ENG1000 Civil and Environmental Engineering Strands

Engineering Drawing - Part I

For hundreds of years drawings have been used by engineers to describe proposed works. Drawings are used to show precisely what is to be constructed, often with sufficient detail to determine how it might constructed as well. The production of drawings closely follows the design process, often going through several iterations. Though drawings are carefully created they may also modified during construction due to inability to construct or undue cost.

In former days, drawings were prepared by hand, often by drafts people working under the instruction of engineers. The end product of their work was duplicated by a photographic process which commonly produced a drawing with white lines on a blue background, the blueprint. Blueprints were used in workshops and in the field, as the source of information about the design.

Different types of drawing are used in various fields of engineering and related disciplines. They include

- survey plans and maps
- plans for road works and earthworks
- drawings of mechanical components and machines
- architectural drawings
- circuit diagrams
- structural drawings

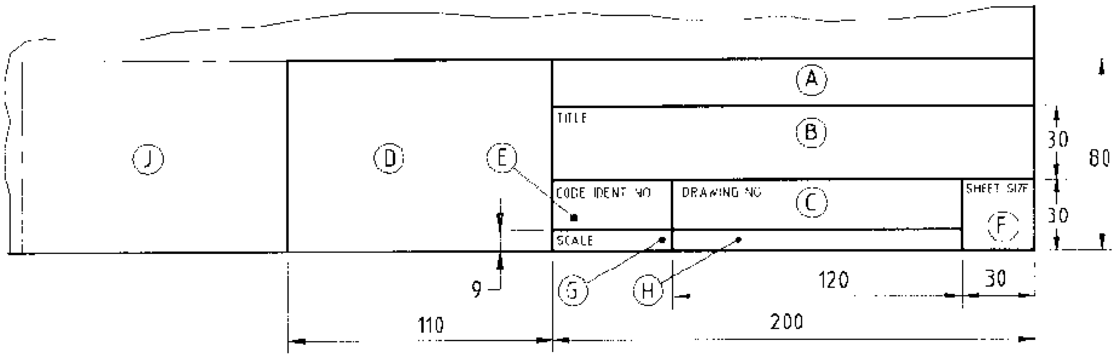
In these notes the more general aspects of engineering drawing will be considered. A general description of engineering drawing standards can be found in **Technical Drawing for Students, SAA HB1-1994**. A complete description of the standard is given in **AS 1100-1994**, published by the Standards Association of Australia.

Drawing Setup

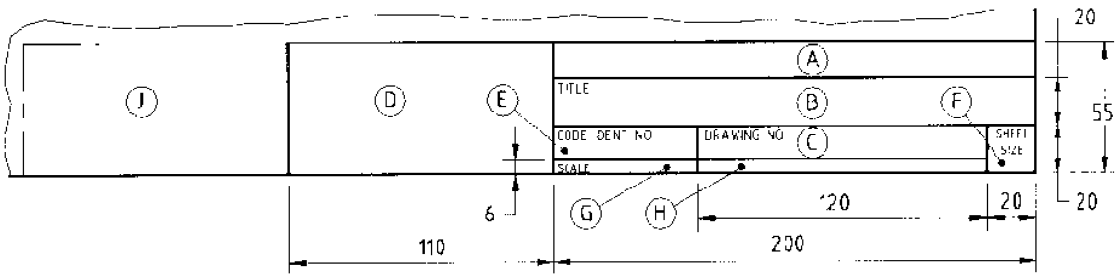
The preferred sizes of drawing sheets in Australia are the ISO A series. These range in size from A4 (297 x 210 mm) to A0 (1189 x 849 mm). Each successive sheet size is exactly twice the area of the previous sheet size. These are also special ‘B’ series which correspond to intermediate sheet sizes.

> In many CAD software, the drawing size is chosen during the initial drawing setup. Note that the drawing size only applies to Paper Space. Model space does not work with such boundaries.
> You can change the paper size at any time by selecting **File -> Page Setup**.

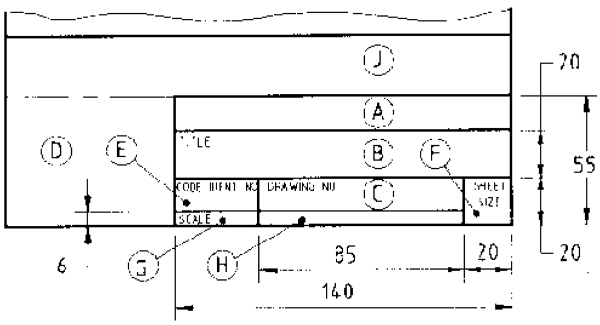
Drawings created by CAD software are still reproduced onto drawing sheets. To preserve the scale it is therefore important that the same sheet size is used as intended for reproduction.



(a) A0 size sheets



(b) A1, A2, and A3 size sheets



(c) A4 size sheets

LEGEND

A Name and address of the design authority, whose code identification number and drawing number appear in the appropriate blocks

B Drawing title

C Drawing number

D Record of information relative to preparation of the drawing, including such information as names of drafter and checker, approving functions, contractor's name, and reference number

E Code identification number where required for identification of the design authority whose drawing number is used in block C

F Drawing sheet size designation

G Predominant scale of the drawing

H Reserved for miscellaneous information such as the estimated mass of the item, sheet number for multisheet drawings or modification number

J Additional blocks as required for general information such as dimensioning and tolerancing notes, material, finish or other requirements

Figure 1: Example title blocks

Sheet Border

Every standard drawing must include a border and title block. This is so that reproduction can be checked in terms of coverage over the sheet. The border width varies from 10 mm for A4 to 20 mm for A0. See Figure 2 for recommended sizes for each sheet.

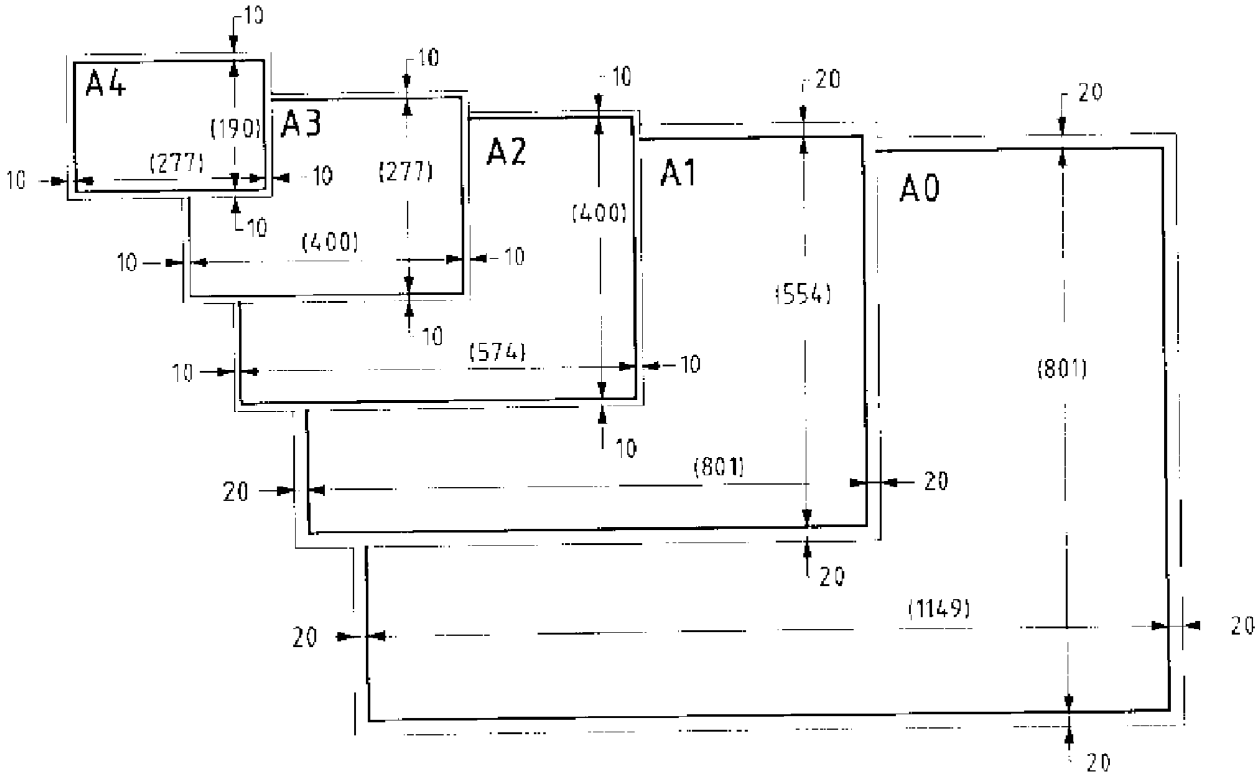


Figure 2: Border for standard drawing sizes

All drawings must also include a title block. This displays important information identifying the drawing which must contain as a minimum: draftsperson, date, scale, title and drawing size. Other information includes drawing number (if part of a series), type of projection, tolerances and revisions. Examples of title blocks are given in Figure 1.

CAD programs provides templates that include the border and title block. Instead of using the Setup Wizard choose a template, such as the A4 template instead. Note that the border and title block are drawn in paper, not model space. This is because they do not form part of the actual object being drawn.

Section, Hidden, Centre Lines and Others

Different line styles are used to represent different aspects of the drawing. Many lines styles are used to enhance drawing information including section lines, centre lines, extension lines and dimension lines.

Types of Lines

The standard line types are shown in Figure 3 while standard line thickness groups are shown in Figure 4. Line thickness groups vary with the sheet size. The main stipulation by the standard is that line thickness is chosen such that all reproductions have a minimum line thickness of 0.18 mm. For CAD purposes this is generally not an issue as scaling does not change line thicknesses. The most common line thicknesses are the 0.5 mm line thickness group.

1	2	3	4
Desig-nating letter	**Type of line**	**Example of line**	**Typical application**
A	Continuous—thick		Visible outlines General details Existing buildings Landscaping in site plans Busbars and transmission paths
M	Continuous—medium		See Note 1
B	Continuous—thin		Fictitious outlines Imaginary intersection of surfaces Dimension lines, projection lines, intersection lines and leaders Hatching and outlines of revolved sections Fold and tangent bend lines Short centre-lines General purpose electrical conductors and symbols
C	Continuous—thin, free-hand		Break lines (other than on an axis)
D	Continuous—thin, ruled with zig-zag		Break lines (other than on an axis)
E	Dashed—thick (see Note 2)		Hidden outlines Hidden edges
N	Dashed—medium (see Note 2)	s q	See Note 1
F	Dashed—thin (see Note 2)	s q s = 1 mm MINIMUM q = 2s to 4s	Hidden outlines Jumper connections magnetic or electric screen
G	Chain—thin	s p q s = 1 mm MINIMUM q = 2s to 4s p = 3q to 10q	Centre-lines and axes of solid Pitch lines Path lines for indicating movement Features in front of a cutting plane Indication of repeated detail Developed views . . . Material to be removed
H	Chain—thick at ends and at change of direction —thin elsewhere	See Note 3	Cutting planes
J	Chain—thick	See Note 3	Indications of surfaces to comply with special requirements Pipelines, drains, services
K	Chain—thin, double dashed	See Note 3	Outlines of adjacent parts Alternative and extreme position of movable parts Centroidal lines Tooling

Figure 3: Line types

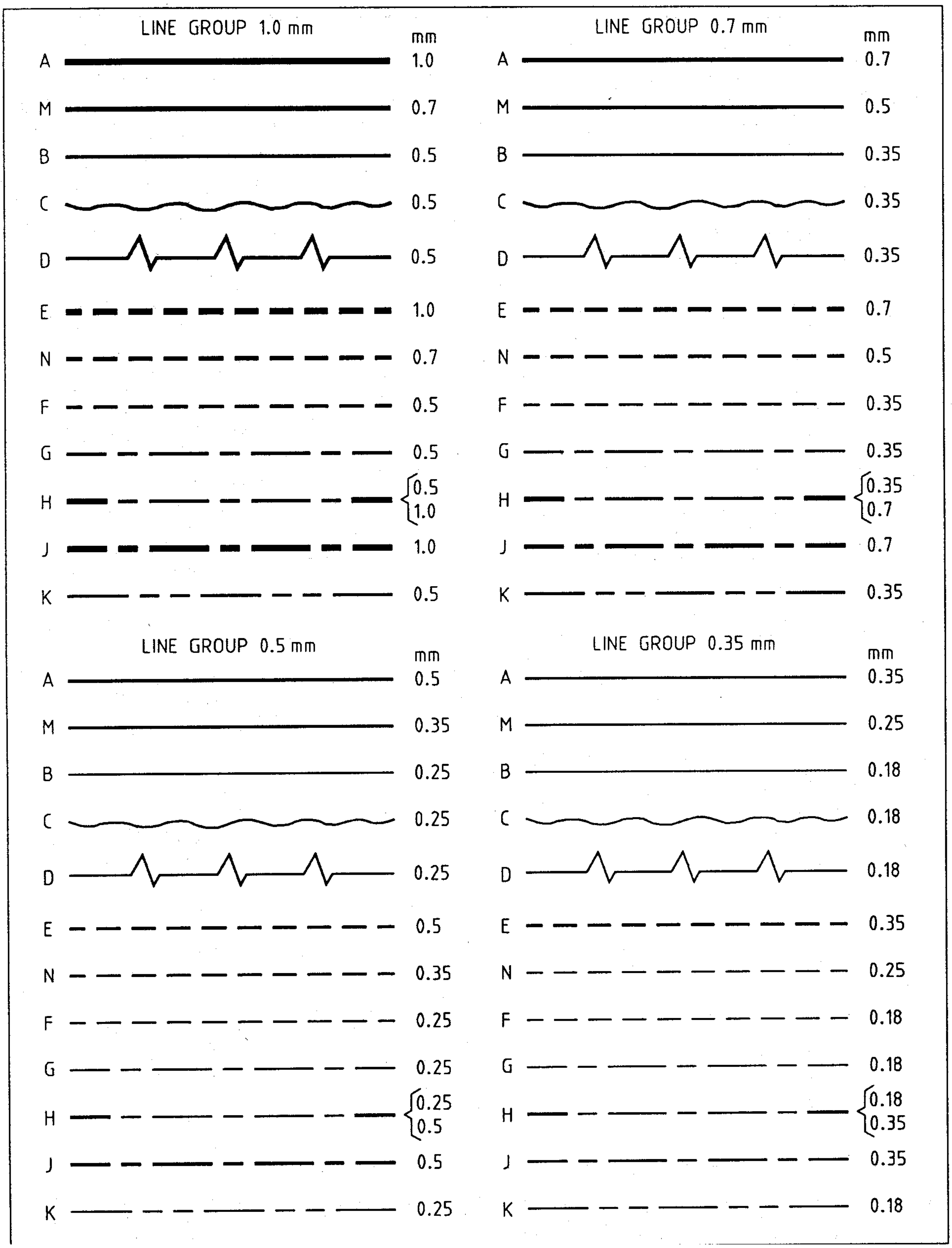


Figure 4: Standard line thicknesses

An example of architectural drawing is shown in Figure 5. Note that solid surfaces (tiles, bricks, ground, concrete etc) use the thickest ‘A’ lines while additional information is represented by thinner ‘B’, ‘D’ & ‘E’ lines. For example:

- Dressed (smooth finish) timber are represented by simulated wood grain (eaves facing panel) – ‘B’ lines

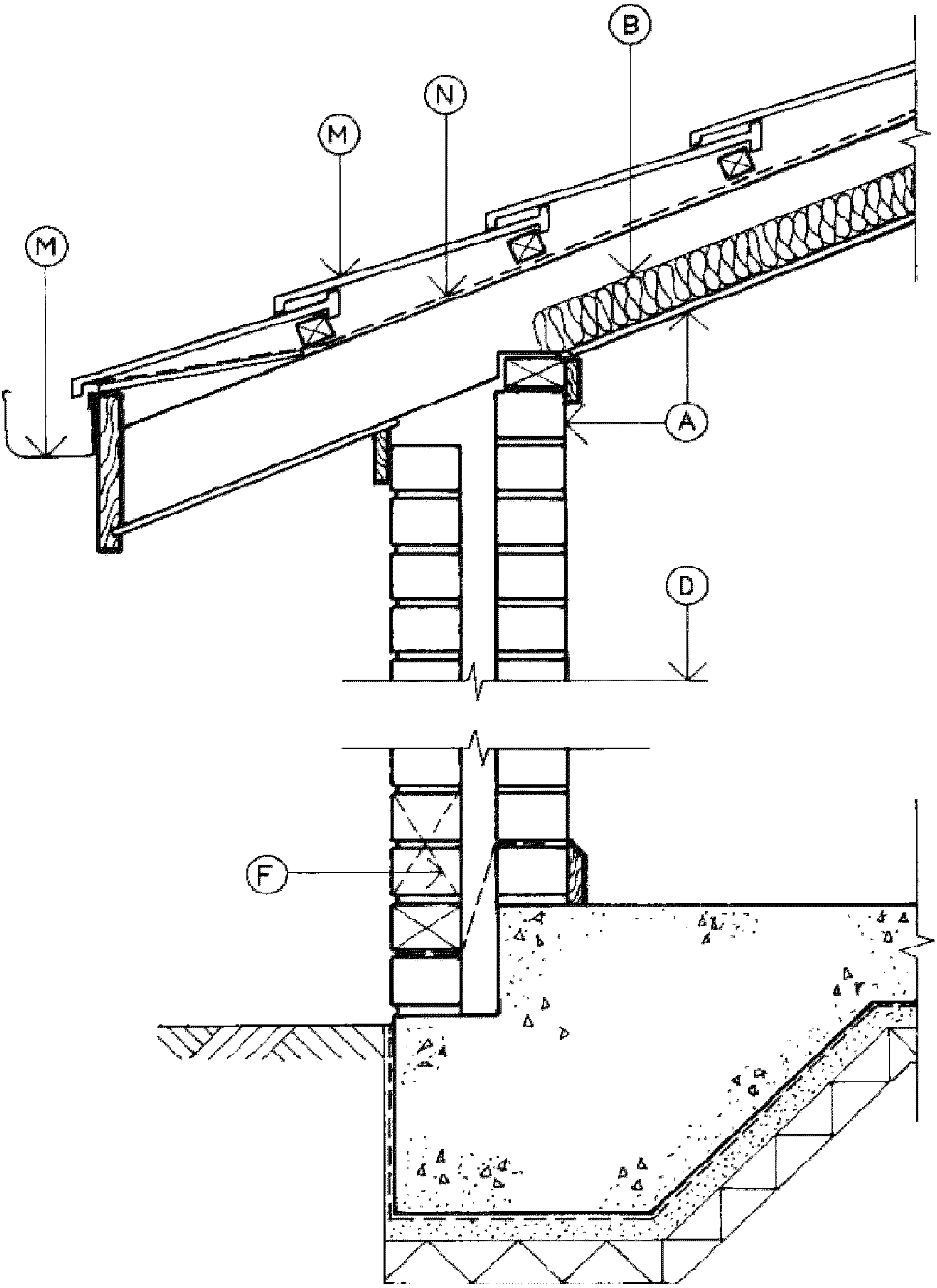


Figure 5: Typical use of line styles in Architectural detailing

- Undressed (rough cut) timber is represented by a cross (roof battens) – ‘B’ lines
- Concrete is represented by small dots and triangles (foundation) – ‘B’ lines
- Sections of drawing that may be inferred and are omitted are indicated by ‘D’ lines
- Membranes are represented by a single dashed line (roof sarking, flashing & plastic lining below the concrete) – ‘E’ lines

Scales

Scale is very important in engineering drawing. The specified scale is used to allow direct measurement of any aspect of the drawing. Although dimensions are generally given they are usually not sufficient to totally describe all of the project. The scale is most commonly represented as a ratio of drawing to real world dimensions. Drawings using this method cannot be scaled upon reproduction without changing this scale. Scale may also be represented using a visual legend on the drawing showing the relationship between drawing and real dimensions. This method may be scaled upon reproduction as the legend is also scaled with the drawing.

The choice of scale for engineering drawing is restricted by the standard to those shown in Table 1. Scales are generally factors of 2, 5 or 10. Unrestricted use of scales would lead to an increased likelihood of error when reading the drawing.

Table 1: Engineering scales

Category	Recommended scales		
Enlargement scales	50:1 5:1	20:1 2:1	10:1
Full size		1:1	
Reduction scales	1:2 1:20 1:200 1:2 000	1:5 1:50 1:500 1:5 000	1:10 1:100 1:1 000 1:10 000

Projections

While most constructions are 3 dimensional, their representation on either paper or computer screen is in 2 dimensions (there are some notable exceptions to this, namely circuit diagrams). Representation of 3D objects necessitates what is generally called a projection.

A projection is the process of projecting the image of the real 3D object onto a 2D plane, this representing the drawing sheet or computer monitor. Common projections include perspective, oblique, isometric and orthogonal. The choice of projection depends upon whether representation requires accuracy of the general form or of dimensions.

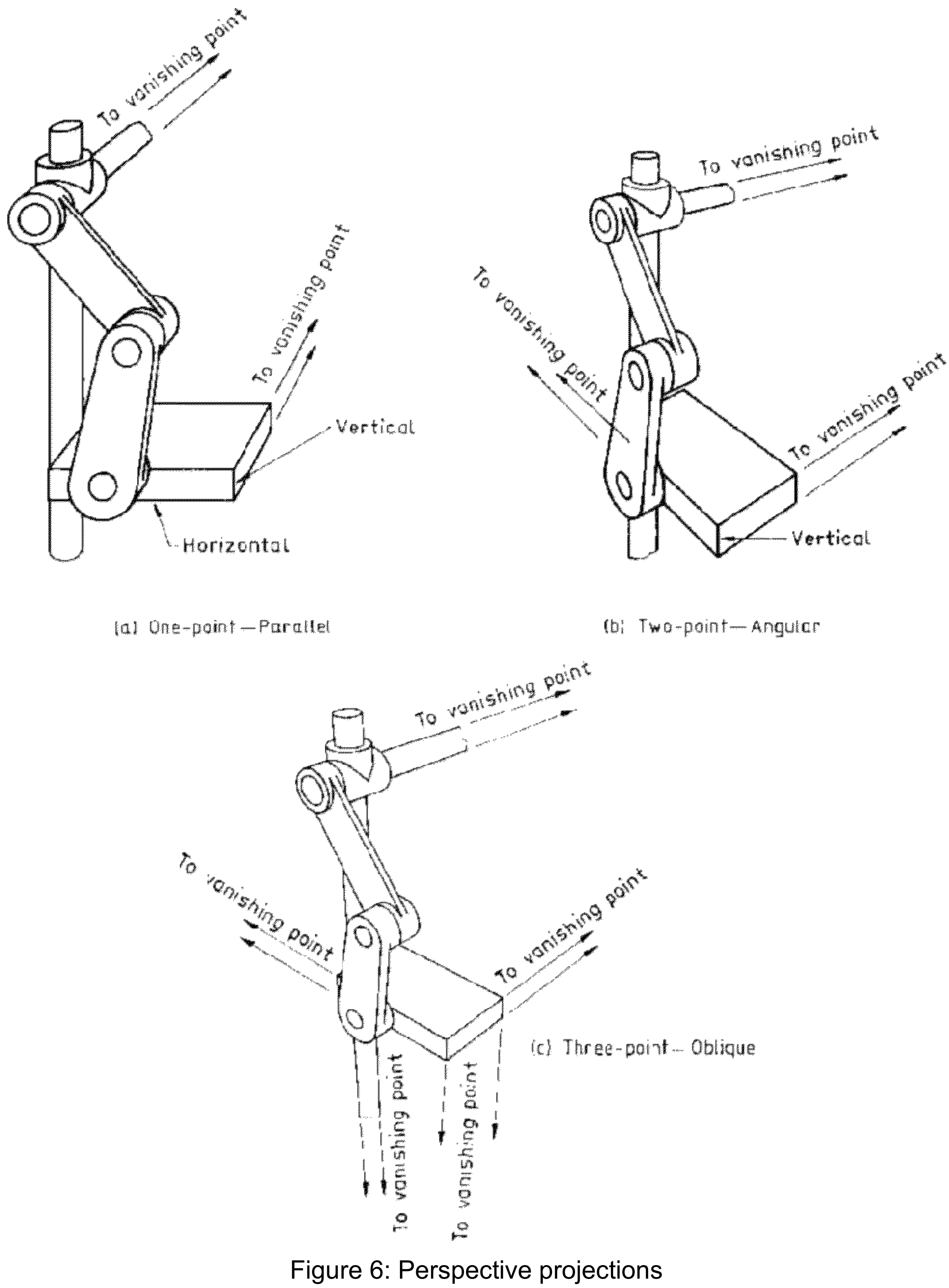


Figure 6: Perspective projections

Table 2: Types of standard projections

Distinctive feature	Projection type		Application
	Generic	Particular	
Parallel lines of sight	Orthogonal	Third angle (preferred) First angle	Two-dimensional multiview drawings
	Axonometric	Isometric Dimetric Trimetric	Three-dimensional single-view ‘pictorial drawings’
	Oblique	Cavalier Cabinet General	
Converging lines of sight	Perspective	One-point (parallel) Two-point (angular) Three-point (oblique)	

Perspective Projections

Perspective dimensions are designed to give the viewer the most accurate representation of the ‘real’ appearance of the object. Parallel lines are drawn so that they converge at some distance called a vanishing point. This mimics the way our eyes capture parallel rays of light. All surfaces normal to our eyes have ‘true’ dimensions on the projection while other surfaces are distorted and cannot be measured. Examples of 1, 2 and 3 point perspective projections are shown in Figure 6.

While perspective projections give the best impression of the size and shape of an object, in reality the actual dimensions cannot be measured in any non-normal plane. For example, since all lines converge at vanishing points it is difficult to tell if lines are parallel or not. Therefore all dimensions must be represented on the drawing with dimension lines. This requirement generally creates over complicated and confusing drawings and for these reasons perspective projections are not commonly used in engineering drawing.

Perspective projects are commonly used in architectural drawings where true representation of form is very important. However, perspective projections are usually accompanied by other more practical projections (see below) to allow correct determination of dimensions.

Axonometric Projection

Axonometric projections are so that vertical edges are parallel and other edges are drawn parallel and a specified angle. All dimensions on all three axes are drawn true to scale. This distorts the appearance of the object but allows direct measurement of dimensions.

The most common form of axonometric projection is the isometric projection where the X and Y axes are drawn at and angle of 120°. Commonly the X and Y axes is drawn at 30° and 150° to the horizontal respectively. An example is shown in Figure 7.

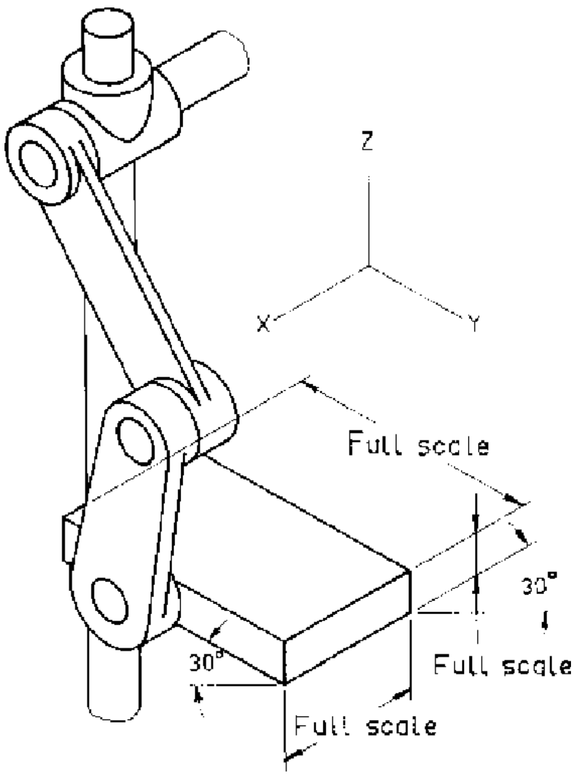


Figure 7: Isometric projection

Oblique Projection

Oblique projections are drawn so that there is a plane normal to the line of sight. Therefore vertical (Z) and horizontal (X) dimensions on this plane are true to scale. Other surfaces in the Y axis with parallel edges are drawn as parallel lines, all at the same angle (vertical and usually 30° or 60°). Although this creates a distorted view of the image it allows parallel lines o be distinguished from non-parallel lines.

Dimensions in non-normal planes are either drawn to full scale or at some reduced scale. By keeping this factor consistent most dimensions of the drawing may be measured directly off the sheet. However the resulting size of some aspects of the drawing reduce the accuracy of these dimensions.

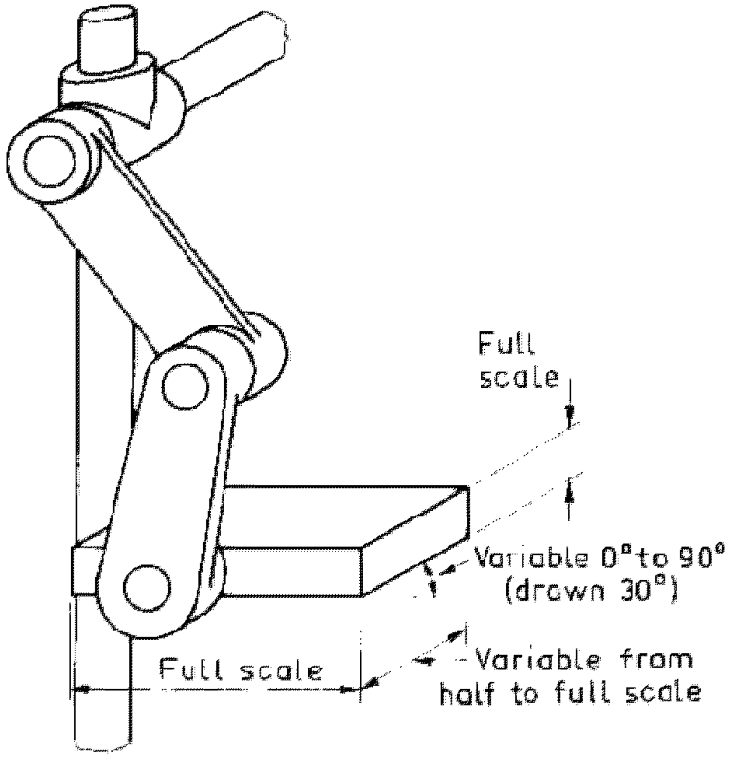


Figure 8: Oblique projection

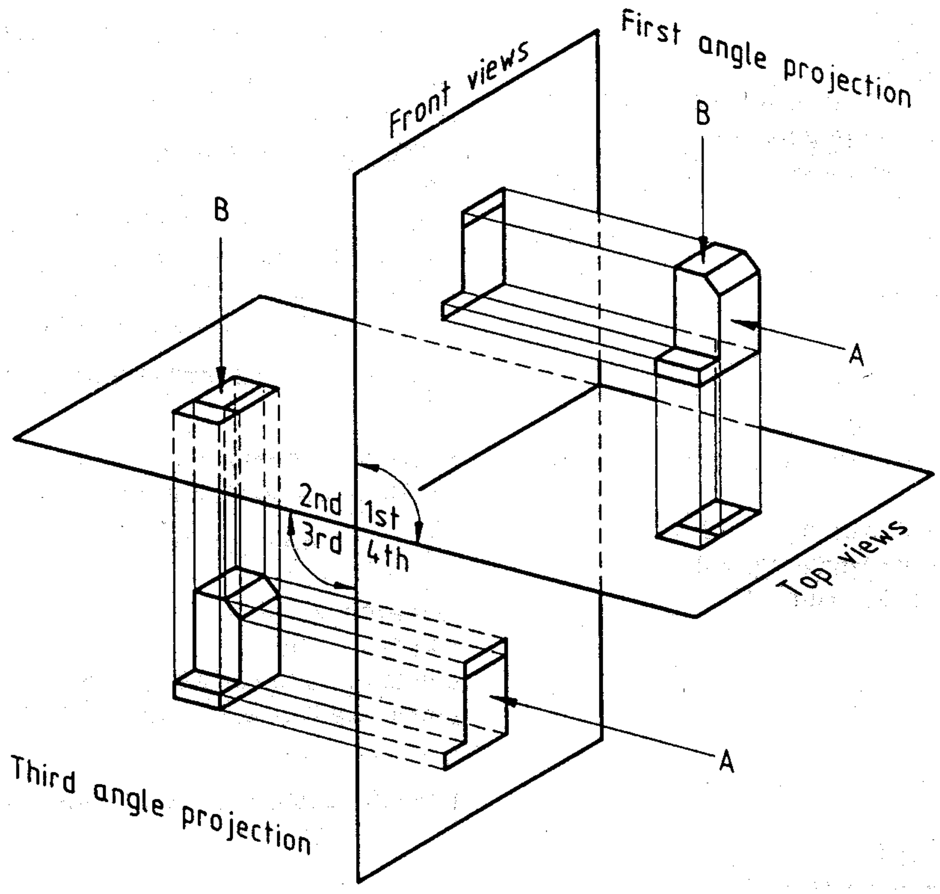


Figure 9: Orthogonal projections

Orthogonal Projections

In many cases, the drawing is intended to portray a solid object, or collection of objects. At the basic level, we try to describe the solid object by plane representations. The standard way of doing this is to show the object from orthogonal viewpoints. Figure 10 shows a picture of a solid object. The labelled arrows show different directions for viewing the solid. These directions are orthogonal, that is, at 90° to each other.

Figure 10 shows drawings of the solid object, labelled A to F. These drawings are representations of the solid object as seen from the different viewing directions.

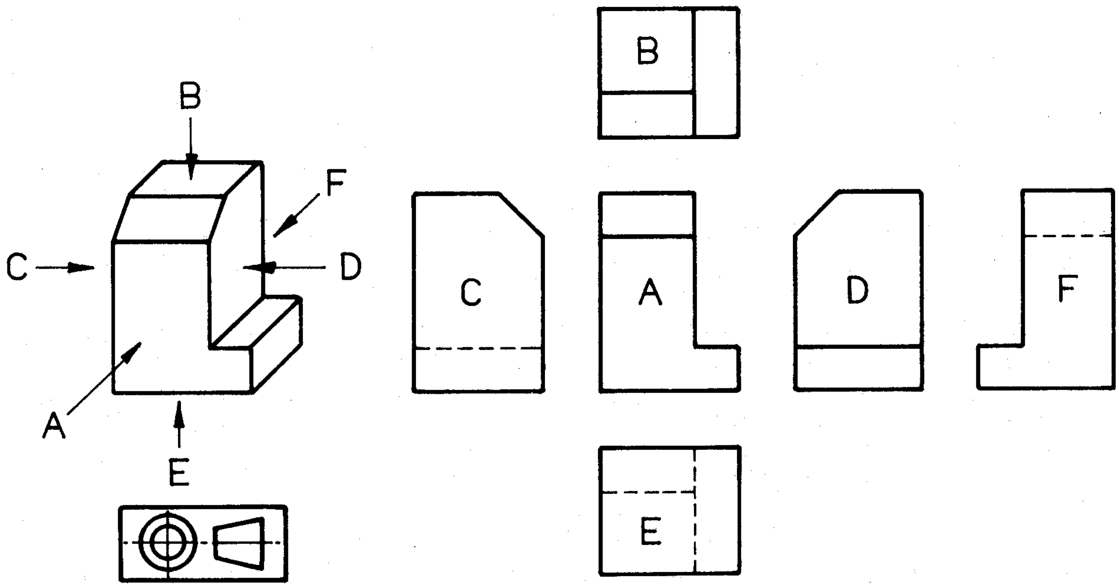


Figure 10: Views for orthogonal projection (3rd angle)

The preferred method of displaying these views is third angle projection, used in Figure 10. Briefly, the top view is placed above the front view, the right side view is placed on the right side of the front view, and so on. You will see that views C, A, D, F are shown from left to right, and form a sequence of views at 90°. Similarly, the views B, A, E are shown from top to bottom, and correspond to a sequence of views at 90°.

The small diagram in the box in the lower left corner of Figure 10 is the projection symbol, indicating that third angle projection is being used. It represents two views of a short tapered bar of circular cross section, using third angle projection. Edges which are invisible in any view (hidden lines) are shown by dashed lines.

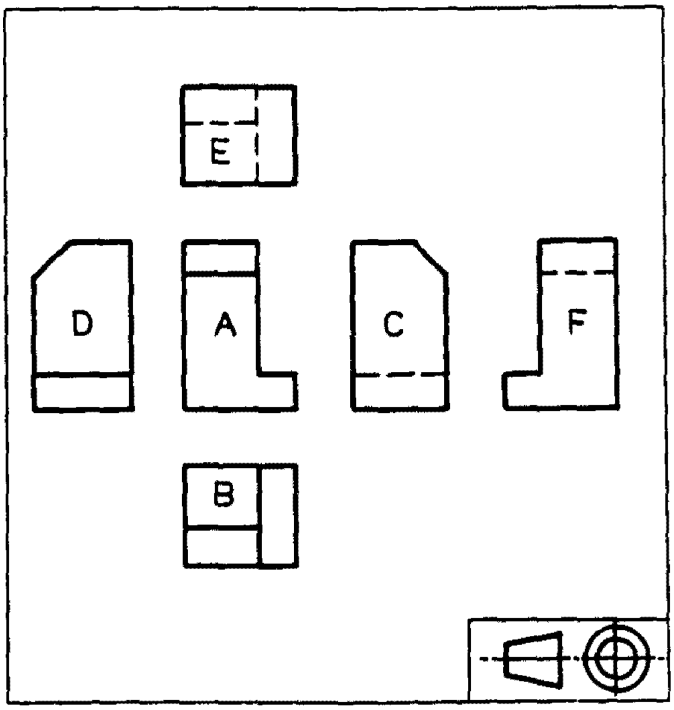


Figure 11: First angle projection

The alternative representation is first angle projection, as in Figure 11. In this projection, the top view is placed below the front view, the right side view is placed to the left of the front view, and so on.

Acknowledgement: These notes are prepared from lecture notes originally prepared by Dr Gareth Swarbrick, School of Civil and Environmental Engineering.