ENGINEERING IS CONCERNED WITH IDENTIFYING and solving problems. A problem exists whenever one has a goal but the action necessary to attain that goal is not immediately obvious. If the goal is to attain some existing object then the solution process is one of obtaining a candidate object and verifying if it matches the goal description. If the goal is something that does not exist (like the design of an unusual structure) then the focus of the solution process switches to producing potential solutions which can be checked against the goal description.

There are three basic approaches to producing solutions to engineering problems, and they are:

1. The Analogue Approach,
2. The Symbolic Approach, and
3. The Iconic Approach

In each of these approaches, solutions to design problems are *'represented'* by solutions in the particular modelling system. Hence, each potential state of the model system corresponds in some definable and logically consistent sense to a particular potential problem solution. Looking at each of the approaches briefly:

The Analogue Approach

This represents potential design solutions using one set of properties in the model system to represent another 'analogous' set of properties in the objective system i.e., in the facility or object being designed. Hence, N.N.Pavlovsky pioneered the use of an electrical analogue to study the flow of groundwater through a permeable medium. In this analogue, Ohm's Law concerning electrical flows, potential and resistance was an analogy for D'Arcy's Law and groundwater flows, potential energy and resistance to flow (permeability) of the soil. Such analogue systems can be mechanical, electrical or any other appropriate type.

The Symbolic Approach

This approach represents potential solutions by means such as words, numbers or mathematical operators. This is the approach that underlies most analytical solutions to engineering problems which are mathematically based. As an example, finite element methods may be used to model groundwater seepage, and to produce solutions to particular design configuration problems.

The Iconic Approach

This is the familiar means of representing design concepts by models that 'look like' them. The graphic approach can be used to solve problems by use of vectors or geometric characteristics. For example, once again groundwater problems can be solved using flow-nets, which provide an iconic representation of the flow domain and enable the quantities of seepage and the potential drops at various points to be estimated.

In addition, of course, the iconic approach is used to produce the architectural and engineering drawings that model structural forms, and that are used to guide construction. Traditionally iconic representations of design solutions have been produced manually. In recent times, however, advances in computer hardware and software have allowed widespread access to the use of computer-aids to the draughting process, and it is this latter form of the iconic approach that is most commonly referred to when the expression Computer Aided Design is used.

Computer Aided Draughting

Although it is quite properly referred to as design in some circumstances, what most people do and mean by CAD, is Computer Aided Draughting, because all they do is transcribe the results of the design that has been undertaken elsewhere. It is no less important because of this. The computer package that is generally considered the 'industry standard' for iconic representations is AutoCAD.

In a CAD system like AutoCAD the physical elements are simulated by modelling their shape algebra. For example, a straight line is specified by identifying the co-ordinates of its end points, and a circle by its centre point and a radius or diameter length. Any shape can be created, and actions like arraying, scaling, mirroring, copying, and changing perspective can be performed by multiplying co-ordinate vectors by transformation matrices.

CAD drawings behave according to the geometric structure built up in the computer's memory as the drawing process takes place. This structure also includes the inherent constraints that govern the relationships between the different elements. In other words, when an element is moved in a CAD system, the neighbouring elements will automatically be adjusted to retain specified alignments and attachments. This structuring is a major advantage of a CAD drawing over a conventional manual drawing.

Another disadvantage of the traditional pen-and-paper approach to drawing is that it requires multiple representations (graphical, mathematical and textual) to build a design solution. Co-ordinating these representations so that they describe the same physical reality is difficult and time consuming, and is a source of many design errors. A CAD system can automate the process of multiple representations with ease and precision. This is perhaps most dramatically felt when design modifications are made, because it takes a great deal of time when it is done by hand, and ensuring that the changes are included and co-ordinated on all the different perspectives is problematic.

In this regard, it is in the areas of 3D modelling and rendering that the real power and advantages of CAD systems are fully displayed. CAD systems have the ability to produce a 3-dimensional model from which drawings with perspective can be presented, and that can have surface colours and textures rendered. This facility is virtually non-existent in the traditional pen-and-paper approach to drawing.

AutoCAD and its Competitors

AutoCAD was the first genuine CAD package that was developed for the personal computer. It was launched in 1983, and now has an 'official' installed base of some 650,000 units on all platforms, of which over 500,000 run on Intel-based PCs. The latest major update of the programme occurred in 1992, when Release 12 came out. This version of the programme introduced a number of new and more efficient drawing tools, a new hidden-line-removal algorithm, a new entity database search algorithmand a new method of handling display data. All of this has helped make AutoCAD faster and more responsive. In 1994, Release 13, a less significant update, came out once again with a number of enhancements, and with greater Windows compatibility. Although AutoCAD is considered the industry standard in many countries, other 3D CAD packages like Fast CAD 3D and MicroStation 4 are extremely competent and popular too. Much depends on the user's preferences as to which package suits them best.

Each of these heavily used applications is constantly being upgraded, and users must be prepared to keep up-to-date if they wish to take advantage of the improvements that are being made. This can be an expensive process, both in terms of finance invested in the computer hardware and software, and in terms of personnel time invested in training and upgrading skills. However, although expensive, it enables significant advances in productivity that should more than compensate for the investment. What may be of more significance in the future, is the tendency for clients to require software copies of their documents and drawings on computer diskettes. This will effectively force engineers who are undecided, or who have been lagging behind, that they now have to enter the computer age. □

Dr. T.M. Lewis
Department of Civil Engineering
The University of the West Indies