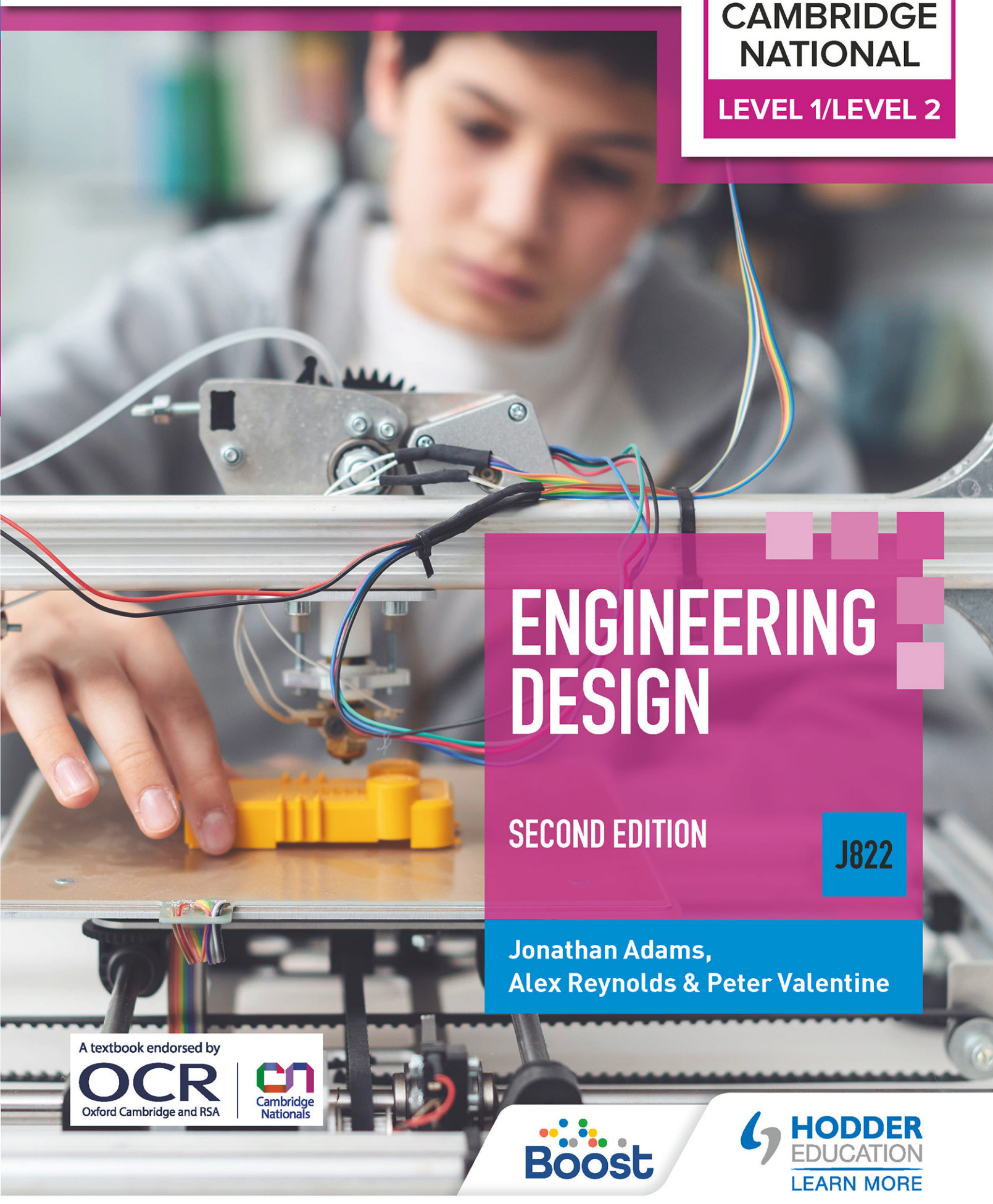
CAMBRIDGE NATIONAL

LEVEL 1/LEVEL 2



ENGINEERING DESIGN

SECOND EDITION

J822

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Alex Reynolds & Peter Valentine

A textbook endorsed by OCR Oxford Cambridge and RSA | Cambridge Nationals

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Contents

Introduction

This book has been designed to help you develop the knowledge, understanding and practical skills you'll need to complete the OCR Cambridge National in Engineering Design (J822) qualification. It will give you an insight into what it is like to work in the engineering design and development industry. You will learn how to use both 2D and 3D engineering techniques to communicate engineering design ideas and how to design new products to meet a design brief.

The qualification includes three units; all of these are covered in this book and you must study all three units.

R038 Principles of engineering design

In this unit you will learn about the different stages involved in the design process. You will learn about different designing requirements and how to communicate design outcomes and evaluate design ideas.

This unit is assessed by a written exam, which is set and marked by OCR. Your teacher will tell you when you will complete this exam. The exam will last one hour and 15 minutes and will have two sections – Sections A and B:

- Section A includes 10 multiple choice questions and is worth 10 marks; and
- Section B has a mixture of short answer questions and extended response questions. This section has 60 marks.

R039 Communicating designs

In this unit you will learn how to communicate your design ideas using a range of techniques, including manual production of freehand sketches and engineering drawings, as well as using computer aided design (CAD).

This unit is assessed by an assignment that includes four practical tasks you will need to complete. It will take you 10–12 hours to complete the assignment. There are 60 marks available.

R040 Design evaluation and modelling

In this unit you will learn how to model design ideas and test them as well as how to evaluate products.

This unit is assessed by an assignment that includes six practical tasks you will need to complete. It will take you 10–12 hours to complete the assignment. There are 60 marks available.

Acknowledgements

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How to use this book

This textbook contains all three units for the redeveloped Cambridge National Engineering Design Level 1/Level 2 qualification (J822).

These units are:

- Unit R038 Principles of engineering design
- Unit R039 Communicating designs
- Unit R040 Design evaluation and modelling

Each unit is divided into topic areas. All of the teaching content for each topic area is covered in the book.

Key features of the book

A range of learning activities are included in the Student Book. They can be used flexibly to embed and supplement learning.

Each chapter (or unit) begins with flexible reference material. This content can be used to introduce the unit, the topics covered and the method of assessment. It will also help to empower the students to take control of their own revision and assessment preparation.

Topic areas

A clear statement of the topic areas so you know exactly what is covered.

How will I be assessed?

Assessment methods are clearly listed and fully mapped to the specification.

There is also a range of in-chapter learning features to support your teaching.

Each of these learning features is showcased in the sample chapter, so you can consider how you will use them in the classroom and with your students.

Getting started

Short activities to introduce you to the topic.

Key terms

Definitions of important terms.

Activities

Short tasks to help you understand an idea or assessment criterion.

Case study

Real-life scenarios to show how concepts can be applied to businesses.

Research

Activities that draw on the content covered in the book, to reinforce understanding.

Test your knowledge

Questions to test your knowledge and understanding of each learning outcome. Answers can be found online at: www.hoddereducation.co.uk/cambridge-nationals-2022/answers

Synoptic links

Links to relevant details in other parts of the book so you can see how topics link together.

Practice questions

This feature appears in Unit R038, which will be assessed via an exam. It includes practice questions, mark schemes and example answers to help you prepare for the exam. Answers can be found online at: www.hoddereducation.co.uk/cambridge-nationals-2022/answers

Assignment practice

This feature appears in other units and will help you prepare for non-examined assessment with model assignments, mark schemes and tips.

Unit R039

Communicating designs

About this unit

This practical unit gives you the opportunity to learn how to communicate engineering designs through freehand sketching, formal engineering drawings and 3D computer-aided design (CAD) presentation.

You will develop skills in sketching to generate a range of initial design ideas. Then you will select ideas to develop into formal engineering drawings, using CAD and other techniques to communicate a final design proposal.

Topic areas

In this unit, you will learn about:

1. Manual production of freehand sketches
2. Manual production of engineering drawings
3. Use of computer-aided design (CAD)

How will I be assessed?

This unit is assessed through an assignment that will take place at your centre. The assignment contains a scenario and a set of tasks for you to complete. Your work will be assessed against a set of marking criteria. The time to complete the assignment is included with the assignment brief. Your teacher will give you clear guidance about the tasks required to complete the assignment and the criteria you need to meet.

Topic area 1 Manual production of freehand sketches

Getting started

Consider the basic shape of the appliances you see around you, at home, in shops or in school. You will notice that many are formed from foundation shapes, such as squares, rectangles, triangles, circles and ellipses; often they use a combination of foundation shapes. For example, many metal appliances that are square or rectangular have rounded corners; doors or drawers are square or rectangular; and controls are often circular.

Produce a quick freehand pencil sketch of an appliance and highlight foundation shapes or combinations of these shapes.

1.1 Sketches for a design idea

An initial sketch is often nothing more than a rough drawing, but it can communicate concept thoughts and ideas, without needing to be formal or accurate. Initial hand-drawn sketches can be developed further and refined to represent a design for a product.

Sketching requires very basic tools. Some engineers prefer conventional pencils (blue or graphite), while others use propelling pencils (mechanical pencils with replaceable graphite leads) or fibre-tip fine-line drawing pens. For pencil sketching, 2H, HB and 2B pencils should be sufficient. For propelling pencils and fine-line pens, line widths of 0.1, 0.3, 0.5, 0.7 mm and 0.8 mm should be adequate.

As designs are developed and refined with additional features and detail, it is often best to use a combination of both pencils and pens.

A pencil eraser is not required. At the early stages of sketching, every line on the page could be useful. Therefore, it would be a waste of time to erase lines.

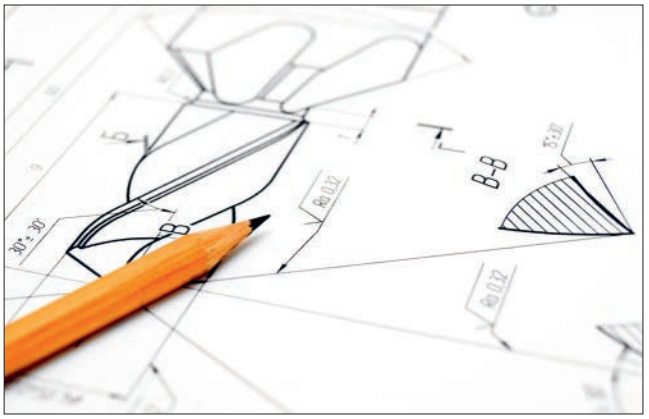


Figure 2.1 Pencil sketching

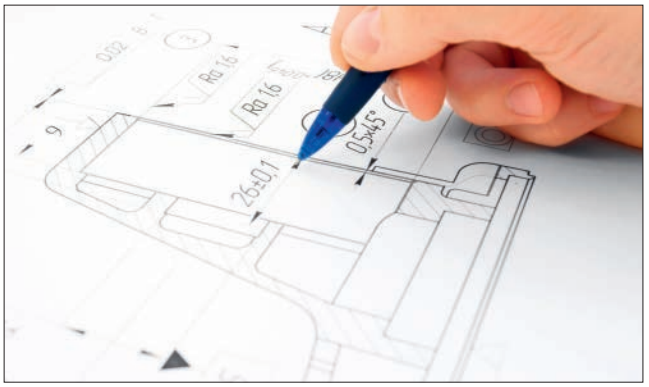


Figure 2.2 Sketching with a fine-line drawing pen

Produce a freehand sketch of a design idea

It can be daunting to pick up a pencil or pen to sketch new creative and **innovative designs**. However, sketching skills can be learned and improved with practice.

Freehand sketching in 2D

The **random line technique** is a method for producing creative and innovative initial design ideas, no matter how good a designer is at sketching. Other techniques can then be used to develop sketches and make them more formal.

In this technique you sketch multiple lines quickly in all directions across a page. These lines can be straight, circular or elliptical, or a combination of all three. By joining some of the lines together to form a boundary outline, you can produce a new creative shape. Thickening the boundary line can help to define the new shape. At this stage, the shape produced simply points towards a potential design. Within the random lines there may be many, very different potential designs.

Key terms

Innovative designs New groundbreaking, inventive designs.

Random line technique Multiple random lines are sketched in different directions across the page. Some of these lines are joined to form an outline shape for a design.

Crating A technique used to provide a framework for sketches and drawings.

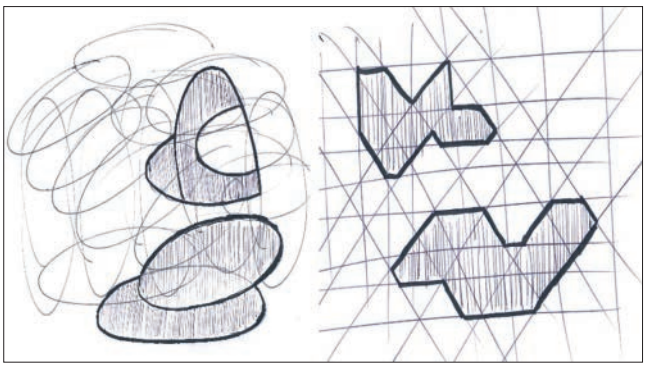


Figure 2.3 Random line sketches

Activity

Divide a portrait sheet of A4 plain paper into three sections.

- In the top third of the paper, create a random pattern of straight lines.
- In the middle third of the paper, create a random pattern of circular and elliptical lines.
- In the bottom third of the paper, create a random pattern of straight, circular and elliptical lines.

Join random lines within the patterns to produce creative shapes for a multi-product charger station (for example, to charge a mobile phone, watch, ear buds and games controller). Try to be innovative with shape and form.

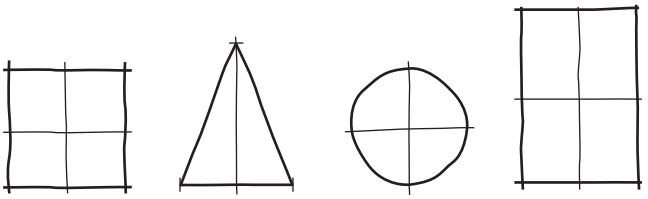


Figure 2.4 2D freehand sketches of shapes

The two-dimensional (2D) shapes shown in Figure 2.4 are the foundation of creative design: the 2D outlines of most products can be developed from these shapes. As you can see in random line sketches, the general form of most designs is rectangular, triangular or circular, or a combination of these shapes. A starting point to develop a design could be to sketch one or more foundation shapes.

- To help with proportion and alignment, it is good practice to sketch some fine **crating** lines first. These are fine construction lines that provide a framework but are barely visible on the page.
- Start with a centre line and lines to indicate height and width. Then add a few lines equally spaced within the crate.
- Don't be too concerned if lines are not as straight or as curved as you would like – at this stage, it doesn't matter.

- When sketching straight lines freehand, start by sketching part of the line and then extend it, overlapping the initial line.
- For curved lines, hold your pencil as normal and lay the base of your hand, below your little finger, on the page. Keeping the base of your hand on the page, move the pencil in an arc shape to sketch a curved pencil line on the page. You can produce a circle by turning the page to draw overlapping curved lines. It may be inaccurate but this does not matter in a sketch.

You can combine simple 2D shapes to form new creative **compound shapes**, as shown in Figure 2.5. Rectangles, triangles, semi-circles and arcs have been joined together to form designs. You may wish to add features such as handles, grips, caps, clamps, dials, switches, screens, lights and speakers. These details can help to characterise a potential product.

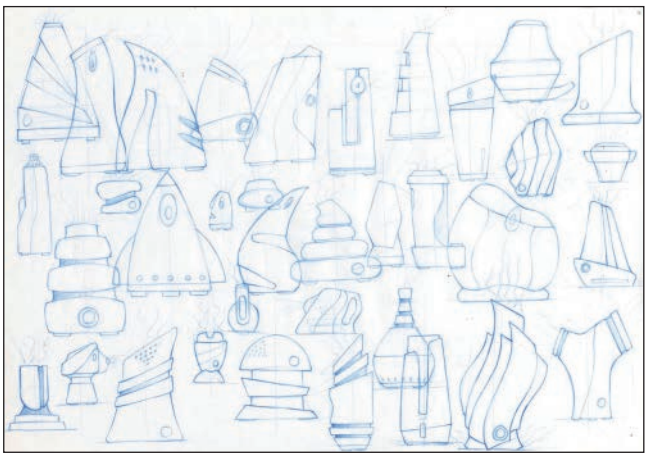


Figure 2.5 2D thumbnail sketches using compound shapes

These initial 2D sketches will be **thumbnail sketches** – small illustrations around 30–40 mm in height or width that are produced quickly.

These thumbnail sketches will include possible product designs. You can use **line enhancement** techniques, which involve changing line thickness or weight, to highlight these designs.

When using the **thick and thin lines technique** for 2D sketches, make the outer boundary lines of a design thicker and bolder – approximately twice the thickness of a standard fine line. Use fine lines to show detail on a design, with slightly thicker lines to show surface details of particular interest. Where boundary edges meet another surface, such as a table or floor, use a very thick boundary line to emphasise surface contact. Use sharp B pencils or fine-line pens to produce thick and thin lines.

Weight of line is a technique used to add line thickness, strength, boldness or darkness. It can add drama to a design, particularly where edges curve or change direction, and where shadows may be formed.

There are no strict rules about line weight when illustrating detail – the main thing is how the sketch looks on the page. Notice how the enhanced sketches in Figure 2.6 stand out; the other initial sketches appear to fade into the background. You can make lines stand out more using fine-line pens, soft B pencils or marker pens.

Key terms

Compound shapes Shapes formed by the combination of two or more simple shapes such as squares, rectangles, triangles or semi-circles.

Thumbnail sketches Small inaccurate sketches of initial ideas for a design.

Line enhancement Increasing the thickness and boldness of object lines to highlight boundary edges.

Thick and thin lines technique A sketching technique in which outer boundary edges are sketched as thick bold lines and detail on the design is sketched using thin fine lines.

Weight of line How light, dark, bold or heavy a line is.

Figure 2.6 Thick and thin lines used to enhance 2D freehand thumbnail sketches

Activity

Using 2D crating techniques, produce several 2D thumbnail sketches of workshop tools (for example, bench hook, engineer's square, hacksaw, wood plane, screwdriver, G cramp).

Photocopy the sketches and save a copy for a later activity.

Add line enhancement (such as thick and thin lines, weight of line) to at least two of the sketches.

Freehand sketching in 3D

Once you have identified potential designs for a product from 2D sketching, the next stage is to develop sketches in three dimensions (3D). This adds depth to the designs.

To do this, you can use techniques including oblique, isometric and perspective sketching. As with 2D sketches, crating can provide a framework for each design. Start by sketching each design using fine construction lines. The basic rules for oblique and isometric sketching are the same as for formal drawing using these techniques. All crate lines that project away at an angle must remain at that angle, so the crate is uniformly shaped. As sketches are developed in 3D, they tend to become larger with more accurately defined detail.

Oblique sketching

When developing a sketch using the oblique technique, start by sketching a 2D crate. Then add lines of sight that project away from the crate at an angle between 60° and 30°. The depth of the sketch can vary between actual depth and a scaled or foreshortened view. The aim is to produce a realistic image of the object being sketched, with depth.

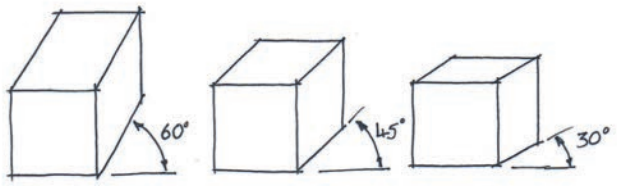


Figure 2.7 Oblique crates at 60°, 45° and 30°

Figure 2.8 shows an oblique sketch of a washing machine developed in a crate. The front view of the washing machine is sketched as a 2D image. Then a 3D crate is constructed along the lines of sight from the top and side, to add depth. When adding detail to the sketch, all vertical lines remain vertical. Arcs and circles on the 2D front of the oblique crate can be sketched in their actual shape; arcs and circles sketched along lines of sight (on the side or top of the object) should be elliptical.

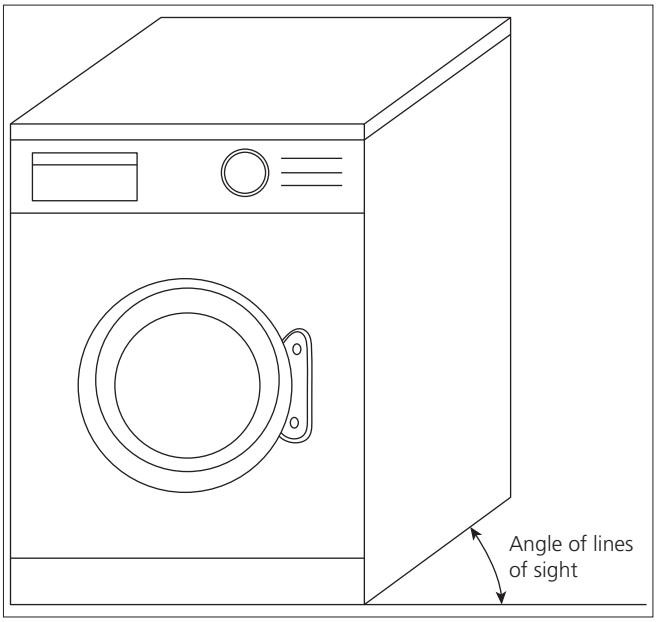


Figure 2.8 An initial oblique sketch of a washing machine

Thick and thin lines on 3D sketches

As with 2D sketching, you can use the thick and thin lines technique to enhance initial 3D sketches. Outer boundary lines should be thick, while detail lines may be thick or thin depending on what they are representing. There are three basic rules when using the thick and thin lines technique on 3D sketches and drawings:

- Boundary edge lines should be thick bold lines.
- Hard-edge lines should also be thick bold lines (see lines 1, 2, 3, 4 and 5 on Figure 2.9). These are lines where only one side of a line can be seen – the other side of the line is around a corner, or in a hollow or recess.
- All other lines should be standard fine lines.

3D thumbnail sketches do not need to be too accurate because the design may not be taken forward for development. Therefore they can be produced fairly quickly. You can improve 3D designs of particular interest by neatening their boundary and hard-edge thick lines using a straight edge or template.

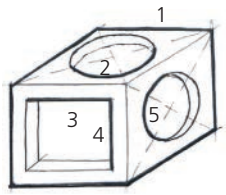


Figure 2.9 Initial 3D thumbnail sketch with thick and thin line enhancement

Key term

Vanishing point (or **viewpoint**) A point on the horizon beyond which an object can no longer be seen.

Activity

Produce a 3D oblique image of a square- or rectangular-shaped appliance (for example, a microwave or refrigerator).

- Produce the 2D crate for the front view of the object.
- Add centre lines to the 2D crate.
- Add basic detail to the front view.
- Add lines of sight.
- Add depth (the line that shows the back of the object).

Repeat the activity to produce two more 3D oblique sketches for the same appliance with lines of sight at a different angle, somewhere between 30° and 60° to the horizontal. The depth of the sketch can be foreshortened.

Photocopy the sketches and save a copy for a later activity.

Using a straight edge and templates, add neat thick and thin line enhancement to at least one of the 3D oblique sketches.

Perspective sketching

Sketching in perspective involves trying to sketch an image as the eye naturally sees it. For example, if you stand in a railway station (see Figure 2.10) and look down the length of a long train, the carriages further away will appear smaller than the carriages closer to you.

When sketching and drawing, the smallest object we can draw on a page is a dot. If we consider this dot to be the **vanishing point** on the horizon (the point beyond which we can no longer see an object) and we sketch towards this point, we can produce realistic object sketches. The nearer parts of an object are sketched proportionally larger than the parts that are further away.

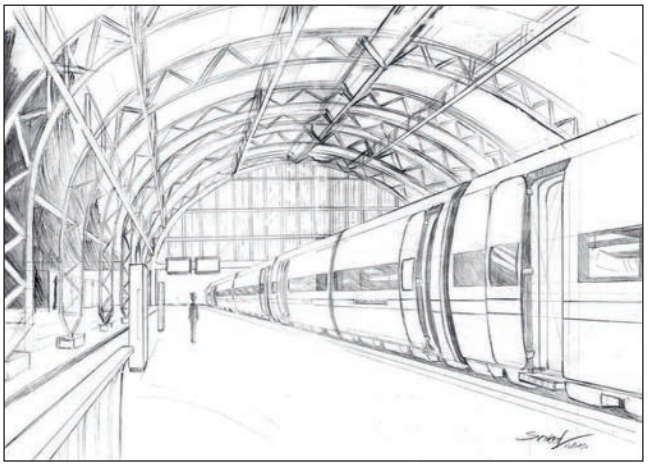


Figure 2.10 A one-point perspective sketch of a train in a railway station

When you are developing a sketch in one- or two-point perspective, sketch the nearest corner of the crate first. Then sketch lines of sight away from the top and bottom of this corner, in the direction of a vanishing point (dot) on an imaginary horizon. A **one-point perspective** sketch has one vanishing point, and a **two-point perspective** sketch has two vanishing points. The vanishing point can also be called the viewpoint.

Key terms

One-point perspective A sketch with one vanishing point.

Two-point perspective A sketch with two vanishing points.

Once you have established the top and bottom lines of sight, you can develop a sketch between them without projecting every line all the way to the vanishing point(s). Curves and circular shapes appear slightly squashed when drawn in perspective, as shown in Figure 2.12.

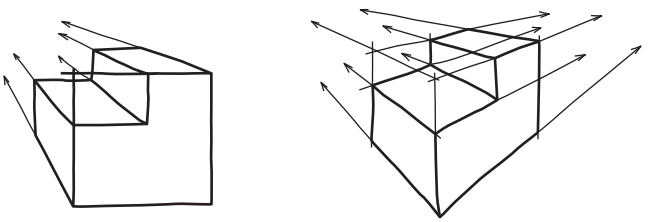


Figure 2.11 One-point and two-point perspective sketching

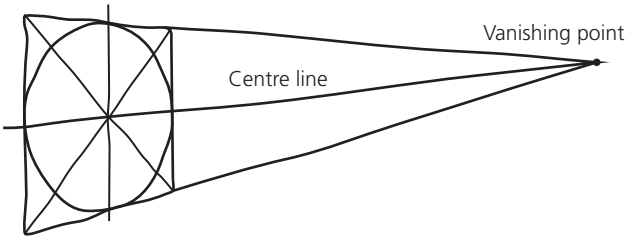


Figure 2.12 Sketching a circle in a one-point perspective

When objects are much higher than they are wide, you can use three-point or four-point perspective to produce a more realistic image. Figure 2.13 shows a three-point perspective image. Notice how the sketch also narrows towards the bottom.

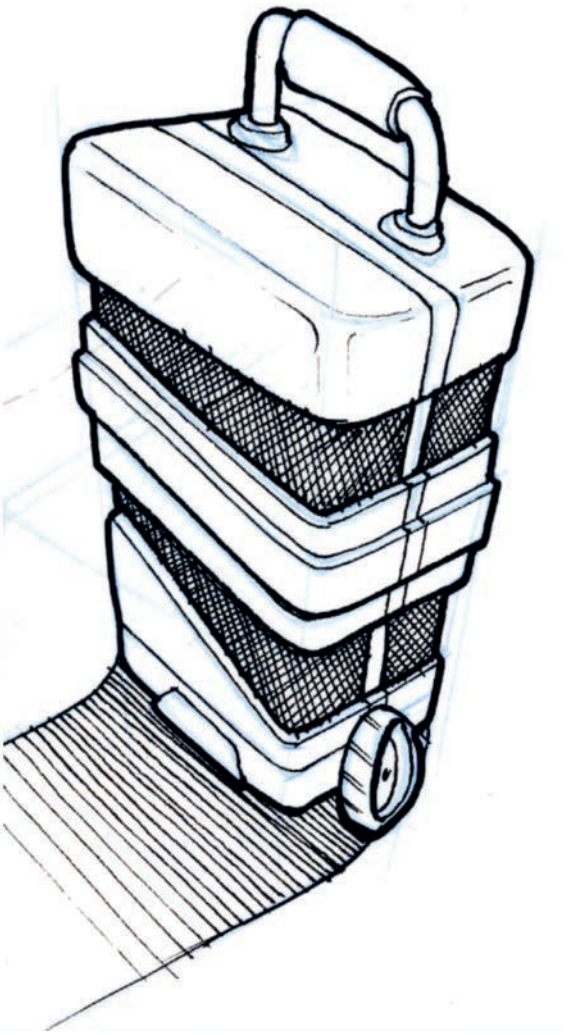


Figure 2.13 A three-point perspective sketch

Activity

Produce a two-point perspective sketch with multiple solid and hollow shapes (squares, rectangles, circles) sketched on, above and below the imaginary horizon, as shown in Figure 2.14. Use the same vanishing points for all sketches.

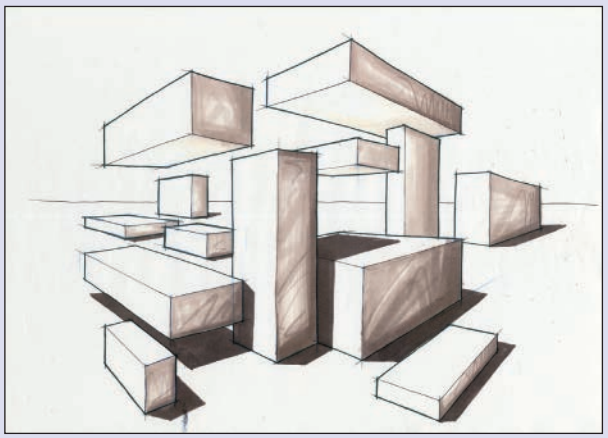


Figure 2.14 Rectangular shapes sketched in two-point perspective

Produce an isometric sketch for a design proposal

Isometric sketches are formed within a 3D isometric crate. Start a crate by sketching the nearest vertical corner. Then sketch lines of sight away from it at 30° to the horizontal (see lines 1 to 5 on Figure 2.15). Sketch vertical lines to mark the length of the sides and provide rear edge lines for the crate (lines 6 and 7). Finally, sketch lines along 30° lines of sight from the top of the rear edge lines (lines 8 and 9) to complete the crate. Sketch the isometric crate using very fine lines. Once you have formed the crate, you can develop the design for an object within it. Using this technique, all vertical lines remain vertical and all horizontal lines from the nearest corner are sketched at 30° to the horizontal. Isometric sketching uses the same scale on each side or face of the object.

Thick and thin lines can be added to enhance isometric sketches (Figure 2.15).

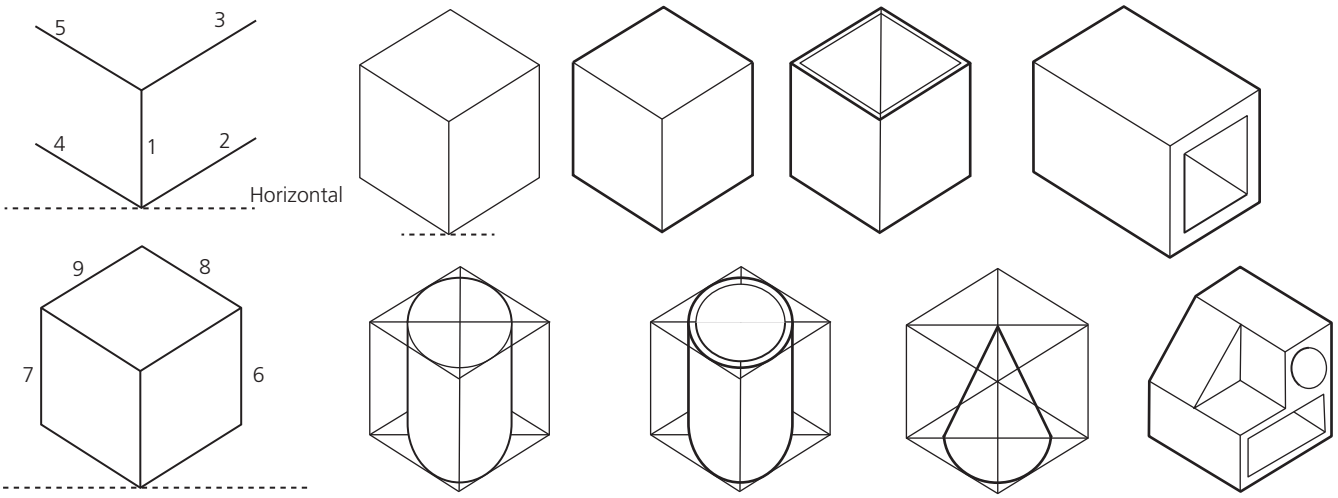


Figure 2.15 Development of isometric sketches

Use an ellipse to add circular detail on isometric sketches. You can sketch an ellipse freehand using an approximate plotting technique such as the $^2/_3$ method, as shown in Figure 2.16. On the longer centre line, plot two dots approximately $^2/_3$ of the way from the centre to each corner. Then plot a dot approximately $^2/_3$ of the way along each side edge.

Sketch a freehand elliptical curve to join each dot to the sides of the isometric crate. Remember, a sketch is an early illustration of a potential design so it does not need to be precise. Ellipse templates are a quick and easy alternative to plotting ellipse sketches.

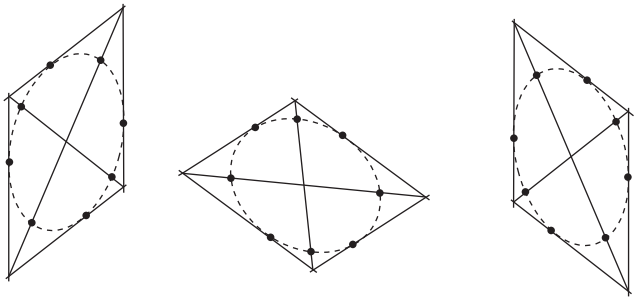


Figure 2.16 Plotting isometric curves using the $^{2}/_{3}$ method

When drawing isometric sketches on plain paper, it can be helpful to place a sheet of isometric grid paper underneath the plain paper. Small isometric grids can be used in this way when you are adding detail. You can develop complex designs by adding an isometric crate for each additional part of the sketch.

Tracing or layout paper can be very helpful when you are developing complex 3D isometric compound shapes. Sketch each component of the design to the same scale, on a different piece of tracing or layout paper. When you have sketched all the components, lay the individual sketches one on top of the other to form the full design. You can then sketch a final tracing over the top of all the underlays. Neaten the final sketch lines (thick and thin) using sketching aids such as a straight edge, French curves and ellipse templates.

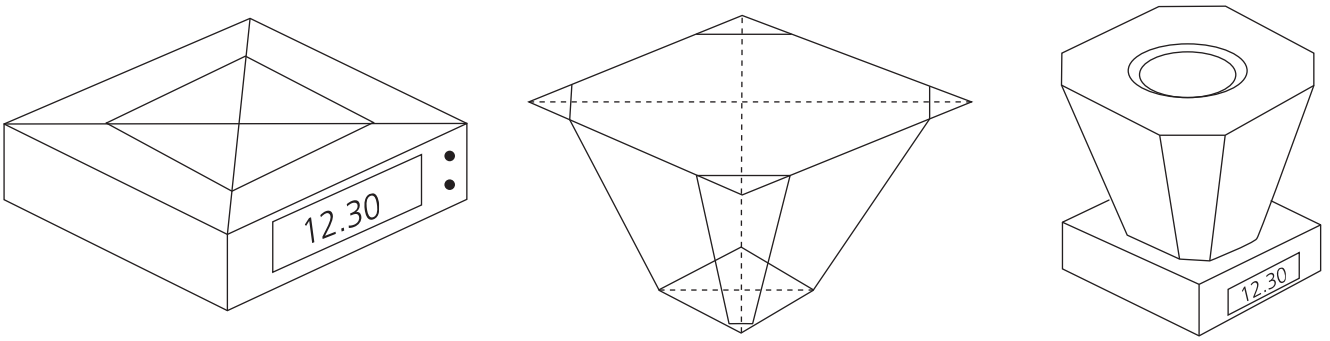


Figure 2.17 Compound shape designs developed using tracing paper

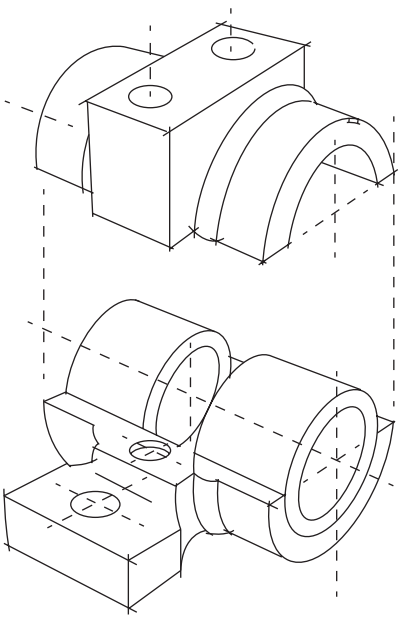


Figure 2.18 A completed 3D sketch in two-point perspective

Tracing and layout paper can also be used to lay out the position of components on an isometric **exploded diagram**. Exploded diagrams show the relationships between components of a product, or the order of their assembly. Sketch each component a short distance away from other components, so it looks as though they have been taken apart and are about to be reassembled. On products with multiple assemblies, you can show the components of each assembly close together, separate from the other assemblies.

Key term

Exploded diagram An image of a product where all the component assemblies are shown outside the product.

Figure 2.19 An exploded diagram of an LED (light emitting diode) lightbulb

Case study

Watch the YouTube video 'Product design sketching (building 3D sketches)': www.youtube.com/watch?v=JkpDCUk17K4

Discuss the techniques demonstrated in the video.

What can you learn from the video? Which techniques can you use as you develop your own design ideas?

Activity

Produce 3D isometric thumbnail sketches of:

- a cube
- a short, long rectangle
- a tall and wide rectangle with a square hollow on one face
- a cube with a circular hole through it
- a tube.

Photocopy the sketches and save a copy for a later activity.

Add thick and thin line enhancement to each sketch.

Rendering using texture, tone and shading

From a range of 2D and 3D sketches, you should be able to select a potential design for further development and **rendering**.

Key term

Rendering Application of surface decoration and detail, such as colour, shade, tone and texture.

Rendering is a process for turning line sketches into realistic design proposals by applying surface decoration and detail, for example colour, texture, tone and shading. Rendering can be added at any stage of design and development to enhance a sketch. At this stage, your line sketch design may still be quite simplistic. However, it should include some of the key elements identified in the specification criteria, such as aesthetics, ergonomics, materials and function.

Coloured, textured or plain white paper can be used for sketches alongside a wide range of rendering materials:

- Coloured pencils are often used to render sketches and they offer a good range of tone. However, low-quality pencils can be difficult to blend and erase.
- Coloured pastels can be used in many ways. You can apply them directly onto paper, scrape them to a dust and apply using cotton wool and a dry brush, or mix them with a solvent to form a paint. They also work well with other rendering techniques such as weight of line. When applied dry they can be erased easily.
- Ballpoint pens, fibre pens, roller tip pens and felt tip pens are good for general sketching and layout work. They are useful for highlighting boundaries, edging and detail, but tend to be made with permanent inks.
- Marker pens can be used to apply a wash of colour to a sketch quickly, but it can be difficult to achieve an even colour without a lot of practice. Marker pens tend to give a sense of colour rather than full colour, which can be a very powerful effect. Once marker ink is dry, other materials can be applied over the top, such as ballpoint pens, fine-line pens, felt pens and paint.

Examples of rendering techniques to communicate texture, tone and shading are shown in Figures 2.20 to 2.23.

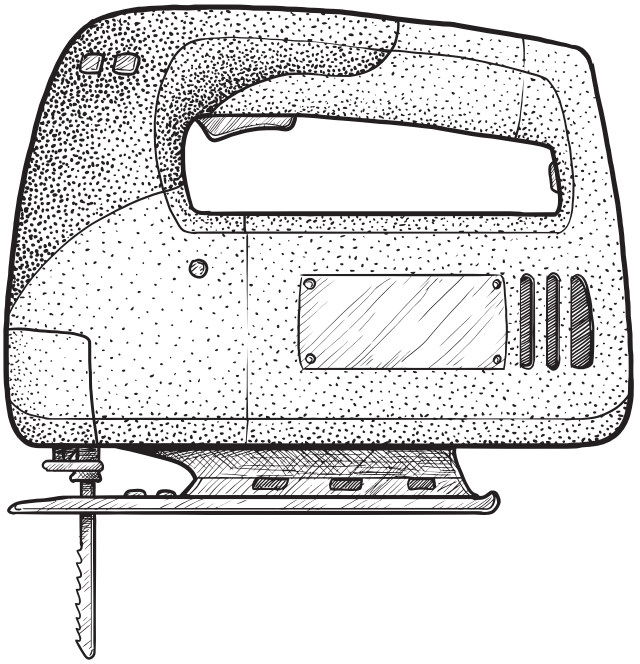


Figure 2.20 Monochrome surface rendering with line enhancement

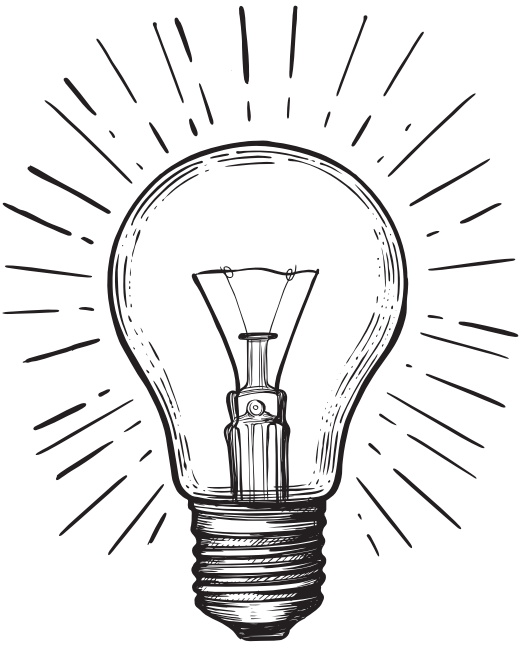


Figure 2.21 Monochrome rendering with line enhancement

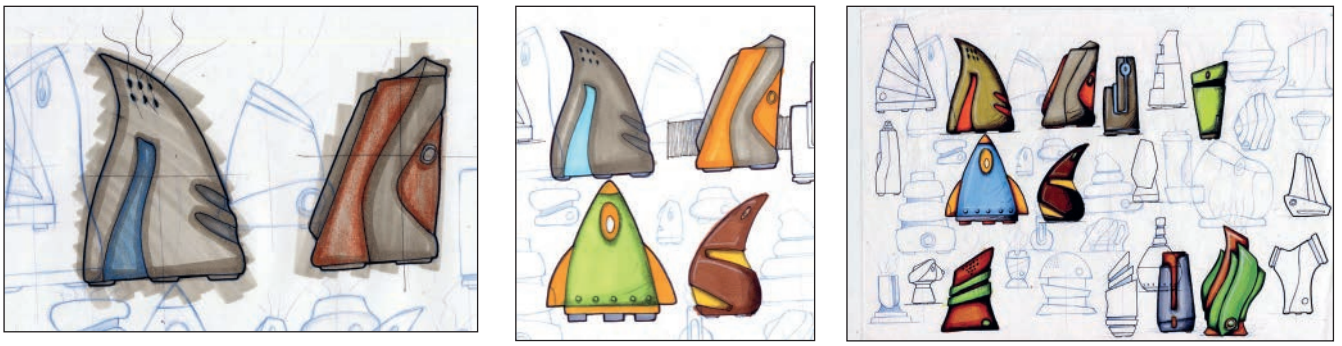


Figure 2.22 Examples of colour wash and marker rendering

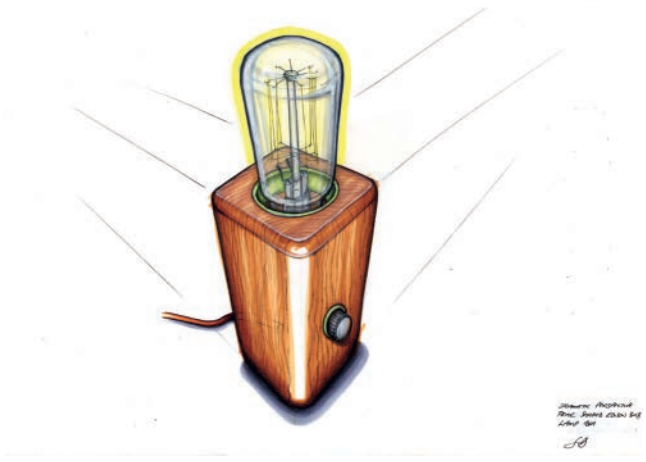


Figure 2.23 A rendered sketch in three-point perspective

Activity

Cover two sheets of A4 paper with multiple copies of the un-enhanced sketches you made for earlier activities in this unit (2D sketching and 3D oblique and isometric sketching).

Add rendering to your 2D and 3D line sketches using a range of rendering techniques and tools (coloured pencils, pastels, pens, markers) to communicate colour, texture, tone and shading.

Assignment practice

Marking criteria

Mark band 1	Mark band 2	Mark band 3
Use of CAD to produce a **simple** model of the design proposal. A **simple** 3D virtual model consisting of a very limited number of components. Production of a 3D virtual model is **dependent** upon assistance or help from other sources.	Use of CAD to produce an **adequate** model of the design proposal. An **adequate** 3D virtual model consisting of some components. A 3D virtual model is produced with **some** assistance or help from other sources.	Use of CAD to produce a **complex** model of the design proposal. A **detailed** 3D virtual model consisting of many components. 3D virtual models are produced **independently**.

Top tips

- For this unit, you will be given a set assignment brief containing a scenario and tasks. Read this carefully and make sure you address all the points in the marking criteria. The scenario will be based on a product.
- Remember to show step-by-step detail of how you have used CAD software to create your design proposals. You can do this by taking regular screenshots and annotating them to describe what you are doing. Don't forget to clearly identify your final designs!
- To satisfy the marking criteria fully, you need to demonstrate both 2D and 3D CAD modelling.
- Your design proposals could also include details of materials to be used, together with manufacturing processes and assembly methods.

Model assignment

Scenario

A new hot glue gun, like the one shown, is to be designed with the following requirements:

- be manufactured with a two-part moulding
- incorporate space for internal components
- incorporate a trigger to dispense the glue
- be easy to reload with a new glue stick
- be able to stand independently
- incorporate an area for branding
- be ergonomically comfortable to use
- be aesthetically pleasing.

Your task

Having produced several initial design ideas, you now need to develop one of your selected design proposals for the glue gun. You should use 2D and 3D CAD techniques to present final design proposals.

Example candidate response

The candidate has provided annotated screenshots to show how they used CAD software to design the separate parts for their glue gun.

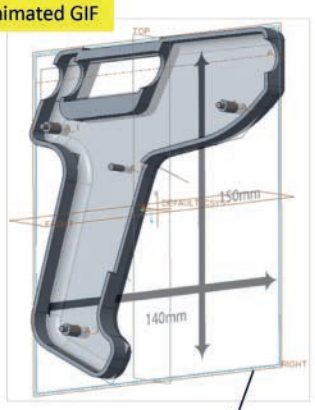
Note that the shell feature has been used to hollow out the housing to allow components to fit inside the glue gun.

Alongside the 3D models, the candidate has produced 2D engineering drawings, including third angle orthographic views of each part.

The commentary justifies how the design proposals satisfy the design requirements – two-part design, space for internal components, trigger to dispense glue, and so on.

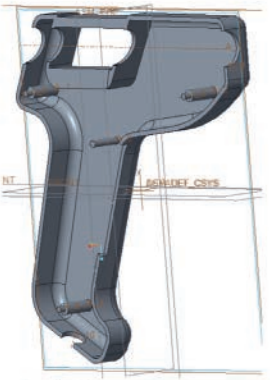
Materials, manufacturing processes and assembly methods for each part have also been considered.

Animated GIF

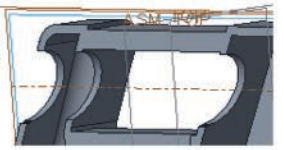


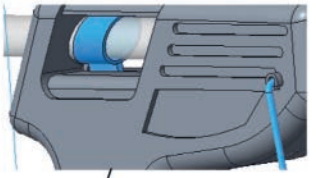
This animated GIF shows my final design of the hot melt glue gun, created in Creo. This GIF portrays how I built up the glue gun with all the components I designed from CAD and how I built it up during assembly.

I started with the left housing of the glue gun and slowly built it up by adding in the components one by one, the order of this being: nozzle, push lever, glue stick, cable, trigger, right housing and, finally, the metal stand of the glue gun so it can stand up by itself independently.

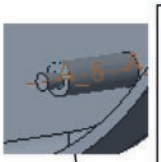


My first step to creating the glue gun on Creo was to first make the left housing of the entire model. I would have to create holes in the ABS housing for the details and components of the glue gun. I knew there would be an opening in the housing between the front and back housing to allow the glue stick to be inserted and loaded, so there is a semi circle gap in the back of the housing. This means that when put against the other side of the housing, there will be a fit circle for the glue stick, which later on will be presented in Creo too.



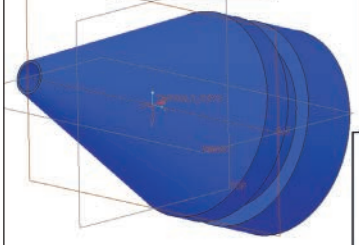


The other side of the glue gun has a lot of detail to it, that I showed cut out of the ABS. Some of this detail is for the look of the glue gun, but some of it is for reasons such as the logo space where the logo will be written. The other details are for the stand and the detail in the housing for sight of the glue gun and how it changes. These will be cut out of the ABS with a laser cutter because it's quick and easy to do so.



Here I have made sure that the left side of the glue gun housing has raised locator pins but the right side has indented locator pins. This means that the two sides can fit together perfectly without anything getting in the way, but it also means the two housings will stay together, along with these and its snap fits or screws. Snap fits would be ideal for DFMA because less material is being used, but screws will make sure it is easy for the user to open the glue gun up and fix it if a problem occurs.

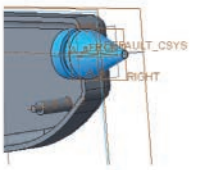
The nozzle



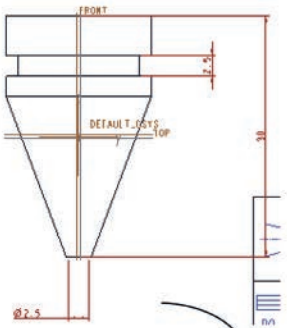
After the two housings were made in Creo, my next step was to follow the designs and create a nozzle for the glue gun. I would need to make sure it has the right dimensions to fit exactly into the glue gun housing without being loose or being too big to fit. I made the indented part of the nozzle 2.5 mm because that's how thick the ABS is on the housing of the glue gun, so it will definitely slot into the gap perfectly.

The nozzle:

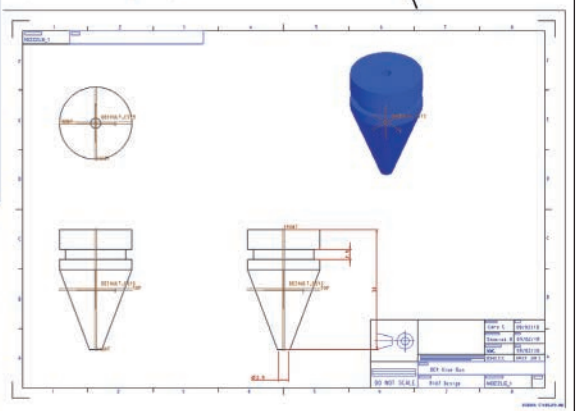
- will be made out of a cheap and easily manufactured metal such as brass.
- will have a total height of 30 mm, which isn't too big that it'll be heavy, plus it's saving as much material as possible, so I have thought back to R105 DFMA
- will get immensely hot when in use, so a rubber coating may be beneficial
- will slot into the front opening of the housing
- will be connected to an internal component called the heating element.

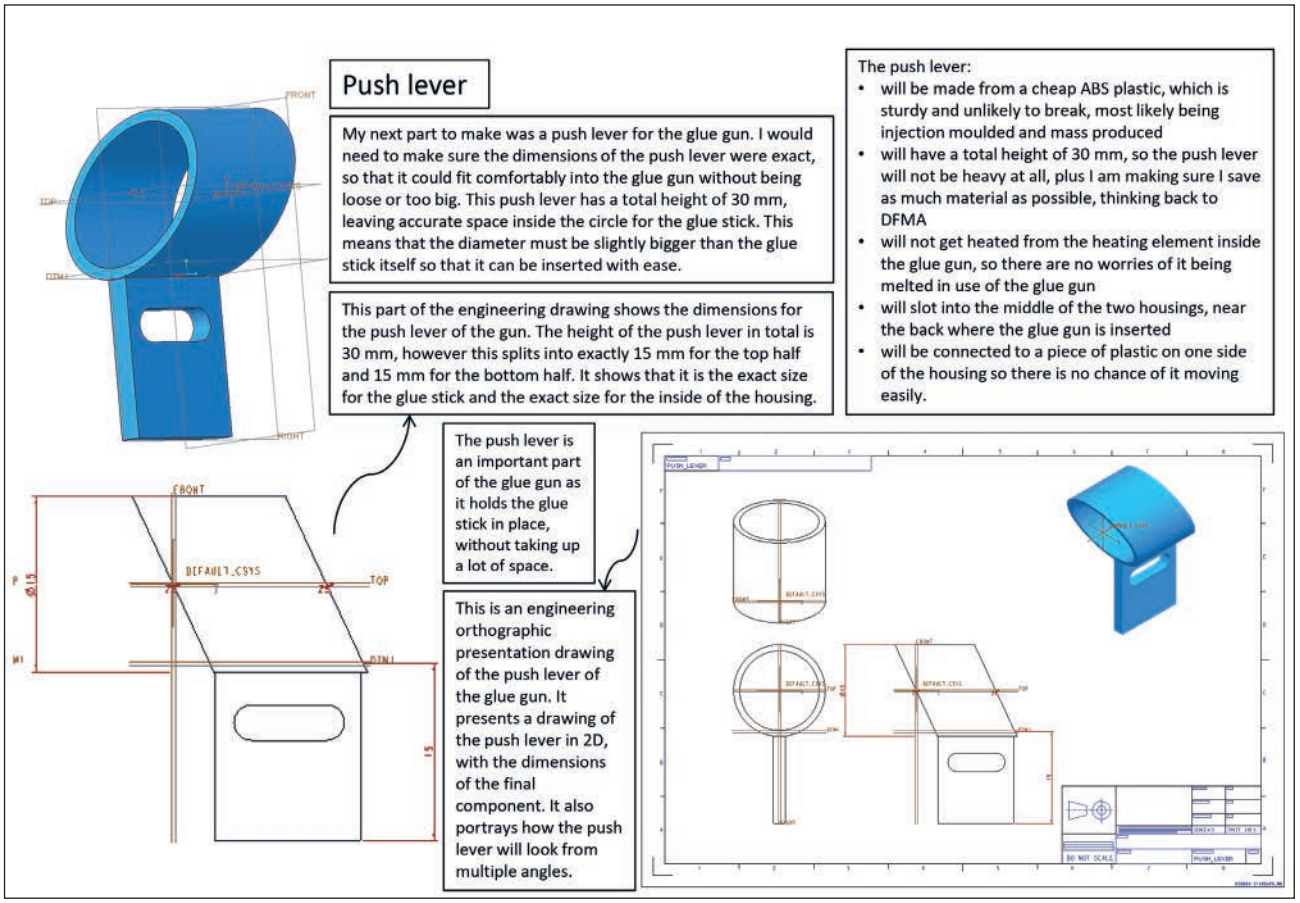


This is an engineering orthographic presentation drawing of the nozzle of the glue gun. It shows the design of the nozzle in 2D, with the dimensions of how big the nozzle will be. It shows how the nozzle will look from all views, and shows how it is designed with the gaps and spaces. The opening at the front of the nozzle will have a diameter of 25 mm, and the nozzle will be 30 mm tall.



This part of the engineering drawing shows the dimensions for the nozzle of the gun. The gap where it will slot into the glue gun housing is 25 mm, as is the opening at the front of the nozzle where the glue comes out. The height of the nozzle itself is 30 mm.





The candidate has presented an assembled 3D model of the glue gun's final design, suitably rendered with colour and shading.

An animation of the glue gun is embedded into the presentation, which has been produced using presentation software.

The final presentation includes a summary of materials, manufacturing processes and assembly methods for the glue gun.

The candidate's work demonstrates a wide range of 2D and 3D CAD techniques, including: producing complex shapes; using revolves and extrudes; using the shell tool; using mates and constraints; creating virtual models; and using more advanced tools such as rendering and animation.

It also includes a summary of a class survey to identify the most popular colour for the design, along with suitably rendered examples to illustrate the different colour options.

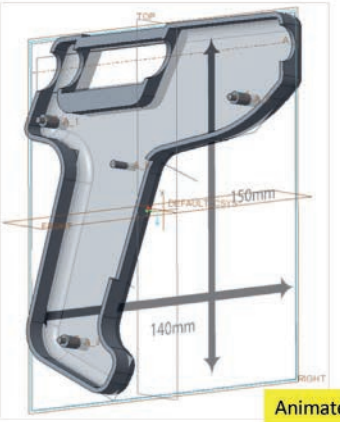
The visuals of my final design

This is my final design, made on Creo. I have created each component independently while taking into consideration the dimensions and how the glue gun will fit together. Then I put all the components together, using assembly in Creo. The animated GIF at the right hand side of the screen portrays how I put this together and how I got all the parts to fit together perfectly, while also showing how everything fits into the housing of the glue gun.

The glue gun:

- will have these components involved: nozzle, push lever, glue stick, cable, trigger, stand and housing
- will have a housing 2.5 mm thick made from ABS plastic, making it as sustainable and durable as possible without being heavy
- will have components such as the nozzle and the stand made out of a metal like brass, which is easy to obtain and cheap
- will have an area for branding, where the logo could be placed
- will have a cable cover made from a rubber type material, which is a bad conductor of heat, making it safer
- will have accurate dimensions so everything fits together perfectly
- will have curved edges so it is safe for the user and they won't be able to cut themselves on sharp edges
- will be able to stand independently due to the metal stand
- will be aesthetically pleasing as the colours go well together and the glossy finish makes it look good.

This animated GIF shows how the glue gun will be assembled part by part. I have made this GIF by adding several photos of the glue gun I created and designed in Creo, each photo adding another component. This is the exact process of how I built up the glue gun during assembly. I started with the left housing of the glue gun and slowly built it up by adding in the components one by one, the order of this being: nozzle, push lever, glue stick, cable, trigger, right housing and, finally, the metal stand of the glue gun.



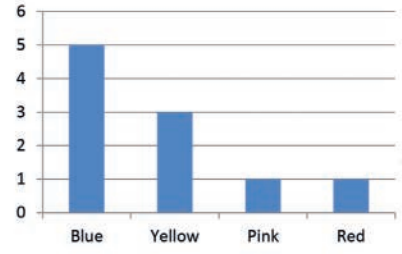
Animated GIF

The hot melt glue gun will:

- be manufactured with a two-part moulding
- incorporate space for internal components
- incorporate a trigger to dispense the glue
- be easy to reload the glue stick
- be able to stand independently
- incorporate an area for branding
- be ergonomically comfortable to use
- be aesthetically pleasing.

Aesthetics can be important for a product, especially if it is a product that is electrical. If a product looks nice to a customer, they would most likely believe that this product works better than a worse looking one, even if this is not the case. It is also important because it allows the customer to believe they have spent their money well and have found something worth their money. This is why the looks of the glue gun would be important for the customers, also the specification says that the glue gun should be 'aesthetically pleasing'.

This slide shows how I have used Creo to change and alter the colours of my glue gun. I did this to see which colours would be the most aesthetically pleasing for the user. The original design, which was grey and light blue, went very well together and is very aesthetically pleasing for the customer. This is important because it means more customers will buy this glue gun over others due to the illusion of working better. I have, however, changed the light blue of the glue gun to colours such as yellow, pink and red. I think the yellow version of the glue gun is the most aesthetically pleasing out of the three because yellow and grey are quite complimentary.



This graph shows which glue gun ten people preferred the aesthetics of, proving that the light blue glue gun is the most popular with five people, the yellow glue gun has three people who prefer it, and the pink and red glue guns both only have one person who preferred them. This means that the blue glue gun design is the one I will be taking forward to make a prototype of.

Synoptic links

Unit R039 allows you to apply the key knowledge, skills and understanding that you learned in Unit R038, particularly with reference to:

- the iterative design process and the generation of design ideas by sketching
- the communication of design outcomes using 2D and 3D engineering drawings and standard drawing conventions
- the use of CAD software, including its advantages and limitations compared with manual drawing techniques.

It also relates to manufacturing considerations that affect design.

The learning in Unit R039 enables you to read, understand and produce 2D and 3D engineering drawings using CAD, in preparation for creating a virtual CAD model and making a prototype in Unit R040.

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