CHAPTER 1

INTRODUCTION

> *"Every cubic inch of space is a miracle."*
>
> WALT WHITMAN (*Leaves of Grass,* "Miracles")

WHAT THIS BOOK IS ABOUT

This book has a very specific focus: the space planning of individual rooms in homes. Many current publications are available that offer an overview of the principles of residential design combined with information about materials, finishes, and furnishings. Also available are beautiful books that provide lavish photographs and descriptions of residential design projects. Unlike those books, this one is meant to serve as a primer on space planning for major rooms/spaces in a home, and to offer related information regarding codes, mechanical and electrical systems, and a variety of additional factors that impact each type of room/space. In addition, this book includes information about accessible design in each chapter in order to provide a cohesive view of residential accessibility.

This book is meant to serve as a reference for use in the design process, and as an aid in teaching and understanding the planning of residential spaces. For purposes of clarity, most chapters follow a similar format, starting with an overview of the particular room or space and related issues of accessibility, followed with information about room-specific furnishings and appliances. Chapters continue with information about sizes and clearances, organizational flow, related codes and constraints, and issues regarding electrical, mechanical, and plumbing. At the end of each chapter, basic information is provided about lighting the specific room.

This book describes the minimum requirements for specific spaces and rooms so that students and designers can get a sense of the amount of space that is minimally necessary in order for rooms to function usefully. Examples of larger spaces are also given, but at its heart, this book is intended to show students how to use space wisely and make good use of space throughout the dwelling. Put another way: The book is about meeting the minimum standards required to create spaces that work functionally. Such minimum standards are dictated by building codes and manufacturers' recommendations, and/or reflect good design practice. With clear knowledge about minimums, designers and students of design can learn when it is appropriate to exceed such standards for a variety of reasons that reflect specific project criteria based upon clients needs, budget, site, and other constraints.

This book is meant as an introduction to the topics covered with the intention of getting the reader comfortable with basic concepts so that he or she might move forward in design education or on to additional research in certain areas. To that end, an annotated bibliography section is provided at the end of each chapter. Thinking of the information provided in each chapter as basic building blocks that allow for the discovery of the basic issues involved is a helpful approach to this book. We state this because there is much that goes into the design of a dwelling that is not covered in this book; our intent is to focus on the use and design of individual rooms (again, a building-block approach) so that the reader will have the core information required to understand the design of these individual spaces. See Figure 1-1.

This building-block or basic informational approach may bring up questions about the role of the interior designer versus the role of the architect. Clearly, the design of the totality of the structure is the role of the architect (or engineer); however, in many cases, the interior designer is taking an increasingly larger role in the design of rooms and spaces. Interior designers engaged in renovation work can take a lead role in the design of the interior architecture of a space, with a significant hand in the design of a room or many rooms. This is in contrast to notions of the interior designer as the person in charge of materials and furnishings selections only.

Home renovation and remodeling continues to be a multibillion-dollar industry providing continuing work for interior designers, architects, builders, and others in the construction trades. Home remodeling and improvements reached a

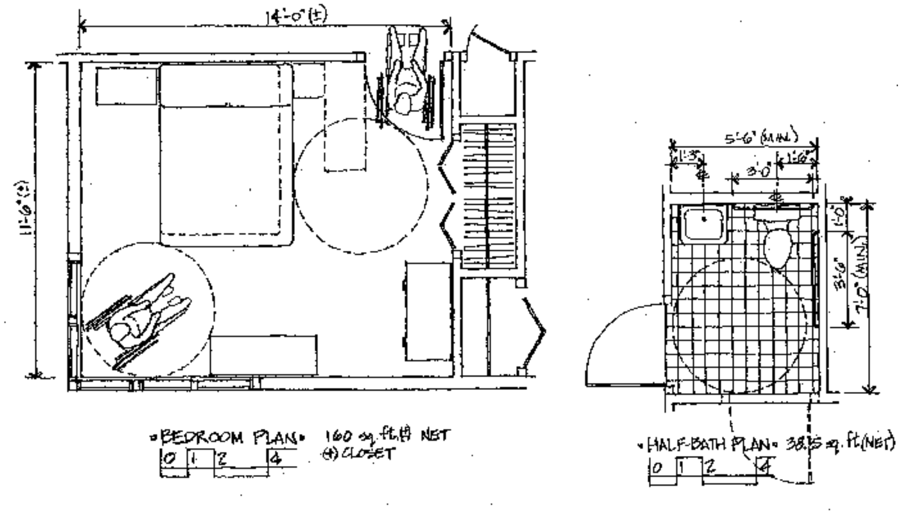


Figure 1-1 This book covers the design of houses using a room-by-room approach as an aid in understanding the use and design of each room.

record of $275 billion in 2005, with industry experts predicting continued growth for the next several years. The most common home remodeling jobs continue to be kitchen and bathroom projects. Readers will note that the detailed kitchen and bathroom information contained in this book is applicable to remodeling as well as new construction.

In new custom-home design, interior designers may take on a variety of roles from materials and furnishings selection to the design of the interior architecture of the dwelling. New-home construction has also shown continued strength, with a decade of incredibly strong sales, providing continued work for those in design, construction, and related industries. The authors believe that interior designers and design students must be well versed in the aspects of residential design covered in this book.

AN OVERVIEW: QUALITY AND QUANTITY

Readers may note that throughout the book, the authors mention the evolution of the use of rooms, room sizes, and growth of the overall size of the American home. It's worth noting that the authors have a bias toward careful consideration of the *quality of design* rather than the *quantity of space* in a given home. We hope to make clear that the successful design of space requires careful consideration of the real needs of clients measured against budgetary, code, climate, and site restrictions—all of which require careful development of a project program prior to the beginning of the actual design of the project.

The last hundred years have brought dramatic changes related to the public perception of the design, furnishing, and size of the American house. According to the National Association of Home Builders (NAHB), the "typical" American house built in 1900 was between 700 and 1200 square feet, with two or three bedrooms and one or no bathrooms (2006). The average home built in 1950 was 983 square feet, with 66 percent of homes containing 2 bedrooms or fewer. These earlier homes are quite a contrast to the 2349-square-foot average found in new single-family homes sold in 2004. A majority of these new homes (those built since 2004) have three or four bedrooms, two and one-half bathrooms or more, with at least one fireplace. A visual representation of the ever-expanding North American home can be found in Figure 1-2.

Interestingly, family size has decreased in this period to the point where the average American household size in 2004 was 2.57 persons–in contrast to 3.67 in

Figure 1-2 The average new home in the United States has grown in size over the last 50 years—despite the fact that family size has grown smaller. However, larger is not necessarily better, and well-planned spaces need not be excessively large. Given land and construction costs, as well as environmental concerns, smaller, well-designed houses may be a future trend. Numbers for square footage shown do not include garage spaces.

1940 (according to the U.S. Census). Based on a review of available figures, new homes are larger than ever, and yet they house fewer people per building than houses held, on average, in the past. The authors argue that a larger house is not necessarily a better house, and that designing a house that works well on a functional level is more important than mere size in creating a useful and pleasant environment. Additionally, large single-family homes are currently out of the financial reach of many citizens and are seen by some as wasteful in a time when issues of sustainability are increasingly engaging the national consciousness.

Consideration of housing size and use of related resources is not unique to this publication. Architect Sarah Susanka's book *The Not So Big House* has proven very popular, has helped many people to consider quality over quantity of space, and has certainly had an impact on the design of many homes (1998). *A Pattern Language*, by Christopher Alexander and colleagues, an earlier book and one considered seminal by many, has at its core the notion that spaces should be designed for the way people really live and that good design can be accessible for all (1977).

The notion of seeking quality of design, rather than quantity of space, is shared by many, and yet larger and larger houses continue to be built to house very small family groups. This dichotomy suggests that two opposing popular views of space exist. Although the architect Phillip Johnson was once quoted as saying "architecture is the art of wasting space," clearly that was a bit tongue-in-cheek, and we concur more with Walt Whitman's notion that "Every cubic inch of space is a miracle"—or should be.

HUMAN BEHAVIOR AND HOUSING

Environmental designers—including interior designers—benefit from gaining an understanding of human behavior as it relates to privacy, territoriality, and other issues related to the built environment studied by social scientists. Privacy can be defined as having to do with the ability to control our interactions with others. According to Jon Lang: "The ability of the layout of the environment to afford privacy through territorial control is important because it allows the fulfillment of some basic human needs" (1987). Lang goes on to state that the single-family detached home "provides a clear hierarchy of territories from public to private."

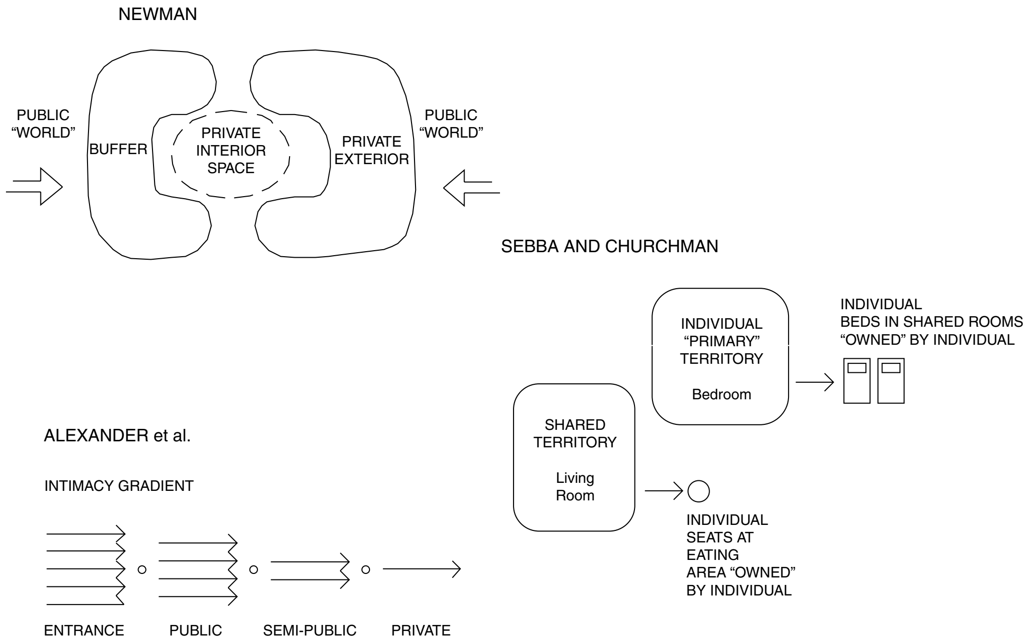
Lang also states that "differences in the need for privacy are partially attributable to social group attitudes." He continues, "Norms of privacy for any group represent adaptation to what they can afford within the socioeconomic system of which they are a part." From Lang's comments we can learn that the need for privacy is consistent but varies based on culture and socioeconomic status.

The notion of territory is closely linked to privacy in terms of human behavior. There is a range of theories about the exact name and number of territories within the home. One, developed by Claire Cooper, describes the house as divided into two components: the intimate interior and the public exterior (1967). Interestingly, Cooper (now Cooper Marcus) later wrote *House as a Mirror of Self: Exploring the Deeper Meaning of Home* (1995), which traces the psychology of the relationship we have with the physical environment of our homes, and in which she refers to work being done by Rachel Sebba and Arza Churchman in studying territories within the home. Sebba and Churchman have identified areas within the home as those used by the whole family, those belonging to a subgroup (such as siblings or parents), and those belonging to an individual, such as a bedroom or a portion of a room or bed (1986). Figures 1-3a and 1-3b illustrate various theoretical approaches to territory and privacy.

The term *defensible space,* coined by Oscar Newman, refers to "a range of mechanisms—real and symbolic barriers . . . that combine to bring an environment under the control of its residents." Defensible space as described by Newman includes public, semi-public, semi-private, and private territories (1972).

For the most part, Newman's *public* spaces, such as streets and sidewalks, are those not possessed by any individual. Semi-public spaces include those areas that may be publicly owned but are cared for by homeowners such as planted parkways adjacent to sidewalks. *Semi-private* spaces can include yards or spaces owned in association (some theoreticians include porches and foyers in this category). *Private* territory is the interior of one's home or fenced areas within a yard, or, for example, the interior of a student's dorm room.

Newman's notions of defensible space and related territories have significant implications for planners, architects, and interior designers because taking them into account in designing homes can help to create spaces in which residents feel safe and have a genuine control over their immediate environment. See Figures 1-3a and 1-3b.



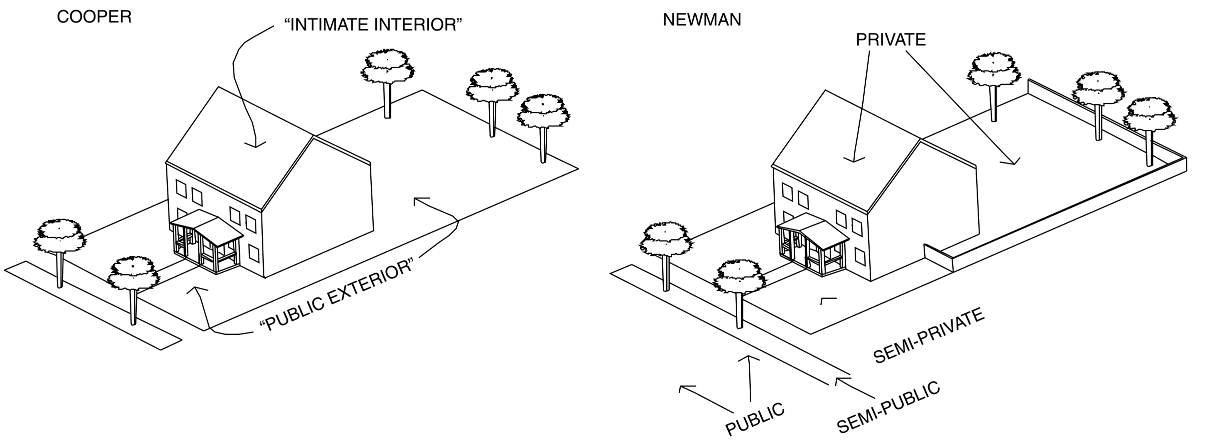
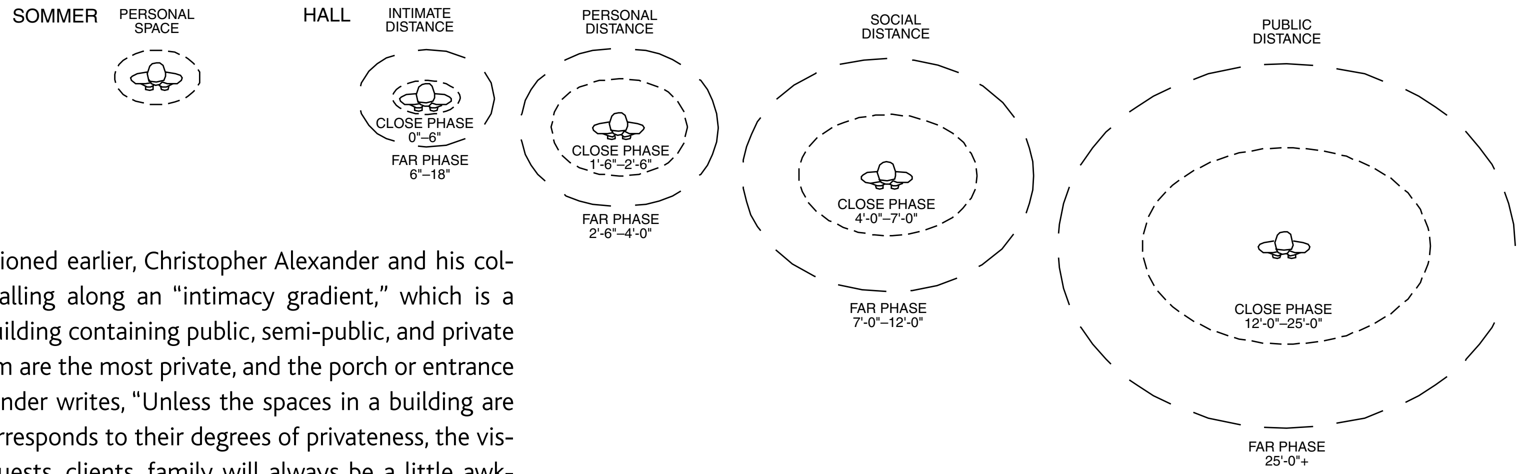


Figure 1-3a An illustration of territories as identified by theoreticians. Cooper identifies a public exterior and an intimate interior. Newman identifies public territories, which are not possessed or claimed; semi-public territories such as sidewalks, which are not "owned" but are seen as being possessed, nonetheless; semi-private territories, which are shared by owners or seen as being under surveillance by neighbors, such as front yards or shared swimming pools.

Figure 1-3b An illustration of territories related to interior space as identified by theoreticians. Newman describes the need for a buffer between the public world and private interior territories. Sebba and Churchman describe areas within a home as "shared territory" when used by all, with limited privacy; "individual primary territories" are those seen as belonging to individuals, such as a bedroom, which becomes the private sanctuary of the individual. Alexander et al. describe an intimacy gradient with the most public spaces related to the entrance leading to a sequence of increasingly private spaces.

Figure 1-3c Sommer's *personal space* and Hall's *body distances*.



In *A Pattern Language*, mentioned earlier, Christopher Alexander and his colleagues describe territories as falling along an "intimacy gradient," which is a sequence of spaces within the building containing public, semi-public, and private areas. The bedroom and bathroom are the most private, and the porch or entrance space are the most public. Alexander writes, "Unless the spaces in a building are arranged in a sequence which corresponds to their degrees of privateness, the visits made by strangers, friends, guests, clients, family will always be a little awkward." See Figure 1-3b. Chapter 8 provides additional information about public and private spaces as they relate to the entry spaces.

Personal space is a term introduced by Robert Sommer in the 1960s. According to Sommer, "personal space refers to an area with an invisible boundary surrounding the person's body into which intruders may not come" (1969). See Figure 1-3c.

A similar sounding term expresses a different concept and comes from work done by Edward Hall, an anthropologist who coined the term *proximics*—for the "interrelated observations and theories of man's use of space as a specialized elaboration of culture" (1966). Hall identified four distinct body *distances* or boundaries that people will maintain in varying social situations: *intimate* (0 to 18 inches), *personal-casual* (1 foot, 6 inches to 4 feet), *social-consultative* (4 to 12 feet), and *public* (12 and beyond). Hall found that while actual spatial boundaries vary based on cultural differences, the concepts of intimate, personal, social, and public distances are consistent cross-culturally. Figure 1-3c also illustrates the spatial boundaries identified by Hall.

Hall's term *personal distance* refers to the distance maintained between friends and family members for discussion and interaction, whereas Sommer used the term *personal space* to refer to the invisible, territorial boundary around each person. Similarly, Hall's *intimate space* is a "bubble" of space around a person that can only be entered by intimates, whereas *social-consultative spaces* are those in which people feel comfortable engaging in routine social interaction for business or in conversation with strangers. *Public space* is that where there is little interaction and people are generally comfortable ignoring one another; this distance also allows one to flee when danger is sensed.

Considering Hall's spatial boundaries can be useful for designers in planning living spaces. For example, most casual social interaction takes place within personal distances. Later portions of this book focus on specific room-related dimensional information for encouraging interaction and creating privacy. It is also worth noting that in designing public and commercial spaces that encourage interaction and help users attain privacy, the designer will find it helpful to reference the work of social scientists such as Hall, Newman, Lang, and others. For those seeking additional information about environmental psychology and the related work of other social scientists, the bibliography section of this chapter includes related bibliographic information.

BASIC RESIDENTIAL BUILDING CONSTRUCTION AND STRUCTURE

Interior designers are not responsible for the design of structural or mechanical systems; however, practicing interior designers must understand the basic structural and mechanical building systems in order to work well within them. Our discussion here is limited to *common* standards of current residential construction and is a brief overview of the basic components of construction intended to supply the reader with the knowledge required to begin to gain an understanding of this topic. This book does not examine any of the myriad alternative, less common modes of construction that are used in residential construction, such as straw bale, adobe, timber frame, rammed earth, geodesic domes, and others. These and others have a place in the construction of homes, in special circumstances, and are covered in detail in specialty publications.

Houses sit on some type of concrete or wood *platform,* which together with the foundation, supports the portions of the house that rise above it. These include the following:

1. A *concrete slab* platform that sits directly on the ground. Concrete can resist termites, moisture, and rot and can serve as a suitable substrate for a wide variety of finish floor materials. The platform (slab) is most typically on a single plane, but it can be designed as a multilevel platform—a more complicated and more expensive option. In some cases, a very slight indentation in the slab is created to accommodate floor finishing materials of varying thicknesses, such as wood flooring, or to provide slopes for drainage (for example, a roll-in shower). In geographic areas subject to frost upheaval due to low temperatures and/or soil conditions (such as water-retaining clays), it is necessary to augment the concrete slab platform with a perimeter foundation wall that extends deep enough into the ground to reach stable soil. Figure1-4 illustrates slab foundations.
2. A *wood platform* that sits off the ground to avoid rot and/or termite infestation. It can sit off the ground far enough to form a crawl space or a basement. Figure 1-5 illustrates wood-frame floors over crawl spaces and basements, and Figure 1- 6a shows a basement foundation.

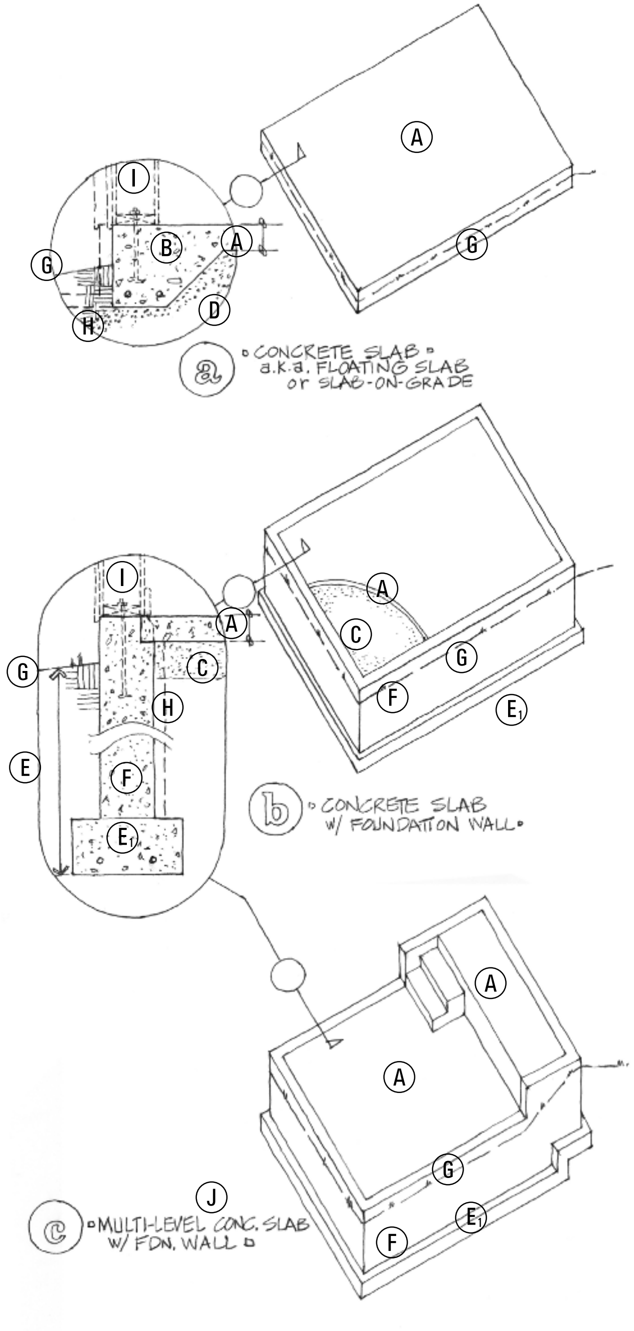


Figure 1-4 Houses sit on some type of a platform. One type is a concrete slab.

A. Slab is typically 4-inch-thick reinforced concrete and serves as suitable substrate for a full range of floor materials.
B. Perimeter of slab is thickened and reinforced.
C. Compacted granular fill (6 inches plus or minus).
D. Well-drained compacted substrate under floating slab.
E. Depth of footings (E1) (below grade) is a function of climate (frost depth) and soil conditions (some layers of soil may be more stable—under load—than others).
F. Foundation wall(s) are commonly 8-inch-thick concrete or concrete blocks (called CMUs), less commonly are brick or stone.
G. Ground line.
H. Rigid insulation (dashed line) required in cold climates.
I. Walls of the building envelope (walls and roof) are anchored to the concrete slab or foundation wall.
J. This is an uncommon multilevel slab, which can be costly but can provide for an interesting ground floor.

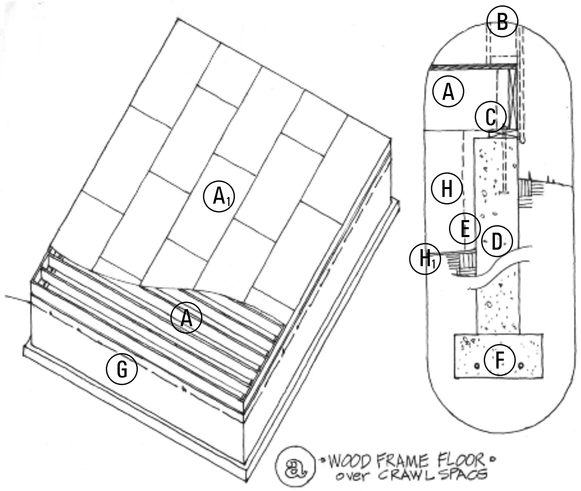
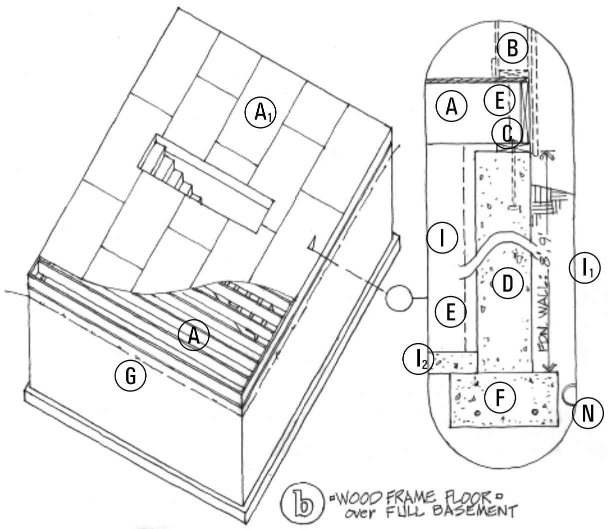
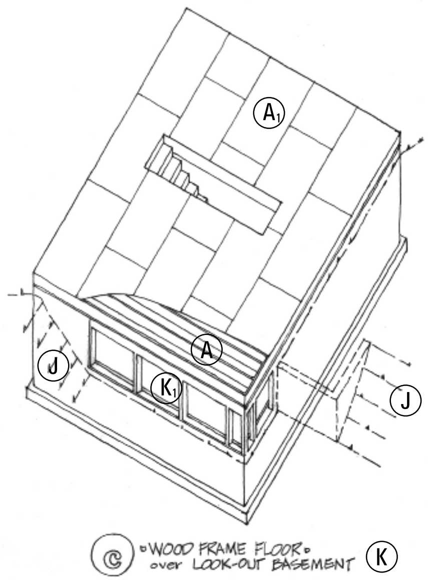
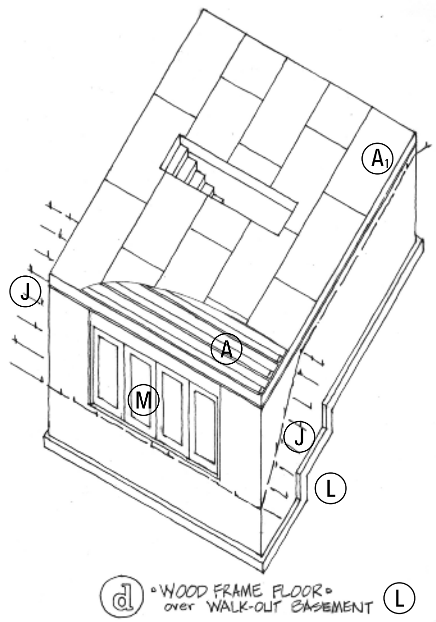


Figure 1-5 Another type is a wood platform that sits off the ground (on some type of foundation wall). It can sit off the ground far enough to form a crawl space or a basement as shown. Figure 1-6a also shows a basement foundation.

A. Floor joists. Floor structure is typically constructed of wood joists (the longer the span, the deeper the joist) and structural sheets (A1) (4 feet by 8 feet) of plywood or oriented strand board (OSB) that is ¾ inch plus-or-minus thick.
B. Frame walls. The floor serves as the platform for the construction of the building envelope (walls and roof) above.
C. Sill plate. Floor joists rest on this "plate" (typically 2 by 6 inches) that rests on and is anchored to the foundation.
D. Foundation wall. Typically reinforced concrete (8 to 10 inches) or concrete block, known as CMU (10 to 12 inches). The higher the foundation wall, the thicker the wall must be.
E. Insulation (shown with a dashed line). Required in colder climates.
F. Footing. Reinforced concrete. Typically the width is twice the thickness of the foundation wall and thickness (depth) is half the width.
G. Grade. Ground line, 8 inches (minimum) below the wood structure.
H. Crawl space. 18-inch height (minimum) with vapor barrier (H1).
I. Full basement. 8-foot-high foundation wall (minimum) (I1) with a 3- to 4-inch-thick concrete slab floor (I2).
J. Look-out and walk-out basements require a site that slopes sufficiently to accommodate the required change of grade and yet drain properly—away from the building.
K. Look-out basement can provide legal egress windows (K1), allowing bedroom(s) without requiring changing the footing depth.
L. Walk-out basement requires stepping down the footings and associated foundation walls in colder climates.
M. Door(s).
N. Drain tile to carry away excess groundwater and reduce the pressure of groundwater against the foundation wall.





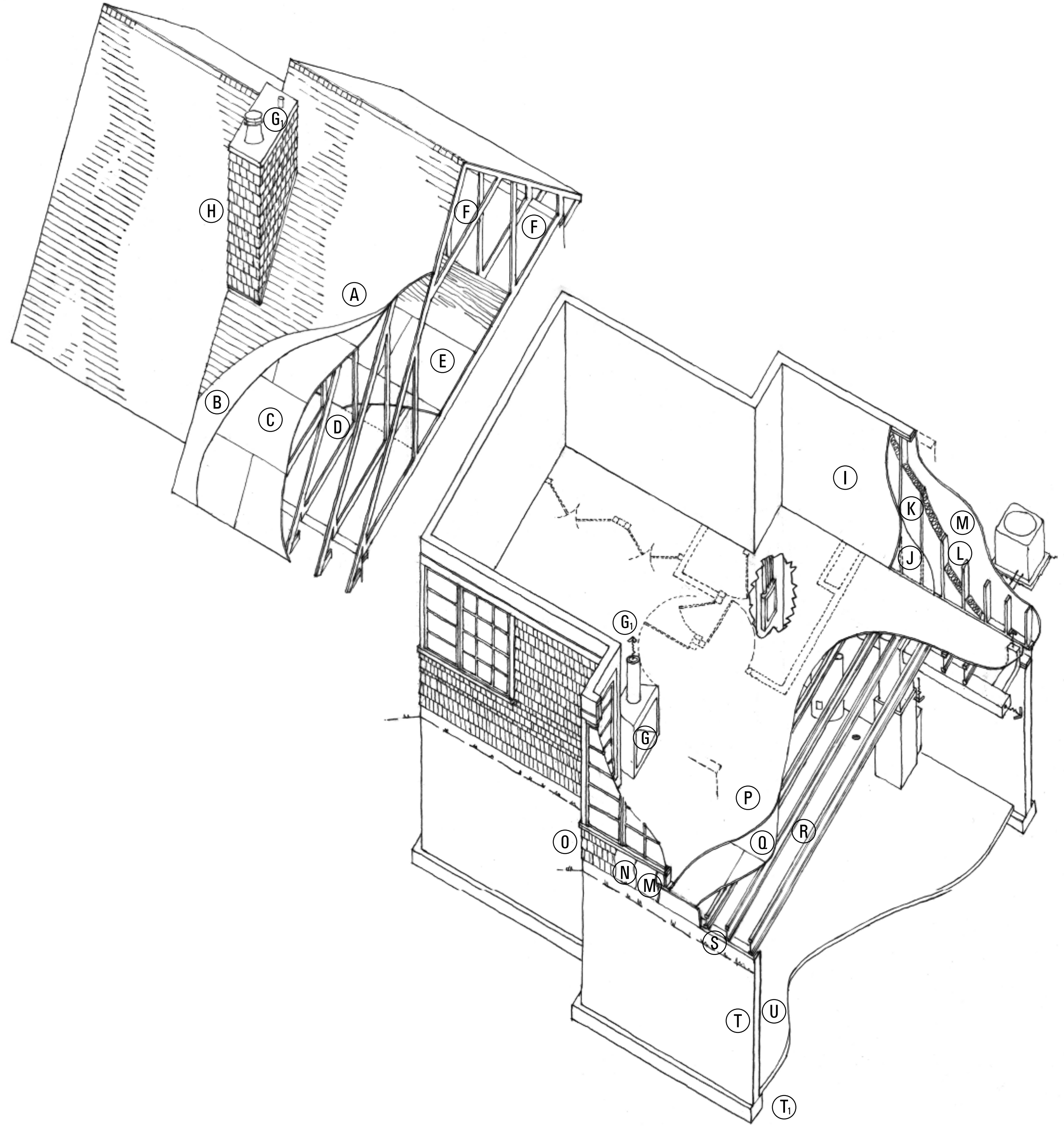


There are methods of support for the wood platform apart from foundation walls. These include piers (posts) of wood, steel, or concrete supporting beams that, in turn, support the platform. While this method is less common, it is useful on hillsides or sites that are prone to flooding.

Major construction elements of a wood-frame building system are illustrated in Figures 1-6a and 1-6b. These include elements that combine to form the roof and walls, including structural and insulating elements and related finish materials, as shown in Figure 1-6a. Electrical, plumbing, heating, and air-conditioning elements are shown in Figure 1-6b, with detailed notes. Information about doors and windows are shown in Figures 1-7a to1-7c.

Figure 1-6a This is a "peel away" exploded view of a wood frame house meant as an illustration of the most common residential construction techniques currently used in the United States.

A. Roofing. Commonly asphalt shingles; less commonly clay tile, wood (cedar shingles), sheet metal (includes copper and other metals), fiber reinforced cement, and slate.
B. Roofing felt. Commonly #15 asphalt-impregnated paper.
C. Roof sheathing (also known as the roof deck). Typically 4-foot-by-8-foot-by-⅝-inch-thick (plus or minus) sheets of structural plywood or oriented strand board (OSB).
D. Roof trusses. Commonly 2 feet on center; shown in this case as attic trusses (see Figure 2-11). Most commonly prefabricated off-site using dimensional lumber (such as 2 by 4 inch, 2 by 6 inch, etc.); less frequently fabricated of light gauge steel.
E. Subfloor. 4-foot-by-8-foot-by-¾-inch-thick (plus or minus) structural plywood or OSB; provides a walkable surface in the unfinished attic (as shown); serves as the structural base (support) for the finished flooring materials.
F. Attic insulation. Commonly fiberglass (batts, blankets, or blown-in); see Figure 2-11.
G. Gas fireplace. Requires venting to the outdoors (G1); shown here, venting to the roof.
H. Chimney. The chimney (in this case a gas vent); the chimney housing can be of light frame construction, as shown, or masonry, such as brick or stone.
I. Interior wall material. Commonly gypsum board, ½ inch thick (also called drywall) serves as a suitable surface for application of paint or wall covering. Alternatives include wood or composite paneling (boards or sheets); composite options include Homasote and medium density fiberboard (MDF).
J. Vapor barrier. Polyethylene sheet, placed on the room side of the insulation in cold climates in order to prevent water vapor from entering (from the interior) and condensing within the insulation.
K. Wall insulation. Commonly fiberglass blanket (batts) fills the entire wall stud cavity.
L. Studs. Commonly 2-by-4-inch or 2-by-6-inch wood 1 foot, 4 inches on center. An alternative is steel (C-studs). These carry roof loads to the floor and/or foundation and serve as a structural entity to attach interior and exterior sheeting/sheathing materials. Exterior studs shown here are 2 by 6 inches; interior studs are commonly 2 by 4 inches.
M. Wall sheathing. Structural sheets (commonly 4-feet-by-8-feet-by-½-inch-thick (plus or minus) fastened securely to the studs (L) to resist lateral forces (such as wind or earthquake).
N. Infiltration barrier (also known as building wrap). Resists air (wind) penetration; does not (and should not) impede water vapor transmission.
O. Exterior finish (also known as siding). Cedar shingles are shown; wood, vinyl, and metal products are used for lap or vertical siding. Alternatives to items mentioned are stucco (and stuccolike products), brick, stone veneers, and so on.
P. Underlayment. ¼-inch- to ⅝-inch-thick wood fiber material (4-foot-by-8-foot sheets); used to level substrate under finish floor materials such as carpet; plywood is used under vinyl; cement based products are used under ceramic tile.
Q. Subfloor. ¾-inch-thick (plus-or-minus) sheets of structural plywood or OSB.
R. Floor joist. I joist is shown; dimensional framing lumber such as 2 foot by 10 foot can also be used. Allowing 12 inches for the total thickness of a structural wood floor system is a good preliminary rule of thumb.
S. Sill. Floor joists sit on a sill plate (commonly a treated 2 by 6), which is anchored to the foundation wall. A rim joist caps the ends of the floor joist and serves as edge support for the subfloor.
T. Foundation wall. Commonly concrete is 8 inches, 10 inches, or 12 inches thick and 8 feet, 9 feet, or 10 feet high (the higher the wall, the thicker the concrete required). Common alternatives include 10- or 12-inch-thick concrete masonry unit (CMU). Treated wood is used less frequently. Liquid or sheet damp-proofing is applied to the exterior prior to backfilling with soil. T1 footing, in most cases, is poured concrete; minimally twice as wide as the thickness of the wall it supports; spreads building loads over more ground surface for support.
U. Concrete slab (also known as basement slab). 4-inch-thick concrete commonly over a membrane vapor barrier (polyethylene).



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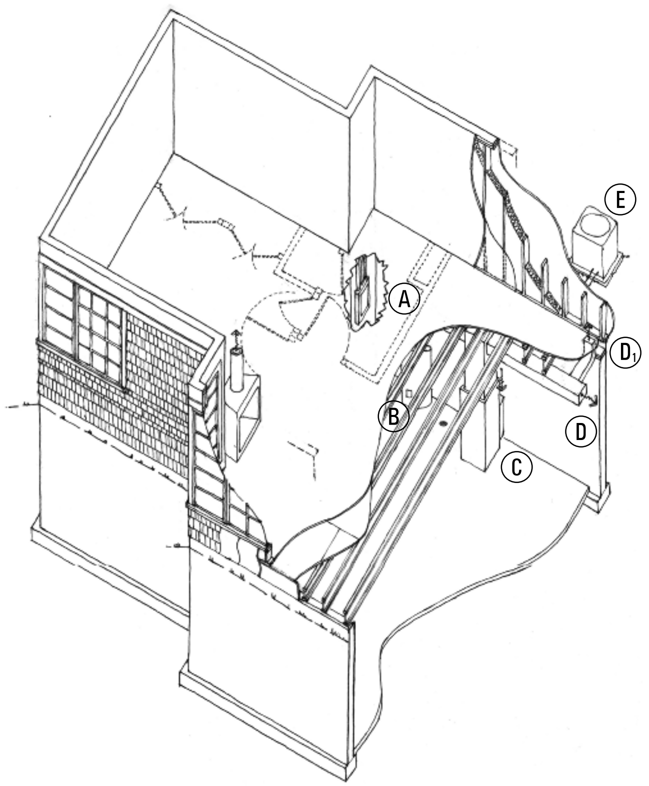

Figure 1-6b A "peel away" exploded view of a house meant as an illustration of building systems.

A. Electrical service panel. 100-amp service is minimum; a 200-amp panel is common. Service is brought to the house by underground or overhead wire, through a meter mounted at an exterior location (typically the exterior wall of the house) and then to the service panel; branch circuits feed from the service panel to a variety of outlets (also known as receptacles), light fixtures, switches, and appliances throughout the house. The International Residential Code requires 3 feet by 2 feet, 6 inches and 6 feet, 6 inches (height) of clear space in front of the service panel.

B. Water heater. Should be located near a floor drain to minimize the length of the hot-water lines that serve sinks and appliances. Heaters that burn a fuel (as compared to electric models) require a vent to the exterior.

C. Furnace/air-handling unit. Designed to heat, clean air (filter), move air (blower), and mix indoor with outdoor (fresh) air—and, with the addition of refrigeration coils and condensing unit, cool and dehumidify air. Located in this example in the basement. For houses without basements, this equipment can be located on any floor or in an accessible attic. Forced-air furnace systems, as shown, are very common because of the ability to integrate the variety of functions listed above. However, other heating unit types are available, such as radiant in-floor heating systems and baseboard convectors. Both can be accomplished with either electricity or hot-water heat systems.

D. Supply air. The furnace blower moves air through ducts to diffusers (D1) located throughout the house. Return air is ducted from the rooms back to the furnace, ideally mixing with ducted outside (fresh) air before it arrives back at the furnace to be recirculated.

E. Compressor/condensing unit. Supplies cold refrigerant to the evaporator coils at the furnace. Unit is commonly located on a concrete slab near the house and requires adequate air circulation space around the unit.

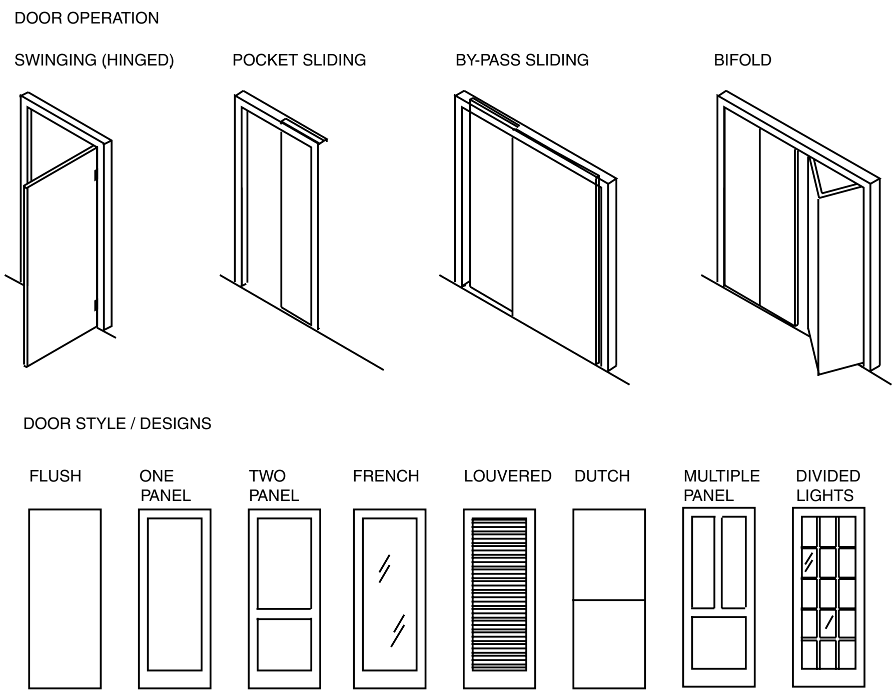

Figure 1-7a Door types and styles. Door types can be classified by operation and include swinging (these swing on hinges or pivots and are the most common), bypass sliding, pocket sliding, surface sliding (not used commonly in residences), and bifold. Door style designs include flush, panel, French, and louvered. Flush types may be solid core ($1\frac{3}{4}$ inch thick) or hollow core ($1\frac{3}{8}$ inch thick). French-types include single glass panels and those divided by muntins (called divided lights).

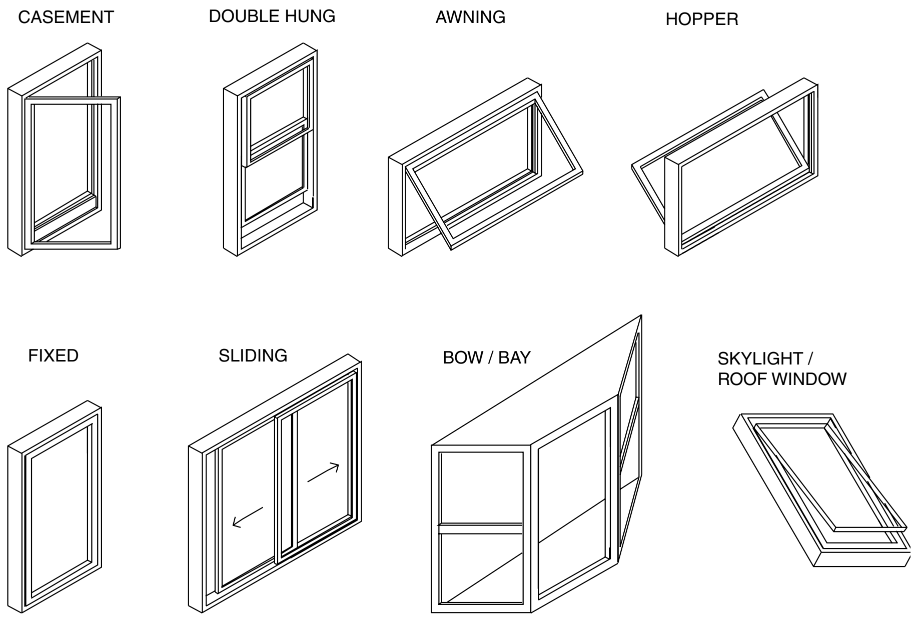

Figure 1-7b Window types and styles include the following:

- Casement windows are hinged at the side and open outward.
- Double-hung windows open by sliding vertically.
- Awning windows are hinged at the top and open outward.
- Hopper windows are hinged at the bottom and open inward (very limited applications)—must be well protected from weather.
- Fixed windows are stationary and can be used in combination with other types—particularly double-hung and casement types.
- Sliding windows open by sliding horizontally.
- Bow and bay windows use types in combination and project outward from the building.
- Skylights and roof windows are designed for installation on sloped surfaces.
- There are also a variety of specially shaped windows that employ curved shapes or angles other than 90 degrees.

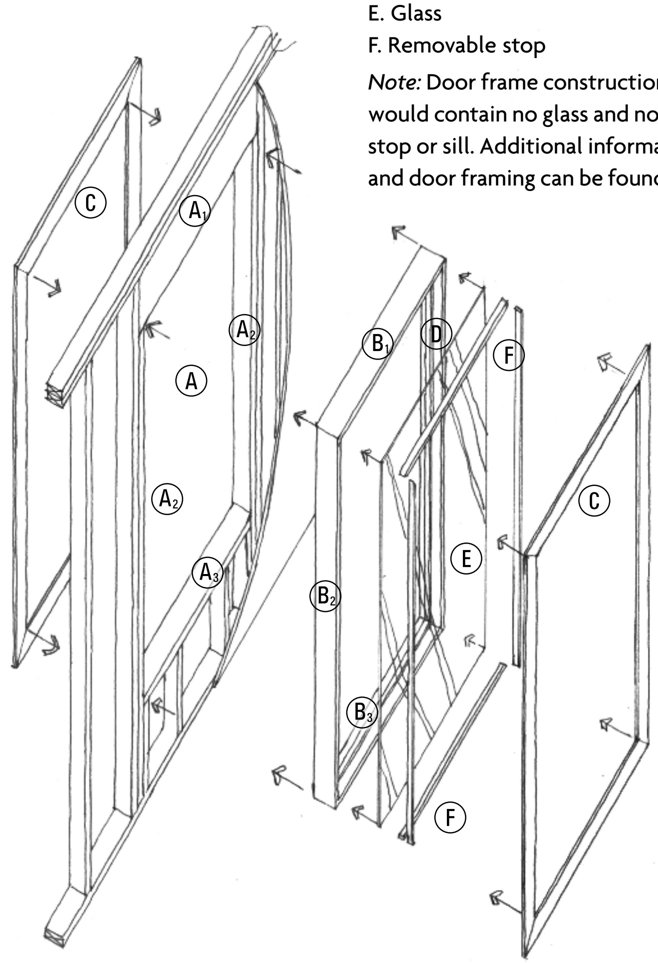

Figure 1-7c Window construction and terminology (applicable to fixed windows).

A. Rough opening
- A1. Header
- A2. Double stud at jamb(s)
- A3. Sill

B. Frame
- B1. Head
- B2. Jamb(s)
- B3. Sill

C. Trim (casing)

D. Fixed stop

E. Glass

F. Removable stop

Note: Door frame construction is similar but would contain no glass and no removable stop or sill. Additional information on doors and door framing can be found in Figure 3-11.

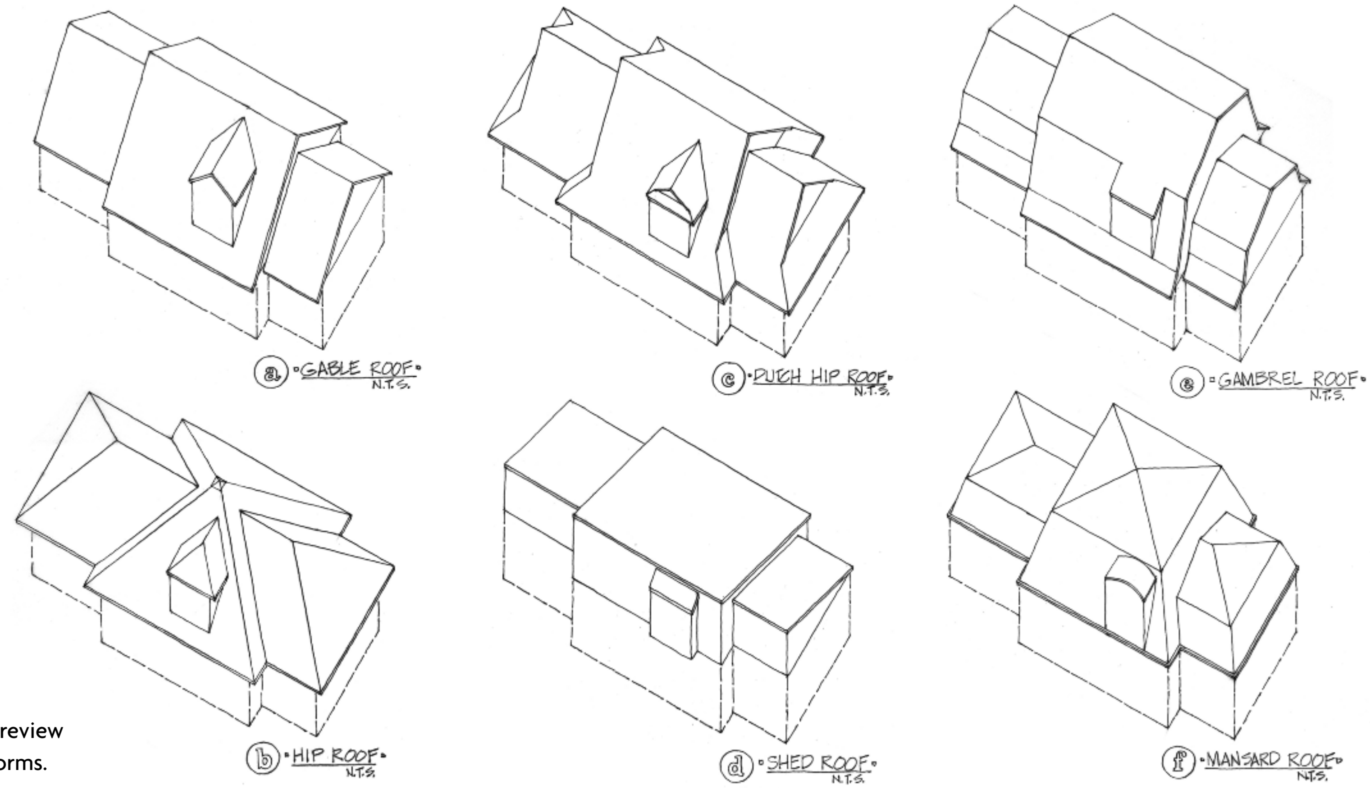

Figure 1-8 An illustrated review of basic roof styles and forms.

Roof design and form have a significant impact upon the visual characteristics of the exterior and can also impact how the interior spaces are formed. The primary function of a roof is to shed water and to shade the interior, as well as to protect walls and windows from the ravages of the elements. Much in the way an umbrella shields a person from the weather, a roof serves to shield and protect a building. In addition, the roof of a house contributes a great deal toward the visual qualities of the building, as do the design and placement of window and door openings. Complex plan shapes generally require complex roof forms, which can be wonderful but typically add to the building cost. Figure 1-8 is a review of simple roof styles and forms.

Roofing materials and configurations for residential construction include shingles, tiles, and sheets. Shingles rely on the redundancy of at least two layers, as well as lapped joints, whereas sheets and tiles are laid as single layers with lapped joints. Asphalt is the most commonly used material for shingles; wood (commonly cedar) and slate are also used. Materials used for roofing tiles include concrete, clay, cement fiber, and metal.

Sheet materials used for roofing include sheet metal with standing seams (including galvanized steel, aluminum, and copper). This type of roof is constructed of interlocking panels that run vertically from the roof's ridge to the eaves. Two materials used for very flat roofs include built-up types (made from multiple layers) and single-ply roofing membranes (ethylene propylene diene monomer, or EPDM).

AN OVERVIEW OF CHAPTER TOPICS

Generally, the remainder of this first chapter is organized in a manner that is similar to later chapters covering individual rooms and spaces. The only chapter that differs organizationally is Chapter 2, which serves as an introduction to design graphics and therefore has its own unique focus. This chapter serves as an introduction to the definitions, concepts, and organizing principles that will be used throughout the book. Topics are as follows:

Accessibility, universal design, and visitability

Ergonomics and required clearances

Organizational flow

Related codes and constraints

Electrical and mechanical

Lighting (While lighting is clearly part of the electrical system, we have separated it merely for purposes of organization.)

Accessibility, Universal Design, and Visitability

Initially used to describe environments that do not present physical barriers for people with physical limitations, such as wheelchair users, the term *accessible* now describes design, including graphics and Web design, that considers the needs of users with a wide range of both physical and cognitive abilities and limitations According to Dr. Edward Steinfeld of the Center for Inclusive Design and Environmental Access (IDEA), "Accessible design allows people with disabilities to demonstrate that they have capabilities—to work, manage a household, marry and raise children [—that] they can play a vital role in the community" (1996).

Generally, the design of private, single-family homes is not mandated by any current accessibility regulations except as noted later in this chapter. However, many homeowners seek residences that are accessible, either because they plan to "age in place" in the home (that is, grow old in one's home without having to relocate) or because they or a family member have current needs that warrant the design of accessible spaces. These two distinct scenarios present two distinct design criteria. In cases where current physical or other limitations create the need for accessible spaces, the design should address the specific needs of the owner or family member. For example, designing a home for a specific person who uses a wheelchair requires meeting a set of appropriate criteria and guidelines, whereas designing a home for a person with a vision impairment requires considering a different set of standards and guidelines.

In contrast, designing a home for aging in place or for general accessibility requires making design decisions based on basic accessibility standards and guidelines. These are presented throughout this book as part of the body of each chapter. Incorporating accessibility information for each area is intended to provide readers with a comprehensive view of accessible design. Information about regulations and standards for accessibility is provided in the "Related Codes and Constraints" section of this chapter.

The concept of *universal design* grew, in part, out of the accessible design movement but is not synonymous with accessibility. Ron Mace, an architect, product designer, and educator, is credited with coining the term; he also established what is now the Center for Universal Design at North Carolina State University.

According to the IDEA Center (SUNY at Buffalo), universal design can be defined as "an approach to the design of all products and environments to be as usable as possible by as many people as possible regardless of age, ability or situation . . ." and that " . . . results in better design and avoids the stigmatizing quality of accessible features that have been added on late in the design process or after it is complete." In "Accessible Design Can be Beautiful," Nancy Mannucci, a designer living with Multiple Sclerosis, writes, "Universal design takes into account multigenerational needs, namely the needs of children, the needs of elderly people, and those who, for whatever reason, have sensory or mobility impairments" (1988).

Universal design is an approach that is becoming increasingly embraced in product design, architecture, interior design, and urban design, as well as in graphic and Web design, that considers usability. One approach to universal design in the home is the notion of *adaptable* elements that may be designed to offer greater flexibility for a range of occupants. For example, counters that can be made so they are adjustable to adapt for users of varying heights (including those using seats and wheelchairs). Adaptable cabinets can be designed with fronts and bases that can be removed to create a clear area underneath for use by someone in a wheelchair. Illustrations of both of these examples can be found in Chapter 5, "Kitchens."

Visitability is a concept that shares some commonalities with universal design concepts; it refers to creating homes that can be visited or accessed by people with physical disabilities. Visitable residences must meet three important criteria:

1. There must be one zero-step entrance into the home.
2. All main-floor interior doors, including the bathroom, must provide 32 inches of clear passage space.
3. There must be at least a half bath (preferably a full bath) on the main floor.

Eleanor Smith is a founder of a group of advocates for this approach that is seeking to have visitability ordinances adopted by various jurisdictions or to be federally mandated. To date, a number of jurisdictions, such as Pima County, Arizona, have adopted visitability ordinances, while others, such as Urbana, Illinois, have adopted visitability ordinances for residences built using city funds.

Of the three criteria for visitability, the most difficult to achieve nationally is the zero-step entrance requirement. This could prove problematic in parts of the country where basements are commonplace. Typically, the main floor of a house with a basement is 18 to 20 inches above ground level, which could require a significant ramp for a zero-step entry. In some cases, through careful building placement and site grading, the driveway and sidewalk to the entrance can be designed with a slope of not more than 1:12 for a zero-step entry. There continues to be controversy within the building community as to the feasibility of making all new houses visitable.

Ergonomics and Required Clearances

The field of study known as *anthropometrics* provides detailed information about the dimensions and functional capacity of the human body. According to authors Julius Panero and Martin Zelnick, anthropometry is "the science dealing specifically with the measurement of the human body to determine difference in individuals, groups, etc." (1979). *Ergonomics* is the application of human-factors data, including anthropometric data, to design. An overview of basic anthropometric data, helpful in residential design, can be found in Appendix A, whereas specific ergonomic information is included in each chapter.

The last chapter of this book is devoted to circulation space; the focus of that chapter is movement from room to room. The discussion of room-specific circulation is covered within each chapter.

The introductory discussion of proximics earlier in this chapter described Edward Hall's finding that human spatial boundaries vary from one culture to another; readers should note that the clearances and ergonomic information provided throughout this book represent North American norms rather than reflecting a world view. This is particularly true of dining and leisure spaces. Many chapters also provide furniture and appliance sizes; these too are based on items currently available in North America.

Organizational Flow

The authors use the term *organizational flow* to refer to the use of activity areas or elements within a room in relationship to traffic flow. For example, in designing a kitchen, one must consider the various activity areas (such as cooking, cleanup, and preparation) and the ease of their use, as well as circulation within the room and to other areas within the residence. Each room in a home serves a distinct purpose, and the design of the room must support that purpose in order for the room to function well. When considering organization flow, a designer must consider the range of uses of the room and make design decisions that support those purposes. For example, bedrooms are used for sleeping but also have other uses such as clothing storage (in closets and dressers); the flow of the room should support both sleeping and accessing stored items, as well as additional activities that occur within the room, such as watching television or working on a computer. Such issues of organizational flow are discussed in detail in the various chapters of this book.

Related Codes and Constraints

Building codes, zoning regulations, and fire, health, and safety codes all influence the design of buildings and their interior elements and provide constraints to the overall design. A basic understanding of the codes and regulations that affect residential design is required as projects are undertaken.

Building codes generally govern the construction of buildings based on the type of occupancy intended for the building. This means that residences are generally regulated by standards different from those regulating public spaces, and public spaces are regulated in varying ways based on intended use. Building codes are adopted by cities, states, and/or municipalities and, in rural areas, often by county agencies. In some cases, states adopt a statewide residential building code; however, often codes adopted within states can vary. Additionally, states and municipalities can add local requirements or amendments to generally adopted model codes to allow for incorporation of regional variation or geographic factors.

Prior to 2000, three model codes were used widely throughout the United States: the Uniform Building Code (UBC), the Building Code Officials and Code Administration National Building Code (BOCA), and the Standard Code. In 2000 these code entities came together to prepare the International Building Code (IBC), which was written to serve as a consolidated model code for commercial and public buildings Many states and municipalities have adopted the IBC, although it is not currently as consistently adopted as the name implies. Many code jurisdictions have intentions of adopting the IBC in the future, however.

IBC also publishes related codes including the International Residential Code (IRC)—which is used in the regulation of single-family homes, the International Mechanical Code, and the International Plumbing Code. Please see the "Electrical and Mechanical" section of this chapter for related information about electrical code requirements called for by the IRC, Section E. The IRC does not cover multi-family dwellings, dorms, apartments, nursing homes, or assisted-living facilities; these are covered by the IBC.

Throughout this book the International Residential Code is the code that is referenced. Referencing this single code is useful for purposes of clarity; however, not all locales or code jurisdictions have currently adopted this code, and this code does not regulate multifamily housing. Therefore, prior to beginning any project, the designer must research the local code and all related regulations where the project is intended to be built.

Zoning regulations control building size, height, location, setbacks, and use. These regulations are adopted by local municipalities and vary greatly throughout the United States. In some areas, there are very strict zoning codes that control many facets of a building's design, while in others, there are few zoning restrictions. As with the building code, zoning regulations should be researched prior to beginning the design of any project.

Additional codes and regulations that govern the design of buildings include energy codes as well as fire and flammability standards. There are also additional standards developed by testing and other agencies that are incorporated into model codes and federal regulations. Such testing agencies include the American National Standards Institute (ANSI) and the American Society for Testing and Materials (ASTM).

Federal regulations that govern the design of multifamily dwellings include the Fair Housing Amendments Act (FHAA), a civil rights law requiring that privately and publicly funded multifamily dwellings (those on the first floor and all in buildings with elevators) provide limited accessibility. In addition, the Uniform Federal Accessibility Standards (UFAS) require a percentage of units within federally funded multifamily dwellings to be accessible.

Early residential accessibility standards were published in 1980 in the ANSI A117.1 standards, which included bathroom and kitchen accessibility standards. The most current version, ANSI A117.1-2003, which was approved in 2003, provides standards for two types of accessible units: Type A and Type B. In brief, Type A units (Section 1003) are fully accessible, while Type B (Section 1004) provide limited accessibility.

Type B units are consistent with Fair Housing Act Requirements, while Type A units are consistent with UFAS. A review of Type A and Type B standards will show that Type B standards are less strict—however, Type B standards are also more broadly applied. ANSI A117.1-2003 also sets standards for accessible communications features for dwelling and sleeping units (Section 1005). Information about kitchen and bath layouts that meet ANSI standards for Type A and B units may be found in Appendix B.

The Americans with Disabilities Act (ADA) is also civil rights legislation that includes federal accessibility guidelines (known as ADAAG). The ADA requires that *public* buildings (including those owned privately) are designed so that they accommodate people with disabilities. ADA guidelines share many similarities with ANSI standards. While the ADA has significant implications for the interior design of public places and should understood by the practicing designer, it does not directly impact the design of single-family homes— except in a small portion of housing built with public funding.

Electrical and Mechanical

These issues are covered in each chapter as they relate to individual rooms and spaces. With that said, there are some general rules for locating electrical switches and convenience outlets, with typical exceptions being in kitchens, bathrooms, and utility spaces. In most other locations, the on/off switches for overhead or general lights are best located close to the room entry door on the latch side of the doorway when possible. In larger rooms with more than one entrance, a second on/off switch can be employed in another convenient location; this is called a "three-way switch." Where a number of light fixtures are used for general lighting, a single switch can be used to control several fixtures and outlets.

The International Residential Code (IRC, section E3893.2) requires that "at least one wall-switch-controlled lighting outlet shall be installed in every habitable room and bathroom." One exception to this requirement is "in other than kitchens and bathrooms, one or more receptacles controlled by a wall switch shall be considered equivalent to the required lighting outlet." The IRC (section E3803.3) requires additional locations for a wall-switch-controlled lighting outlet in hallways, stairways, and attached and detached garages with electric power. This section of the code also requires that a wall-switch-controlled lighting outlet be installed on the exterior of egress doors with grade-level access.

The on/off switch should be mounted at 44 to 48 inches off the floor. Because there are two receptors, typical household electrical outlets are referred to as

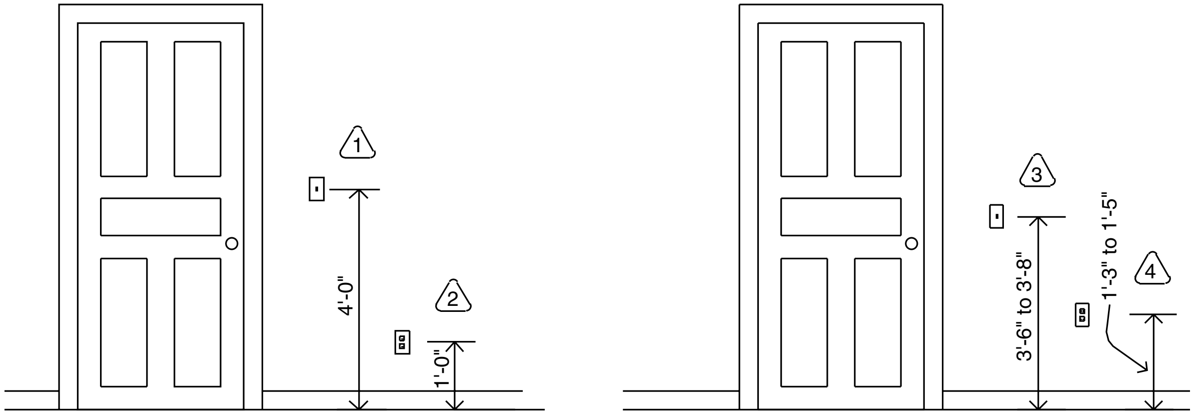

Figure 1-9 Switching and outlet locations for standing adult and seated (wheelchair) users.

1. Standard switch placement is convenient to latch side of door and centered at 48 inches above the floor.
2. Standard wall outlet placement is one outlet for each 12 feet of wall area in general living spaces. Actual locations in individual rooms will vary based on room design and possible furniture arrangement.
3. For wheelchair users, switches are best located centered 42 to 44 inches above the floor and never higher than 48 inches above the floor.
4. For wheelchair users, wall outlets are best placed 15 to 17 inches above the floor and never lower than 15 inches above the floor.

duplex outlets or *duplex receptacles*. These outlets are commonly placed about 12 inches off the floor, as shown in Figure 1-9.

This is rather low for wheelchair and other users. For these users, outlets are best placed between 15 and 17 inches off the floor and wall switches should be placed no higher than 48 inches off the floor, as shown in Figure 1-9. The Center for Inclusive Design and Environmental Access indicates "wall outlets should be located no lower than 15 inches from the floor" and controls "that will be used frequently should be within the 24–48 in. 'comfort range.'" Such controls include thermostats and alarm systems. It is worth noting that placing controls in this comfort range and locating receptacles between 15 and 17 inches above the floor makes rooms meet universal design criteria and adds no extra expense, making them worth considering on many projects.

A general rule of thumb for electrical outlet placement is one duplex receptacle per 12 feet of wall space in order to avoid the use of extension cords (standard appliance cords are often 6 feet long). Following such rules can be a good starting point; however, the placement of outlets must be considered in relation to the design and layout of the room. It is also important to consider the various possibilities for furniture placement so that the outlets can be designed in a way that is useful for a variety of scenarios.

The term *mechanical* is an umbrella term used to describe the heating, ventilation, air-conditioning (known together as HVAC), and plumbing elements of a building. With very few exceptions, all residences in the United States are required by code to be heated; for example, the International Residential Code calls for heating to a minimum of 68°F when the winter temperature is below 60°F. Cooling may not be required by code, but it is seen as necessary by most people in many parts of the country.

The most common solution for providing heat is a furnace that burns a fossil fuel (such as natural gas, liquid propane, or heating oil) and less commonly wood, charcoal, and in some cases coal, or the furnace will derive heat from electric resistance coils or a heat pump. In almost all cases, the furnace uses a fan that moves air, via ducts, to the various rooms where heat is required. This type of system can be equipped to clean (with filters), humidify, and—with the addition of a compressor or condensing unit—cool the air (which in the process dehumidifies the air).

Other heating systems are available, such as a boiler that heats water in tandem with a pump that moves the heated water to a baseboard convector unit; a similar result can be achieved with electric resistance baseboard units. Hot water can also be delivered to radiant-heating pipes located in the floors of a residence, with similar results achieved with resistance heating in the floors. All of the methods described do not work to accomplish the cooling, cleaning, and dehumidifying that forced-air systems allow; these must be achieved through the use of separate equipment.

Air-to-air heat pumps are commonly used in temperate climates; these remove heat from the inside air in warm weather and work in reverse to provide heat to the interior during colder weather. In these systems, air is delivered much like the forced air described previously.

Increasingly, consumers are seeking alternative sources for heating and cooling homes. Geothermal heat pumps use the relatively constant temperature of the soil or surface water as a heat source for a heat pump that can provide heating (and cooling). These use buried tubing submerged in soil or a nearby lake or pond. Many consumers find the initial higher cost of geothermal heat pumps offset by energy savings and special energy and possible tax incentive programs. For years solar energy has been used to heat homes, and a number of passionate advocates see this as a realistic solution to energy independence and cost reduction. A great deal of additional information is available on designing solar heating and geothermal heating and cooling systems. These areas are clearly not the purview of this book, but designers are encouraged to seek additional information about these systems.

While interior designers are not responsible for the design of such heating, ventilation, and air-conditioning systems, they should understand the various types of systems and their impact on the design of interior spaces. For example, knowing that hot-water heat may require the use of baseboard convector units and that the location of such units will have a direct impact on the design and layout of interior spaces is useful.

Forced-air systems require the use of return-air grills and supply-air registers/diffusers. These are available in a range of styles and in types such as baseboard, wall, and floor units. Location of these items has an impact on the layout of a room and the level of comfort found there; for example, a favorite seating location that receives a constant blast of air will not remain a favorite for long. In addition, the visual qualities of grills, diffusers, and registers should be in keeping with the overall design intent of the project—a Victorian-style grill placed within a mid-century modern interior may look ridiculous. Placement of grills, diffusers, and registers in relationship to trim and architectural details is also worth careful consideration.

Lighting

Information about lighting specific rooms and spaces is provided in this book as a means of acquainting students with basic concepts related to planning and design. In no way is the information provided intended to be a significant source of a student's lighting design education. Instead, information offered is introductory in nature and related to the overall design of rooms and spaces. So that the student can understand and work with the information provided in each chapter, an overview of terminology and basic lighting concepts is provided here. The bibliography at the end of this chapter includes lighting design publications helpful for more in-depth study.

Types of lighting discussed for various rooms include ambient, accent, task, and decorative lighting. *Ambient light* is general illumination that provides a uniform light level throughout the area or room. According to Randall Whitehead (2004), in residences "the best ambient light comes from sources that bounce illumination off the ceiling and walls." This type of lighting is referred to as *indirect lighting*, which means that light arrives at a given surface after being reflected from one or more surfaces, which tends to cause less glare than *downlights* (defined as those sources that direct light downward). Whitehead adds that dark ceilings make this type of lighting ineffective. There are also a number of direct-light sources that provide ambient lighting. Figure 1-10 illustrates ambient light sources.

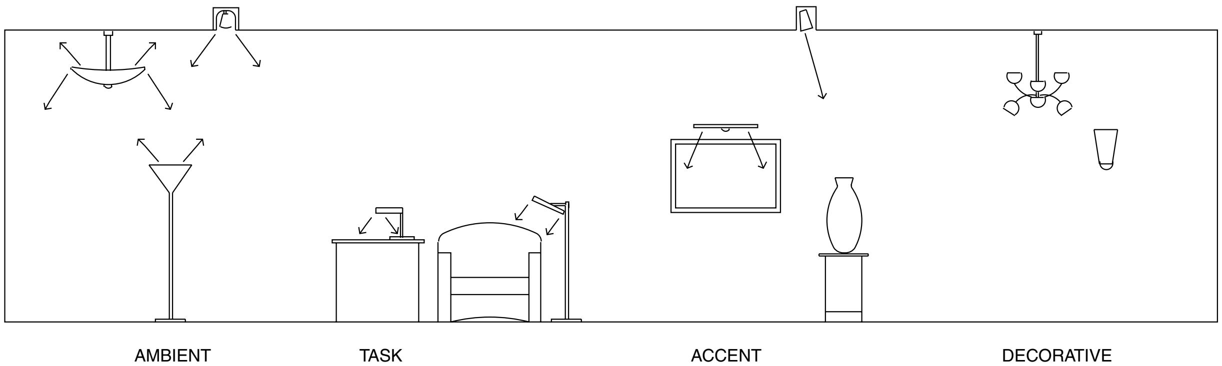

Figure 1-10 Ambient light is general illumination that provides a uniform light level. Task lighting aids in performing work such as reading or preparing food. Accent lighting functions to illuminate objects or special features, and decorative lighting tends to draw attention to itself in the form of a decorative element such as a chandelier or wall sconce (decorative elements can add to a room's ambient lighting).

Also referred to as *focal lighting*, *accent lighting* illuminates features, objects, and/or specific areas. This type accents items or creates focal points and can add a level of interest to the general or ambient lighting. Well-planned accent lighting puts the focus on the desired objects rather than the light source or fixture. Generally, using only accent lighting in a room without giving thought to ambient lighting creates clusters of darkness within rooms. Figure 1-10 illustrates some accent light sources.

As its name implies, *task lighting* has a job to do; it aids in performing work and specific tasks. In a residence, many of these tasks are performed at table or counter height, requiring that the work surface is illuminated. Considering the type of task performed and the body positions required to complete them helps the designer make task-lighting choices; for example, at kitchen counters and work tables, light coming directly from the ceiling is blocked by the human body (or head), creating shadows at the work surface rather than illumination. Figure 1-10 illustrates some task light sources.

Decorative lighting is ornamental in nature and provides interest based on its design and material qualities. Unlike accent lighting, decorative lighting functions to show itself off and make a visual statement. Decorative lighting can be used to accent elements and spaces or to add interest to ambient lighting, yet its function is typically secondary to the visual impact of the light source itself. Figure 1-10 illustrates some decorative light sources.

Basic lighting design requires an understanding of *glare*, which is defined as "loss of visibility and/or the sensation of discomfort associated with bright light within the field of view" by the Lighting Research Center (at Rensselaer Polytechnic University). There are two types of glare: *direct glare*, which results from bright light in the field of view, and *reflected glare*, which results from reflections in the field of view (including surfaces and reading material). Locating light sources out of the line of vision or shielding them in some manner can prevent direct glare. Reflected glare can be minimized by using less reflective surfaces and placing the light source so that it is not directly above but rather at an angle to the surface and/or viewer.

The term *luminaire* is used to describe the complete lighting unit consisting of (1) a lamp or lamps (the general public calls these lightbulbs) and (2) the parts (housing) necessary to distribute the light, position and protect the lamps, and connect the unit to the power supply. *Light fixtures* are luminaires that are permanently affixed to the architecture of the building. Portable luminaries are, as the name implies, easily moved; these include what the general public calls table lamps, desk lamps, floor lamps, and so on. A range of luminaires and fixtures may be used to create ambient, accent, task, and decorative light; some of these are shown in Figure 1-11. Recessed luminaires are illustrated in Figure 1-12.

Daylight is a term that correctly refers to what most people call natural light; it is light produced by solar radiation and includes direct sunlight as well as reflected light. The term *daylighting* refers to the process of designing buildings to utilize daylight. True daylighting requires careful consideration of the totality of the architecture of the building, so that the orientation of the building to the site, the location and size of building openings, and adequate shading devices are incorporated into the building design. Daylighting is a useful component of sustainable design because it does not require electricity and can save energy on building cooling as well, when done properly Currently daylighting is a strategy employed more commonly for public buildings than for private homes.

Regardless of how well daylighting is incorporated into a building design, electric light (referred to by the general public as artificial light) is required when it becomes dark outside. The appearance of electric light is rated by the *color rendering index* (CRI), which according to a glossary produced by the Lighting Research Center (at Rensselaer Polytechnic University) is

> "A technique for describing the effect of a light source on the color appearance of objects" being illuminated, with a CRI of 100 representing the reference condition (and thus the maximum CRI possible). In general, a lower CRI indicates that some colors may appear unnatural when illuminated by the lamp."

For residences, a CRI of 80 to 89 provides color rendering where color quality is important in residential applications, such as spaces where the visual quality of colors, materials, finishes, artwork, and accessories are an important part of the experience of the room. In some cases, such as residential, utility, and storage spaces, a CRI lower than 80 is acceptable.

Another measure of color appearance called *color temperature* or *correlated color temperature* (CCT) "describes the color appearance of the actual light produced in terms of its warmth or coolness," according to the Lighting Research Center. Color temperature is measured using the Kelvin (K) temperature scale, with lower temperatures (3000 K and lower) used to describe a warm source and high temperatures (4000 K and above) to describe a cool source. Typical incandescent lamps and warm fluorescent lamps are lower than 4000 K.

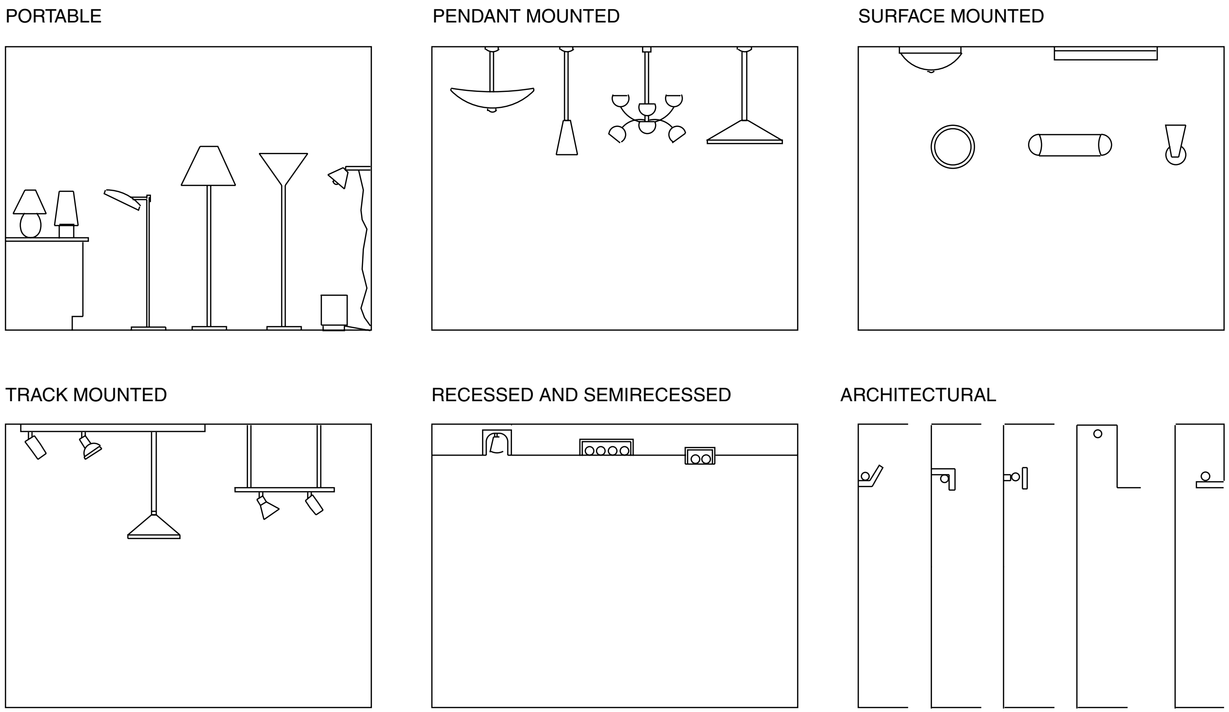

Figure 1-11 Luminaire is a term used to describe a complete lighting unit. Luminaires may be portable, pendant-mounted (also known as suspended), surface-mounted on walls or ceilings (decorative luminaries mounted on walls are often called sconces), or track-mounted (the track can be mounted on the ceiling or suspended and can include track heads or pendants). Other options include recessed and semi-recessed fixtures, as well as other architectural lighting options (this term applies to lighting permanently affixed to the architecture of the building) such as cove and valance lighting. More information on recessed luminaries can be found in Figure 1-12.

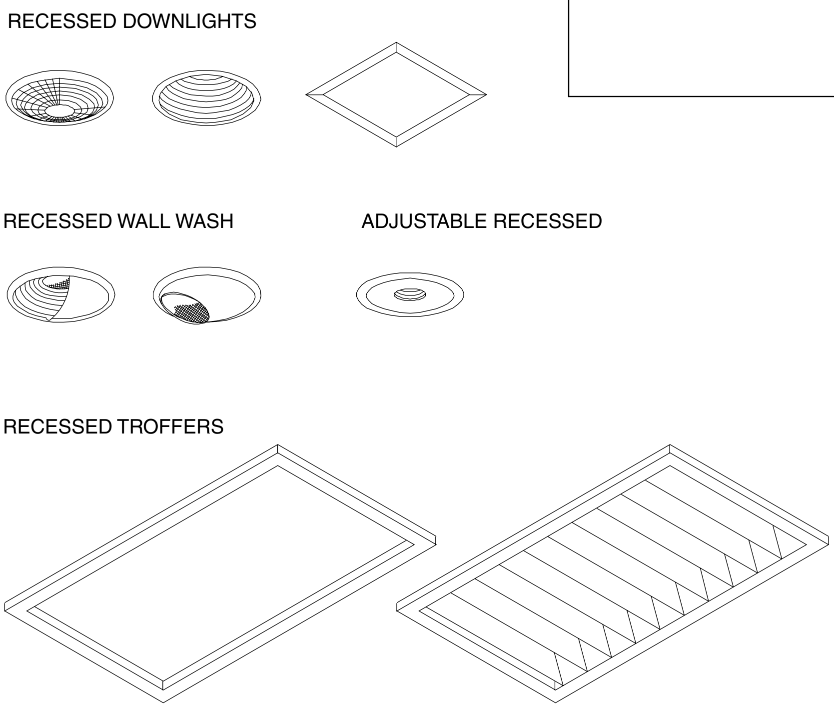

Figure 1-12 Recessed luminaires include recessed downlights, and recessed adjustable downlights can be used for ambient lighting. Another type, recessed wall washers, direct light down at an angle and are used for accent lighting. Recessed troffers are square or rectangular luminaries that house fluorescent lamps. They are available with diffusers or with louvers. Those with diffusers are used to provide ambient light, whereas louvers can direct light for tasks such as computer work. Surface-mounted versions with diffusers are used more commonly in residential settings.

Designers must understand the roles of lamps in lighting design (remember, these are called lightbulbs by the general public). Lamps are divided into three broad categories: incandescent, fluorescent, and high-intensity discharge. Within each category there is variety in how the lamps look and perform and the quality of light produced. Incandescent lamps create light as electricity flows through a filament, heating it and making it glow. Incandescent lamps are popular due to the color quality of light they create (remember the CRI and CCT). However, they use a great deal of energy to produce limited light. Only 10 to 15 percent of the energy that goes into the filament is emitted as light; the remainder is generated as heat.

Incandescent lamps come in a range of shapes and sizes, with a letter designating shape and a number indicating the maximum diameter of the lamp (in eighths of an inch). For example, for a common A19 household lamp, the *A* refers to a standard bulb shape (A for "arbitrary") and the *19* stands for 19 eighths of an inch (or 2 3/8 inches). Figure 1-13 illustrates the shapes of other incandescent lamps. Other terms referred to in code have to do with the glass used in the lamp, such as clear or frosted types. The frost effect is referred to as *inside frost* based on the location of the glass treatment.

There are also *reduced-wattage* incandescent lamps, which are shaped similarly to other incandescent types but use a different gas inside the lamp that

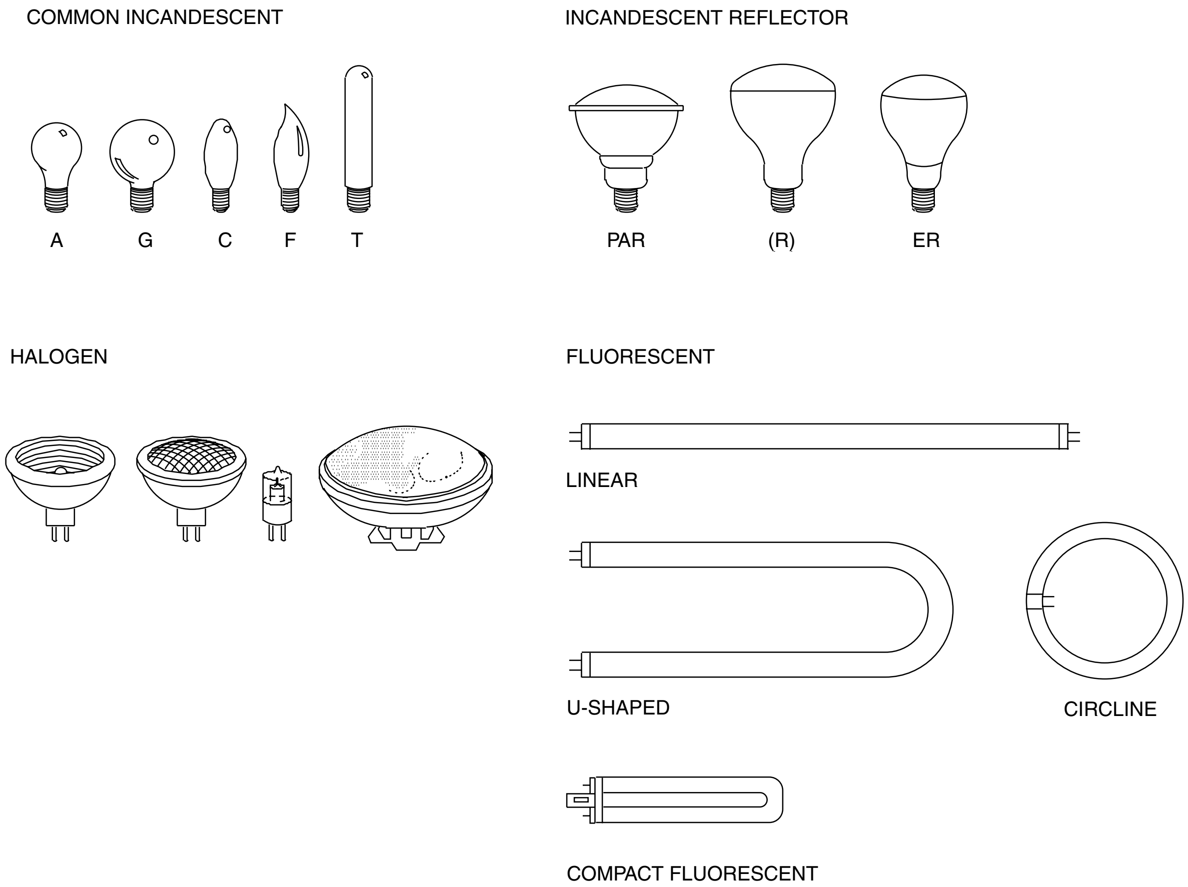

Figure 1-13 Lamps are divided into three broad categories: incandescent, fluorescent, and high-intensity discharge (not shown). Incandescent and fluorescent are used most commonly in residences. Incandescent lamps come in a range of shapes and sizes, with a letter designation referring to shape and a number indicating the maximum diameter of the lamp (in eighths of an inch). Halogen lamps are another type of incandescent lamp. PAR, R, and ER lamps are incandescent reflector lamps that create directional beams. A range of fluorescent lamp shapes and types are available, including straight tubular (or linear), u-shaped, twin-tube, and circular (properly called circline) lamps. In addition, there are compact fluorescent lamps.

allows different wattages or, in some cases, a longer lamp life. *Halogen* lamps (also called *tungsten-halogen*) are another type of incandescent lamp in which the filament is inside a halogen-filled capsule. The use of halogen gas allows lamps of a similar wattage to produce more light. These can become quite hot, requiring special care or lamp protection. Dimming these lamps changes the color dramatically and can shorten lamp life.

Specialized *incandescent reflector* lamps have reflective coatings that create a directional light source and are available in a range of beam spreads from spot to flood. PAR lamps (for parabolic aluminized reflector), R lamps (for common reflector), and ER lamps (for ellipsoidal reflector) types are all incandescent reflector types.

Incandescent lamps are also available in *low-voltage* versions, which require transformers to change primary power (120 volts) to the required low voltage (often 12 volts). This type includes MR16 (the *MR* is for mirrored reflector; the *16* is for 16 eighths of an inch, or 2 inches) and PAR 36 lamps, which are often used for accent or display lighting. Figure 1-13 shows some halogen lamps.

Fluorescent lamps are coated glass tubes filled with gas; light is produced when the gas reacts to electrical energy, producing ultraviolet light, which in turn is absorbed by the coating and produces visible light. Fluorescent lamps require ballasts within the luminaire or lamp. These provide the starting voltage and control the current when in use. Compared to standard incandescent lamps, fluorescent lamps produce minimal heat and are more energy-efficient. Lamp color, such as "cool white" or "warm white," is created by the chemicals (called *phosphors*) used to coat the lamps and is controlled by the manufacturer.

A range of fluorescent lamp shapes and types are available, including *straight tubular* (or linear), *u-shaped*, *twin-tube*, and *circular* (properly called *circline*) lamps. In addition, there are *compact fluorescent* lamps, which, as the name implies, are smaller in size (allowing them to fit in smaller locations). Compact fluorescent lamps also require the use of a ballast, which may be integral to the lamp or may be part of a separate module that can be replaced separately. Figure 1-13 includes illustrations of some fluorescent lamps.

Another type of lamp, known as *high-intensity discharge* (HID), operates using a current and gas or vapor under high pressure to produce light. These also require a ballast. While highly energy-efficient, these are not widely used in residential interiors except for applications where lights are left on for extended periods of time, such as for security or in multifamily stairway applications.

Additional issues that relate to residential lighting involve lamp bases, which come in a range of sizes and types and are referred to by name. For example, a standard A lamp with a screw-in base is referred to as a *standard* base, whereas a smaller flame-tip shaped lamp (for use in a chandelier) may have a *medium* or *candelabra* base. Also, compact fluorescent lamps are available with an integral ballast and a standard screw-in base for use in a standard socket.

Controls for lighting include switches, dimmers, timers, sensors, central controls, and motion detectors. This large family of controls can be divided into two categories: manual and automatic controls.

Switches and dimmers are commonly used manual controls, with switches used to turn lamps on and off and dimmers used to control the light output of some lamps. Timers are automatic controls that are intended to control lamps based on a designated time period. Controls vary a great deal in complexity and cost, with the more advanced and costly options used in many cases as part of a complete home security system.

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