Primary features of engineering products

Engineers need to be familiar with a range of components and parts that may appear in potential briefs or projects. These should include:

Electrical components

- **Connections:** these can include push fit electrical tabs, solder, screw down, etc.
- **LEDs:** a range of LED forms and sizes including bar graph, eight segment blocks and LED panels.
- **Resistors:** fixed and variable resistors.
- **Fuses:** their application and purpose.
- **Diodes:** identifying and understanding their use in a circuit.
- **Power supplies:** battery types, mains and low voltage systems.

Mechanical components

- **Fixings:** nuts, bolts, washers, etc.
- **Clamping devices:** cam locks, level locks, etc.
- **Adjusting mechanisms:** screw threads, ratchet systems and cams.

Properties of component materials

- **Conductivity:** looking at conductivity of both heat and electrical current, plus how these can be isolated when needed.
- **Friction:** the effects that friction can have on a product including intentional friction.
- **Durability:** how durable is the product, look at the materials and construction.
- **Quality:** does the quality of the product look high or low grade, flash on mouldings, sink marks in plastic, uneven fit of parts, etc.

Identifying features of other engineering products allows engineers to research and compare other similar products to determine if there are features that could be replicated or adapted to meet the criteria for the new-engineered product in the brief.

For example:

- **Aesthetics:** looking at how the aesthetic of other similar products meet the brief. Aesthetics focus on how a product looks.
- **User/customer/client needs:** how the products final outcome meet the needs of user and client.
- **Safety:** what safety factors or features are evident in the design.
- **Ergonomics:** how well do the ergonomics of the product function (comfort, use etc.).
- **Anthropometrics:** does the product conform to standard anthropometric data.
- **Mechanisms:** what mechanisms are featured, gears, levers, cranks, etc.
- **Electronics:** how have electronics been incorporated, what components have been used.
- **Sustainability:** has sustainable materials been used, is it easy to recycle the product?
- **Material properties:** what properties are required or seen in the materials used. Look at hardness, toughness, malleability, brittleness, etc.

Function of the proposed solution

Functional requirements are identified in briefs and specifications for engineered products and are an explanation of what the expectations of the product are.

Engineers need to ensure that details of how the product functions is clearly explained. This is often undertaken using notes and sketches to further detail their solutions.

Details should be given on areas such as:

- **Mechanical function:** should include any mechanisms in the solution, gears, cams and levers, as well as mechanical fixings such as clamps and catches should be explained.
- **Electrical function:** should detail the electrical or electronic details of a solution. Details on inputs, outputs and components could feature in this area.
- **Interrelating components:** should also be details, especially if unclear from an engineering drawing. Electrical input resulting in a mechanical output, for example.

Generating a range of engineering solutions

Engineers create new products through a process of research and iterative development.

Research can include the analysis of products that may have similar solutions or even parts of them could be incorporated into a new idea.

The **brief** should be followed in all areas to ensure that solution and proposals meet the specific requirements of the task. If a specification is issued alongside the brief, then those points should also appear in annotation within the design process.

Sketches should be used to explore a range of ideas but should be fully supported by clear and detailed annotation. Where appropriate, links or references to a brief and specification should be present.

Development should be clearly annotated and form a part of an iterative process that clearly shows how the idea has progressed through to a final conclusion. Again, annotation and links to the specification and brief should clearly be evident.

CAD can be used to show clear development and is an excellent tool to make the iterative process clearer. Designs can be modified and saved in stages prior to presenting. It is also a good way of generating engineering drawings for the final solution. CAD also allows the production of high quality and realistic visuals.

Testing is used to support development of ideas and can focus on a number of areas:

- **Aesthetics:** seeing how the overall product looks from a visual sense.
- **Materials:** testing on materials to see if they are fit for purpose.
- **Ergonomics:** can be tested to see if the interface between product and user meets expectations.
- **Mechanical:** simple tests to check if mechanisms work in the way expected.
- **Electronic:** tests on circuits using breadboards or prototypes.

Developing ideas through to a conclusion

Ensuring that all aspects linked to the brief and design specification are addressed is a vital part of the designing stages. As a part of this process, evaluative methods such as a SWOT analysis should be undertaken against a small number of design ideas.

SWOT analysis looks at four key areas of selected design proposals:

1. **(S) Strengths:** these focus on the strengths of the design, what works well, what makes it better than the competitions' products, etc.
2. **(W) Weaknesses:** explore areas that need improving to ensure the design is successful.
3. **(O) Opportunities:** unexpected benefits from the design.
4. **(T) Threats:** looks at what could be problematic for the design, such as a better product being launched by a competitor.

Communicating design ideas

The information in design proposals needs to be relevant and use a suitable media to display the information. Sketches and CAD are the most common form of displaying ideas and development stages.

It's important that sketches have a logical structure so that the iterative nature of the development of ideas can be seen. Annotation should include appropriate terminology associated with design and engineering.

Ideas are often easier to explain when supported by models and detail sketches showing more complex sections in possibly enlarged details, exploded views or isometric.

Models, such as the above example (of a torch), can use a variety of materials including paper and card, foam, clay or other materials. They are not required to be fully detailed or functional but to be a visual aid to assist in the design process.

WJEC Level 1-2 Engineering Unit 2: Communicating an engineering design solution

Producing a manufacturing specification

Before undertaking any making, a complete manufacturing specification should be produced. This should be a document to guide the manufacturers on how to produce the engineered product, as well as providing specification points that must be met during, and at the end of manufacture.

Parts of the information may already be given on sections of drawings from sketch sheets and testing outcomes however, the manufacturing specification pulls all of this information together into a concise document, making it easier to find key information. For example:

Materials information should be included to inform the manufacturer what materials each part should be made from. This may include stock material as well as any additional details about quality, etc.

Technical details should include details of any components used as well as specific tolerances linked to finished parts. This section should also identify bought in parts such as fixings, hinges, brackets, etc.

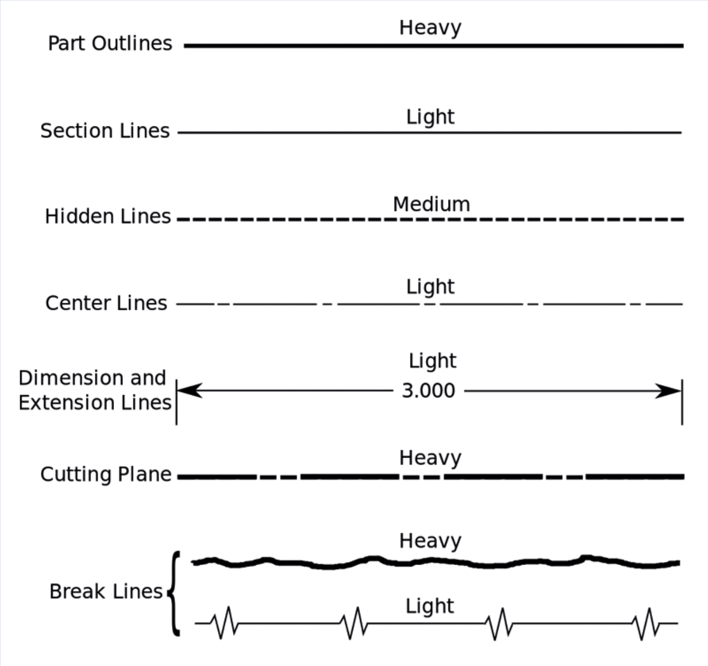
Finishing details focuses on the type of finish applied to each manufactured part, these could be machine finishes such as knurling or polishing or applied finish such as anodising or spray painting. Other finishes, such as printing or spark eroding, could also be covered here.

Drawing an engineering design to standards

Engineering drawings are used to provide all of the details for items to be manufactured in all areas of design and engineering.

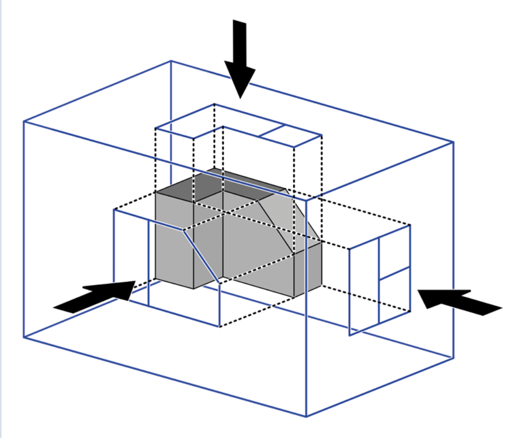
Engineering drawings must follow a set of conventions laid out by **British standards** and these dictate the way that the drawings should be laid out, dimensioned, what scales should be used as well as the types of lines to be used to depict certain views and actions.

In the United Kingdom, designers and engineers use the **third angle projection** method to layout their information on plans and drawings. Drawings undertaking using traditional drawing boards must follow the same conventions as those drawn on CAD (computer aided design) using PC's.



Line weights in engineering drawings also follow British standards and should again be used in traditional and CAD work.

Isometric drawings should be used to illustrate an accurate three-dimensional representation of the part of product. Lines are set up on 30° angles using an isometric grid.



Associate symbols on drawings, including:

- Dimensions and associated symbols:
    - **diameter:** the size of a line that runs from one side of a circle, through the centre to the opposite side
    - **circumference:** the perimeter of a circle or ellipse
    - **radius:** half of the diameter
    - **height, depth and width.**
- **Conventions**, such as:
    - **title block:** gives additional information on a drawing such as scale, name and title
    - **dimension lines:** the actual sizes on an engineering drawing
    - **extension lines:** continue or extend from the surface of the object and establish the size of the dimension
    - **centre lines:** show the exact centre of a circle or arc
    - **metric:** units of measurements to be used.

Using mathematical techniques

Engineers use mathematical techniques to solve areas of engineering design problems across a wide range of areas, such as:

Area and volume is often required to be calculated to understand material us, cost, weight, etc.

Ohm's Law is commonly used in electronics for calculating the correct resistor to use with an LED or the amount of amps of a circuit.

Estimates are created to predict prices of material and production rates.

Ratios are calculated by equations to determine mechanical advantage in gears, levers and pulleys.

Linear dimensions often need to be calculated to ascertain a total dimension size on a drawing.

Scale may be applied to enlarge and reduce parts and components on engineering drawings.

Costings should be used to calculate the price totals of a range of items on a design such as:

- cost of electronic components to be used in a circuit
- unit process on parts created from stock sizes
- quantity process of components parts such as nuts, bolts, washers, etc.

Justifying suitable materials for use in an engineered final solution

Engineers must specify what materials are to be used to produce each component part within their design solution.

The materials must be appropriate and fit for purpose to meet the requirements placed upon them such as friction, torsion, loads, etc.

To successfully achieve this, testing should be undertaken to ensure that the selected or proposed materials are suitable for the task intended. Test can include destructive and non-destructive tests such as:

- **Impact testing:** how the material reacts to being struck by a weight or load.
- **Tension testing:** how the material responds to forces pulling in opposing directions.
- **Compression test:** the materials ability to resist deforming when squeezed together.
- **Shear test:** the materials ability to resist snapping (sheering) when a load is applied to it.

All of these tests are in indications of a materials characteristics such as:

- hardness
- density
- ductility
- elasticity
- plasticity

Justifying suitable processes for manufacturing the final engineered solution

Engineers need to suggest or select appropriate manufacturing techniques for their engineered solutions. These should include:

Method for material removal should focus on how forms can be achieved using cutting and filing techniques or using equipment such as lathes and millers.

Methods for shaping material should make recommendations to tools and equipment, which could be used to fabricate shapes through bending or forming. This could include the use of a sheet metal bender, vacuum former, strip heater for plastics, etc.

Joining methods covers both permanent and temporary fixings. Brazing, soldering and welding could be applied as well as riveting or using nuts and bolts or other temporary methods.

Assembly methods should look at how components and parts are put together. Is there a sequence? Does one part need to be assembled before another can be but in place?

Heat and chemical treatments should focus on the need to anneal or temper materials. Chemicals can be applied to clean or etch metals.

Finishing should state what finish is to be applied to a part such as knurling or painting.