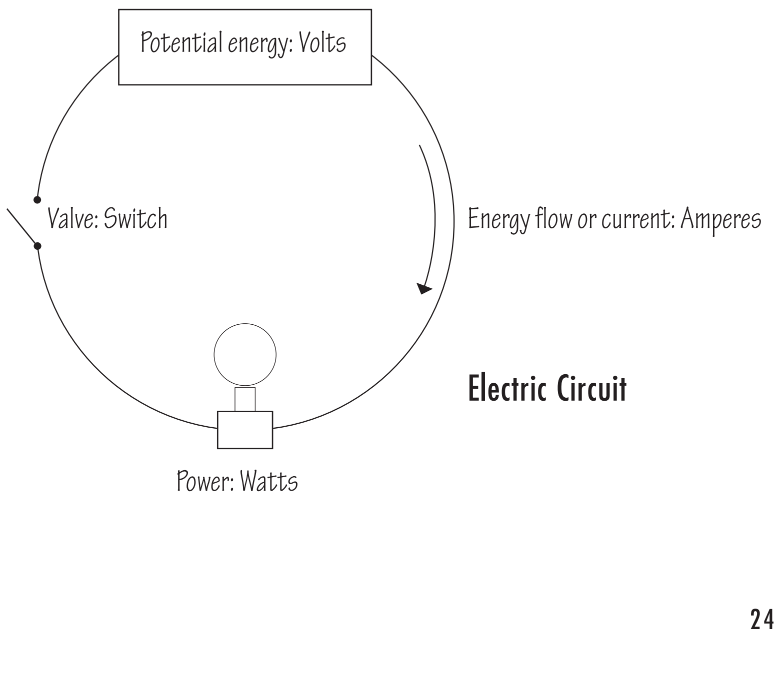
In 2016, about 67 percent of the electrical energy generated in the U.S. came from fossil fuels, with about 33 percent coming from coal, a finite fossil fuel source with serious environmental issues. Deriving energy from coal damages landscapes and produces pollutants, while converting only one-third of its energy potential to electricity. Other existing and developing sources include hydroelectric power, nuclear energy, wind power, solar (photovoltaic) power, natural-gas-powered fuel cells, solid-waste incineration, and biomass fuels.




The transmission of electricity over long distances results in energy loss, and storing electrical energy for later use can be problematic. Energy conservation by the user decreases the amount of energy that needs to be generated, and is an important part of sustainable design.

Electrical energy flows through a conductor because of a difference in electrical charge between two points in a circuit. This potential energy is measured in *volts*. The actual amount of energy flow or current is measured in *amperes*. The power required to keep an electric current flowing is measured in *watts*.

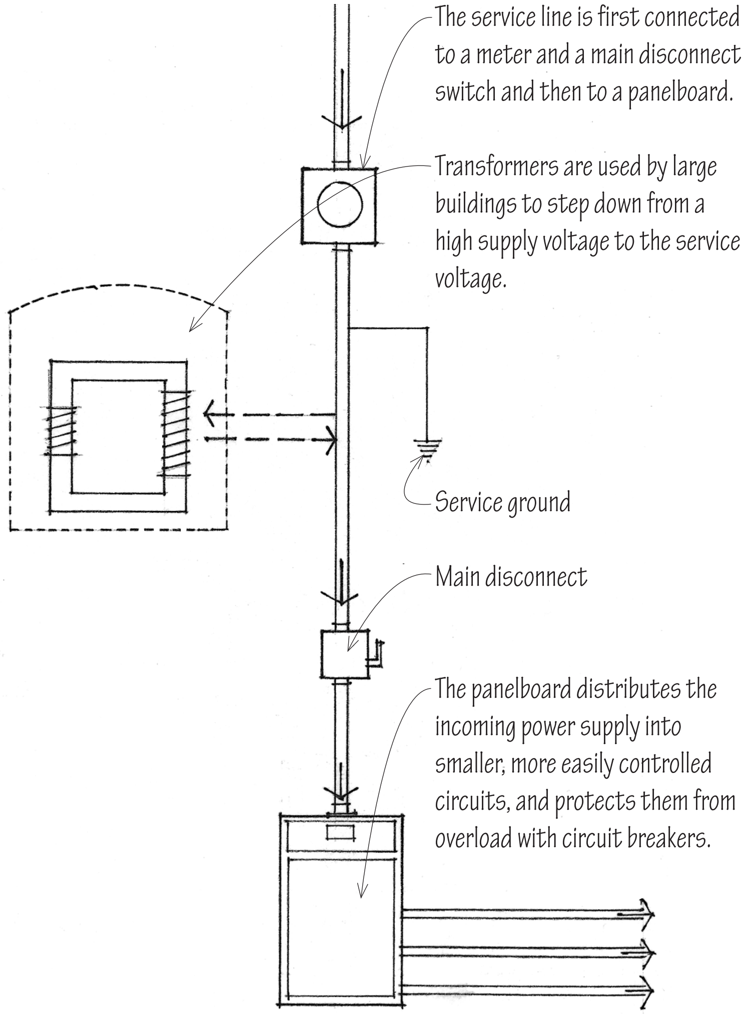
Power in watts = Current in amperes × Pressure in volts

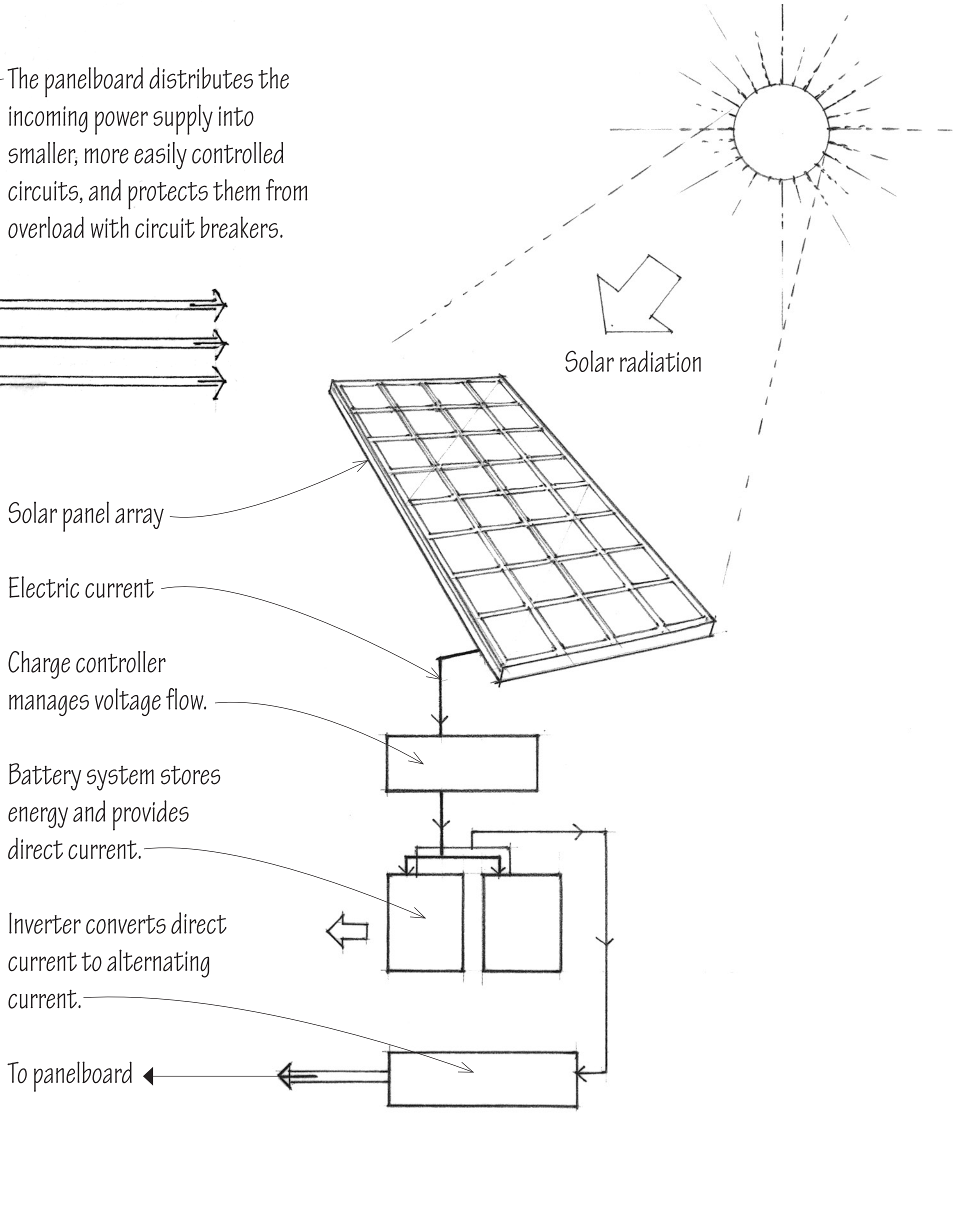



**Electric Circuit**

The electrical power system of a building supplies power for lighting, heating, and the operation of electrical equipment and appliances. This system should be installed to operate safely, reliably, and efficiently. A second system of wiring provides connections for data, communications, and control equipment and for security systems.

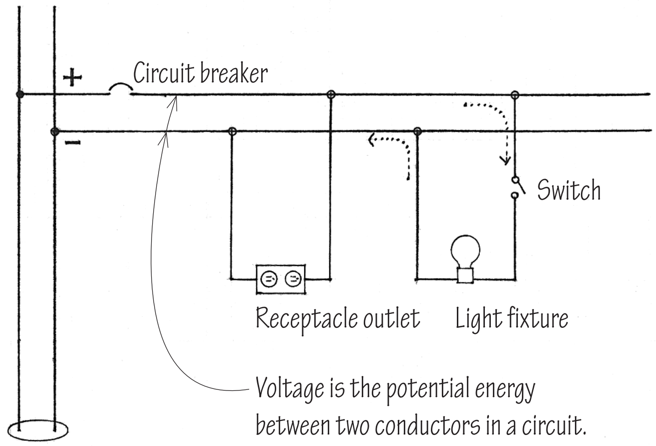
Power is usually supplied to a building by the electric utility company. Most electric power is used in the form of *alternating current (AC)*; large pieces of machinery use *direct current (DC)*. *Photovoltaic (PV)* technology converts sunlight directly into electricity. Site-generated PV uses direct current, which is then converted to AC and usually tied into the central electrical energy grid.

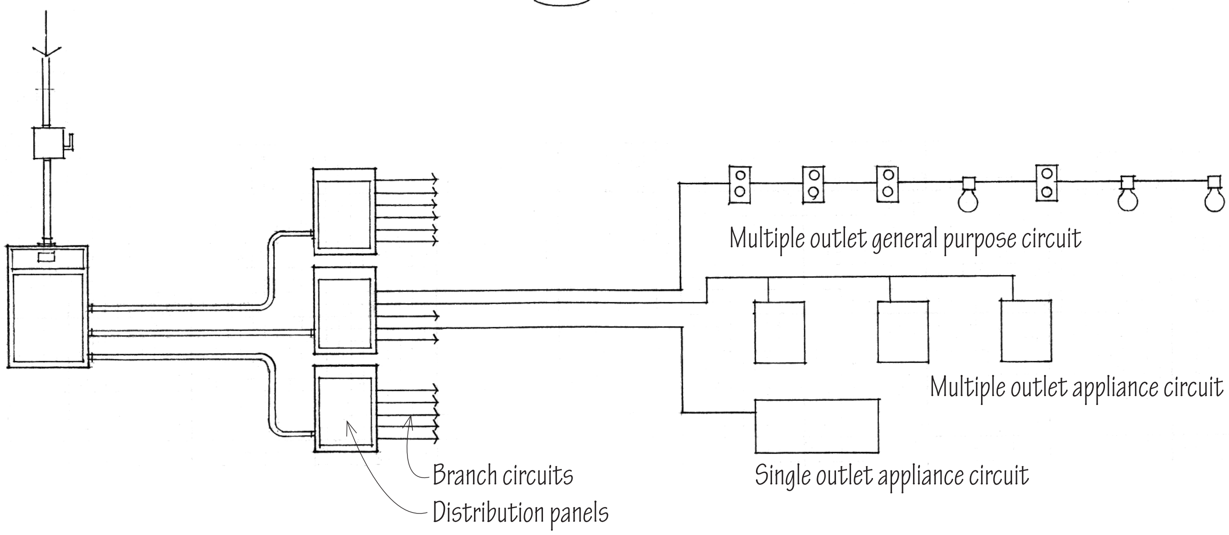


For electric current to flow, a circuit must be complete. Switches control current flow by introducing breaks in a circuit until power is required.

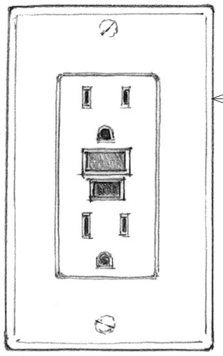
Branch circuits distribute electric power to the interior spaces of a building. The wiring in a circuit is sized according to the amount of current it must carry. A fuse or circuit breaker in the distribution panel disconnects a circuit when too much current is drawn for its wiring.




Low-voltage circuits carry alternating current below 50 V, supplied by a step-down transformer from the normal line voltage. These circuits are used in residential systems to control heating and cooling systems, window treatments, and remote lighting fixtures. Low-voltage wiring does not require a protective raceway such as conduit.

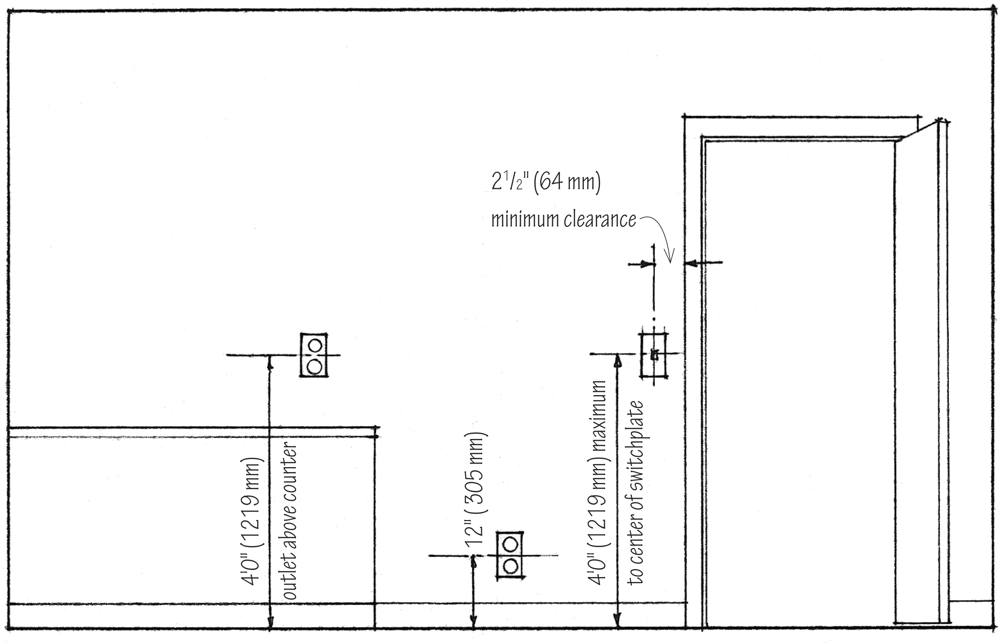
Today, wireless electrical power distribution is widely used for the ever-expanding variety of digital devices. Wireless communication transfers information between two or more points using electromagnetic energy, most commonly radio waves. Each switch and sensor has a small transmitter that sends a radio-frequency signal to the device it controls and to an area controller, all of which have radio receivers (detectors). Sensors can be powered by replaceable batteries, light falling on photocells, or thermal energy. Wireless switches can also be controlled by throwing or pushing a switch.



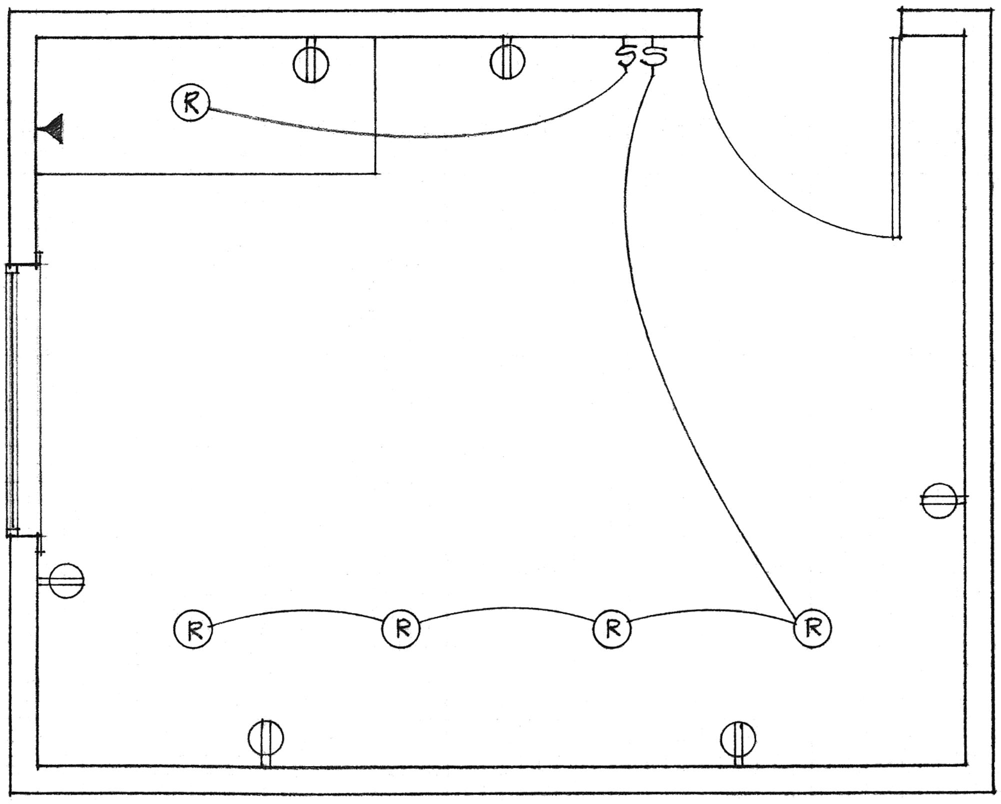
Electrical systems are designed by electrical engineers. The interior designer often provides information on the location of lighting fixtures, power outlets, and the switches that control their operation. The designer should be aware of the power requirements of an electrical installation so that they can be coordinated with the existing or planned circuits.

Load requirements for lighting fixtures and electrically powered equipment are specified by their manufacturer. The design load for a general-purpose circuit, however, depends on the number of receptacles served by the circuit and how they are used. The National Electrical Code (NEC) should be consulted for these requirements.

Ground fault circuit interrupters (GFCIs) are required along with circuit breakers in circuits where there is an increased hazard of accidental electrical shock, such as near a bathroom sink. If the GFCI senses any leakage of current from the circuit, it will disconnect the circuit instantly and completely.

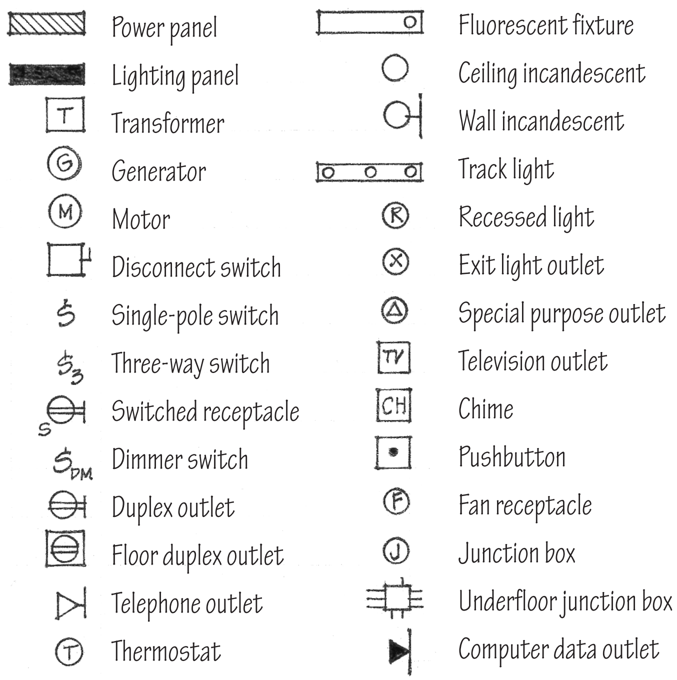


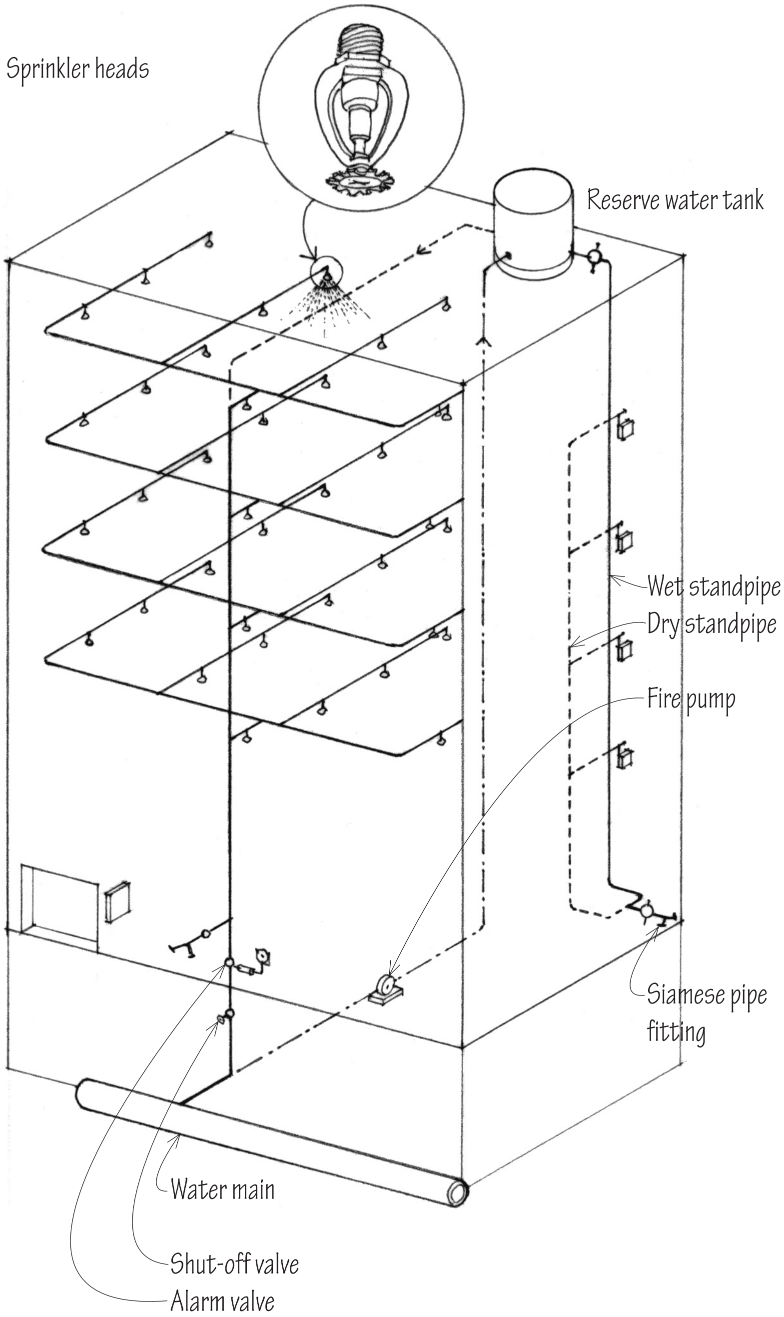

## Heights of Switches and Outlets



Typical Electrical and Lighting Plan

Common Electrical Symbols






Fire alarm and suppression systems connect electrical sensing and annunciation devices to a system that carries water to the location of a fire. Many parts of these systems are highly visible within the finished interior space and therefore must be integrated into the interior design, while remaining unblocked.

Automatic sprinkler systems are fed from very large pipes that branch out to supply water to grids of sprinkler heads. Sprinkler heads are nozzles for dispersing a stream or spray of water, usually controlled by a fusible link that melts at a predetermined temperature. When the system detects a fire, water sprays out of the closest sprinkler heads to drown the fire. Sprinkler heads are available in upright, pendant, and sidewall types, and can be recessed or capped in finished ceilings. Their locations are dictated by code, and they must not be painted once installed. The interior designer should coordinate ceiling design elements, including lighting fixtures, with the location of sprinkler heads.

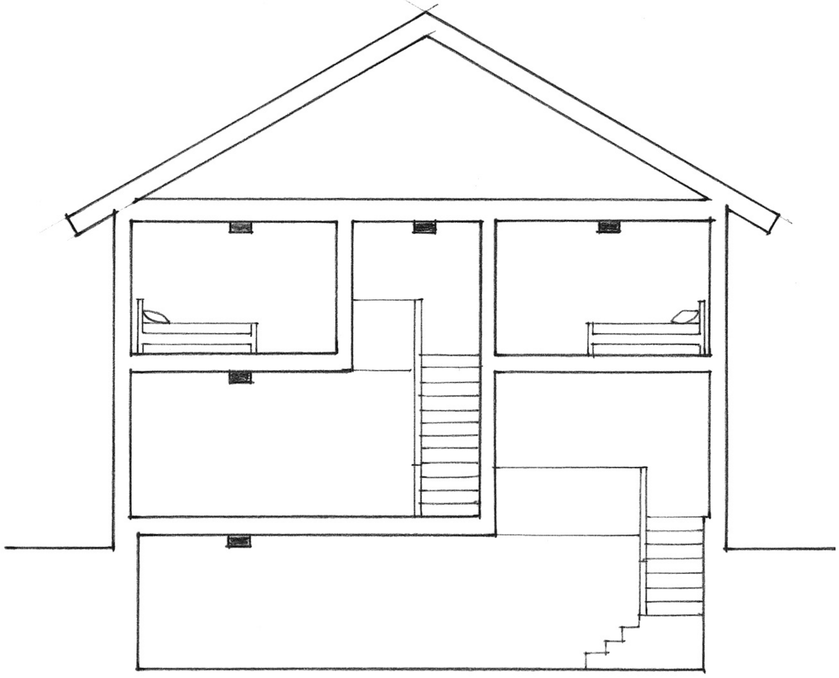
Many buildings have standpipes extending vertically through the building, to supply fire hoses at every floor. A fire pump maintains required water pressure in the standpipe system. A Siamese pipe fitting provides two or more connections through which the fire department can pump water to a standpipe or sprinkler system.

Fire and smoke detectors are categorized by their ability to detect incipient, smoldering, or flaming fires, or abrupt rises in heat. Residential smoke detectors are required by code outside and adjacent to each sleeping area, in each sleeping room, and at the head of every stair, with at least one detector on every level, including the basement.

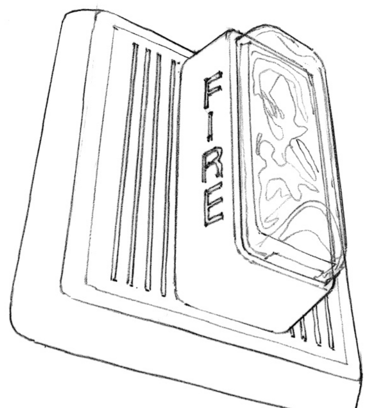
Fire alarms usually include both a flashing light and an audible alarm. Typically, these fire alarms are bright red and conspicuously mounted on walls or ceilings. They are intended to be seen easily by building occupants and may not be concealed or camouflaged.

Annunciator panels may be located at building entrances and other strategic sites to help firefighters identify the location of fires. They are sometimes quite large, bright red, and very conspicuous.

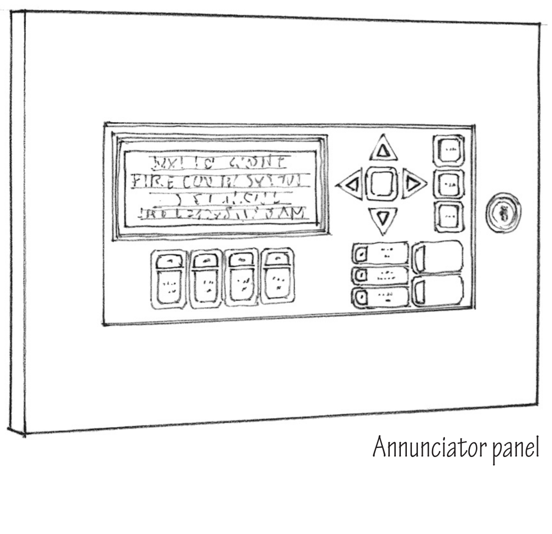
Many buildings are supplied with communications systems designed to alert occupants of conditions during an emergency and to allow firefighters to keep in touch while fighting a fire. Some buildings also have a central emergency desk with controls.



**Smoke Detector Locations**




Audible and visual fire alarm



Annunciator panel

This section outlines some considerations of a system that, while not immediately visible, affects the design of a building and its interior spaces. This system consists of a variety of laws and regulations enacted by federal, state, and local governments, in an effort to protect the public health, safety, and general welfare.

Zoning regulations control the size, location, and use of buildings. Building codes regulate how a building is constructed and occupied. Many of these regulations incorporate standards established by governmental or independent testing agencies.

While architects and engineers bear the primary responsibility for complying with code requirements, the interior designer should be aware of these regulatory devices and their effect on the design of interior spaces. It should also be remembered that codes often set minimum standards, and mere compliance will not ensure that a building will be efficient, comfortable, or well designed.

The applicable building code usually specifies minimum standards for the structural stability of a building and the quality and design of its materials and construction. When planning the interior of a new building or the remodeling of an existing one, the designer should consult an architect or engineer if any alterations to a building's structural elements are anticipated.

## Model Codes and Sponsoring Organizations

International Code Council, Inc. (ICC)
- International Building Code
- International Residential Code
- International Energy Conservation Code
- International Plumbing Code
- International Mechanical Code
- International Existing Building Code

National Fire Protection Association (NFPA)
- NFPA 1 Fire Code
- NFPA 70 National Electrical Code
- NFPA 101 Life Safety Code

## Organizations That Issue Standards

| | |
|---|---|
| ANSI | American National Standards Institute |
| ASTM | American Society for Testing and Materials |
| FHA | Federal Housing Administration |
| GSA | General Services Administration |
| HUD | Department of Housing and Urban Development |
| NFPA | National Fire Protection Association |
| NIST | National Institute of Standards and Technology |
| UL | Underwriters Laboratories Inc. |

## Fire Safety Codes

Fire safety is a prime area of concern of building codes. Requirements for the noncombustibility or fire resistance of a building's structural elements and exterior walls are specified according to the building's occupancy, floor area, height, and location. In addition, fire-resistant walls and doors may be required, to subdivide a building into separate areas and prevent a fire in one area from spreading to others.

Even when a building's structure would not support combustion, a fire can occur because of its finish materials and contents. This is of particular significance for interior designers when specifying wall, floor, and ceiling finishes and furnishings such as carpet, draperies, and upholstery. Regulations may prohibit the use of materials with a low flash point or set standards for the degree of flame spread and smoke emission allowed.

*Flame retardant chemicals* inhibit or resist the spread of fire. Their widespread use has shown that they appear to be less effective as fire safety elements than previously believed, and more dangerous to the environment and human health. *Polybrominated diphenyl ethers (PBDE)* have been used as flame retardants in building materials, furnishings, polyurethane foams, and textiles. PBDE and some other flame retardants have been associated with fertility problems in humans. They have been banned in the U.S. since 2004.

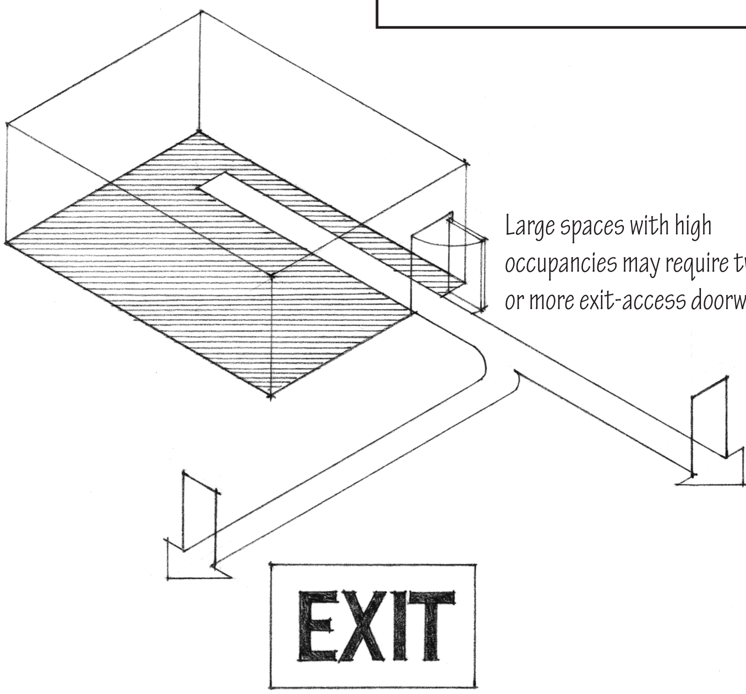
Sprinkler systems are increasingly being relied on to control fire. In addition, a fire/smoke detector and alarm system is usually required to warn of fire.

## Means of Egress

The means of egress requirements of fire codes provide for the safe and efficient evacuation of a building in case of fire or other emergency. These requirements are usually based on a building's size, construction, and type of occupancy. In principle, there should be at least two separate ways of exiting a building from any space, in case one route is cut off by fire or smoke. Exit passages, stairs, ramps, and doorways should be clearly marked, well lit, and wide enough to accommodate the appropriate number of occupants. Exit doors should swing outward in the direction of travel and, in places of public assembly, be equipped with fire exit hardware that will unlatch under pressure.

## Health and Safety Codes

In addition to structural and fire safety, general areas of health and safety are dealt with in building codes. These include the design of stairways in terms of allowable riser-to-tread ratios, minimum widths based on occupancy, the use of landings, and requirements for handrails. Restaurants, healthcare facilities, and other interior spaces may have additional health code requirements. For habitable spaces, natural light must be provided by exterior glazed openings, and natural ventilation by means of exterior openings. These requirements are usually based on a percentage of a room's floor area. For some types of occupancy, artificial light and a mechanically operated ventilating system can be substituted.




Large spaces with high occupancies may require two or more exit-access doorways.

## Accessibility

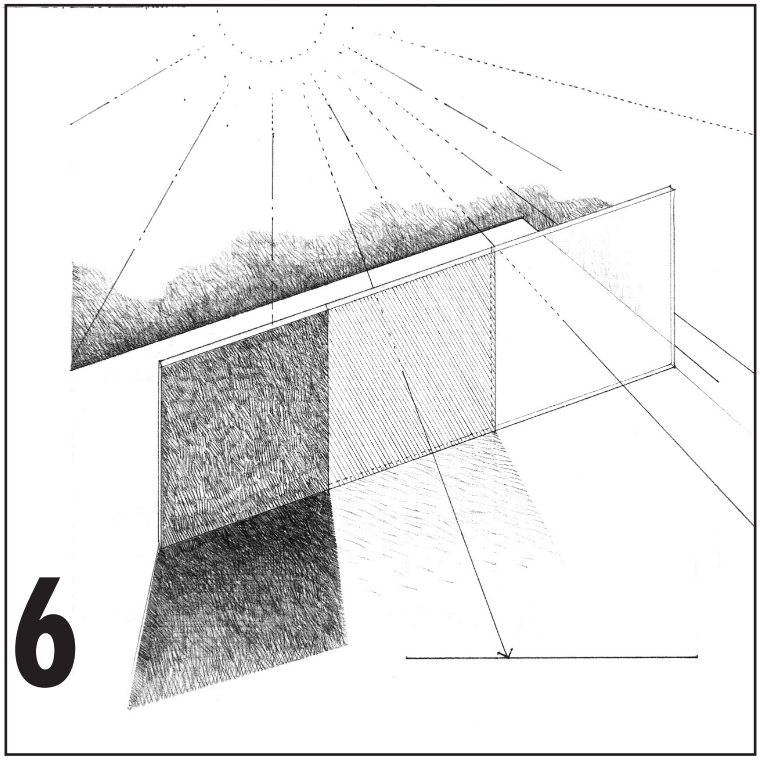
The Americans with Disabilities Act (ADA) of 1990 is federal legislation that requires buildings to be made accessible, as a civil right, to persons with physical and certain defined mental disabilities. Access is to be provided for people with all types of disabilities, not just for people with mobility impairments. These include people with hearing, vision, speech, and cognitive impairments, as well as persons of short stature and those with limited mobility not necessarily requiring the use of a wheelchair. The ADA also requires that barriers to access be removed from existing buildings where such work is readily achievable.

Specific concerns affecting interiors include accessible routes, plumbing fixtures and facilities, communication elements, and built-in elements. Wheelchair spaces and sight lines for assembly spaces, and clearances for kitchens, medical facilities, and guest rooms are among the considerations for special spaces that are covered by the act.

Designers should first concentrate on complying with codes and standards adopted locally, and also keep national statutory requirements such as the ADA in mind. It is prudent to review design work against the *2010 ADA Standards for Accessible Design* at the same time as the model code review.

## Energy Conservation Codes

The International Energy Conservation Code (IECC) contains requirements for energy-efficient design. Many states and local jurisdictions have adopted their own energy conservation codes that may have quite different standards than this model code. Energy conservation codes limit a building's total energy use, including lighting and electrical power and mechanical systems, and require documentation of the design and calculation of the energy loads to ensure compliance. Limits for lighting use are integrated into the total building energy design and can strongly affect the interior designer's work.



# 6

# Lighting and Acoustics

Light is radiant energy. It radiates equally in all directions and spreads over a larger area as it emanates from its source. As it spreads, it also diminishes in intensity according to the square of its distance from the source.

As it moves, light reveals to our eyes the surfaces and forms of objects in space. An object in its path will reflect or absorb the light striking its surface, or allow it to pass through.

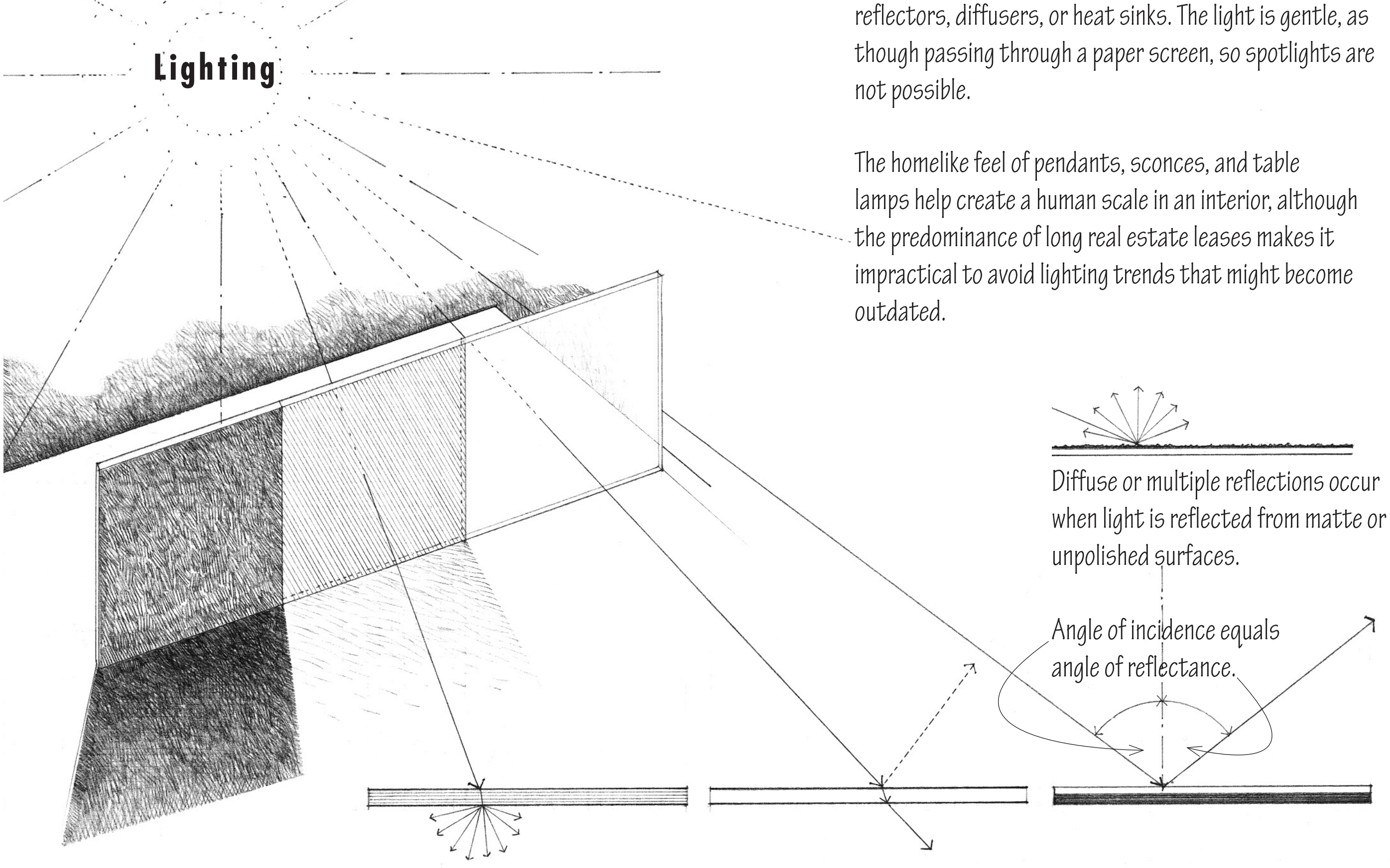
In the past, lighting design focused on technical subjects such as watts per square foot, kilowatt-hours, and footcandles. Sustainable design has brought that world into close contact with lighting concerns such as beauty, appearance, and health and well-being. The gap between the two approaches is closing. The result is sustainable designs that are about energy savings but also include human factors, comfort, and productivity.

Light-emitting diodes (LEDs) are becoming the dominant type of lighting source, due to their energy efficiency and long life. Initially, LEDs tried to imitate other lighting sources, but they are now evolving their own styles. Today's designs include preset and wireless controls and provide personal and programmable lighting.

LED lights have been investigated for health implications of blue light. The Department of Energy (DOE) has found no risk of blue-light hazard in LEDs or any other source used in general lighting applications. However, LED brightness and its blue content may pose harm to infants or people with eye disorders who might not avert their eyes from the light source frequently enough.

Organic light-emitting diode (OLED) luminaires are becoming available in the U.S., with a thin surface that directly emits light. OLED fixtures do not require reflectors, diffusers, or heat sinks. The light is gentle, as though passing through a paper screen, so spotlights are not possible.

The homelike feel of pendants, sconces, and table lamps help create a human scale in an interior, although the predominance of long real estate leases makes it impractical to avoid lighting trends that might become outdated.




Diffuse or multiple reflections occur when light is reflected from matte or unpolished surfaces.

Angle of incidence equals angle of reflectance.

Opaque materials block the transmission of light and cast shadows.

Diffused transmission occurs through translucent materials, such as frosted glass. The light source is not clearly visible.

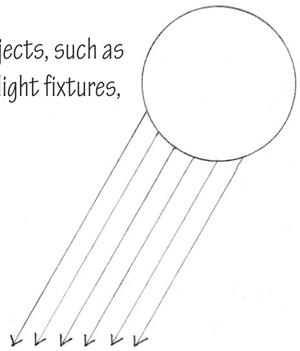
Nondiffuse transmission occurs through clear, transparent materials, such as glass and some plastics.

Specular reflection occurs when light is reflected from a shiny, opaque surface.

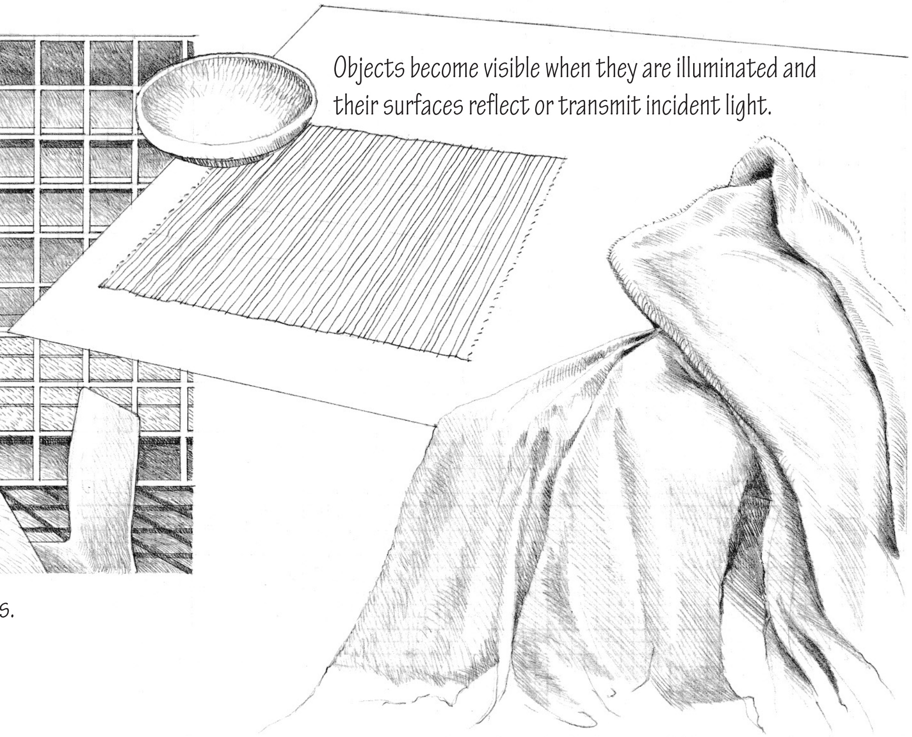
Light sources such as the sun, stars, and electric *lamps* are visible to us because of the light they generate. Most of what we see, however, is visible because of the light that is reflected from the surfaces of objects. Our ability to see well—that is, to discern shape, color, and texture, and to differentiate one object from another—is affected not only by the amount of light available for illumination but also by the following factors:

- Brightness
- Contrast
- Glare
- Diffusion
- Color

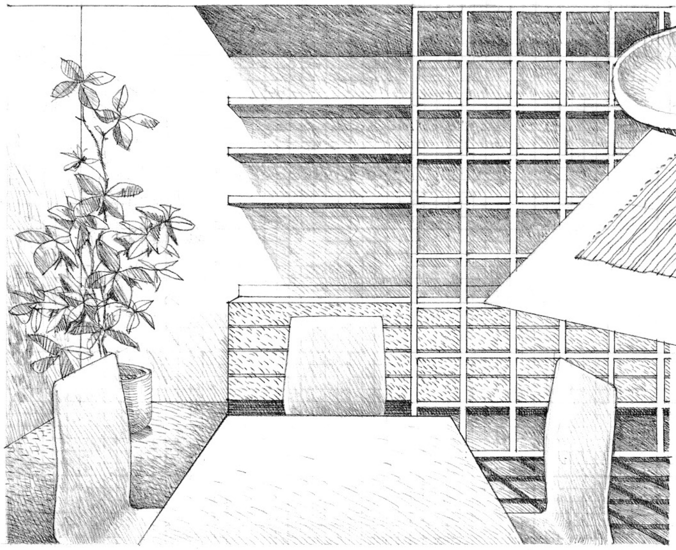
Luminous objects, such as translucent light fixtures, emit light.



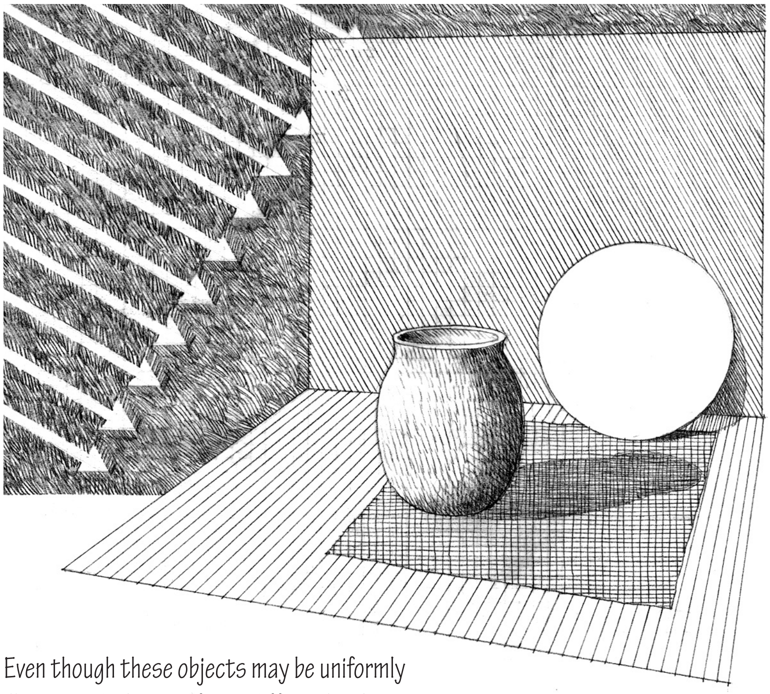
Incident light



Objects become visible when they are illuminated and their surfaces reflect or transmit incident light.



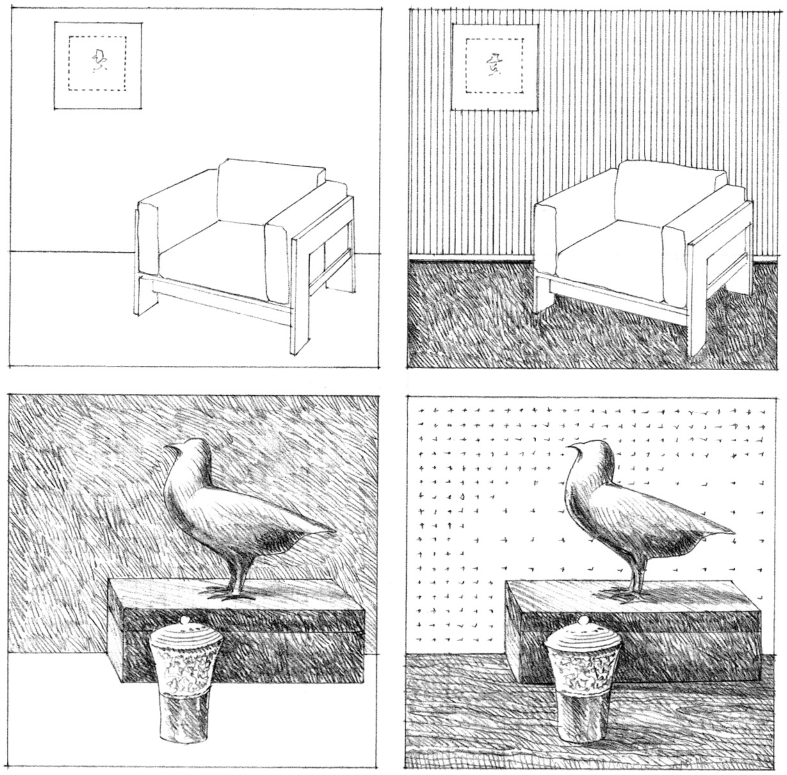
Light reveals the shape, color, and texture of objects.



*Brightness* refers to how much light energy is reflected by a surface. The degree of brightness of an object, in turn, depends on the color value and texture of its surface. A shiny, light-colored surface will reflect more light than a dark, matte, or rough-textured surface, even though both surfaces are lit with the same amount of illumination. Generally speaking, visual acuity increases with object brightness. Of equal importance is the relative brightness between the object being viewed and its surroundings. To make its shape, form, and texture discernible, some degree of contrast or brightness ratio is required. For example, a white object on an equally bright white background would be difficult to see, as would a dark object seen against a dark background.

Even though these objects may be uniformly illuminated, their surfaces differ in brightness according to their color value and texture and, consequently, their ability to reflect light.

Brightness = Illumination x Reflectance

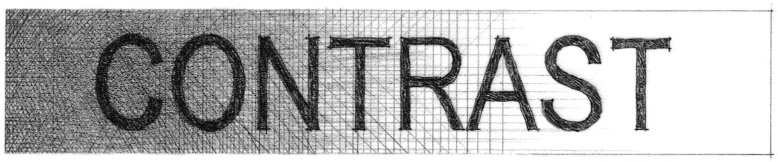


Contrast in brightness aids our perception of shape and form.

Contrast between an object and its background is especially critical for visual tasks that require the discrimination of shape and contour. An obvious example of this need for contrast is the printed page, where dark letters can best be read when printed on light paper.

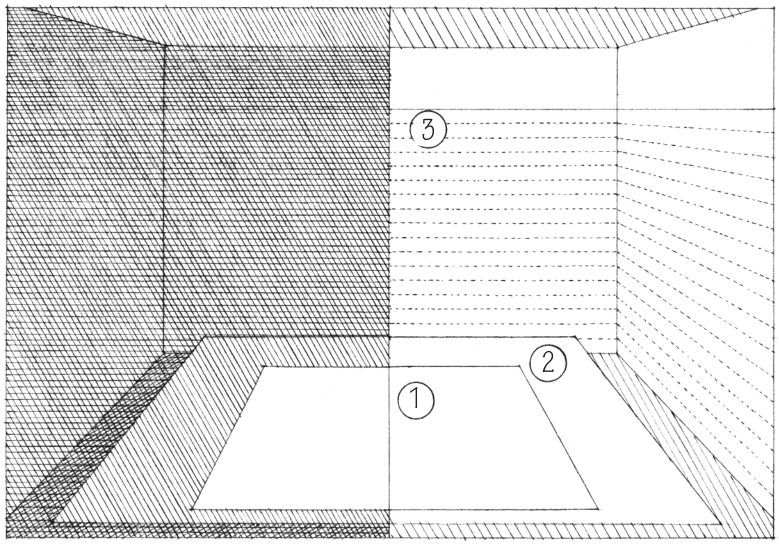
For seeing tasks that require the discrimination of surface texture and detail, less contrast between the surface and its background is desirable because our eyes adjust automatically to the average brightness of a scene. Someone seen against a brightly illuminated background would be silhouetted well, but it would be difficult to discern that person's facial features.

The surface brightness of a task area should be the same as its background, or be just a bit brighter. A maximum brightness ratio of 3:1 between the task surface and its background is generally recommended. Between the task area and the darkest part of the surrounding room, the brightness ratio should not exceed 5:1. Higher brightness ratios can lead to glare and associated problems of eye fatigue and loss in visual performance.




High background brightness is helpful in delineating shape and outline.

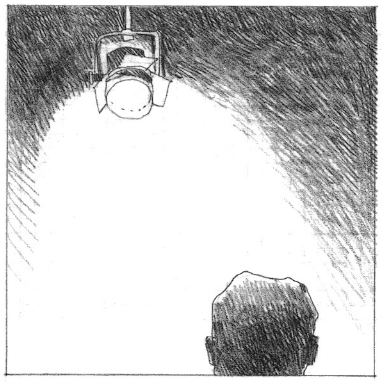
To aid in discriminating surface detail, surface brightness must be increased.




Surrounding area (3) should range from $^1/_5$ to 5 times the brightness of the task area (1).

The maximum recommended brightness ratio between the visual task area (1) and its immediate background (2) is 3:1.

Contrasting brightness levels can be desirable in certain situations.

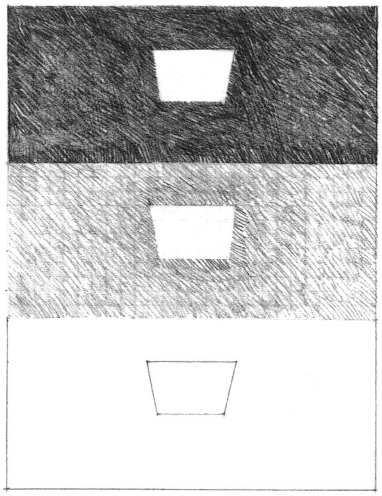


Direct glare is caused by the brightness of light sources within a person's normal field of vision.

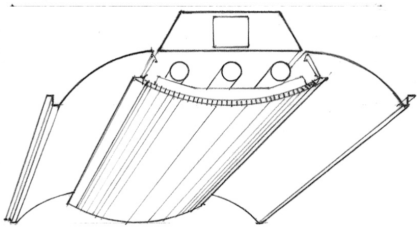
Although our eyes prefer even lighting, particularly between a task surface and its background, our eyes are able to adapt to a wide range of brightness levels. We can respond to a minimum brightness ratio of 2:1 as well as to a maximum of 100:1 or more, but only over a period of time; our eyes cannot respond immediately to extreme changes in lighting levels. Once our eyes have adjusted to a certain lighting level, any sudden significant increase in brightness can lead to glare, eyestrain, and impairment of visual performance.

There are two types of glare, direct and indirect. Direct glare is caused by the brightness of light sources within our normal field of vision. The brighter the light source, the greater is the glare potential. Possible solutions to problems of direct glare include the following:

- Locate the sources of brightness out of the direct line of vision.
- If this is not possible, use properly shielded or baffled lighting fixtures.
- In addition, raise the background brightness of the light sources and reduce the brightness ratio.



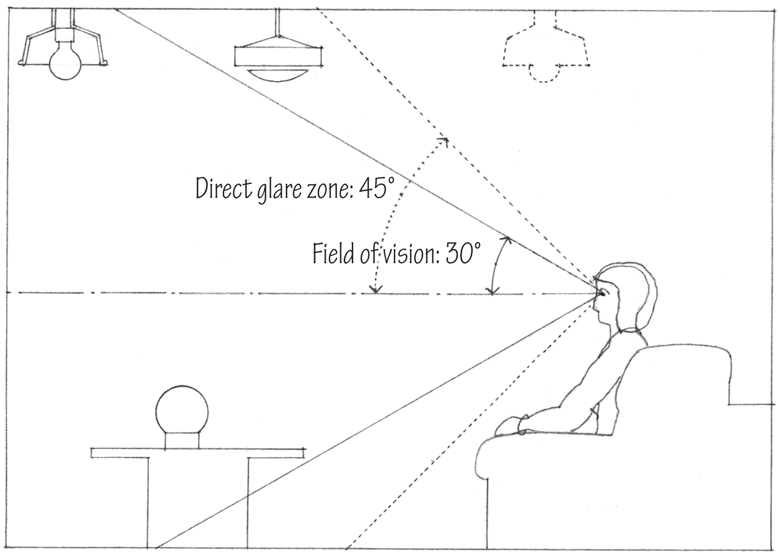
Reduce the brightness ratio between the light source and its background.



Use well-shielded or baffled light fixtures that minimize a direct view of bulbs or lamps.

Perhaps the greatest potential problem with LEDs is glare. Bare LEDs can exceed the maximum acceptable luminance of any light source. Glare problems with LEDs can be solved with combinations of shielding, refraction, diffusion, indirect lighting, and illumination of adjacent surfaces to reduce contrast. Many of the fixtures being designed and sold today deal with glare problems, which should be considered for all LED fixtures.

## Possible Solutions to Glare

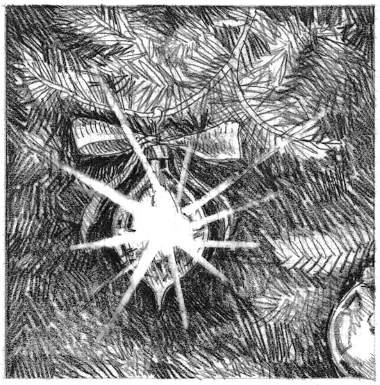



Locate light fixtures out of the direct-glare zone.

Indirect glare is caused by a task or viewing surface reflecting light from a light source into the viewer's eyes. The term *veiling reflection* is sometimes used to describe this type of glare because the reflection of the light source creates a veiling of the image on the task surface and a resultant loss of contrast necessary for seeing the image.

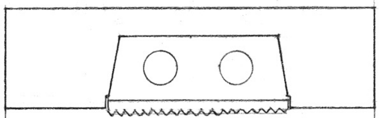
Indirect glare is most severe when the task or viewing surface is shiny and has a high specular reflectance value. Using a dull, matte task surface can help alleviate—but will not eliminate—veiling reflections.

Possible solutions to problems of reflected glare include the following:
- Locate the light source so that the incident light rays will be reflected away from the viewer.
- Use indirect lighting fixtures, or ones with diffusers or lenses that lower their brightness levels.
- Lower the level of general overhead lighting and supplement it with localized task light closer to the work surface.

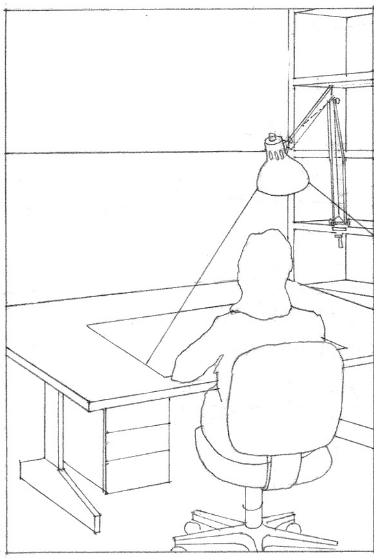


Glitter and sparkle are desirable types of glare.

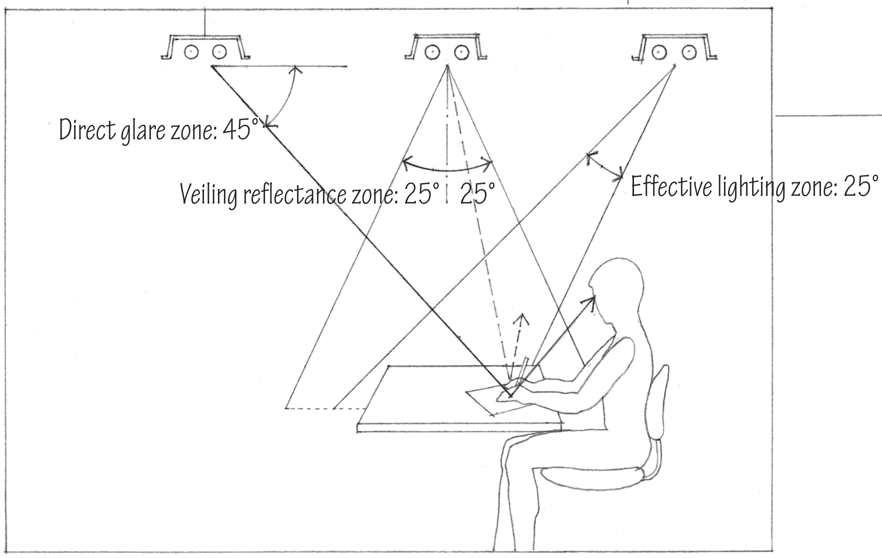

Reflected glare affects our ability to perform critical seeing tasks, such as reading or drawing.



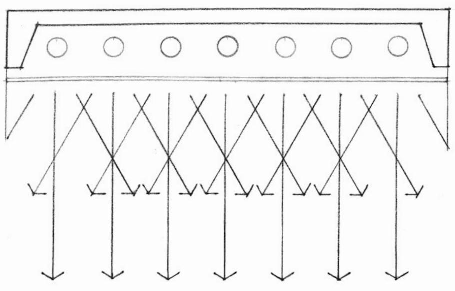
To minimize veiling reflections when the task locations are unknown, use low-brightness lighting fixtures or rely on a low level of ambient lighting.



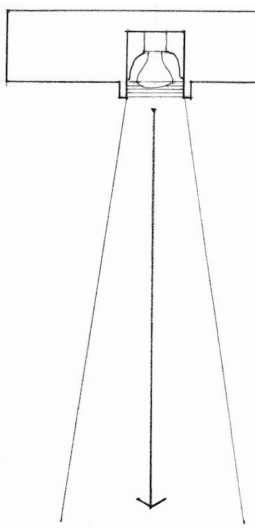
Low-level ambient lighting supplemented by individual task lighting, which is adjustable by the user, is a good general-purpose solution.




Bright, concentrated light sources above and forward of the task surface can cause veiling reflections.



Broad sources of light produce diffused illumination.

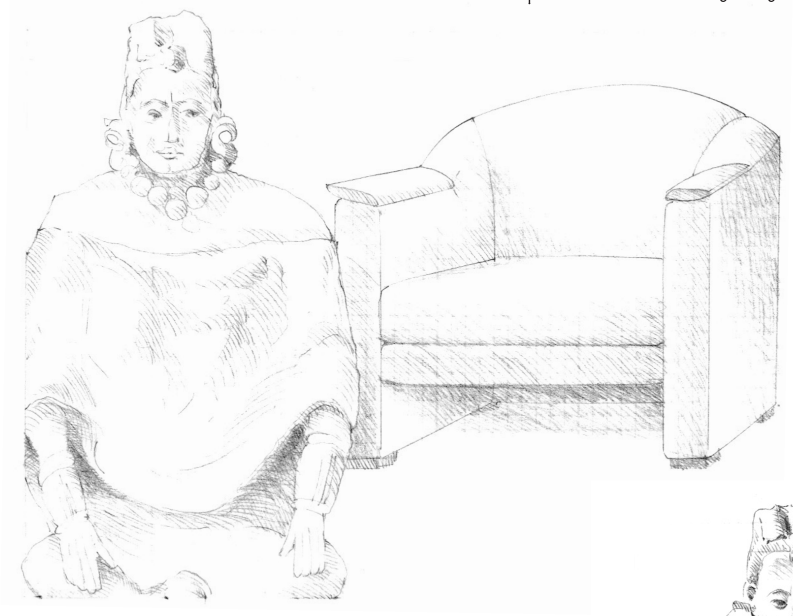


Concentrated light sources produce directional lighting.

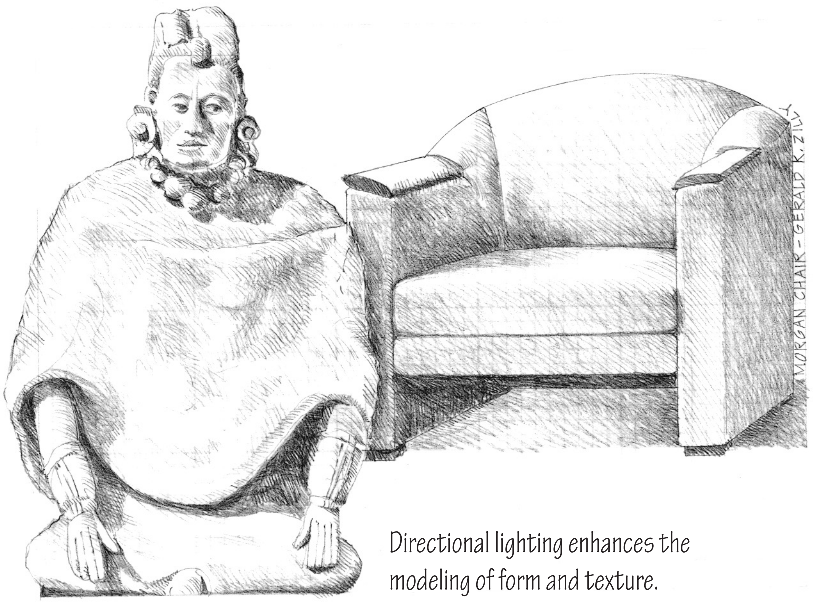
Diffuseness is a measure of a light's direction and dispersion as it emanates from its source. This quality of light affects both the visual atmosphere of a room and the appearance of objects within it. A broad source of light, such as direct/indirect fluorescent fixtures suspended below the ceiling, produces diffused illumination that is flat, fairly uniform, and generally glare-free. The soft light provided minimizes contrast and shadows; however, it can make the reading of surface textures difficult.

On the other hand, a concentrated source of light, such as a spotlight, produces a directional light with little diffusion. Directional lighting enhances our perception of shape, form, and surface texture by producing shadows and brightness variations on the objects it illuminates.

Although diffused lighting is useful for general vision, it can be monotonous. Some directional lighting can help relieve this dullness by providing visual accents, introducing brightness variations, and brightening task surfaces. A mix of both diffused and directional lighting is often desirable and beneficial, especially when a variety of tasks are to be performed in a room.



Diffused illumination minimizes contrast and shadows.




Directional lighting enhances the modeling of form and texture.

Another important quality of light is its color and the way it affects the coloration of objects and surfaces in a room. We assume most light to be white, but the spectral distribution of light varies according to the nature of its source. Noon daylight is considered to be the most evenly balanced white light; in the early morning hours, daylight can range from purple to red. As the day progresses, it will cycle through a range of oranges and yellows to blue-white at noon, and then back again through the oranges and reds of sunset.

The spectral distribution of electric light sources varies with the type of *lamp*. For example, an incandescent lamp produces a yellow-white light, while a cool-white fluorescent produces a blue-white light.

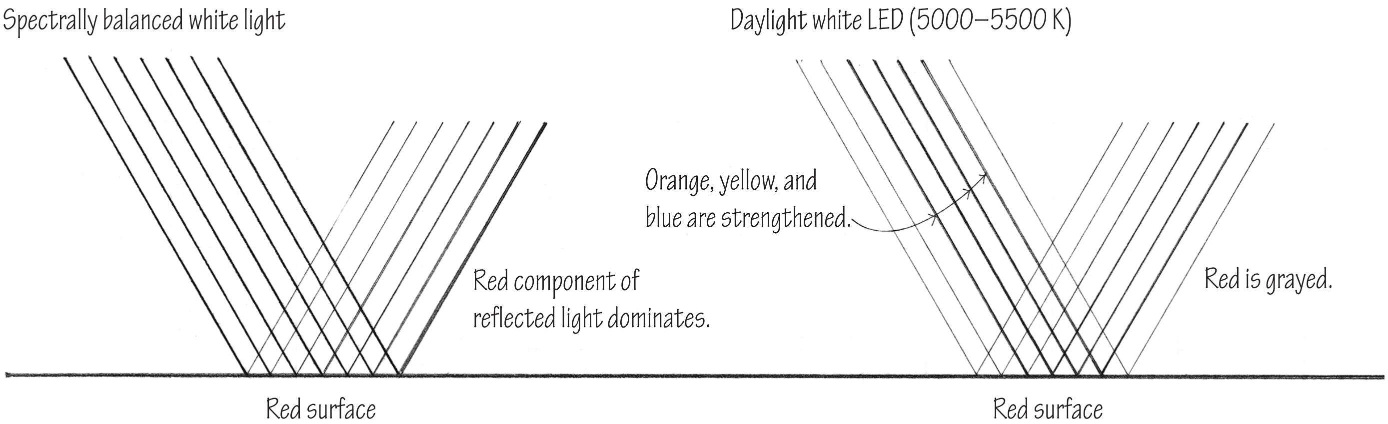
The apparent color of a surface is a result of its reflection of its predominant hue and its absorption of the other colors of the light illuminating it. The spectral distribution of a light source is important; if certain wavelengths of color are missing, then those colors cannot be reflected and will appear to be missing or grayed in any surface illuminated by that light.

The appearance of a specific light source when lighted is called its color temperature, which is measured in kelvins (K). For example, an incandescent lamp produces light with a color temperature of 2700 K to 3000 K; the light from a cool-white fluorescent lamp has a color temperature of about 4250 K. Generally speaking, the lower the color temperature of a light source, the warmer it will appear.

Earlier LED products had difficulty delivering uniform white light with consistent color rendition. Today, institutions including the Illuminating Engineering Society (IES) have proposed new color rendering metrics more attuned to the unique characteristics of LEDs.

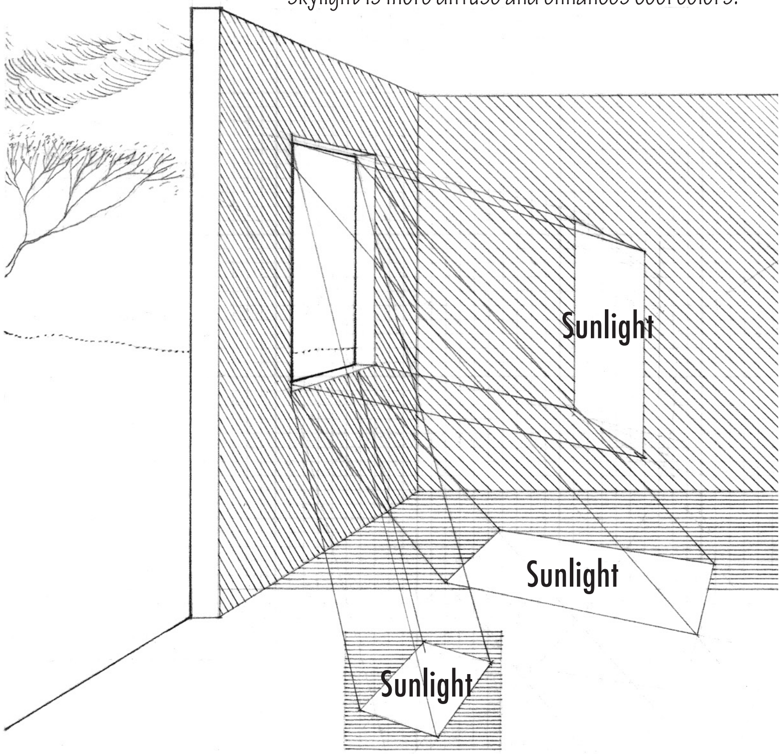
### Color Temperature Scale

| Kelvin | Light Source |
|---|---|
| 10000 | Clear blue sky (up to 25,000 K) |
| 9000 | |
| 8000 | North light |
| 7000 | Daylight fluorescent |
| | Cool-white LED |
| 6000 | Overcast sky |
| | Blue tint |
| 5000 | Noon sunlight |
| | Daylight white LED |
| 4000 | Daylight incandescent |
| | Natural white LED |
| 3000 | Warm-white fluorescent |
| | Warm-white LED |
| 2000 | Incandescent lamp |
| | Sunrise |



The source of all natural daylight is the sun. Its intense light varies with the time of day, from season to season, and from place to place. It can also be diffused by cloud cover, haze, precipitation, or any pollution that may be present in the air.

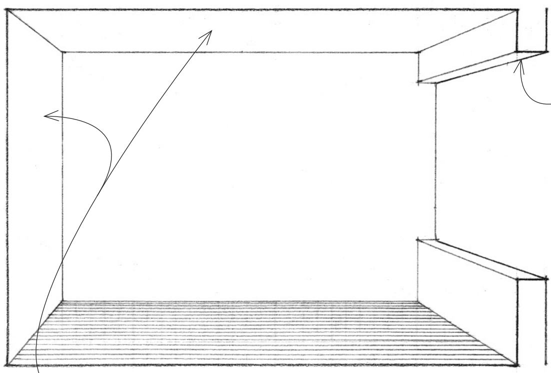
In addition to direct sunlight, two other conditions must be considered when designing the daylighting of a space: reflected light from a clear sky and light from an overcast sky. While direct sunlight emphasizes hot, bright colors, skylight is more diffuse and enhances cool colors.




Until 2013, when the IES adopted and published the testing and calculation guide *Lighting Measurement 83 (LM-83), Approved Method: IES Spatial Daylight Autonomy (sDA) and Annual Sunlight Exposure (ASE)*, equitable comparisons of daylight performance were not possible. LM-83 was the first IES-adopted evidence-based annual daylighting performance metric in the lighting industry. Now incorporated in lighting analysis and design software packages, sDA and ASE (also known as climate-based daylight metrics or dynamic-daylight metrics) increase the rigor and complexity of daylighting design consultation and building performance assessment.

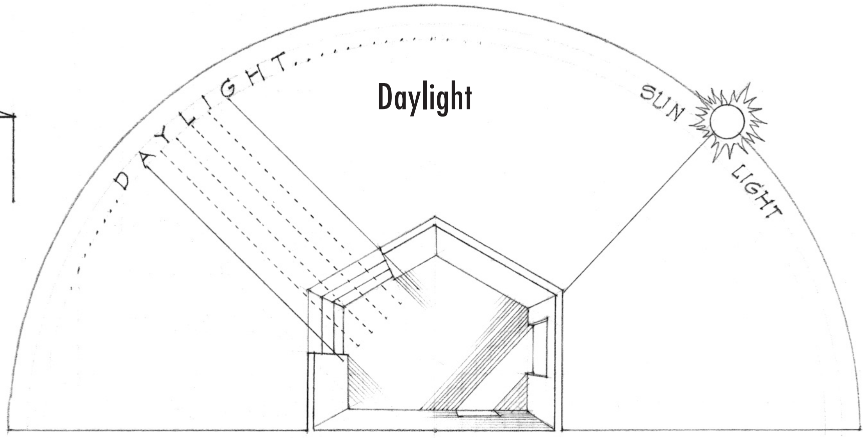
Circadian rhythms are a biological system that involves melatonin (the hormone that triggers sleep cycles). The main regulator for the circadian rhythm is light, although nighttime activity and other factors can also affect it. As the sun sets and darkness increases, melatonin increases and starts to calm our body down to prepare for sleep as part of a natural rhythm.

Today people may spend both day and night indoors, and a person can spend an entire day without direct contact with sunlight. We may not use our circadian rhythms to tell us when to sleep and when to be awake. Providing access to daylight in most offices may, for example, involve moving perimeter offices into the building's core.



The larger and higher a window, the more daylight will enter a room.

The ceiling and rear wall of a room are generally more effective than the side walls or the floor in reflecting and distributing daylight.



The blue light in LEDs is more effective at suppressing melatonin. With color-tunable LEDs, bright daylight can be shifted to warmer, yellower lighting later in the day, helping to prepare people to sleep when they get home. Concentrated LED lighting, when used inappropriately, can be harmful to certain populations. Research into the amount and type of lighting that is desirable continues. Introducing sunlight into a building can decrease dependence on artificial lighting, which in turn reduces lighting energy use. Sunlight will also bring solar heat into the building, which may result in energy savings in cold weather but can increase air-conditioning costs in warmer months.

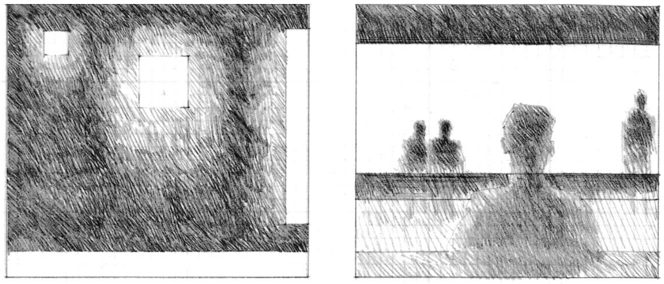
For the many regions of the world with little or no access to an electrical grid, a solar-powered charging device can provide over 150 hours of LED illumination from 7.5 hours in bright sunlight.

## Glare

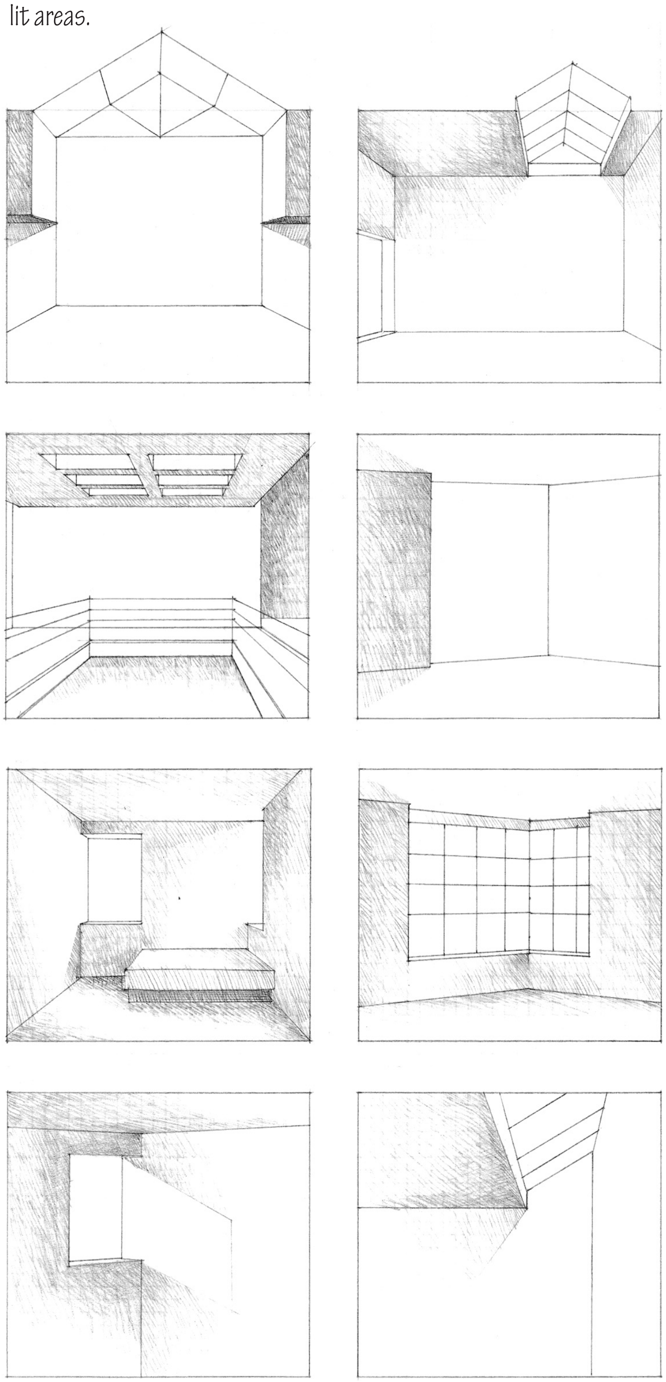
A problem associated with daylighting is glare caused by excessive contrast between the brightness of a window opening and the darker wall surfaces or cast shadows adjacent to it. The placement of windows is as important as their size when dealing with glare. The optimum condition is balanced lighting from at least two directions—from two walls or a wall and the ceiling. Skylights, in particular, can help soften the harshness of direct sunlight.

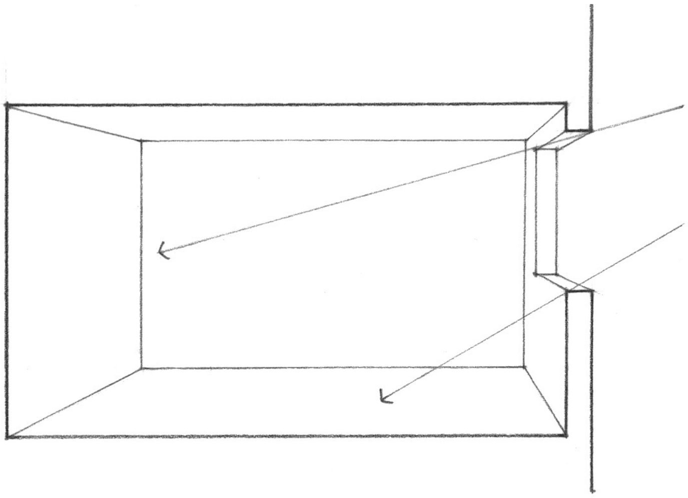
In rooms with windows close to the floor, glare can be caused by the light reflected off the exterior ground surface. This ground glare can be reduced through the use of shade trees or a screen of horizontal louvers. Interior window treatments can also be used to diffuse or block glare.

Bidirectional lighting—lighting from two directions—raises the level of diffused light in a space and reduces the possibility of glare.

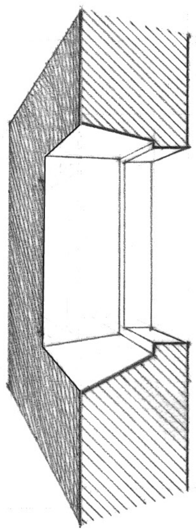


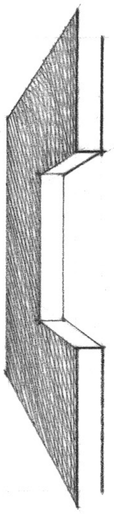
Glare results when our eyes cannot adjust simultaneously to widely contrasting areas of brightness. Our eyes adjust to the brightest light in our field of vision, reducing our ability to discern less brightly lit areas.



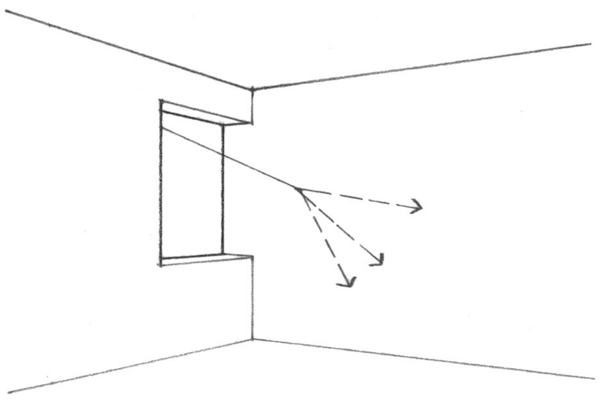


High window openings allow daylight to penetrate more deeply into an interior space and help to reduce glare.



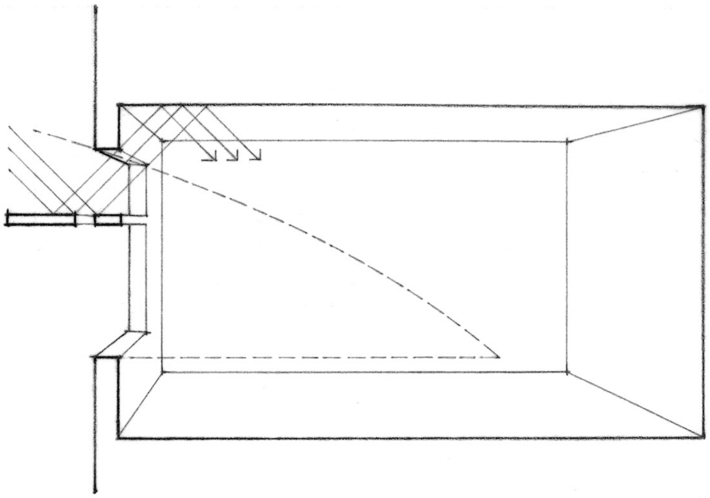


Windows set flush in a wall or ceiling accentuate contrasts between the bright exterior and the darker interior surfaces. Deep-set windows, splayed jambs, and rounded jambs can soften this contrast.

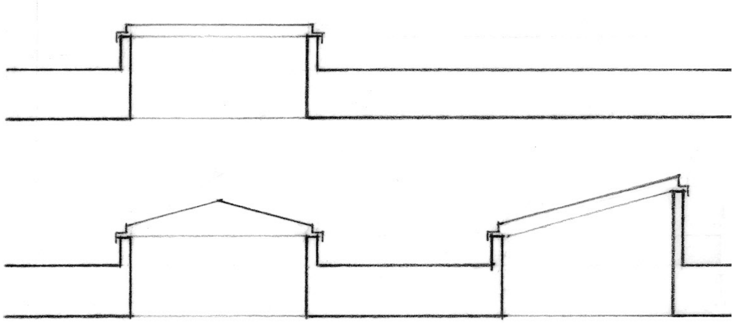


Locating a window adjacent to a perpendicular wall or ceiling surface maximizes the light entering the window. The perpendicular surface is illuminated by the entering light and becomes itself a broad source of reflected light. The use of wall and ceiling finishes with high levels of reflectance, such as white paint, helps to bounce reflected light deeper into an interior space, reducing the amount of electric lighting needed and saving energy.

A light shelf is an exterior horizontal construction located below the head of a window opening and typically just above eye level. The light shelf shades the lower portion of the window from direct sunlight and reflects daylight onto the ceiling of the room, diffusing light deeper into the space.



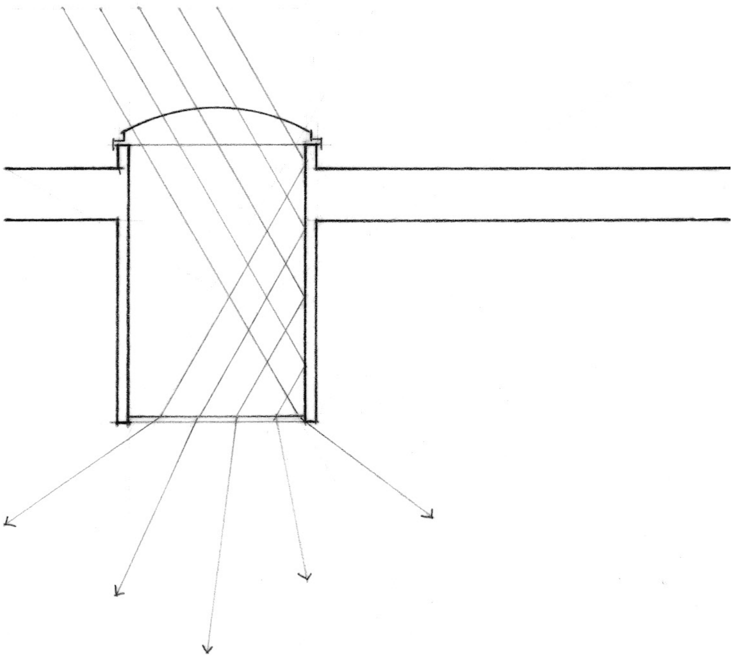
Skylights are glazed with clear, patterned, or translucent glass, or with clear, gray-tinted, or milk-white acrylics. Skylights can be fitted with remote-control window treatments that diffuse light and reduce the transmission of solar heat.



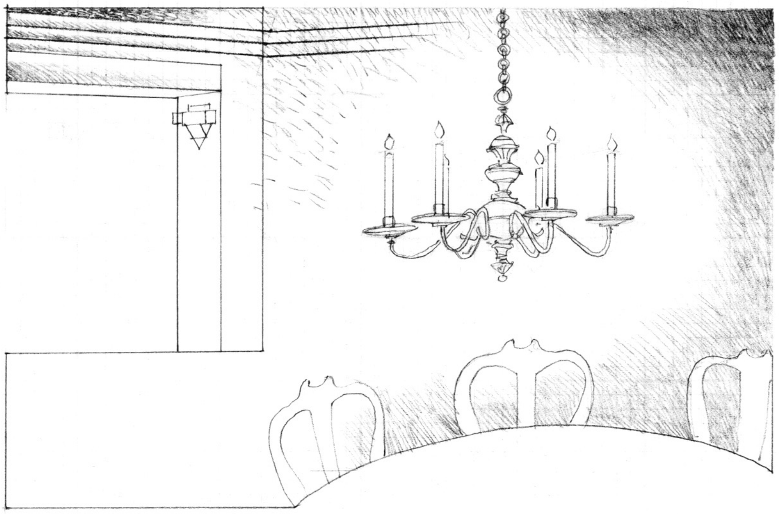
Flat skylights may be prone to leaks and dirt accumulation.

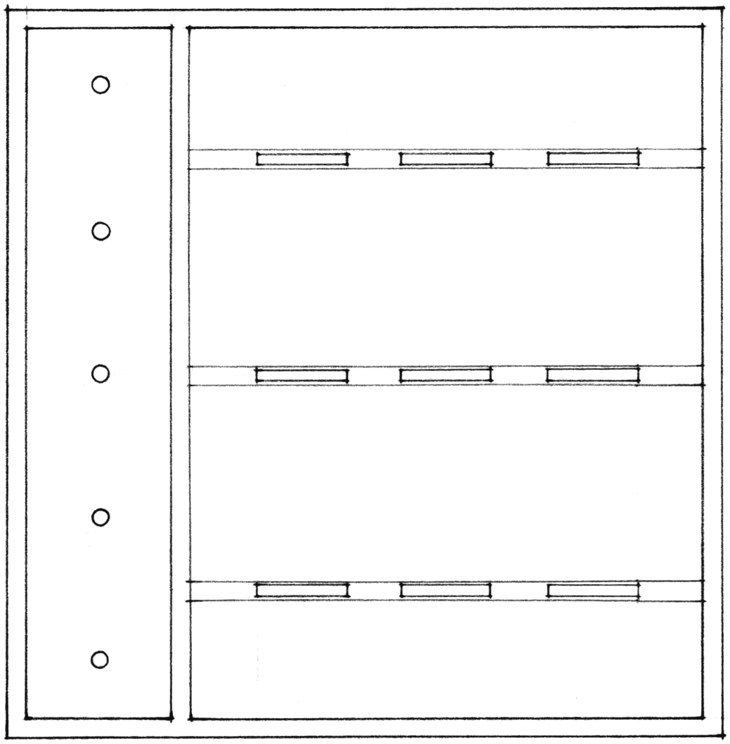
Domed or slanted skylights stay cleaner and tend to leak less.

Tubular skylights (light tubes) collect sunlight through a small, clear acrylic dome on the roof, transmit it though a cylindrical shaft, and disperse it through a translucent diffuser lens into interior spaces.



Light is the prime animator of interior space. Without light, there would be no visible form, color, or texture, nor





### Lighting Patterns

Poorly placed or irregularly scattered lighting fixtures contribute to distracting visual clutter. Carefully organized lighting patterns emphasize architectural features, provide cues to the use and orientation of the space, and support the designer's intent. Lighting layout drawings coordinate lighting fixture locations with sprinkler heads, air diffusers, return grilles, smoke detectors, loudspeakers, and other ceiling elements.

any visible enclosure of interior space. The first function of lighting design, therefore, is to illuminate the forms and space of an interior environment, to enable users to undertake activities and perform tasks with appropriate speed, accuracy, and comfort. Interior lighting can effectively guide the viewer through a space or series of spaces and direct the viewer's gaze to points of interest. Lighting also provides security through the illumination of spaces and any potential hazards.

Lighting design has entered a new era, with solid-state lighting fitting into a broad context of systems that have the ability to gather and transmit all types of data at an unprecedented scale. Innovation is no longer primarily about seeing new products with their new shapes and styles. Lighting has become less about the fixture and more about software and controls. New technologies such as LED lighting can require significant technological study on the designer's part and thus result in the loss of time available to focus on lighting design.

Lighting designers have responded to the emergence of LED lighting with self-education about solid state lighting products and project-time learning. They advocate field-measurable metrics such as candlepower, correlated color temperature, CRI and other values, flicker, and beam spread as criteria for testing and gauging product performance.

LEED did not originally include lighting design in its requirements. Lighting designers had advocated for sensible energy codes, and, as LEED gained influence, many lighting designers adopted LEED design principles and aided in the refinement of lighting-related credits in early versions of LEED. LEED's popularity has raised the awareness of lighting as a major component of energy-efficient and environmentally responsible design.

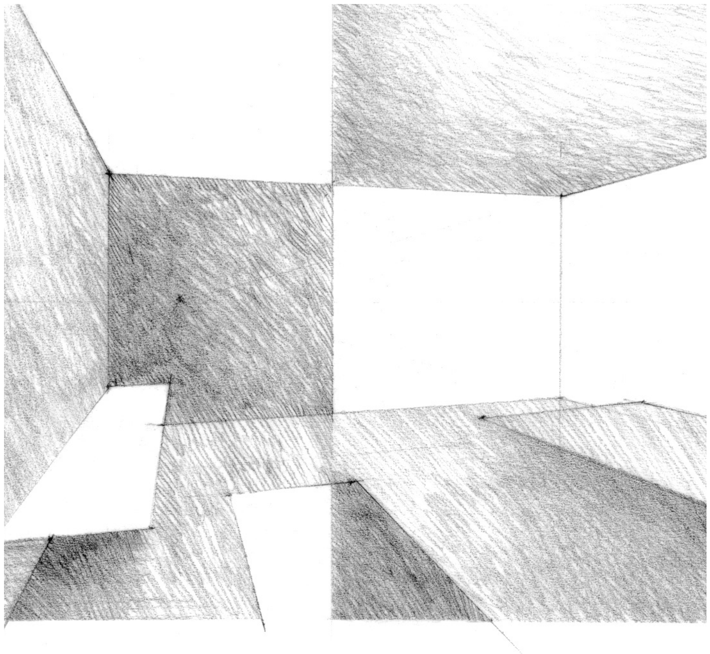
Interior lighting enables us to see forms, navigate space, and perform tasks. Lighting design is a process of integrating light with the physical structure of the building, the designer's concept for the interior space, and the functional uses of the space. It begins with thinking about light, not product. Lighting design education should promote a wider literacy about light across all disciplines so that designers can focus on the lighting design practices that are relevant today.

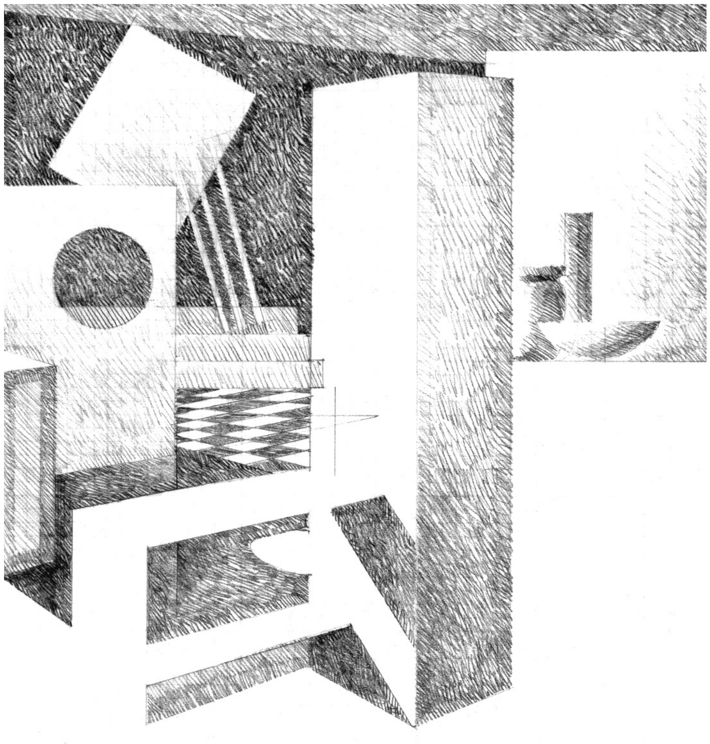
## Brightness Balance

Vertical surfaces are the most visually conspicuous features in a space. Lighting should preserve the integrity of vertical planes, highlight special features or finishes, and avoid spatial distortions such as scallops on walls. Strategies include the following:

- Light opposite walls of a space.
- Wallwashers on one wall can be mixed with nonuniform lighting on the other.
- Balance perimeter illumination of a space with its center.
- Lighting horizontal surfaces within a space emphasizes detail, people, and movement, and de-emphasizes the architecture.
- Illuminate vertical and overhead surfaces to emphasize architectural form.

Recently, manufacturers have developed ways to integrate lights into architectural surfaces. These include illumination of floors with patterns or wayfinding signs, ceiling applications that provide surfaces of light, and prefabricated sheet-metal panels with built-in LEDs that enliven walls with a variety of visual effects. Both standard and custom designs are available; keeping records of a design is suggested so that panels can be easily replaced.





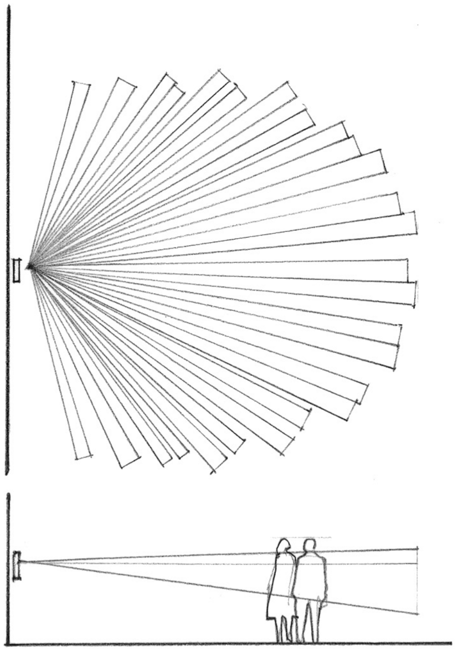
## Luminance Ratios

Luminance differences are specified as a ratio between one luminance and another.

- Vary luminances at some points in the space to increase visual interest and prevent eye fatigue.
- Computer screens tend to reflect bright areas, although this is less of a problem than in the past, thanks to brighter screens with better angle adjustments. Indirect lighting fixtures also help with this problem.

## Shadows

Patterns of light and shadow create visual interest by rendering the texture and three-dimensional form of objects.



Occupancy sensors detect activity within a certain area and turn lights on automatically when someone enters a room. They reduce lighting energy use by turning lights off soon after the last occupant has left the room.

## Energy Efficiency

The U.S. Energy Information Administration (EIA) estimates that in 2016 about 10 percent of total electricity consumed by both the residential and commercial sectors in the U.S. was used for lighting; this was about 7 percent of total U.S. electricity consumption. Building codes limit the number of watts available for lighting. Energy conservation criteria are increasingly driving the selection of light sources, the quantity and type of lighting fixtures, and the specification of lighting controls. Consequently, designers must be aware of energy use as they design lighting.

- Use available watts to supply light where and when needed; limit unwanted light.
- Integrate and control daylight in the space.
- Choose light sources carefully, and locate them with discretion.
- Control lighting with dimmers, timers, and occupancy sensors.

Upgrading from conventional controls (on-off, occupancy, and dimming) to video and sensor technologies that make a building truly smart is a logical move from putting in single-purpose systems that will very soon become obsolete. Wireless controls and sensors have been designed in fixtures themselves, avoiding the need for separate installation. Integrating software streamlines the equipment required for building systems while reducing the physical space needed for installation.

*Illuminance* is the measure of incident light (i.e., the light falling) on a surface. Illuminance does not determine how bright a surface will appear; a dark surface will not reflect as much of the light that falls on it as a light one. The conditions of a specific task, as well as the visual acuity of the viewer, determine the required level of illuminance.

- Orientation and simple visual tasks: Illuminance levels are relatively unimportant.
- Common visual tasks: Visual performance is important, but illuminance levels vary with the task.
- Special visual tasks: Higher levels of illuminance are required for tasks that are very small, or that have very low contrast for critical elements.

The electric light sources used in lighting fixtures are called lamps. The quantity and quality of light produced differ according to the specific type of lamp used. The light is further modified by the housing that holds and energizes the lamp and any reflector, lens, or baffle used to control how the light is distributed, diffused, or shielded.

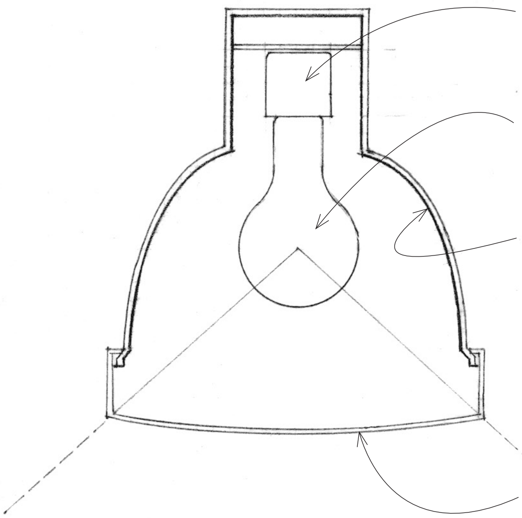
The *color rendering index (CRI)* rating is a measure of a lamp's ability to render color accurately when compared with a reference light source of similar color temperature. Manufacturers are working to improve the CRI of all light sources, so that good color rendering can be achieved while maintaining efficiency. However, the best way to check an LED light source's blue emission, light output, and other color rendering abilities is with a spectometer, rather than relying on CRI or CCT ratings.

The IES TM-30 color fidelity metric (Rf) is a substantial improvement over CRI, due to its use of 99 color samples, a more-uniform color space, and calculations that fit and express real-world conditions better. Although this still does not provide all that is needed to fully consider color rendering, when used with the procedure's color distortion icon, the addition of TM-30s color gamut metric (Rg) heightens an understanding of how a light source will reveal color.

Light sources have traditionally been classified as warm or cool, and specific light sources were often available in only a single color. Today, there are a variety of light sources with a wide range of apparent colors, including fluorescent and LED lamps. With the arrival of multicolor emitter arrays and other blended LED source options, white light and its color rendering abilities can be designed to a particular project need, according to Randy Burkett, FIALD, FIES, of Randy Burkett Lighting Design, St. Louis (*Architectural Lighting*, November/December 2016).

The correlated color temperature (CCT) is a reference standard that correlates to a standard color and is identified in kelvins (K). The higher the number, the cooler is the light source, and vice versa.

*Efficacy* is a measure of the efficiency of a light source, measured in lumens per watt. A *lumen* is a measure of the amount of light emitted by a light source or falling onto a surface, regardless of directionality.

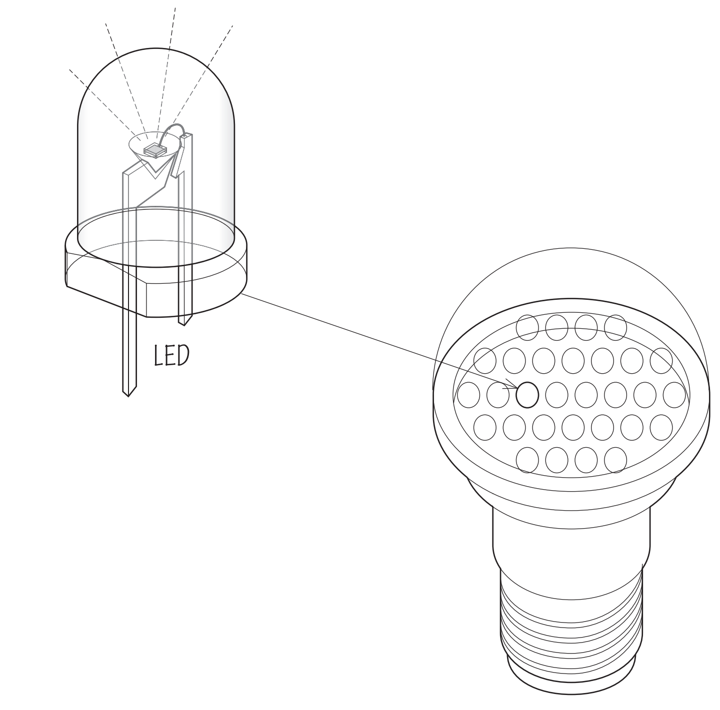



## Color Rendering Index (CRI) of Various Light Sources

| CRI | Light Source |
|---|---|
| 100 | Noon sunlight; average daylight |
| 93 | 500-watt incandescent |
| 89 | Cool-white deluxe fluorescent |
| 78 | Warm-white deluxe fluorescent |
| 62 | Cool-white fluorescent |
| 52 | Warm-white fluorescent |

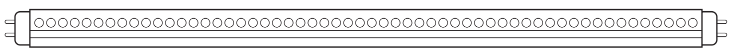
## Correlated Color Temperature (CCT)

| CCT in Kelvins | Light Source |
|---|---|
| 2700 | Incandescent |
| 3000 | Halogen |
| 2700–6500 | Fluorescent |
| 3000–4000 | Metal halide |
| 2800–6000 | LED |
| 5500–7500 | Daylight |



LED

LED lamp



LED tube

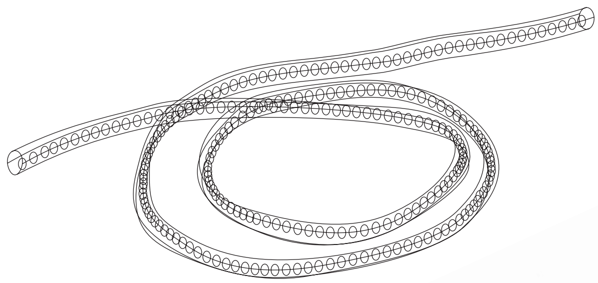
Light-emitting diodes (LEDs) radiate very little heat and are highly energy-efficient. LEDs have an extremely long life, typically about ten years. High-powered white-light LEDs are used for illumination. They are insensitive to vibration and temperature, are shock resistant, and contain no mercury. The tiny 1/8-inch (3-mm) lamps can be combined into larger groups to mix colors and increase illumination. LEDs operate on DC voltage, which is transformed into AC within the fixture.

LEDs are used for both residential and commercial lighting. Today, LEDs are being designed for most lighting purposes. They can be designed to focus light, and are widely used for task lights. LED downlights, panel fixtures, step lighting, and exit signs are also available. Bendable ribbon lights are available to provide even light distribution for curved runs or crisp right angles.

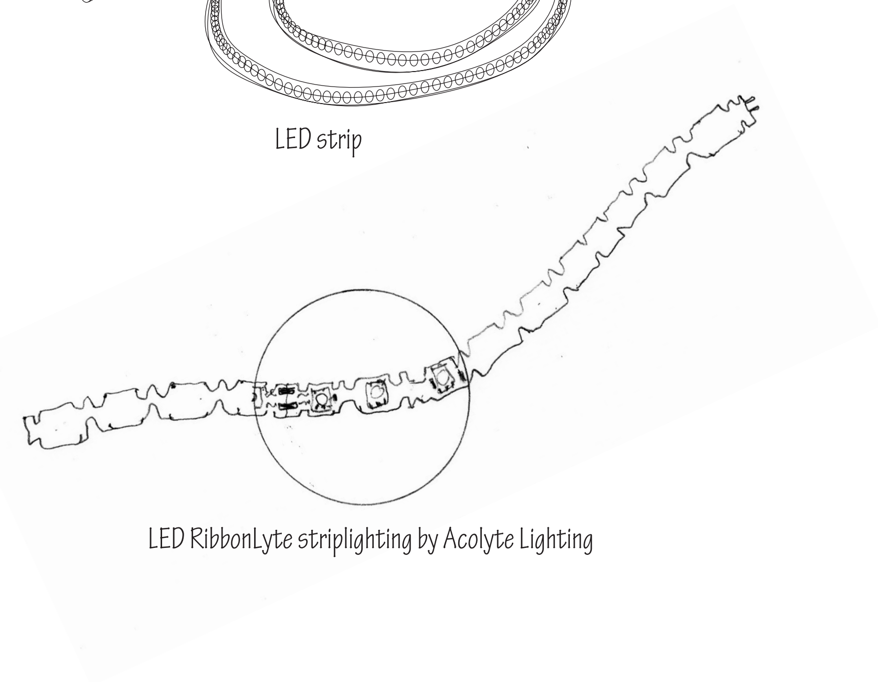
LEDs are designed to use less energy and have lower watts ratings. Watts are a measure of energy use, so watts are not used to determine the brightness of LEDs. The higher the lumen (lm) rating, the brighter the bulb will be. For example, a 6- to 9-watt LED has a 450 lm rating, equivalent to a 40-watt incandescent. A 25- to 28-watt LED has a 2600 lm rating, equivalent to a 150-watt incandescent.

A potential problem with LEDs is thermal management. High heat loads can reduce an LED's phosphors that are used to convert blue and violet light to white light, degrade the color of optical-grade silicone, and shorten diode life spans. Unmanaged, these effects depreciate lumens over an LED's lifetime, and cause color change. Manufacturers learned to add heat sinks to their products, which at times added more than 50 percent to a fixture's overall weight, increasing material use and shipping costs, and resulting in bulkier designs. More recent designs are much more sophisticated, resulting in lighter and sleeker fixtures that use lighter aluminum, ceramic, or other materials for heat sinks. Even more recently, LED fixtures are being made with the heat sink integrated into the design of the fixture, or with cross-flow ventilation that whisks heat away from the LEDs. Some fixtures have been designed with fans, but these run the risk of overheating should the fan fail.

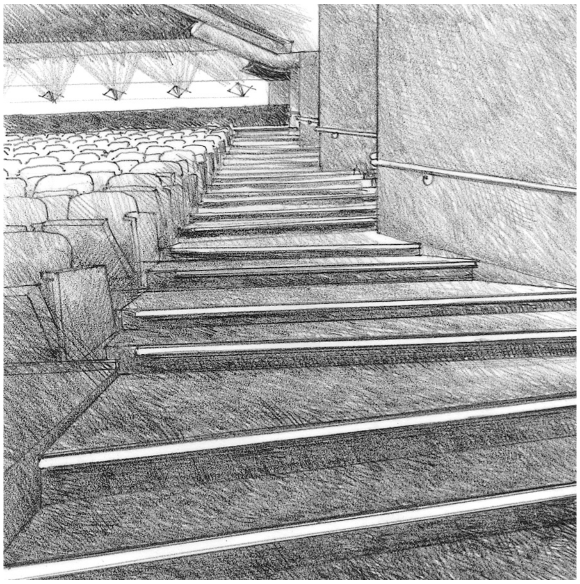
Some LED problems arise from lack of compatibility with fixture components and controls from both legacy and solid-state lighting manufacturers. The continuously changing nature of LED technology has made it almost impossible to develop a set of technical standards. As use of LED lighting continues to spread, solutions to these problems can be expected to develop.



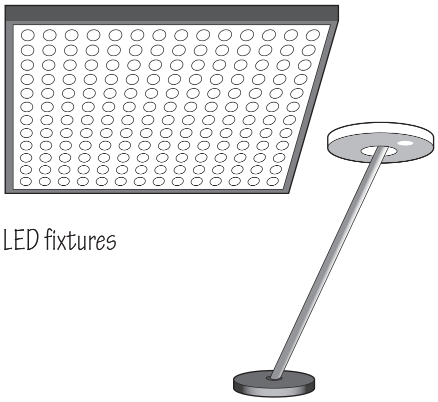
LED strip



LED RibbonLyte striplighting by Acolyte Lighting



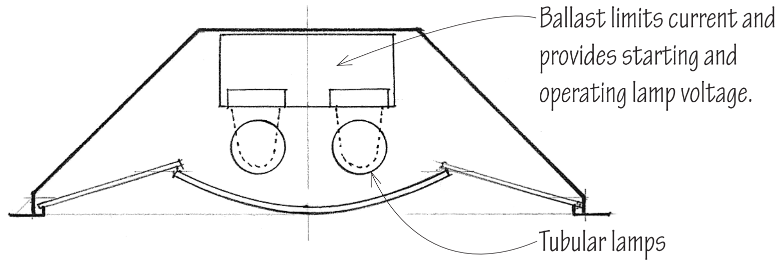
LED step lighting

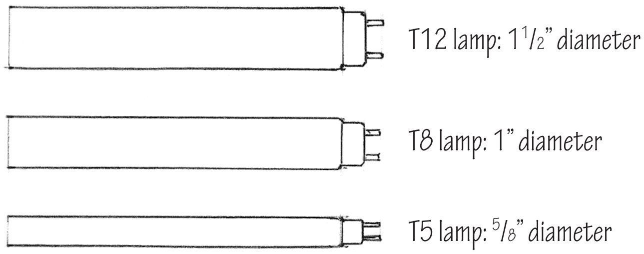


LED fixtures

## Comparative Lamp Efficiencies

| Lamp Type | Lumens/Watt |
|---|---|
| 100–200 W incandescent (230 V) | 13–15 |
| 100–200–500 W tungsten halogen (230 V) | 16–20 |
| 5–40–100 W incandescent (120 V) | 5–18 |
| T12 fluorescent tube, electronic ballast | 60 |
| 9–32 W compact fluorescent | 46–75 |
| T8 fluorescent tube, electronic ballast | 80–100 |
| Spiral fluorescent tube, electronic ballast | 114–124 |
| Metal halide lamp | 65–115 |
| High-pressure sodium lamp | 85–150 |



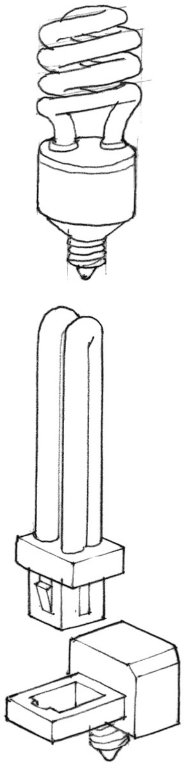

The standard T12 lamp is now considered outdated, replaced by T8 lamps.

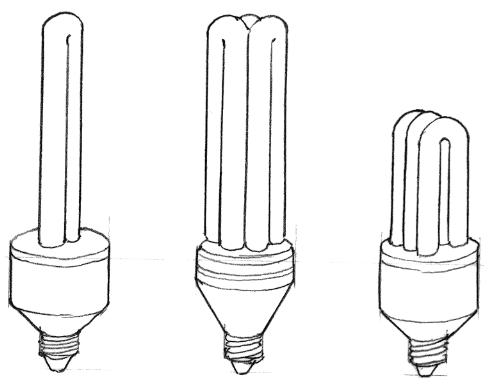
*T8 and T5 Lamps*

- Better color rendering than standard T12.
- T5 has better lighting efficiency than T8 or T12.
- Smaller tube diameters than T12.
- T5 lamps are smaller than T8, but produce roughly the same amount of light, making glare an issue.

*Compact Fluorescent Lamps*

- Available from 5 to 80 watts.
- High efficacy (typically 60 to 72 lumens per watt).
- Good color rendering.
- Very long lives (6000 to 15,000 hours).
- Tubular or spiral types.
- Many are available with built-in ballast and screw bases for direct replacement of incandescent lamps.
- Lack of beam control and dimming capability.
- Mercury content.





Discharge lamps produce light by the discharge of electricity between electrodes in a gas-filled glass enclosure. A common type is the fluorescent lamp.

Fluorescent lamps are low-intensity discharge lamps that produce light by generating an electric arc that passes through the mercury vapor sealed within their tubes. This produces ultraviolet light that energizes the phosphors that coat the tubes' inner walls, thus emitting visible light. Because fluorescent lamps contain mercury, they require special handling for recycling. Effective April 15, 2007, U.S. manufacturers in the National Electrical Manufacturers Association voluntarily capped the total mercury content in compact fluorescent lamps (CFLs) less than 25 watts at 5 milligrams (mg) per unit, and those 25 to 40 watts to 6 mg per unit. A broken fluorescent tube will release its mercury content, requiring special procedures for safe cleanup. LEDs, which do not contain mercury, are replacing fluorescent lamps in many applications.

Fluorescent lamps are more efficient and have a longer life (6000–24,000+ hours) than incandescent lamps. They produce little heat and are available in a variety of types and wattages. Common lengths range from a 4-watt T5 at 6 inches (152 mm) to a 125-watt T12 at 8 feet (2438 mm). Fluorescent lamps require a ballast to regulate electric current through the lamp. Some lamps have pin bases, while others have screw-in bases.

With LED replacements for fluorescents relatively new to the market, fluorescent lamps remain a viable option based on performance, lamp-life, and cost. Fluorescents serve as a bridge technology between incandescent lamps and LED solid-state lamps.

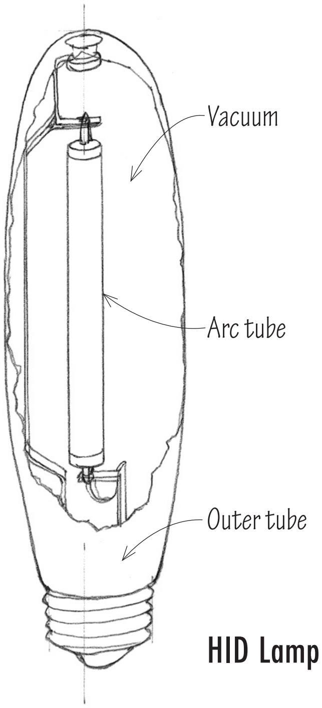
Fluorescent lamps are now available in a variety of colors, including warm white, cool white, sunlight, cool daylight, and sky white. Approximate CRI ratings range from 50 to 95, and color temperatures from 2700 K to 8000 K. Dimmable fluorescent lamps are available.

*High-intensity discharge (HID)* lamps—mercury vapor, high-pressure sodium (HPS), and metal halide lamps—produce light by passing an electrical current through a gas or vapor under high pressure. These lamps have a long life expectancy and consume little energy to produce a great amount of light from a relatively small source. They take several minutes to warm up. Most HID lamps are used primarily for industrial, commercial, roadway, and security lighting. They typically have low to average color rendering. HID lamps are being replaced by LEDs in many applications.

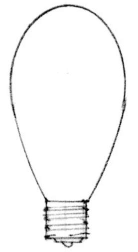
Metal halide lamps are used in spaces with high ceilings where lamps are left on for extended periods. Their start times range from 1 to 20 minutes, depending on the type. Metal halide lamps have excellent color, efficacy, and lamp life. CRIs commonly rate 70 to 90, and CCTs range from 2500 K to 5000.

High-pressure sodium lamps produce a pinkish orange light when warmed. The white SON lamp is a variation on the HPS with a color temperature around 2700 K and a CRI of 85, similar to that of an incandescent light. White SONs are sometimes used indoors in restaurants. However, they have higher purchase costs, shorter lives, and lower light efficiency than other HPS lamps.

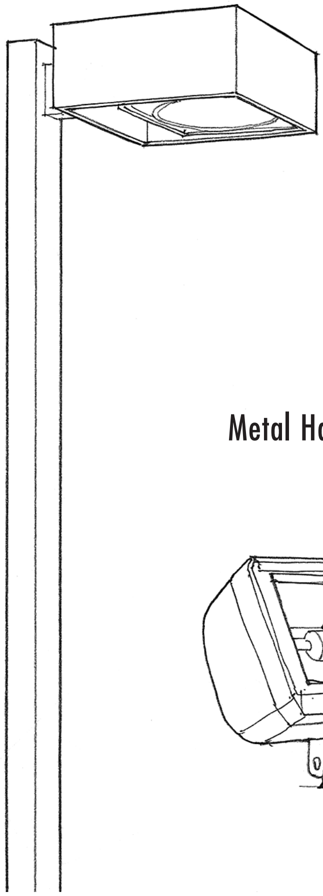
Mercury vapor lamps are primarily used outside for parking and security lighting. They are the least efficient of the HID lamps.

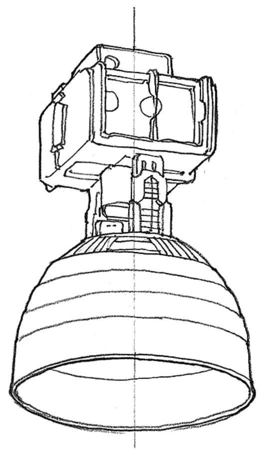


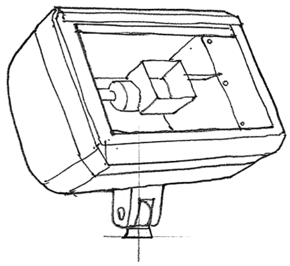

**HID Lamp**



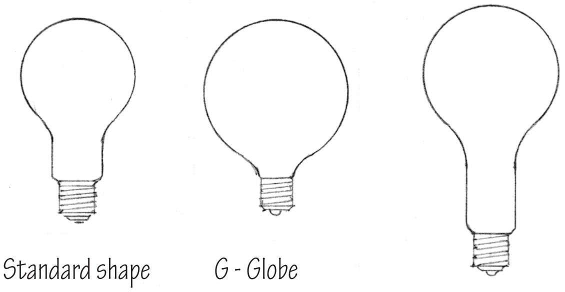
Both metal halide and white SON HPS lamps have ellipsoidal bulb shapes.







**Metal Halide Light Fixtures**

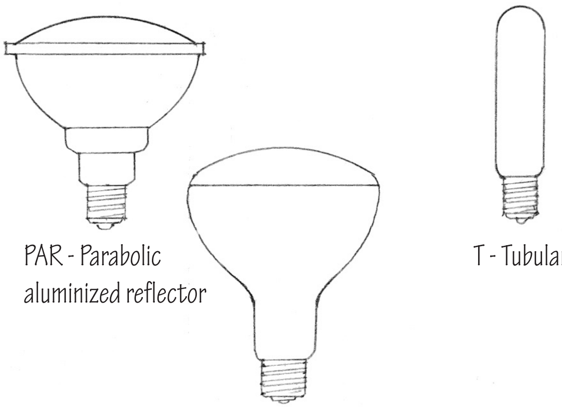


A - Standard shape G - Globe

PS - Pear shape

C - Cone shape

F - Flame shape



PAR - Parabolic aluminized reflector

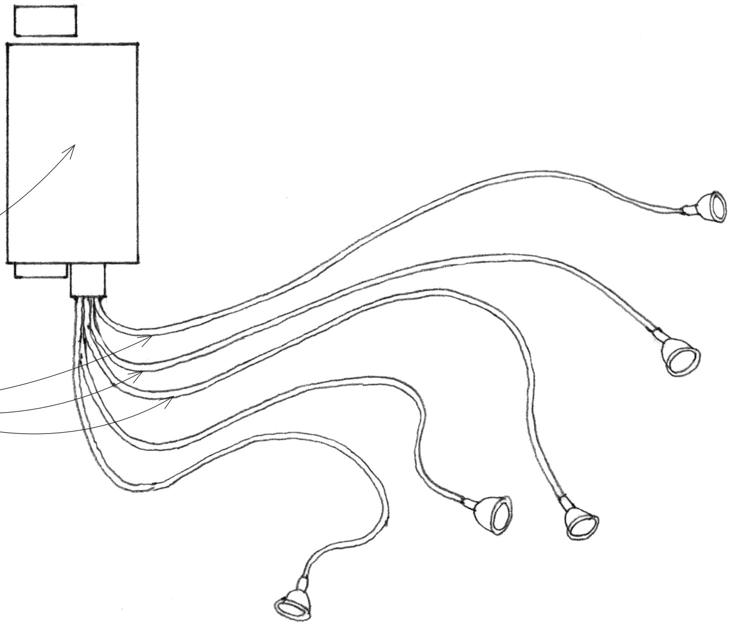
T - Tubular

R - Reflector

Incandescent lamps consist of metal filaments that are heated within a glass enclosure until they glow. Incandescent lamps are available from 6 to 1500 watts, and have a low efficacy rating of from 4 to 24.5 lumens per watt. Only about 12 percent of the wattage used goes toward the production of light; the remainder is given off as heat. They also have a comparatively short life of from 750 to 4000 hours. Because of their energy inefficiency, incandescent lamps are being regulated or phased out in several countries, including the U.S.

Tungsten-halogen lamps, also known as halogen or quartz lamps, are incandescent lamps with a small amount of halogen gas sealed inside the bulb. They maintain close to their full output over time. Available from 5 to 1500 watts, they produce 10 to 22 lumens per watt.

While standard incandescent lamps operate on standard-voltage circuits, low-voltage lamps, including tungsten-halogen, operate between 6 and 75 volts. Their design offers more precise beam control, higher efficacy, energy savings where focused light is needed, and 1000 to 6000 hours of life. Although they are more efficient than standard incandescent lamps, they still perform less efficiently than LEDs or fluorescent lamps, and require an AC step-down transformer to lower the power to 12 V. Dimming requires the use of magnetic transformers specially designed for use with low-voltage lighting components. Low-voltage lighting is considered most beneficial for accent or task lighting, but not for ambient lighting.



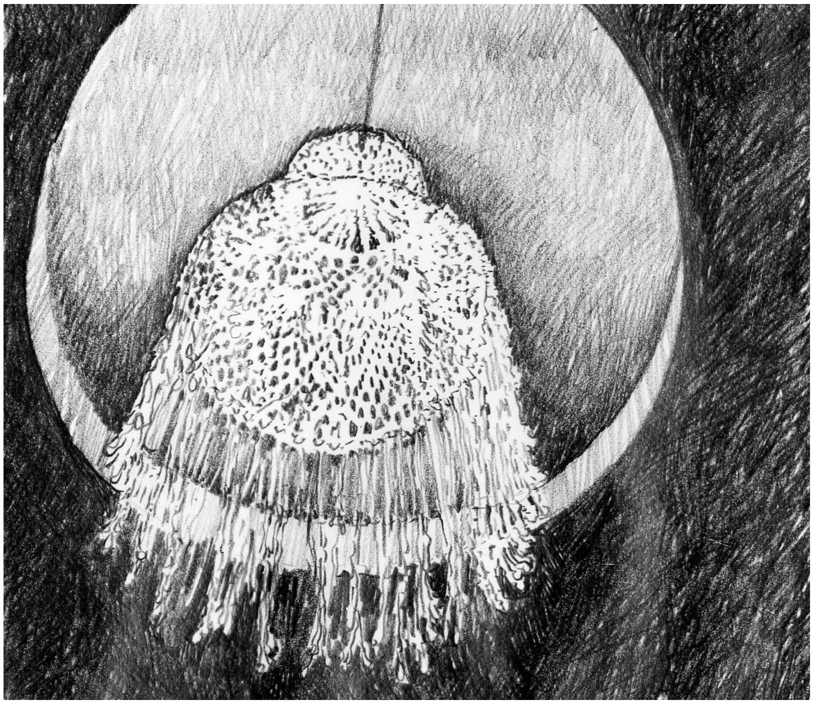
The optical glass or plastic fibers in fiber-optic lighting transmit light from one end to the other by reflecting light rays back and forth inside their cores in a zigzag pattern. Each small-diameter fiber is protected by a transparent sheath and combined with others into flexible bundles.

A typical fiber-optic lighting system includes:

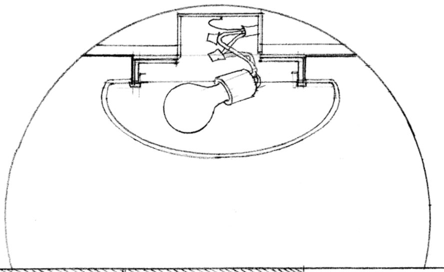
- A light projector, which may have a color wheel
- A tungsten-halogen or metal halide light source
- An optical-fiber harness
- Bundles of optical fibers and their fittings

Fiber-optic lighting remains a good solution to transmit light from a single bulb that is located discreetly to illuminate stairways or focal points at a distance. They are useful in illuminating museum displays, as the cables themselves do not heat up.

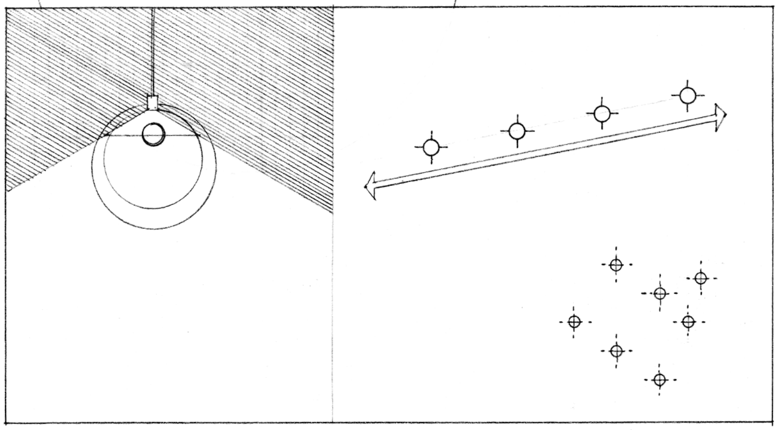
Manufacturers are beginning to coordinate their fiber-optic products so that they are compatible with each other. Acrylic cables are less expensive than glass ones, but may degrade over time. Dust deposited during installation is also a problem.



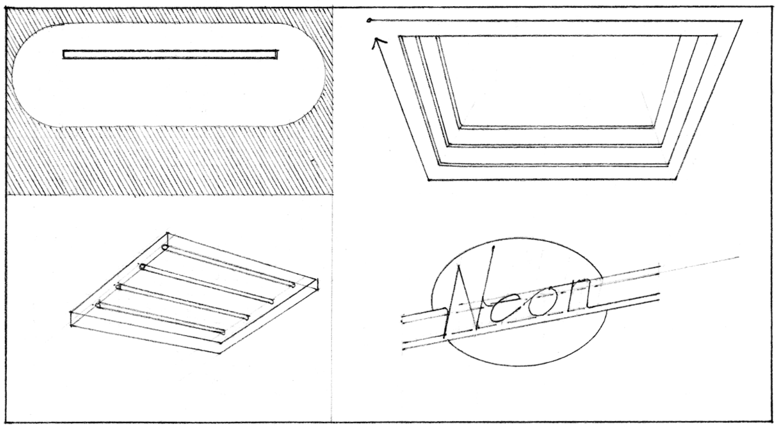
A fiber-optic chandelier



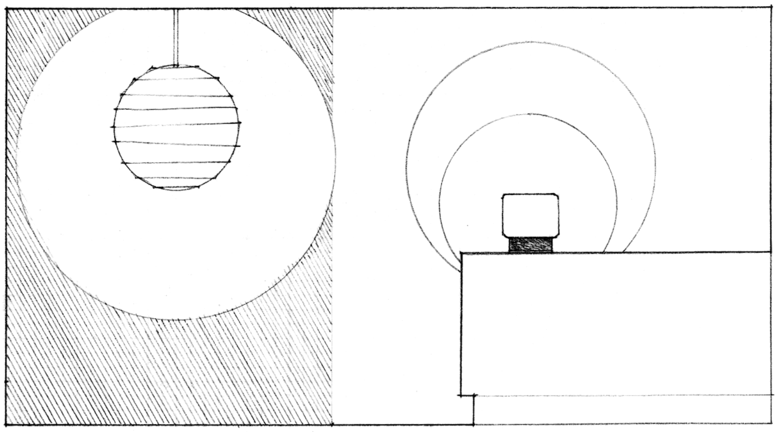
Light fixtures are integral parts of a building's electrical system, transforming energy into usable illumination. Light fixtures require an electrical connection or power supply, a housing assembly, and a lamp.



We are concerned not only with the shape and form of the fixture but also with the form of the illumination it provides. Point sources give focus to a space, since the area of greatest brightness in a space tends to attract our attention. They can be used to highlight an area or an object of interest. A number of point sources can be arranged to convey rhythm and sequence. Small point sources, when grouped, can provide glitter and sparkle.



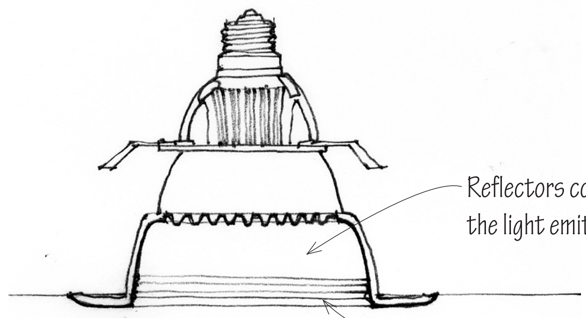

Linear sources can be used to give direction, emphasize the edges of planes, or outline an area. A parallel series of linear sources can form a plane of illumination that is effective for the general, diffused lighting of an area.



Volumetric sources are point sources expanded by the use of translucent materials into spheres, globes, or other three-dimensional forms.

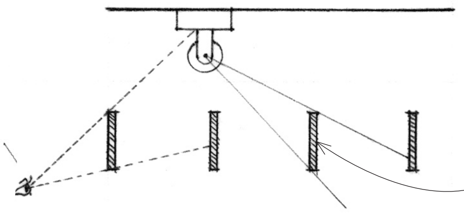
A light fixture consists of one or more electric lamps with all of the necessary parts and wiring for supporting, positioning, and protecting them, connecting them to a supply of power, and distributing the light.

Light fixtures can provide direct and/or indirect illumination. The form of distribution depends on the design of the fixture as well as its placement and orientation in a space. Some light sources serve primarily as decorative focal points. Others provide needed light while the fixtures themselves are de-emphasized or hidden.

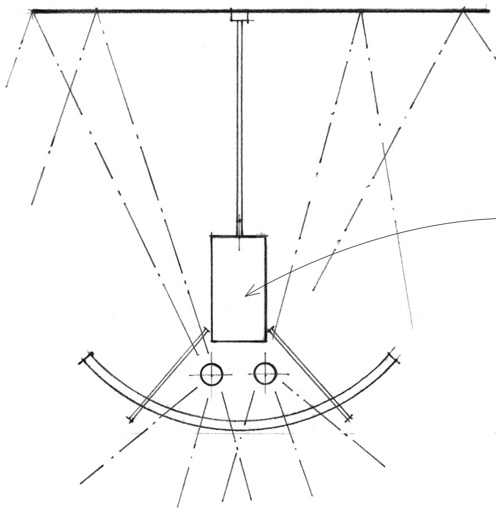


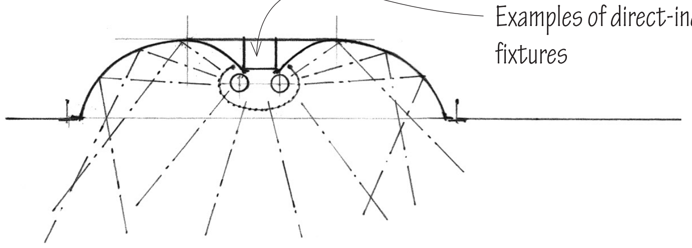
Reflectors control the distribution of the light emitted by a lamp.

Ridged baffles reduce the brightness of a light source at the aperture of the housing.

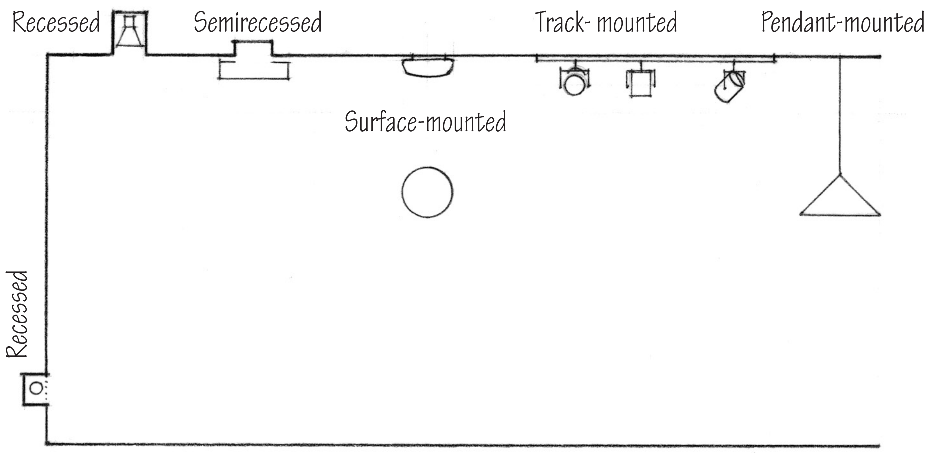


Baffles, such as louvers and eggcrates, redirect the emitted light and/or shield the light source from view at certain angles.



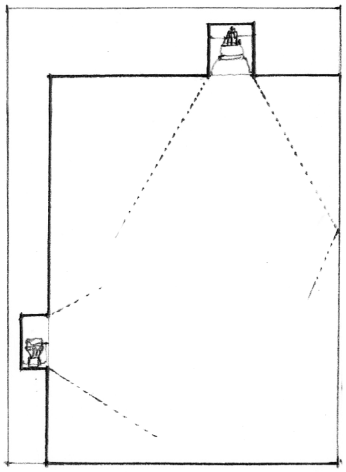


Examples of direct-indirect light fixtures




A light fixture's housing may be mounted on a ceiling or wall and be:

- Recessed
- Semirecessed
- Surface-mounted
- Track-mounted
- Pendant-mounted

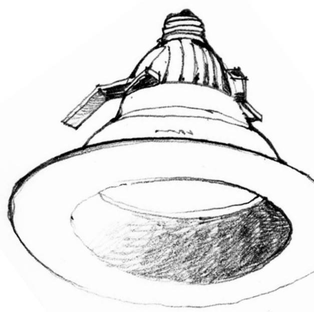


Lighting fixtures may be recessed in the ceiling or a wall.

Recessed lighting fixtures are hidden above the finished ceiling and shine light through an aperture in the ceiling plane. They preserve the flat plane of the ceiling.

Recessed lighting fixtures offer an unobtrusive way to bring light to circulation paths within a larger space, or to provide increased light levels in a specific area. When used indiscriminately throughout a space, however, they can create a monotonously even pattern on the ceiling and a uniform but dull level of illumination.

Adjustable eyeball



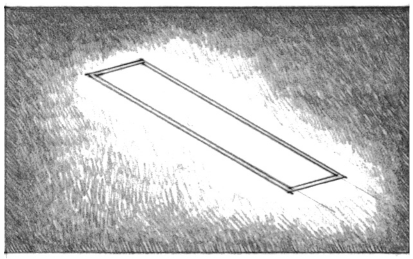
Baffled downlight

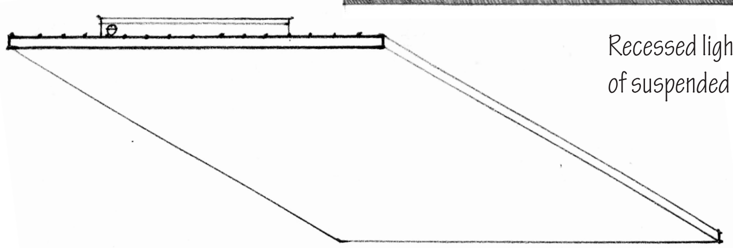
Downlights are used in multiple arrangements to provide ambient light for a large space, or to offer a focal glow on a floor or work surface. LED downlights are now available. Lamps and accessories for recessed downlights are available in a variety of styles, allowing the designer a range of effects. Some recessed fixtures appear as black holes in a light-colored ceiling when they are turned off. Downlights located too close to a wall can create an unattractive scalloped pattern. Wallwashers are designed to illuminate a matte vertical surface in a more uniform manner. Walls can be illuminated in one of two ways: wallwashing and wall grazing, which vary in the distance of the fixture from the wall surface.

Pinhole downlight

Wallwashers are typically located at least 12 inches from the wall plane, giving the wall texture a flat appearance. For wall grazing, the fixture is positioned very close to the wall—a maximum of 12 inches—to bring out the wall texture. The overall height of the wall determines the fixture's distance from the wall. Adjustable LED wallwashers are available.

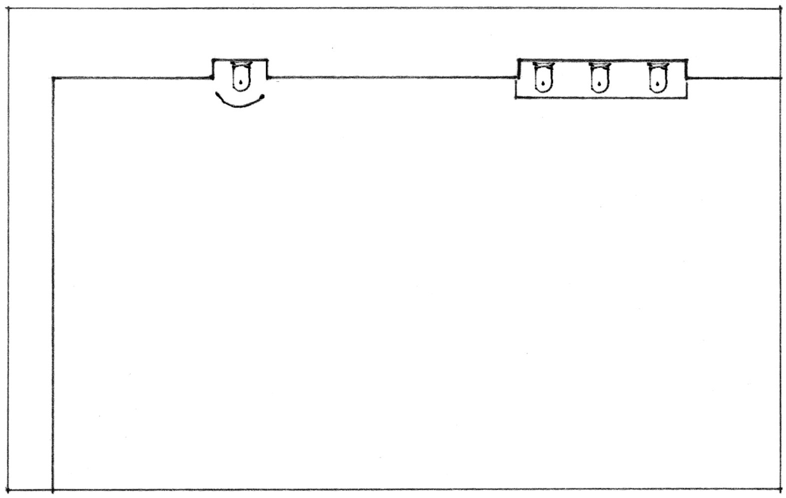
Baffled wall washer





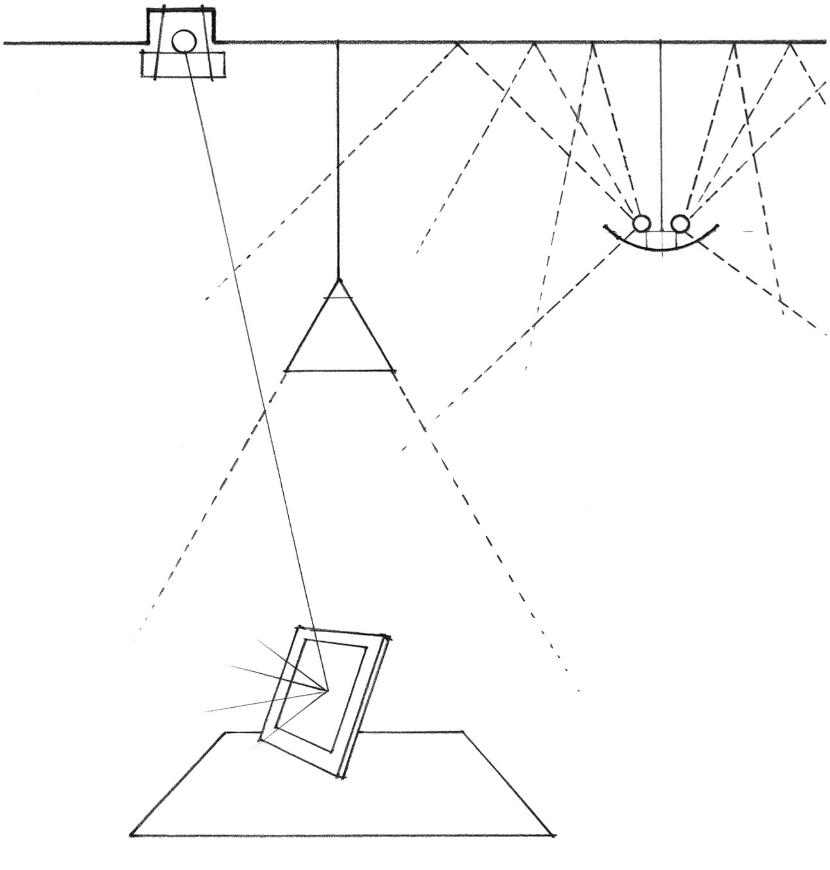
Recessed lighting fixtures often form part of suspended ceiling systems.

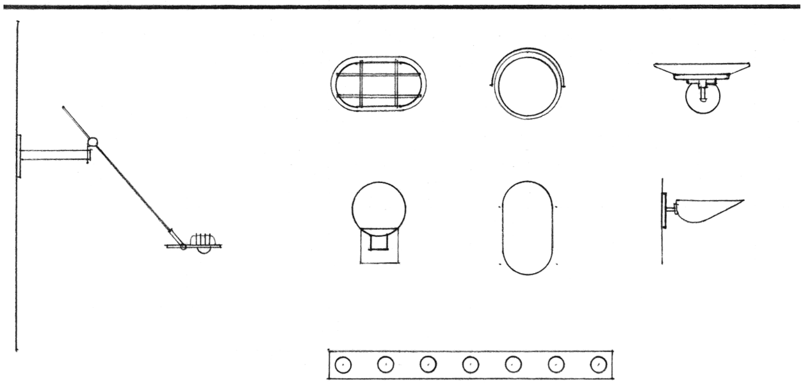
The housings of some light fixtures are partially recessed into the ceiling or wall construction, while part of their housing, reflectors, or lenses projects beyond the ceiling or wall surface. The smaller sizes of many LED fixtures allow them to be fully recessed, where larger incandescent models had to be partially recessed.

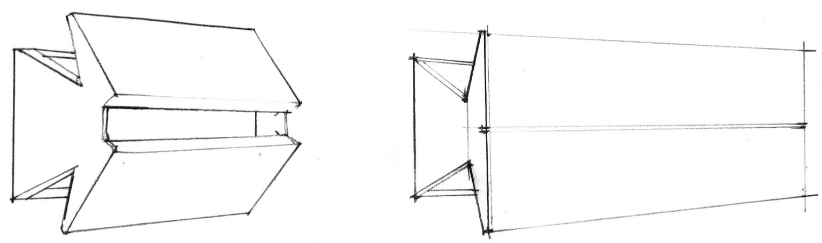


Fixtures that shine down from above can cause glare on computer screens, especially if the lamps are visible or if the fixture creates a bright area in the darker field of the ceiling. This is less of a problem with the brighter, thinner screens now in use, which are easier to adjust to avoid glare.

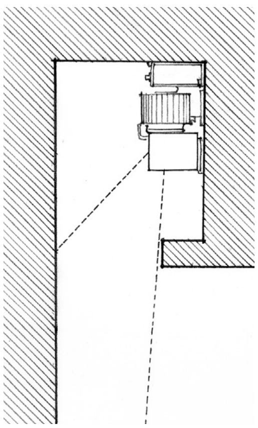
Diffusers provide some protection, but suspended fixtures that bounce light off the ceiling and filter light downward as well do a better job of minimizing glare.



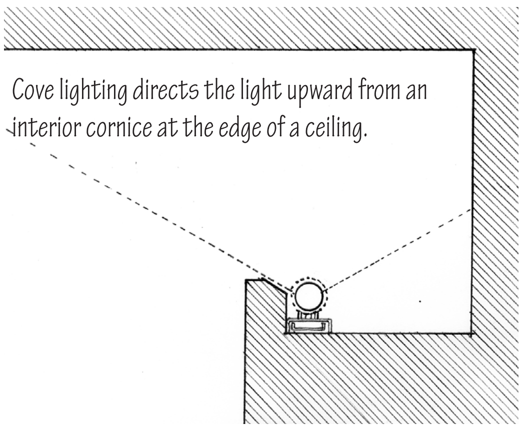




The ADA mandates that surface-mounted fixtures that are between 2'3" and 6'8" above the floor should not extend more than 4" into the space.



Cornice lighting directs the light downward from an interior cornice at the edge of a ceiling.



Cove lighting directs the light upward from an interior cornice at the edge of a ceiling.

Surface-mounted light fixtures are mounted on the finished ceiling or wall and are usually attached to a recessed junction box. Light fixtures that are mounted directly on a ceiling are generally positioned above the people and furnishings in the room and can spread their light over a broad area.

Wall-mounted light fixtures are often decorative and help to create the ambiance of the space. Wall sconces can shine light upward, downward, or sideways, as well as produce a gentle glow from the fixture itself.

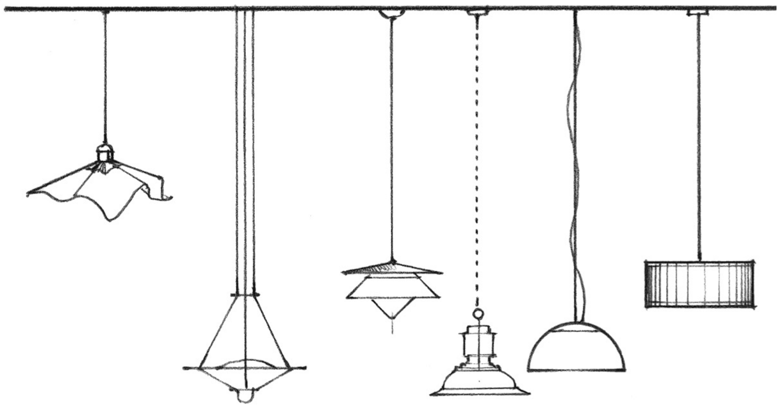
Wall-mounted fixtures can provide task lighting when their illumination is focused on the task area. When shining on a wall or a ceiling, they add to the general illumination of the space. Their horizontal and vertical positions must be carefully coordinated with windows and furnishings. A versatile design for task lighting consists of a lampshade that uses magnets to facilitate its placement anywhere along metal supports.

Cove, *valance*, and *cornice* lighting are all methods for illuminating a space indirectly from within an architectural detail or a manufactured fixture. They give a soft, indirect glow to the area they illuminate and are often used to highlight ceiling details or wall textures.

Considerations when designing a cove lighting detail include (*Architectural Lighting*, March/April 2015):

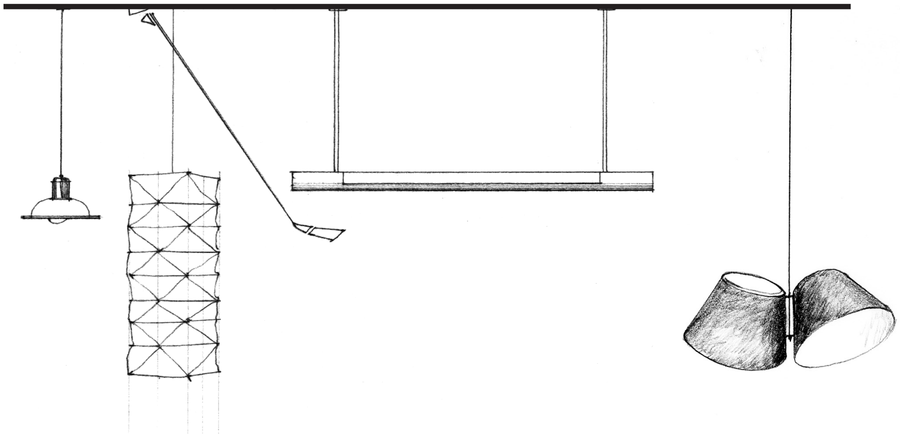
- Be aware that joints or gaps between lighting fixtures will appear in the pattern of light. Placing fixtures end to end or in a staggered or slanted arrangement can eliminate dark spots at the end of a lamp.
- The top of the lamp should be level with the fascia of the cove to prevent shadow lines.
- Stop a cove short of an end wall to avoid sharp cutoff lines.
- As a cove nears an end wall, keep at least 12 inches clear at inside corners to prevent hot spots.
- The ceiling surface should generally be a high-reflectance matte or satin finish, while the inside surface of the cove should be flat white to minimize specular reflections.
- As the cove's distance from the ceiling plane increases, the uniformity of the ceiling brightness will also increase.

Pendant-mounted light fixtures are attached to either a recessed or surface-mounted junction box concealed by a canopy, and may hang below the ceiling on a stem, chain, or cord. The fixtures may throw light up, down, or at an adjustable angle.

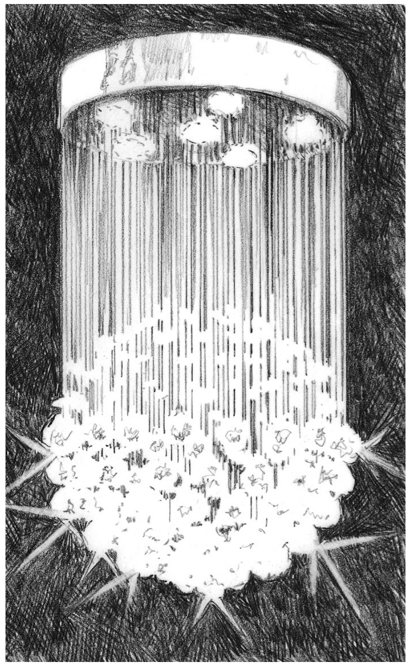


Uplights or indirect lighting fixtures wash the ceiling in light. Some also provide downlight. They may be:

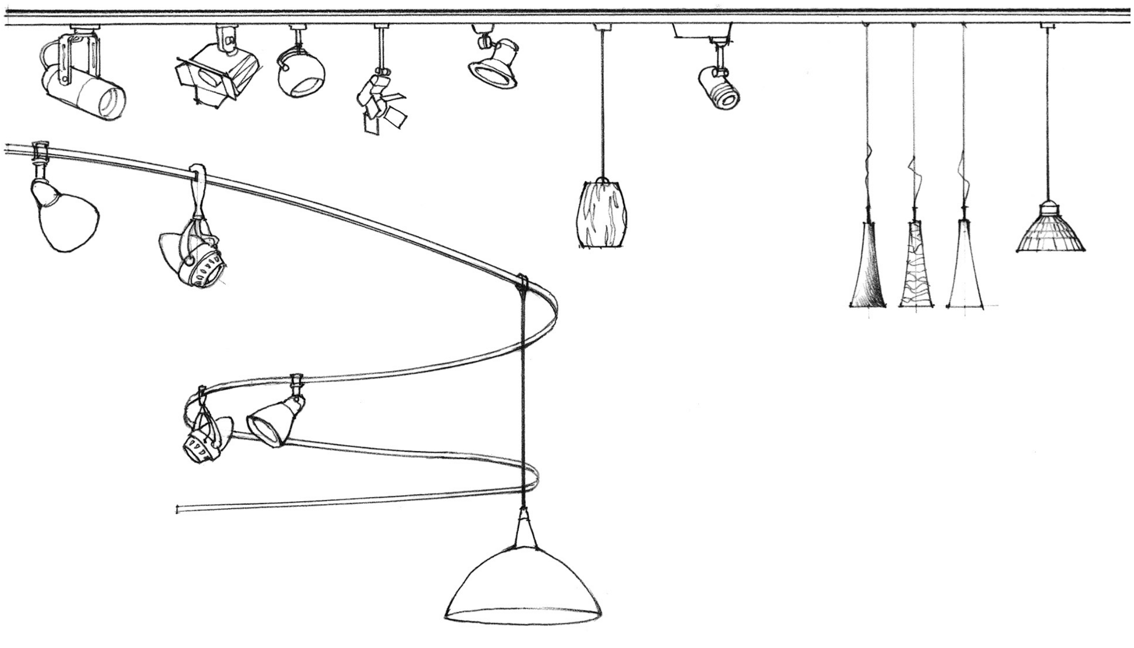
- Suspended from the ceiling
- Mounted on top of tall furniture
- Attached to walls, columns, or floor stands



Track-mounted light fixtures consist of adjustable spotlights or floodlights mounted on a recessed, surface- or pendant-mounted track through which electrical current is conducted. The light fixtures can be moved along the track and adjusted to shed light in multiple directions. Building energy codes may require that each head on the track be counted as a separate fixture.



Chandeliers often provide more sparkle than illumination and become a focal point in the space.



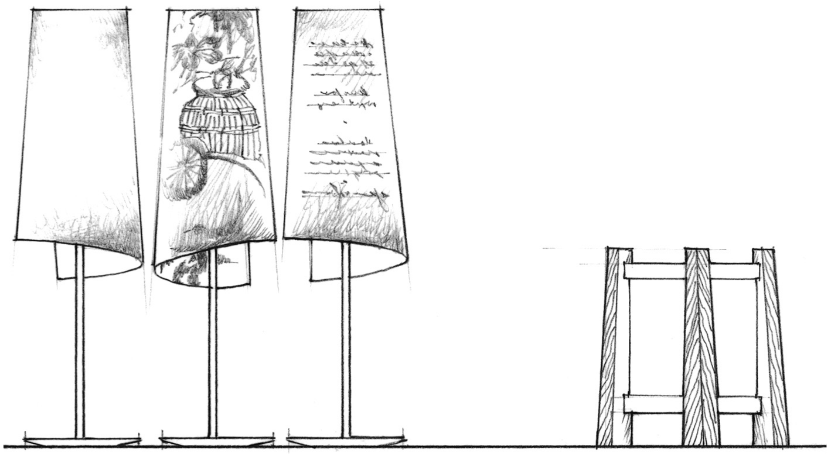


Table Lamps

Decorative lights serve as accents within the space. The light they produce may be secondary to the appearance of the fixture, the glowing surface of which draws the eye. Portable lighting fixtures are commonly referred to as lamps, and their light sources as light bulbs.

Desk and task lamps are found in both residential and workspaces. Many are adjustable to accommodate varied tasks and individual preferences. Desk and task lights can help save energy by providing focused light where it is needed, allowing lower levels of *ambient lighting*.

Table lamps often serve both decorative and practical functions. They become part of the room's décor, while providing either general illumination or task light.

Floor lamps may shine up (torchières), down, or at adjustable angles. Like table lamps, they become part of the décor and can provide either task or general lighting.

Portable lamps help to bring human scale to architectural spaces by creating decorative detail and localized light. They are usually operated at the fixture itself, giving users easy control over their environment.

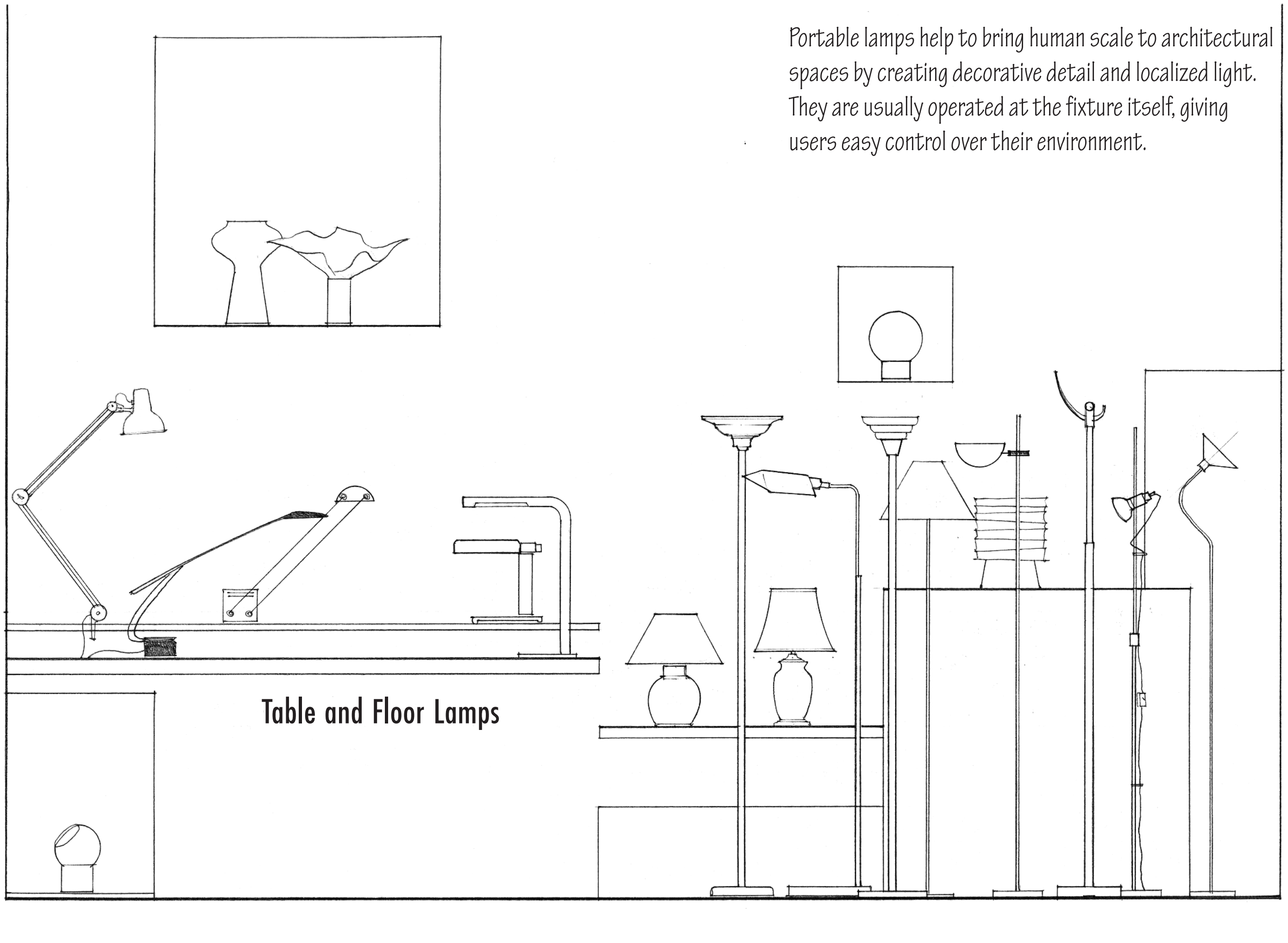


Table and Floor Lamps

The layout of lighting fixtures and the pattern of light they radiate should be coordinated with the architectural features of a space and the pattern of its use. Since our eyes seek the brightest objects and the strongest tonal contrasts in their fields of vision, this coordination can serve to reinforce the architectural features and support the function of the space.

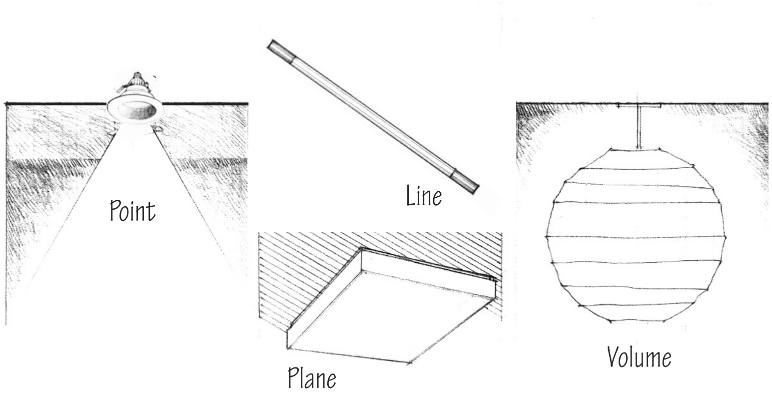
For the purpose of planning the visual composition of a lighting design, a light source can be considered to have the form of a point, a line, a plane, or a volume. If the light source is shielded from view, then the form of the light emitted and the shape of surface illumination produced should be considered. Whether the pattern of light sources is regular or varied, a lighting design should be balanced in its composition, provide an appropriate sense of rhythm, and give emphasis to what is important.

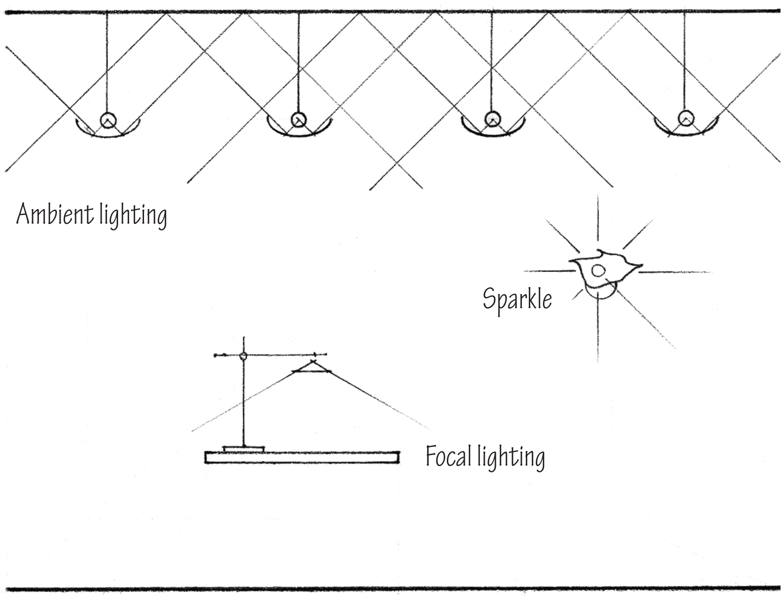
Lighting design manipulates the fundamental elements and qualities of ambient and *focal lighting* as well as sparkle:

- Ambient lighting provides a general, shadowless light level that is restful and minimizes interest in objects and people.
- Focal lighting offers a contrast in brightness that is directive and creates a sense of depth. Examples include task and accent lighting.
- Sparkle—such as highlights, scintillating sequins, crystal chandeliers, and twinkling stars—is stimulating and may be distracting, but it is also often entertaining.

The changes brought to the lighting industry by LED solid-state lighting have caused legacy companies such as Philips, Osram, and GE to reconsider their lighting businesses completely. As this edition of *Interior Design Illustrated* is being prepared for publication, the dramatic recasting of players once mainstays of the pre-LED era is difficult to track. Even Lightfair, the preeminent event for lighting designers in the U.S., has moved from New York to Philadelphia to San Diego, with a focus on technology more than on product appearance.

Light animates space and reveals forms and textures.

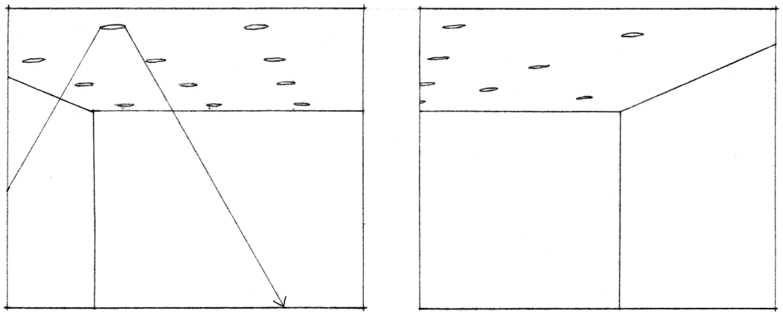


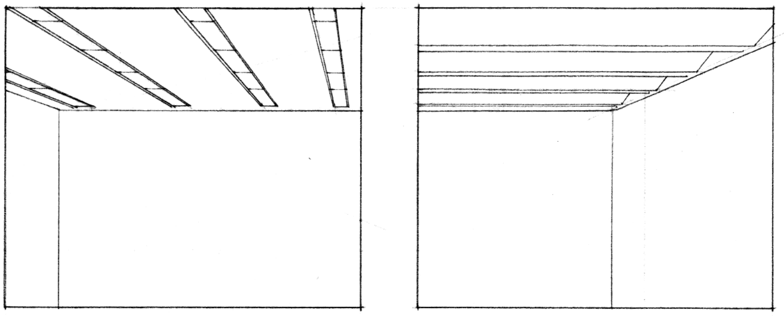
Ambient or general lighting illuminates a room in a fairly uniform, generally diffuse manner. The dispersed quality of the illumination can effectively reduce the contrast between task lighting and the surrounding surfaces of a room. Ambient lighting can also be used to soften shadows, smooth out and expand the corners of a room, and provide a comfortable level of illumination for safe movement and general maintenance.

Ambient lighting is appropriate for frequently reconfigured spaces and for areas where the location of tasks varies widely. Ambient fixtures may be direct, direct/indirect, or indirect point or linear sources. LED strip-lighting fixtures can provide ambient light.

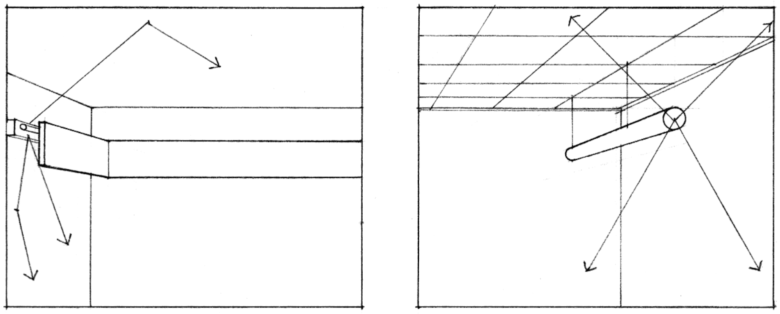
The addition of task lighting to ambient systems provides a higher level of focal lighting for task areas, with surrounding areas illuminated at a lower level. Task-ambient lighting saves energy, improves the quality of lighting, and gives the user more control.



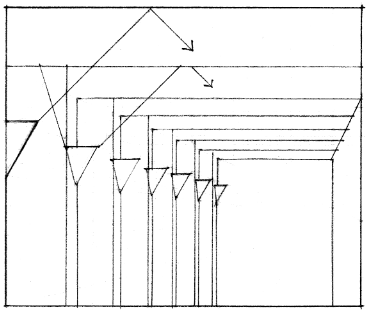
Ambient point sources



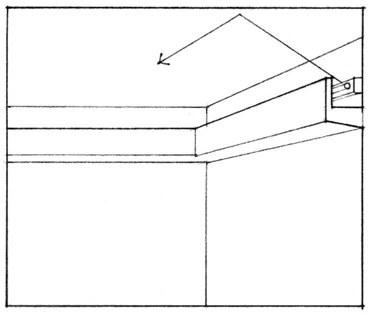
Ambient linear sources



Direct/indirect linear sources

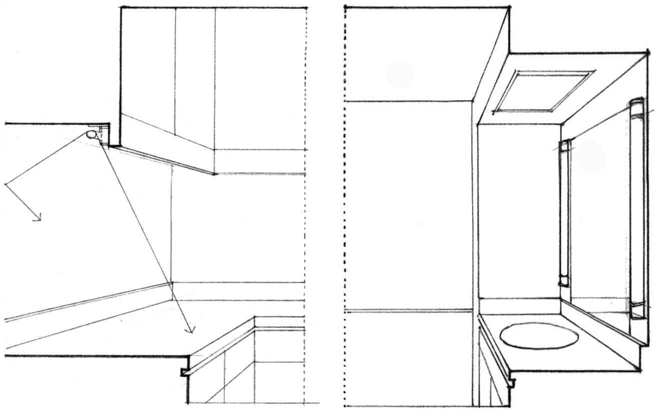


Indirect point sources



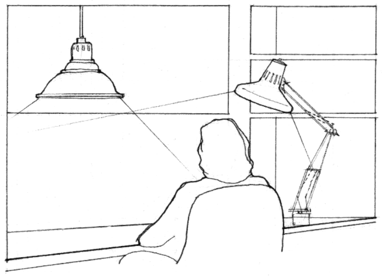
Indirect linear sources

Focal lighting creates brighter areas within the ambient light levels of a space through the use of task lighting and accent lighting.



Task lighting illuminates specific areas of a space for the performance of visual tasks or activities. The light sources are usually placed close to—either above or beside—the task surface, enabling the available wattage to be used more efficiently than with ambient lighting. The lighting fixtures are normally of the direct type, and adjustability in terms of brightness and direction is always desirable.

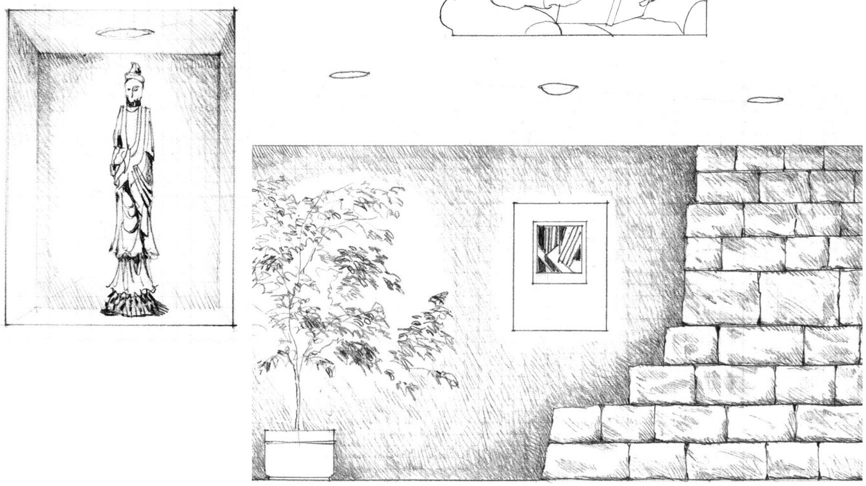
To minimize the risk of an unacceptable brightness ratio between task and surroundings, task lighting is often combined with ambient lighting. Depending on the types of lighting fixtures used, focal lighting can also contribute to the general illumination of a space.



Desk lighting

Reading lamp

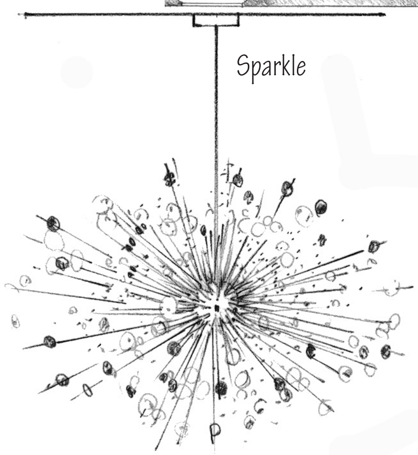
In addition to making a visual task easier to see, focal lighting can also create variety and interest, divide a space into a number of areas, encompass a furniture grouping, or reinforce the social character of a room.



Accent lighting

## Accent Lighting

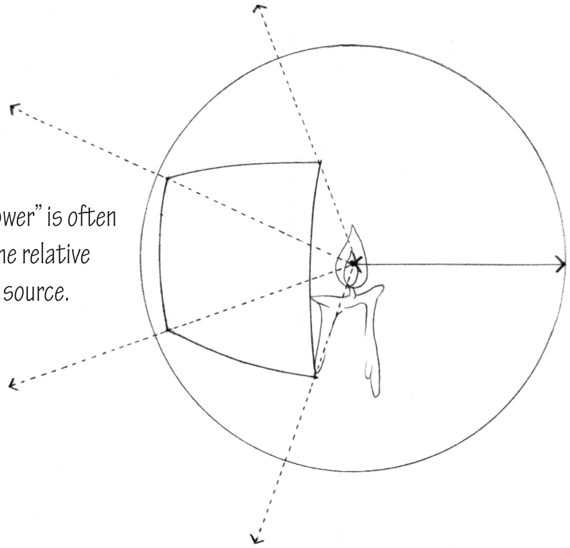
Accent lighting is a form of focal lighting that creates focal points or rhythmic patterns of light and dark within a space. Instead of serving simply to illuminate a task or activity, accent lighting can be used to relieve the monotony of ambient lighting, emphasize a room's features, or highlight art objects or prized possessions.



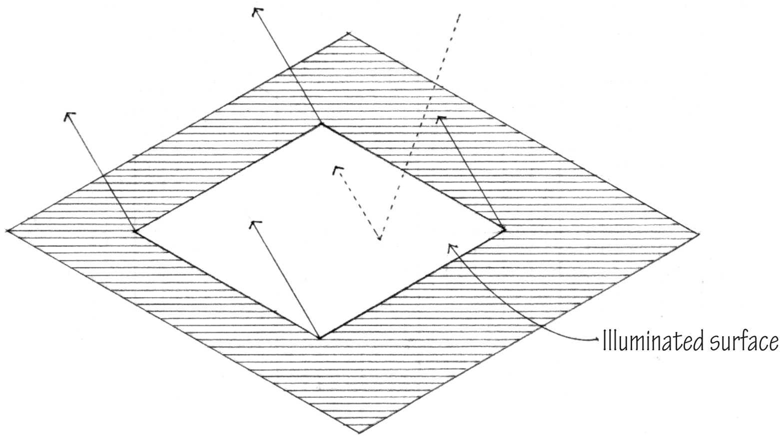
Sparkle

## Sparkle

Lighting can bring out the highlights in the objects that it shines on or introduce sparkle through the brilliance of the fixture itself. Small, tightly focused lamps reflect dancing bits of light off reflective surfaces. Chandeliers often produce little ambient light—they are all about sparkle.



The term “candlepower” is often used to describe the relative intensity of a light source.




Lighting technology is advancing about as fast as computer technology. The basic principles of lighting design have not changed, but the available tools have. Energy conservation is a major issue for lighting design, and computer software is available to perform the calculations required by codes. The major challenge today is to minimize lighting energy use without sacrificing quality.

Quantitative recommendations that address lighting design standards include *luminance* (brightness), *illuminance* levels, uniformity, and glare. Traditionally, lighting standards have used a quantitative approach of determining how many *footcandles* are needed. These standards do not reflect qualitative issues, and may result in lighting that is overly uniform and less energy-efficient.

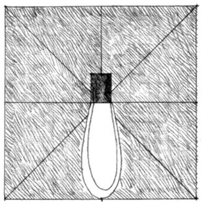
Illuminance is a measure of incident light on a surface. It is measured in lumens per square foot (footcandles) or lumens per square meter (lux). One footcandle is a unit of illuminance equal to one lumen spread evenly over an area of one square foot. This measure of light can be calculated by the lumen method (also called the point-by-point method), or with a more accurate computer program. Today, computer modeling programs model lighted spaces increasingly accurately.

Brightness is our subjective perception of varying degrees of light intensity. Luminance is the amount of light energy that is reflected off a surface and interpreted by our visual system. Interpreting luminance can be technically quite complex, but it is also very intuitive and dependent on experience.

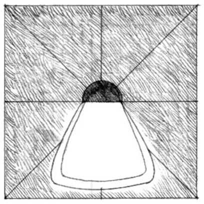
Lighting designers are moving toward a new approach that looks at qualitative design issues such as the following:
- Desired appearance of the space
- Color and luminance of finishes
- Integration of daylighting
- Glare control
- Light distribution on surfaces and the task plane
- Modeling of people and objects, and shadows
- Focus on points of interest
- Lighting system controls

A successful lighting design is determined by the balance of relative luminances rather than by the quantity of illuminance striking the surfaces of a room. Measurements of illuminance, however, are used to select lamps and lighting fixtures and to evaluate a lighting design. The photometric data to be considered include:

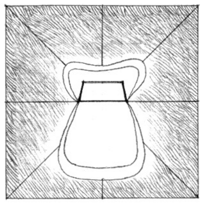
- The luminous intensity distribution curve (LIDC) represents the light pattern produced by a lamp or light fixture in a given direction from the center of the light source.
- The coefficient of utilization indicates the efficiency of a light fixture.
- The light loss factor (LLF) reflects the decrease in luminous output that occurs over the operating life of a lamp, which can be affected by the accumulation of dirt on the surfaces of the light fixture and by the effects of temperature.



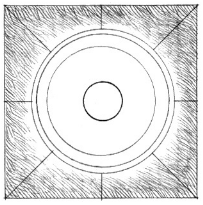
**Direct-Concentrating**
0%–10% upward
90%–100% downward



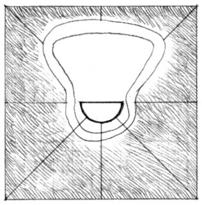
**Direct-Spread**
0%–10% upward
90%–100% downward



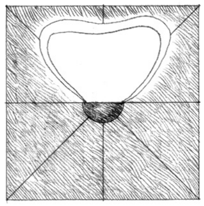
**Semidirect**
10%–40% upward
60%–90% downward



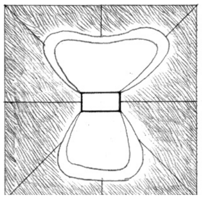
**General Diffuse**
40%–60% upward
40%–60% downward



**Semi-Indirect**
60%–90% upward
10%–40% downward

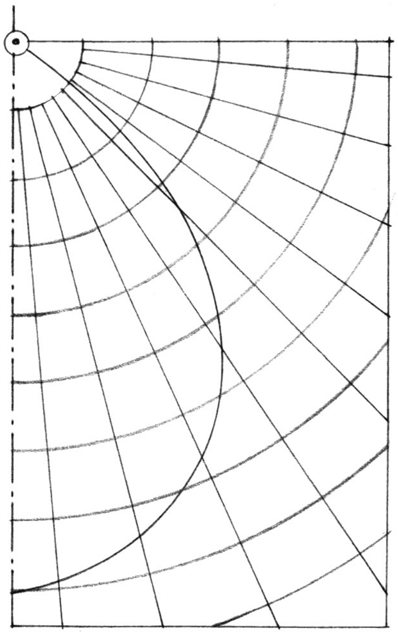


**Indirect**
90%–100% upward
0%–10% downward

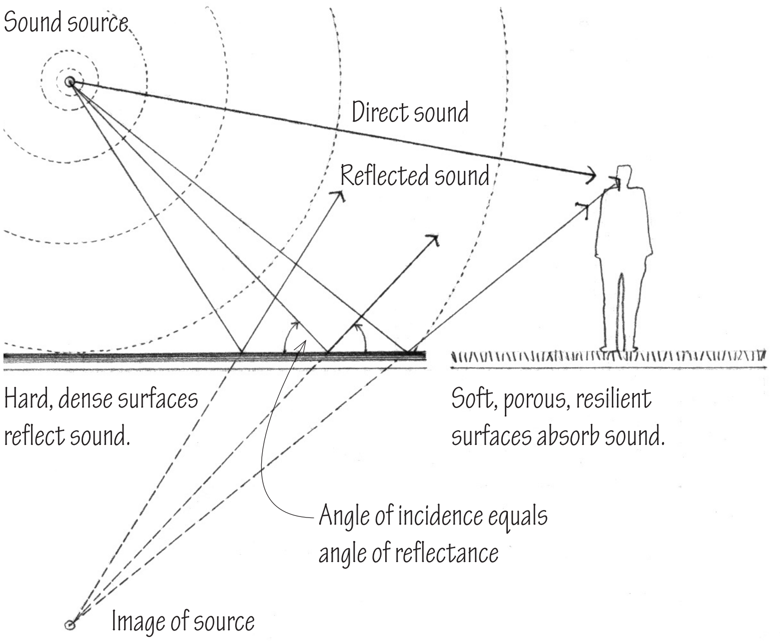


**Direct-Indirect**
40%–60% upward
40%–60% downward

Light fixtures may be classified according to the way they distribute the light emitted by their lamps. The basic types shown here are based on the percentage of light emitted above and below the horizontal.



Example of a luminous-intensity distribution curve of a direct-concentrating light fixture




Acoustics deals with the production, control, transmission, reception, and effects of sound. In interior design, we are concerned with the control of sound in interior spaces. More specifically, we want to preserve and enhance desired sounds and reduce or eliminate sounds that would interfere with our activities.

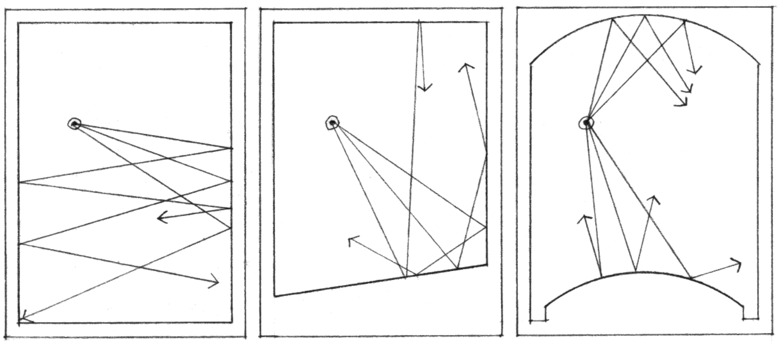
Sound occurs when energy is transmitted as pressure waves through the air or another medium. A sound wave travels outward spherically from its source until it encounters an obstacle in its path. When a sound wave strikes an object, it is either absorbed or reflected, or a combination of the two.

In a room, we first hear a sound directly from its source and then from a series of reflections of that sound. Reflective surfaces are useful when they reinforce desirable sounds by directing and distributing their paths in a room. The continued presence of reflected sounds, however, can cause problems of echo, flutter, or reverberation.

## Acoustic Principles

Echoes occur in large spaces when surfaces reflect sound waves that are loud enough and received late enough to be perceived as distinct from the source. In smaller rooms, parallel reflective surfaces can cause a rapid succession of echoes we call flutter.

*Reverberation* refers to the persistence of a sound within a space, caused by multiple reflections of the sound after its source has stopped. Some music is enhanced with long reverberation times, but speech can become muddled in such an acoustic environment. Altering the shape and orientation of a room's surfaces or adjusting the proportion of reflective and absorbent materials can aid sound clarity.



Parallel reflective surfaces can cause echoes and flutter.

Splayed surfaces can help diffuse sound.

Concave surfaces focus sound; convex surfaces diffuse sound.

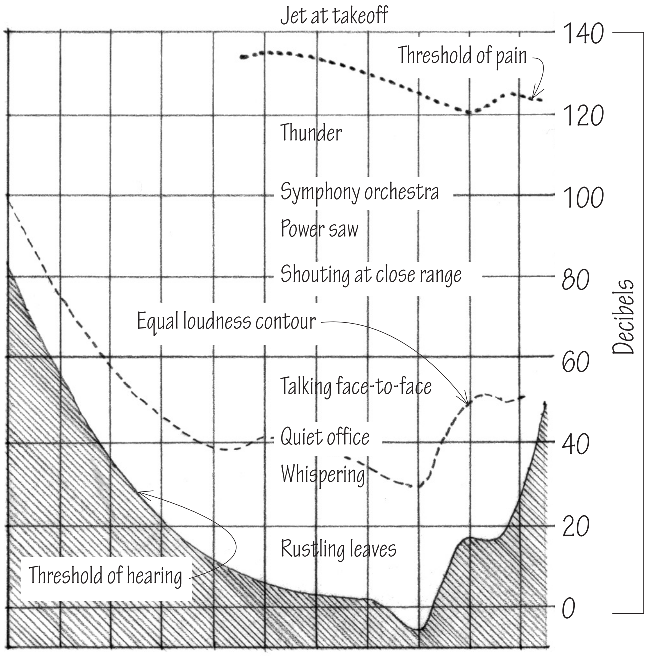
The requirements for sound level, reverberation time, and resonance vary with the nature of the activity and the types of sounds generated. An acoustical engineer can determine the acoustical requirements for a space. The interior designer should be aware of how the selection and disposition of reflective and absorbent materials affect the acoustical qualities of a room.

Acoustical design is becoming integrated into the best design practices, with designers thinking through how to integrate better acoustics into all kinds of spaces earlier in the design process. Some states are adopting new acoustic standards for classroom acoustics. As the population continues to age, hearing issues are taking a greater importance.

*Decibel* (dB) is a unit expressing the relative pressure or intensity of sounds on a uniform scale, from 0 for the least perceptible sound to about 130 for the average threshold of pain. Because decibel measurement is based on a logarithmic scale, the decibel levels of two sound sources cannot be added mathematically. For example, 60 dB + 60 dB = 63 dB, not 120 dB.

An equal loudness contour is a curve that represents the sound pressure level at which sounds of different frequencies are judged by a group of listeners to be equally loud.

A *sone* is a unit for measuring the apparent loudness of a sound.



Audio frequencies from 15 Hz to 16,000 Hz

## Noise

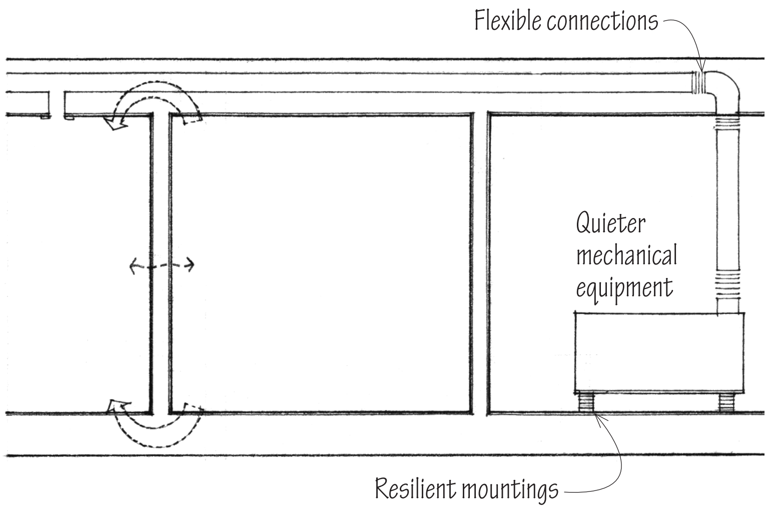
We refer to unwanted, annoying, or discordant sounds as noise. Noise from outside of a space can be controlled in the following ways:

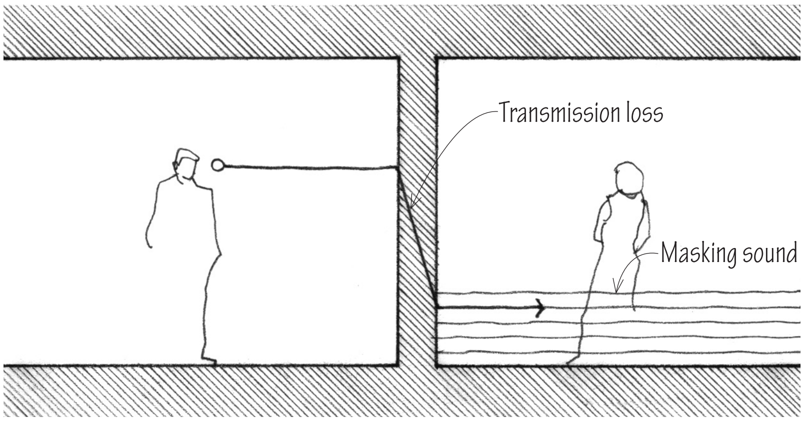
- Isolate the noise at its source.
- Locate noisy areas as far away as possible from quiet areas.
- Reduce the transmission of sound from one space to another.

Noisy spaces significantly impact the way our brains and bodies function. Excess noise in school environments has been shown to slow cognitive development. In hospitals, noise has been found by a University of Chicago Medical Center study to disrupt the sleep needed for recovery of four out of ten patients. Both LEED and WELL standards take noise into consideration. Office noise can both distract and annoy, and overheard conversations in an office setting can reduce worker productivity. Doing an acoustic analysis of the design has become a critical part of any design solution for most commercial building types. Newer acoustical products are designed to blend with other interior elements.

## Isolating Sound

Sound can be transmitted through air as well as through the solid materials of a building's structure. Because structure-borne sounds are difficult to control, they should be isolated at their source whenever possible. Strategies include using quieter mechanical equipment, using resilient mountings and flexible connections to isolate equipment vibrations from the building structure, and eliminating flanking paths along interconnecting ductwork or piping that the noise can take from its source to the space.





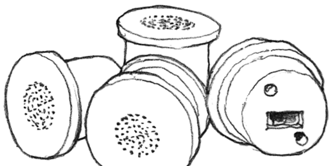

Noise reduction refers to the perceived difference in sound levels between two enclosed spaces. Noise reduction depends on the following:

- The transmission loss through the wall, floor, and ceiling construction.
- The absorptive qualities of the receiving space.
- The level of masking or background sound, which can increase the threshold of audibility for other sounds in its presence.

Background or ambient sound from both exterior and interior sources is normally present in an environment. Background sound is not distinctly identifiable by the listener. A type of background sound called white noise is sometimes deliberately introduced into a space to mask or obliterate unwanted sound.

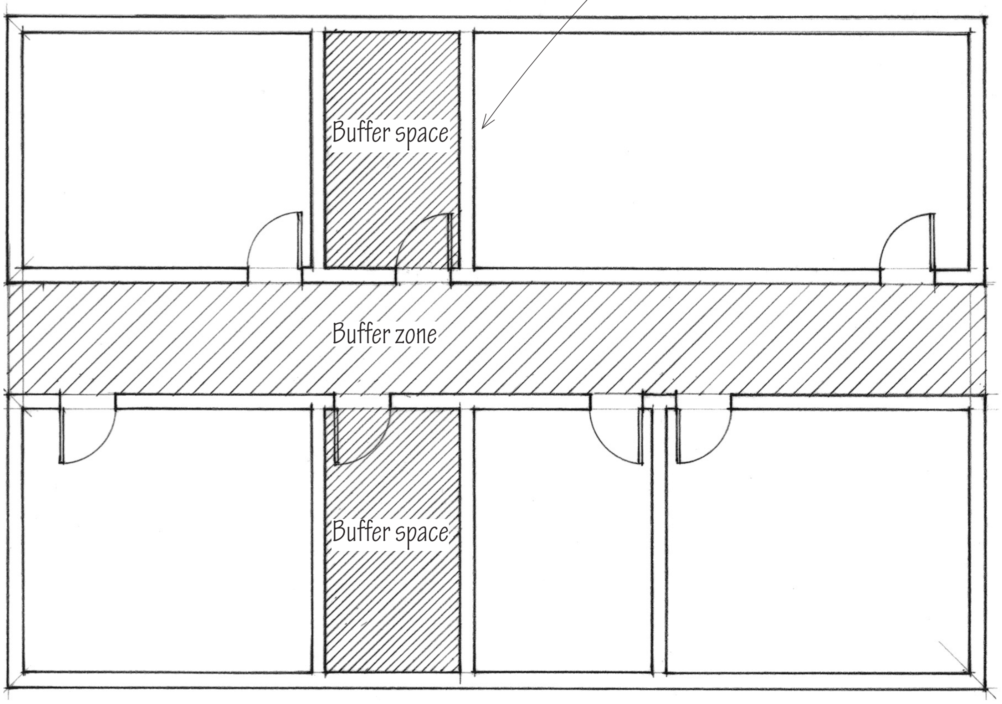
The required noise reduction from one space to another depends on the level of the sound source and the level of sound intrusion that may be acceptable to the listener.

Every material has acoustic implications, and any finish or object in a space can absorb, block, or transmit sound. Some furniture makers are creating product lines that use contemporary aesthetics to address noise reduction with acoustic space dividers and privacy pods. However, acoustic control with furnishings and panel systems, along with quieter HVAC systems like chilled beams, can sometimes make a space too quiet for comfort, where even quiet sounds are a disturbance.



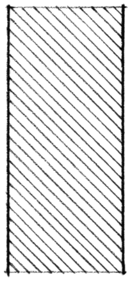
Masking sound devices

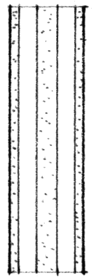
Creating zones for activities according to sound levels, by isolating quiet areas from noisier ones or separating them with mass or distance, can be an effective method of noise reduction.

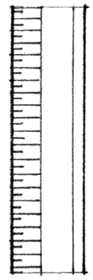


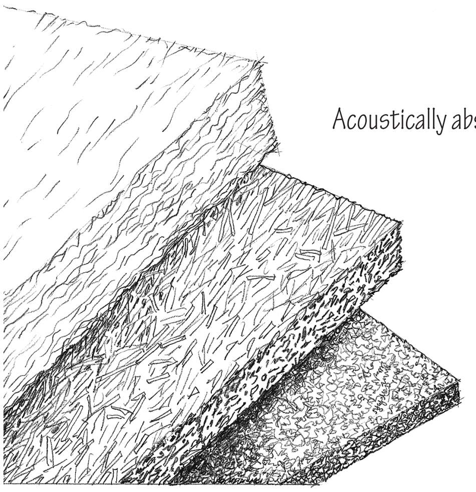
*Transmission loss (TL)* is a measure of the performance of a building material or construction assembly in preventing the transmission of airborne sound. Three factors enhance the TL rating of a construction assembly:

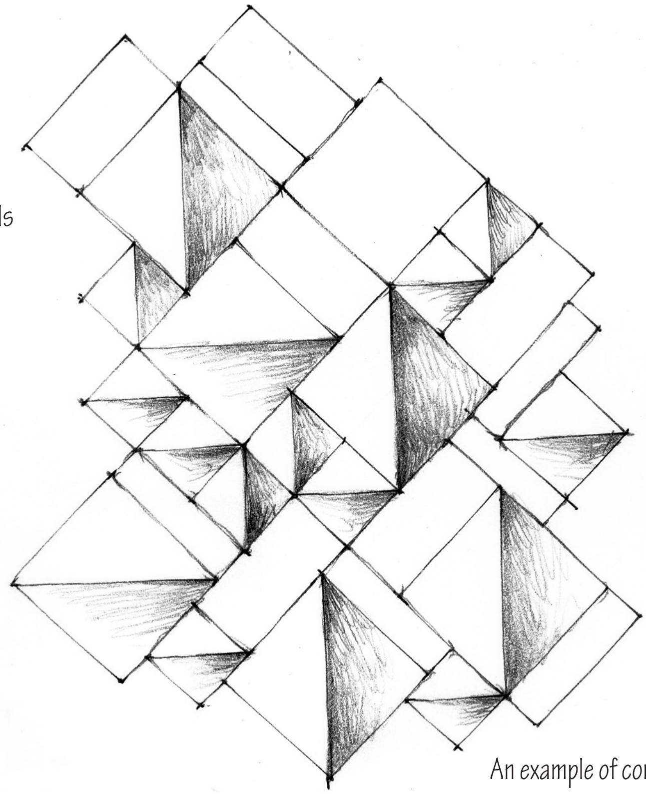
- Mass: In general, the heavier and more dense a body, the greater is its resistance to sound transmission.
- Separation into layers: Introducing air spaces into the construction assembly disrupts the path through which sound may be transmitted from one space to another.
- Absorption: Absorptive materials help to dissipate sound in a room.


Mass

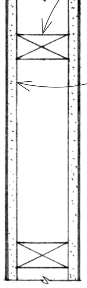

Layers


Absorption

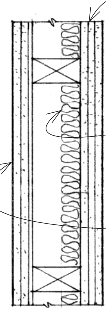

Acoustically absorptive materials


An example of commercially available acoustical panels

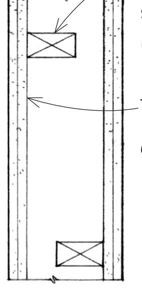
A *sound transmission class* (STC) rating is a single number that combines TL values from many frequencies. The STC provides an estimate of the performance of a partition in certain common sound insulation situations. The higher the STC rating, the greater is the sound-isolating value of the material or construction. An open doorway has an STC rating of 10; normal construction has STC ratings from 30 to 60; special construction is required for STC ratings above 60.



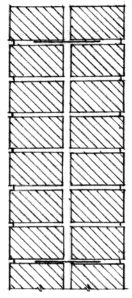
STC: 30–34



STC: 60–64



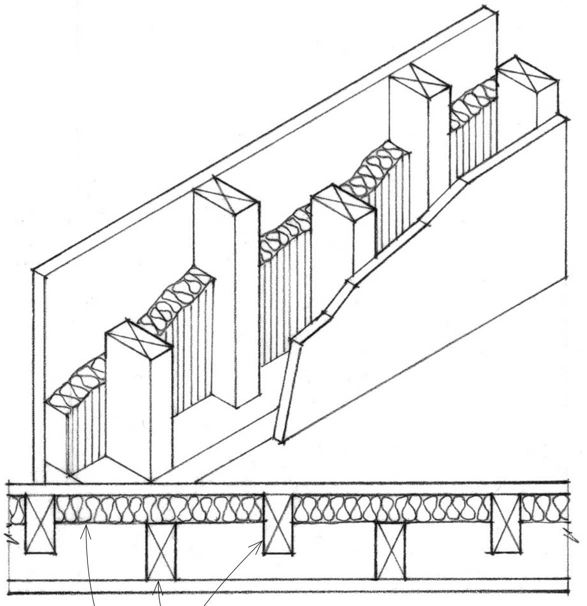
STC: 50–54



STC: 52

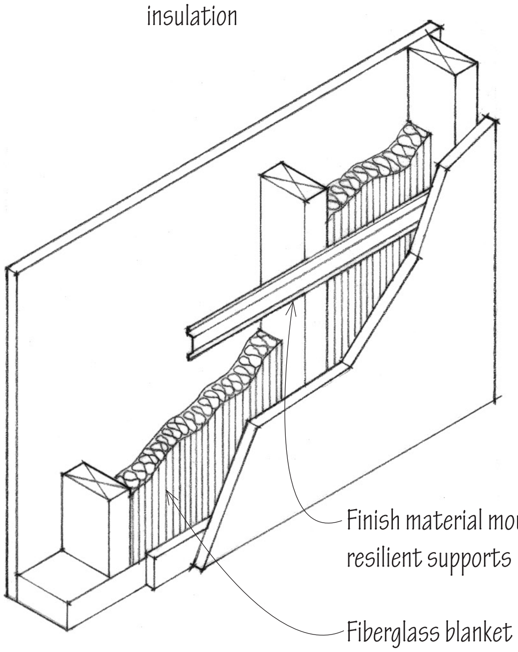
Staggering the studs of a wall or partition—forming two separate rows of studs arranged in a zigzag fashion—breaks the continuity of the path through which structure-borne sound can be transmitted.

Installing a fiberglass blanket in between the two rows of studs increases the transmission loss.

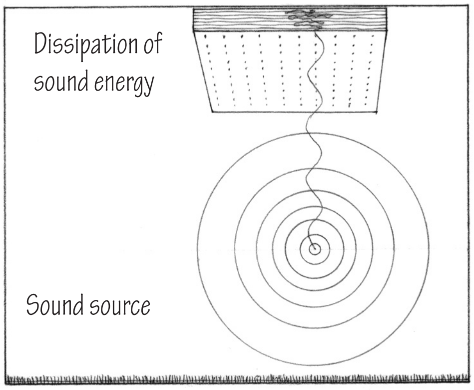



Mounting the finish material on resilient channels permits the surface to vibrate without transmitting noise to the supporting structure.

Sound can be transmitted through any clear air path, even the tiniest cracks around doors, windows, and electrical outlets. Careful sealing of these openings can prevent airborne noise from entering a room.

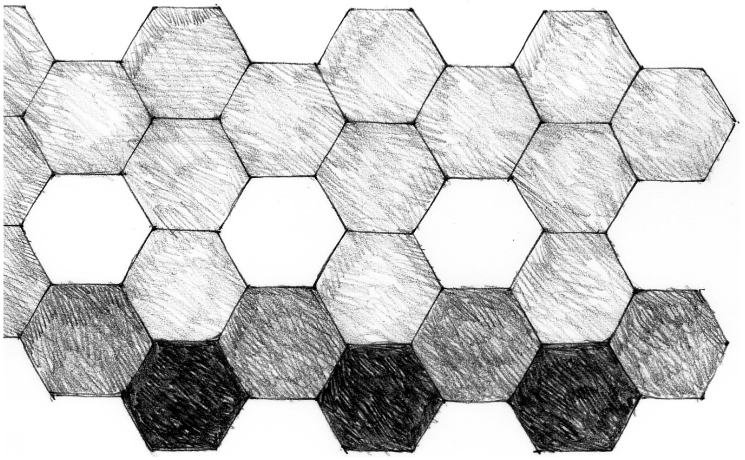


The sound-absorptive qualities of a material depend on its thickness, density, porosity, and resistance to airflow. Fibrous materials allow the passage of air while trapping sound energy, and are therefore often used in acoustic materials such as batts and blankets of fiberglass or mineral fiber.



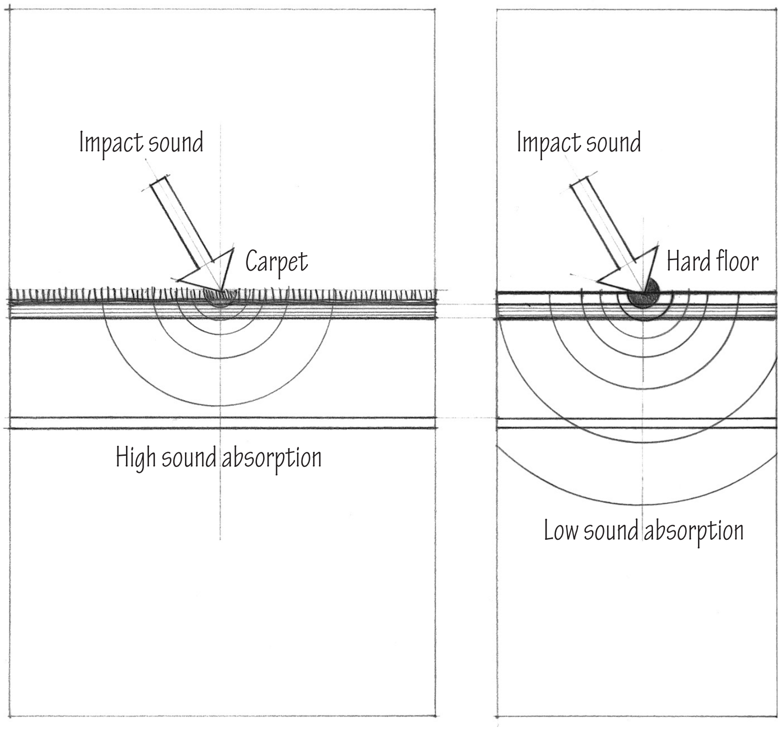

In a normally constructed room without acoustical treatment, sound waves strike the wall, ceiling, and floor surfaces, which then transmit a small portion of the sound to adjacent spaces. The room surfaces absorb another small amount of the sound, but most of it is reflected back into the room.

Absorptive materials can dissipate some of the incident sound energy and reduce the portion of sound transmitted. This is particularly helpful in spaces with distributed noise sources, such as offices, schools, and restaurants.


Acoustical wall panels

Reducing reverberation from the ceiling plane is usually the most common approach to sound control in a room. Acoustical ceiling tiles are excellent absorbers of sound. They absorb more sound when mounted in a suspended ceiling system than when attached directly to a surface. Perforated metal ceiling panels with acoustic backing and acoustical ceiling panels made of bonded wood fibers also work well to control noise.

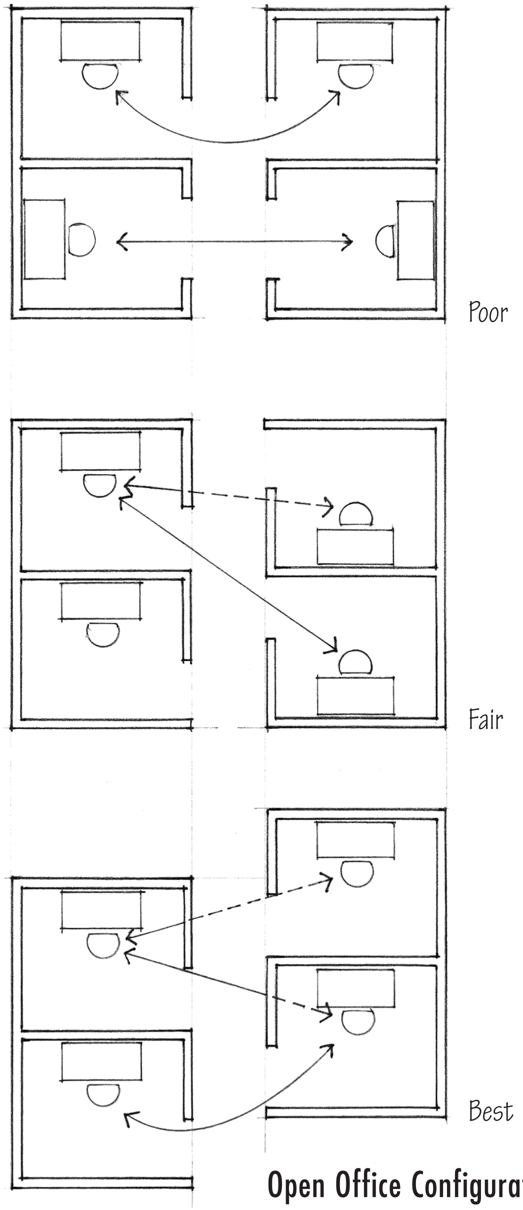
Treating walls and floors also helps to control sound. Acoustical wall panels can accomplish this, and may be made of felt or have fire-rated fabric coverings. Acoustical room dividers are becoming increasingly common, including ones designed as blinds that can open or close with a simple twist. Felt wall covering panels are also available for acoustical control.




Carpet is the only floor finish that absorbs sound. In addition, it can cushion footfalls and the sounds of furniture movement, thus limiting transmission of impact noise to the space below.

The average coefficient of absorption measures how efficiently materials in a room absorb sound; the lower the rating, the more sound is being absorbed.

The sound absorption average (SAA) is the average of sound absorption coefficients at a range of frequencies. Manufacturers list SAA ratings for acoustic products; some may use older noise reduction coefficient (NRC) ratings, which are similar.




Open Office Configurations

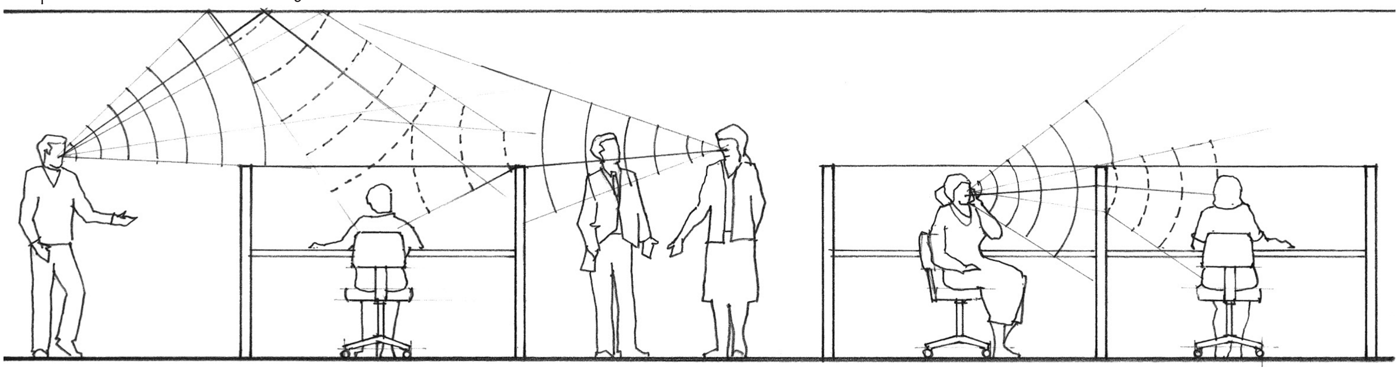
Acoustic privacy continues to be a desired trait for office workers, as well as for those who telecommute. Material choices and room typologies affect the sound of a space, as well as employee health and comfort. Open-plan offices can have detrimental effects on acoustic privacy and speech intelligibility.

Office workstations or cubicles do not usually have full-height partitions, and noise can be a problem. Office cubicles often use acoustical material to absorb some of the sound, but sound often travels through cubicle openings and over the tops of low walls. Locating workstations carefully can help to block some of this sound.

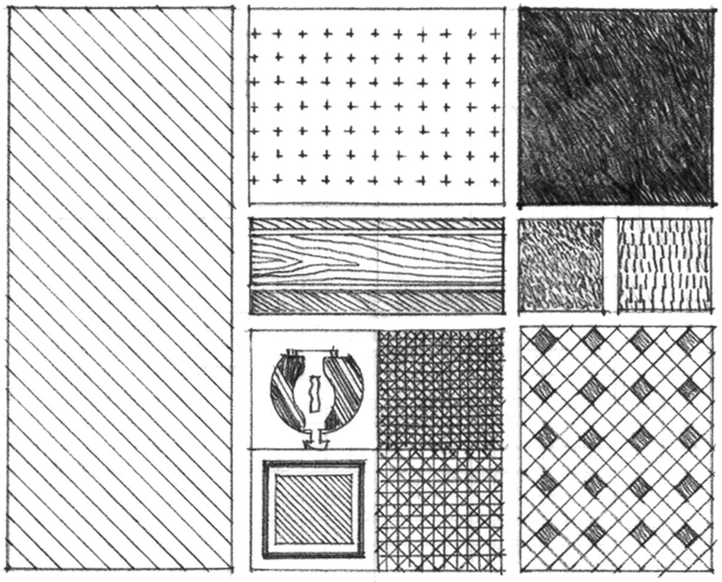
A significant amount of the sound in offices is reflected off the ceiling. A suspended acoustical tile ceiling will absorb unwanted sound. Where an open ceiling is desired, acoustical clouds or canopies over noisy areas can help control sound levels. Combining ceiling and wall treatments with careful siting of furnishings helps to keep sounds from spreading.

The intrusiveness of overheard speech is related to its intelligibility. Electronic sound-masking systems can help to reduce the intelligibility of overheard speech by raising the ambient noise level of an otherwise quiet space. Emitting sound that is often compared to whooshing air, sound masking systems are engineered to block the frequencies of human speech, keeping a neighbor's conversations from distracting an individual from his or her task. Systems are available as networks of 3-inch speakers that are installed in the ceiling and project sound directly into the workspace. They are particularly desirable for unfinished or exposed ceilings.

Suspended acoustical tile ceilings can absorb unwanted sounds.

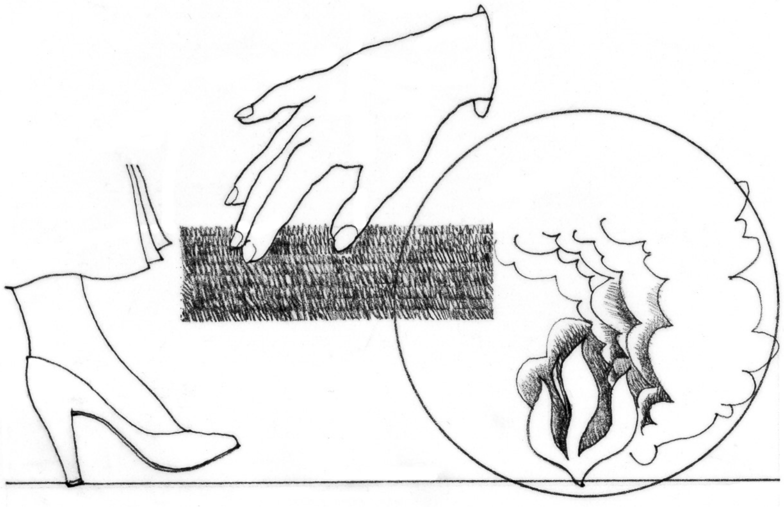


Open Office Acoustics



# 7

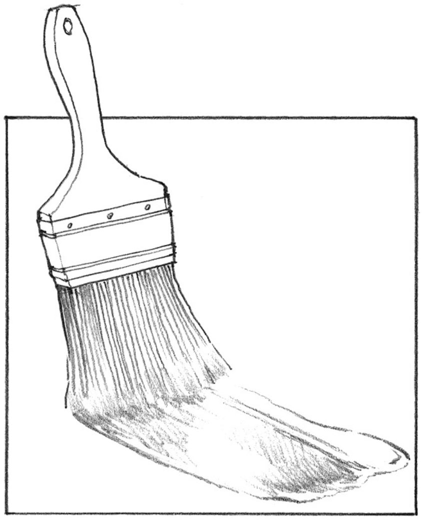
# Finish Materials



Finish materials may be an integral part of the architectural assemblies that define an interior space, or they may be added as an additional layer or coating to the constructed walls, ceiling, and floor of a room. In either case, they should be selected with the architectural context in mind. Together with furnishings, finish materials play a significant role in creating the desired atmosphere in an interior space.

The search for new finish materials can begin in trade and general design magazines. The Internet is next, starting with design blogs easily bookmarked for future reference. A Pinterest account provides the option to establish boards to organize "Pins" for inspiration—and to keep track of *furniture, furnishings, and equipment* (FF&E) as well as finishes you want to remember—is also a help. Design trade shows and fairs—including those beyond your immediate location—are another great source of inspiration. If you cannot attend in person, follow up with press accounts. Follow trends in related fields, such as fashion and industrial design, and the world at large.

*Faux finishes* imitate natural materials. Manufacturers are introducing faux finishes that perform better than the real thing, such as onyx-like surfacing that is scratch, stain, and heat resistant.



Today, handcrafted finish materials are providing options for designers who want products that say something about clients as individuals. Many craftspeople rely on social media to publicize their products.

## Functional Criteria

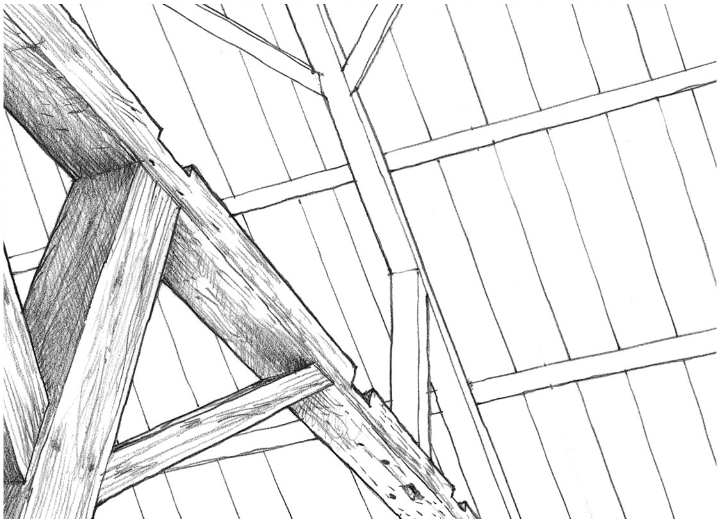
Hydrophobic properties have begun to take their place among the functional criteria for interior finish materials. What is called the Lotus Effect derives from the property of lotus plant leaves that are coated with tiny wax crystals, causing water to bead up and roll off, leaving no moisture behind. Scientists have applied nanotechnology to the lotus effect to produce a variety of products, including self-cleaning paint that washes itself clean with rain; countertops, tiles, and appliances that repel liquids; floors that resist dirt, oil, and foods without wax or silicone sealants; fabrics that will not allow penetration by dirt, water, and oils; wall coverings that resist moisture, fire, and chemicals; and carpets that help clean air of household odors.

The phenomenon that keeps a shark's skin free of barnacles or algae is being used to develop germ-resistant surfaces with little water resistance, properties of great value in kitchen and healthcare design.

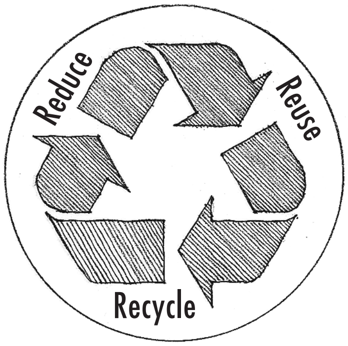
Other functional criteria include:
- Safety, health, and comfort
- Durability in anticipated use
- Ease of cleaning, maintenance, and repair
- Required degree of fire resistance
- Appropriate acoustic properties

## Aesthetic Criteria
- Color, natural or applied
- Texture
- Pattern

## Economic Criteria
- Initial cost of acquisition and installation
- Life-cycle assessment (LCA) of materials and products, including environmental and health impacts, from acquisition of raw materials through end-of-use recovery

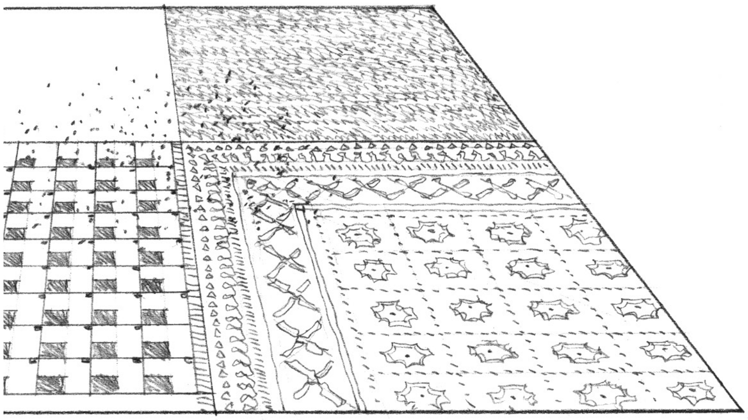


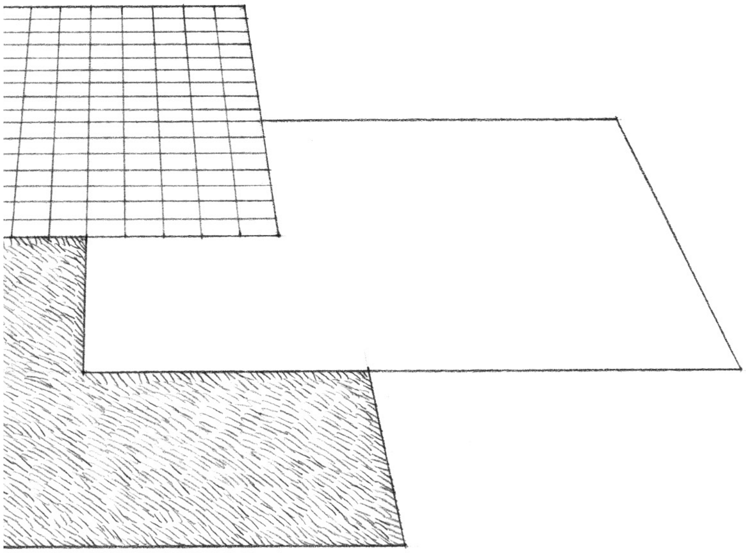
Recycling of timber

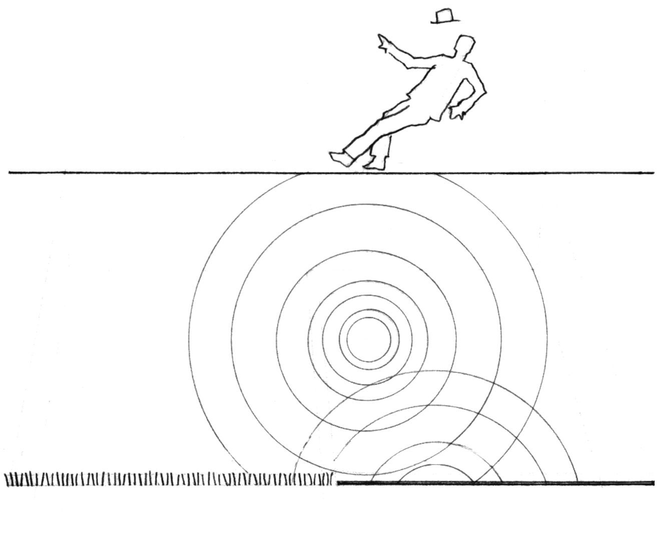



Logo of the Forest Stewardship Council

## Sustainable Design Criteria
- Minimization of new materials and reuse of existing materials
- Use of materials with recycled content
- Use of rapidly renewable and certified sustainable materials from local sources
- Use of products from manufacturers who use sustainable processes
- Minimization of waste in construction, installation, and packaging
- Durability and flexibility of use
- Reduction of *embodied energy* used in processing and shipment
- Avoidance of toxic materials







Finish flooring is the final layer of the floor assembly. Because flooring is subject to direct wear and represents a major portion of a room's surface area, it should be selected with both functional and aesthetic criteria in mind.

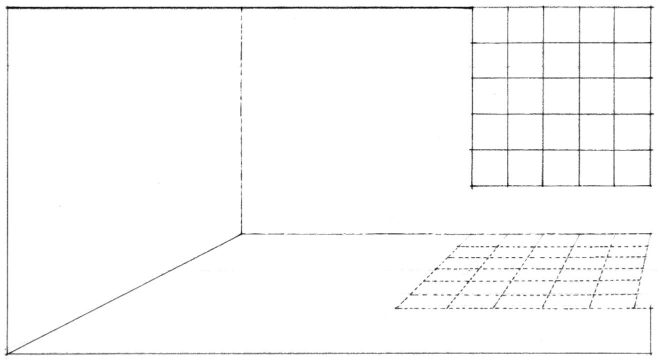
- Durability: Resistance to physical abrasion, denting, and scuffing.
- Ease of maintenance: Resistance to dirt, moisture, grease, and staining, especially in work and high-traffic areas.
- Foot comfort: This quality is related to the degree of resilience and—to a lesser degree—warmth.
- Slip resistance: Avoid hard, slick flooring materials, especially in areas susceptible to wetting.
- Impact noise: Resilient flooring can cushion some impact noise. Soft or porous flooring materials reduce impact noise and airborne sound.

The dirt that normally collects on a floor can be disguised by a mixture of neutral colors of middle value, a pattern that camouflages any dirt and surface marks, or a material whose natural color and texture is more noticeable than any dirt on the floor.

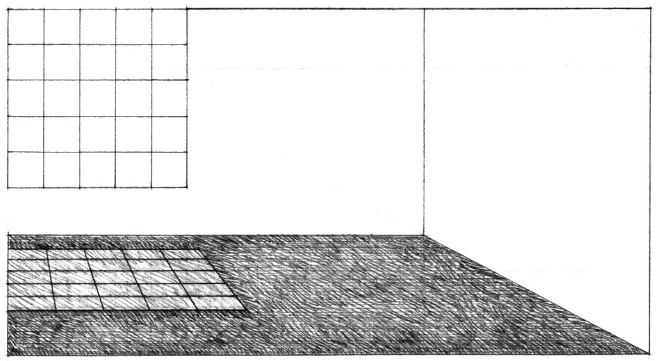
The warmth of a floor may be real or apparent. A flooring material may be warmed by radiant heat and kept warm by its own thermal mass or by insulating the floor. The flooring may appear warm if it has a soft texture, a middle-to-dark value, or a warm hue. Of course, in warm climates, a cool floor surface would be more comfortable than a warm one.

Electrostatic discharge (ESD) is the phenomenon that produces a mild jolt of electricity from static electricity when you touch a metal doorknob after walking across a carpeted floor. Today, the rapid proliferation of electronic devices has led to higher sensitivity to ESD control in any company that desires to successfully manufacture and deliver undamaged electronic parts. The need for dissipative flooring solutions has taken on added significance. Common materials that may carry an electrostatic charge include waxed, painted, or plastic work surfaces; waxed, common vinyl tiles, or sealed concrete floors; clothing; vinyl, fiberglass, or finished wood chairs; common plastic bags, foam, trays or tote boxes; and assembly equipment. Once established, a material becomes electrostatically charged if it is not grounded or dissipated naturally over time. It can then be transferred from the material to create an ESD event. ESD has the potential to disrupt the normal operation of an electronic system and cause degradation, destruction, failure, or malfunction of equipment.

ESD assessments should be conducted under the advisement of a qualified and certified professional. Many flooring products are designed to be used in conjunction with other wearable antistatic products. Various types of ESD flooring can minimize static charge generation and drain static electricity from occupants of spaces at risk for an ESD event. They are available as vinyl tiles/sheets, vinyl composition tile, rubber, or carpet flooring products.



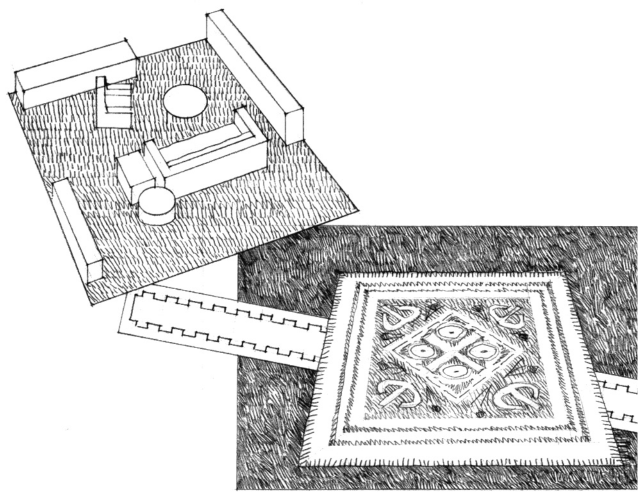
The floor can play an active role in determining the character of a space through its color, pattern, and texture.



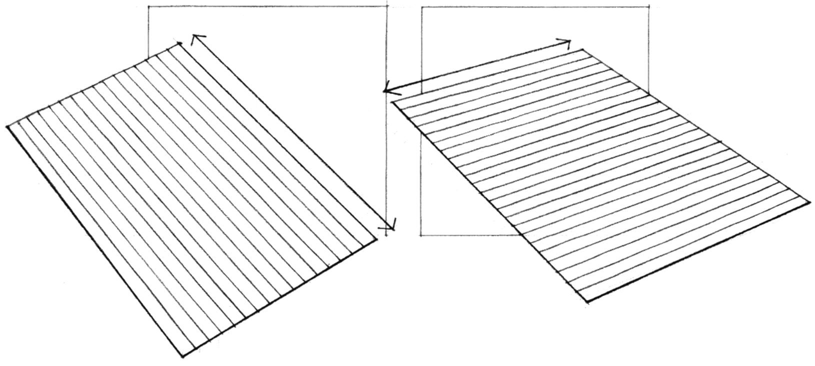
A light-colored floor will enhance the light level within a room, while a dark floor will absorb much of the light falling on its surface. A light color suggests spaciousness and emphasizes the smoothness of polished floors. A dark color gives a floor plane depth and weight.

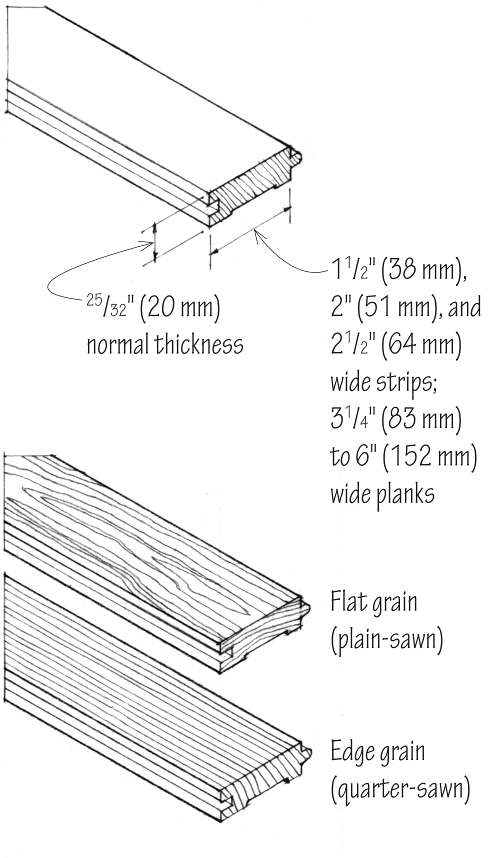
Unlike the wall and ceiling surfaces of a room, a floor transmits its tactile qualities—its texture and density—directly to us as we walk across its surface. The physical texture of a flooring material and the way it is laid are directly related to the visual pattern created.

A neutral, patternless floor can serve as a simple background for a room's occupants and furnishings, but through the use of pattern, a floor can also become a dominant element in an interior space. The pattern can be used to define areas, suggest paths of movement, or provide textural interest.

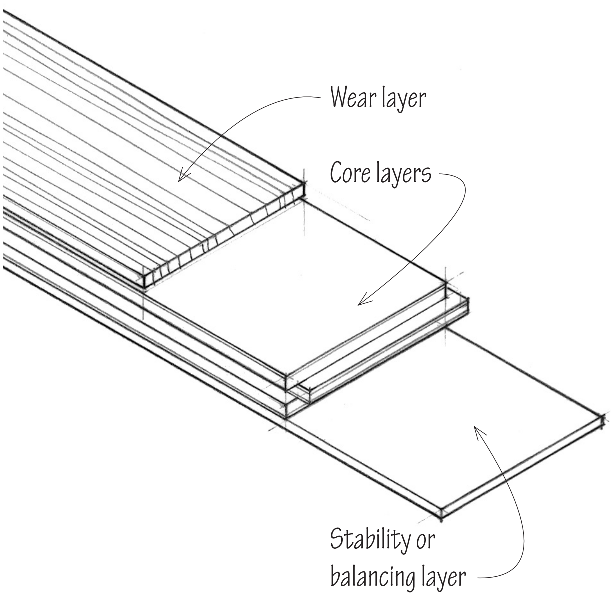


Our perception of a flooring pattern is affected by the laws of perspective. Thus a small-scale pattern may be seen as a fine texture or a blended tone, rather than as a composition of individual design elements. In addition, any continuous linear elements in a flooring pattern will dominate. Directional patterns can affect the apparent proportion of a floor, either exaggerating or foreshortening one of its dimensions.






Solid Wood Flooring




Laminated Wood Flooring

Finish flooring is usually separated into hard flooring such as wood, stone, and tile; resilient flooring such as linoleum or cork; and soft floor coverings, which consist primarily of carpets and rugs.

Of the hard floor finishes, wood flooring is admired for its warm, natural appearance and its attractive blend of comfort, resilience, and durability. It is also fairly easy to maintain under moderate use and, if damaged, can be refinished or replaced.

Durable, close-grained species of hardwoods (white and red oak, maple, birch, beech, and pecan) and soft woods (Southern pine, Douglas fir, Western larch, hemlock, and others) are used for wood flooring. Of these, oak, Southern pine, and Douglas fir are the most common. The best grades are clear or select, which minimize or exclude defects such as knots, streaks, checks, and torn grain.

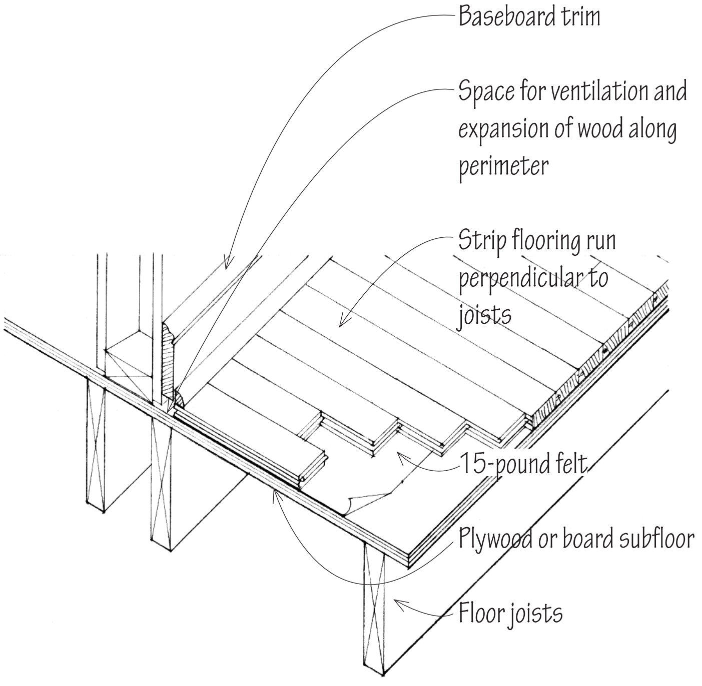
Woods used for flooring should be from certified sustainable sources. Rare or exotic species should be avoided. Antique or reclaimed wood flooring, retrieved from buildings that are about to be demolished, offers a distinctive character and patina.

Other types of wood used for flooring include bamboo and antique or reclaimed wood flooring. Bamboo is technically a grass, and its ability to regrow quickly after harvesting has earned it a reputation as a sustainable material. Bamboo flooring was originally laminated with a urea-formaldehyde adhesive. Today, much less toxic glues provide the same strength and finish, making bamboo floors available in virtually the same styles and finishes as hardwoods. Bamboo floors are available in three types of grains: strand-woven grain, vertical or edge grain, and horizontal or flat grain.

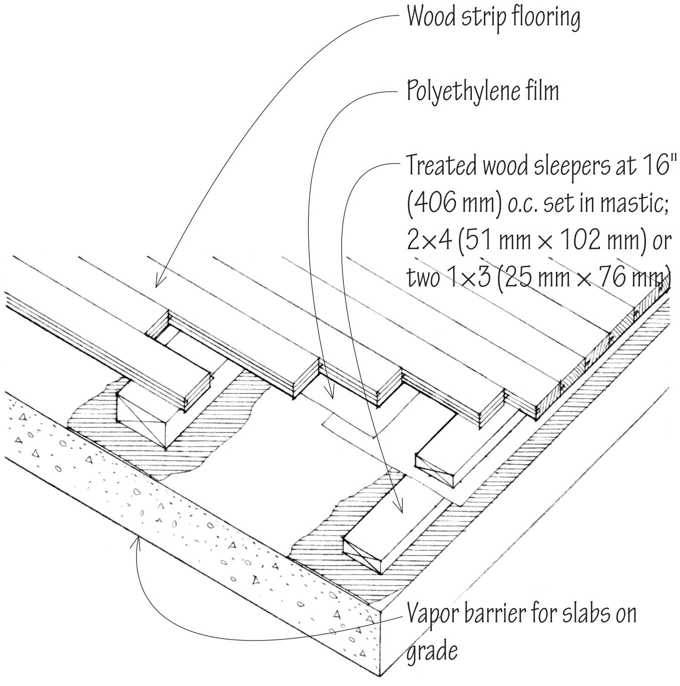
Solid wood flooring is available in strips and planks. Board flooring is usually sold in the form of narrow strips, although planks up to 6 inches (152-mm) wide are also available.

Engineered hardwood flooring is impregnated with acrylic or sealed with urethane or vinyl. Laminated flooring assembles high-pressure laminates, including wood veneers, into durable, acrylic-urethane sealed panels. Bamboo is also laminated under high pressure, milled into planks, immersed in polyurethane, and coated with acrylic polyurethane. Most bamboo products must travel long distances to reach the U.S. market.

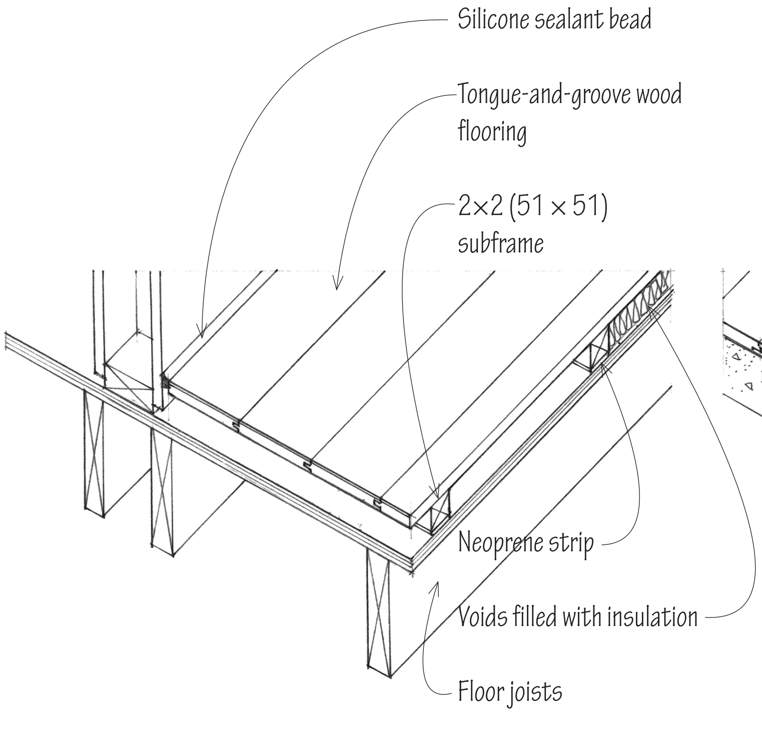
Wood flooring is most often finished with clear polyurethane, varnish, or a penetrating sealer. Finishes can range from high gloss to satin. Ideally, the finish should enhance the durability of the wood and its resistance to water, dirt, and staining, without concealing the wood's natural beauty. Stains are used to add color to the natural color of the wood without obscuring the wood grain. Wood flooring can also be waxed, painted, or stenciled, but painted surfaces require more maintenance.



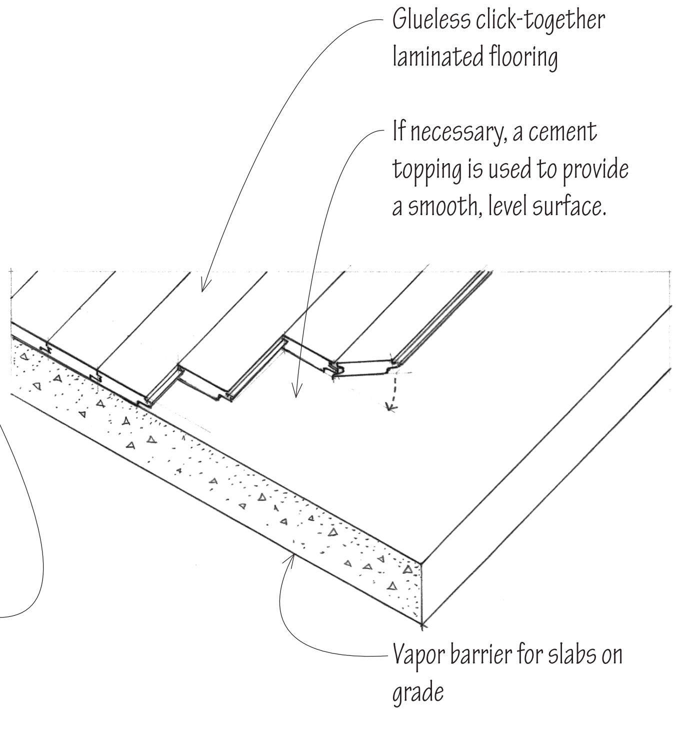

Wood Flooring over a Subfloor and Joists



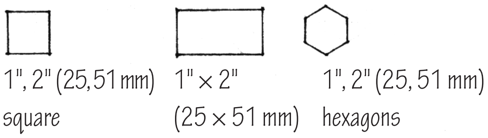

Wood Flooring over a Concrete Slab

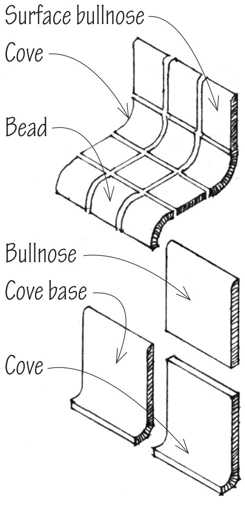



Floating Wood Flooring Installation

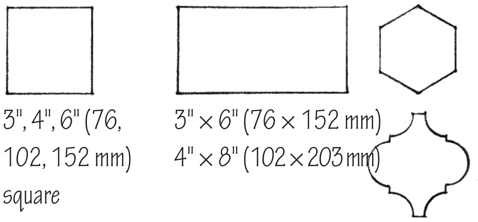



Glueless Laminated Wood Flooring Installation

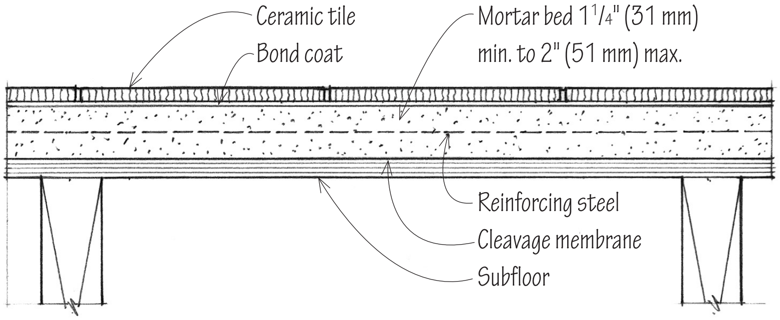


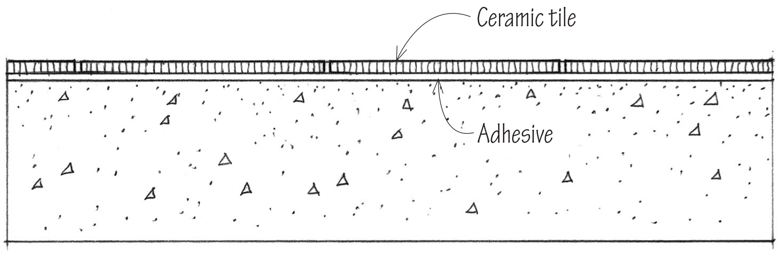

**Ceramic Mosaic Tile** —1/4" (6 mm) thick



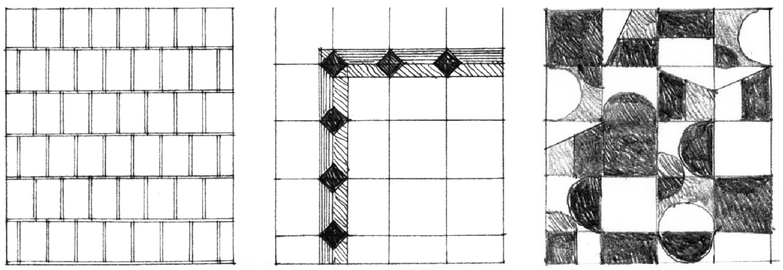

**Quarry Tile and Pavers** —3/8", 1/2", and 3/4" (10, 12 and 19 mm) thick




**Thickset Tile Installation**




**Thinset Tile Installation**



**Stone Flooring Patterns**

Tile and stone flooring materials are solid and durable. Depending on the shape of the individual pieces and the pattern in which they are laid, these flooring materials can have a cool, formal appearance or give a room an informal feeling.

Ceramic mosaic tiles—small, modular units of natural clay or porcelain—are widely used for flooring. The natural clay type is unglazed, with muted earth colors; the porcelains can have bright colors and are *vitreous* (glasslike, dense, and impervious).

Quarry tiles and pavers are larger modular flooring materials. Quarry tiles are unglazed units of heat-hardened clay. Larger-sized ceramic tiles are available in a range of patterns, some of which mimic natural stone or wood, and are practically impervious to moisture, dirt, and stains.

Stone tile flooring materials provide a solid, permanent, and highly durable floor surface. Types of stone commonly used for flooring include:

- Slate: Reddish browns, grays, greens, blues, and blacks. Available in square or irregular shapes, can be formal or informal.
- Marble: White, pinks, greens, browns. Shaded and striped. Lends itself to high polish and formal elegance.
- Granite: Over 200 colors. Polishes well, also honed or thermal finishes.

Tile installations are either thinset or thickset. Thinset installation uses adhesive to attach the tile. Thickset installation is used over floors subject to bending and deflection. The tile is set on a layer of mortar that helps prevent cracking.

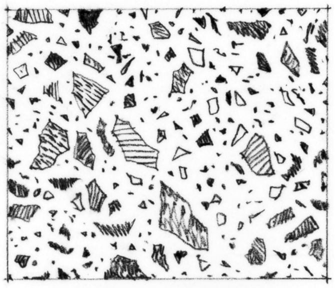
Tile or stone flooring is set in grout. Grout is available in a variety of colors and can be selected to blend or contrast with the flooring material.

Current trends in tile include wood, steel, stone, and concrete-effect tiles; geometric forms including hexagons; references to contemporary art; mirrored and metallic surfaces; and raised surfaces that mimic motion. Glazed porcelain tiles are available in solid blocks of color or abstracted graphic designs.

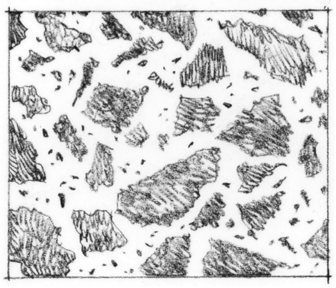
Concrete can be used as a finish floor surface if smooth and level enough. It should be sealed against stains and grease. Concrete can be painted, stained, or integrally colored when cast. An exposed aggregate finish can provide textural interest.

Terrazzo is a special type of exposed aggregate finish with mosaic-like patterns created by marble chips. It is available in poured or precast forms. Standard terrazzo has a ground and polished finish consisting mainly of relatively small stone chips, with resin or cement-based binders. Designer or exotic terrazzo use specialty aggregates with epoxy resin binders. Venetian terrazzo has large stone chips, with smaller chips filling spaces. Palladiana terrazzo consists of cut or fractured marble slabs set by hand into a pattern, with smaller chips set into the spaces between. Rustic terrazzo has a uniformly textured finish that exposes rough chips and is primarily for exterior use.

Seamless, durable fluid-applied flooring materials are used for commercial, industrial, and institutional installations. The flooring materials are poured over concrete or other rigid *substrates*. Seamless quartz flooring consists of colored quartz aggregates in clear or colored epoxy.



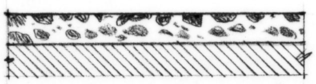
**Standard terrazzo** is a ground and polished finish that consists mainly of relatively small stone chips.



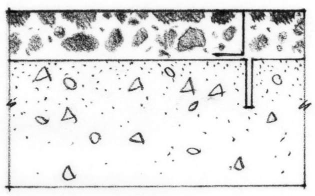
**Venetian terrazzo** consists mainly of large stone chips, with smaller chips filling the spaces between.

## Types of Terrazzo

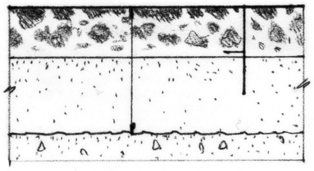
**Thinset Terrazzo**
$^1/_4$" to $^1/_2$" (6 to 13 mm) epoxy terrazzo topping is placed over a wood, metal, or concrete subfloor.

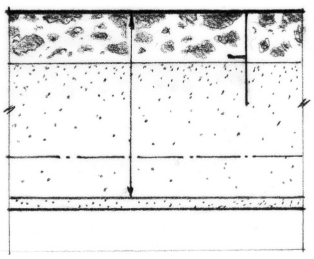


**Monolithic Terrazzo**
$^1/_2$" (13 mm) thick cement matrix terrazzo topping is laid over a rough-finished concrete slab.

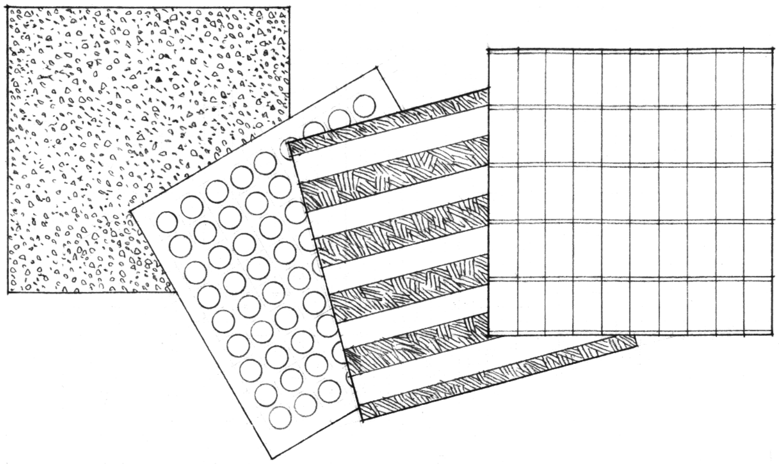


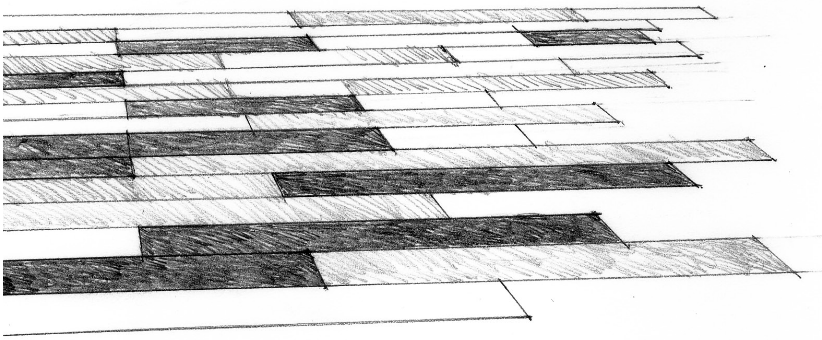
**Bonded Terrazzo**
$^1/_2$" (13 mm) thick cement matrix terrazzo topping and a sand-cement underbed are mechanically bonded to a rough-finished concrete slab.

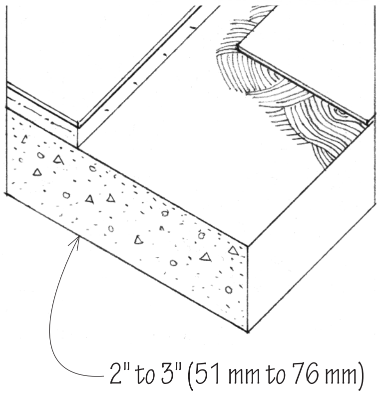




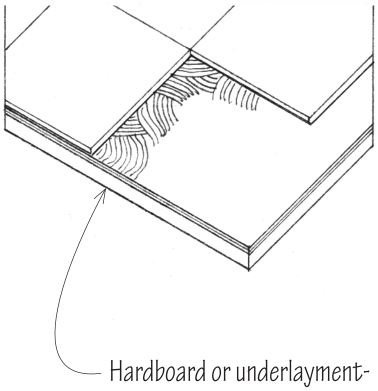
**Sand-Cushion Terrazzo**
$^1/_2$" (13 mm), $^5/_8$" (16 mm), or thicker cement matrix terrazzo topping is installed over a reinforced mortar underbed and an isolation membrane of sand to control cracking when structural movement is expected.







2" to 3" (51 mm to 76 mm) of reinforced concrete topping is required over precast concrete planks.



Hardboard or underlayment-grade plywood

Resilient flooring materials provide an economical, dense, nonabsorbent flooring surface with relatively good durability and ease of maintenance. Their degree of resilience enables them to resist permanent indentation while contributing to their quietness and comfort underfoot. The degree of comfort provided will depend not only on the material's resilience but also on the type of backing used and the hardness of the supporting substrate.

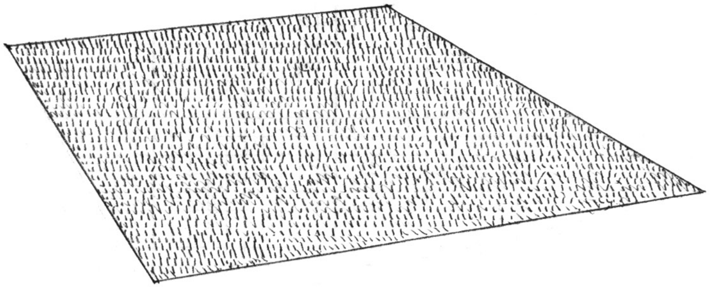
Linoleum and vinyl sheets come in rolls from 6 to 15 feet (1829- to 4572-mm) wide, as well as in square tiles and planks. They can be cut into patterns in the factory or the field. Resilient flooring materials are available as tiles, typically 12 inches (304-mm) square. While sheet goods provide a seamless floor, tiles are easier to install if the floor outline is irregular. Individual resilient tiles can be replaced if damaged.

Resilient flooring types vary in their performance and sustainability.

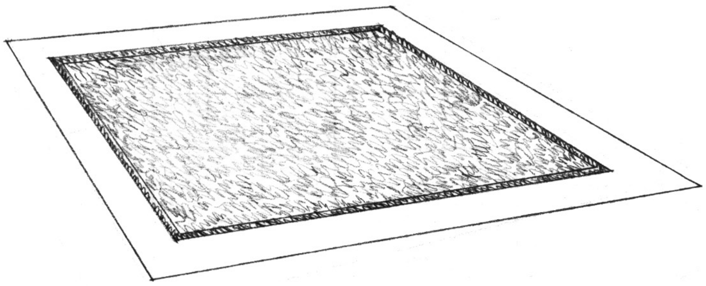
- Rubber tile (available in square tiles and planks), vinyl sheet, linoleum, and cork products offer the best resilience.
- Vinyl and linoleum sheets and tiles resist staining, grease, and cigarette burns well.
- Vinyl products, especially sheet materials, are not sustainable materials.
- Natural linoleum and cork are made of renewable materials and have lower VOC levels.
- The pattern on vinyl tiles and sheets can wear off, whereas linoleum and cork have consistent color throughout.
- Leather tiles, which are comparatively expensive, develop an attractive patina with time and use.

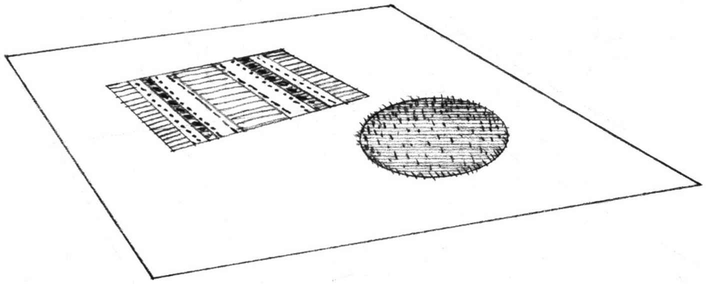
The wood or concrete substrate for resilient flooring should be clean, dry, flat, and smooth to prevent any irregularities in the base material from showing through. Resilient flooring materials are not designed to be laid over ceramic tile. Linoleum and cork tiles should not be laid below grade. Some resilient flooring materials come with their own adhesive for ease of application.

There are two major categories of soft floor coverings—carpeting and rugs. These coverings provide floors with both visual and textural softness, resilience, and warmth in a wide range of colors and patterns. These qualities enable carpeting to absorb sound, reduce impact noise, and provide a comfortable and safe surface to walk on. As a group, carpeting is easier to install than hard floor coverings, and is fairly easy to maintain in a relatively clean environment.



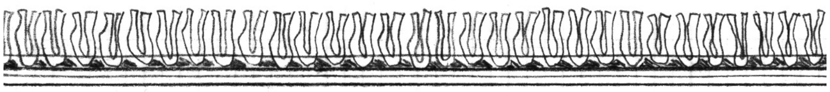
Nearly all of the many kinds of carpet are recyclable. Some face fibers can be broken down and used to make new product. Many companies that recycle carpet will also take carpet padding, which is recycled separately from carpet. Recycled carpet is usually turned back into plastic resin, which can be used to create other products, sometimes including new carpet. Carpeting is most often manufactured in 12-foot (3658-mm) wide rolls, referred to as broadloom. Some specialty carpet comes in widths up to 18 feet (5486-mm) wide. Woven carpet is also manufactured in 27- to 36-inch (6858- to 9144-mm) widths referred to as narrow goods or runners and typically used in residential installations.



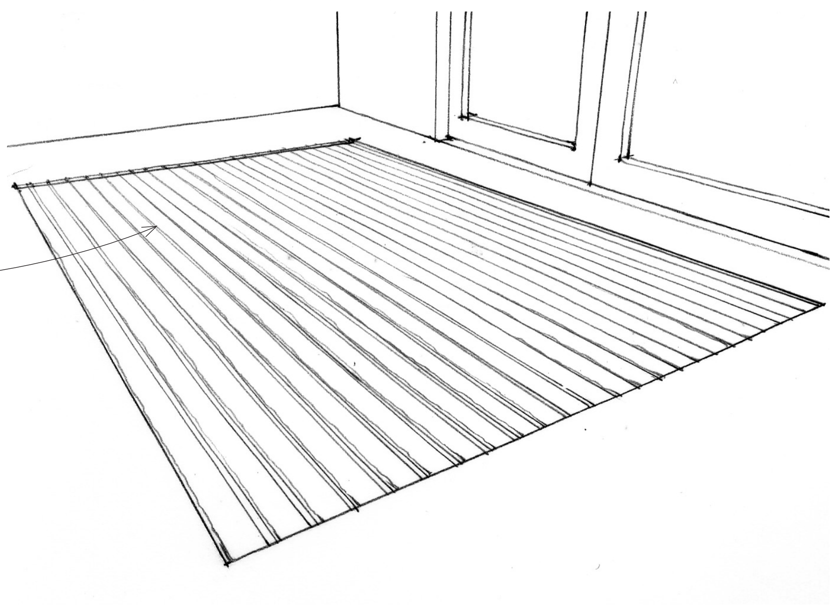


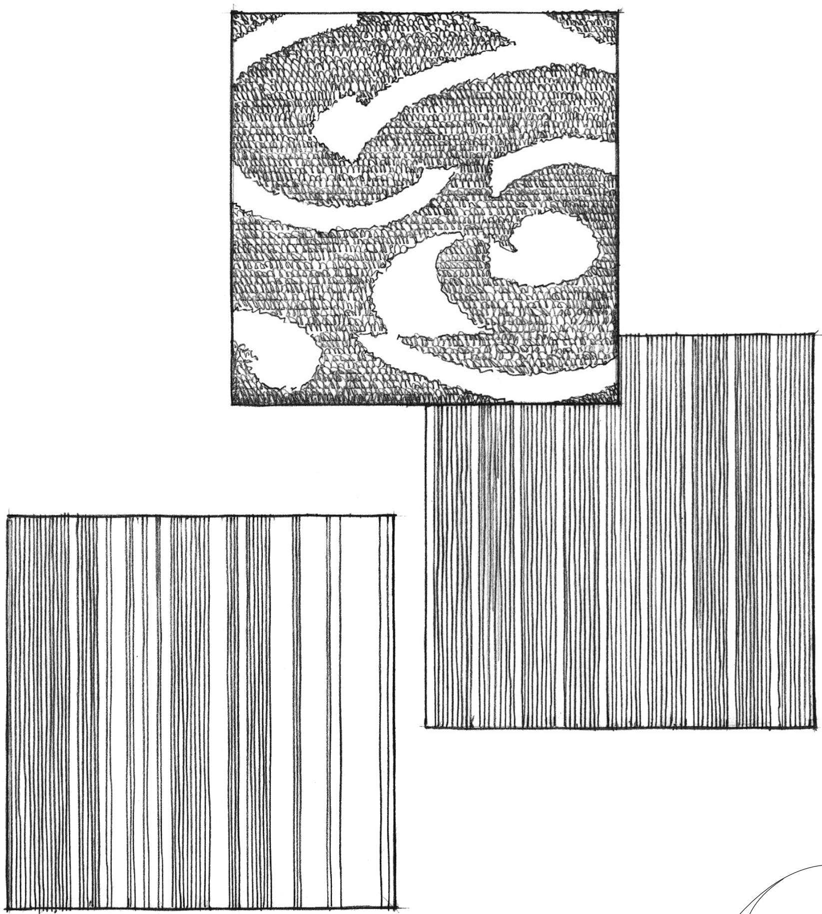
Broadloom carpet is sold by the square foot, cut to fit, and installed over cushion using tackless strips, or glued down using an adhesive. Carpeting normally is installed wall-to-wall, covering the entire floor of a room.

Because carpet is usually fastened to a floor, it must be cleaned in place and cannot be turned to equalize wear. The location of seams, the type of backing, and the technique used to seam carpet can have a substantial effect on the useful lifespan of a broadloom carpet.



Metal and fiber entrance matting systems are now available in a wider variety of options that keep entrances safe, dry, and clean. Some are soft and fibrous, while others have metal components.



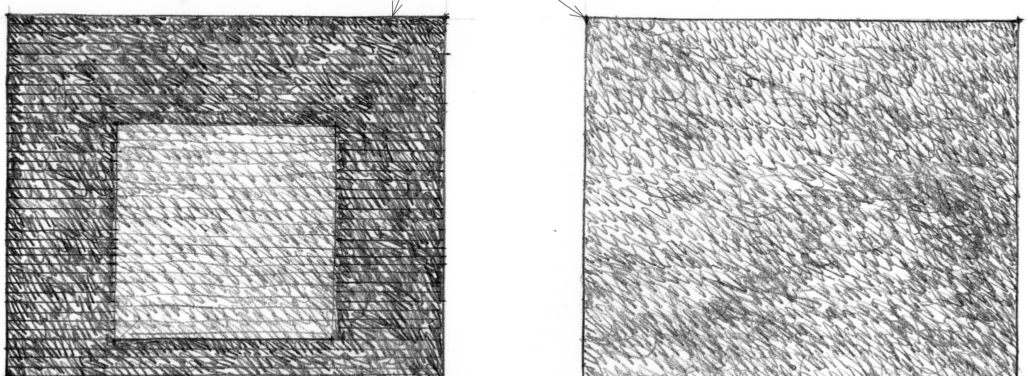


Carpet tiles are modular pieces of carpet that can be laid to resemble a seamless wall-to-wall installation or can be arranged in subtle or bold patterns. They are designed to be used in both residential and commercial settings. They are usually constructed by tufting, although some are made by fusion bonding. Carpet tiles offer the following advantages over broadloom carpet:

- They can be easily cut to fit odd-shaped contours with a minimum of waste.
- Individual tiles can be replaced if worn or damaged.
- They can be moved easily and reused.
- In commercial installations, the tiles can be removed for access to underfloor utilities.

Carpet tiles are available in a range of square sizes, as well as a growing variety of planks and other shapes. Tiles are designed to be free-laid on a subfloor with only the perimeter tacked in place with adhesive, fully glued down, or tacked in place with pressure-sensitive adhesive dots. Commercial-grade carpet tiles have a backing strong enough to prevent shrinkage or expansion of the tile and to protect the carpet edges from unraveling.

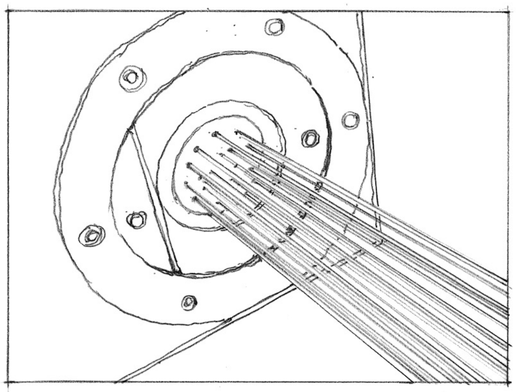
Textile composite flooring combines attributes of soft floor coverings with long-wearing performance qualities. It is available in 24-inch squares or planks.



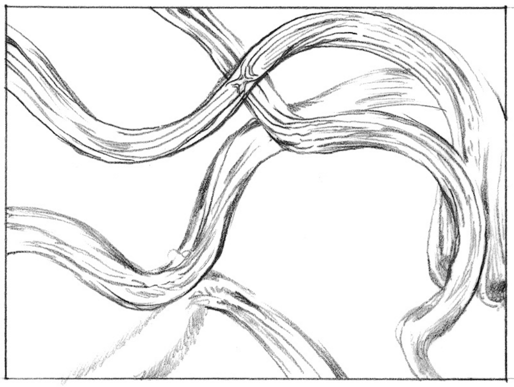
The performance of a carpet depends upon several factors, most importantly the type of fibers used. Each carpet manufacturer offers blends of the generic face fibers that improve on specific characteristics such as durability, soil resistance, cleaning ability, color, and luster.

## Carpet Fiber Types

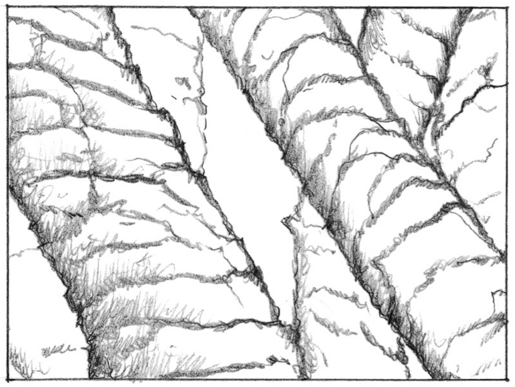
**Nylon** has excellent strength and wearing ability, is soil-, mold-, and mildew-resistant, and dries quickly. Solution-dyed nylon resists fading from sunlight and chemicals. Newer branded soft nylons with smaller-diameter fibers have increased nylon's desirability for residential use.
**PET polyester** is a durable form of polyester made from recycled plastic containers. It resists soiling, abrasion, stains, and fading.
**Olefin** (polypropylene) is colorfast and resistant to abrasion, soil, and mildew. Most olefin lacks nylon's resiliency and crush resistance, and is often used for indoor/outdoor carpets. A new type of olefin fiber is specially processed for softness, stain resistance, and durability.
**Wool** has excellent resilience and warmth, and good soil, flame, and solvent resistance. Wool is a sustainable material with an outstanding ability to absorb color. It cleans and maintains well, has superior long-term appearance retention, and ages gracefully.



A spinneret is a multipored device through which viscous plastic polymer is extruded into cool air or liquid to cool and form fibers.



Microscopic view of nylon fibers

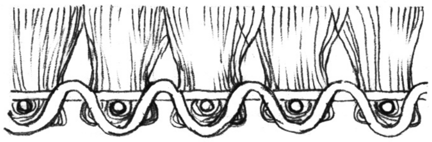


Microscopic view of wool fibers

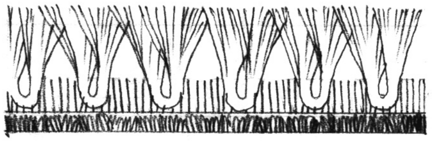
## Dye Techniques

**Solution dyeing** consists of adding dye to synthetic carpet fiber material before the yarn is extruded. This technique is the most colorfast and resistant to chemicals, gasses, bleaches, and sunlight.
**Continuous dyeing** involves applying dye to the open face of a carpet and setting it by steam injection. This is the least expensive dyeing method, but it is less colorfast and uniform.
**Piece or beck dyeing** consists of running white carpet with primary backing (called greige goods) through a large, shallow dye vat (beck) before the secondary backing is applied.
**Print or contact dyeing** can be used on almost any type of pile. This technique produces good colorfastness and penetration.

Tufted carpet



Woven carpet



Fusion-bonded carpet

## Tufted Carpet

Most commercial carpet is made by inserting tufts of yarn into a primary backing. A secondary backing may be added as a cushion and for greater dimensional stability.

## Woven Carpet

Made on looms, woven carpet is the product of a much slower and more expensive process than tufting. Axminster carpets, which are generally made of 100 percent wool or 80 percent wool and 20 percent nylon, are the most durable and long-wearing carpet type. They are often used in hospitality and residential applications. Wilton carpet is a decorative wool carpet used in homes. Both of these carpet types are woven through the back of the fabric and do not require a secondary backing.

## Fusion-Bonded Carpet

Fusion-bonded carpets are constructed in facing pairs with the pile embedded in the backing on each side, then cut apart to create cut pile. They are used for heavy foot traffic, such as in airport terminals.

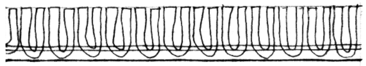
## Carpet Cushions

Carpet cushions add resilience, lessen impact noises, and can significantly extend the life of a carpet. They are most commonly used with residential carpets. However, some types will compress too easily and are not durable under heavy traffic.

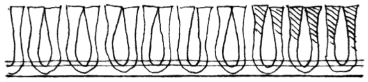
- Foam or sponge rubber pads have a synthetic facing laminated on top, and may break down with use.
- The backing of urethane foam pads breaks down with use, and they are not recommended for heavy traffic.
- Different colors and densities of foam scraps are bonded together and compressed to make rebounded pads, which have a top skin.
- Slab rubber contains less air and provides better resistance to furniture denting and crushing.
- Waffle rubber pans work well with humidity but not with dry air, and may be too soft.
- Jute, hair, synthetic, or recycled textile fibers are dense and used for area rugs and commercial carpet.
- Super-dense urethane frothed foam is extremely durable, and is used for woven carpets and radiantly heated floors.

After color, texture is a carpet's prime visual characteristic. The various carpet textures available are a result of the pile construction, the pile height, and the manner in which the carpet is cut. There are three major groups of carpet textures:

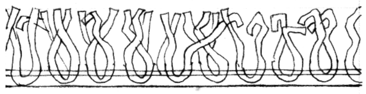
- **Cut pile** results when every yarn loop is cut. It can be produced in tufted, woven, or bonded constructions.
- **Loop or uncut pile** is tougher and more easily maintained than cut pile. Loop pile can be produced through tufted, woven, and knitted techniques. It is durable and easy to maintain, and works well with wheeled furniture.
- **Cut-and-uncut pile** adds a degree of softness to all-loop pile with varying proportions of cut and uncut pile. It can be produced in tufted and woven constructions.



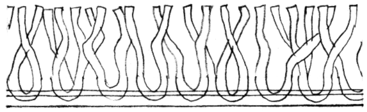
**Velvet or Plush**
Smooth, finely sheared cut pile shows traffic marks.



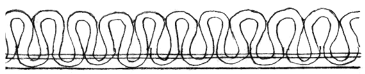
**Saxony**
Multi-ply yarn gives smooth, soft appearance, shows footprints.



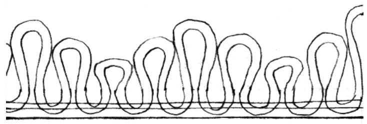
**Twist or Friezé**
Twists are set into yarn to create a heavier, rougher texture.



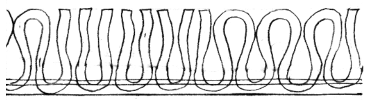
**Shag**
Textured surface is created with long, twisted yarns.



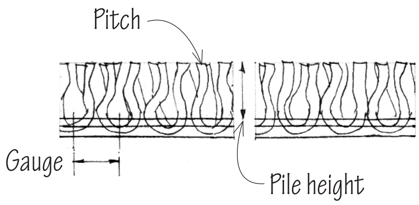
**Level Loop**
Looped tufts of the same height



**Multi-Level or Patterned Loop**
Uncut loops create sculptured patterns.

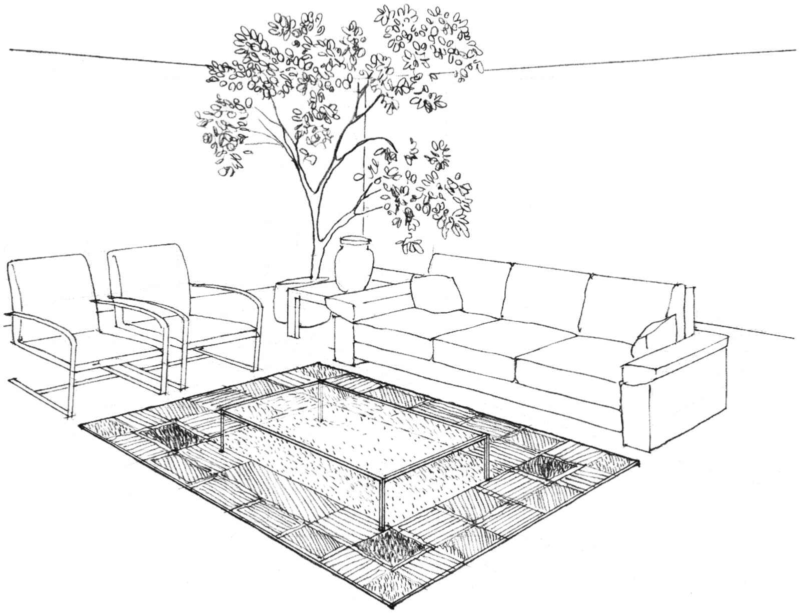


**Cut and Loop**
Combination of loop pile with cut pile creates patterns.




## Carpet Pile Terms

- Density is a measure of the amount of pile fiber by weight in a given area of carpet. Increased density generally results in better performance.
- Pitch refers to the number of ends of yarn in a 27-inch (685-mm) width of woven carpet.
- Gauge refers to the needle spacing across the width of a tufting machine, expressed in fractions of an inch.
- Face weight is the total weight of face yarns measured in ounces per square yard.

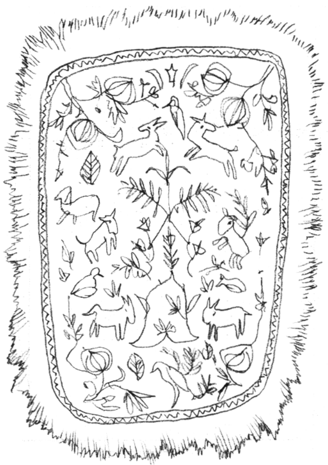


Rugs are floor coverings manufactured or cut to standard sizes, often with a finished border. They are not intended to cover the entire floor of a room and are therefore simply laid over another finish flooring material.

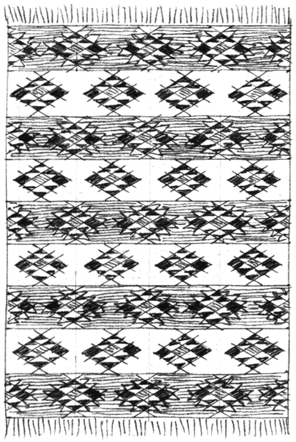
Room-sized rugs cover most of a room's floor, leaving a strip of finish flooring exposed along the room's edges. They approximate the appearance of wall-to-wall carpeting but can be moved if desired, removed for cleaning when necessary, and turned for more even distribution of wear.

Area rugs cover a smaller portion of a room's floor and can be used to define an area, unify a furniture grouping, or delineate a path. Decorative rugs, especially handmade ones, can also serve as a dominant design element and provide a focal point for a room's arrangement.

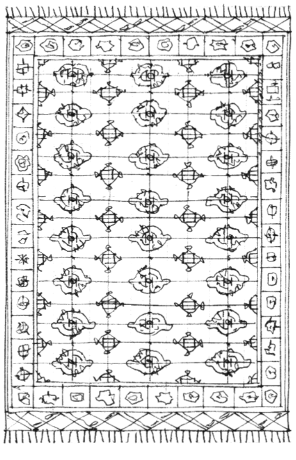
Knotted, hooked, braided, or hand-tufted techniques produce various styles of looped and/or cut yarns that are commonly used for area rugs. Oriental rugs are hand-knotted, and made with individual knots that will not unravel. Today, digital printing allows manufacturers to collaborate with designers on custom designs.



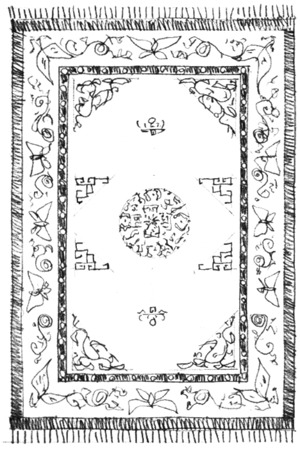
Indian Numdah



Navajo Rug



Afghanistan Bokhara

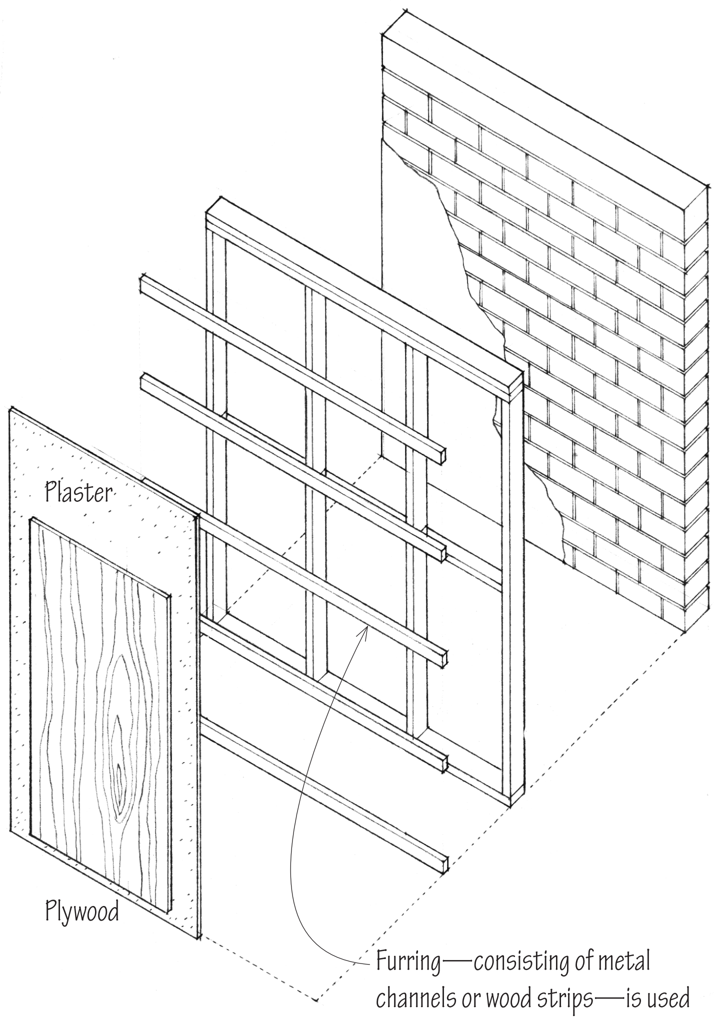


Chinese Bengali

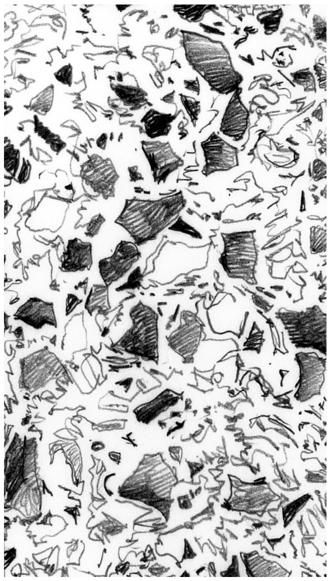
Wall finishes are used to increase a wall's durability, sound absorption, light reflectance, or appearance. Some wall finishes are an integral part of a wall's material structure, some are separate layers attached to the frame of a wall, and still others are thin coatings or coverings that are applied over a wall surface. In addition to aesthetic factors such as color, texture, and pattern, there are functional and economic considerations in selecting a wall material and finish, including the following:

- If it is an applied material, what type of support or base is required?
- What type of finish, coating, or covering will a wall accept?
- How durable must the material or finish be, and how easy is it to maintain?
- What degree of sound absorption, light reflectance, and fire resistance is required?
- Does the wall finish contain toxic materials or off-gas volatile organic compounds (VOCs)?
- Does the wall finish contain recycled or recyclable materials?

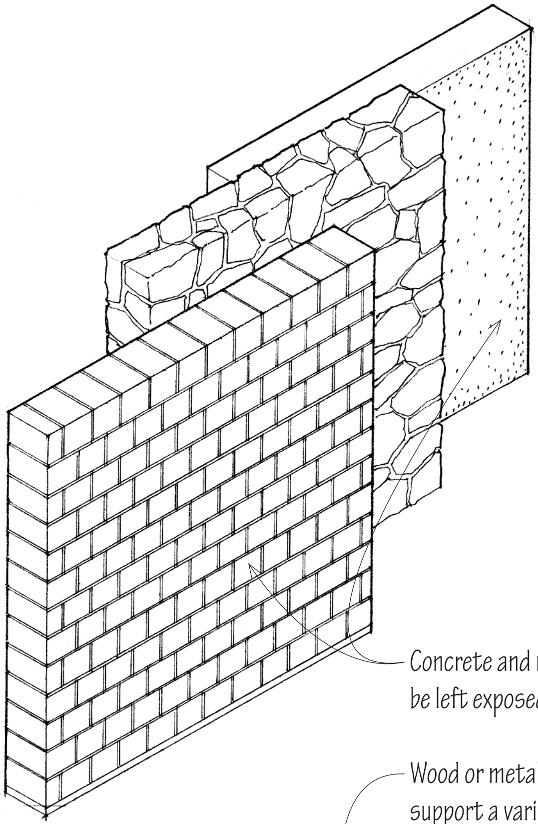
Storing finish material samples on open shelving with nearby tables for discussions encourages office occupants to keep the materials organized.



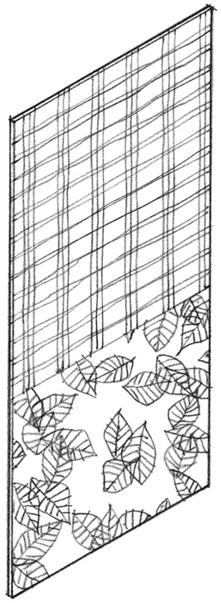

Furring—consisting of metal channels or wood strips—is used to support board, sheet, and panel materials when applied over masonry and concrete walls or when the framing of a stud wall is not flush and true.



Made in the U.S. from recycled glass, this finish has color, pattern, size, and shape unique to each slab.



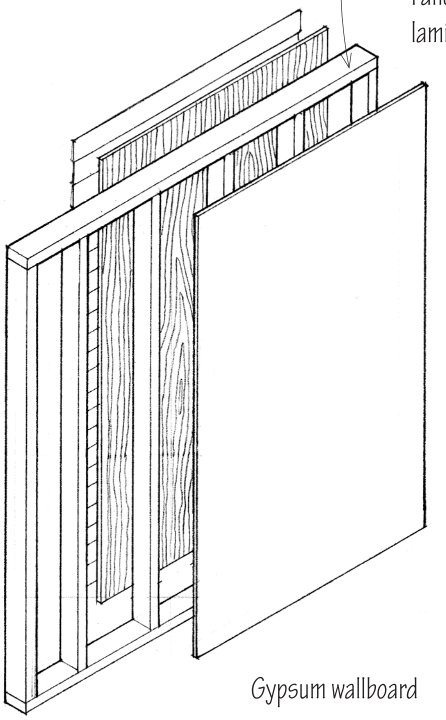
Concrete and masonry walls may be left exposed or plastered.



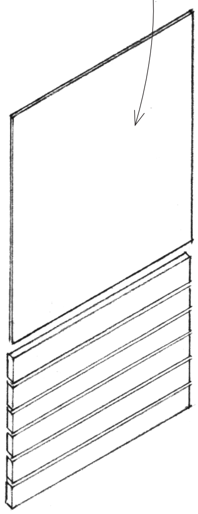
Architectural resin panels are available as translucent or clear sheets, with embedded materials and interlayers, and as prepatterned sheets. Some products contain preconsumer recycled resin; panels without embedded materials can be more easily recycled. These panels can be mounted as dividing walls or attached off a wall surface with offset hardware.

Wood or metal stud walls can support a variety of wall finishes.

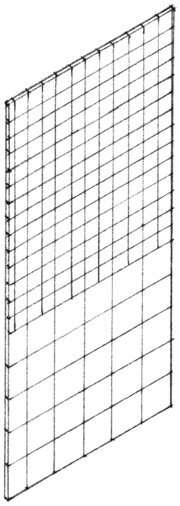
Panels prefinished with plastic laminate, or fabric



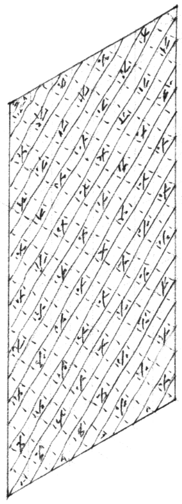
Gypsum wallboard



Wood boards



Ceramic tile

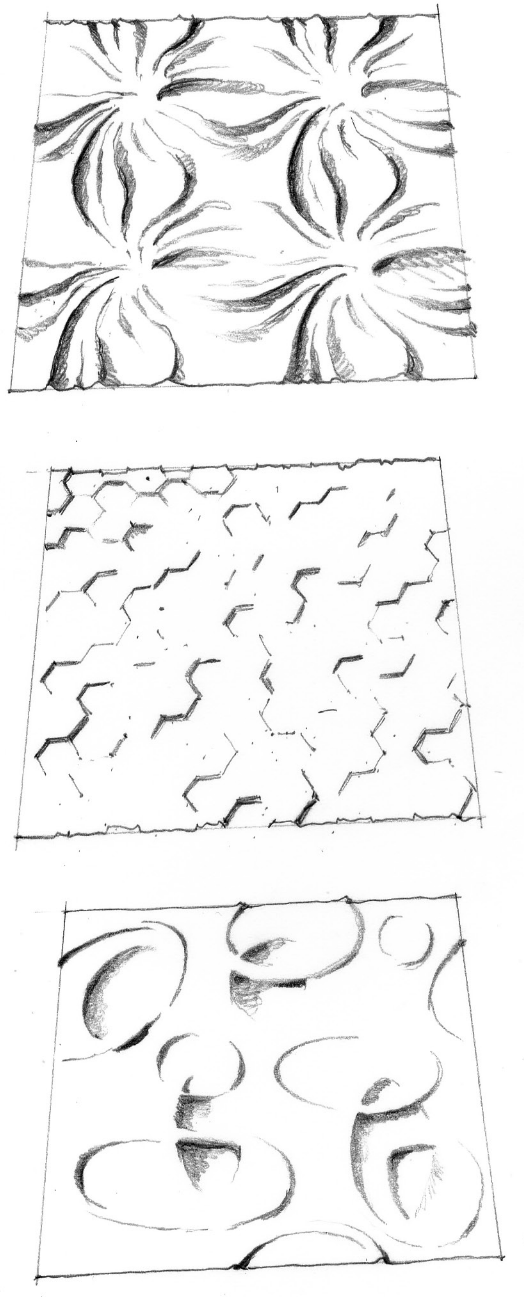


Flexible wall coverings

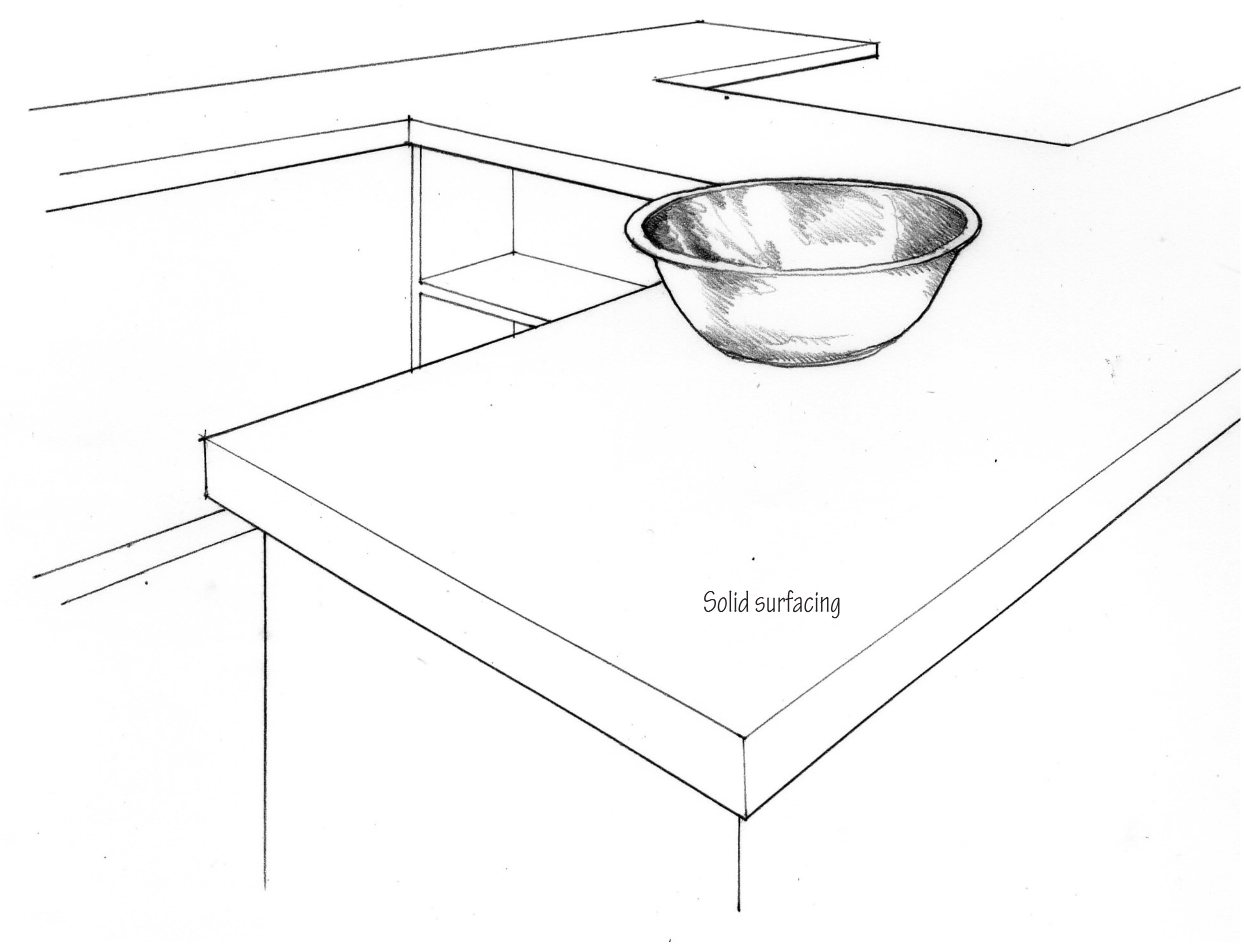
Advances in laminate technology today provide vacuum-formed 3D panel products (3DLs) with ever-increasing realism that helps to reshape interiors well beyond the typical two-dimensional surface. These tactile panels have opened up virtually endless design options for commercial interiors. Both attractive and durable, they offer design flexibility and are available in multiple sizes, useable for walls, wainscoting, ceilings, backsplashes, furniture, display fixtures, and other interior design applications. The fresh patterns and textures combine with customization options to deliver both aesthetic appeal and design advantages.

Today's 3D laminate manufacturing provides consistent quality, custom patterns, and color matching at smaller minimums and lower costs than available for laminate panels in the past. A construction specifier can choose from a wide variety of three-dimensional patterns and then combine them with one of many finish options to create a unique panel. Some manufacturers also offer custom sheets with logos or other branding features.

The base of the finished product is a raw thermoplastic material such as polyvinyl chloride (PVC), polyethylene terephthalate glycol (PETG), or acrylonitrile-butadiene-styrene (ABS). Roll-formed decorative foils give the finish a metallic, patina, wood grain, or solid color appearance. Invisible layers of special coatings or protective masking can provide protection. After lamination and sheeting, the substrate is vacuum formed into the finished pattern. This is followed by cooling and cutting, and inspection for quality control. Finished panels are extremely lightweight, and can be rolled for cost-effective shipping. Manufacturers often sell wall panels up to 4 × 8 feet (1219-mm × 2438-mm) in size, wainscot panels between 30 and 32 inches × 48 inches (762- and 813-mm × 1219-mm), and smaller panels for kitchen backsplashes and glue-up from 18 × 24 inches (467-mm × 610-mm) or less.



Solid surfacing materials are often used for countertops, as well as for other residential and commercial finishes. Solid surfacing materials are resistant to water, stain, heat, chemicals, wear, and impact and have high bacterial and fungal resistance. They are available in a variety of thicknesses, including 1/8-inch (3-mm) thick veneer. Solid surfacing materials are usually prefabricated at the installer's shop, and then assembled on-site. Installation seams are glued, leaving little evidence of the joint.



## Wood Wall Panels

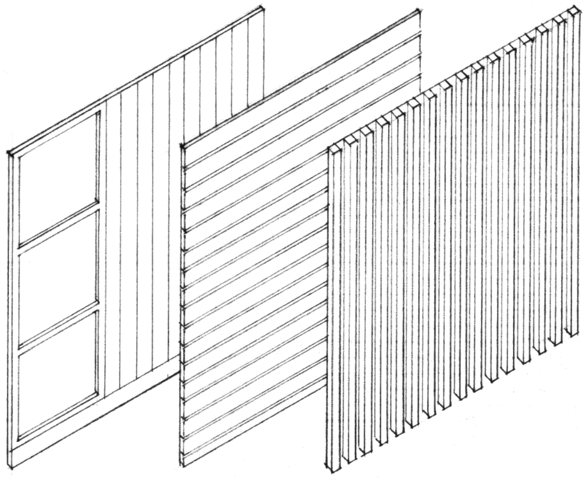
Wood paneling consists of a series of thin sheets of wood framed together by strips of wood. Vertical strips are called stiles, and horizontal strips are referred to as rails. Wood paneling includes solid lumber paneling, wood veneer paneling, and plastic-laminate faced wood paneling. Ready-to-use stained and finished hardwood panels are available in many different colors and wood species.

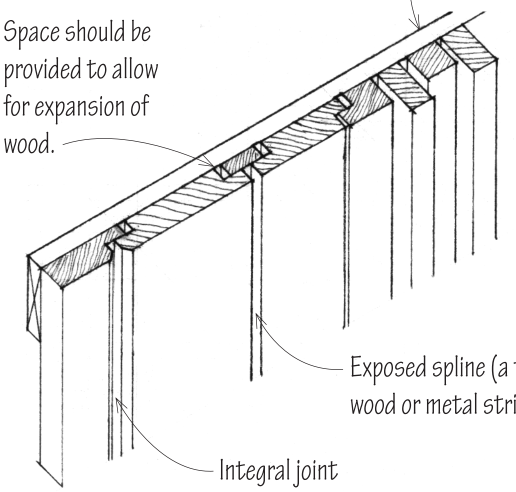
Solid wood boards offer durability and create texture. Wall pattern and texture depend on the width, orientation, and spacing of the boards as well as on the joint details. Beadboard consists of tongue-and-groove strips of wood grooved to look like two thin strips; it is used as wainscots on walls and on ceilings.

Composite wood panels use wood fiber left over from other manufacturing processes. They are more structurally stable than solid wood, and may last longer as well. The wood in composite panels acts as a carbon sink that may sequester more carbon than is expended in their production, transportation, and installation. Composite panels produced in North America now meet and usually exceed established indoor air quality goals.

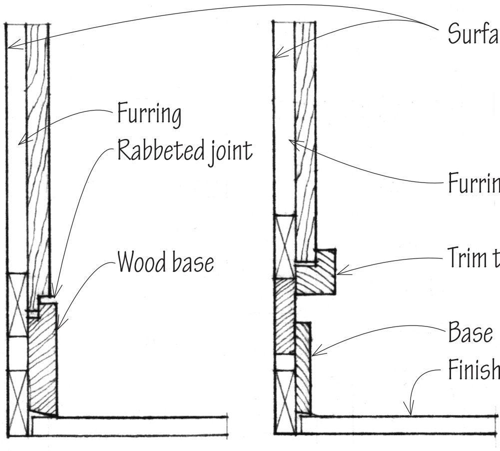
Particleboard and medium density fiberboard (MDF) panels are manufactured by mixing wood particles or fibers with resin, paraffin wax, and other additives. The panel is then consolidated and cured under pressure and heat, then sanded and sawn to the dimensions desired. Composite panels can be engineered for moisture resistance, fire resistance, indoor air quality goals, density, and screw-holding power. They can be designed to be lightweight and produced in different thicknesses and dimensions. Most composite panels have a decorative surface of veneer or high-pressure laminate. Thermally fused laminate (TFL) is a common surface, made of printed or solid-colored decorative paper saturated with melamine resin and fused to the composite panel core under heat and pressure.

Particleboard is made up of small wood particles. The wood chips in MDF are further refined to cellulosic fibers, producing a panel with both a smooth surface and homogeneous core.






**Examples of Joints**

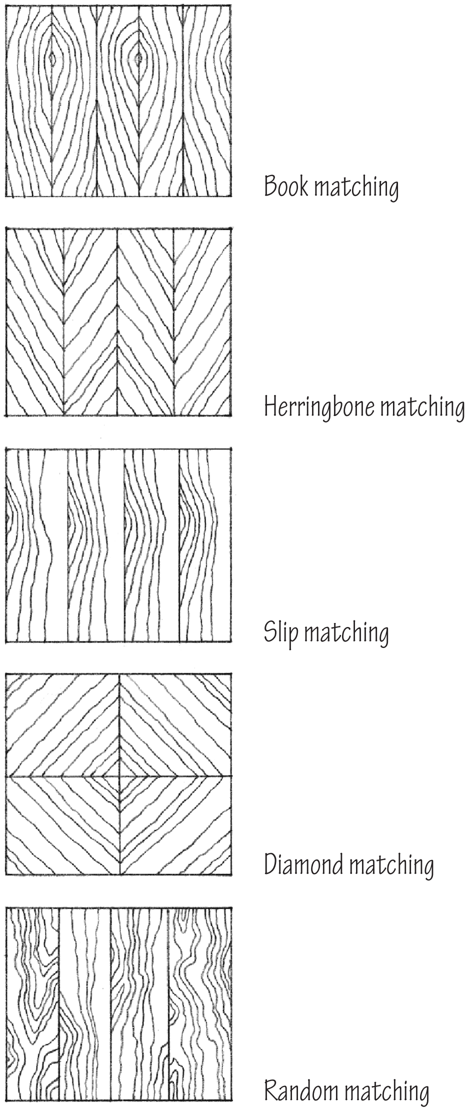



**Wood Board Base Details** *Details at ceiling can be treated in a similar manner.*

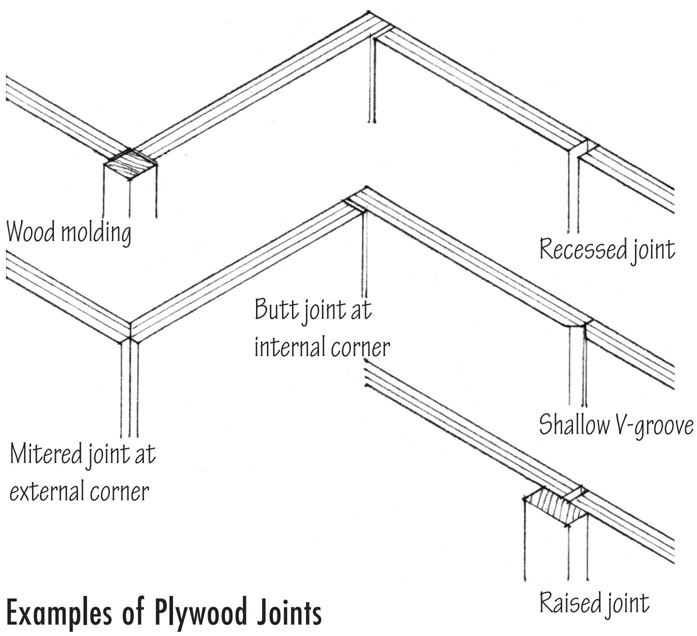
## Plywood

Plywood is a wood panel product made by bonding veneers together under heat and pressure, usually with the grain of adjacent plies at right angles to each other. Plywood cores may be made of particleboard, medium-density fiberboard (MDF), veneer core, or lumber core. Some plywood products contain formaldehyde. Panels are typically 4 feet × 8 feet (1219-mm × 2438-mm) and $^{1}/_{4}$ to $^{3}/_{4}$ inch (6- to 9-mm) thick.

Wood panel products are typically faced with either decorative laminates/overlays or wood veneers. There are two types of wood veneers, hardwood and softwood; hardwood is used for wall finishes. Veneers are sliced in a variety of ways, including quarter slicing, rift cutting, and rotary cutting. Adjacent thin leaves of sliced wood can then be arranged in patterns such as book, herringbone, slip, diamond, and random matching.

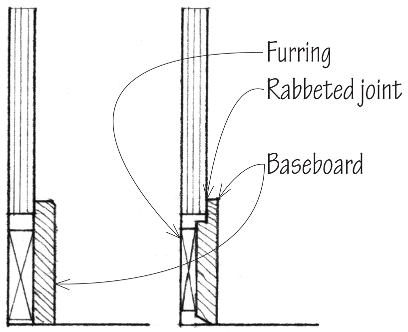



**Plywood Veneer Matching**




**Examples of Plywood Joints**

Exposed edges of plywood panels must be finished with a hardwood strip or concealed with trim molding.



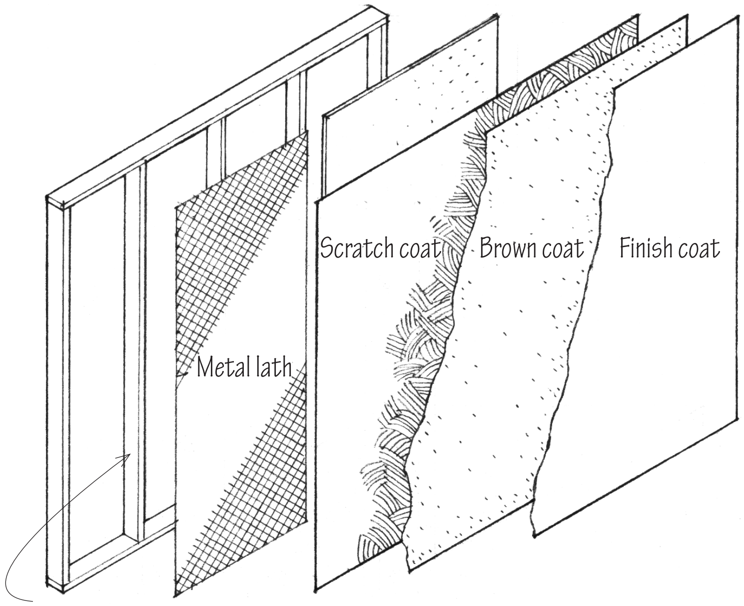

**Plywood Base Details**

Plaster is a composition of gypsum or lime, water, sand, and sometimes another fiber. It is applied in a pasty form to the surfaces of walls or ceilings and allowed to harden and dry. Gypsum plaster is a durable, relatively lightweight, and fire-resistant material that can be used on any wall or ceiling surface that is not subject to moist or wet conditions. Veneer or thin-coat plaster is a ready-mixed gypsum plaster applied as a very thin *skim coat* finish over a veneer gypsum board base, which is commonly called blueboard.

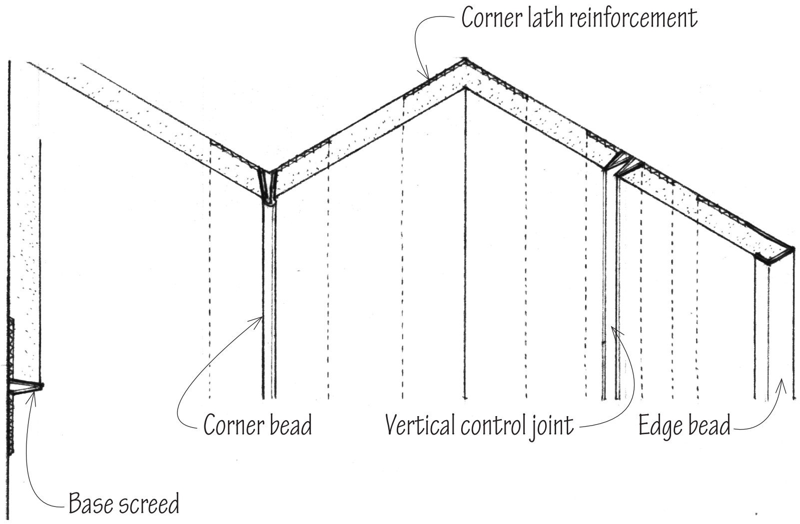
Plaster is applied in either two or three layers, the number of which depends on the type and strength of base used. Two-coat plaster uses a base coat followed by a finish coat. Three-coat plaster is applied in three successive coats, a scratch coat followed by a brown coat and a finish coat.

- The scratch coat is the first coat in three-coat plaster. It must adhere firmly to the lath and provide a better bond for the second or brown coat.
- The brown coat is a roughly finished, leveling coat of plaster—either the second coat in three-coat plaster or the base coat applied over a gypsum lath or masonry.
- The finish coat of plaster serves as the finished surface or as a base for decoration.
- The total thickness of a plaster finish is from $^1/_2$ to $^3/_4$ of an inch (12- to 19-mm).

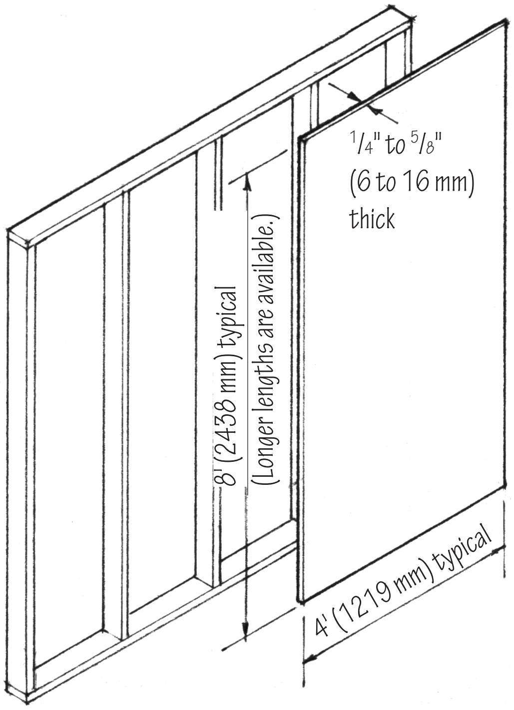
The final appearance of a plaster surface depends on both its texture and its finish. It is usually troweled to produce a smooth, nonporous finish. Plaster may have one or more integral colors, or may be painted either a single color or with multiple layers of paints and glazes. Smooth finishes will accept textile or paper wall coverings. Plaster can be molded and cast into sculptural shapes by specialists for renovations of historic projects.




Wood or metal stud frame or furring over masonry or concrete wall



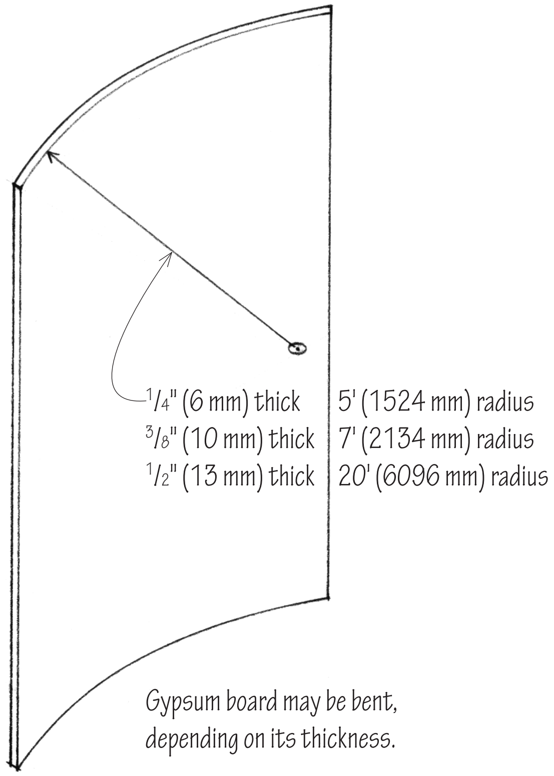

Metal accessories are required to finish and protect the edges and corners of plaster surfaces



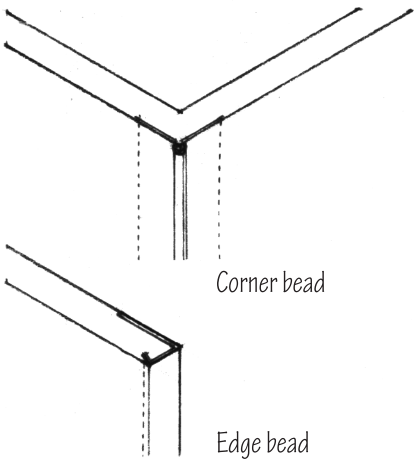

Gypsum board—often called drywall or plasterboard—consists of a gypsum core surfaced with paper or other covering material. It may be finished by painting or by the application of ceramic tile or a flexible wall covering.

Common types of gypsum board include the following:

- Regular gypsum board for interior walls and ceilings
- Moisture-resistant gypsum board used as a backing for ceramic tile in high-moisture conditions
- Fire-resistant (Type X) gypsum board used in fire-resistant construction



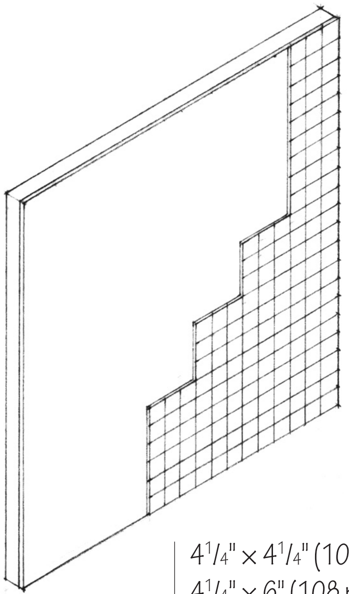

Gypsum board may be bent, depending on its thickness.




Metal trim shapes are required to finish and protect the edges and corners of gypsum board surfaces.

## Ceramic Wall Tile

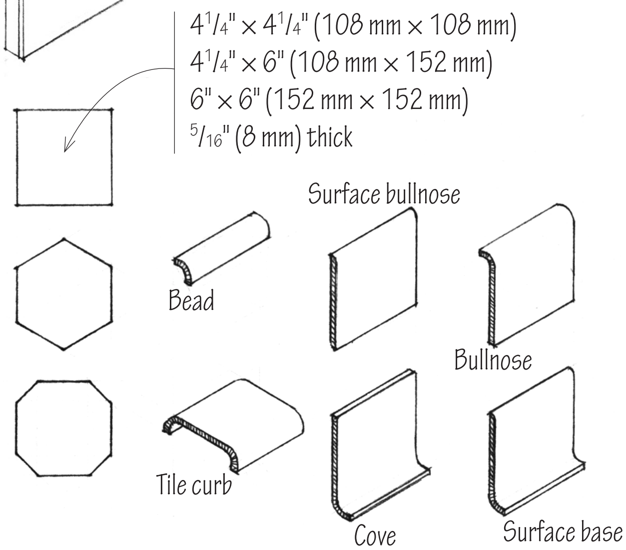
Ceramic wall tiles are modular surfacing units of fired clay and other ceramic materials. They provide a permanent, durable, waterproof surface for interior walls. They are available in bright or matte glazes in a wide range of colors and surface designs.



Specialty tiles include glass tiles, handmade and custom tiles, special sizes, and trim pieces. Grouts for wall tiles are available in a wide variety of colors. Avoid using highly pigmented grouts with contrasting colored tiles, as they may bleed.

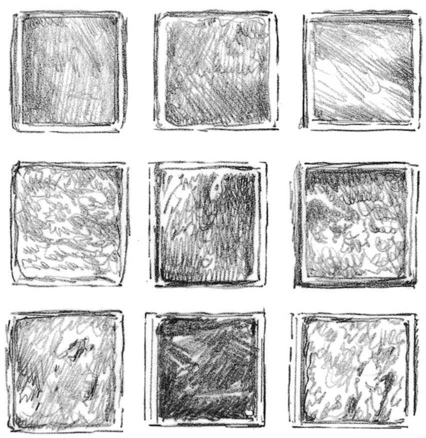
Ceramic tile may be applied with either the thinset or the thickset process.

- In the thinset process, ceramic tile is bonded to a continuous, stable backing of gypsum plaster, gypsum board, or plywood, using a thin coat of dry-set mortar, latex-portland cement mortar, epoxy mortar, or an organic adhesive.
- In the thickset process, ceramic tile is applied over a bed of portland cement mortar. The relatively thick $\frac{1}{2}$- to $\frac{3}{4}$-inch (13- to 19-mm) bed allows for accurate slopes and true planes in the finished work. Suitable backings include metal lath over concrete, masonry, plywood, gypsum plaster, gypsum board, and stud framing.

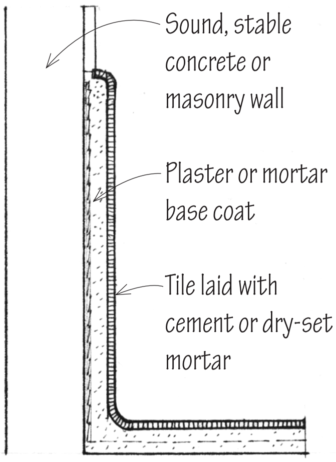



**Standard and Trim Shapes**

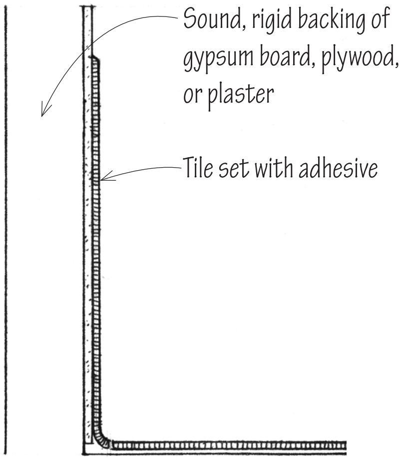
Glass tile can be used on walls, floors, and countertops, both interior and exterior. Manufactured glass tiles with flat surfaces and regular dimensions are easier to install than hand-cut, highly textured tiles. Colored manufactured glass tiles are installed with white thinset adhesive with a latex additive and latex-modified grout.



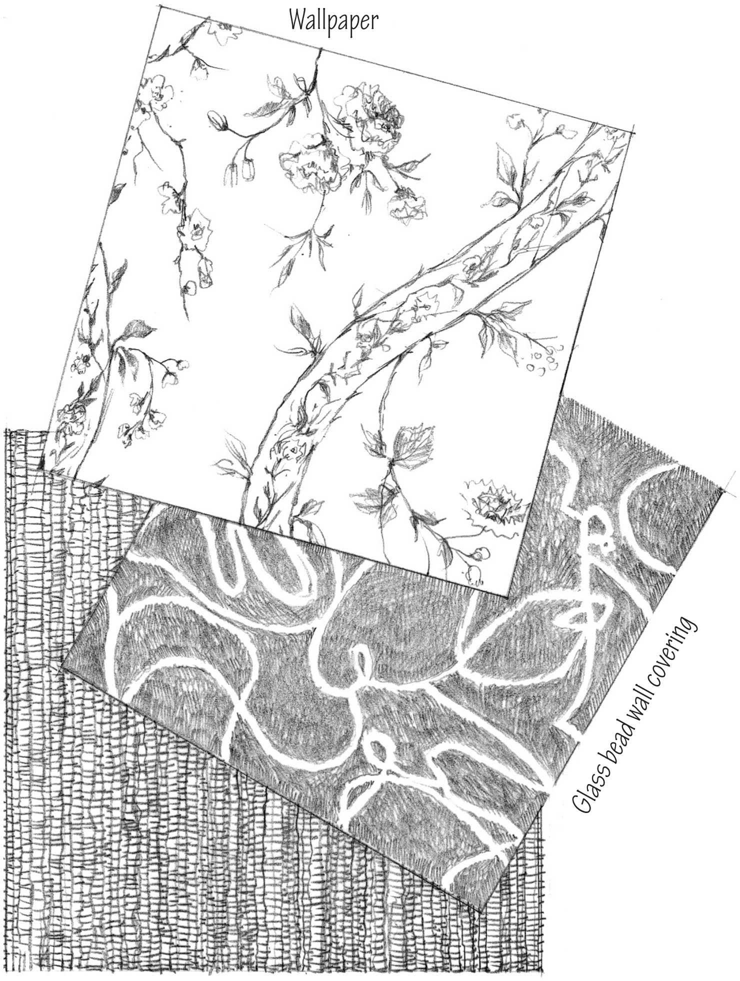
**Glass Tiles**




**Thickset Process**




**Thinset Process**




Rib weave wall covering

Photographic wall covering

In addition to being painted, smooth plaster and gypsum board surfaces can be finished with a variety of flexible wall coverings that are available in a wide range of colors, patterns, and designs. There are six wall-covering categories based on performance:

I. Decorative only: Untested wallpaper and other residential wall coverings
II. Decorative with medium serviceability: Tested but primarily for residential use
III. Decorative with high serviceability: Tested for medium residential use
IV. Type I commercial serviceability: Tested for heavy consumer and light commercial use, such as private offices and hotel rooms
V. Type II commercial serviceability: Tested for higher standards and appropriate for public areas such as dining rooms, corridors, and classrooms
VI. Type III commercial serviceability: Tested for the highest standards and used for high-traffic service corridors

Wallpaper has a paper face and a paper back. It is not commonly used in commercial design, as it is subject to soiling, abrasion, and fading, and is not tested for flame resistance.

Cloth- or paper-backed vinyl wall coverings are designed for serviceability and durability, and are tested for flame resistance as well. They are easily cleaned and resistant to fading and abrasion. However, environmental problems exist in their manufacture, use, and disposal, and alternatives are increasingly used.

Fabrics such as wool, linen, cotton, burlap, and grasscloth require back-coating as a barrier to prevent adhesive from bleeding through to the fabric's face and to improve dimensional stability. They should be treated for soil resistance and some may require flame-retardant treatment, which has sustainability problems.

Cork obtained from the renewable bark of the cork oak tree is both durable and resilient. It accepts either wax or polyurethane finishes and possesses excellent acoustical and thermal ratings, but moisture may cause problems.

## Paints

Paint is a mixture of a solid pigment suspended in a liquid vehicle and applied as a thin, usually opaque coating. Paints can decorate, protect, and modify the surface to which they are applied. Primers are paints that improve the adhesion of subsequent coatings. They may also provide a base color and can serve as a moisture barrier or a rust inhibitor.

| | | |
|---|---|---|
| Pigment is a finely ground, insoluble substance suspended in a liquid vehicle to impart color and opacity to a coating. | + | Vehicle is a liquid consisting of a binder and a solvent in which pigment is dispersed before being applied to a surface to control consistency, adhesion, gloss, and durability. |

Latex paints are the most commonly used type of interior paints. They are water-based, fast drying, porous, and easy to clean up with water. Alkyd paints are made with solvent-thinned resins that utilize oil-modified polyesters as a vehicle. Use of alkyd paints may be restricted in some parts of the United States for environmental reasons.

From its early days prior to the 1700s, paint was mixed by hand in small batches. The 1800s brought the advent of paint factories producing ready-mixed paints and greatly increasing demand. In the twentieth century, manufacturers replaced natural ingredients with synthetic pigments and stabilizers, producing uniform batches of paint.

Lead is a neurotoxin that is especially damaging to fetuses, infants, and young children, and can cause learning disabilities, nausea, trembling, and numbness in the arms and legs. Lead was banned from most paint in the U.S. in 1978 by federal law. Lead particles from older paint in existing buildings are suspended in the air or settle on surfaces such as carpets, which can release the particles back into the air when disturbed. Children ingest and inhale lead-based paint chips or dust by playing on floors and other dusty surfaces and then putting their hands in their mouths or noses. Lead exposure has been implicated in attention deficit disorder, impaired hearing, reading, and learning disabilities, delayed cognitive development, reduced IQ scores, mental retardation, seizures, convulsions, coma, and death.

Houses built prior to 1950 are likely to contain paint with high levels of lead. Current efforts to remove and/or repair deteriorated lead-based paint, along with other measures to reduce and prevent recurring accumulation of lead in dust, have resulted in substantial and sustained reductions in interior lead dust and children's blood levels.

Antimicrobial paint is a new product useful in passive infection control. It contains a disinfectant quaternary ammonium compound that kills 99.9 percent of five pathogens commonly associated with hospital-acquired infections (HAIs) within two hours of exposure on a painted surface, and remains effective for four years on an intact and properly maintained surface. It is recommended for patient rooms, as well as for childcare centers, assisted-living facilities, cruise ships, and other environments where infections can spread easily.

## Paint Sheens

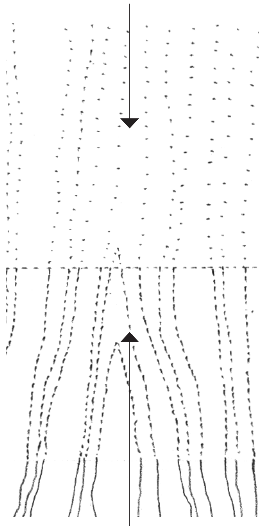
The sheen or gloss of paint depends on the size of the particles of pigment and the ratio of pigment to liquid. Although different manufacturers use a variety of names for the levels of gloss, the basic categories are flat, semigloss, and gloss. Some companies sell eggshell, pearl, and/or satin paints that are more washable than flat paints and less shiny than semigloss.

- Flat paints are used for ceilings, and for walls in rooms with low surface contact. Their low sheen can conceal minor surface imperfections. They can be gently washed, but not scrubbed.
- Semigloss paints are used for walls in high-contact areas such as kitchens and bathrooms, and for trim. They are very durable, washable, and scrubbable, and somewhat shiny.
- Gloss paints have a high sheen, and are the most durable for doors, trim, and cabinets. These washable and scrubbable surfaces will show imperfections.
- Dry erase coatings are used to turn any painted surface into a dry erase board. Clear gloss coatings let the wall color show through.

## Stains

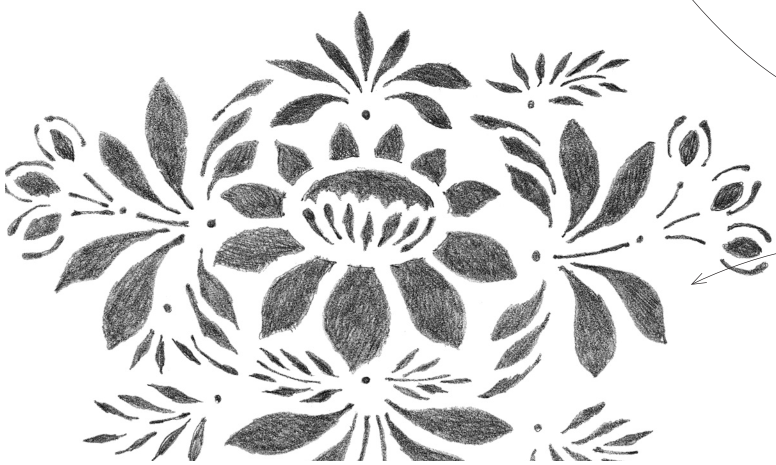
Stains are translucent or transparent solutions of dyes or pigments applied to penetrate and color a wood surface. They typically do not provide a protective finish.

Pigmented or opaque stains are oil stains that contain pigments capable of obscuring the grain and texture of a wood surface.



Penetrating stains permeate a wood surface, leaving a very thin film on the surface.

Trompe l'oeil: Self-Portrait, Gerard Dou, Ca. 1650



## Light Reflectances

The light reflectance of a painted surface depends on both its level of gloss and its color. The relatively higher ratio and larger size of particles of pigment in flat paint diffuse light waves more than do the smaller, fewer particles in gloss paint. As we have already discussed, darker colors absorb light rays more than do light colors. In addition, the greater amount of pigment in darker paints decreases their reflectance.

For maximum penetration of daylight, paints with high reflectance should be used on ceilings and walls. High light reflectance levels also help to make the most of the energy used for electrical lighting.

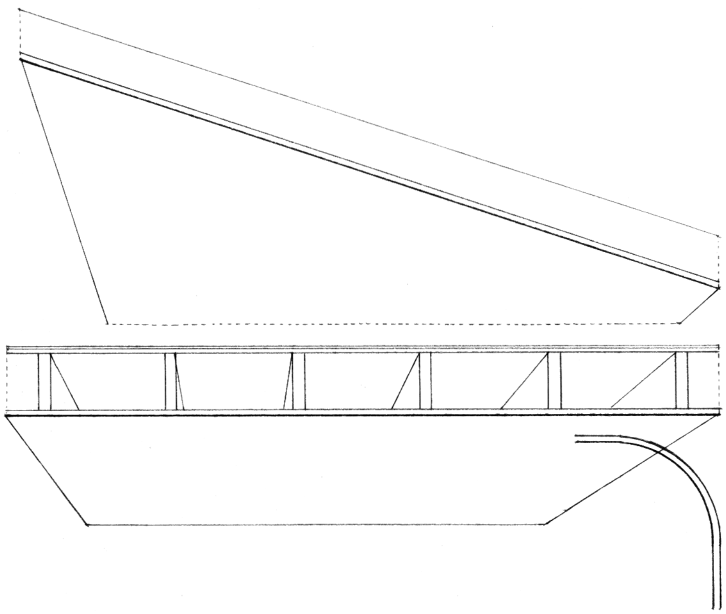
## Decorative Paint Finishes

*Faux finishes* are technically those that imitate natural materials—wood graining and marbleizing, for example—but the term is often used for any decorative painted finish. They are typically made of layers of paint and/or plaster. Special paint finishes also use paint and plaster, but seek to create an original finish rather than imitate an existing material.

There are many types of decorative paint finishes, including the following:

- Transparent paint layers (glazes) can be applied in multiple layers to create complex colored surfaces.
- A colored glaze can be applied in a broken pattern with a rag or sponge, dragged with a tool, or painted on as a color wash.
- *Trompe l'oeil*, French for "fool the eye," uses perspective and shadow to create the illusion of three-dimensional architectural or natural objects.
- Stenciling can be used to apply borders or larger repeating patterns.
- Distressing techniques are used to give a painted surface the appearance of wear and age.

The underside of the floor or roof structure above can be left exposed and serve as the ceiling. More often, however, a separate ceiling material is attached to or hung from a supporting structure. The range of ceiling materials is similar to that for walls, except for those that are too heavy to be hung from an overhead structure.

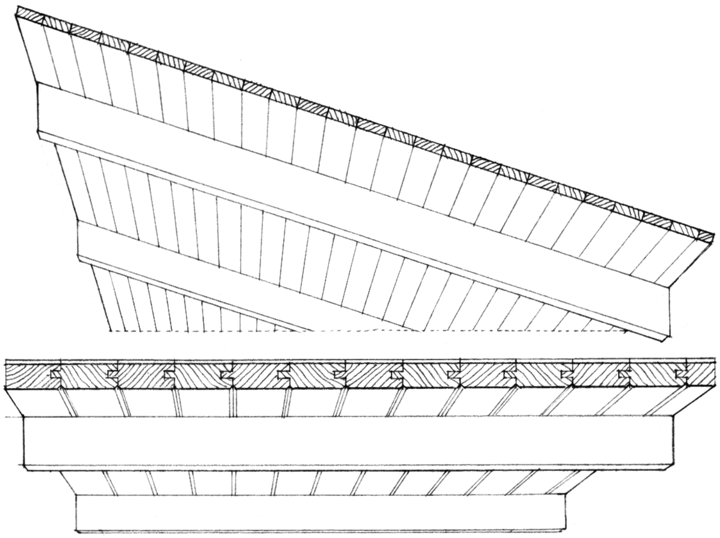


## Plaster and Gypsum Board

Plaster and gypsum board provide uninterrupted ceiling surfaces that can be finished smooth, textured, or painted.

Plaster also affords the opportunity for merging ceiling and wall planes with curved coves.

Both plaster and gypsum board require a supporting framework of wood or metal that is attached to or suspended from the roof or floor framing.

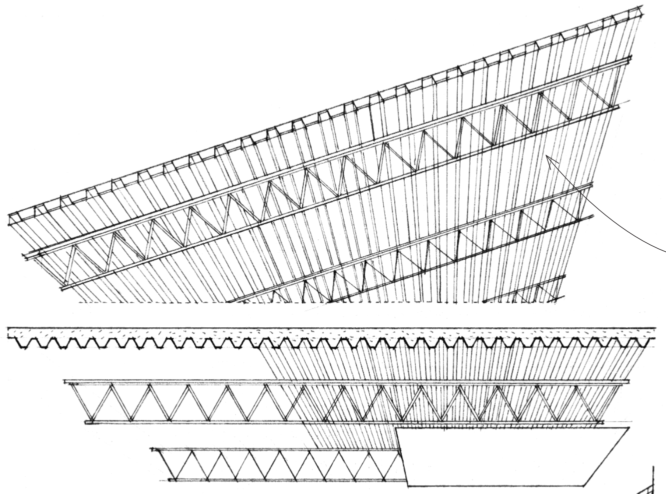


## Wood

Wood decking or planks can span the spaces between beams to form the structural platform of a floor or roof. The underside of the planks may be left exposed as the finished ceiling.

Wood planks are normally $5^1/_2$ inches (133-mm) wide and typically have V-shaped tongue-and-groove joints. Channel groove, striated, and other machined patterns are also available.

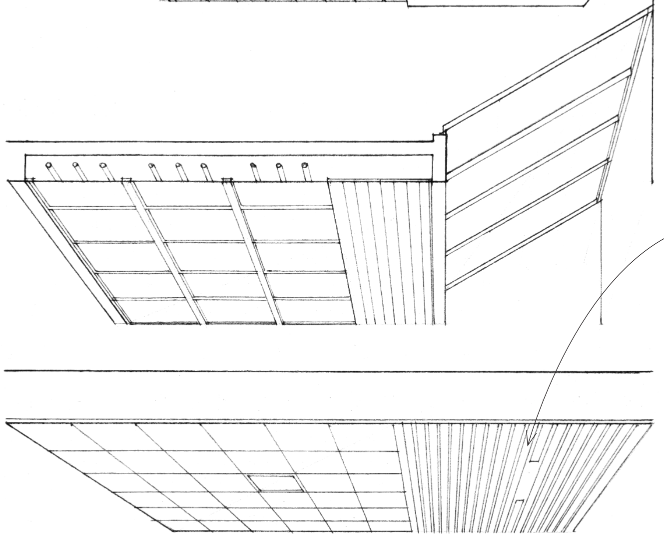
With an exposed wood ceiling system, there is no concealed ceiling space.



## Metal

On roofs, corrugated steel decking may form the structural platform for thermal insulation and roofing material. Cellular or corrugated steel decking also provides permanent formwork and reinforcement for concrete floor slabs.

The underside of steel decking can be left exposed as the ceiling surface. Together with open-web steel joists, steel decking defines ceilings with a linear, textural quality. However, exposed steel decking may transmit impact noise such as footfalls from the floor above.



## Modular

Modular ceiling materials are normally supported on a metal grid suspended from a roof or floor structure. Acoustical ceiling tiles form a square or rectangular grid pattern that may be strong or subtle, depending on the tile design.

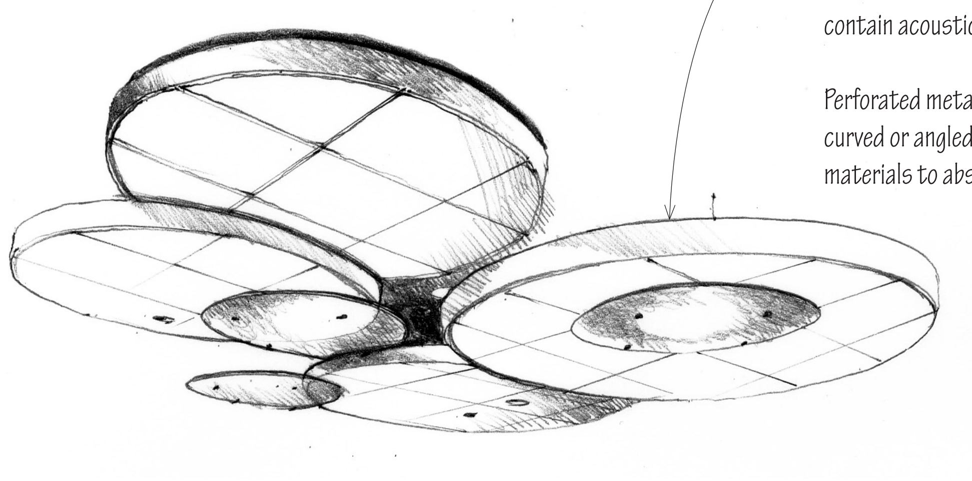
Long, narrow metal panels can be mounted to create gentle curves parallel to their length. In both cases, light fixtures, air diffusers, and other equipment can be integrated into the modular system. Open slots permit sound to be absorbed by a backing of acoustic insulation.

## Canopies and Clouds

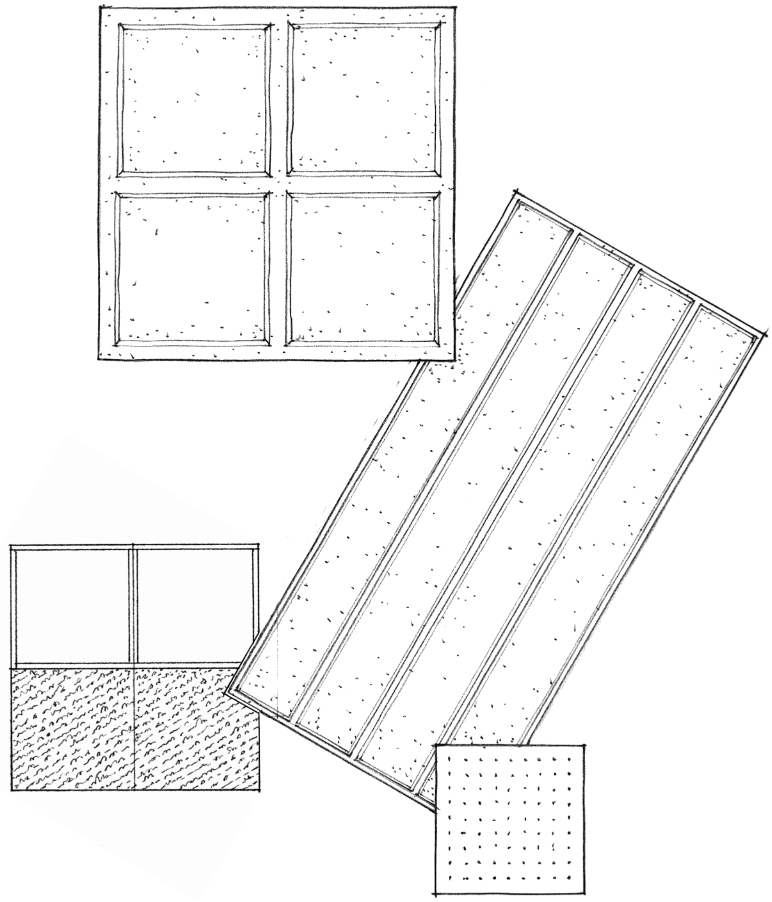
Ceiling canopies are hung from ceilings to define interior spaces. Their gently curved surfaces can be finished to enhance light reflected.

Suspended acoustical cloud ceilings offer the benefits of full-ceiling grid systems while retaining a higher level of visibility and access to ceiling-mounted equipment. Cloud ceilings contain acoustic panels, and are edged with metal frames.

Perforated metal sheets or panels can be suspended in curved or angled designs. They can be backed with acoustical materials to absorb sound.



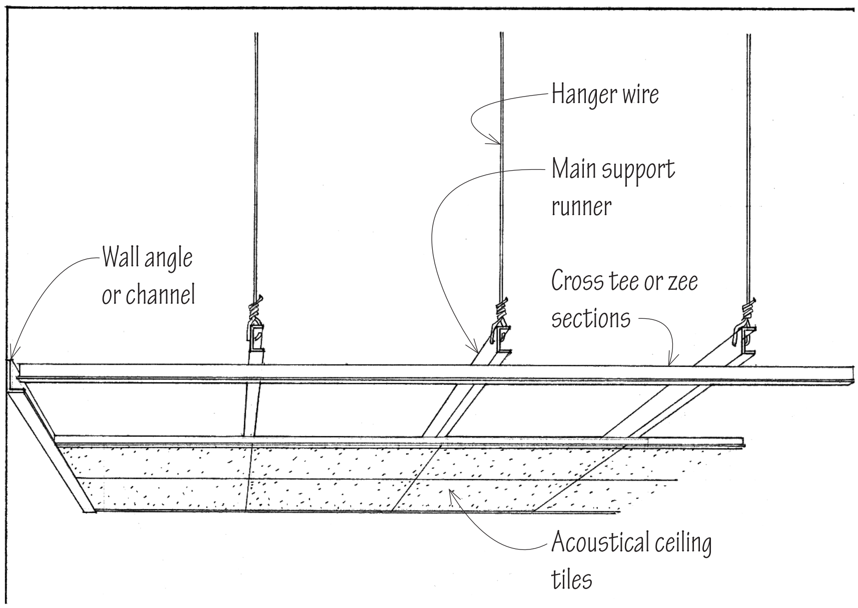
In commercial spaces, a modular suspended ceiling system is often used to integrate, and provide flexibility in, the layout of lighting fixtures and air distribution outlets. The typical system consists of modular ceiling tiles supported by a metal grid suspended from the overhead structure. The tiles are usually removable for access to the ceiling space.



Acoustical tiles are modular units of fiberglass or mineral fiber. They are available in a variety of square and rectangular styles. Some have aluminum, vinyl, ceramic, or wood faces. Their edges may be square, beveled, rabbeted, or tongue-and-groove. Acoustical tiles come in perforated, patterned, textured, or fissured faces.

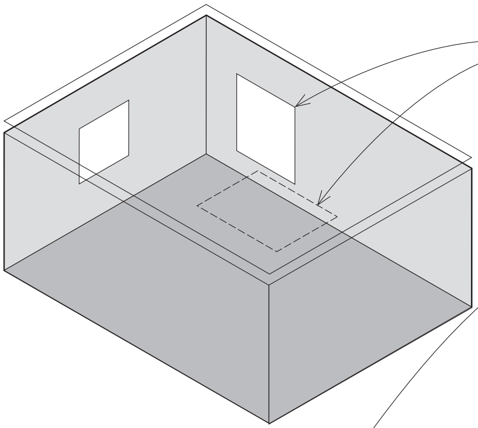
Acoustical tiles are excellent absorbers of sound within a room. Tiles are often fire rated, and some are rated for use in high-humidity areas.

Perforated metal pans backed by fibrous batts are available for use with suspended ceilings. With the acoustic backing removed, they can be used for taking in the return air of an HVAC system.



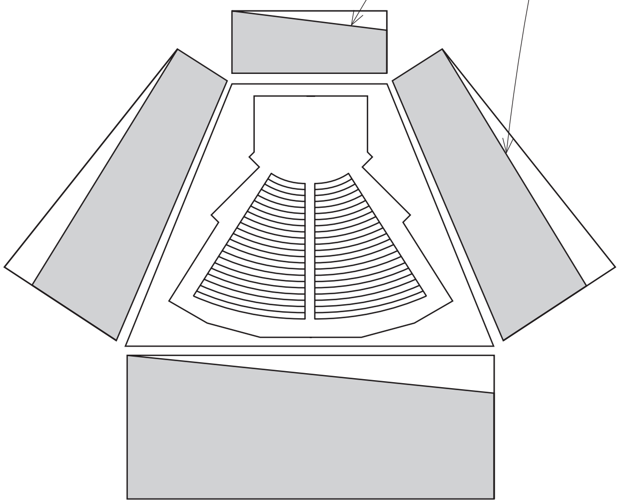

Typical Suspended Ceiling Section

Building codes regulate the flame-resistance of suspended decorative materials in assembly buildings, educational facilities, and dormitories. These decorative materials, such as curtains, draperies and hangings, must be flame-resistant or noncombustible. In some institutional settings, higher standards apply, even including such items as paintings or photographs.



In assembly buildings, educational facilities, and dormitories, flame-resistant combustible materials are limited to 10 percent of the area of the specific wall or ceiling to which they are attached.

When auditoriums are equipped with sprinklers, the amount of flame-resistant decorative materials may not exceed 75 percent of the aggregate area of walls and ceiling.



The widespread use of flame retardant chemical finishes to inhibit or resist the spread of fire is undergoing scrutiny, as they appear to be less effective as fire-safety elements than previously believed, and more dangerous to the environment and human health. Polybrominated diphenyl ethers (PBDE) have been used as flame retardants in building materials, furnishings, polyurethane foams, and textiles. PBDE and some other flame retardants have been associated with developmental problems in children, and scientists have recommended that regulations requiring the use of flame retardant finishes be reviewed, and that their use be limited. The apparently deceptive campaign by tobacco and chemical industries to promote the use of flame retardants in spite of flawed research that showed little evidence of their effectiveness has highlighted the need for specifiers to understand health and safety factors of materials.

# 8

# Furnishings

Furnishings are the one category of design elements that lies almost wholly within the realm of interior design. While walls, floors, ceilings, windows, and doors are established in the architectural design of a building, the selection and arrangement of movable interior elements—furniture, window treatments, and accessories—are major tasks of interior design.

Furnishings mediate between architecture and people. They offer a transition in form and scale between an interior space and the individual. Furnishings make interiors habitable by providing comfort and utility in the tasks and activities we undertake.

Interior designers commonly differentiate between residential and commercial furnishings. Furnishings purchased for offices under *furniture, furnishings, and equipment* (FF&E) contracts, such as modular partition systems, chairs, and desks, are sometimes referred to as *contract furnishings*. The distinction may be one of style, durability, or fire resistance. Some pieces serve equally well in either residential or business settings. With the proliferation of home offices, many crossover pieces are now on the market. Some residential manufacturers have brought out lines of commercial office furniture with durable upholstery that are intended for both markets.

With recent changes in how office spaces have been designed and used, human- and earth-centered design have come to the forefront. Designers are moving away from lists of undesirable materials to focus on information and transparency in materials selection. Health Product Declarations (HPDs) put this sort of information into designers' hands for better decision making.

Designers are creating spaces that people want to explore. The power to be flexible with one's space, and to go somewhere else, creates a push and pull about ownership of the space. In offices, whiteboards are placed almost everywhere so that people can write down ideas and put them where others will see them.

Prebuilt offices recently have undergone a complete transformation. Commercial landlords are turning to finished office spaces for start-ups that would rather lease an office where set-up is not required. Businesses do not want to do anything beyond installing furniture, telephones, and computers; they want plug'n'play spaces. To appeal to businesses in technology, advertising, media, and information services, these spaces must incorporate ideal market positioning, technology, workplace organization, and aesthetics. Commonly, open-ceiling buildings require that architects work with engineers to ensure that the exposed mechanical layout meshes with the interior design.

Spaces open to use by the public usually have more stringent requirements for fire safety. Requirements for accessibility also affect furnishings in public spaces and at work. Facilities that receive intensive use, such as classrooms, healthcare facilities, and restaurants, require very durable and well-constructed furnishings.

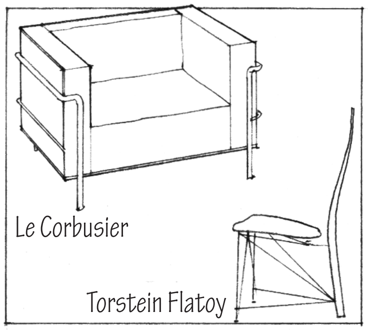
In addition to fulfilling specific functions, furniture contributes to the visual character of interior settings. The form, lines, color, texture, and scale of individual pieces, as well as their spatial organization, play a major role in establishing the expressive qualities of a room. Furniture pieces can be linear, planar, or volumetric in form; their lines may be rectilinear or curvilinear, angular or free flowing. Their proportions can be primarily horizontal or vertical; they can be light and airy, or sturdy and solid. Their texture can be slick and shiny, smooth and satiny, warm and plush, or rough and heavy. Their color can be natural or transparent in quality, warm or cool in temperature, and light or dark in value.

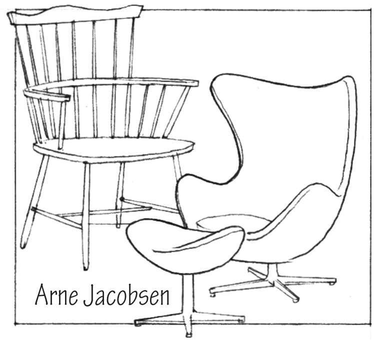
Many designs mix furniture from different historical periods with contemporary pieces. Most designers do not seek to design period rooms, although these are appropriate in historic settings or for a client with a collection of antiques. Historical and cultural references extend to furniture arrangements and the selection of finishes and accessories as well as to pieces of furniture. The designs of the past that endure today are still in production, although some reproductions may lack the quality of the originals in material, craftsmanship, or durability.

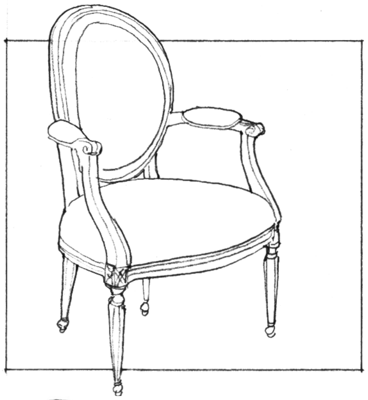
Antique furniture is generally recognized as being at least 100 years old. Antiques are often identified with major cultures, periods, countries, or individuals.

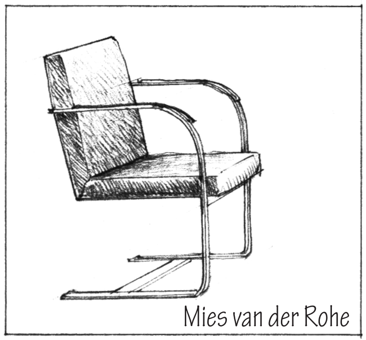
Modern furniture is a term that refers to pieces produced in the late nineteenth and early twentieth century by designers including Michael Thonet, Charles Rennie Mackintosh, and the craftsmen of the Bauhaus movement.

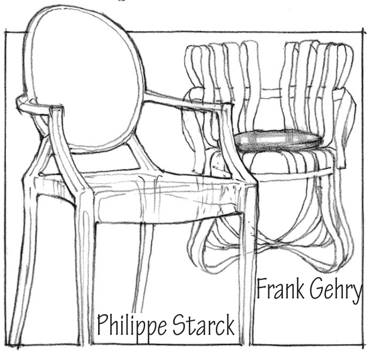
Contemporary furniture encompasses pieces produced today by working designers.

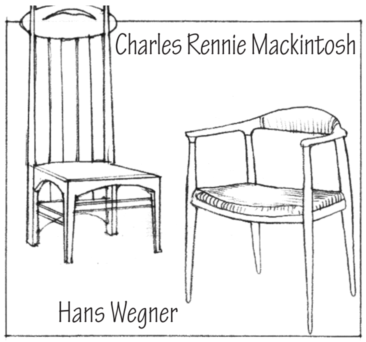


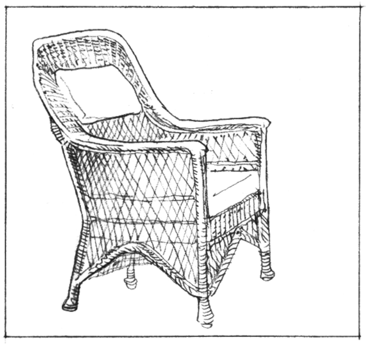



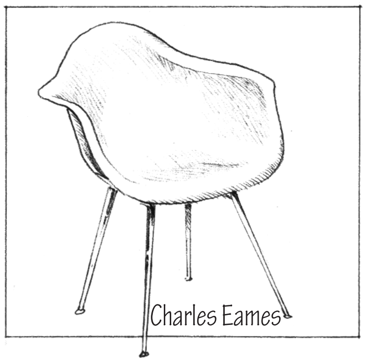



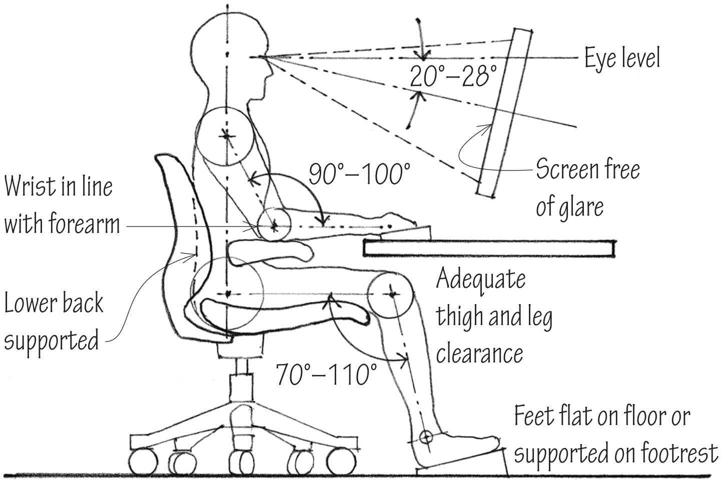


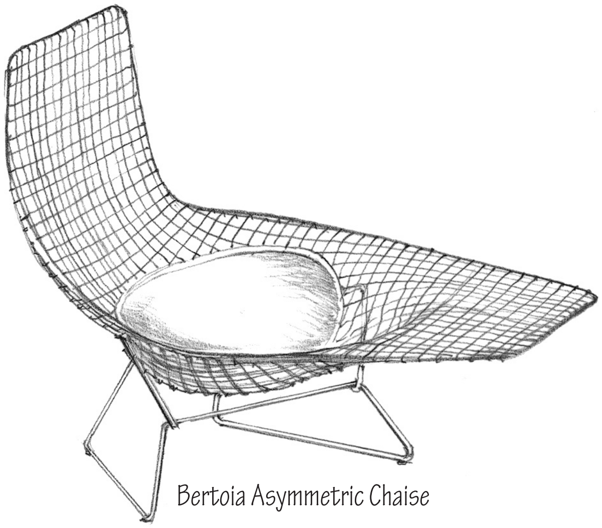








Ergonomic Guidelines

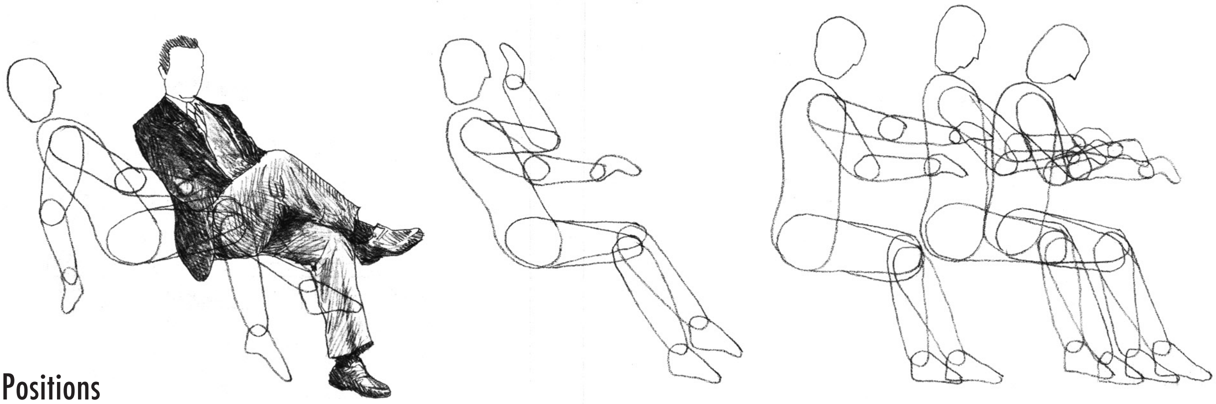


Bertoia Asymmetric Chaise

Furniture can, depending on the quality of its design, either offer or limit physical comfort in a real and tangible way. Our bodies will tell us if a chair is uncomfortable or if a table is too high or too low for our use.

Human factors, therefore, are a major influence on the form, proportion, and scale of furniture. *Ergonomics* is the application of human factors to design. To provide utility and comfort in the execution of our tasks, furniture should be designed first to respond or correspond to our dimensions, the clearances required by our patterns of movement, and the nature of the activity we are engaged in.

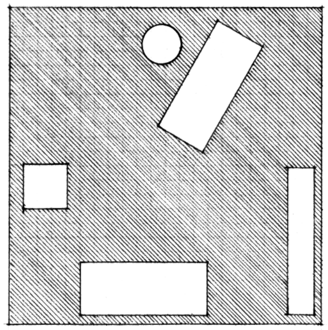
Our perception of comfort is, of course, conditioned by the nature of the task or activity being performed, its duration, and other circumstantial factors such as the quality of lighting, and even our state of mind. At times, the effectiveness of a furniture element may depend on its correct use—on our learning how to use it.

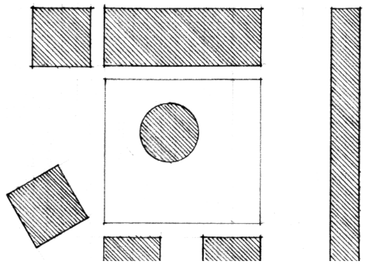


Seating Positions

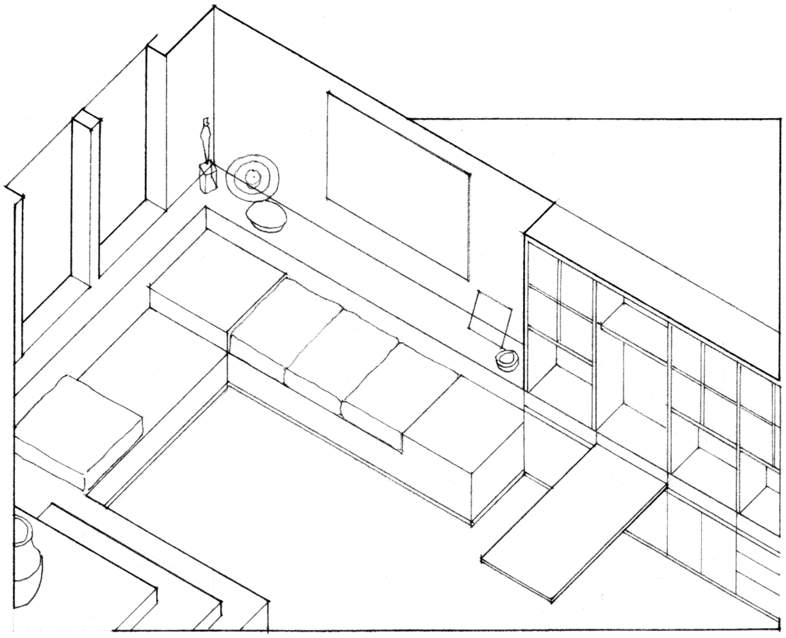
The way furniture is arranged in a room will affect how the space is used and perceived. Furniture can simply be placed as sculptural objects in space. More often, however, furniture is organized into functional groupings. These groupings, in turn, can be arranged to organize and structure space.

Most furniture consists of individual or unit pieces that allow for flexibility in their arrangement. The pieces are typically movable and may consist of various specialized elements as well as a mix of forms and styles.

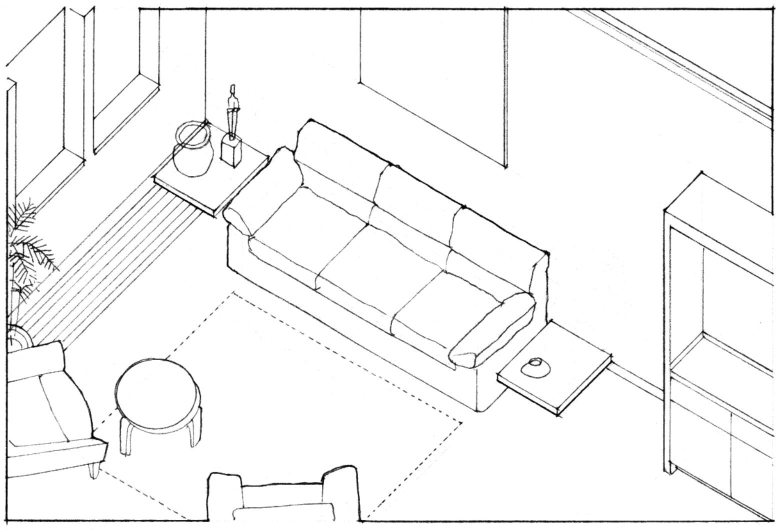




Built-in arrangements of furniture, on the other hand, help retain more open space. There is generally more continuity of form among the furniture elements with fewer gaps between them.



Modular units combine the unified appearance of built-in furniture with the flexibility and movability of individual unit pieces.



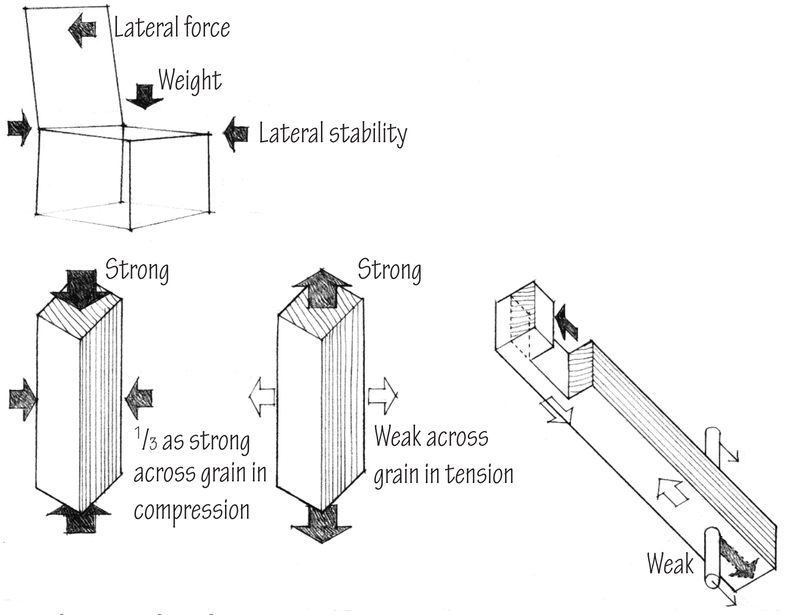
Furniture is commonly constructed of wood, metal, or plastic and other synthetic materials. Each material has strengths and weaknesses that should be recognized in furniture design and construction if the piece is to be strong, stable, and durable in use.

## Wood

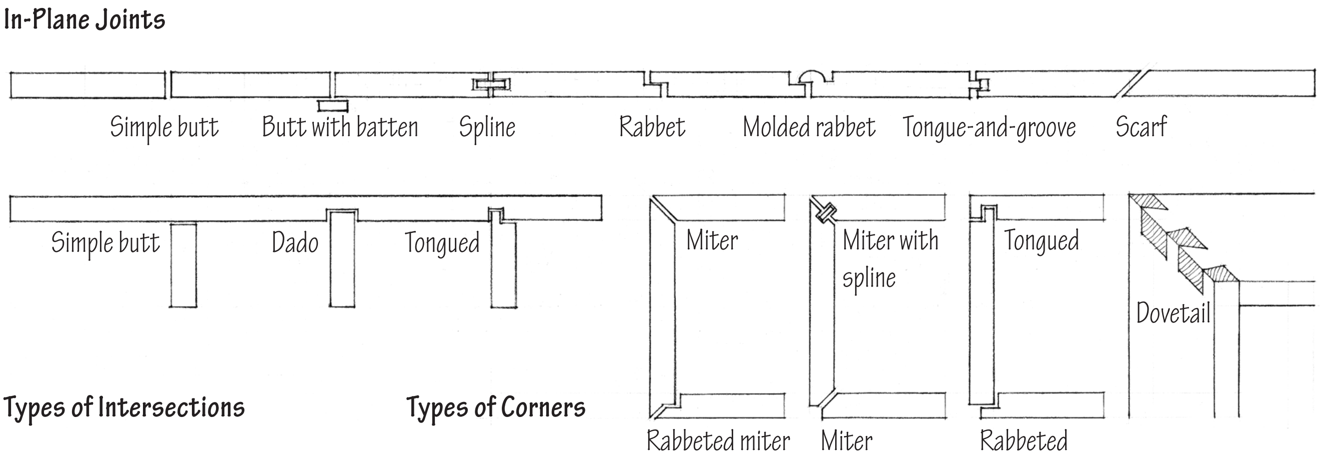
The direction of its grain determines how wood is used and joined. Wood is strong when compressed with the grain, but can be dented or crushed when loaded perpendicular to the grain. In tension, wood can be pulled in the direction of its grain, but will split when pulled at a right angle to the grain. Wood is weakest in shear along its grain. Wood expands and contracts across its grain with changes in moisture content. All these factors bear on the way wood is configured and joined in furniture construction.

Plywood sheets consist of an odd number of plies (thin sheets) layered at right angles in grain direction to each other, giving strength in two directions. In addition, the quality of the face veneer can be controlled to increase strength in the outer layers, where stresses are greatest.

Particleboard is made by bonding small wood particles under heat and pressure. It is commonly used as a core material for decorative panels and cabinetwork. Adhesives used in both plywood and particleboard may contain formaldehyde; lower-VOC-content products are available.




**Wood Strength Relative to Grain Direction**




**Types of Wood Joints**

## Metal

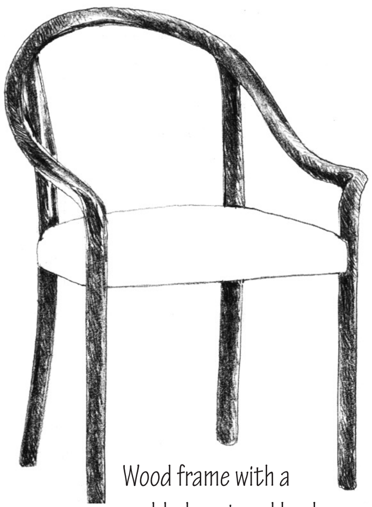
Like wood, metal is strong both in compression and tension, but it does not have a strong grain direction. Metal is *ductile* (capable of being drawn into wire and hammered thin). These factors, along with a high strength-to-weight ratio, enable metal to have relatively thin cross sections and to be curved or bent in furniture construction. Metal can be screwed, bolted, riveted, or welded.

## Plastic

Plastic is a unique material in the ways it can be shaped, formed, textured, colored, and used. There are thousands of types and variations of plastic materials available and under development today. While not as strong as wood or metal, plastic can be strengthened with glass fiber. More significantly, it can be easily shaped into structurally stable and rigid forms. Plastic furniture often consists of a single piece without joints or connections, and furniture made from other materials frequently contains plastic parts.

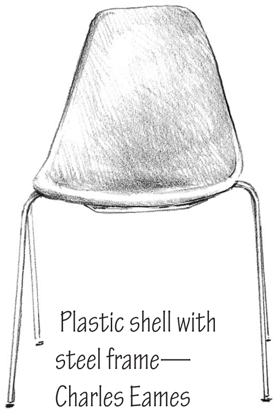
Textiles combining synthetic fibers and *elastomers* offer strength with flexibility and the property of returning to their original shape after being stretched. These materials are stimulating the design of furniture that supports the body without compressing tissues and nerves.

Many pieces of furniture combine a variety of materials, including chairs with wood or metal frames and fabric or plastic seats and backs, dressers with mirrors, and tables with glass tops. Upholstered furniture adds a layer of fabric-covered cushioning to a firmer frame, both for comfort and appearance. Some chairs and other furniture are being designed for disassembly and recycling of parts.



Wood frame with a padded seat and back—Bernd Makulik

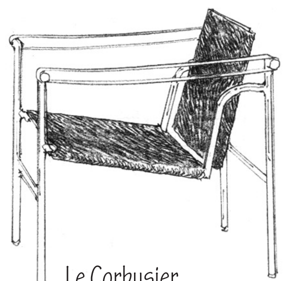
Molded plywood seat and back with steel frame—Charles Eames



Plastic shell with steel frame—Charles Eames

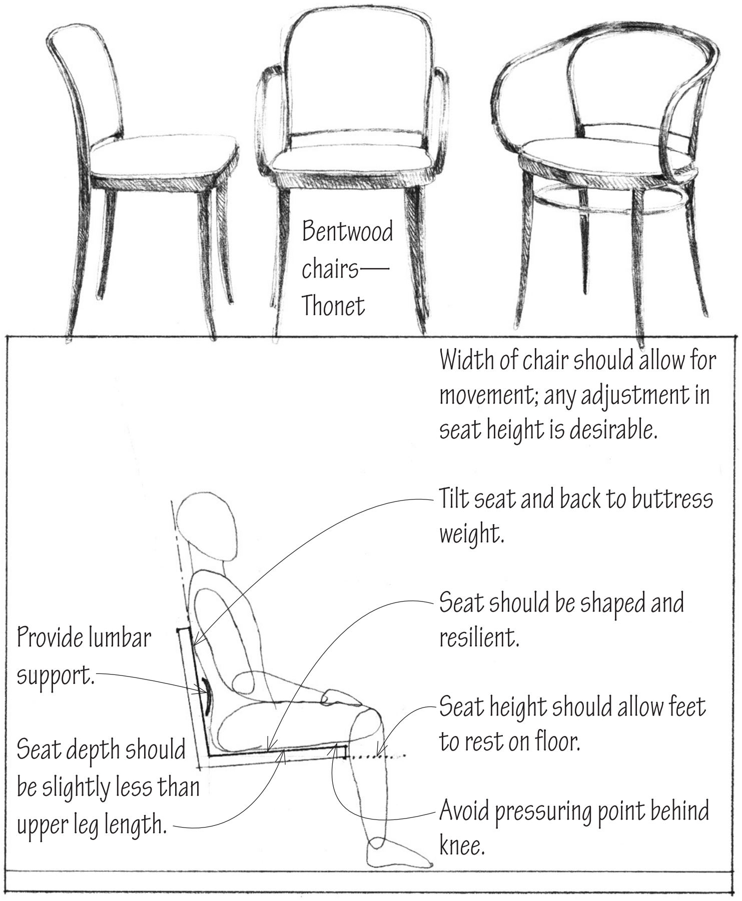
Aeron chair—Don Chadwick and Bill Stumpf for Herman Miller

Mies van der Rohe

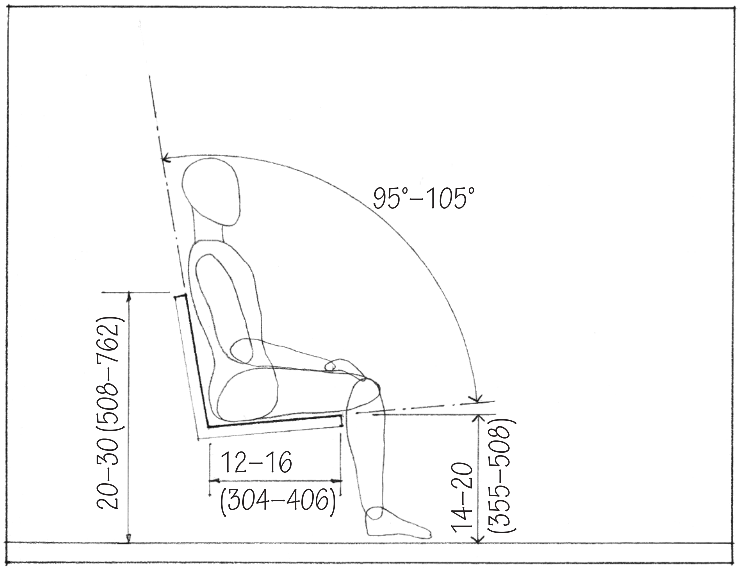


Le Corbusier

Tubular steel frame chairs with leather seats and backs




General Considerations




General Purpose Chair

Seating should be designed to support the weight and shape of the user comfortably. Because of the great variation in body size, however, and the danger of designing too precisely for specific conditions, these illustrations reflect the factors that affect our personal judgment of comfort and a range of dimensions that should serve only as guidelines. All dimensions are in inches, with their metric equivalents in millimeters (shown in parentheses.)

The appropriate dimensions for a chair are determined not only by the dimensions of the human body and the chair's proposed use, but also by cultural factors and matters of scale and style. A relatively uncomfortable, small, hard chair may encourage the customers in a fast-food restaurant to move on. A deeply upholstered lounge chair invites the user to relax.

The comfort factor is also affected by the nature of the activity the user might be engaged in. There are different types of chairs and seating for different uses. Ergonomic design principles are especially important for chairs intended for long periods of use, such as computer desk chairs. Adjustable heights and back supports allow different users to customize their chair's fit. Poorly designed seating is a major cause of health problems among sedentary workers, and today's designers are working on designs that encourage employees to stand up and move around.

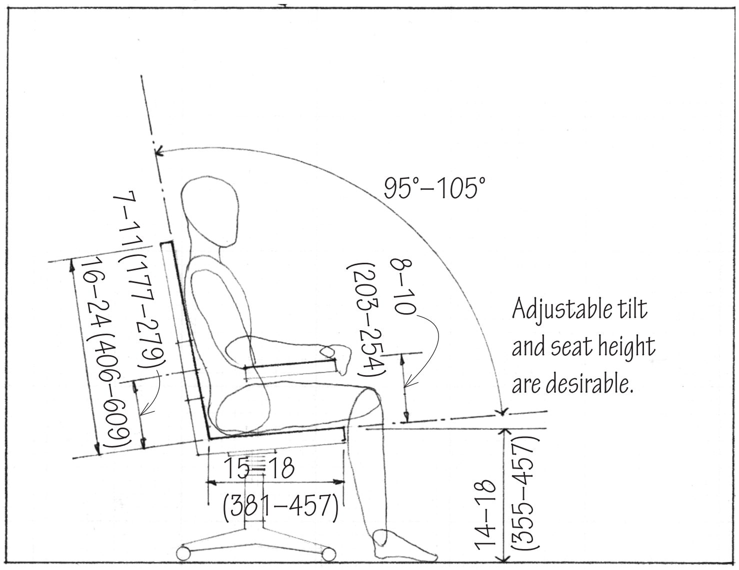
Manufacturers are producing seating systems that provide both visual and acoustical privacy. They feature low-, mid-, or high-back panels and come in straight or curved forms, with upholstered, laminate, or wood surfaces. Some attach seating to backrests that serve as room dividers.

As new chair mechanisms have been developed recently, some existing chairs are being redesigned for the digital-era workplace for use by people no longer tethered to a desk.

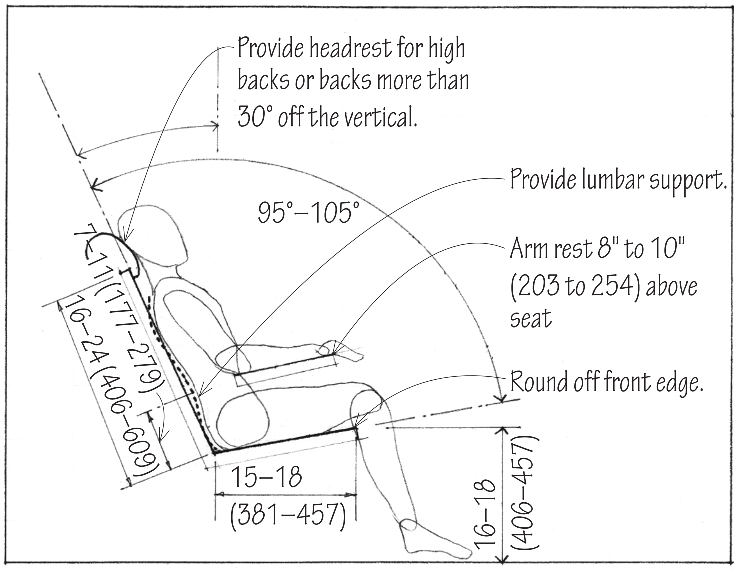
Chairs for older users and people with mobility problems should have sturdy arms, relatively high seats, and stable bases. Bariatric seating accommodates very large people, and may perhaps also be shared by an adult and a child. Children's furniture has its own dimensional constraints.

All dimensions are in inches, with their metric equivalents in millimeters (shown in parentheses).

Italian upholstered chair with metal legs, circa 1950s

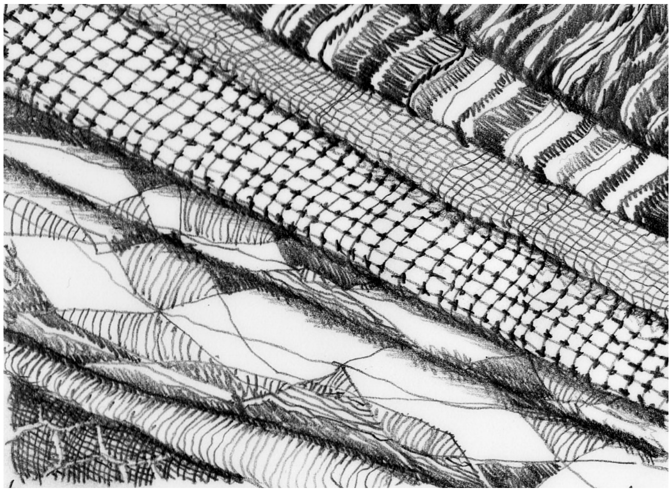



Office Chair




Easy Chair

Upholstery fabrics should be selected to withstand the normal wear of their intended use. Commercial-grade fabrics are labeled for wear, sun, and fire resistance. The desire to avoid toxic materials such as formaldehyde, polyvinyl chloride, and phthalates that have raised health concerns has led designers to ban these materials. The Red List maintained by the International Living Future Institute (ILFI) classifies certain products as hazardous. Although a majority of the harmful chemicals are rinsed out in the production process, a percentage often remains that can be off-gassed into homes and workplaces or absorbed by people's skin. Designers today rely on HPDs to determine possibly toxic material contents. This level of transparency is not always available, and designers must rely on certifications by third-party organizations such as Greenguard, Cradle to Cradle, the Global Organic Textile standard, and the Living Product Challenge. Some manufacturers currently produce entire fabric lines that are PVC free, Greenguard certified, and made with recycled or natural fibers.



Upholstery materials include:

| | |
|---|---|
| Cotton | Plant fiber with low elasticity and resiliency. Combustible and wrinkles easily. Primarily residential use. |
| Linen | Derived from stalk of the flax plant. Extremely strong, tends to be brittle, wrinkles easily. Commercial and residential use. |
| Ramie | Very strong, lustrous natural fiber. Stiff, brittle, nonelastic. Often blended with linen and cotton for commercial and residential use. |
| Silk | Produced by silk moths. Strongest natural fiber, resistant to solvents but degenerates in sunlight. Typically, only residential use. |
| Rayon | Manufactured from wood pulp. Viscose rayon blends well with other fibers and takes dyes well. Commercial and residential use. |
| Acrylic | Mimics silk or wool. Accepts dyes well, may pill. Outdoor use. |
| Vinyl | Simulates leather or suede. Durable, easy to clean. Not sustainable material. Residential and commercial use. |
| Polyester | Wrinkle resistant, abrasion resistant, dimensional stability, crease resistant. Commercial use. |

Indoor/Outdoor Fabrics
Manufacturers such as Sunbrella Contract now sell their weather-resistant fabrics for both residential and commercial indoor and outdoor use.

Cork cloth An impermeable and antimicrobial, pliable material available in several colorways, and used as an alternative to leather that lends itself to fabric-wrapped panels and upholstery.

## Special Fabrics

Elastomeric fibers (spandex) return to their original shapes after being stretched. Commercial use.

Crypton® is a process for treating a variety of fabrics, such as cotton, linen, silk, wool, acrylic, rayon, polyester, and coated fabrics, to make them highly durable, stain- and moisture-resistant.

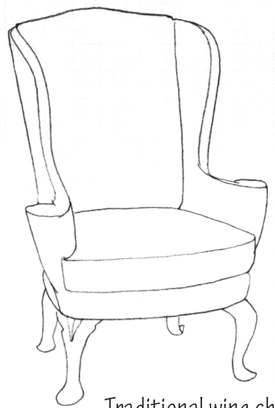
Nanotex® technology changes fibers on the molecular level to prevent damage by dirt, stains, and soil.

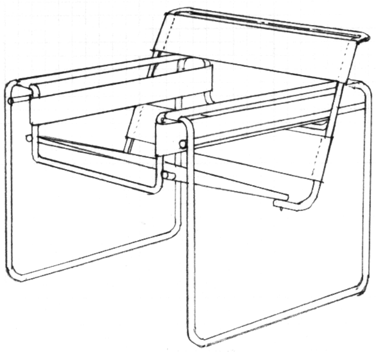
Metal fabrics are produced for interior and exterior applications including sunshades, ceilings, safety and security, partitions, and other uses.

Custom upholstery fabrics are specified through the Customer's Own Material (COM) system, which has now become part of the digital age with websites filled with information and advice. Designers can now have expedited communication with experts, quick turnaround times, overnight FedEx sampling, and access to important information on the behavior of upholstery fabrics.

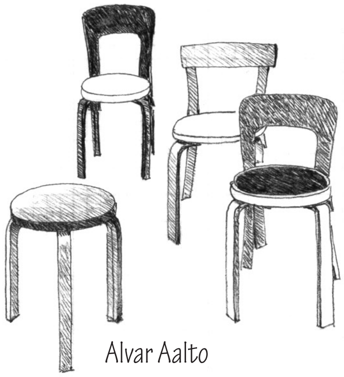
## Chairs

| | |
|---|---|
| Armchairs | Intended for relaxing, conversation, or reading. Fully upholstered; constructed of wood, plastic, steel, or a combination of materials. |
| Side chairs | Usually lighter and smaller than armchairs; upright backs for dining and studying. |
| Lounge chairs | For relaxing in a semireclining position, often adjustable. Should be easy to get into and out of, neither too low nor too soft, and should provide proper back support. |

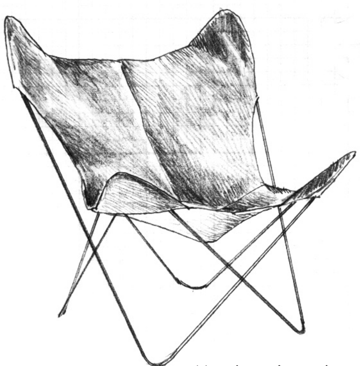

Traditional wing chair

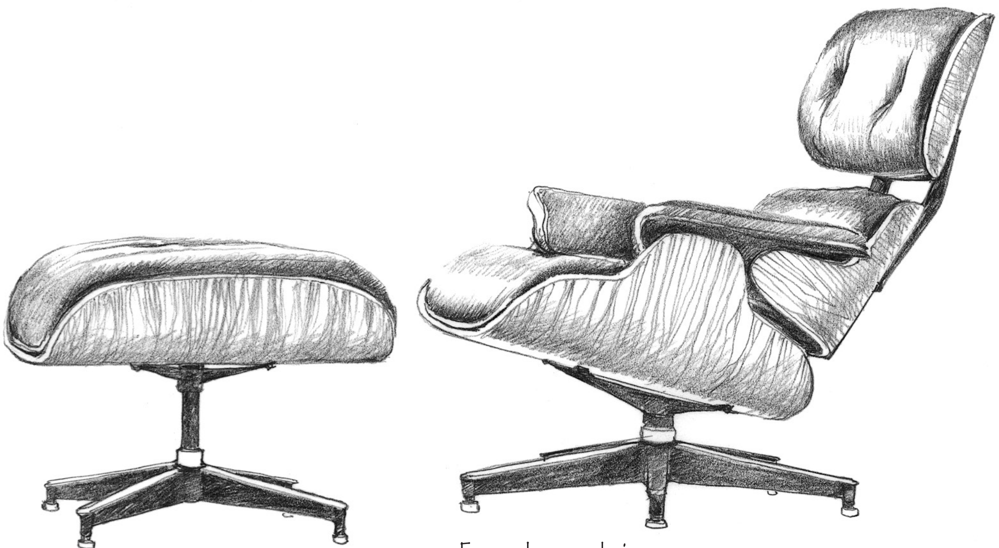

Wassily chair—Marcel Breuer


Arne Jacobsen

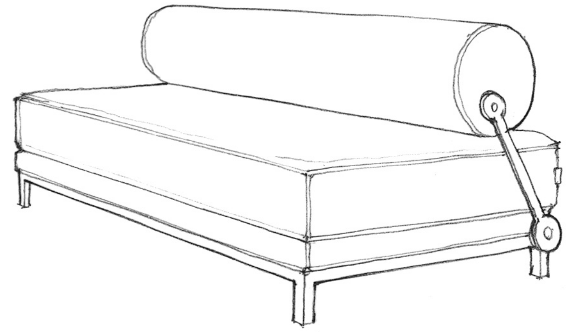

Alvar Aalto

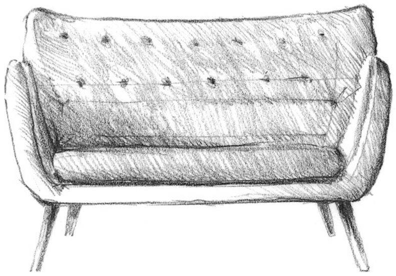

Shaker ladderback chair

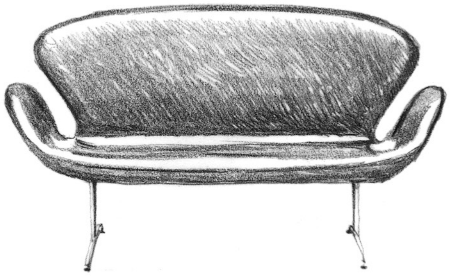

Hardoy sling chair

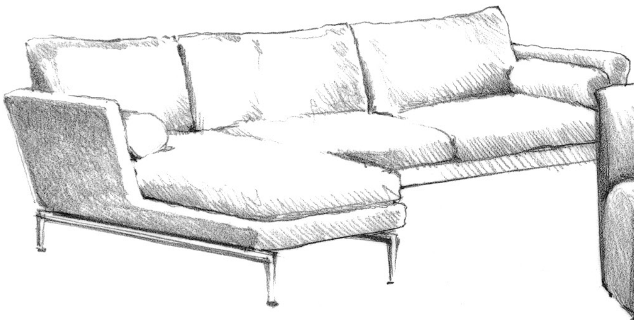

Eames lounge chair

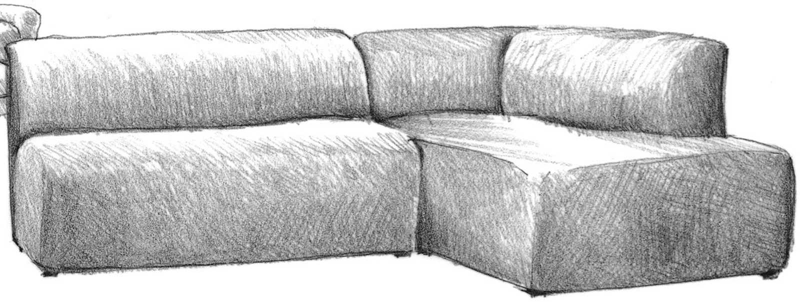
| | |
|---|---|
| Sofa | Designed for seating of more than two people. Generally upholstered; curved, straight, or angled; with or without arms. |
| Loveseat | A small sofa with only two seating positions. |
| Sectional | A sofa divided into separate parts that may be used in various configurations. |
| Sleeper | A sofa designed to be transformed into a bed. |

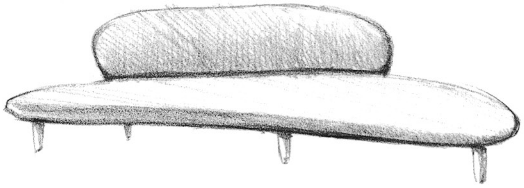

Twilight sleeper sofa—Flemming Busk for Softline

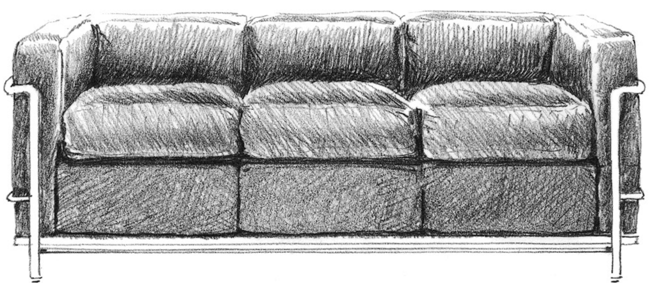

Poet sofa – Finn Juhl, produced by Onecollection


Swan loveseat – Arne Jacobsen for Fritz Hansen


Suita sectional—Antonio Cittero for Vitra


Josie sectional—Mitchell Gold + Bob Williams


Freeform sofa—Isamu Noguchi, produced by Vitra

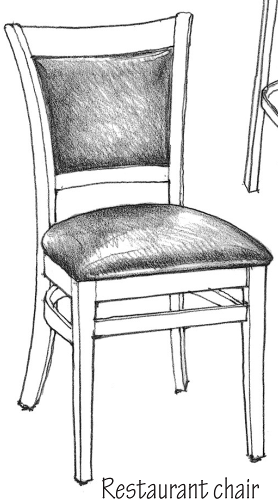

Petit Modele sofa—Le Corbusier, Pierre Jeanneret, and Charlotte Perriand, produced by Cassina

Ergon 3 chair—Herman Miller

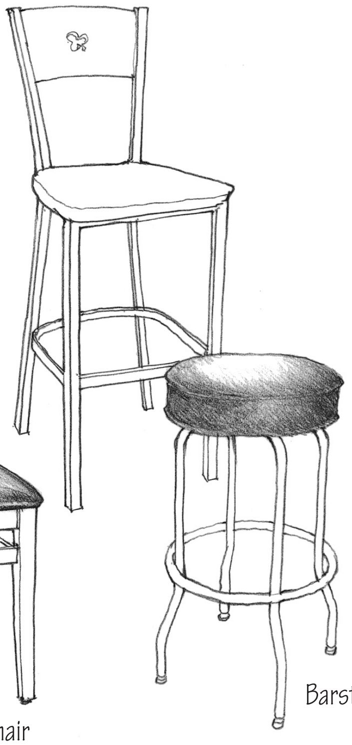
Executive work chair—Alyssa Coletti/Nonfiction Creative

Adjacent desk seating

Charles Eames



Restaurant chair

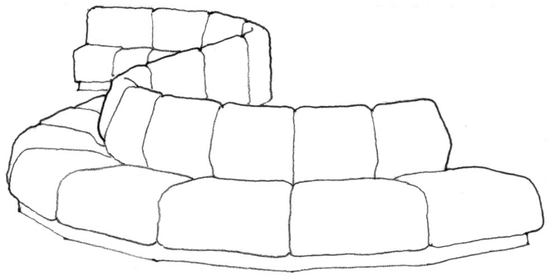


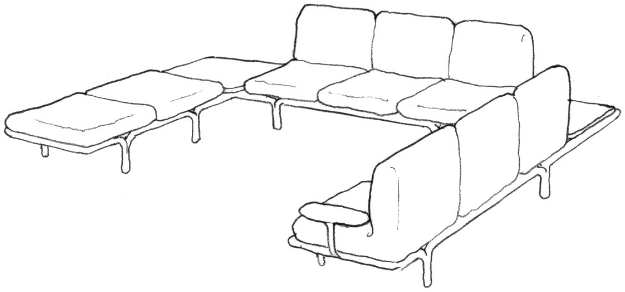
Barstools

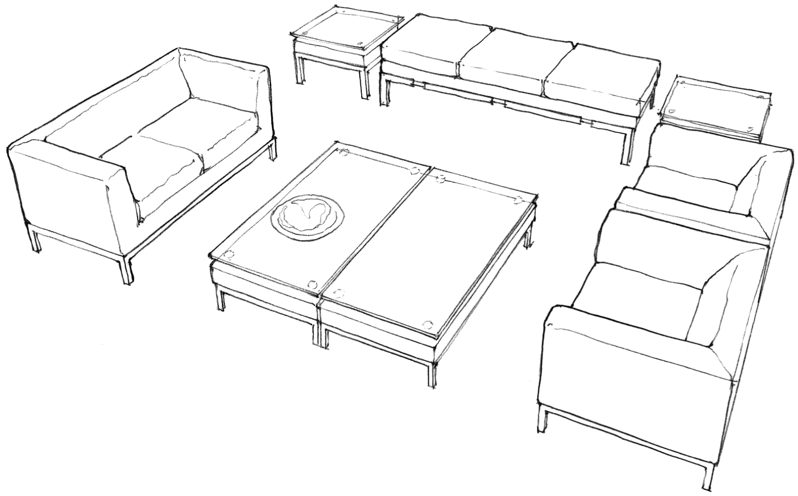
Commercial seating must be durably constructed to support workers without stress throughout the workday. Seating should not be selected solely on the basis of the user's status within the company or enterprise, but rather selected to accommodate the size of the individual user and to provide proper support for the type of activity envisioned.

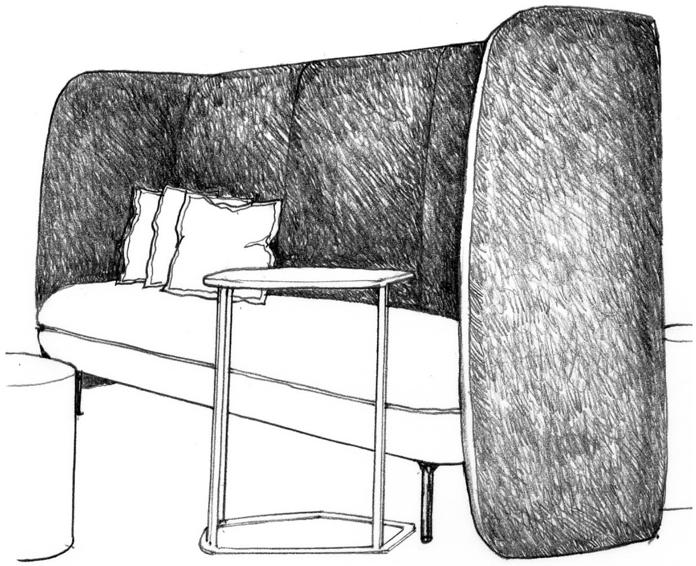
| | |
|---|---|
| Desk chairs | Designed to be flexible and mobile. Swivel mechanism, rolling casters, arms. |
| Executive chairs | Often designed as status symbols, these allow the user to lean back from the desk. Swivel mechanism. May not be appropriate for extended computer use. Being redesigned, trimmed back as much as possible, while still being comfortable. |
| Side chairs | Intended for office visitors or short-term use. Usually small in scale and often armless. |
| Stacking and folding chairs | Used for large gatherings of people or as auxiliary seating. Lightweight and modular, often made of steel, aluminum, or plastic. Some are available with arms and with padded seats and backs; some have coupling devices for use in rows. |
| Restaurant chairs | Must be durably constructed; comfort level is usually selected to match intended service style. Chairs with arms must be coordinated with tabletop heights. Chair size may affect seating patterns. |
| Stools | Should be selected for stability and ease of movement as well as for appearance. |

| | |
|---|---|
| Sofas | Arranged in L-shapes or U-shapes for conversation groups in lobbies, large private offices, waiting areas. Strangers generally sit at opposite ends, leaving center seat empty. |
| Loveseats | Useful in smaller private offices where they can be used for naps. |
| Modular or sectional seating | Available armless, with left or right arm only, or as corner piece. Modular seating also refers to seating with a continuous base to which individual seats are attached. |
| Booths | Commonly designed for two to four persons; larger booths and U-shaped or circular configurations present access problems for central seats. Usually upholstered. |
| Seating with privacy walls | Sofas or benches with high backs and sides that offer acoustic privacy for employees. |
| Banquettes | Long, usually upholstered seats facing multiple tables with chairs opposite, allowing tables to be moved along their length and clustered to accommodate varying sizes of groups. |
| Fixed seating | Used in auditoriums, lecture halls. Provides acoustic absorption as well as seating. Fire safety requirements for materials and arrangements. The advent of the "flipped classroom" where classwork and homework are reversed, with students listening to lectures and reviewing material online, and then working on assignments in class, has led to the use of mobile tables and wireless technology rather than theater-style seating in classrooms. |
| Sleep chairs | These chairs convert from lounge to sleep positions to support the needs of patient's families, whose presence can contribute to improved patient outcomes. |

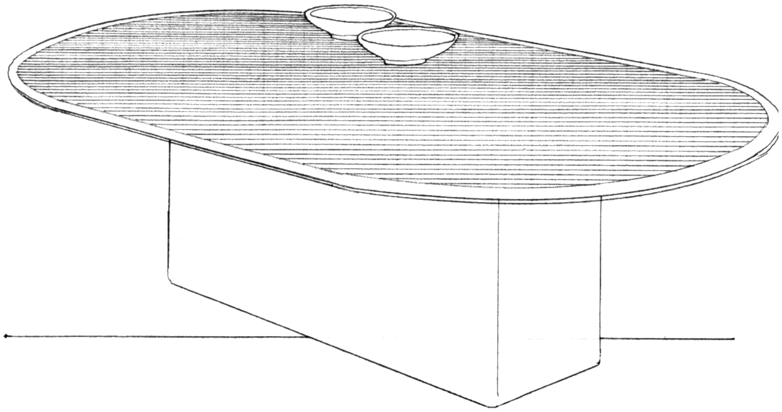








Chappelle—Jerry Helling/Bernhardt Design

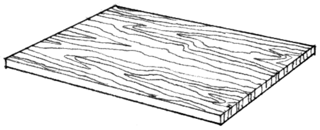


Tables are essentially flat, horizontal surfaces, supported off the floor, and used for dining, working, storage, and display. They should have the following attributes:

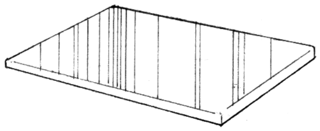
- Strength and stability to support items in use
- Correct size, shape, and height off floor for intended use
- Construction of durable materials

Tabletops can be of wood, glass, plastic, stone, metal, tile, or concrete. The surface finish should be durable and have good wearing qualities. The surface color and texture should have the proper light reflectance for the intended visual task.

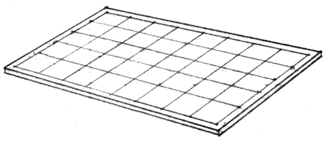
Tabletops can be supported with legs, trestles, solid bases, or cabinets. They can also swing out or down from wall storage units and be supported by folding legs or brackets. Table bases should relate in scale and size to the tabletop to provide adequate support and stability.



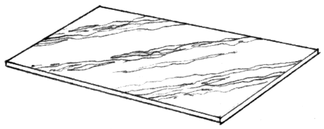
Wood



Glass, metal, or plastic

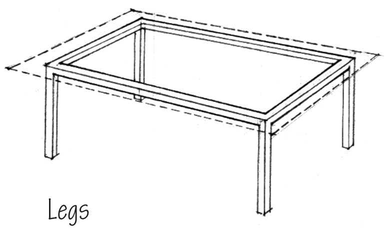


Tile

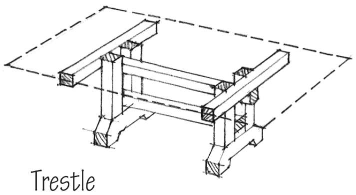


Marble or granite

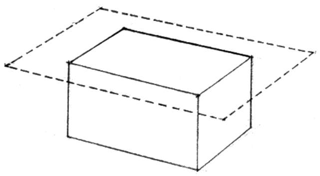
### Tabletops



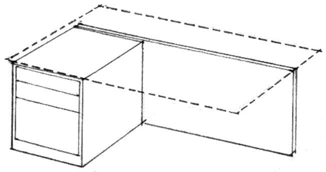
Legs



Trestle



Solid pedestal



Cabinet or casework

### Table Supports

A minimum of 24 inches (609-mm) should be provided for each person around the perimeter of a dining table.

Table shape should be compatible with the shape of the room.

Surface finish should provide an attractive background for table settings.

For flexibility in accommodating both small and large groups, tables that extend with leaves are desirable.

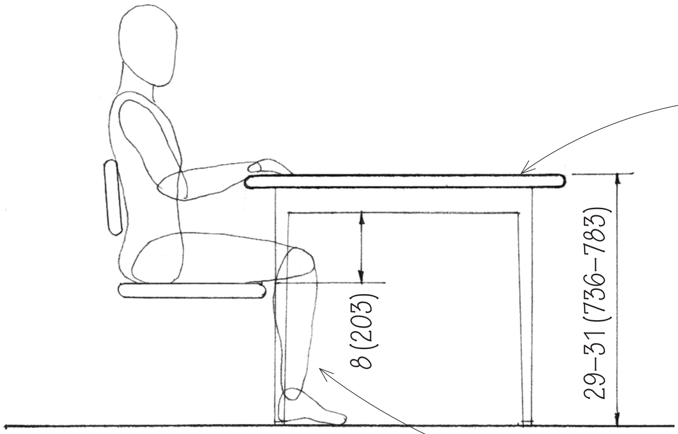
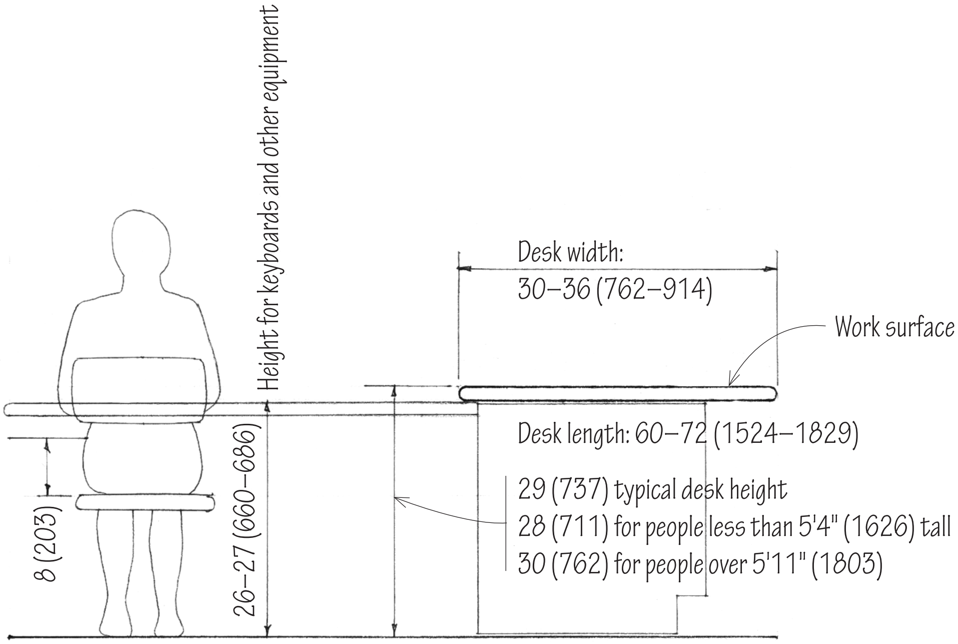



Table supports should not reduce the space for users' knees and legs.

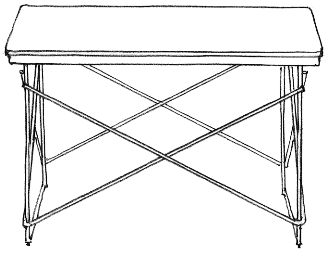
## Dining Tables



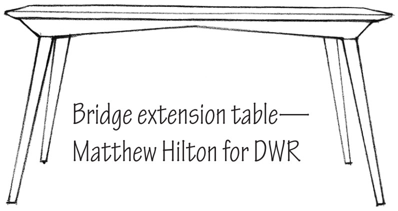

Work surface should be free of glare.

## Desks and Work Surfaces

All dimensions are in inches, with their metric equivalents in millimeters (shown in parentheses).

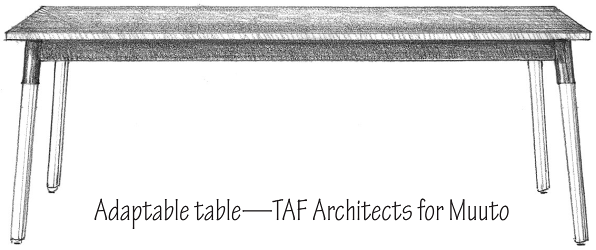


Wire base table—Charles and Ray Eames for Herman Miller

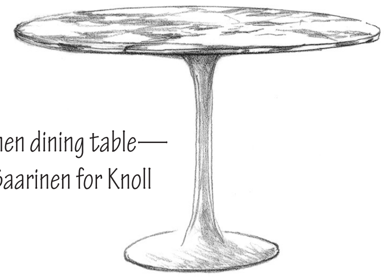


Bridge extension table—Matthew Hilton for DWR

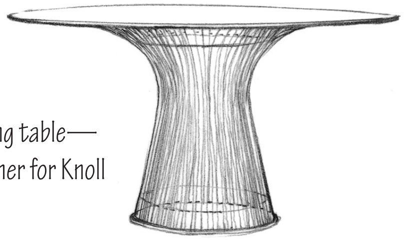
| | |
|---|---|
| Dining tables | Selected for style, number of seats (with optional leaves for expansion), and fit in room. Both custom and manufactured designs are available. |
| Occasional tables | Coffee tables are designed to hold books, magazines, and beverages in front of a sofa. End tables provide surfaces for a lamp and other accessories next to a seat. Other small tables hold accessories and help to balance the room's décor. |



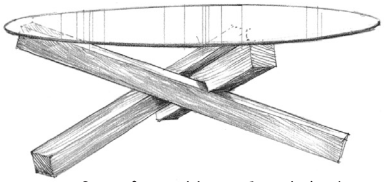
Adaptable table—TAF Architects for Muuto



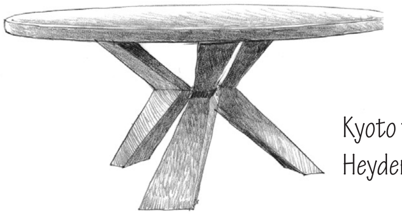
Saarinen dining table—Eero Saarinen for Knoll



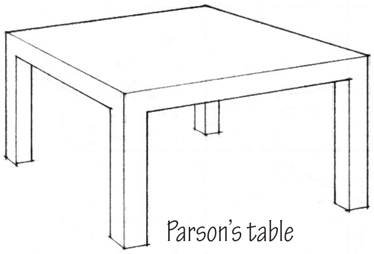
Platner dining table—Warren Platner for Knoll



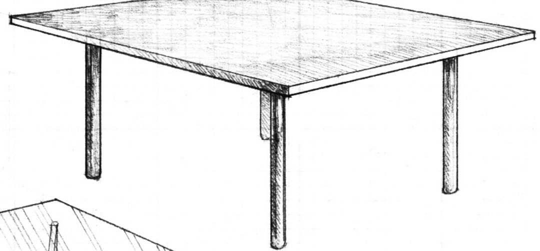
Campfire table—Tomek Archer

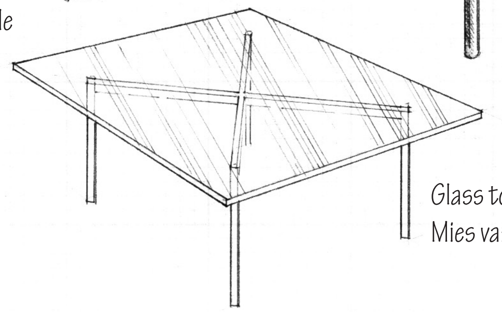


Kyoto table—Frans van der Heyden for Birdman Furniture



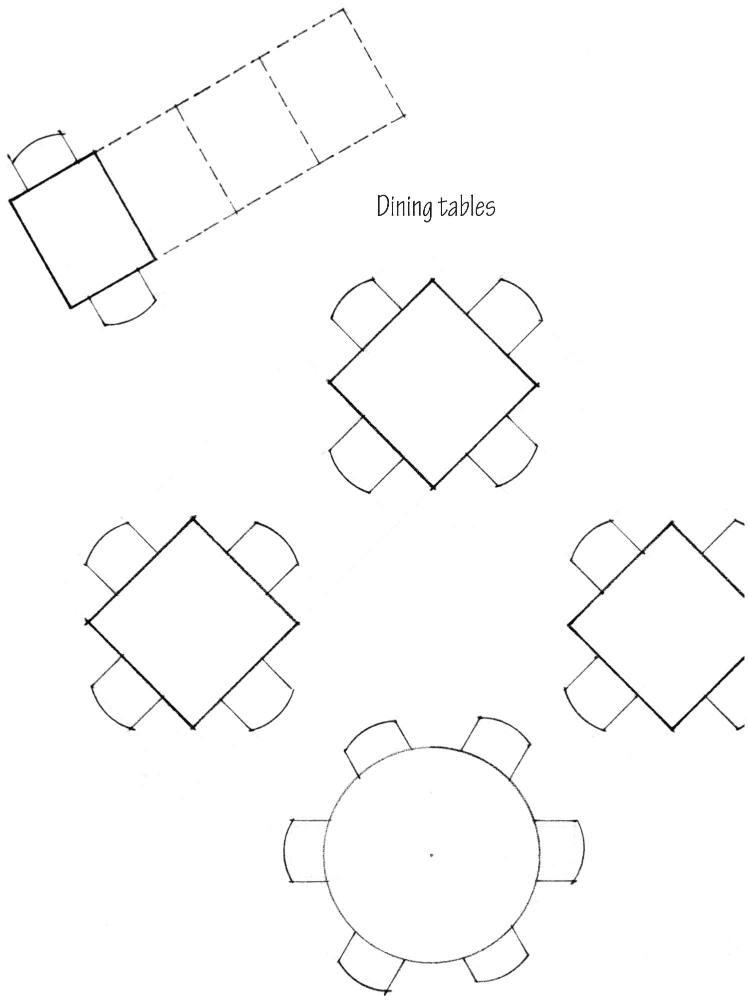
Parson's table



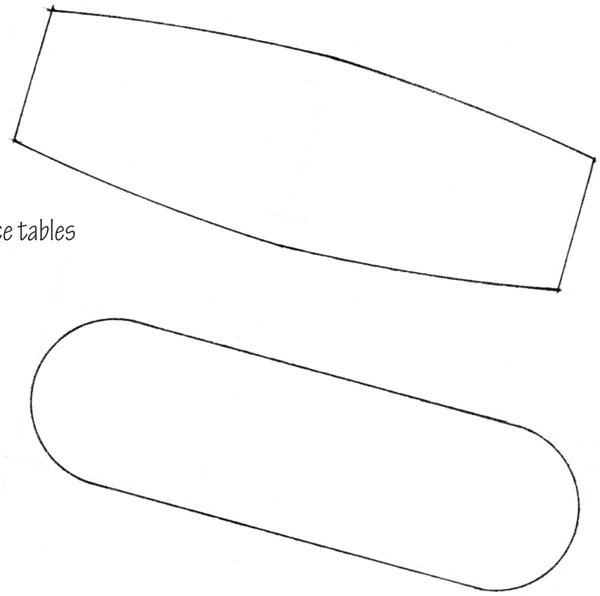


Glass top and steel base—Mies van der Rohe

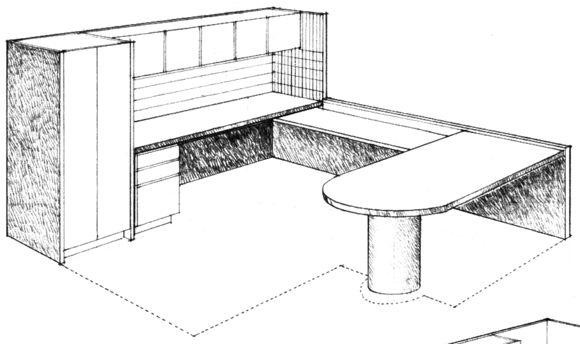
| | |
|---|---|
| Restaurant tables | Selected for durability, style, number of seats, and fit in space. Center post support; tabletops can be custom or stock. Rectangular "deuces" (tables for two) can be combined for larger parties, circular tables are often used for large groups, and square tables can be oriented on diagonal. |
| Conference tables | Large single tables with many seats, or smaller tables designed to be reconfigured for conference and seminar rooms. Selected for capacity, flexibility, and appearance. |
| Boardroom tables | Large tables, often custom, designed for prestige and style. May have built-in data and communications equipment. |
| Hotel guest room tables and desks | Similar to residential pieces in style, but with commercial quality for durability. |

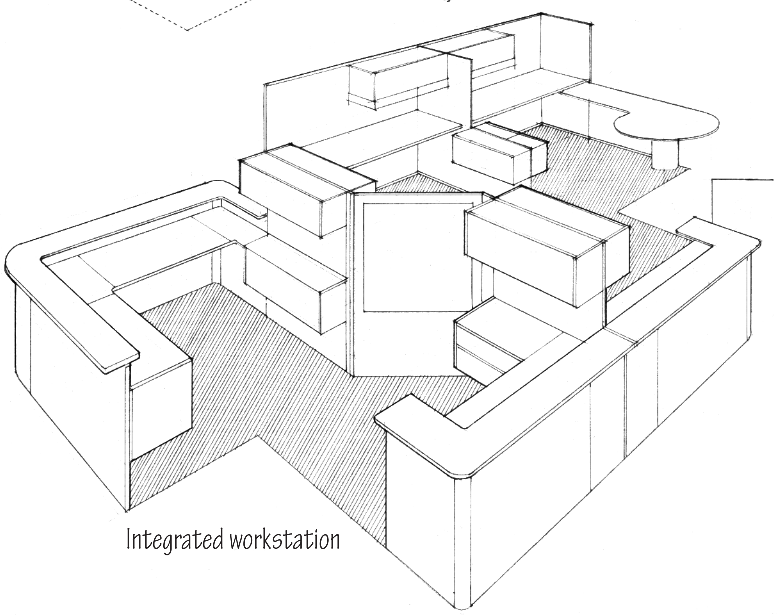


Dining tables



Conference tables





Integrated workstation

Designers often refer to an individual's work area—comprising a desk, chair, computer and related equipment, and storage as well—as a workstation. The desk and adjacent horizontal surfaces are called work surfaces. Office environments continue to change, but many people still work in cubicle-based workstations. These systems are still manufactured, and are also available for reuse, which has both economic and sustainability advantages. For individuals needing a high level of focus for their work, private offices and other acoustically protected spaces are still necessities. Today, these spaces are somewhat more likely to be assigned for the task, rather than for the status of the user.

However, the trend toward home offices and the use of portable computers and wireless communications are creating a market for office furnishings that are flexible in use and easy to move. Seating and work surfaces are now designed for multiple employees who come and go on varied schedules. Furnishings can be clustered for small group work and meetings, then dispersed for individual work.

These very open workspaces raise the bar for acoustic privacy issues, and must be carefully planned. Some workspaces are designed around four popular work styles: collaborative, learning, interacting, and focusing. The goal is to encourage collaboration, concentration, and chance encounters, with a variety of furnishings and layouts. Workstations can become a bit more personal, with options to make people feel better and help them do their work better.

Coworking spaces for start-ups and freelancers provide opportunities for those working from a home office to meet, collaborate, and enjoy the company of other people. Coworking spaces tend to be big, airy, and welcoming, with opportunities to take a break and chat with others. They offer a way to meet friends, expand networks, and eventually find opportunities and people to work with.

Open workspaces

Desks vary in style and function. The traditional desk incorporates drawers and storage into its base. A desk may also consist simply of a freestanding table or work surface supported on a pedestal base with storage. This basic workstation can be extended with additional work surfaces to the side or behind the user.

The selection of a desk should consider how it would be used as well as issues of style and status. The size and configuration of the desk should respond to the need to accommodate storage and equipment, including computers and peripherals. Desks may also be shared by a number of workers.

## Standing Desks

Sitting at a desk all day, especially with poor posture and little overall motion, can have negative effects on the human body, such as obesity, back problems, and heart disease.

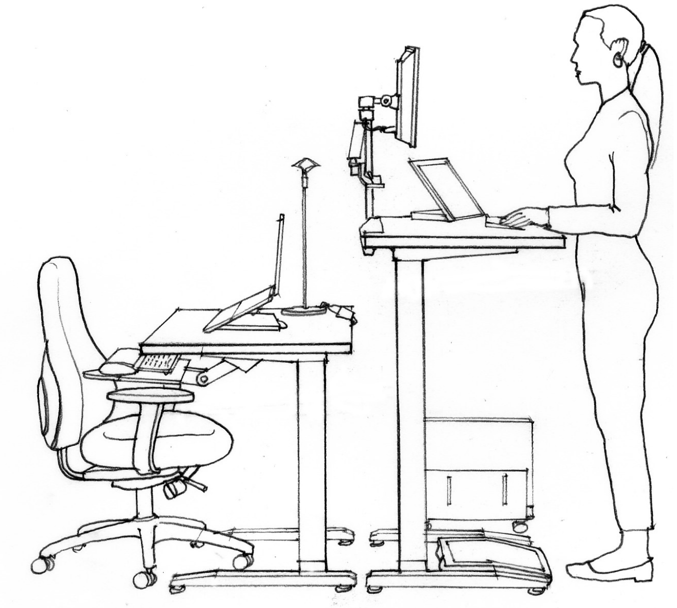
Standing desks are adding a vertical dimension to the interiors of progressive office spaces. Some are fixed at heights for use when standing, while others are adjustable for standing or sitting (sit-stand desks). Standing at a desk can substantially reduce worker reports of muscular-skeletal discomfort. Standing can lower fatigue while supporting the worker's ability to change posture more readily are often viewed as a healthier way to work.

There are typically three varieties of sit-stand desks:

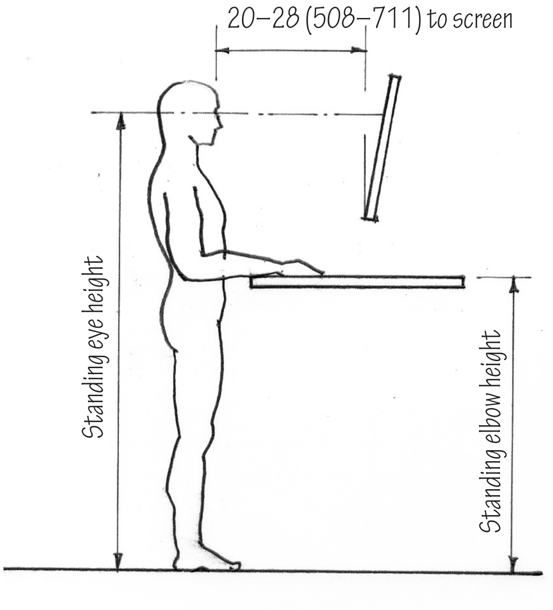
1. Hand-crank: The user manually turns a handle to raise or lower the desk. Tend to be less expensive.
2. Electric: Typically operated by pushing buttons to adjust the height or bring the desk to a preset position.
3. Counter-balanced: Manually operated more easily than hand-crank models.

There may be significant differences in height adjustment between models, and especially between different mechanisms. Add-on adjustable accessories can be used with fixed-height desks, but may introduce new ergonomic risks due to set heights and limited adjustments. Height-adjustable sit-stand benches are another option that provides flexibility and health benefits. For offices where workers stand at their desks, extra space may be required to put their chairs while they stand.

It is becoming more common for the workplace culture to be designed to encourage movement throughout the day. Offices are being designed with a wide variety of work settings, including standing areas, lounge settings, and private rooms, so that employees can easily change their workspace. Where this is not possible, sit-stand desks can still encourage more movement and better posture.



Adjustable sit-stand desk




## Standing Desk

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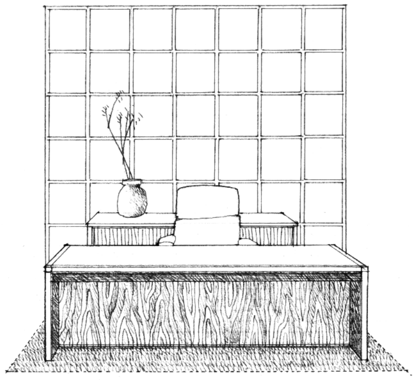
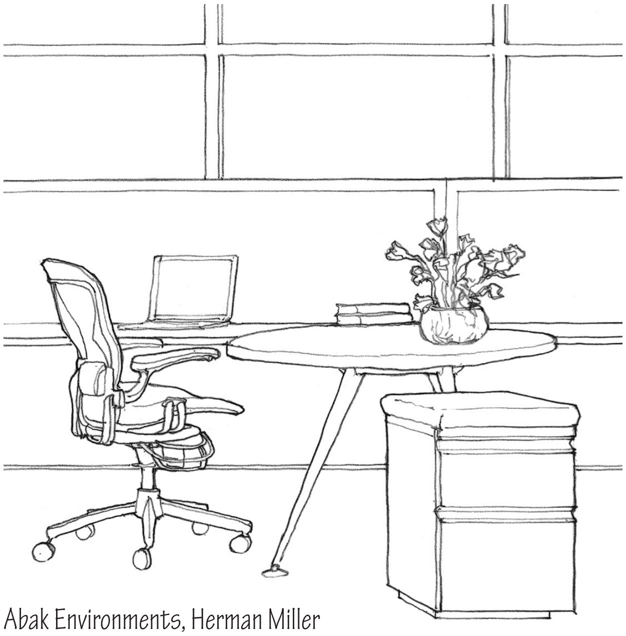


Traditional Desk and Credenza

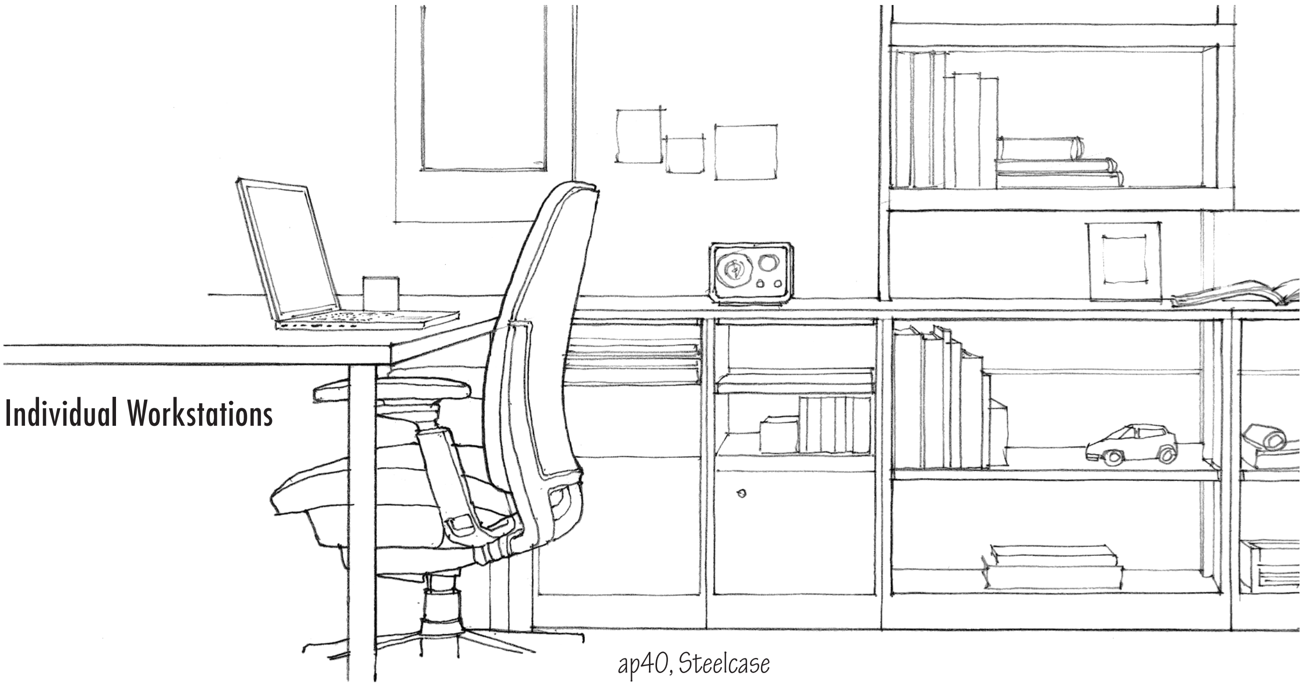
While the private office encloses a workstation within a room, open office environments utilize modular work surfaces and storage units to integrate multiple workstations and enhance user communication and productivity.

Today, open office environments are more likely to be freestanding than housed in cubicles. As equipment becomes lighter and less wiring is needed, walls are less essential. Short panels provide little or no visual and acoustical separation.

Office workers may find themselves with minimal amounts of real estate. Work surfaces can be arrayed in closely spaced rows. This can aid communication and cooperation, but may create stress and territorial problems for some workers. Whether working in such close quarters increases or decreases productivity and worker satisfaction may depend on individual work-style preferences, the amount of time spent at the workstation, and whether the rest of the space offers other options.



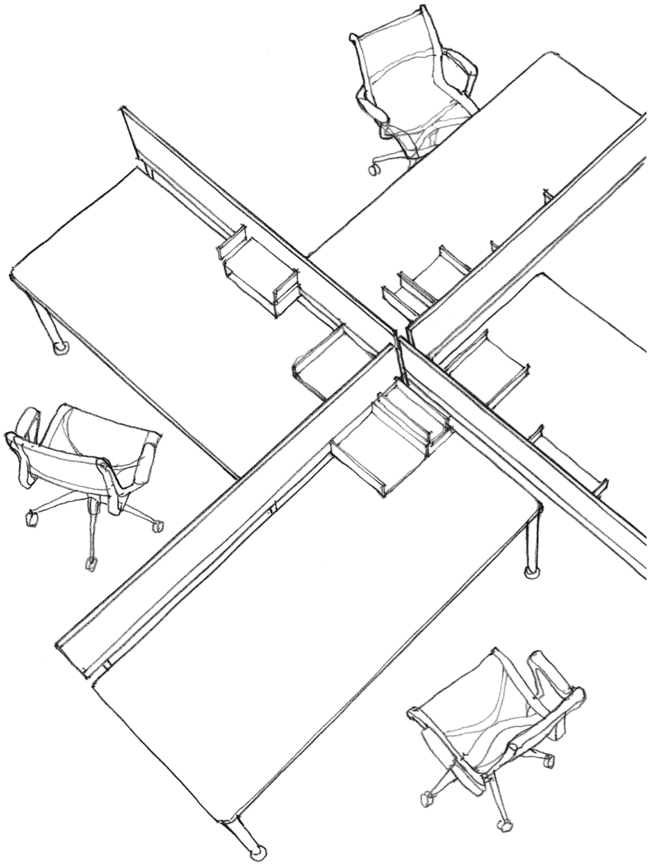
Abak Environments, Herman Miller



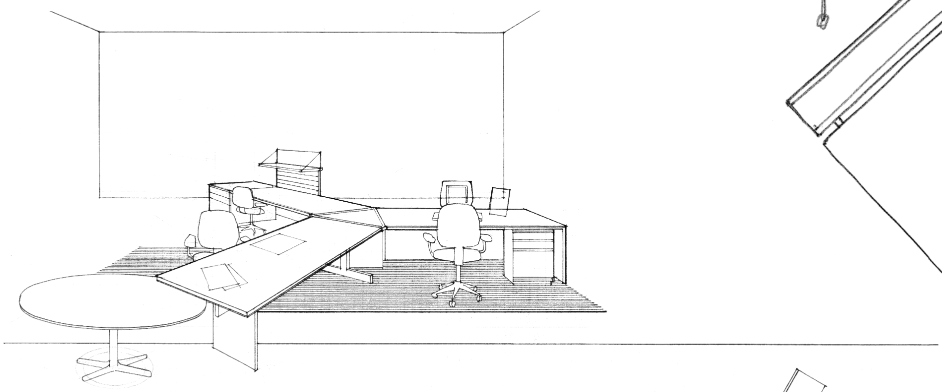
Individual Workstations

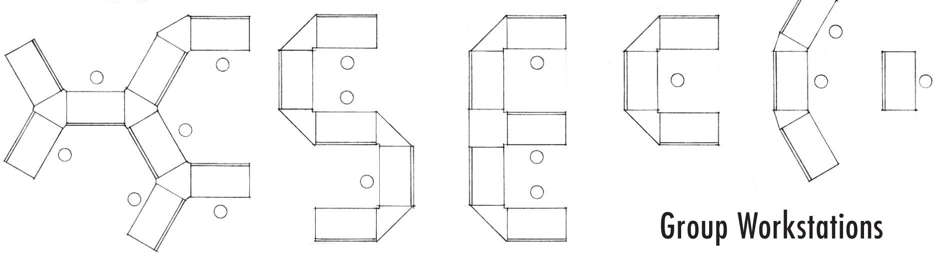
ap40, Steelcase

In the past, the commercial office furnishings market was too large-scale and expensive for small home businesses to access. Many of the pieces being designed today can work well in a home office, and manufacturers are beginning to make office furnishings available to this new market.

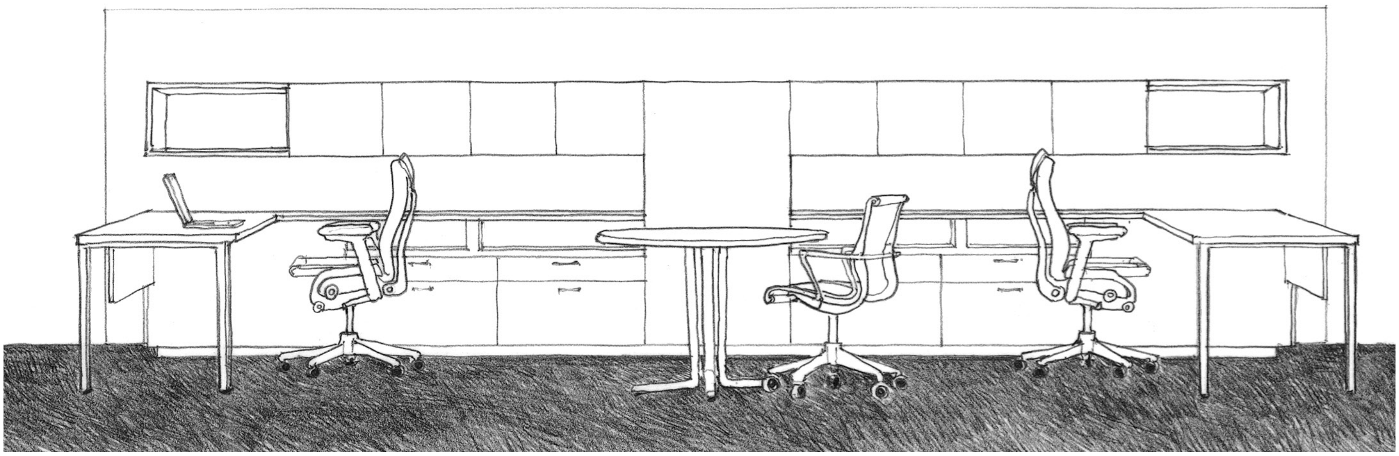


Sense desking system, Herman Miller

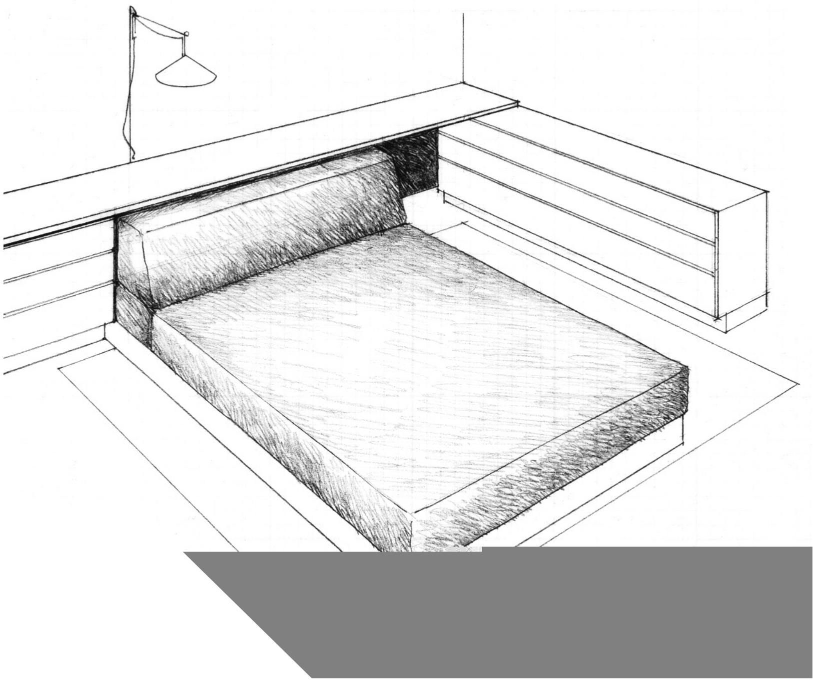




Group Workstations



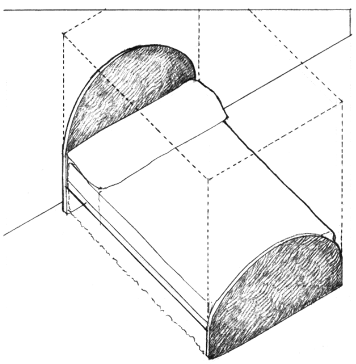
Canvas office landscape, Herman Miller



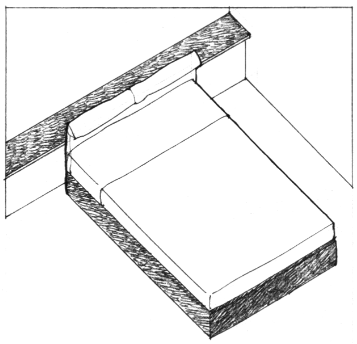
Beds consist of two basic components: the mattress or mattress set and the base or support frame. There are various types of mattresses, each made in its own way to respond to and support the user's body shape and weight. Personal judgment and choice, therefore, are required in the selection of a mattress.

Not all coil-spring mattresses are equal; most today are made with synthetic fibers and foam, and all have the same spring gauge. Experts generally agree that the best mattresses are the simplest, made with ingredients like organic cotton, wool, and natural (from trees) latex.

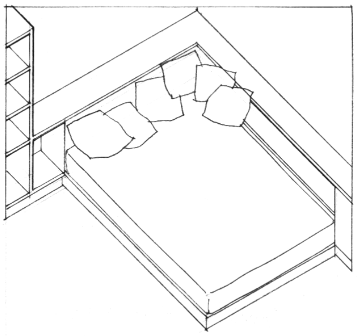
Interior designers are involved in the selection of the base or bed frame, headboard, footboard, canopy, associated tables, storage pieces, lighting, and electronic controls. The designer may also specify bed linens and covers and other room furnishings.



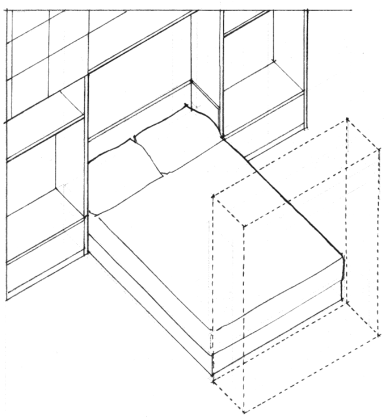
Headboards, footboards, and canopies define the volume of space occupied by a bed.



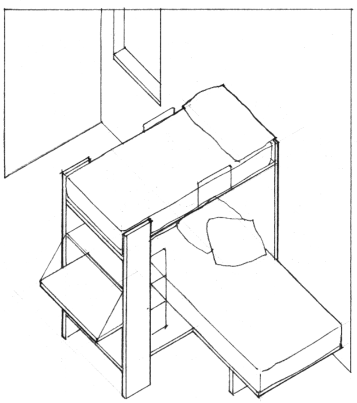
A bed can rest on a platform base, emphasizing the horizontality of the setting.



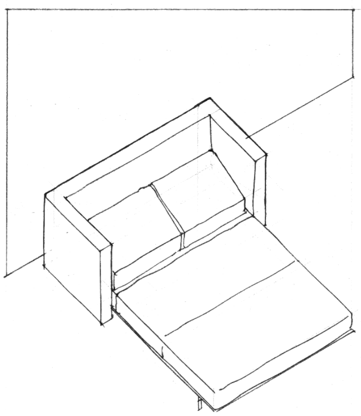
A bed built into a corner or alcove takes up less floor space, but it may be difficult to make.



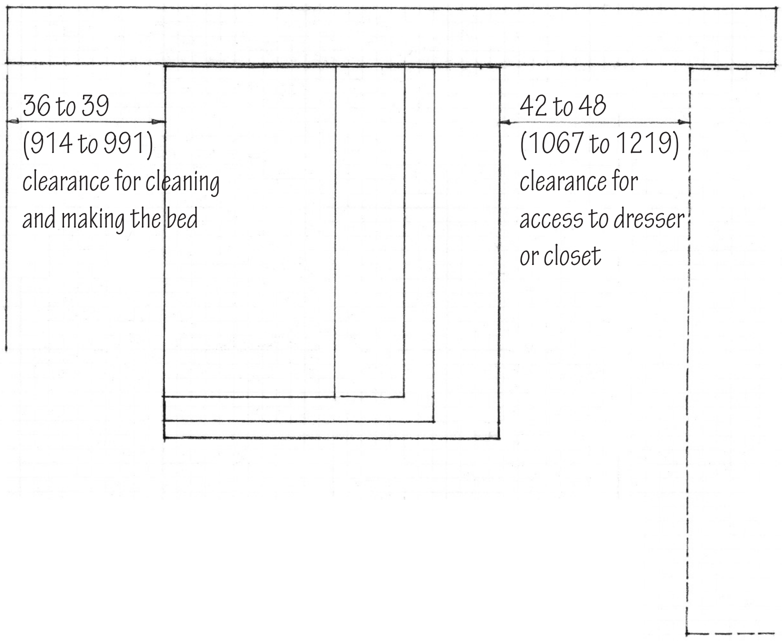
A bed can be integrated into a wall storage system at the head or foot of the bed, or both.



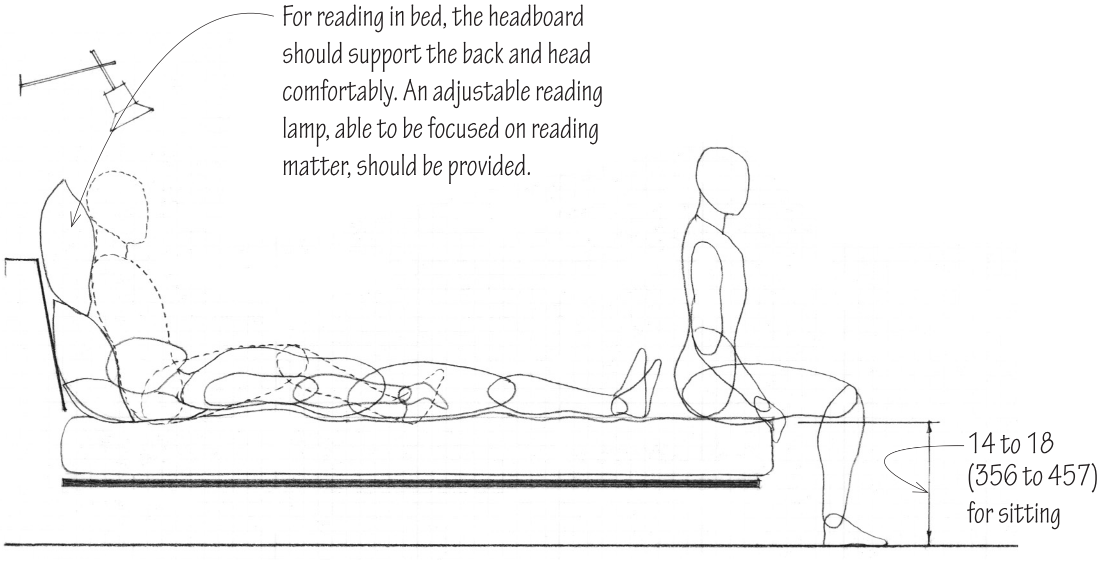
Bunk beds utilize vertical space to stack sleeping levels. Storage and desk surfaces can also be integrated into the system.

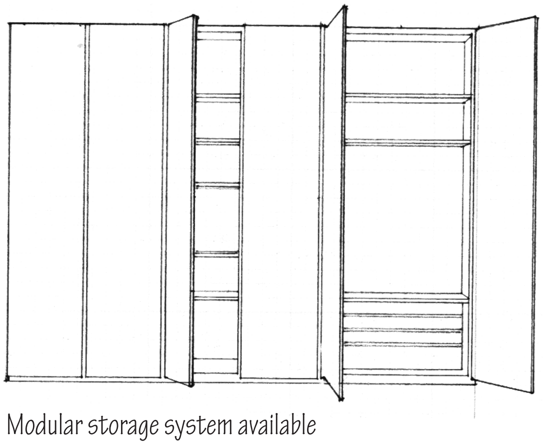


Sofas and armchairs that convert into beds offer convenient short-term sleeping arrangements.




All dimensions are in inches, with their metric equivalents in millimeters (shown in parentheses).

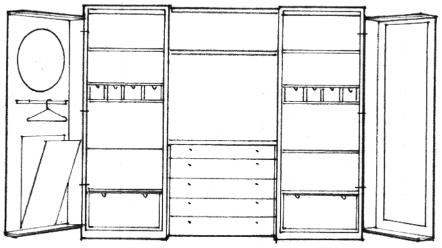




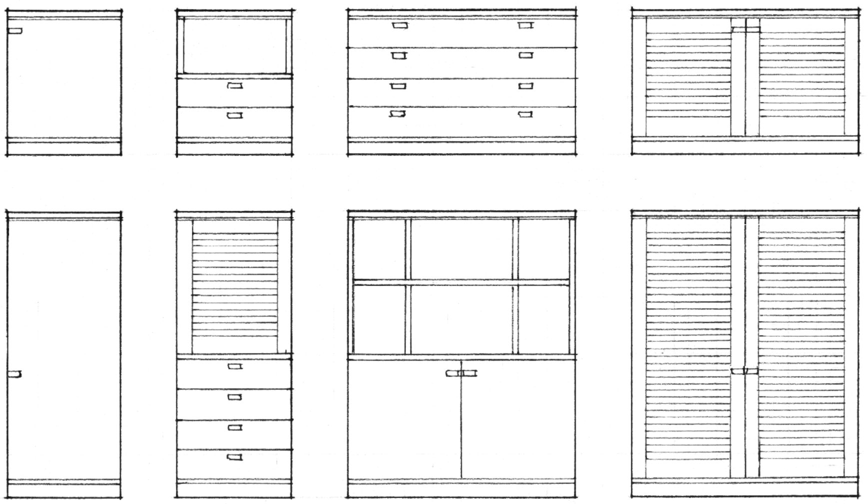
Modular storage system available with plain, glass, or louvered doors

The amount and type of furniture in a bedroom depends on the size of the room, the style of the project, and the needs of the intended user. A bedroom with a separate walk-in closet or dressing room may need fewer pieces of unit furniture for storage. A child's bedroom may double as a playroom or study area, while guest bedrooms may have alternate lives as home offices, sewing rooms, or storage rooms. Bedrooms may include extensive video and audio equipment or computer equipment, requiring special provisions for wiring.

Built-in storage can help to keep the lines of the room clean and avoid clutter. Individual pieces can balance the size and scale of the bed and add style, detail, and useful surfaces.



Armoire—Luigi Massoni



Modular set of chests of drawers and cupboards can be used singly or in stacked or tandem groupings.

Armoires are freestanding closets with doors covering the front, often with drawers inside at the bottom.

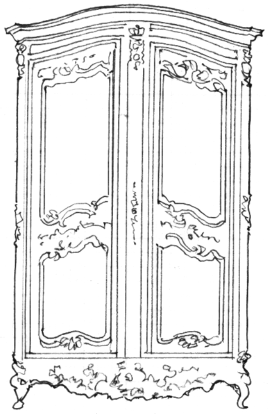
Chests for bedcovers and clothing storage range from simple wood boxes opening at the top to more elaborate pieces with drawers below.

Antique-style court cupboards and press cupboards have drawers or doors in both their upper and lower sections.

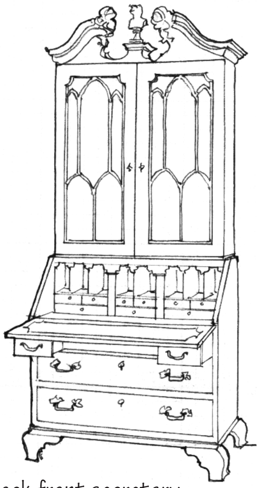
Secretaries, also called escritoires and highboys, have slanting fronts that drop down to create a writing surface with drawers below. They sometimes have bookcases or display cases above.

Dressing tables are designed for the user to sit facing a mirror while applying makeup or jewelry. Dressers hold smaller items of clothing and often include a mirror.

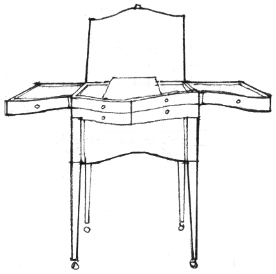
Night tables and nightstands are designed for bedside use.



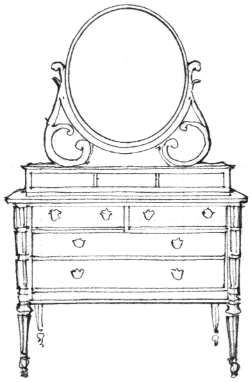
French Provincial armoire



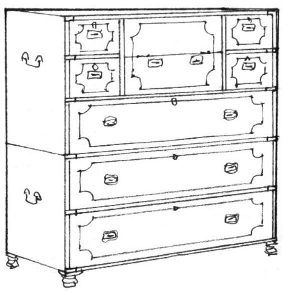
American block-front secretary



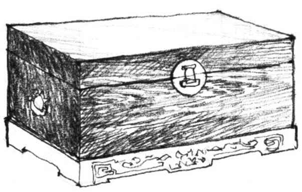
English dressing table



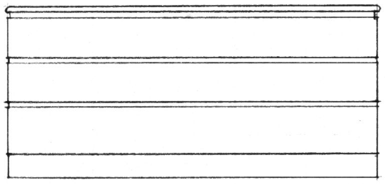
Early American dresser



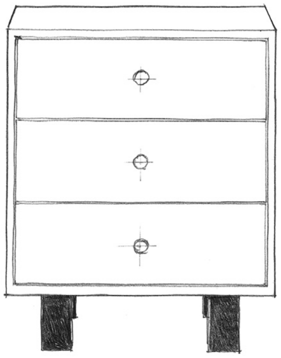
English naval captain's chest



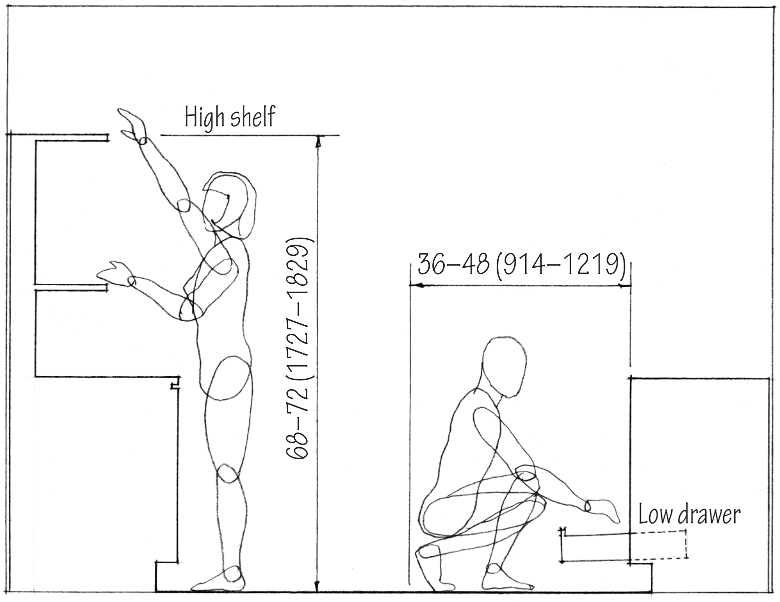
Chinese chest

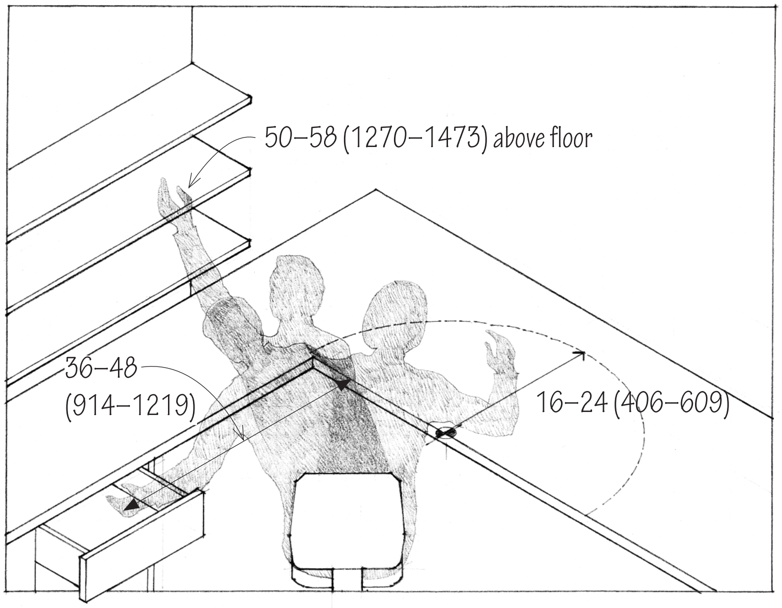


Chest of drawers



BCS 3-Drawer nightstand—George Nelson for Herman Miller




## Dimensional Criteria

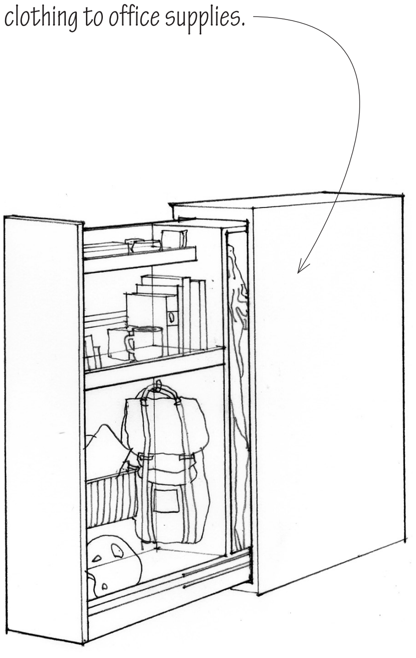
All dimensions are in inches, with their metric equivalents in millimeters (shown in parentheses).

Providing adequate and properly designed storage is an important concern in the planning of interior spaces, particularly where space is tight or where an uncluttered appearance is desired. To determine storage requirements, analyze the following:

**Accessibility**: Where is storage needed?
**Convenience**: What type of storage should be provided? What sizes and shapes of items are to be stored? What is the frequency of use?
**Visibility**: Are items to be on display, or concealed?

Storage should be distributed where needed. How far we can reach while we are seated, standing, or kneeling should govern the means of access to the storage area. Active storage of often-used items should be readily accessible, while dead storage of little-used or seasonal items can be hidden away.

Office furnishings are being designed with relatively small pieces that offer flexibility for a variety of storage and personal needs. Pull-out cabinets can hold everything from clothing to office supplies.

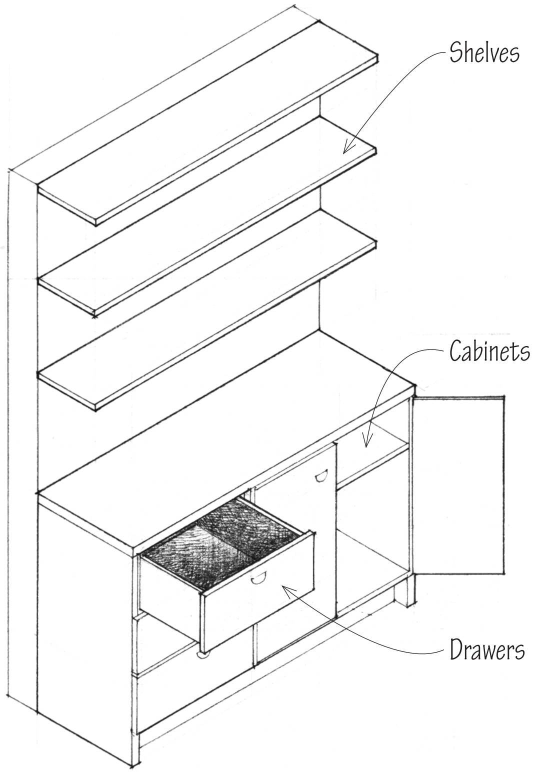


Knoll pull-out storage

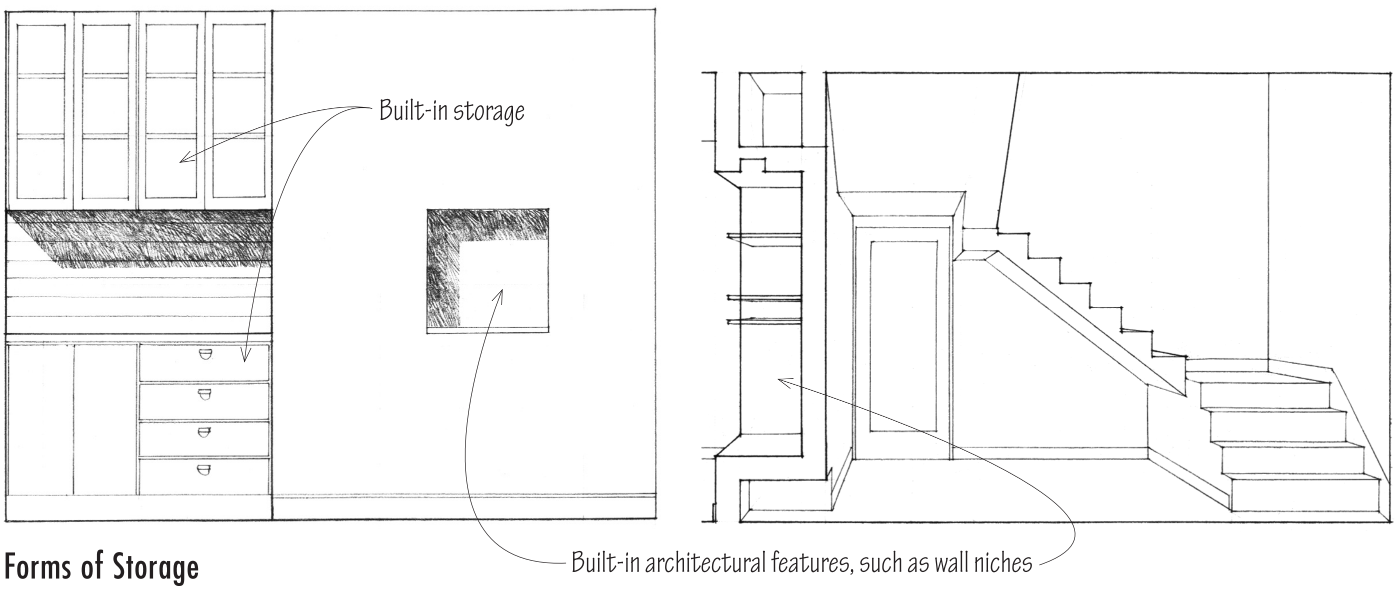
The size, proportion, and type of storage units used depend on the type and amount of items to be stored, the frequency of use, and the degree of visibility desired. Basic types of storage units are shelves, drawers, and cabinets. These may be suspended from the ceiling, mounted on a wall, or simply placed on the floor as a piece of furniture. Storage units can also be built into the thickness of a wall, occupy a niche, or utilize otherwise unusable space such as under a stairway.

## Forms of Storage

Shallow shelves are best for active storage because items are always in view. In deep storage spaces, little-used items gravitate toward the back, while often-used items migrate toward the front. The term "cabinets" generally refers to the casework built to accommodate shelves and drawers. Drawers are suitable for items that lie flat or for items that can be contained within the drawer compartments.




Basic Types of Storage

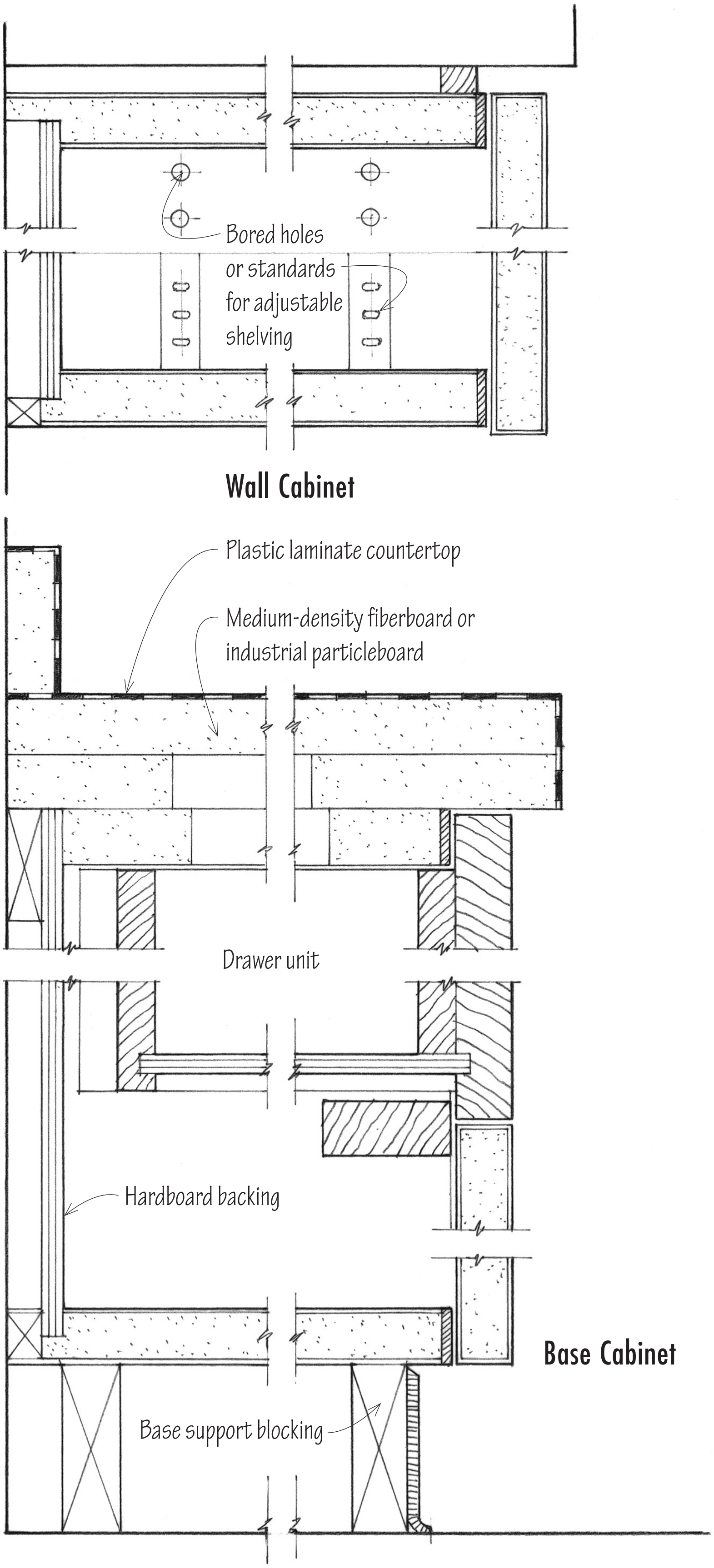



Forms of Storage

In a residence, built-in storage and cabinetry are most common in kitchens, pantries, and bathroom spaces, but can effectively be extended into other spaces as well. Standard-sized bases and wall cabinets are fitted into the kitchen layouts of most homes.

In commercial buildings, the varying demands of offices, schools, research facilities, libraries, retail stores, and other facilities are met by a wide variety of manufactured casework and custom-built pieces.

- Offices often feature bookcases and credenzas for storage and display.
- Reception desks may be custom-designed to project a corporate image.
- Retail display cases may be stock design, corporate standard pieces, or custom designs.
- Food-service counters and server lines must accommodate equipment and flow, as well as meet accessibility requirements.
- Hospital nurses' stations and patient-room cabinetry accommodate equipment. Increasingly, rather than large, imposing reception desks, patients are greeted by staff members carrying tablets in the hospital's entry area.

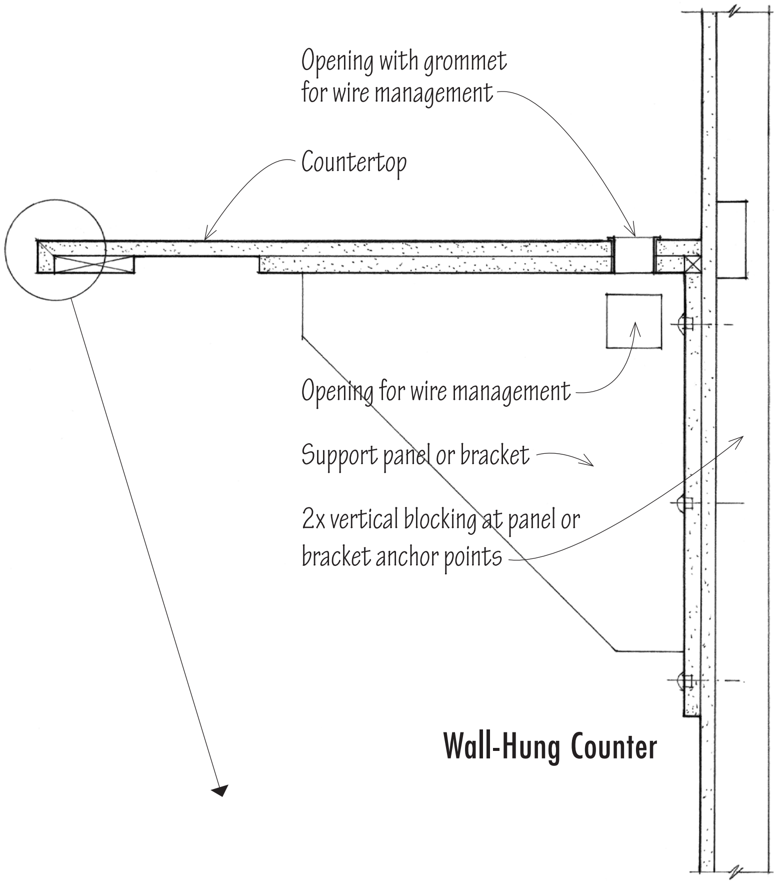



Typical Cabinet Section

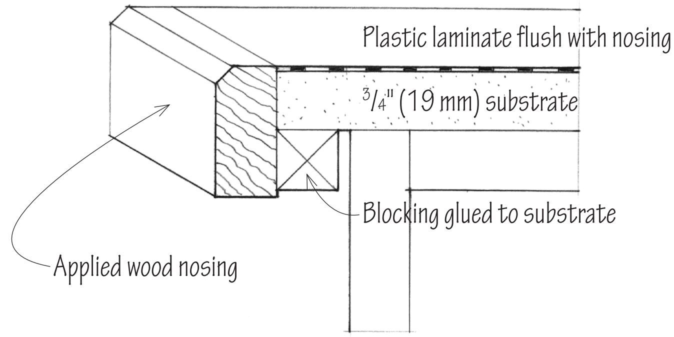
Countertops are used in both residential and commercial projects. Residential countertops are typically found in kitchens and bathrooms, but may also occur in laundry rooms, pantries, and home offices. Commercial countertops may be subject to heavier use, and where food is prepared, materials must meet health codes.

Sustainable options include reuse of existing countertop materials and use of recycled materials. Countertop materials include:

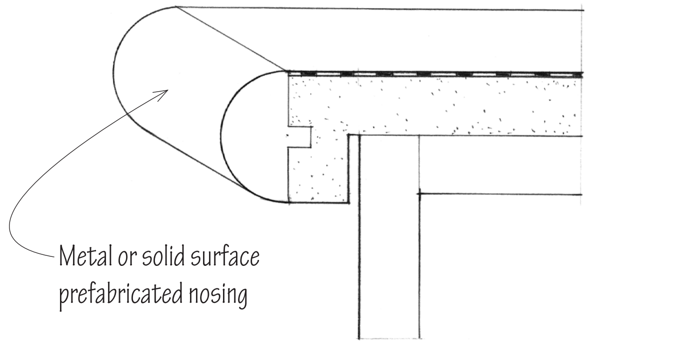
- Plastic laminates: Waterproof, stain resistant, easily cleaned. Not heat resistant; joints may be damaged, scratches are not repairable. Dark edge line requires trim.
- Granite: Durable, water resistant, and heat resistant.
- Slate: Water and heat resistant, stain proof, antibacterial.
- Soapstone: Water, heat, and stain resistant; pleasant feel. Bimonthly oil treatment required.
- Marble: Wine will stain, sealant required; heat resistant.
- Solid surfacing: Water and stain resistant; light stains, scratches, scorch marks can be buffed out; may water spot. Integral sinks available.
- Epoxy resin: Durable, poured surface over painted or other surfaces.
- Engineered composite stone: Nonporous; abrasion, stain, and impact resistant. Resinous feel and appearance.
- Concrete: Durable, tactile surface acquires patina from use; may stain and crack; sealer recommended.
- Tile, ceramic: Heat and stain resistant, durable; grout requires maintenance.
- Wood: Water may damage surface; requires monthly application of mineral oil. Light damage may be sanded off.
- Paper composite: Made of paper treated with resin, then pressed and baked into solid sheets. Sanitary, scratch and heat resistant.
- Zinc: Warm metal appearance, easy maintenance. Many finishes available.



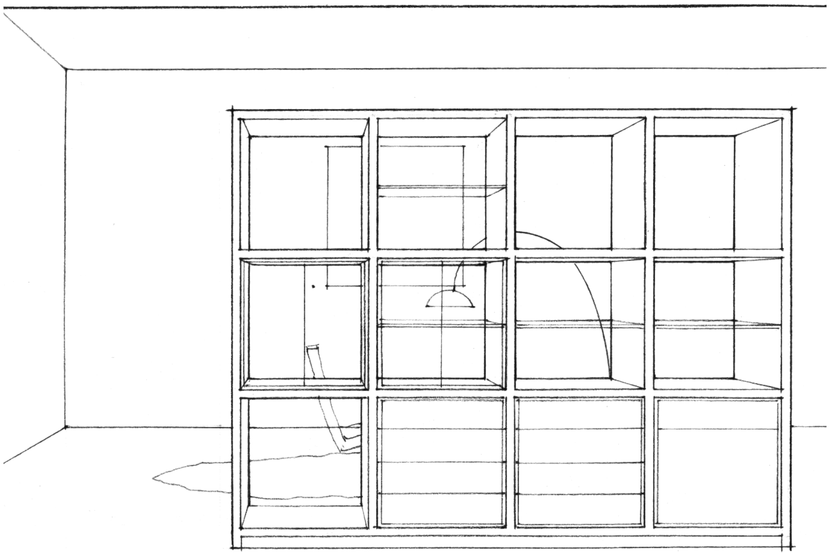

Wall-Hung Counter



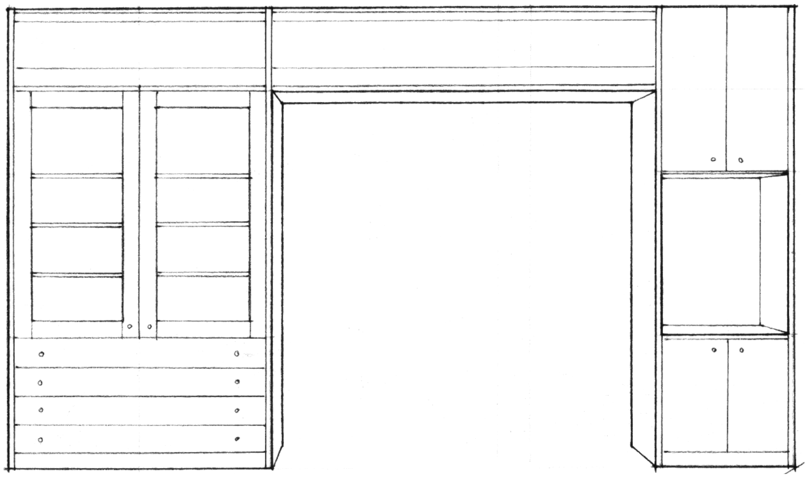

Countertop Nosings



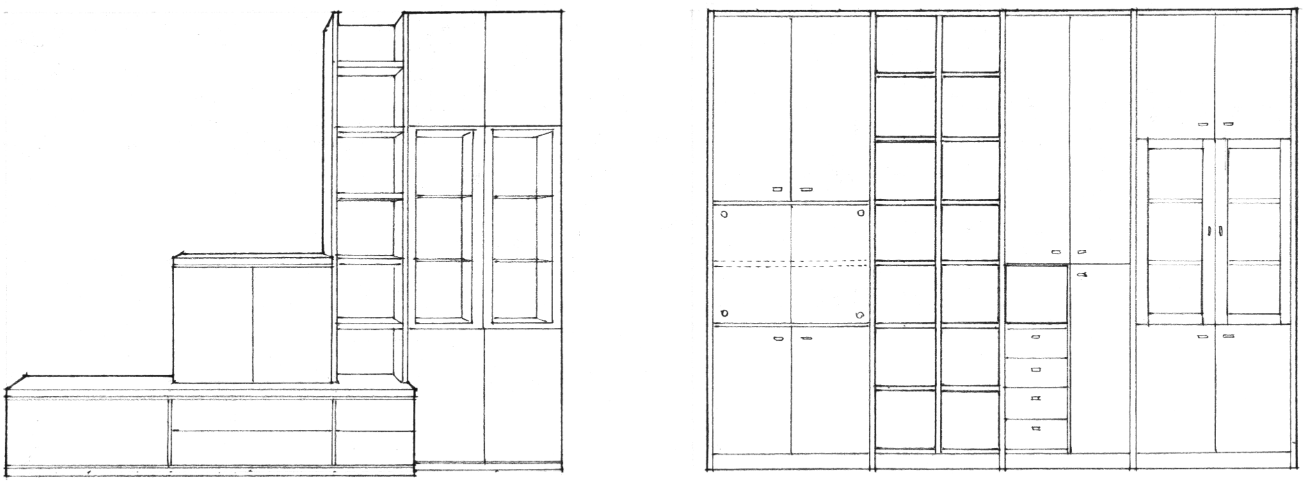
Wall storage systems consist of modular shelving, drawer, and cabinet units that can be combined in various ways to form self-supporting assemblies. The units may have open fronts or be fitted with solid, glass, or louvered doors. Some systems integrate display lighting into their construction.



A wall system can serve effectively as a freestanding room divider.



A wall storage system can form a shallow alcove space.



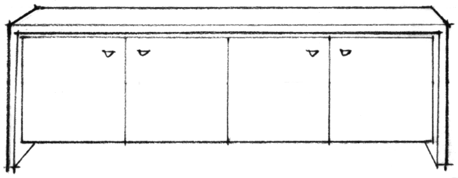
A wall storage system may be a freestanding assembly or be placed into a wall recess.

## Offices

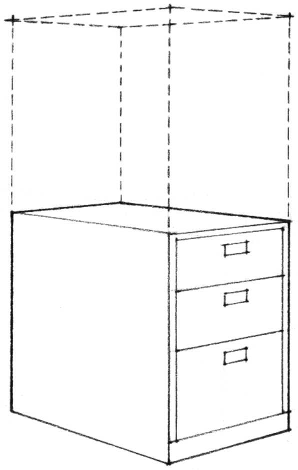
Back storage units or credenzas are designed for storing documents, supporting equipment, and displaying work in progress. They eliminate clutter on the desk by containing box drawers, file drawers, doors with shelves, pullout equipment shelves, or bar units.

Filing systems should be selected for the client's filing needs, space availability, and quality of workmanship. Vertical files have two to five drawers, usually 15 or 18 inches (381- or 457-mm) wide, and 18 to 29 inches (457-mm to 736-mm) deep.

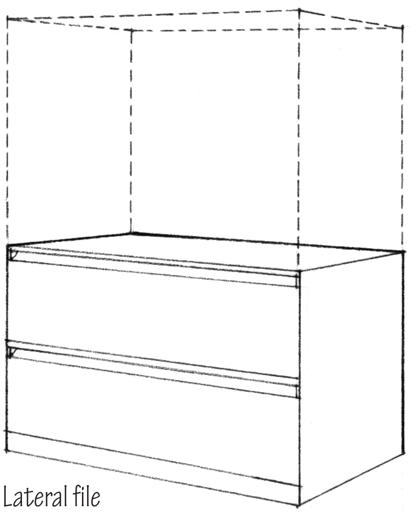
Lateral files are two to five drawers high and are usually 30, 36, or 42 inches (762-, 914-, or 1067-mm) wide and 15 or 18 inches (381- or 457-mm) deep.



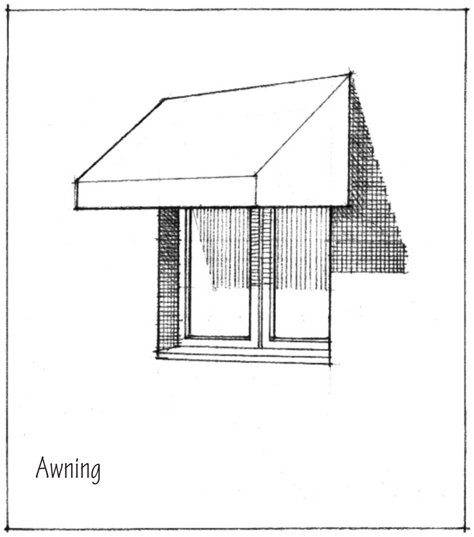
Credenza
29" (736-mm) high
18" to 20" (457- to 508-mm) deep



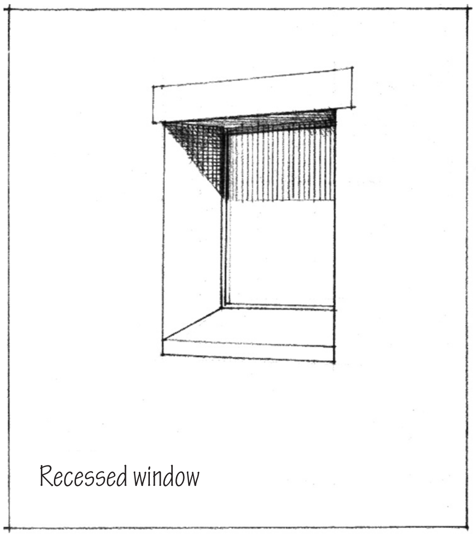
Vertical file



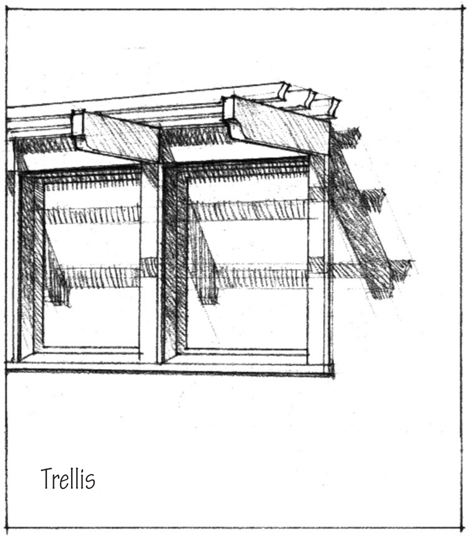
Lateral file



Awning



Recessed window



Trellis

In the broad category of window treatments are included devices that aid in the control of light, available views, and the passage of air, heat, and cold. Some window treatments can reduce heat loss in the winter and heat gain in the summer. However, window treatments are not effective at reducing air leakage or infiltration; this requires caulking and weatherstripping around windows.

## Exterior Window Treatments

Exterior treatments are normally designed as integral elements of a building's architecture. If added to an existing building, such alterations should respect the existing architectural style.

| | |
|---|---|
| Awnings | Made from water-repellant and mildew- and fade-resistant synthetic fabric stretched over a frame to provide shade. Some are retractable. |
| Overhangs and recessed windows | Provide protection from sun and rain. If oriented properly, overhangs will allow sunlight in through windows in the winter. |
| Trellises | Open framework that filters light and provides support for vines, whose leaves provide summer shade. |

## Interior Window Treatments

Interior window treatments vary according to how they temper the light, provide ventilation and a view, and alter a window's form and appearance. They play a role in absorbing sound, conserving energy, and enhancing fire safety. Window treatments differ in how they open and close; they should not interfere with a window's operation or restrict access to its hardware.

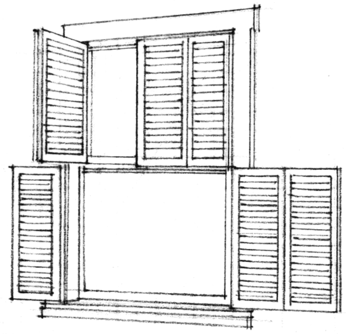
Innovations in solar shading, including how shades can enhance overall building performance and occupant comfort, are well worth the interior designer's attention. It is important to consider both the product's appearance from the room side and from the outside. Light-colored fabrics usually reflect more solar energy and reduce interior heat gain better than dark-colored ones, but allow more visible light transmission, which may increase visual discomfort and glare. Dark-colored fabrics reduce glare and create better views to the exterior. The density of a shade's weave can help achieve optimal levels of daylighting, privacy, and views of nature, but the trend to light-colored fabrics remains strong.

Shade fabrics offer the greatest adjustability to balance daylight, glare, and view according to occupant needs. However, a shade is only effective if used in the correct position at the appropriate time. Occupants near a west-facing façade need to control heat and glare. Automated shade controls (preferably with manual overrides) can help with these potential issues, and can be especially effective in large, shared spaces such as lobbies and conference rooms.

## Hard Window Treatments

### Shutters

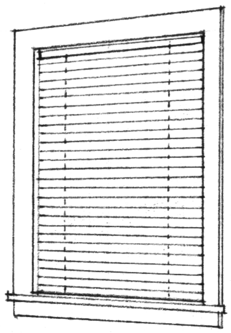
- Rigid panels, usually of wood, are hinged to open and close like miniature doors.
- Panels usually have adjustable louvers so that filtering of light and view can be controlled.
- Shutters provide a clean, precise, uncluttered appearance.
- When closed, shutters enhance a sense of enclosure.
- Louvered shutters work best for summer shading, allowing ventilation and natural daylight to enter, while blocking some solar heat; they are less effective at blocking winter heat loss.



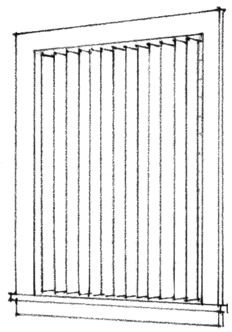
Shutters

### Blinds

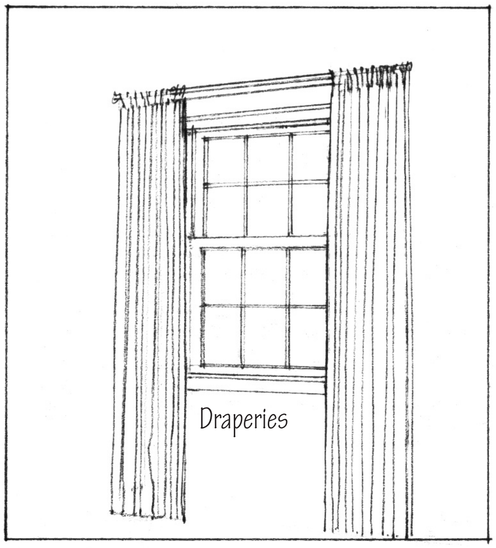
- Horizontal blinds consist of thin or wide slats of wood, plastic, or metal.
- The spacing and adjustability of slats provide good control of light and airflow; thin slats obstruct a view less than wide slats.
- Blinds are difficult to clean and tend to collect dust.
- Thin horizontal blinds inserted between the panes of thermal glazing in a window remove this problem.
- Vertical blinds have slats, generally of opaque or translucent fabric, that pivot at the top and bottom.
- Use only cordless blinds to remove threat of strangling in spaces occupied by infants and young children. Manual or automatic controls are available.
- Blinds are more effective at reducing summer heat gain than winter heat loss.



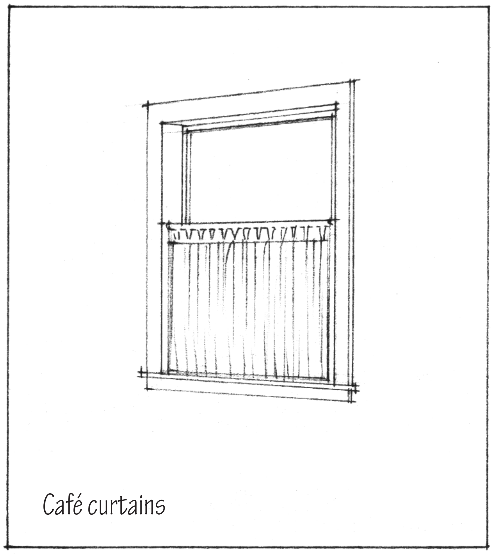
Horizontal blinds



Vertical blinds



Draperies



Café curtains

Fabric window treatments soften the lines of an interior space and add visual stimulation and detail. They can adjust for privacy needs and varying light levels, absorb sound, and provide thermal insulation. Sheer fabric softens and diffuses light, filters the view, and provides daytime privacy. Synthetic drapery fabrics including acetate, polyester, nylon, and acrylic offer better resistance to sun and flame.

**Draperies**

Draperies are fabric panels made of heavy opaque, partially opaque, or translucent fabrics that are generally pleated, hung on a rod, and pulled to one or both sides of the window.

Types of drapery pleats include pinch, barrel, box, and pencil pleats.

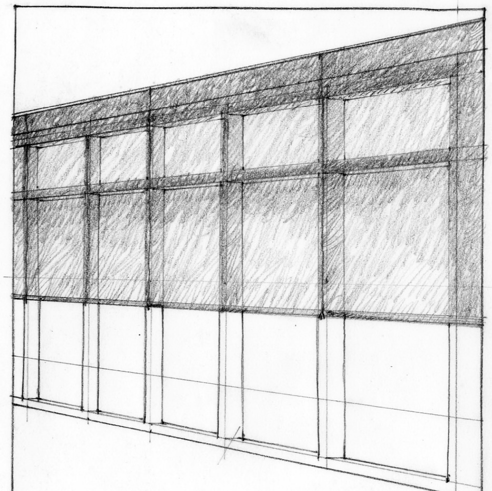
- Draperies can be full and hung straight, tied back, or gathered into puffs (pouffed). Festoons are fabric swags hanging between two points.
- Draperies can reduce heat exchange or convection when hung close to windows and down to the windowsill or floor, sealed at both sides, and overlapped at the center.
- Drapery color and the use of an open or closed weave fabric also contribute to heat gain and loss.

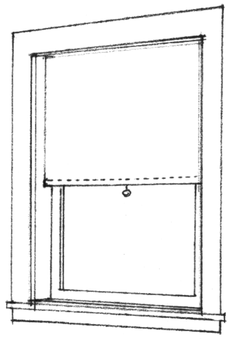
**Curtains**

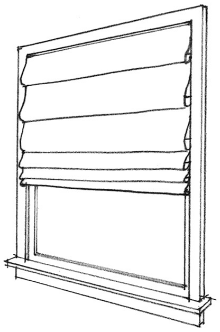
- Curtains are less formal than draperies. They may be stationary or hand operated. Their tops can be looped, shirred, scalloped, or pleated. There may be a valance at the top.
- Curtains can be hung within the window frame or outside the frame to unify a group of windows.
- Shirred or sash curtains are gathered directly on rods across the sash of a window, and either hang straight down or are fastened to another rod at the bottom.
- Café curtains are made in tiers, either to cover the whole window or only the bottom half.

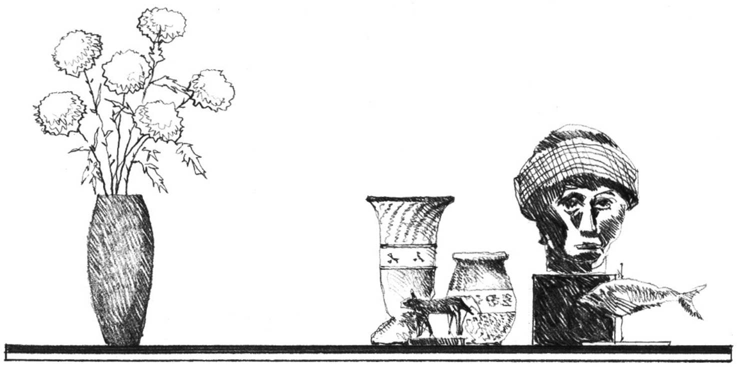
### Shades

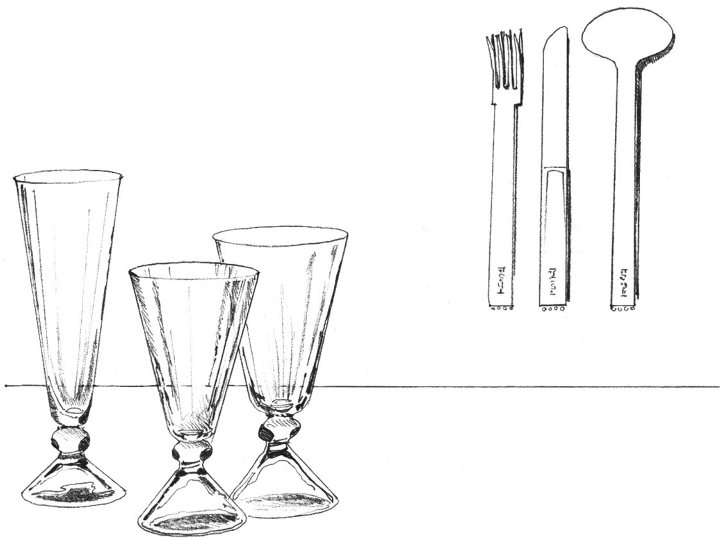
- Shades work best to prevent heat loss or gain when mounted close to glass with sides close to wall.
- Shades can be made of translucent, opaque, or blackout fabric. Vinyl, fiberglass mesh, bamboo, or wooden slatted shades are also available.
- Shades usually operate from the top down to cover part or all of a window opening, although bottom-up styles are available. Manual and automatic controls and skylight mountings are available.
- Mesh shades may not meet the openness factor they advertise. There are shades available with close tolerances for openness factors to manage glare.
- Mesh shades are available in white, black, and a variety of grays in between.
- Roller shades have a spring mechanism attached to a length of flexible material.
- Translucent, transparent, or opaque pleated shades fold into a compact accordion shape.
- Cellular or honeycomb blinds are made by bonding two or three layers of polyester fabric with an insulating layer of air. They offer limited thermal insulating properties and varying degrees of translucence. Cellular shades stack compactly.
- Roman shades are pulled up into horizontal pleats when raised by cords, and hang flat when extended.
- Austrian shades are made of sheer or semi-sheer fabric gathered vertically into soft horizontal scallops by cords.
- Balloon, pouf, or cloud shades form balloonlike poufs when pulled up with vertical cords.
- Dual shades have a highly reflective white surface on one side and a heat-absorbing dark surface on the other; they can be reversed seasonally, with the reflective side facing the warmer (indoor or outdoor) side.
- Quilted roller shades and some types of Roman shades feature layers of fiber batting and sealed edges to provide both insulation and an air barrier.

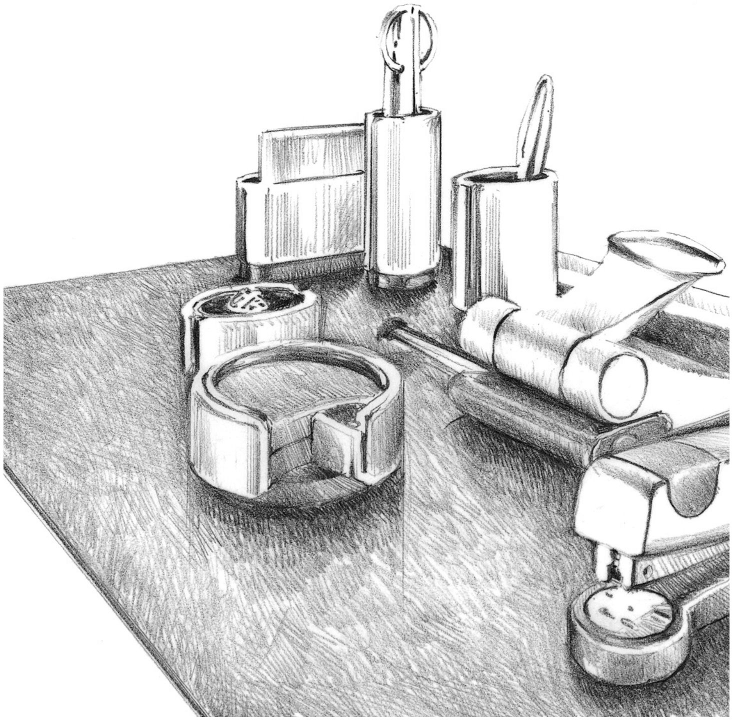

Solar shading system


Roller shade


Roman shade







Accessories in interior design are those items that provide a space with aesthetic enrichment and embellishment. These items may provide visual delight for the eye, textural interest for the hand, or stimulation for the mind. Ultimately, accessories—individually or collectively—are the inevitable evidence of habitation.

Accessories help relate architectural interiors to human scale and to differentiate personal, social, and public zones around the human body. They help to identify the intended use of a space and the character of its users.

Accessories should be selected to support the design concept of the space and to reinforce design principles such as rhythm, balance, texture, pattern, and color. They can tie design elements together or function as a focal point.

Accessories that can add visual and tactile richness to an interior setting may be utilitarian or decorative.

## Utilitarian Accessories

Utilitarian accessories include useful items such as the following:

- Accessories for office use, such as desktop mats, business card holders, paper clip holders, and filing trays, are often sold as sets.
- Tabletop accessories for restaurants support the concept and style of service.
- Guest room accessories express a hotel's concept and level of service.
- Residential cooking, dining, and bathroom accessories are often used for both function and display.

## Decorative Accessories

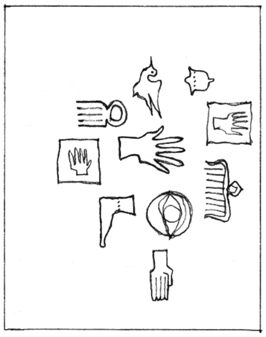
Decorative accessories delight the eye, the hand, or the intellect without necessarily being utilitarian in purpose. Decorative accessories and artwork should be included in the project budget, and provisions must be made for display and lighting. Decorative accessories may include:

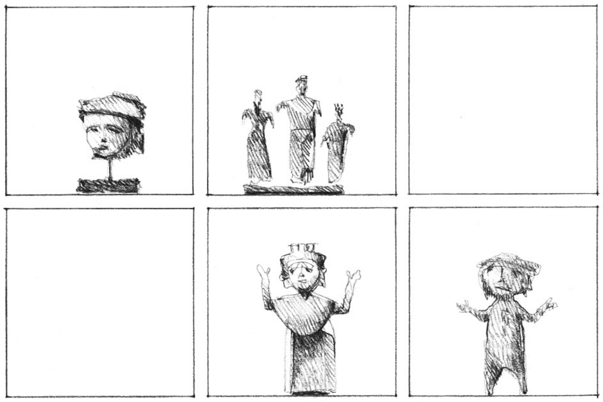
**Artwork** Research has shown that art's purpose in our lives ranges from the purely decorative to the highly functional, providing stress relief, serving as a wayfinding tool, supporting corporate culture, and connecting companies to local communities. The selection and placement of artwork can emphasize strong design elements or alter the perception of the proportions of the space. Artwork may be selected from a client's collection, acquired to start a collection, or commissioned especially for a given project. Art consultants help designers and clients find and acquire appropriate pieces. In addition to paintings, prints, and photos, designers may include sculpture and crafts such as ceramics, art glass, metalwork, and textiles.

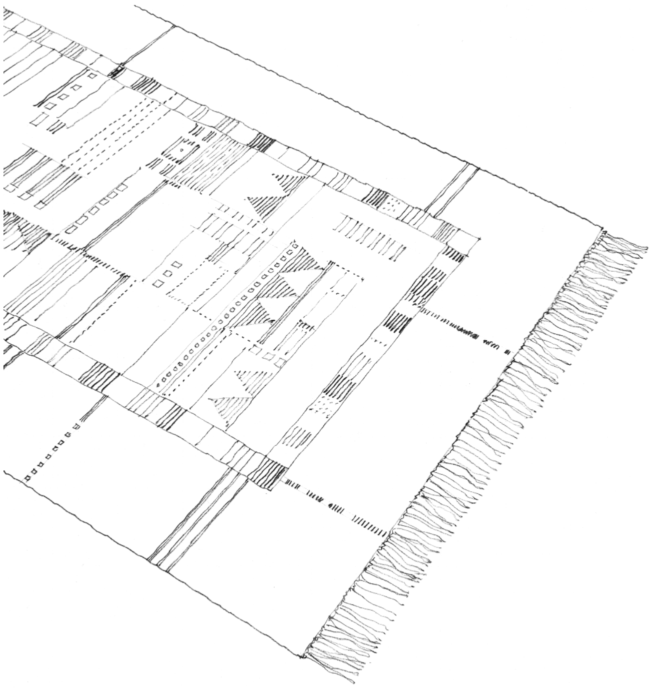
**Collections** Collections of objects almost always have personal meaning. Collections often create an opportunity for repetition of form, color, texture, or pattern. Individual pieces may be featured as focal elements.

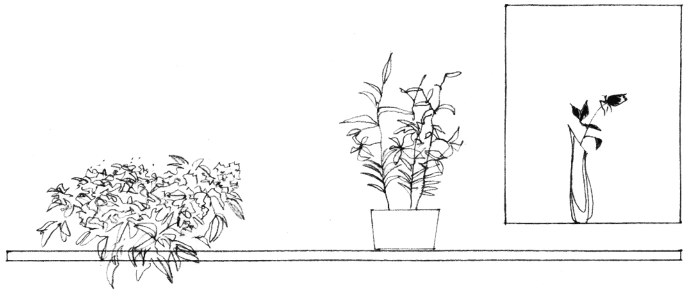
**Residential** What we choose to display in our homes expresses how we live and what we value. Designers can help clients edit their possessions, select new ones, and display them effectively. Accessories that express individuality are generally more interesting than product lines preselected to coordinate.

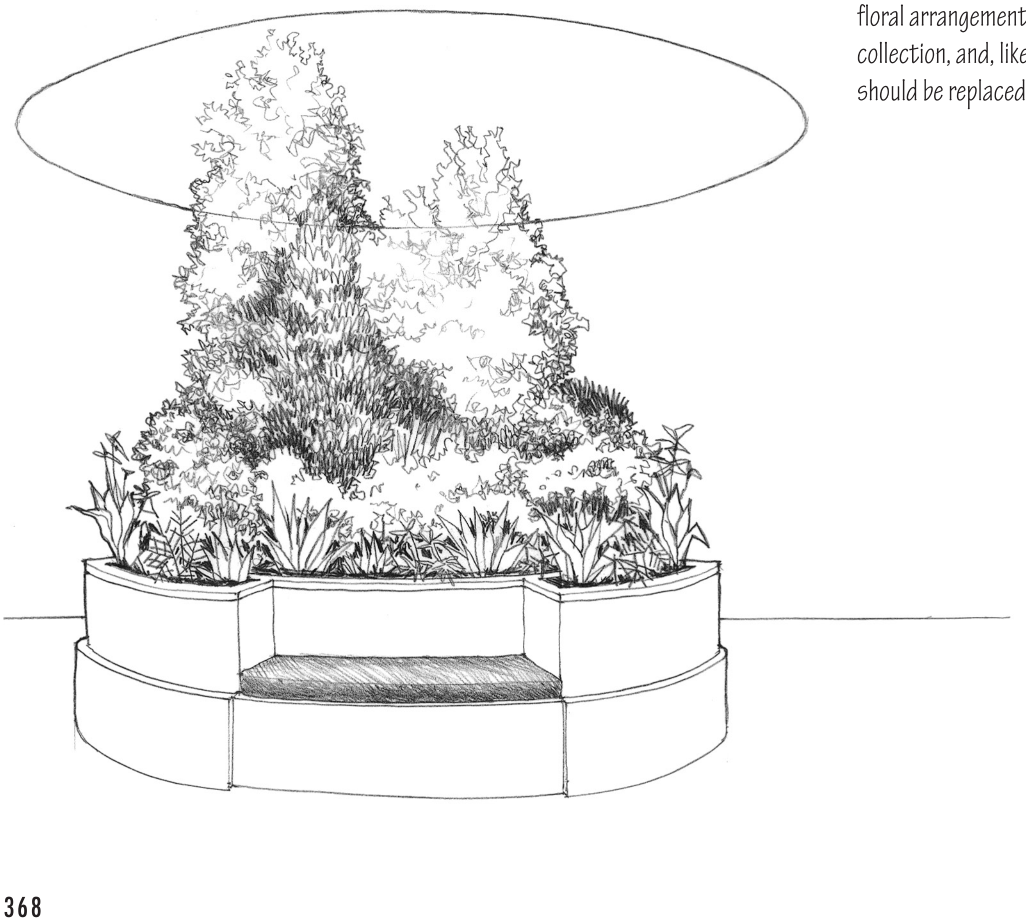

Artisanal crafts are a reviving trend. Working with artisans brings its own challenges and frustrations, along with opportunities such as employment for women in rural communities and the opportunity to bring rare craft techniques into a design. To be successful, a designer must dedicate time to understanding the craft and its techniques. Visiting artisan suppliers helps the designer to successfully work in the new technique. It is important to set clear expectations about communication and the need for the artisan to be able to say "no" when necessary. Handmade pieces often take longer to make than manufactured ones, and this needs to be built into the schedule. Investing in the development of artisan suppliers is also an important step in developing a long-term relationship. Handmade products tend to have more imperfections than manufactured ones, and this can become a source of interest and pride. Slight inconsistencies can make the pieces very special.











Plants and flowers, as visible signs of nature, bring their expression of life and growth to interior spaces. Plants can improve air quality and raise indoor humidity levels. However, planting materials may shelter insects and other pests and can harbor molds. Plants must be carefully selected for their required levels of light and maintenance, as well as for scale, form, and color. Some businesses hire companies to select, place, maintain, and replace plants on a schedule.

Artificial and preserved plants can closely resemble living plants and can substitute for them where the use of live plants is limited by lack of light or pest control concerns. The use of artificial and preserved plants continues to expand as their quality improves.

Artificial plants are composed of polyester fabric leaves attached to plastic petioles, which are in turn attached to real or composite wood branches and trunks. The leaves are often realistically photo embossed.

Most preserved plants are palms; real leaf sheaths and fronds are attached to artificial trunks. The fronds are treated to stay soft and green, and for fire safety. Although they do not need irrigation, artificial plants and floral arrangements may be prone to brittleness and dust collection, and, like live plants, require maintenance. They should be replaced when they begin to deteriorate.

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# GLOSSARY

**accessibility** A property of design describing elements of the physical environment that allow people with disabilities or special needs to use them with safety and dignity.

**active solar-heating system** A heating system that uses mechanical means to collect, store, and distribute solar energy.

**adaptive reuse** Changing the function of a building onto something not intended for the original structure.

**alternating current (AC)** An electric current that reverses direction at regularly recurring intervals.

**ambient lighting** Lighting designed to provide a nondirectional, shadowless light level from all sides.

**ampere** A measure of the actual amount of energy flow or current in an electric circuit.

**axonometric projection** A paraline drawing having all lines parallel to the three principal axes drawn to scale, but with diagonal and curved lines distorted.

**bariatric** Relating to or specializing in the treatment of obesity.

**beam** A rigid structural member designed to carry and transfer transverse loads across space to supporting elements.

**brightness** The sensation by which an observer is able to discern how much light energy is reflected by a surface.

**building envelope** The shell of a building, consisting of its exterior walls, windows, doors, and roof, which protect and shelter interior spaces from the exterior environment.

**building information management (BIM)** A digital representation of physical and functional characteristics of a building that serves as a shared knowledge resource.

**chroma** The degree by which a color differs from a gray of the same lightness or brightness, corresponding to saturation of the perceived color.

**color rendering index (CRI)** A measure of a lamp's ability to render color accurately when compared with a reference light source of similar color temperature.

**column** A rigid, relatively slender structural member designed primarily to support loads applied at its ends along its axis.

**compact fluorescent lamps (CFLs)** Fluorescent lamp with integral ballast, available in many forms.

**complementary hues** Those hues directly opposite each other on a color wheel.

**computer-aided design (CAD)** The use of computer technology for the process of design and design documentation.

**conduction** Direct transfer of heat from the warmer to the cooler particles of a medium or of two bodies in direct contact.

**contract furnishings** Furnishings purchased for commercial office spaces under a furniture, furnishings, and equipment (FF&E) contract.

**convection** Heat transfer due to the circulatory motion of the heated parts of a liquid or gas.

**cornice** A continuous molding that crowns or horizontally divides a wall.

**cove** (1) A concave surface at the edge of a ceiling that eliminates the interior angle between the wall and ceiling planes, and (2) A concave molding or trim.

**dead loads** Static loads acting vertically downward on a structure, including the weight of the structure itself and the weight of building elements, fixtures, and equipment permanently attached to it.

**decibel (dB)** A unit expressing the relative pressure or intensity of sounds on a uniform scale from zero for the least perceptible sound to about 130 for the average threshold of pain.

**direct current (DC)** A electric current flowing in one direction only.

**ductile** Capable of being drawn into wire or hammered thin.

**dynamic loads** Loads applied suddenly to a structure, often with rapid changes in the size of the force and the point to which it is applied, including earthquakes and the loads caused by winds.

**efficacy** The measure of the efficiency of a light source in lumens per watt.

**elastomers** Fibers capable of returning to their original shape after being stretched.

**embodied energy** The total energy consumption associated with a particular material, from raw material acquisition and manufacturing through transportation to point of use.

**emphasis** The stress or prominence given to an element in a composition by means of contrast, anomaly, or counterpoint.

**ergonomics** The application of human factors to design.

**evaporation** Heat loss due to the process of converting moisture into a vapor.

**evidence-based design** An approach to design that seeks to create better design outcomes by basing decisions on credible research.

**faux finish** Any of various techniques intended to imitate natural materials, such as wood graining and marbleizing; the term is often used for any decorative painted finish.

**fenestration** The design and placement of windows in a building.

**figure–ground** The relationship between the outline or exterior surface of a shape or form (figure) and the receding part of a visual field against which the figure is seen (ground).

**flame retardant chemical** A compound that inhibits, suppresses, or delays the production of flames to prevent the spread of fire.

**floor plan** A drawing representing a section through a building or portion of a building after a horizontal slice is made and the upper part removed.

**flutter** A rapid succession of echoes with sufficient time between each reflection for the listener to be aware of separate, discrete signals, produced by repetitive reflections off hard surfaces arriving at different times, and perceived as a buzzing or clicking sound.

**focal lighting** Lighting that offers a contrast in brightness that is directive and creates a sense of depth.

**footcandle** A unit of illuminance derived from the light produced by a candle at the distance of one foot, equal to one lumen incident per square foot.

**form** The shape and structure of something, as distinguished from its substance or material.

**foundation** The substructure that forms the base of a building, anchors it to the ground, and supports the building elements and spaces above.

**furniture, furnishings, and equipment (FF&E)** Term used in commercial design for office furnishings purchased under contract.

**furring** Wood strips or metal channels attached to a wall to provide a base for lath or a finish material, or to add an air space to composite construction.

**gable** The triangular portion of wall enclosing the end of a pitched roof.

**galvanic corrosion** Deterioration of a metal caused by an electrical current flowing between dissimilar metals through a liquid that conducts electricity.

**girder** A large primary beam designed to support concentrated loads at isolated points along its length.

**glazing** The panes or sheets of glass or other transparent material made to be set in frames, as in windows, doors, or mirrors.

**golden section** Proportion between two unequal parts of a whole in which the ratio between the smaller and greater parts is equal to the ratio between the greater part and the whole.

**harmony** The consonance or pleasing agreement of elements or parts in a composition.

**header** (1) A framing member supporting the ends of joists, studs, or rafters to transfer the load to parallel joists, studs, or rafters, and (2) A masonry unit laid horizontally in a wall with its end parallel to the surface.

**high-intensity discharge (HID) lamp** A lamp that produces light by the discharge of electricity through a metallic vapor in a sealed glass enclosure.

**hue** The attribute by which we recognize and describe a color, such as red or yellow.

**illuminance** The quantity of light striking a surface, measured in footcandles or lux.

**infiltration** The flow of outside air into an interior space through cracks around windows and doors or other openings in the envelope of a building.

**interior elevation** An orthographic projection of any of the significant interior walls of a building.

**joists** A series of small, parallel beams for supporting floors, ceilings, or flat roofs.

**kerf** A groove cut into the edges of a material, such as an acoustical tile, to receive a supporting grid.

**laminated glass** Two or more plies of glass bonded to an interlayer that retains the fragments if the glass is broken.

**lamp** (1) A device that produces light; a bulb or tube within a lighting fixture, and (2) Common name for a plug-in lighting fixture, such as a table lamp or floor lamp.

**lateral force** Any force acting horizontally on a structure.

**lath** Thin strips of wood or metal attached to framing to provide a substructure for plaster.

**lavatory** A bowl or basin with running water for washing the face and hands.

**line** A geometric element that conceptually has only one dimension, length. A line's length visually dominates whatever thickness it must have to be visible.

**lintel** An arch or a short beam that supports the wall load above an opening and allows compressive stresses to flow around the opening to adjacent sections of the wall.

**live loads** Loads that change over time, but generally gradually, including the weight of a building's occupants, any mobile equipment and furnishings, and any collected snow and water.

**load-bearing wall** A wall capable of supporting an imposed load, as from a floor or roof.

**lumen** A measure of the amount of light emitted by a light source or falling onto a surface, regardless of directionality.

**luminance** A measure of brightness of a light source or an illuminated surface.

**motif** A distinctive and recurring shape, form, or color in a design.

**multiview drawings** A set of related orthographic projections of an object or construction, including plans, elevations, and sections.

**natural ventilation** Providing fresh air by means of the natural movement of air, rather than by mechanical means.

**oblique projection** The representation of a three-dimensional object with one principal face parallel to the picture plane, created by projecting parallel lines at angles other than 90 degrees to the picture plane.

**off-gassing** The vaporization of chemical compounds into surrounding air.

**orthographic projection** A method of projection in which parallel projectors meet the picture plane at right angles; any element that is parallel to the picture plane remains true in size, shape, and configuration.

**paraline drawing** A drawing in which parallel lines remain parallel to each other rather than converge, as they do in linear perspective.

**partition** A non-load-bearing interior wall dividing a room or part of a building into separate areas.

**passive solar-heating system** A heating system that uses a building's design and the natural flow of heat to collect, store, and distribute solar energy, with minimal use of fans or pumps.

**pattern** The decorative design or ornamentation of a surface that is almost always based on the repetition of a design motif.

**perspective drawing** A drawing that represents three-dimensional objects and spatial relationships on a two-dimensional surface as they might appear to the eye.

**photovoltaic (PV)** Of or related to a technology that uses a solid-state device capable of converting solar energy into electrical energy, such as that employed by a solar panel to produce an electric current when exposed to light.

**pigment** A finely ground, insoluble substance suspended in a liquid vehicle to impart color and opacity to a coating.

**pilaster** A shallow rectangular projection from a wall, architecturally treated as a column.

**plane** A surface generated by a line moving in a direction other than its intrinsic direction. A plane's width and length dominate whatever thickness it must have to be visible.

**plenum** The space between a suspended ceiling and the floor structure above, or the space below a raised access floor, especially when used for distributing or returning conditioned air.

**point** A dimensionless geometric element marking a location space. Conceptually, it has no length, width, or depth; commonly manifested as a dot.

**polybrominated diphenyl ethers (PBDE)** Chemicals used as flame retardants in building materials, furnishings, polyurethane foams, and textiles, which may be associated with fertility problems in humans.

**potable** Water fit for human consumption.

**proportion** The relationship of one part to another or to the whole, or between one object and another.

**rabbet** A channel, groove, or notch cut along or near one edge of a member so that something else can be fitted into it.

**radiation** Heat energy emitted by a warm body, transmitted through an intervening space, and absorbed by a cooler body, without being affected by air motion or temperature.

**reveal** A continuous recess that visually separates the meeting of two planes and articulates their edges by the shadow lines they create.

**reverberation** The persistence of a sound within a space, caused by multiple reflections of the sound after its source has stopped.

**rhythm** Movement characterized by a patterned repetition or alternation of formal elements or motifs in the same or a modified form.

**riser** (1) The vertical face of a stair step, and (2) A vertical pipe, conduit, or duct in a utility system.

**safety glazing** Glazing that meets Consumer Product Safety Commission test requirements, such as tempered glass and laminated glass.

**saturation** The purity or vividness of a hue; the intensity of a color.

**scale** A certain proportionate size, extent, or degree, usually relative to some known standard or recognized constant.

**section** An orthographic projection of an object or structure as it would appear if cut through by a vertical plane to show its internal configuration.

**seismic** Of, pertaining to, or caused by an earthquake or vibration of the earth.

**shade** A relatively dark value of a color, produced by adding black to it.

**shape** The outline or surface configuration of a form or figure, usually with some emphasis on the enclosed area or mass.

**shear wall** A vertical diaphragm acting as a thin, deep cantilever beam in transferring lateral loads to the ground foundation.

**shed roof** A roof having a single slope.

**skim coat** A thin leveling or finish coat of plaster.

**slab** A horizontal, rigid, usually monolithic plate, such as a reinforced concrete slab.

**soffit** The underside of an architectural element, such as an arch, beam, cornice, or staircase.

**sone** A unit for measuring the apparent loudness of a sound.

**sound transmission class (STC)** A single-number rating of the performance of a building material or construction assembly in preventing the transmission of airborne sound.

**specular** Reflection on a smooth surface such as polished glass or stone, where the angle of incidence equals the angle of reflection.

**stop** The projecting part of a doorframe against which a door closes.

**structure** (1) A stable assembly of elements designed and constructed to function as a whole in supporting and transmitting applied loads safely to the ground, and (2) The organization of elements or parts in a complex system as dominated by the general character of the whole.

**substrate** Any material that underlies or serves as a base or foundation for another material.

**superstructure** The structural frame of a building, consisting of columns, beams, and load-bearing walls that support the floor and roof structures.

**sustainable design** A holistic approach to building design that reduces negative social, economic, and ecological impacts on the environment through conservation and reuse of natural resources, energy, water, and materials.

**tempered glass** Annealed glass reheated and cooled to increase its resistance to impact and thermal stresses; it breaks into small cubical pieces.

**texture** The visual and tactile quality of a surface, apart from its color or form; most often used to describe the relative smoothness or roughness of a surface.

**tint** Lightening a hue's normal value by adding white creates a tint of that hue.

**tone** An intermediate value of a color between a lighter tint and a darker shade.

**transmission loss (TL)** A measure of the performance of a building material or construction assembly in preventing the transmission of airborne sound.

**tread** The horizontal upper surface of a step in a stair, on which the foot is placed.

**trompe l'oeil** A drawing or painting that uses perspective and shadow to create the illusion of three-dimensional objects.

**valance** (1) A horizontal board or band used to conceal lighting, and (2) A short, ornamental piece of drapery placed across the top of a window.

**value** The degree to which a color appears to reflect light, corresponding to the lightness of the perceived color.

**vault** An arched structure forming a ceiling or roof over an enclosed space.

**veiling reflection** Reflected glare on a task surface that reduces the contrast necessary for seeing details.

**visitability** A movement to construct the majority of new homes so that they can be readily lived in and visited by people with impaired mobility.

**vitreous** Resembling glass in transparency, hardness, brittleness, luster, or imperviousness.

**volatile organic compound (VOC)** A hydrocarbon compound that evaporates readily; some VOCs are gases at room temperature.

**volt** Measure of the potential electrical energy flow through a conductor, in response to a difference in electrical charge between two points in a circuit.

**volume** The extent of a three-dimensional object or the amount of space that it occupies, measured in cubic units.

**water closet** A fixture consisting of a ceramic bowl with a detachable, hinged seat and lid and a device for flushing with water; also called a toilet.

**watt** A measure of the power required to keep an electric current flowing.

**winder** A wedge-shaped tread used in circular, spiral, and turning stairs.

**wire glass** Flat or patterned glass having a wire mesh embedded into the center of the glass sheet to prevent shattering in the event of breakage or excessive heat.

# INDEX

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