BTEC Engineering guide to exam…

Everything you need to know for component 3 is found in this booklet. Use this to aid your revision for your exam.

Tick the box next to the section once confident with the information.

A	Responding to an engineered brief
B	Provide a design solution for an engineered product against the needs of an engineering brief
C	Provide solutions to meet the needs of an engineering brief

A: Carry out a process	
A: Recording a process	
A: Interpretation of data	
B: Interpretation of a given brief for an engineered product	
B: Redesign	
B: Evaluation	
C: Analysing engineering information associated with the problem	
C: Selecting a solution	
C: Problem solving	

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Level 1 pass	12-17
Level 1 merit	18-23
Level 1 distinction	24-29
Level 2 pass	30-35
Level 2 merit	36-41
Level 2 distinction	42-48

A: Carrying out a process

Why are work instructions important? What might happen without them in place? Circle the correct.

1. Important to ensure processes are carried out in the correct way
2. Reducing the likelihood of mistakes
3. Ensuring the correct tools are being used

Symbol	Name	Function
	Start/end	An oval represents a start or end point
	Arrows	A line is a connector that shows relationships between the representative shapes
	Input/Output	A parallelogram represents input or output
	Process	A rectangle represents a process
	Decision	A diamond indicates a decision

How may work instructions be displayed?

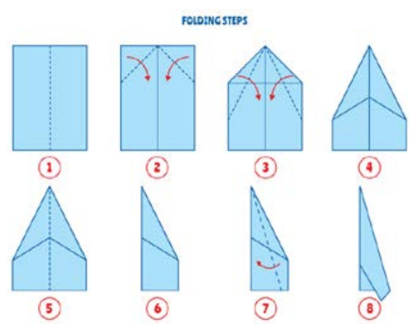
1. Flow charts
2. Schematic drawings and diagrams
3. Process documentation
4. Production plans
5. Job cards

Using either a flow chart or a sequential drawing- produce a production plan for a simple engineering activity, choose from the following.

- Laser cutting
- Turning on a lathe
- Die casting

How might we improve a production plan? Choose from the following.

1. Simplifying the task
2. Add more complicated processes
3. Remove any unnecessary stages of the process
4. Reduce the number of tools/machinery used



Take your production plan from the previous activity and…

1. Highlight any stages in the plan where tasks could be simplified
2. Note any stages that could be removed
3. Is there opportunity to remove any tools, components or equipment?

Why do we use prototypes?

____

Why is disassembly of a product important?

____

(Is there anything in your house that you could have a go at disassembling, if so, have a go and see what you find?)

If not take a look at the image on the next page.

Reverse engineering is the process of disassembly and analysis of a product to investigate how a product was manufactured.

- Produce a spider diagram stating why **reverse engineering** might benefit engineers

DID YOU KNOW?
Many classic cars, steam railway engines and old aircraft are still in use today only because of reverse engineering. It allows engineers to manufacture replacements for obsolete components.

Think about the different tools you will need to disassemble an engineered product?

HANDLING AND USING MATERIALS, EQUIPMENT AND MACINERY

1. Name the two categories of metals…

____

1. Name the two categories of polymers/plastics…

____

____

Key term:
Alloys- are mixtures of two or more metals that have improved properties and characteristics.

Health and safety…

Name the safety rules you must follow when carrying gout the following processes:

1. Handling sheet metal
2. Welding
3. Spray painting

Many material forms are supplied with a safety data sheet, which will give information on:

- **Safe handling and storage requirements**
- **PPE that should be worn**
- **What to do if there is an accident or spillage**

You should only use equipment and machinery that you have been instructed how to operate, so that you are aware of the safe working practices that you need to follow. Some equipment can only be used with certain materials, which is why it is important to check that the equipment is suitable for the process.

1) Research methods of handling a range of metallic and polymer materials.
2) List the safe working practices advised for each material

Recording the process

Accuracy:

It is important to record data with values of accuracy. This means that any measurements are within an agreed tolerance level. Depends on the way in which measurements are taken and how they are recorded.

Reliability:

Is important when analysing information. If there are mistakes in recorded data then the results will not be reliable and could lead to you drawing the wrong conclusions. Depends on there being only small variations in data and measurements being within tolerance.

Precision:

When you are recording data, one of the decisions hat you will need to make is the degree of precision required. This will depend on what you want to use the data for. It refers to the closeness of two or more measurements to each other. For example if you weigh a given substance five times and get 3.2kg every time then your measurement is very precise.

What is a unit of measurement? Give three examples:

____

____

Title: How Do We Get to School?

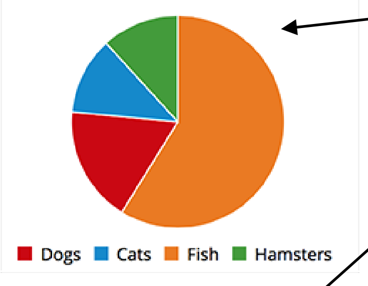
Categories	Tallies	Total
Walk	𝍸 II	7
Bike	III	3
Car	IIII	4
Bus	𝍸 𝍸 II	12

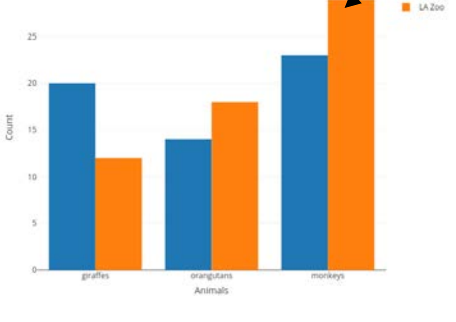
Collecting data, take a look on the internet at some tally charts and familiarise yourself with how they work and how data is collected through them.

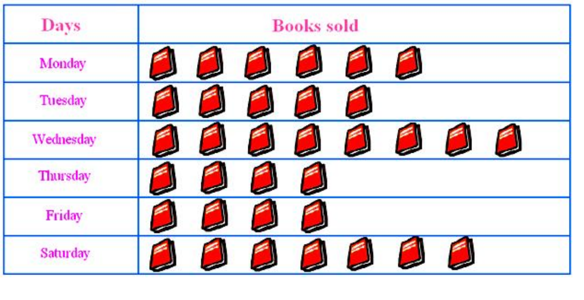
So how do we display this data?

TYPES OF CHARTS:

Chart type	Graph type
Pie chart	Line graph
Bar chart	Scatter graph
Pictograph	

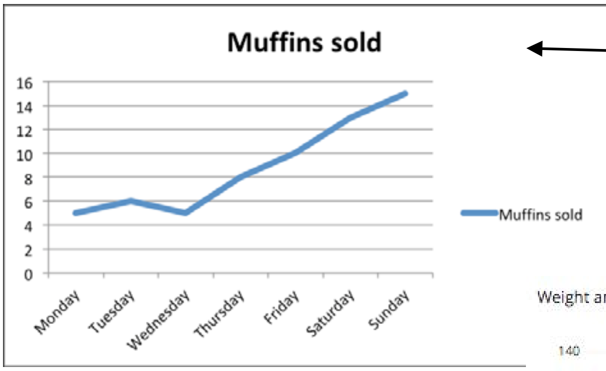


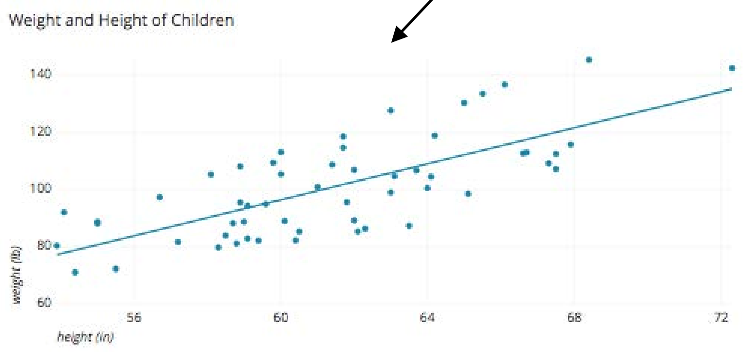




TYPES OF GRAPH:

Chart type	Graph type
Pie chart	Line graph
Bar chart	Scatter graph
Pictograph	





Input the following data into each different chart and graph:

1.

Diameter of screw (mm)	Total
4	18
5	12
6	23
8	19

2.

Load-extension data								
Load (newtons)	50	75	100	125	150	175	200	225
Extension (mm)	14	26	38	50	62	74	86	98

Benefits of each display form:

1. Pie chart- good for showing the relationship between individual groups of data and the total amount of data.
2. Bar chart- useful for identifying trends, such as what is most popular or what happens the most.
3. Pictograph- show data by using images.
4. Line graph- useful for showing how things change over a period of time or where one value is being compared to another.
5. Scatter graph- can be useful if you are collecting lots of measurements from an investigation.

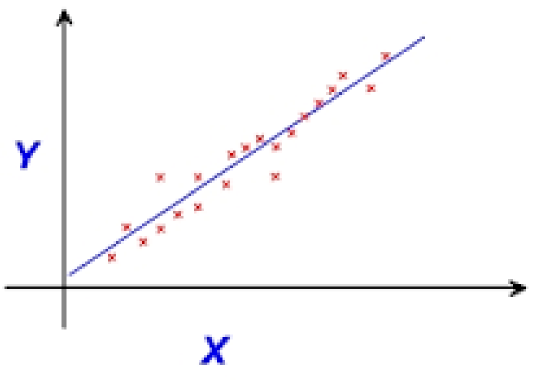
Lines of best fit:

So far we have looked at data that:

- Can be sorted into groups
- Follow a trend or pattern

SCATTER GRAPHS

Once you have created a scatter graph, the results are presented visually but they are not always very effective at communicating information. It is difficult to identify patterns or trends that might be useful.



A line of best fit is shown above. A line of best fit is used to help identify any values that have been measured incorrectly.

1. **Note down reasons why you think tabulated data and scatter graphs are useful in engineering investigations?**
2. **Have a go at plotting the following results into a scatter graph and draw a line of best fit. Draw this to the right of the table and remember to ALWAYS label your graph.**

	Length (mm)				
Mass (g)	Test 1	Test 2	Test 3	Test 4	Test 5
50	10	12	11	8	10
100	14	15	13	17	15
150	19	20	21	21	19
200	26	25	27	24	26
250	32	30	29	30	28
300	34	35	37	33	35

Interpretation of data

Comparison of trends and patterns:

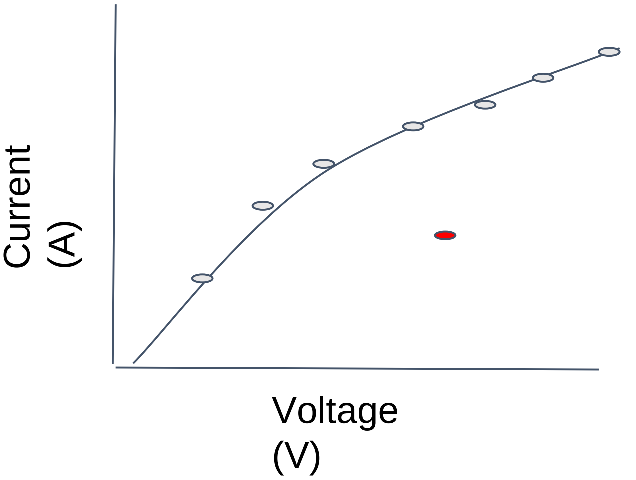
Figure 1:

Distance-time comparison								
Time (seconds	0	5	10	15	20	25	30	35
Distance (metres)	0	10	20	30	40	50	60	70

Sometimes a table alone can be enough data to allow us to compare results and identify trends or patterns. For example in figure 1 above it can be clearly seen that as time increases he distance from the start point also increases.

Sometimes however, the results of an investigation can be harder to interpret as patterns may not be so clear.

V (V)	I (A)
0.00	0.00
1.50	0.40
3.00	0.78
4.50	1.00
.00	1.15
7.50	1.28
9.00	1.42
12.00	1.62



We can see that as the voltage increases so does the current but the rate of increase is not consistent. Therefore we would not get a straight line on a line graph. The line graph above shows that there is a trend; as the voltages increases, the current increases but the rate of increase becomes slightly less.

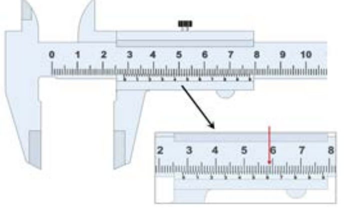
Anomalous results

The red dot on the line graph indicates an anomalous result where it does not fit the expected pattern or trend. ‘The odd one out’. Usually this is caused by a mistake when taking the readings or a faulty sample. Anomalous results are much easier to spot when data is put into a line graph/scatter graph compared with a chart of data.

<u>CHALLENGE YOURSELF:</u> Use the internet to look up some scatter graphs from practical investigations and see if you can spot the anomalous results.

Evaluating processes, drawing conclusions and making recommendations:

Measurement	**Equipment**
Length/diameter	• Ruler: used for measuring lengths to a precision of 1mm. • Vernier callipers: used to measure the length or diameter of smaller components, to a precision of 0.02mm. Vernier callipers are used for very accurate measurements. • Micrometer: used to measure the dimensions of small components to a precision of 0.001mm. • Tape measure: used for larger length measurements.
Mass	• Balance: used to measure the mass of an object, eg. beam balances for large masses and digital balances for smaller masses.
Time	• Stop watch: used to measure time, to a precision of 0.01 seconds. (In reality, accuracy depends on the person operating the stopwatch). • Electronic systems: automatically start and stop when a sensor is actuated and are more accurate.



Sometimes it might not be necessary to measure the exact size of a component. For instance you may simply need to know whether as component and any of its features are correct, such as whether a drilled hole has a large enough diameter.

Gauges

Go/no-gauges can be used for checking the diameters of holes.

- The go gauge coloured green must be able to fit through the hole. If the go gauge does not fit, the hole is too small.
- If the no-go gauge coloured red fits through the hole this means the whole is too big and a smaller drill bit should have been used.
- If the hole is within tolerance the go gauge will fit in the hole and the no-go gauge will not.

Activity:

Use the internet to find videos of how to use some of the tools mentioned above. Especially a gauge.

Check your learning: **Strength**	**Challenge**
• Describe four methods of presenting data graphically • Give an example of one type of work instruction and what it is used for? • Which methods can be used to improve an engineered product?	• Explain why an engineer might use a gauge when carrying out quality checks. • Describe two advantages of using mechanical fixings for engineering products. • Explain what should be done if data show anomalous results.

B: Interpretation of a given brief for an engineered product

Getting started

Note down all the types of information that would need to be included in a design brief for an engineered product.

A design brief will include a range of factors:

- Physical requirements
- Aesthetics
- Size
- Function
- Performance requirements

Physical requirements:

Does the design need any specific physical requirements? Will the component need to be able to hold a specific loading or be connected to another component in a specific way?

Does the component need to offer any form of protection?

Aesthetics:

You will need to think about why the product is shaped in the way that it is. Is the component designed in a specific shape and style for a particular reason, or simply to make it look good?

Size:

How big does the component or product need to be? Are there any maximum or minimum size requirements for the product?

You might be designing something that is going to be a direct replacement for something that already exists. In this case the size of the new component will be the same as the current one.

Function:

You need to think about what the product or component is designed to do. This could be a list of statements. For example, a light switch must control electrical current to a light fitting and must also enclose all the wires and prevent the user from getting an electric shock.

Performance requirements:

You need to think about how the success of the product is measured. Does it need to last for a set time or be able to move a specified distance? Performance requirements will be different for each product, but they can often be thought of as targets that need to be met for the product or component to be termed a success.

Activity:

Research an engineered product, either by looking on the internet or by examining a physical product. Write out a design brief for the product, you need to include the following: Physical requirements, Aesthetics, Size, Function and Performance requirements.

Features of an engineered product:

Dimensions, Surface finishes, physical form.

DIMENSIONS:

The dimensions of a product are very important. If a dimension is too big it will probably not fit in the space it is designed for; if it is too small then connections to other components will not be possible. This is known as tolerance.

When you examine a product to check it's dimensions, you will use one of the following measuring tools:

- **Steel rule-** steel rules are used for measuring lengths to a precision of 1mm.
- **Micro meter-** can be used to find the dimensions of small components to a precision of 0.001mm.
- **Vernier callipers-** these are used to measure the length or diameter of smaller components to a precision of 0.02mm.
- **Tape measure-** these are used for larger dimensions when precision is less important.

Tolerances: remember for components parts of an engineered product to fit together properly, they need to be produced to an agreed tolerance.

SURFACE FINISHES:

The surface finish of an object says how smooth its surface is. Surface finish is measured in micrometres (µm) **1µm = 0.0000001m.**

The finish of an object will have a significant impact on how the component looks, but will also influence how resistant the component will be to wear and damage, or to corrosion, eg. Rust.

PHYSICAL FORM:

The physical form of a component is the shape it takes.

Try to be descriptive about the form of an object; think about whether it is a regular shape, such as a cone or cube or an abstract shape that is harder to describe, Consider the terms **2D, 3D, flat and curved** to support your descriptions.

ACTIVITY:

Number the component 1-6 on the right hand side and have a go at describing their form and surface finish.

Write a short paragraph on your understanding of tolerance and why it is important for engineered products.

Selecting engineering materials:

Categories of materials:

FERROUS METALS:

These metals **CONTAIN IRON.**

Material	Properties
Mild steel	Good tensile strength, good levels of ductility and malleability.
Stainless steel	Very tough, corrosion resistant.
Wrought iron	Very tough, corrosion resistant, good levels of ductility and malleability.

NON--FEROUS METALS:

These metals **DO NOT CONTAIN IRON.**

Material	Properties
Aluminium	Soft and malleable, good conductor of electricity.
Titanium	Low density, quite good levels of ductility.
Copper	Tough, very ductile, very good electrical conductor.

THERMOSETTING POLYMERS:

These are plastics that **cannot be reshaped or remoulded once shaped.**

Material	Properties
Phenol-formaldehyde	High electrical resistance, high heat resistance, hard wearing.
Polyimides	Self-lubricating, resistant to oil, fuels and chemicals.
Polyurethane	Good hardness properties, high tensile strength and impact resistant.

THERMOFORMING POLYMERS (THERMO POLYMERS):

These are plastics that can be reshaped or remoulded once shaped.

Material	Properties
Polyethylene	Excellent chemical resistance, good wear resistance.
Polypropylene	Quite high tensile strength, good resistance to cracking and stress.
Acrylic	Very stiff material, good durability, good electrical insulator.

Activity: find an example of an engineered product and examine to product o identify the materials used to make it. Name the material, research the properties of materials and suggest an alternative material that could be used.

Manufacturing processes:

CUTTING:

Process:	**Examples of use:**
Drilling	Making holes and producing blind holes and flat bottomed holes that do not go all of the way through the material.
Sawing	Mechanical or manual methods can be used, coping saws used for many polymers and hack saws are generally used for metal materials.
Filing	Used to remove burns or sharp edges from the surface of the material, used to add a round edge or chamfer and can be used to make holes bigger or to shape them.
Shearing	Used to produce straight cuts and can be used on sheet materials or bar.

SHAPING:

Process:	**Examples of use:**
Turning	Producing flat faces that are a square end to a bar, producing a range of diameters on bars and adding features to the outside of bar including screw threads and chamfers.
Milling	Producing flat, square and parallel features and machining shoulders, steps, slots, grooves and recesses.

FORMING:

Process:	**Examples of use:**
Casting	Sand casting is used for large components where accuracy is less important, die casting is used for large batches and where tolerance is tight and investment casting is used for very complex shapes where tolerance are very important.
Forging	Drop forging is used for smaller shapes, upset forging is used for simple products such as head of a bolt, press forging is used for large objects.
Extruding	Extruding is a process used for polymers. Complicated hollow sections can be made by forcing soft polymers through a die.
Moulding	Injection moulding is used for complex shapes (housings for electronics), blow moulding is used for hollow containers and vacuum forming is used for simple hollow containers and enclosures.

JOINING AND FABRICATION:

Process:	**Examples of use:**
Fastening	Fastenings provide a mechanical joint between components. Most are temporary-nuts, screws and bolts.
Bonding	Similar to gluing, giving an adhesive joint between materials.
Soldering	The process for joining electronic components to circuit boards. When solder solidifies the joint is made.
Brazing	Similar to soldering but at a much higher temperature. Used to join different metal together.

Activity:

Find out the process used to make or ioin the following components:

1. Nuts
2. Hinge
3. Circuit board


B: Redesign

Identifying issues with existing designs:

This is an important part of the engineering design process and often involves asking questions such as:

- Are the existing materials suitable?
- Has the product been manufactured using the most suitable processes?
- Are there any weak points in the design?
- Is the product too complicated- how many parts are used in the assembly?
- Does the product make the most efficient use of materials?

Once you have identified issues with your design, you can then start to look at methods to develop and share your design.

CONCEPT 2D SKETCHING:

Have a look at the redesign sketches on the right for an existing product.

1. Make a list of all of the similarities and differences between the designs.
2. Think about the reasons why some parts of the designs are similar.
3. Produce a small selection of alternative sketched ideas for the product.

PRACTISING SKETHING:

1. Find some images of engineered components using the internet.
2. Print out images of the components or have them in front of you if you cannot print at home.
3. Sketch out the components using only 2D views. On the next page)
4. Add annotations to the sketches to explain the different features of the components.

Sketch page

3D sketching:

Oblique projection

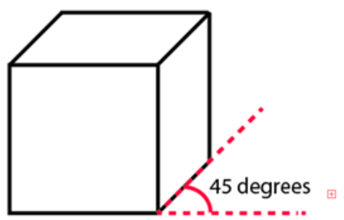
With an oblique projection you draw one full face of an object and then the other lines are projected back at a 45^{0} angle from the corners shown. Sometimes drawn to scales or sometimes halved.

Isometric projection

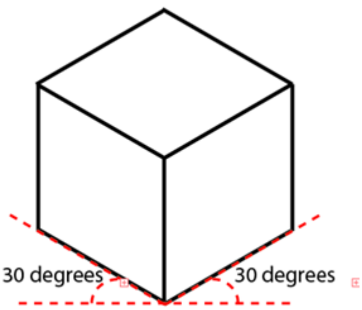
Unlike oblique projection, isometric has all the sides drawn at an angle. Vertical lines always remain vertical however the horizontal lines are drawn at 30^{0}. Isometric drawings are good for showing how things fit together.

Perspective drawings

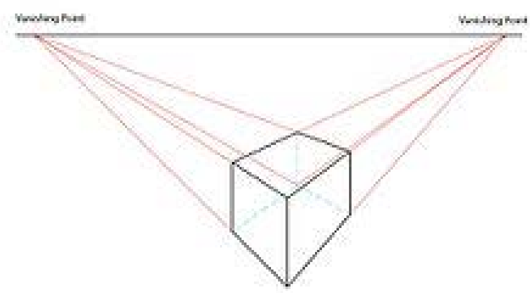
There are three types of perspective drawings; one point, two point and three point perspectives. One point perspectives is similar to an oblique projection with a front face being drawn in full. Two point perspective is probably the most useful method as it can be drawn to show whichever features of the component need to be emphasised.



OBLIQUE PROJECTION



ISOMETRIC PROJECTION



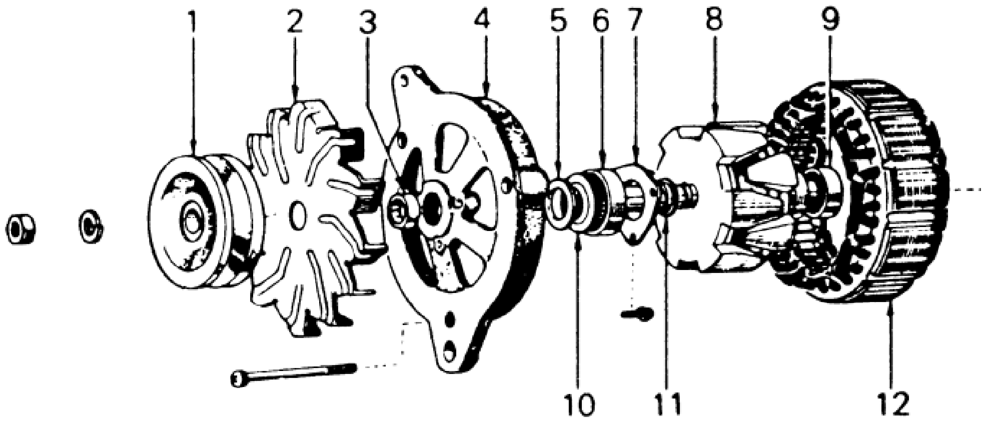
3D drawing type	Advantages	Disadvantages
Oblique	Gives an accurate view of one face, gives an impression of thickness or depth, measurements can be taken from the front face.	Circles are shown as ellipses except on the front face, component can look distorted due to perspective.
Isometric	Shows three sides of a component clearly, no changes to the proportions of drawing, easy to interpret by most people.	Can be hard to add dimensions or take measurements from, circles are drawn as ellipses.
Perspective	Gives a realistic view of the product or component, allows the component to be shown from any angle.	Due to the perspective, some details may be hard to see, difficult to add dimensions, circles and curved edges are hard to show.

Activity:

Sketch the component below trying each 3D technique. There is some isometric paper on the next page.

Isometric sketch page

Exploded diagrams:



Guidelines to follow when producing an exploded diagram:

- Parts should always line up with each other to show exactly how they fit together.
- Parts should be easy to identify, using either part names or a reference number system.
- If a part cannot be shown in the line with where it needs to fit into the assembly, add projection lines to show where the part needs to be placed.

ACTIVITY:

Label the component which has a projection line shown to where it would fit in using the number 13.

For the multifunctional bike tool to the right which we disassembled in class. Could you produce a rough exploded diagram showing how it is assembled.

- Produce sketches of each component/part.
- Add annotations to show what each component is.

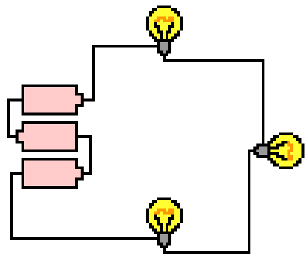
Produce a parts list like the one below for each of the components you have labelled on your exploded diagram.
Remember to include:

- Components identifiable part number
- Components description
- Information on the component's materials
- Quantities of each amount

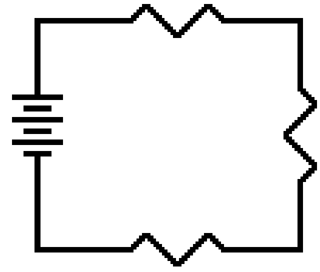
Find NO.	QTY	Part	Material
12	6	BOLT	STEEL
11	4	5mm SCREW	STEEL
10	6	WASHER	COPPER
9	1	SHIELD	STAINLESS STEEL

Electronic circuit diagrams:

Drawing of Circuit



Schematic Diagram of Circuit



When you draw a circuit schematic diagram it needs to meet the international design standards. So you must use the correct symbols. It should be possible for anyone who understands circuit schematic diagrams to manufacture the circuit from the diagram.

Criteria for when drawing a circuit schematic diagram:

- Use straight horizontal and vertical lines
- Draw all components symbols at the same scale
- Avoid having symbols too close together, making sure that it is clear how different components are connected.

ACTIVITY:

Using the symbols below create a table at includes the following:

- The description/name of each component
- An image of the actual electronic component
- The electronic circuit schematic symbol for the component.