Working drawings

Drawings which contain all the information needed to make the object you have designed, including dimensions and details of components, materials and assembly instructions, are called **working drawings**. Although working drawings for simple products may sometimes be done in isometric or planometric projection, the normal drawing technique for working drawings is **orthographic projection**.

Some products may need a **section drawing** to give extra structural information, or an **assembly drawing** to show how parts fit together.

1. ORTHOGRAPHIC PROJECTION

Orthographic projection shows complex objects by doing a 2D drawing of each side to show the main features. Orthographic drawings usually consist of a front view, a side view and a **plan**, but more views may be shown for complex objects with lots of detail. A drawing board and parallel motion or T-square is used to project one view from another.

Orthographic drawing may be done using **first angle projection** or **third angle projection**. The graphic below shows the differences between the two.

<table>
<thead>
<tr>
<th>Orthographic drawing</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Orthographic Diagram" /></td>
</tr>
</tbody>
</table>

Note the British Standard symbols for 1st angle and 3rd angle projection at the base of the drawing (BS 8888:2000).

**FIRST ANGLE - ORTHOGRAPHIC PROJECTION**

Orthographic Projection is a way of drawing an object from different directions. Usually front, side and plan views are drawn so that a person looking at the drawing can see all the
important sides. Orthographic drawings are useful especially when a design has been
developed to a stage whereby it is almost ready to manufacture.

**IMPORTANT:** There are two ways of drawing in orthographic - First Angle and Third Angle. They differ only in the position of the plan, front and side views. Below is an example of **first angle** projection.

Opposite is a simple L-shape, drawn in three dimensions. Below is the same shape drawn in orthographic projection.

This orthographic projection appears to have three separate drawings but they are the same L-shape. The first drawing is the front view (drawn looking straight at the front of the L-shape), the second is a drawing of the L-shape seen from the side and last of all a drawing from above known as a plan view. The *red* lines are faint guidelines and they are drawn to help keep each view in line, level and the same size.

Please Note! This is an example of first angle orthographic project (as used mainly in Europe). There is another type called third angle which is used by countries such as the USA. The front, side and plan views are in different positions.

Imagine standing directly in front of the L-shape. You would only see the front edges, not the sides.

Now imagine standing directly at the side of the L-shape, the drawing opposite shows exactly what you would see.
Carefully study the symbols shown below. Normally when drawing in first or third angle projection a symbol is drawn underneath this clearly shows which angle of projection has been used.

Another example of first angle orthographic projection is shown below. Follow the blue, red and green guidelines as the front, side and plan view are constructed.

The final arrangements of the views are shown in the second drawing. Notice how the symbol for first angle orthographic projection has been added and the paper has a title block and borderline.

**THIRD ANGLE - ORTHOGRAPHIC PROJECTION**

Opposite is an L-shaped object. In the previous section it was drawn in first angle orthographic projection but below it is drawn using the more popular third angle projection.

The position of the three views differs compared to first angle orthographic projection. Look at the first angle projection - what are the main differences?
Another example of **third angle** orthographic projection is shown below. Follow the blue, red and green guidelines as the front, side and plan view are constructed.

**DIMENSIONS**

It is very important to add dimensions (measurements) when drawing accurate orthographic or working drawings. An orthographic drawing is usually the last drawing before manufacture and so dimensions must be clearly presented and understood. Dimensions can also be applied to simple sketches and designs as they help anyone looking at these to understand the overall size or scale. However, dimensions are usually drawn in a particular way and some examples are shown below.

The drawing below is in first angle orthographic projection.
Normally at least six dimensions are placed on a working drawing. They are drawn quite faintly except for the arrow heads and the numbering which are darker. The arrow head must be sharp but above all the dimensions must be accurate.

This type of dimension is normally used for a circle. The unusual symbol (zero with a line through it) is simple way of writing diameter.

Curved corners can be dimensioned like this. ‘R’ means radius (the compass setting).

Example of a standard dimension. The dimension is drawn quite faint with the exception of the number and arrow heads.

If a measurement is 9mm or smaller the dimension is drawn in a slightly different way. The arrows point inwards, towards the number

WORKING DRAWINGS

A working drawing is the final ‘constructed’ drawing, produced as part of the design process. It usually consists of a front, side and plan view of the solution. Sometimes there are two views but this depends on the complexity of the solution. Dimensions are added so that any person using the working drawing can manufacture the design. Usually there are at least six dimensions but you can add as many as you feel are required in order for the manufacturer to make your solution.

The working drawing should be precise and drawn to a scale. If the drawing is half the size of the solution then the scale is 1:2. If the drawing is a 3rd the size of the solution then the scale is 1:3.

Use a 2H pencil or a fine black pen for the final outline. This will allow the drawing to stand out. The dimensions are usually quite faint apart from the arrow heads and the measurement
WORKING DRAWING SEEN ABOVE IS DRAWN IN FIRST ANGLE PROJECTION

Parts List

A ‘Parts List’ is a very important feature of the working drawing as all the parts are listed, with measurements. The materials used are also mentioned as well as the finish applied to the individual pieces.

Can you complete the parts list on the right? The working drawing clearly shows a clock with an electronic mechanism. Also included are hands and numbers.

<table>
<thead>
<tr>
<th>PART No</th>
<th>No OFF</th>
<th>DESCRIPTION</th>
<th>MATERIALS</th>
<th>DIMENSIONS</th>
<th>FINISH</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>CLOCK FACE</td>
<td>MDF</td>
<td></td>
<td>RED PAINT</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>CLOCK BACK</td>
<td>PERSPEX</td>
<td>Dia. 156mm x 20mm</td>
<td>NONE</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>MECHANISM</td>
<td></td>
<td></td>
<td>NONE</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>GLASS</td>
<td></td>
<td></td>
<td>POLISH</td>
</tr>
<tr>
<td>5</td>
<td>1</td>
<td>HANDS</td>
<td></td>
<td></td>
<td>BLACK</td>
</tr>
<tr>
<td>6</td>
<td>2</td>
<td>NUMBERS</td>
<td></td>
<td></td>
<td>RED</td>
</tr>
</tbody>
</table>

Try to complete the parts list above - you may need to estimate some measurements

The example shown below has a back view, side view and plan view of a pine box with a perspex lid. The box contains an educational toy. The front view is not needed because it is plain, with no detail. The back view has hinges and consequently it is important that it is drawn. The working drawing (seen below) is accurate and detailed so that a suitably skilled person could manufacture the design from the information shown.

1. The working drawing should be precise and drawn to a scale. The drawing opposite is half the size of the solution, the scale is 1:2. If the drawing was a 3rd the size of the original then the scale would be 1:3.
2. Usually there are at least six dimensions but you can add as many as you feel are required in order that the precise size of your design can be determined by anyone reading the drawing.
3. Use a 2H pencil or a fine black pen for the final outline, as the drawing will then stand out.

4. Draw the measurements (dimensions) very carefully. Some example dimensions are shown below. They should be drawn with a sharp 2H pencil.

![Example Dimensions](image)

The arrows and the written measurement should be dark and the rest of each dimension should be faint. Dimensions are normally drawn as shown in (a) although dimensions under 9mm should be drawn as shown in (b). Diameters and radii are drawn as shown in (c).

5. A parts list should be included. This gives details such as overall dimensions, materials and finishes of each part.

6. Usually a working drawing is drawn in 3rd angle projection, add the symbol to the drawing.

**Suggestions**
- Consider carefully the type of views you need to draw (front, side, plan etc...) and draw a rough version.
- Number the parts in order, so that the numbers are in sequence.
- Use a T-square and set squares to help you draw the proper version of the working drawing.
- Add six dimensions, or more if necessary.
- Do not fall behind in your work as you may find it difficult to catch up.
OBLIQUE PROJECTION

The sketch opposite is of a former and block that are used to bend perspex to 90 degrees. The perspex is heated until it becomes soft and then it is placed in the former until it cools. The diagram can be drawn quite quickly because the designer used a style of drawing called oblique projection. So long as basic rules are followed, oblique projection is quite easy to master and it may be a suitable style for you to use in a design project. The basic rules are outlined below.

Opposite is a cube with all edges the same length. To draw it in oblique projection follow three main rules:

1. Draw the front or side view of the object.
2. All measurements drawn backwards are half the original measurement.
3. 45 degrees is the angle for all lines drawn backwards

STAGE ONE: Draw the front view and project 45 degrees lines from each corner

STAGE TWO: draw the back two lines of the cube in position. Go round the outline of the cube with a fine black pen or dark, sharp pencil

Example of a basic design for a camera, drawn in oblique projection. Shade/colour has been added - see earlier sheets for shading and colouring techniques.
OBLIQUE PROJECTION – DRAWING CYLINDERS

Drawing cylinders in oblique projection is quite simple if the stages outlined below are followed. In comparison with other ways of drawing cylinders (for example, perspective and isometric) using oblique projection is relatively easy.

- Draw a vertical and horizontal centre lines to indicate the centre of a circle, then use a compass to draw the circle itself.

- Draw a 45 degree line to match the length on the cylinder. At the end of this line draw vertical and horizontal centre lines. Remember the general rule for oblique is to half all distances projected backwards. If the cylinder is 100mm in length the distance back must be drawn to 50mm.

- Draw the second circle with a compass.

- Draw two 45 degree lines - to join the front and back circles.

- Go over the outline of the cylinder with a fine pen or sharp pencil. Add shade - if required.
2. Section drawings

Section drawings show the various parts of a product as if it had been sliced in half. (Sometimes they are called cross-sections.) The position of the imaginary cut is called a section plane, sometimes represented by a line consisting of long and short dashes.

The purpose of a section drawing is to make clear how a product is constructed. Parts of the object that are cut through are shaded with lines at 45° and spaced 4mm apart - called cross-hatching. If two parts of a product are touching, then the cross-hatching goes in opposite directions. Parts such as nuts and bolts and axles are not normally sectioned.

3. Assembly drawings

An assembly drawing shows the various parts of a product drawn to show exactly how they fit together. They are often used for products such as construction and model kits or flat-pack furniture, to show the user how to assemble the parts. They can be drawn in two ways.

A fitted assembly drawing shows the parts put together, and can be drawn in 2D or 3D.

An exploded drawing shows the parts separated, but in the correct relationship for fitting together. Exploded views are usually drawn in 3D, as illustrated.

Exploded views

Exploded views are often a good way of showing detail. The animation below shows the pens being disassembled and then reassembled. In an exploded drawing the pens would only be drawn with all the parts disassembled (taken apart). It is important to recognise that all the parts are in line with each other, drawn usually along a centre line which is drawn through the entire centre of the design.
This is an example of a joint for wood called a comb or finger joint. In an exploded drawing the joint would be drawn disassembled (taken apart). In this way it is possible to see how the joints looks before it is glued together. An exploded view can make designs and ideas easier to explain especially when adding detailed notes. The animation shows the joint being disassembled and then reassembled.