Chapter 1 Introduction

Engineering designs start as images in the mind's eye of an engineer. Engineering graphics has evolved to communicate and record these ideas on paper both two- and three-dimensionally. In the past few decades, the computer has made it possible to automate the creation of engineering graphics. Today engineering design and engineering graphics are inextricably connected. Engineering design is communicated visually using engineering graphics.

1.1 The Importance of Engineering Drawings

"Visualizing" a picture or image in your mind is a familiar experience. The image can be visualized at many different levels of abstraction. Think about light and you might see the image of a light bulb in your "mind's eye". Alternatively, you might think about light versus dark. Or you might visualize a flashlight or table lamp. Such visual thinking is necessary in engineering and science. Albert Einstein said that he rarely thought in words. Instead, he laboriously translated his visual images into verbal and mathematical terms.

Visual thinking is the foundation of engineering. Walter P. Chrysler, founder of the automobile company, recounted his experience as an machinist apprentice where he built a model locomotive that existed "within my mind so real, so complete, that it seemed to have three dimensions there." Yet, the complexity of today's technology rarely permits a single person to build a device from his own visual image. The images must be conveyed to other engineers and designers. In addition, those images must be constructed in such a way that they are in a readily recognizable, consistent, and readable format. This assures that the visual ideas are clearly and unambiguously conveyed to others. Engineering graphics is a highly stylized way of presenting images of parts or assemblies.

A major portion of engineering information is recorded and transmitted using engineering graphics. In fact, 92 percent of the design process is graphically based. Written and verbal communications along with mathematics account for the remaining eight percent. To demonstrate the effectiveness of engineering graphics compared to a written description, we can try to visualize an object based on this word description:

An object is generally in the shape of a 140 mm × 80 mm × 10 mm rectangular prism. One end is beveled from zero thickness to the maximum thickness in a length of 40 mm to form a sharp edge. The opposite end is semicircular. A 20 mm-diameter hole is positioned so the center of the hole is 40 mm from the semicircular end and 40 mm from either side of the scraper.

It is evident immediately that the shape of the object is much more easily visualized from the graphical representation shown in Fig. 1.1 than from the word description. Humans grasp information much more quickly when that information is presented in a graphical or visual form rather than as a word description.

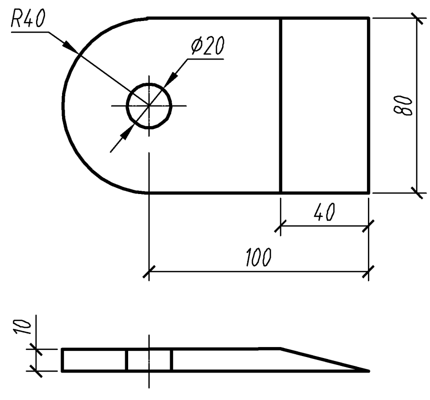

Fig. 1.1 The shape of the object

Engineering drawings, whether done using a pencil and paper or a computer, start with a blank page or as creen. The image of an engineer's mind's eye must be transferred to the paper or a computer screen. The creative nature of this activity is similar to that of an artist. Perhaps the greatest example of this is Leonardo da Vinci, who had exceptional engineering creativity devising items such as parachutes and ball bearings, shown in Fig. 1.2, hundreds of years before which were re-invented. He also had exceptional artistic talent, creating some of the most famous pictures ever painted such as *Mona Lisa* and *The last supper*.

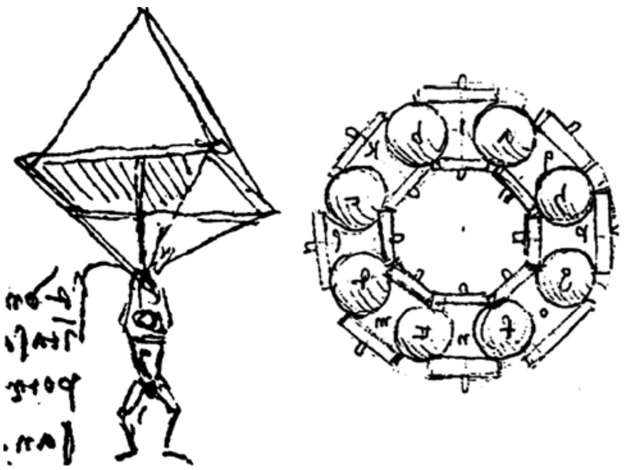

Fig. 1.2 Sketches by Leonardo da Vinci

1.2 Engineering Graphics

The first authentic record of engineering graphics dates back to 2130 B. C., based on a statue now in the Museum of the Louvre, Paris. The statue depicts an engineer and governor of a small city-state in an area later known as Babylon. At the base of the statue are measuring scales and scribing instruments along with a plan of a fortress engraved on a stone tablet.

Except for the use of pen and paper rather than stone tablets, it was not until printed books appeared around 1450 that techniques of graphics advanced. Around the same time, pictorial perspective drawing was invented by artist Paolo Uccello. This type of drawing presents an object much like it would look into the human's eyes or a photograph, as shown in Fig. 1.3. The essential characteristic of a perspective drawing is that parallel lines converge at a point in the distance like parallel railroad tracks seem to converge in the distance. Copper-plate engravings permitted the production of finely detailed technical drawing using pictorial perspective in large numbers. The pictorial perspective drawings were crucial to the advancement of technology through the Renaissance and the beginning of the Industrial Revolution. But these drawings could not convey adequate details of the construction of an object. One solution to this problem was the use of the exploded view developed in the 15^{th} century and perfected by Leonardo da Vinci. The exploded view of an assembly of individual parts shows the parts spread out along a common axis. The exploded view reveals details of the individual parts along with showing the order in which they are assembled.

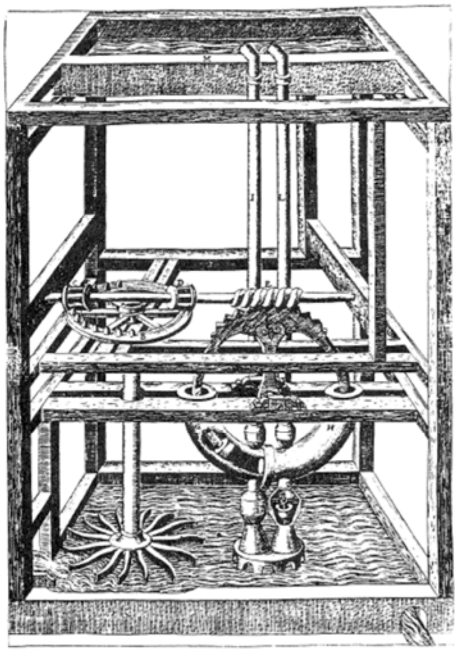

Fig. 1.3 An example of pictorial perspective by Agostino Ramelli in 1588.

The Industrial Revolution brought with it the need to tie more closely the concept of a design with the final manufactured product using technical drawing. The perspective drawing of a simple object in Fig. 1.4(a) shows pictorially what the object looks like. However, it is difficult to represent accurately dimensions and other details in a perspective drawing. Orthographic projections, developed in 1528 by German artist Albrecht Durer, who accomplish this quite well. An orthographic projection typically shows three views of an object. Each view shows a different side of the object (say the front, top, and side). An example of an orthographic projection is shown in Fig. 1.4(b). Orthographic projections are typically easy to draw, and the lengths and angles in orthographic projections have little distortion. As a result, orthographic drawings can convey more information than a perspective drawing. But their interpretation takes more effort than a pictorial perspective, as is evident from Fig. 1.4. French philosopher and mathematician Rene Descartes laid the foundation for the mathematical principles of projection by connecting geometry to algebra in the 17th century. Much later Gaspard Monge, a French mathematician, "invented" the mathematical principles of projection known as descriptive geometry. These principles form the basis of engineering graphics today. However, because these principles were thought to be of such strategic importance, they remained military secrets until 1795. By the 19th century, William Farish, and the English mathematician, formalized the isometric view and introduced it to engineers. The isometric view simplifies the pictorial perspective. In an isometric view, parallel lines remain parallel rather than converging to a point in the distance, as shown in Fig. 1.4c. Keeping parallel lines parallel distorts the appearance of the object slightly. But the distortion in an isometric view is negligible for objects of limited depth. For situations in which the depth of the object is large, such as an architectural view down a long hallway, the pictorial perspective is preferable. The advantage of the isometric view, though, is that it is much easier to draw than a pictorial perspective view.

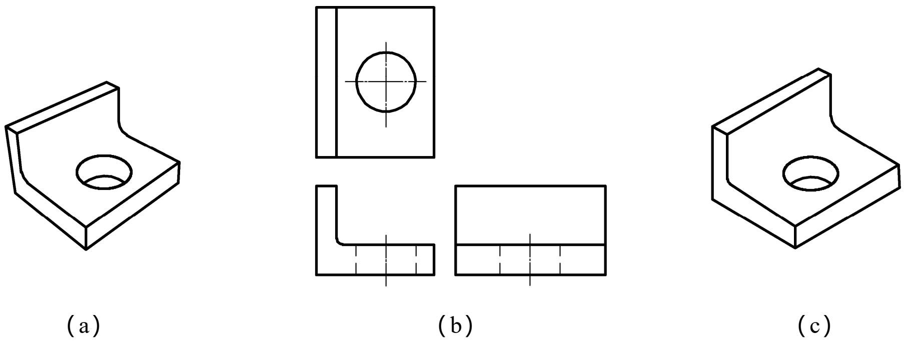

Fig. 1.4 Technical drawings

1.3 CAD

The introduction of the computer revolutionized engineering graphics. Pioneers in computer-aided engineering graphics envisioned the computer as a tool to replace paper and pencil drafting with a system that is more automated, efficient, and accurate. The first demonstration of a computer-based drafting tool was a system called SKETCHPAD developed at the Massachusetts Institute of Technology in 1963 by Ivan Sutherland. The system used a monochrome monitor with a light pen for input from the user. The following year IBM commercialized computer-aided drafting.

During the 1970s, computer-aided drafting blossomed as the technology changed from scientific endeavor to an economically indispensable industrial tool for design. Commands for geometry generators to create commonly occurring shapes were added. Functions were added to control the viewing of the drawing geometry. Modifiers such as rotate, delete, and mirror were implemented. Commands could be accessed by typing on the keyboard or by using a mouse. Perhaps most importantly, three-dimensional modeling techniques became a key part of engineering graphics software.

By the 1980s, computer-aided drafting became fully developed in the market place as a standard tool in industry. In addition, the current technology of solids modeling came about. Solids models represent objects in the virtual environment of the computer just as they exist in reality, having a volume as well as surfaces and edges. The introduction of Pro/ENGINEER@ in 1988 and Solid Works@ in the 1990s revolutionized computer-aided design and drafting. Today solids modeling remains the state-of-the-art technology.

What we have been referring to as computer-aided drafting is usually termed CAD, an acronym for Computer Aided Design, Computer Aided Drafting, or Computer Aided Design and Drafting. Originally the term Computer Aided Design included any technique that uses computers in the design process such as drafting, stress analysis, and motion analysis. But over the last 35 years CAD has come to refer more specifically to Computer Aided Design and Drafting. Computer Aided Engineering(CAE) is used to refer to the broader range of computer-related design tools.