Bishop Chadwick
Catholic Education Trust

KS5 BTEC ENGINEERING Knowledge Organiser

Level 3 Extended Certificate in Engineering

NAME:			
CLASS:		**TEACHER:**	

Target Grade		WAG	Mod 1	Mod 2	Mod 3
Confidence Gauge	1 2 3 4 5 6 7 8 9 10				

MODULE REVIEW CLOSING THE LOOP	WWW	EBI
MODULE 1		
MODULE 2		
MODULE 3		
MODULE 4		
MODULE 5		
MODULE 6		

Intent, Implementation and Impact in KS5 Technology

Our Mission Statement:

'We aim to use an iterative and explorative design cycle to empower students to become creative and critical thinkers. To find solutions to everyday problems that meet users' needs and make the world a better environment for all in an inclusive way.'

What this means in your lessons:

- ***An iterative and explorative design cycle***

We want you to try to always be improving your ideas and looking for new solutions.

- ***Creative and critical thinkers***

We want you to think outside the box and challenge the ordinary designs you see every day.

- ***Solutions to everyday problems***

We want you to be the people who solve the challenges the world is facing through your new thoughts and exciting ideas.

- ***Meet users' needs***

We want you to think about what your users need every step of the way so your design is 'human centred.'

- ***Make the world a better environment***

We want you to help protect and improve the world for future generations to come.

- ***In an inclusive way***

We want you to design with an awareness of the challenges and barriers your customers may have.

Course Structure KS5 BTEC Engineering

Level 3 Extended Certificate in Engineering

Extended Certificate in Engineering 360 GLH

Same size as 1 A Level Applied General

Total units: 4
3 Mandatory Units
PLUS 1 Optional Unit

Purpose:

- Provides a broad basis of study for the engineering sector
- Designed to support progression to higher education when taken as part of a study program that includes other appropriate BTEC National qualifications or A Levels

Assignments (internally assessed)

Set and marked by: Centre
Verified by: Pearson

Assignments are practical tasks set in work-related scenarios that can be tailored to local industry needs for your learners.

Learners demonstrate how they apply knowledge and skills to complete a practical project over a period of time, working individually or in groups.

Tasks (externally assessed)

Set and marked by: Pearson

Tasks are practical work-related scenarios completed in realistic, time-based situations.

They are completed in controlled conditions and tasks have pre-released information.

Learners demonstrate how to apply learning to common workplace or HE scenarios. Tasks provide evidence of a consistent standard of assessment for all BTEC learners.

Written Exams (externally assessed)

Set and marked by: Pearson

For written exams, learners draw on essential information to create written answers to practical questions in exam conditions.

Learners demonstrate they can apply appropriate knowledge to a work-related challenge in timed conditions.

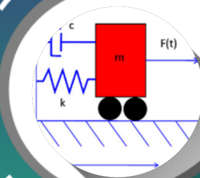
Unit	Title	Focus
1	Engineering Principles	Applied math and physics for engineers
2	Delivery of Engineering Processes Safely as a Team	Practical, design communication and project management skills.
3	Engineering Product Design and Manufacture	Design improvement and development.
9	Work Experience in the Engineering Sector	Bespoke work experience to gain real industry awareness

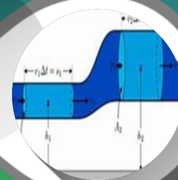
Learning Journey 12-13 BTEC Engineering

Read like an engineer…

Year 12: *Sustainable Energy – Without the Hot Air*
David J.C. MacKay
Engineering: A Beginner's Guide
Natasha McCarthy
The Gecko's Foot: How Scientists are Taking a Leaf from Nature's Book
Peter Forbes

Year 13:*Engineer to Win*
Caroll Smith
An Astronaut's Guide to Life
Chris Hadfield
***Sustainable Materials – With Both Eyes Open* Julian Allwood and Jonathan Cullen**





Engineering Principles
Algebraic and trigonometric mathematical methods
Static engineering systems
Dynamic engineering systems

Delivery of a process safely as team
Common engineering processes
Health & safety
Human Factors
Principles of engineered drawings

Engineering Product design and manufacture
Design triggers and challenges
Equipment & system constraints and opportunities
Material properties
Mechanical power transmission
Manufacturing processes

Work experience in the engineering sector
Developing skills and attributes
Clarifying expectations for employment in engineering
Exploring career options

Revision
Engineering principles
Engineering systems
Iterative design process

On to university, apprenticeship or employment…

Careers Links
Year 12: engage with issues, organisation and personal responsibility, creativity, collaborative working, contextual analysis
Year 13: evaluate skills, monitor performance, drive own project, problem solve, explain reasoning.

Engineering systems
Fluid and thermodynamic
Static and direct current electricity and circuits
Magnetism and electromagnetism
Single phase alternating current

Manufacture
Principles of effective teams
Team set-up and organisation
Health & safety risk assessment
Batch manufacture
Delivery of an engineered service

Design process
Regulatory constraints and opportunities
Market, Performance and Manufacturing analysis
Design proposals
Iterative development process
Statistical methods
Validating designs

Work experience
Work shadowing and observations
Reviewing personal and professional development
Using feedback and action planning

Exams
Unit 1: Engineering Maths exam
Unit 3: Supervised set design engineering task to a brief

Content KS5 BTEC Engineering

Unit 1	
A	Algebraic methods
	Trigonometric methods
B	Static engineering systems
	Loaded components
C	Dynamic engineering systems
D	Fluid systems
E	Static and direct current electricity
	Direct current circuit theory
	Direct current networks
F	Magnetism
G	Single-phase alternating current theory

Unit 9	
A	Own skills and attributes
	Clarifying expectations for employment in engineering
	Exploring career options
B	Preparation for work experience
	Setting goals and learning objectives
C	Work experience tasks
	Work shadowing and observation
D	Reviewing personal and professional development
	Using Feedback and action planning

Unit 2	
A	Examining common products and working drawings.
	Control Plan
	Flow Chart and BOM
	H&S
	Operating processes
B	Drawing conventions
	1st Angle Projection
	3rd Angle Projection
	Dimensions
	Tolerances and Surface Finishes
	Scale and BS 8888
	Layers
	Line types and key terms
	Common features
	Circuit diagrams, symbols and components.
C	Good Communication
	Planning
	Team competencies and development
	Preparation for batch manufacture
	Manufacture

Unit 3	
A	Design Triggers
	Design Challenges
	Equipment level and system level constraints and opportunities
	Material Properties
	Mechanical Power Transmission
	Manufacturing Processes
B	Design for a customer
	Regulatory constraints and opportunities
	Market Analysis
	Performance Analysis
	Manufacturing Analysis
C	C1 – Design Proposals
	C2 – Communicating Designs
	C3 – Iterative Design Process
D	D1 – Statistical Methods
	D2 – Validating Designs

Knowledge Organiser: KS5 BTEC Engineering

Unit 1 Learning Aim A1: Algebraic methods

Key knowledge

Index Laws – Rules for manipulating powers with the same base.
Multiplication Law: $\boldsymbol{a^m \times a^n = a^{m+n}}$
Division Law: $\boldsymbol{a^m \div a^n = a^{m-n}}$
Power Law: $\boldsymbol{(a^m)^n = a^{mn}}$
Zero Law: $\boldsymbol{p^0 = 1}$
Negative Power Law: $\boldsymbol{a^{-m} = \frac{1}{a^m}}$

Fractional Power Law: $a^{\frac{m}{n}} = (\sqrt[n]{a})^m$

Log Laws - $\log_a(n) = x$ means that $a^x = n$

Multiplication Law: $\log_a(xy) = \log_a(x) + \log_a(y)$
Division Law: $\log_a(xy) = \log_a(x) - \log_a(y)$
Power Law: $\log_a(x)^k = k\log_a(x)$

Natural Log – log to the base e
$N = e^x = \log_e(N) = x$, can be written $\ln(N) = x$

Exponential Growth - When we **multiply** a number **repeatedly** by the **same number** ($\neq 1$), resulting in the number **increasing by the same proportion** each time. The original amount can grow very quickly in exponential growth.

Exponential Decay - When we **multiply** a number **repeatedly** by **the same number** ($\boldsymbol{0 < x < 1}$), resulting in the number **decreasing by the same proportion** each time. The original amount can decrease very quickly in exponential decay.

Straight Line Graphs
Straight line graphs are linear. Contain an x term, but no higher power of x. e.g. y = 2x + 1
y = mx + c is the equation of a straight line. m = gradient, c = y-intercept

Straight line graphs can be used to solve simultaneous equations. The point of intersection between the two lines is the solution to the simultaneous equations.

Simultaneous Equations –
A set of **two or more equations**, each involving **two or more variables** (letters).
The **solutions** to simultaneous equations **satisfy both**/all of the **equations**.
Example:

$5x + 2y = 9$ $\quad\quad$ $10x + 3y = 16$
Multiply the first equation by 2.
$10x + 4y = 18$ $\quad\quad$ $10x + 3y = 16$
Same Sign Subtract (+10x on both)
$$y = 2$$
Substitute $y = 2$ in to equation.
$$5x + 2 \times 2 = 9$$
$$5x + 4 = 9$$
$$5x = 5$$
$$x = 1$$
Solution: $\boldsymbol{x = 1, y = 2}$

Expand and Factorise
To expand a bracket, **multiply** each term **in the bracket** by the expression **outside** the bracket.
The **reverse** of **expanding**. Factorising is writing an expression as a product of terms by **'taking out' a common factor**.

When a quadratic expression is in the form $x^2 + bx + c$ find the two numbers that **add to give b** and **multiply to give c**.
$$x^2 + 7x + 10 = (x + 5)(x + 2)$$
(because 5 and 2 add to give 7 and multiply to give 10)

A quadratic in the form $ax^2 + bx + c = 0$ can be solved using the formula:
$$\boldsymbol{x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}}$$
Use the formula if the quadratic does not factorise easily.

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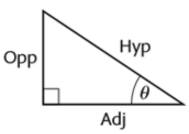
Unit 1 Learning Aim A2: Trigonometric methods

Key knowledge

<u>Converting Radians to Degrees</u> - A **radian** is the **angle** subtended **at the centre** of a circle by an **arc whose length** is **equal to that of the radius** of the circle.

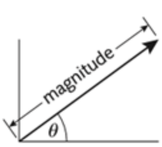
2π radians = 360^o
1 radian = $180/\pi^o$
$1^o = \pi/180$

<u>Trigonometry</u>
In right-angled triangles we name the three sides in relation to the right angle and one of the other two angles, θ



- **sine** (sin), where $\sin\theta = \frac{\text{opp}}{\text{hyp}}$
- **cosine** (cos), where $\cos\theta = \frac{\text{adj}}{\text{hyp}}$
- **tangent** (tan), where $\tan\theta = \frac{\text{opp}}{\text{adj}}$

<u>Vectors</u>
Many quantities encountered in engineering, such as force and velocity, are only fully described when magnitude, direction and sense are known (see diagram below). Such quantities are called vectors. When adding or subtracting vectors you must always take into account the direction in which they act.

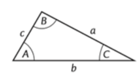


Diagrammatic representation of vectors
- The length of the arrow represents the magnitude of the vector.
- The angle θ specifies the direction of the vector.
- The head of the arrow specifies the positive sense of the vector

<u>Using Radians</u>
The use of radians makes it straightforward to calculate some basic elements of circles with the general formulae shown in Table below, where the angle θ is measured in radians.

Arc length	$= r\theta$
Circumference of a circle	$= r(2\pi) = 2\pi r$
Area of a sector	$= \frac{1}{2}r^2\theta$
Area of a full circle	$= \frac{1}{2}r^2(2\pi) = \pi r^2$

<u>Sine and Cosine Rules</u>
The basic definitions of the trigonometric functions sine, cosine and tangent only apply to right-angled triangles. However, the sine and cosine rules can be applied to any triangle of the form shown below

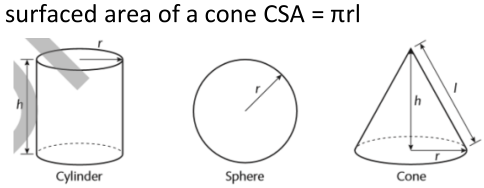


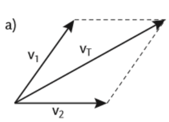
- The sine rule: $\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}$

Cosine rule:

$a^2 = b^2 + c^2 - 2bc\cos A$
$b^2 = a^2 + c^2 - 2ac\cos B$
$c^2 = a^2 + b^2 - 2ab\cos C$

<u>Area and Volume</u>
Volumes of a cylinder $V = \pi r^2 h$
Total surface area of a cylinder $TSA = 2\pi rh + 2\pi r^2$
Volume of sphere $V = 4/3\pi r^3$
Surface area of a sphere $SA = 4\pi r^2$
Volume of a cone $V = 1/3\pi r^2 h$
Curved surfaced area of a cone $CSA = \pi rl$





To find the sum (or resultant) of two vectors v1 and v2, you can represent the situation graphically by drawing a vector diagram.

<u>Trig Values and Graphs</u>

Figure 1.10 Graph of y = cosθ

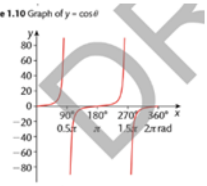


Figure 1.11 Graph of y = tanθ

Graphs of the trigonometric functions

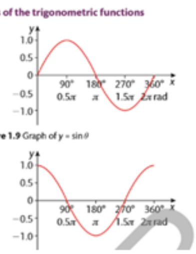


Figure 1.9 Graph of y = sinθ

θ°	θrad	sin θ	cos θ	tan θ
0	0	0	1	0
30	0.52	0.50	0.87	0.58
60	1.05	0.87	0.50	1.73
90	1.57	1.00	0	±∞
120	2.09	0.87	−0.50	−1.73
150	2.62	0.50	−0.87	−0.58
180	π	0	−1.00	0
210	3.67	−0.50	−0.87	0.58
240	4.19	−0.87	−0.50	1.73
270	4.71	−1.00	0	±∞
300	5.24	−0.87	0.50	−1.73
330	5.76	−0.50	0.87	−0.58
360	2π	0	1.00	0

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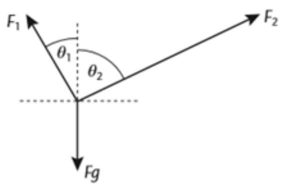
Unit 1 Learning Aim B1: Static engineering systems

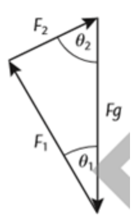
Key knowledge

Non-concurrent Coplanar Forces – **Forces that don't all pass through the same point that act in the same two-dimensional plane**.

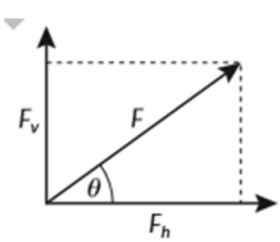
Free Body Diagram: sketch containing just the forces acting on the system or the part of the system that you are interested in.



Vector Diagram: a sketch in which the lengths of the lines representing the force vectors correspond to the magnitudes of the respective forces. The vectors may also have been rearranged to form a triangle of forces.



One way to add or subtract vector quantities is to split each vector into components acting in specific, perpendicular directions. A force acting in any direction can be resolved into a vertical and a horizontal component. The horizontal components of multiple forces can be simply added to calculate a single horizontal force. Similarly, the vertical components of multiple forces can be simply added to calculate a single vertical force. These can then be recombined into a single resultant force that represents the combined effect of all the original individual forces



$$F_v = F\sin\theta$$

$$F_h = F\cos\theta$$

$$\frac{F_v}{F_h} = \tan\theta$$

$$F^2 = F_v^2 + F_h^2$$

Static Equilibrium: - The resultant force for a system in static equilibrium is zero.
Conditions for static equilibrium $\sum F_x = 0$, $\sum F_y = 0$, $\sum M = 0$

Simply Supported Beams: - Beams are used to support structures.
Two ways beams can be loaded:

- Concentrated loads – a narrowly focused force that can be assumed to act at a specific point along the length of the beam; for example, the weight of a car parked on a bridge.
- Uniformly distributed loads (UDL) – a force distributed along the full length (or a defined section) of the beam, for example, the weight of the bridge itself.

Reactions A simply supported beam is supported from below at two points, A and B. At each of these points, support reaction forces act on the beam to maintain the static equilibrium of the system. These can be calculated if we know the magnitude and position of the forces acting on the beam.

Figure 1.33.
(Note that the UDL can be treated as a point load acting at the centre of the distribution.)

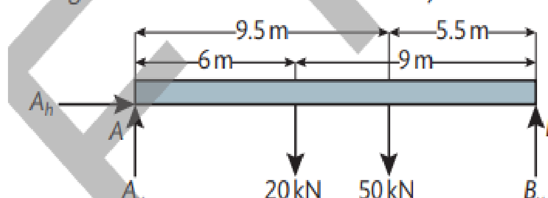


Figure 1.33 Free body diagram of the simply supported beam

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Unit 1 Learning Aim B2: Loaded components

Key knowledge

Direct/Shear Stress and Strain: -

Forces acting on a body may be separated into two different types:

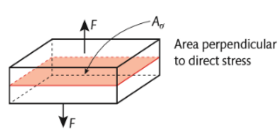
- direct forces – include tensile forces which tend to stretch and pull apart a material, and compressive forces (acting in the opposite direction) which tend to squash or compress a material.

- shear forces – forces cutting across a material which tend to shear or cut it apart

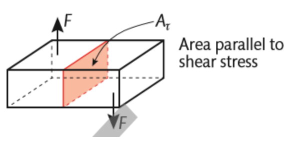
Stress is a measure of the load distribution within a material and is expressed as the load carried per unit area of material. The unit of stress is newton per square metre (Nm−2) or pascal (Pa).

We can consider two types of stress – direct and shear.

- $\text{direct stress } (\sigma) = \dfrac{\text{normal force } (F)}{\text{area } (A_\sigma)}$



$\text{shear stress } (\tau) = \dfrac{\text{shear force } (F)}{\text{shear area } (A_\tau)}$



Elastic Constants Cont.: -

The modulus of rigidity (G) is a similar ratio, which expresses the linear relationship between shear stress and shear strain observed in many materials. Its unit is newton per square metre (Nm−2).

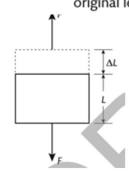
$$\text{modulus of rigidity } (G) = \frac{\text{shear stress } (\tau)}{\text{shear strain } (\gamma)}$$

Tensile and Shear Strength: -

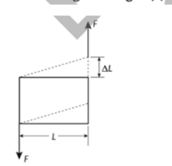
Tensile and shear strength are material-specific properties that specify the maximum tensile and shear stresses that can be applied to the material. If either the tensile or the shear strength of a material is exceeded, the material will rupture.

Strain quantifies the deformation of a body as a proportion of its original length.

$\text{direct strain } (\varepsilon) = \dfrac{\text{change in length } (\Delta L)}{\text{original length } (L)}$



$\text{shear strain } (\gamma) = \dfrac{\text{change in length } (\Delta L)}{\text{original length } (L)}$



Elastic Constants: - A material is considered to perform in its elastic region while any change in strain brought about because of an applied stress will reduce back to zero once that stress is removed.

The modulus of elasticity (E), also known as Young's modulus, expresses the linear relationship between direct stress and direct strain exhibited by a material in the part of the stress–strain curve below the elastic limit. Its unit is newton per square metre (Nm−2).

$$\text{modulus of elasticity } (E) = \frac{\text{direct stress } (\sigma)}{\text{direct strain } (\varepsilon)}$$

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Unit 1 Learning Aim C1: Dynamic engineering systems (1)

Key knowledge

Kinetic Parameters and Principles: - Basic principles and techniques that are used to understand dynamic systems. Kinetic parameters describe the uniform linear motion of an object over time. They include displacement, velocity and acceleration.

- Displacement (s) – the distance travelled by an object in time t.
- Initial velocity (u) – the starting velocity of an object when t = 0.
- Final velocity (v) – the final velocity of the object at time t.
- Acceleration (a) – the uniform acceleration of an object over time t.
- Time (t) – the period of time over which you will consider the motion of an object.

The SUVAT equations of motion are:

- $s = \frac{1}{2}(u + v)t$
- $s = ut + \frac{1}{2}at^2$
- $v = u + at$
- $v^2 = u^2 + 2as.$

Newton's Laws of Motion: -

Newton's first law of motion states that 'a body continues in its present state of rest or uniform motion in a straight line unless it is acted upon by an external force'.

Newton's second law of motion states that 'the rate of change of momentum of a body is directly proportional to the resultant force that is producing the change'.

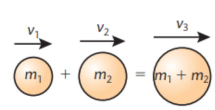
Newton's third law states that 'to every acting force there is an equal and opposite reacting force'.

It is Newton's second law that underpins the derivation of an important equation that establishes the relationship between force (F), mass (m) and acceleration (a):
F = ma

Dynamic Parameters and Principles: - Dynamic parameters link the motion of an object to the forces involved in causing, influencing or stopping that motion. There are several important dynamic parameters:

Force (F) - a push or pull acting on an object
Static frictional force (Fs) - a force that must be overcome to set a sliding body in motion
Sliding (kinematic) frictional force (Fk) - a sliding body once in motion must overcome kinematic frictional resistance to its motion.
Inertia force (Fi) - the resistance that an object of mass m has to any acceleration (a) that changes its state of motion
Momentum (p) - the product of the mass (m) of a moving body and its velocity (v)
Work done (W) - the energy used when a force moves an object. It is the product of the applied force (F) and the associated displacement (s)
Power (P) - the average rate of doing work (W) over time (t)
Instantaneous power (Pi) - the product of force (F) and velocity (v)
Weight (Fg) - the force exerted by a gravitational field (g) on a body with mass (m)
Gravitational potential energy (Ep) - the potential energy possessed by a body of mass m in a gravitational field (g) when raised to a vertical height (h)
Kinetic energy (Ek) - the energy possessed by a body of mass (m) travelling with velocity (v)

Conservation of Momentum: - 'the total amount of momentum in a system remains constant unless the system is acted upon by an external force'



Given that no external forces have been applied, the momentum prior to impact equals the momentum afterwards:
p1 + p2 = p3
m1v1 + m2v2 = (m1 + m2)v3

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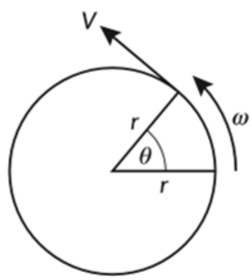
Unit 1 Learning Aim C1: Dynamic engineering systems (2)

Key knowledge

<u>Rotational Motion</u>: -

The fundamental parameters describing rotational motion are shown below:



Angular displacement (θ) – the angle in radians through which a point or line has been rotated about a specific point (the centre of rotation).
Angular velocity (ω) - the rate at which angular displacement (θ) changes over time (t)
Angular acceleration (α) - the rate at which angular velocity (ω) changes over time (t)
Tangential velocity (v) - the linear velocity of a point moving in a circular path.
Centripetal acceleration (a) - the linear acceleration acting on a rotating body towards its centre of rotation.
Torque (τ) - a turning force or moment that tends to cause rotational movement.
Work done(in uniform circular motion) (W) - the work done by a torque (τ) moving through an angular displacement (θ).
Power (in uniform circular motion) (P) - the rate of work done expressed as the product of torque (τ) and angular velocity (ω)
Moment of inertia (I) - sometimes called angular mass, is used in calculations relating to rotational motion in a similar way to which mass is used for linear motion.
Kinetic energy (of uniform circular motion) (Ek) - the energy possessed by a rotating body is calculated using its moment of inertia (I) and angular velocity (ω).

<u>Lifting Machines</u>: - Lifting machines are used to allow relatively small forces to lift heavy objects. They include inclined planes, pulleys and scissor jacks.

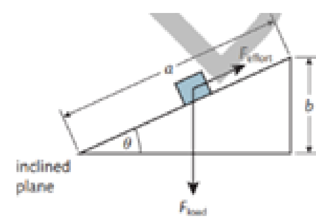
For all lifting machines**, mechanical advantage** (MA) is the ratio between the output force or load (F_l) and the input force or effort (F_e):

The **velocity ratio** (VR) is the ratio between the distance moved by the effort (s_e) and the distance moved by the load (s_l).

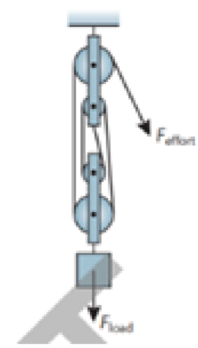
The **efficiency** of a simple machine is given by the ratio of useful work output to work input.

Types of systems:

Inclined plane



Pulleys



Screw jack

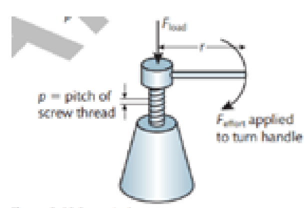
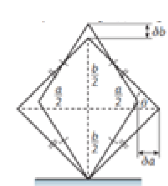
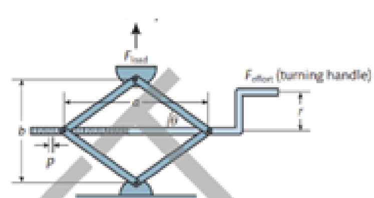


Figure 1.48 Screw jack

Scissor mechanism



Scissor jack



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Unit 1 Learning Aim D1: Fluid systems

Key words	Definitions
Mass	= amount of material an object contains
Weight	= the force of gravity pulling down on your mass
Volume	= the space occupied by an object
Density	= how compact the atoms are in a material
Pressure	= a measure of force over a given area

Key words
Mass
Weight
Volume
Density
Pressure

Fundamental formulae	Symbols and units
Weight = mass x gravity	W = m x g N = kg x N/kg
Density = mass / volume	ρ = m / V $kg/m^3 = kg / m^3$
Pressure = force / area	P = F / A $Pa = N / m^2$
Note: Pressure measured in Pascals (Pa) or N/m^2 $1\ Pa = 1\ N/m^2$	

Equations
W = m x g
ρ = m / V
P = F / A

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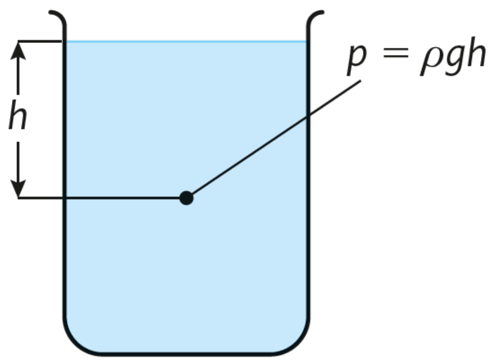
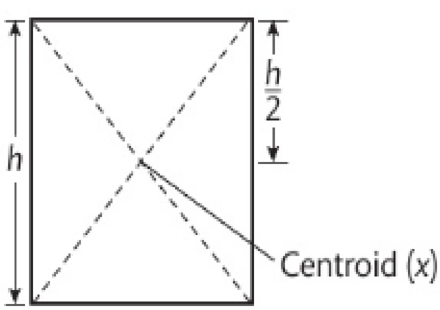
Unit 1 Learning Aim D1: Fluid systems

Key Picture	Theory (Pressure at depth)
	The pressure at a depth h below the surface of a liquid, is determined by 3 factors: Depth h Gravity (9.81) Density of liquid ρ

Key Picture	Theory (Hydrostatic thrust)
	The centroid is the geometric centre of a shape with area A. Average pressure and force (hydrostatic thrust - F) occur at the centroid

Key words

Hydrostatic thrust:

The force on a surface due to fluid pressure

Equations

Pressure at depth:

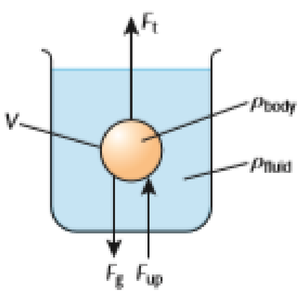
$$P = \rho g h$$

Hydrostatic thrust:

$$F = \rho g A \frac{h}{2}$$

Knowledge Organiser: KS5 BTEC Engineering

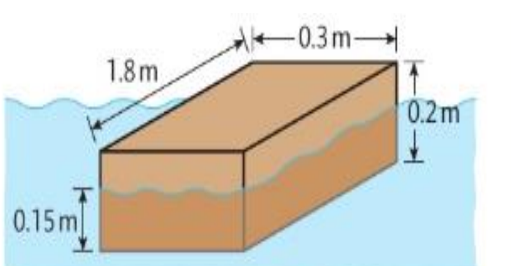
Unit 1 Learning Aim D1: Fluid systems

Key Picture	Theory (Archimedes' principle)
An object with weight Fg will feel light in water due to upthrust Fup. Apparent weight will be Ft Where Ft = Fg - Fup 	Archimedes' principle states that 'a body totally or partially submerged in a fluid displaces a volume of fluid that weighs the same as the apparent loss in weight of the body'

Key words

Upthrust: An upwards supporting force in fluids

Relative density: The density of the substance compared with the density of pure water.

Key Picture	Theory (Flotation)
	The volume of water displaced is: 1.8 x 0.3 x 0.15 = 0.081m^3. Water has a density of 1000, so the mass of water displaced is: M = 0.081 x 1000 = 81kg. This means the mass of the block is also 81kg

Equations

Density:
$\rho = m / V$

Relative density D:

$$D = \frac{\rho \text{ substance}}{\rho \text{ water}}$$

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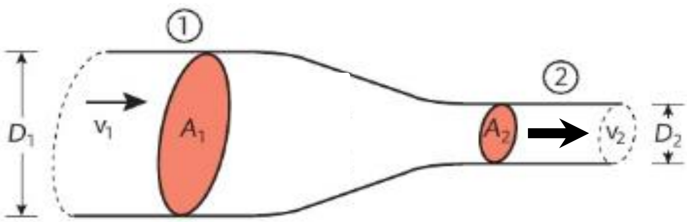
Unit 1 Learning Aim D1: Fluid systems

Key Picture



The diameter of a pipe D, determines the cross sectional area A of a pipe which in turn determines the speed v the liquid will flow

Theory (Fluid low)

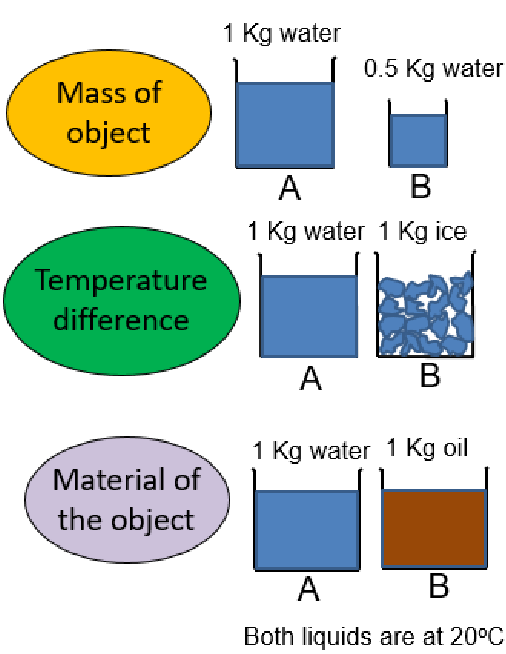
The rule:

If D (and A) is reduced then the speed v will be increased.

The maths:

$A_1 \times v_1 = A_2 \times v_2$

Key Picture



Theory (Thermal energy transfer)

Factors affecting heat transfer

A greater mass will require more heat energy so A requires more energy than B to boil

Heating through a bigger temperature difference requires more heat energy so A requires more energy than B to boil

All materials are made of different atoms and are bonded together differently. We need to know what the specific heat capacity of the material to see which requires most energy

Key words

Volumetric flow rate is:
"The volume (V) of fluid that passes a given point in time (t)."

Mass flow rate is:
"The mass (M) of fluid that passes a given point in time (t)."

Specific heat capacity:
The energy required to raise the temperature of 1 kg of a material by 1 K

Equations

$A \times v = \text{const}$

$Q = m\,c\,\Delta\theta$

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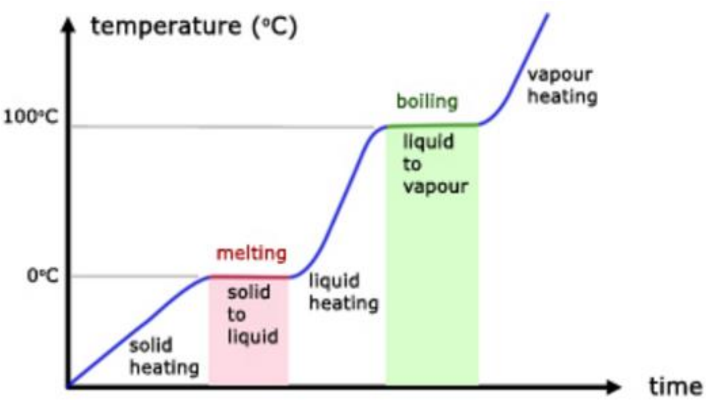
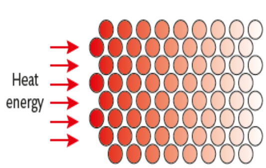
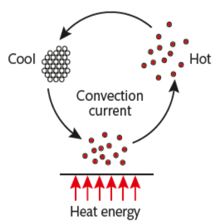
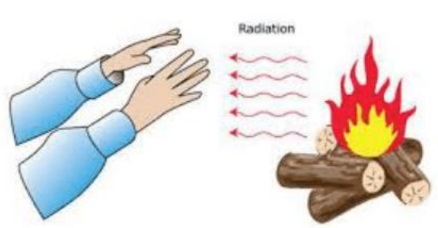
Unit 1 Learning Aim D1: Fluid systems

Key Picture	Theory (changing state)
	When materials change state they do so at constant temperature. The input heat energy is used to break the bonds between molecules an is known as **latent heat**

Key Picture	Theory (Thermal energy transfer)
Conduction:  **Convection:**  **Radiation:** 	**Conduction** is the transfer for heat energy from atom to atom **mainly in solids**. Metals are the best conductors due to **free electrons**. The opposite of a conductor is an **insulator.** **Convection** is the transfer of heat in **liquids and gases** due to changes in density as they are heated. The motion creates a **convection current** All hot objects emit waves of heat known as **radiation**

Key words

All materials have two latent heat values:

Latent heat of fusion L_f :
Energy needed to change 1kg of a solid to a liquid

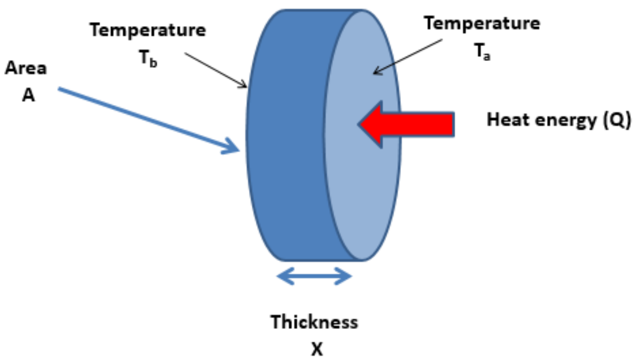
Latent heat of vaporisation L_v
Energy needed to change 1kg of a liquid to a gas

Equations

$$Q = m \times L$$

Knowledge Organiser: KS5 BTEC Engineering

Unit 1 Learning Aim D1: Fluid systems

Key Picture	Theory (conductivity)
	The rate of conduction in a material is determined by the dimensions of the object and the material it is made from.

Key words
Thermal conductivity λ: the rate of heat flow by conduction through a material

Key Picture	Theory (Expansion)
	When a material is heated up through a temperature , ΔT, it will increase in size from L by an amount ΔL. This change of size acts in all directions. It differs from material to material, and is known as the coefficient of thermal expansion α

Equations
Thermal conductivity Q: $Q = \frac{\lambda A (T_a - T_b)}{x}$ Thermal expansion: $\Delta L = \alpha L \Delta T$

Knowledge Organiser: KS5 BTEC Engineering

Unit 1 Learning Aim E1: Static and direct current electricity

Key words	Definitions
field strength	= force per unit charge in a field
flux density	= amount of flux passing through an area
permittivity	= the resistance of a material to the formation of a field
potential difference	= the difference in energy between two points in a circuit
Voltage	= the potential difference between two points in a circuit
current	= the rate of flow of electrical charge
resistance	= The opposition to electric current
resistivity	= how much specific materials resist current flow

Key words
Field strength Flux density Permittivity Potential difference Voltage Current Resistance Resistivity

Equations
$E = F / Q$
$I = Q / t$
$R = \frac{\rho \times L}{A}$

Fundamental formulae	Symbols and units
Field strength = force/charge	$E = F / Q$ $N/C = N / C$
Current = charge / time	$I = Q / t$ $A = C / s$
Resistance = $\frac{\text{resistivity} \times \text{length}}{\text{area}}$	$R = \frac{\rho \times L}{A}$ $\Omega = \frac{\Omega m \times m}{m^2}$

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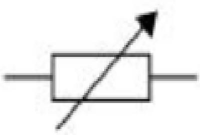
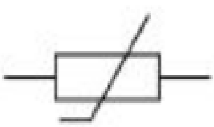
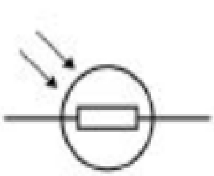
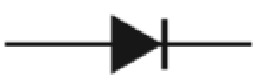
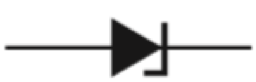
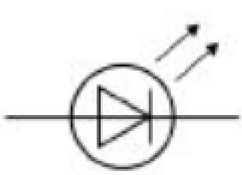
Unit 1 Learning Aim E2: Direct current circuit theory

Key Picture	Theory (Circuit components)
 resistor  variable resistor  thermistor  LDR	**Resistors** are components used to limit the flow of current through a circuit. They are available in a wide range of values, from a fraction of an ohm to many mega ohms ($10^6\ \Omega$) **Fixed resistors** have a single specific value. **Variable resistors** are resistors designed so that their resistance can be changed (such as a rotary volume control on an amplifier). **Thermistors and light dependent resistors (LDR),** vary when they are given heat/light energy
Semiconductor diode Anode (+)  Cathode (−) **Zener diode** Anode (+)  Cathode (−)  LED	A **diode** is a very common electronic component made of a semiconductor material. It allows current to flow in only one direction. Current will flow in the direction of the arrow on then symbol. This is known as **forward bias.** A **light emitting diode or LED**, will emit light when conduct. A **Zener diode** is a special diode designed to be used in the **reverse bias** direction

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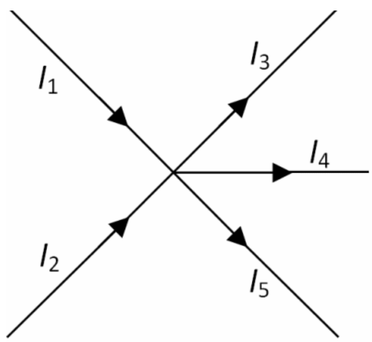
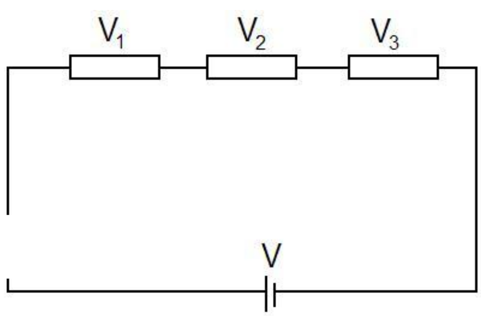
Unit 1 Learning Aim E2: Direct current circuit theory

Key Picture



$$I_1 + I_2 = I_3 + I_4 + I_5$$



$$V = V_1 + V_2 + V_3$$

Ohm's law:

$$\frac{V}{I} = \text{constant}$$

The constant is called the resistance (R)
It is often written as:

V = IR

Theory (Circuit laws)

Kirchhoff's current law:
At any junction of an electric circuit, the total current flowing towards the junction is equal to the total current flowing away from the junction.

Kirchhoff's voltage law:
In any closed loop network, the total p.d. across the loop is equal to the sum of the p.d.s around the loop.

Ohm's law:
The relationship between voltage (V) and current (I) at constant temperature obeys Ohm's law:

Key words

Kirchoff's laws

Ohm's law

Equations

V = I x R

Knowledge Organiser: KS5 BTEC Engineering

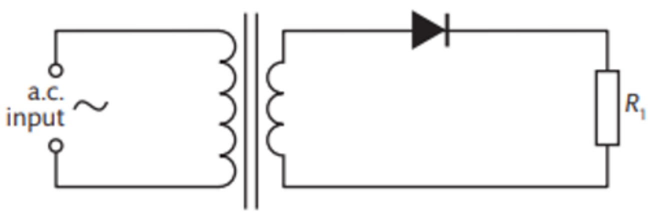
Unit 1 Learning Aim E2: Direct current circuit theory

Key Picture	Theory (Diodes in circuits)

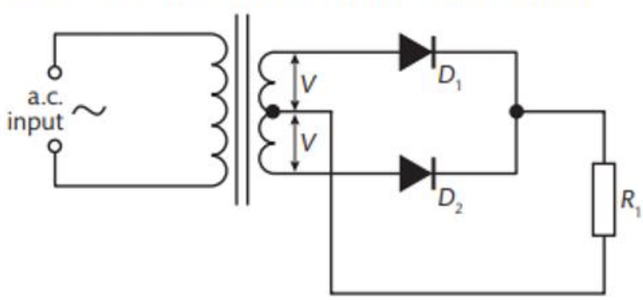
Key Picture

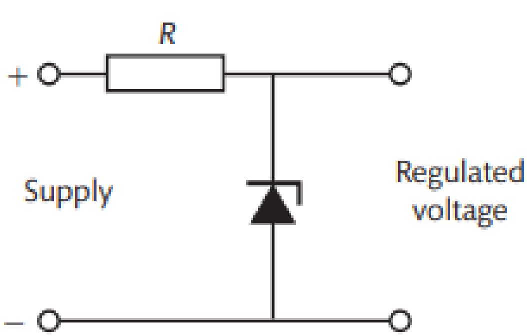
Two main uses of diodes are:
Rectification and **Voltage regulation**

Half-wave (1 diode)



Bi-phase full-wave (2 diodes, tapped transformer)

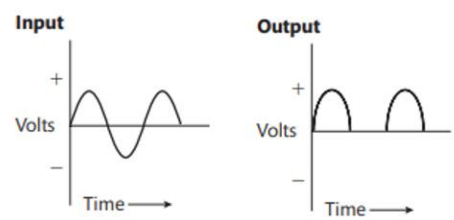




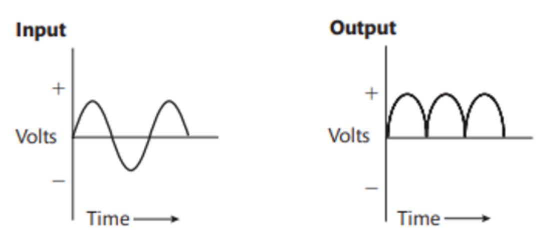
Theory (Diodes in circuits)

Rectification is the **conversion of an alternating current to a direct current. (a.c. to d.c.)**

Half- wave rectification uses one diode, the output current is always positive, however half of the input it lost.



Full - wave rectification uses two diodes so all of the input is converted to positive.



Zener diodes are use in reverse bias mode to regulate voltage supplies. They can have values from 2V to 150V. They allow an unsteady power supply to remain constant.

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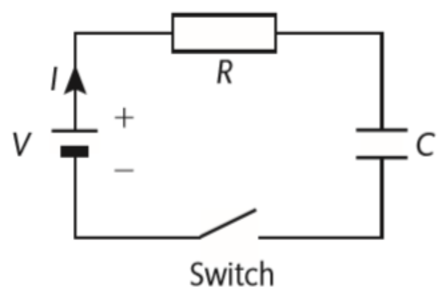
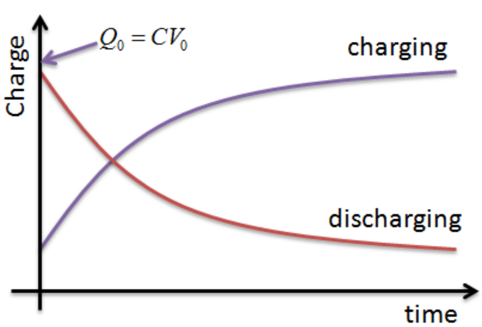
Unit 1 Learning Aim E2: Direct current circuit theory

Key Picture





Charging equation:

$$V_C = V_0(1 - e^{-t/RC})$$

Discharging equation:

$$V_C = V_0 e^{-t/RC}$$

Time constant is the product of capacitance and resistance.

$$\tau = RC$$

Theory (Capacitors in circuits)

Capacitors are electrical components that store charge. When connected to a battery, current (i.e. charge) flows through the resistor and builds up on the capacitor.

We describe this process as charging. When this charge is released and used to deliver current to the circuit, we say the capacitor is discharging.

The rate of charge /discharge is exponential and depends upon the value of capacitance x resistance, known as the **time constant**.

V_0 = battery voltage
V_c = capacitor voltage at t
t = the charge/discharge time
RC = the time constant

Key words

Charging: The process where charge (and voltage) builds up on a capacitor.

Discharging: The process where charge (and voltage) decrease on a capacitor

Time constant

Equations

$$V_C = V_0(1 - e^{-t/RC})$$

$$V_C = V_0 e^{-t/RC}$$

$$\tau = RC$$

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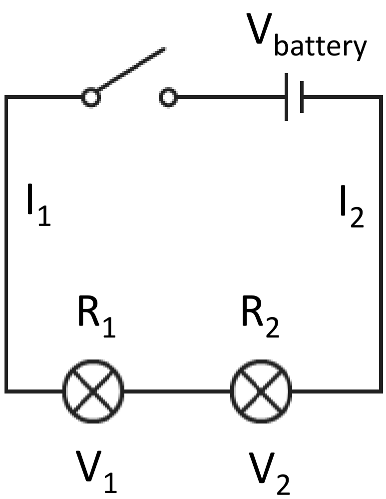
Unit 1 Learning Aim E3: Direct current networks

Key Picture	Theory (series and parallel lamps/resistors)

Series circuits



In **series,** components are connected in line and the circuit has one loop. This means **the current, I is the same through each lamp.**

$$I_1 = I_2$$

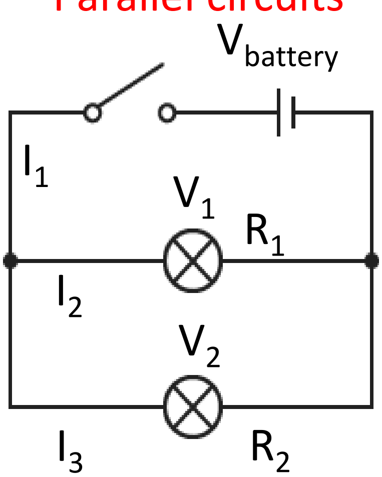
The **potential difference (voltage) V across the lamps adds up to the battery potential difference**

$$V_{battery} = V_1 + V_2$$

The **total resistance** of the circuit is:

$$R_{total} = R_1 + R_2$$

Parallel circuits



Parallel circuits have more than one loop
The current I, splits up around the circuit

$$I_1 = I_2 + I_3$$

The **potential difference (voltage) V across the lamps is the same as the battery potential difference**

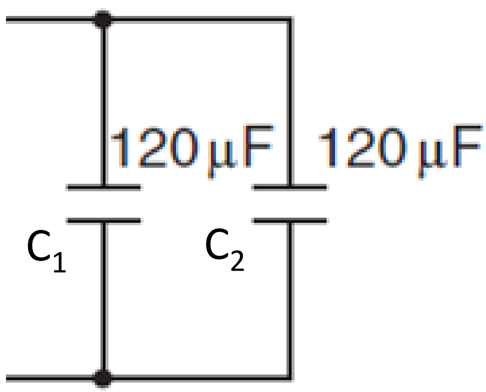
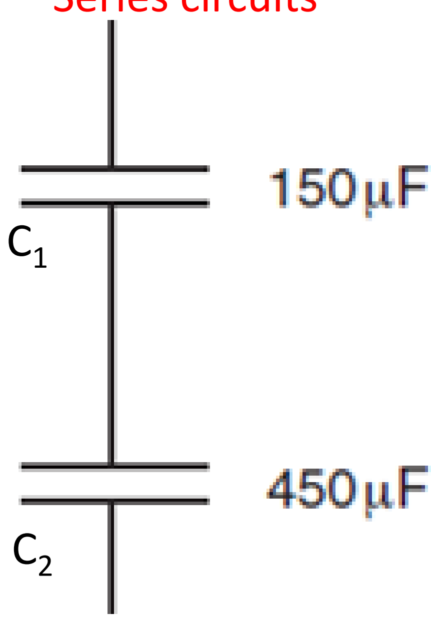
$$V_{battery} = V_1 = V_2$$

The **total resistance** of the circuit is:

$$1/R_{total} = 1/R_1 + 1/R_2$$

Knowledge Organiser: KS5 BTEC Engineering

Unit 1 Learning Aim E3: Direct current networks

Key Picture	Theory (series and parallel capacitors)
Parallel circuits 	**In parallel,** the total amount of charge that can be stored increases. (i.e. capacitance increases) The total capacitance is calculated by: $C_{total} = C_1 + C_2$ $C_{total} = 120 + 120 =$ **240µF**
Series circuits 	**In series** the total capacitance decreases. The total capacitance is calculated by: $1/C_{total} = 1/C_1 + 1/C_2$ $1/C_{total} = 1/150 + 1/450$ $= 8888.8$ so $C_{total} = 1/8888.8$ **= 112.5µF**

Knowledge Organiser: KS5 BTEC Engineering

Unit 1 Learning Aim F1: Magnetism

Key words	Definitions
Magnetic flux	= a measure of the size of the magnetic field produced by a source of magnetism.
Flux density	= a measure of how closely packed the lines of magnetic flux (Φ) produced by a source of magnetism with area (A) are.
Magnetic field strength	= a measure of the strength of the magnetising field
Permeability	= a measure of the degree of magnetisation a material undergoes when subject to a magnetic field

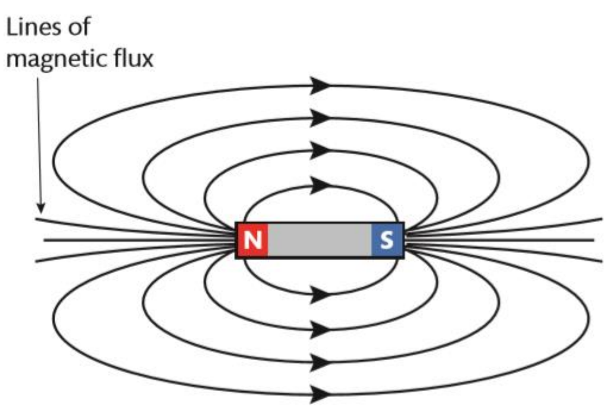
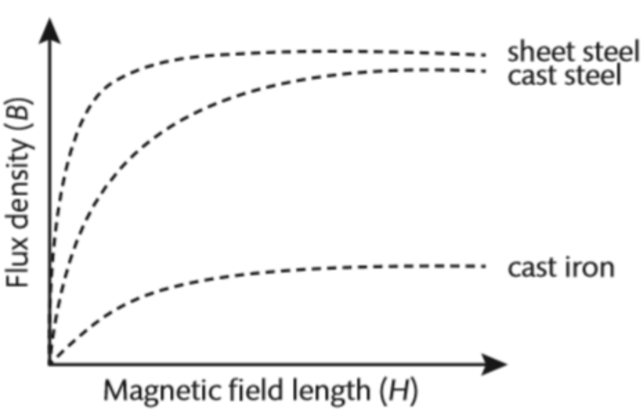
Key words
Flux **Flux density** **Field strength** **Permeability**

Fundamental formulae	Symbols and units
Flux density = magnetic flux/area	$B = \phi / A$ $T = Wb / m^2$
Magnetic Field strength (solenoid) $= \dfrac{\text{turns x current}}{\text{length}}$	$H = \dfrac{N \times I}{L}$ $A/m = A / m$
Permeability $= \dfrac{\text{flux density}}{\text{field strength}}$	$\mu = B / H$ H/m

Equations
$\phi = B / A$ $H = \dfrac{N \times I}{L}$ $\mu = B / H$

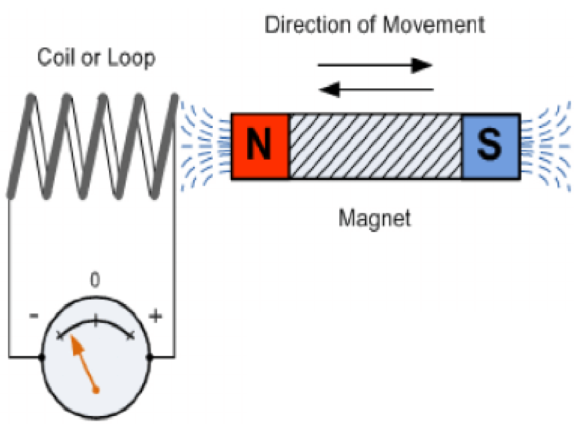
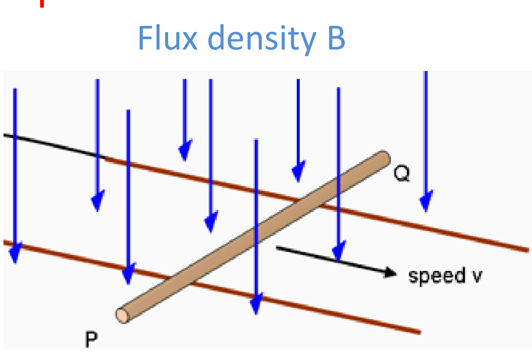
Knowledge Organiser: KS5 BTEC Engineering

Unit 1 Learning Aim F1: Magnetism

Key Picture	Theory (Magnetic fields)
Magnetic fields 	A **magnetic field** is the area around a magnet where other magnetic materials would feel a force. **Fields lines** show the size and strength of the field. Lines that are close together show a stronger field **Field direction** is shown by arrows on the field lines. They always point from north to south.
B/H curves 	A **B/H curve** is a graphical representation of the relationship between the magnetic flux density (B) formed in a specific material when the material is exposed to a magnetic field strength (H)

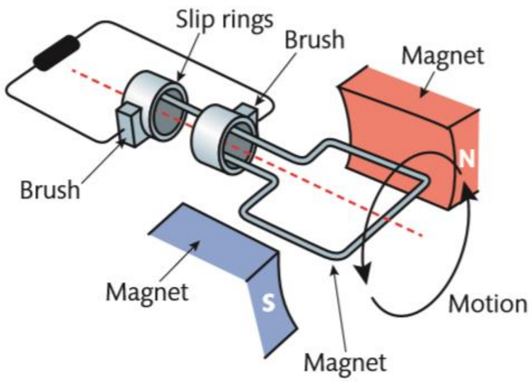
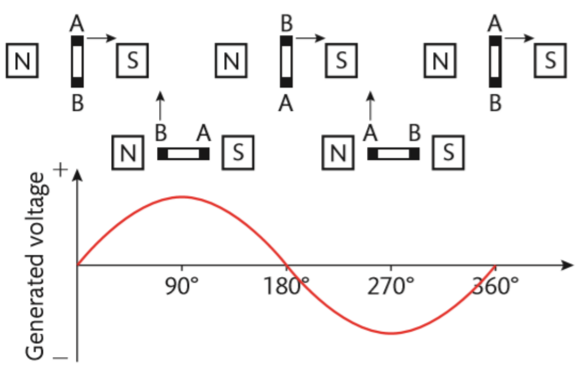
Knowledge Organiser: KS5 BTEC Engineering

Unit 1 Learning Aim F2: Electromagnetic induction

Key Picture	Theory (Faraday's law of induction)
Faraday's law  	An e.m.f. (voltage) will be generated in the coil whenever the magnet is moved into or out of a coil. **Faraday's law states**: The size of the induced e.m.f. (E) depends on the number of turns in the coil (N) and the rate of change of magnetic flux ϕ i.e. $E = - d\Phi / dt$
Simple induction  Wire PQ has a length L metres	A **simple method** to generate an e.m.f. (E) is to move a wire of length (L) with a velocity (v) through a magnetic field with flux density (B). The e.m.f. E generated is: $E = B \times L \times v$

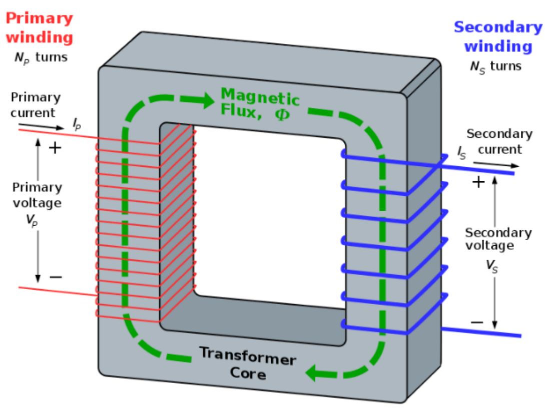
Knowledge Organiser: KS5 BTEC Engineering

Unit 1 Learning Aim F2: Electromagnetic induction

Key Picture	Theory (Generators and a.c.)
A simple a.c. generator 	The simplest practical generator consists of a coil of wire spinning between the N and S poles of two magnets. The magnitude of the e.m.f. induced in the coil is proportional to the number of turns of the coil N. It is also dependent on the speed of rotation and the strength of the magnetic field.
Alternating current waveforms 	The **e.m.f. is a sine wave** because the angle between the coil and flux lines varies continuously. Peak voltage occurs where the motion of the coil is at right angles (perpendicular) to the flux lines. Voltage falls to zero after 90° of rotation. At this stage the motion of the coil is parallel to the lines of flux and so does not cut through them at all.

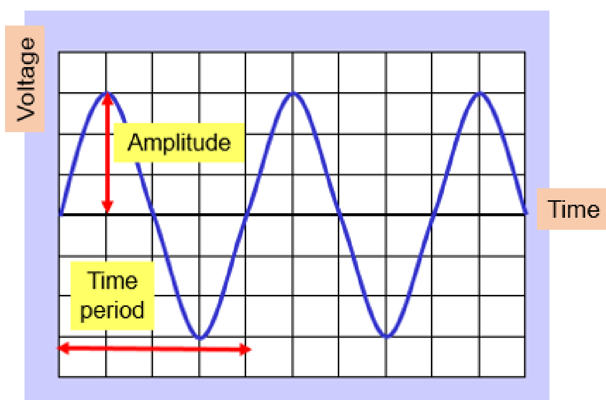
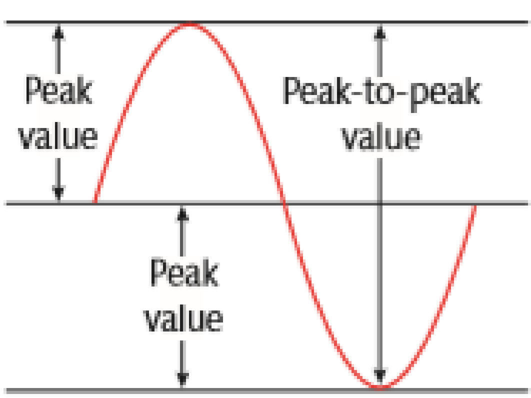
Knowledge Organiser: KS5 BTEC Engineering

Unit 1 Learning Aim F2: Electromagnetic induction

Key Picture	Theory (Transformers)
Transformers  Stepping up and down To increase (step-up) a voltage, more coils are wound on the secondary side than primary. e.g. N_p = 10 and N_s = 50, the input voltage would be stepped up by N_s/N_p = 50/10 = 5 times. To decrease (step-down) reverse the process e.g. N_p = 100 and N_s = 5, the output voltage would be: N_s/N_p = 5/100 = 1/20, i.e. 20 times lower Conservation of power Electrical power P = V x I With a step-up transformer, if voltage increases at secondary (e.g. x2), current must decrease by the same proportion. e.g. V_p = 10V, I_p = 10A, V_s = 20V, Secondary current I_s must be 5A The maths: $V_p \times I_p = V_s \times I_s$ 10 x 10 = 20 x 5 This conserves the power	**Transformer action** A transformer consists of two coils (turns) wound on a core of magnetic material. The primary coil is the input, the secondary the output. A transformer can increase (step-up) or decrease (step-down) a voltage connected to the primary. This is achieved by varying the ratio of primary coils N_p to secondary coils N_s **The input voltage must be a.c.** This varying a.c. voltage, produces a varying current in the primary winding, which in turn generates a varying magnetic flux in the transformer core. This flux links to the secondary coil. The varying flux induces an emf in the secondary coil by electromagnetic induction.

Knowledge Organiser: KS5 BTEC Engineering

Unit 1 Learning Aim G: Single phase alternating current

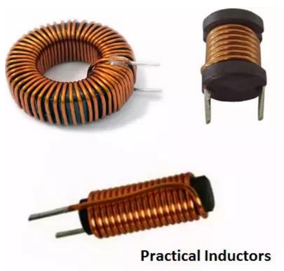
Key Picture	Theory (a.c. waveforms)
Describing a.c. waveforms  	The height of the wave is the **amplitude**, in volts (V). **Time period** is the time in seconds (s) for one complete wave. **Frequency** in Hertz (Hz) can be calculated from the time period by: $\text{Frequency} = \frac{1}{\text{time period}}$ It is the number of waves per second
Peak and root mean square values  	Root mean square (r.m.s.) is a way over comparing power usage on a.c. and d.c. circuits To find the r.m.s. value we take the peak value and divide it by the square root of 2. $V_{rms} = \frac{1}{\sqrt{2}} V_{peak}$

Knowledge Organiser: KS5 BTEC Engineering

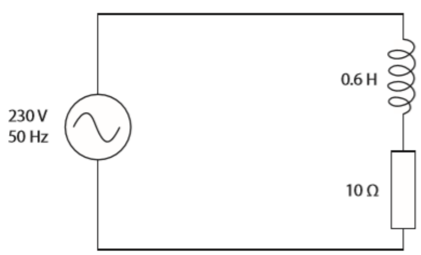
Unit 1 Learning Aim G: Single phase alternating current

Key Picture

Inductors



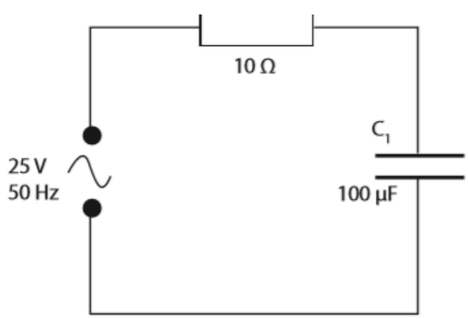
Inductors and resistor circuits



$$X_L = 2\pi \times 50 \times 0.6 = 60\pi\ \Omega$$

Capacitors and resistors

$$Z = \sqrt{60\pi^2 + 10^2} = 188.8\ \Omega$$



$$X_C = 1/2\pi \times 50 \times 100\mu F = 31.8\ \Omega$$

$$Z = \sqrt{31.8^2 + 10^2} = 33.3\ \Omega$$

Theory (Impedance and reactance)

An inductor is simply a coil of wire (e.g. a solenoid).
The size of the inductor and number of coils it has gives an inductance. Inductance is given the letter L, it has units called Henrys (H)!

Inductors and capacitors have resistance (called reactance) to a.c. supplies (with frequency f)

Capacitive reactance $X_C = \dfrac{1}{2\pi f C}$

Inductive reactance $X_L = 2\pi f L$

When resistors are combined with capacitors or inductors in a.c. circuits, they have an overall resistance which is known as Impedance (Z). It is calculated using:

$$Z = \sqrt{X_C^2 + R^2}$$

or

$$Z = \sqrt{X_L^2 + R^2}$$

Knowledge Organiser: KS5 BTEC Engineering

Unit 2 Learning Aim A: Examining common products and working drawings.

Key skills

- Transforming ideas and materials into products or services.
- Understanding common processes used to create engineered products.
- Explain Common processes used in engineering services.

Key words

Specification
Components
Scale
Quality

Key knowledge

Documents that accompany the processes and manufacture tend be around the following types to aid organised production.

- Technical specification: defines exactly what a product or service can do.
- Engineering drawings: contain key information on how the product should be and could be many views and drawings for even individual components.
- Scale of production: How many of the products or services are needed will define how big the operation will be and resources needed.
- Work plans: Set of instructions for completing processes in a certain way or order.
- Quality control: When will quality be checked, this needs to be planned in order to be monitored and be made effective

WHAT processes are used to make a product? You need to be able to recognise some basics.

Filing

Cutting

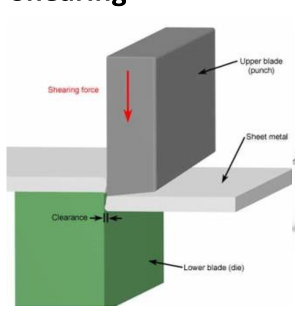
Drilling

Turning

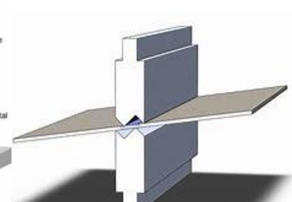
Milling

Fabrication

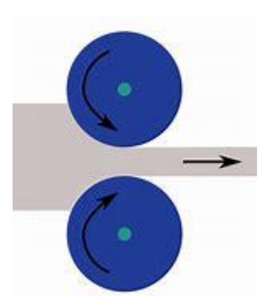
Shearing



Forming



Rolling



Knowledge Organiser: KS5 BTEC Engineering

Unit 2 Learning Aim A: Control Plan, Flow Chart and BOM

Key words

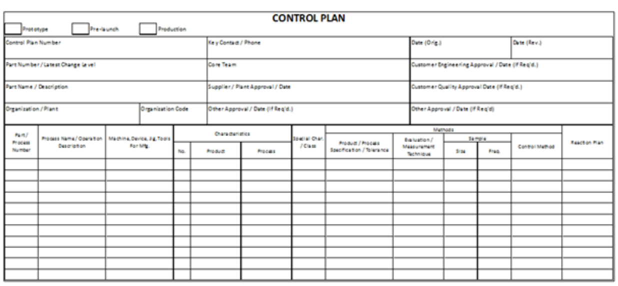
Control
Flow
Process
Schematic
Diagram

Key skills

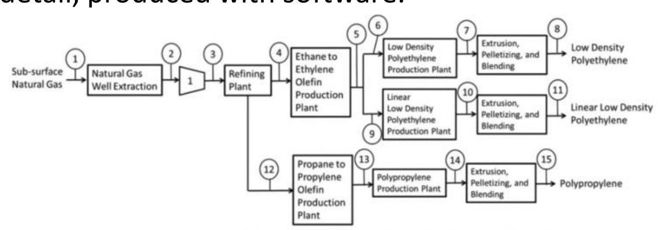
- Make processes clearer and more efficient to aid planning.

Key knowledge

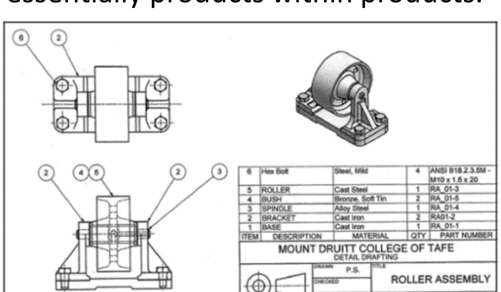
The **Control Plan** is a document that describes the actions (measurements, inspections, quality checks or monitoring of process parameters) required at each phase of a process to assure the process outputs will conform to pre-determined requirements. In simpler terms, the Control Plan provides the operator or inspector with the information required to properly control the process and produce quality parts or assemblies. It should also include instructions regarding actions taken if a non-conformance is detected. The Control Plan does not replace detailed operator instructions. In some cases the Control Plan is used in conjunction with an inspection sheet or checklist.



A **Process Flow Diagram (PFD)** is a type of flowchart that illustrates the relationships between major components at an industrial plant. It's most often used in chemical engineering and process engineering, though its concepts are sometimes applied to other processes as well. It's used to document a process, improve a process or model a new one. Depending on its use and content, it may also be called a Process Flow Chart, Flow sheet, Block Flow Diagram, Schematic Flow Diagram, Macro Flowchart, Top-down Flowchart, Piping and Instrument Diagram, System Flow Diagram or System Diagram. They use a series of symbols and notations to depict a process. The symbols vary in different places, and the diagrams may range from simple, hand-drawn scrawls or sticky notes to professional-looking diagrams with expandable detail, produced with software.



A **bill of materials (BoM)** is a list of the parts or components that are required to build a product. At its most complex, a BoM is a multi-level document that provides build data for multiple sub-assemblies, which are essentially products within products.



Bill Of Materials

No.	Parts	Qty	Description	Weight (lb)	Cost
1	Nose and back plates (A & B)	1	20"x50"x0.16" sheet, 2024-T361 Al.	15.7	$41.75
2	Axle Bracket	28 in.	2024-T361 Al. Bar, 1 in. x 0.16 in.	0.7	$3.35
3	Handle (D)	20 in.	2024-T361 Al. Rod, 1 in. dia.	2.4	$7.00
4	Wheels (E)	4	Hard Rubber Tread 4 in. dia.	4.0 (estimate)	$38.40
5	Nose-back plate connection	1	Box of bolts ¼ in. dia. x 1"		$5.00
6	Link	1	Swivel bolt		$2.50
			Total:	22.8	$98.00

Knowledge Organiser: KS5 BTEC Engineering

Unit 2 Learning Aim A: H&S and Operating Processes

Key skills

Current Health and Safety at Work legislation
- Reporting of Injuries, Diseases and Dangerous Occurrences Regulations (RIDDOR)
- Personal Protective Equipment (PPE) at Work Regulations
- Control of Substances Hazardous to Health Regulations (COSHH)
- Manual Handling Operations Regulations (MHOR)

Key words

Regulation
Legislation
Substances
Injury
Containment
Manual
Operation

Key knowledge

The key place to review all the key documents and keep up to date is HSE Health and Safety Executive www.hse.gov.uk (as the law is always changing e.g. COVID 19 guidance)

RIDDOR
In law, you must report certain workplace injuries, near-misses and cases of work-related disease to HSE. This duty is under the Reporting of Injuries, Diseases and Dangerous Occurrences Regulations, known as RIDDOR.

PPE at work regulations
Employers have duties concerning the provision and use of personal protective equipment (PPE) at work. PPE is equipment that will protect the user against health or safety risks at work. It can include items such as safety helmets, gloves, eye protection, high-visibility clothing, safety footwear and safety harnesses. It also includes respiratory protective equipment (RPE).

COSHH
COSHH is the law that requires employers to control substances that are hazardous to health. You can prevent or reduce workers exposure to hazardous substances by:
- finding out what the health hazards are;
- deciding how to prevent harm to health (risk assessment[1]);
- providing control measures to reduce harm to health;
- making sure they are used ;
- keeping all control measures in good working order;
- providing information, instruction and training for employees and others;
- providing monitoring and health surveillance in appropriate cases;
- planning for emergencies.

MHOR
The main aim of the Regulations is to prevent injury, not only to the back, but to any part of the body. They require employers to take into account the whole handling operation, including the external physical properties of loads which might either affect grip or cause direct injury, for example slipperiness, roughness, sharp edges and extremes of temperature.

Knowledge Organiser: KS5 BTEC Engineering

Unit 2 Learning Aim B: Drawing Conventions

Key skills

Attributes of orthographic projections, including:

- geometry – shape of the component represented as different views, how the component is viewed from various angles, visibility of component features
- dimensions – size of the component in defined units
- tolerances – allowable variations for defined dimensions
- material – what the component is to be made from
- surface texture – surface quality required, e.g. roughness, flatness
- scale – the ratio of a drawing's size to the actual dimensions of the object.

Key words

Orthographic
Isometric
Projection
Annotation
Dimensions
Tolerances

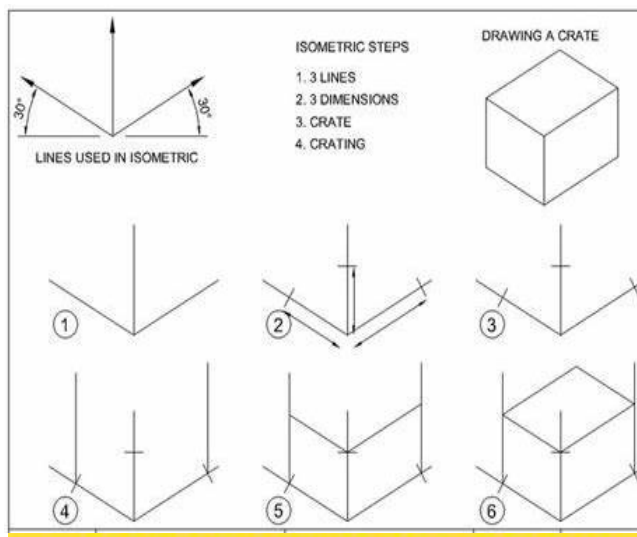
Key knowledge

The best way to communicate a design or redesign changes is through a sketch as it can make things clear as to how something is shaped. Apart from regular 2D sketches there are some key drawing methods you must be familiar with.

ISOMETRIC

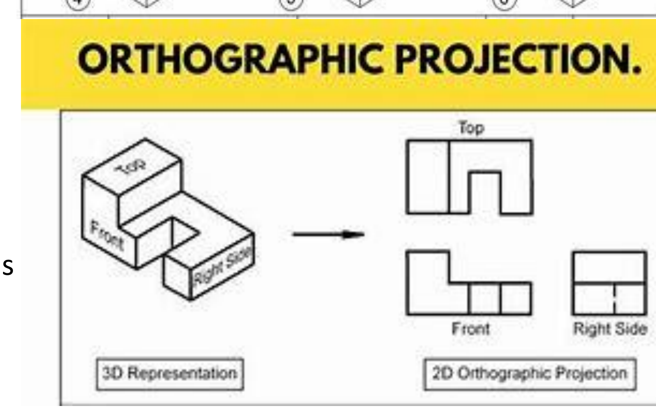
A basic 3D drawing method which puts the drawing at a 30 degree angle so you can see the 3 sides (Top, Front, Side) needed to get a good idea of the shape.

In the example shown (Right) is how to set up a simple box or crate as it is known. This 'Crate' can for the box to help draw more complicated shapes such as cylinders. Try using the method to draw a rectangular product you are familiar with.



ORTHOGRAPHIC PROJECTION

Is a lot more complex and tends to be used show products in a lot more detail, usually in the final production stages when dimensions are clear. It basically shows the drawing from the 3 views (Top, Front, Side) in the order shown to give clear dimensions and to a scaled size. It may also include a 3D view.



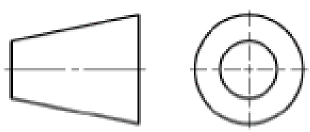
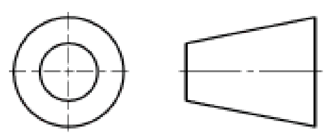
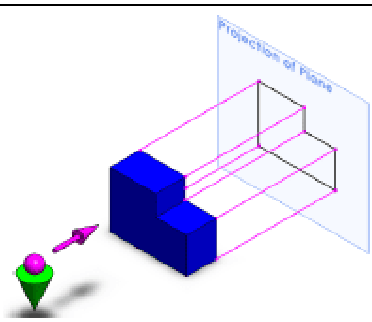
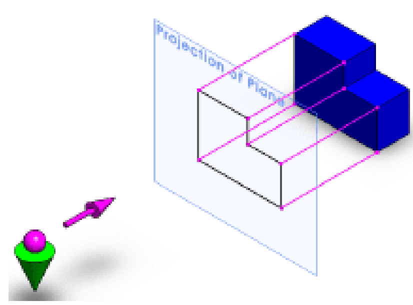
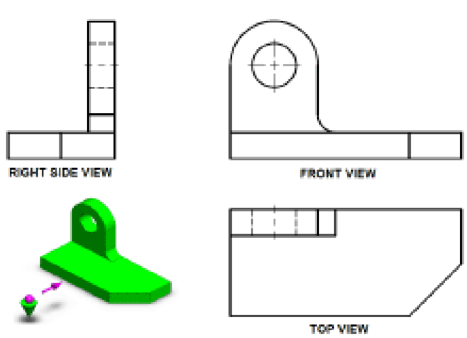
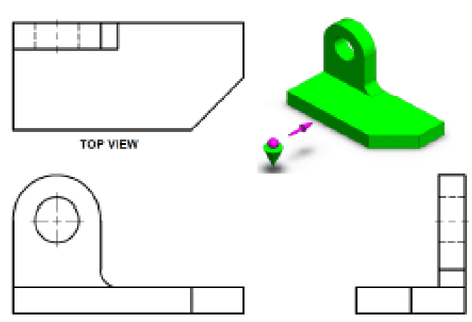
ANNOTATION

Although the drawings help , annotation alongside to help point out key manufacture points or materials, textures etc. are still key to getting your redesign across.

Knowledge Organiser: KS5 BTEC Engineering

Unit 2 Learning Aim B: 1st and 3rd Angle Projection

Key knowledge

First Angle Projection	Third Angle Projection
The object is imagined to be in first quadrant.	The object is imagined to be in third quadrant.
The object is lies between the observer and plane of projection.	The plane of projection lies between the observer and object.
The plane of projection is assumed to be non transparent.	The plane of projection is assumed to be transparent.
When view are drawn in their relative position Top view comes below Front view, Right side view drawn to the left side of elevation.	When view are drawn in their relative position Top view comes above Front view, Right side view drawn to the right side of elevation.
 SYMBOL	 SYMBOL
	
	
www.enggwave.com	

Key words

Projection
Plane
Quadrant
Transparent
Elevation

Key skills

These drawings are to be used to help give all details needed for manufacture with a high level of accuracy, you must be able to interpret these effectively.

Why and where are they used? First angle projection method is used in **Europe**, **India**, **Canada** and the rest of world as a default projection system. Third angle projection is used in Australia and United States as a default projection system for industrial designs for product fabrication.

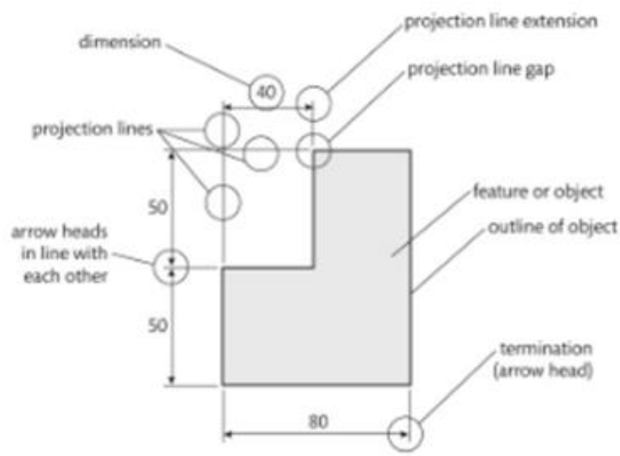
Knowledge Organiser: KS5 BTEC Engineering

Unit 2 Learning Aim B: Dimensions, Tolerances and Surface Finishes

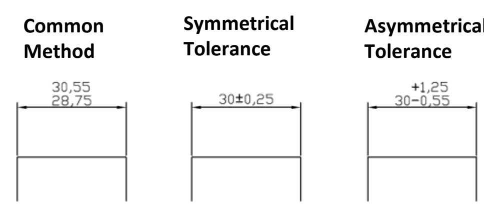
Key knowledge

Dimensioning should:

- not interfere with the component drawing lines or any other features
- be neatly aligned and spaced out evenly
- be consistent in the use of font, text size and style
- be clear and easy to interpret
- comply with the requirements of an appropriate standard (such as BS8888).

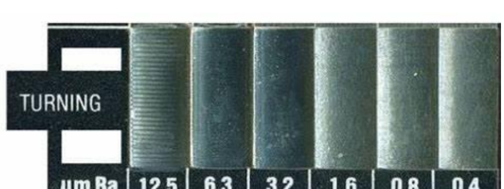


TOLERANCE: When products are manufactured in industry due to manufacturing processes it is very difficult to achieve absolute accuracy in the size of the finished item. This creates problems when manufactured items have to **fit accurately with other parts** and also possibly the **function of the product.** When individual component parts are manufactured in batches of thousands or more, it is **not economic** to accept parts that do not fit and so cannot be assembled. To overcome this problem, items are manufactured with **an acceptable margin of dimensional error** called **Tolerance**.

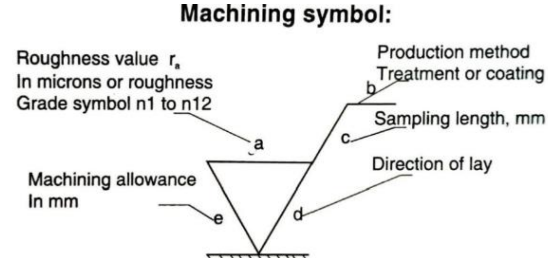


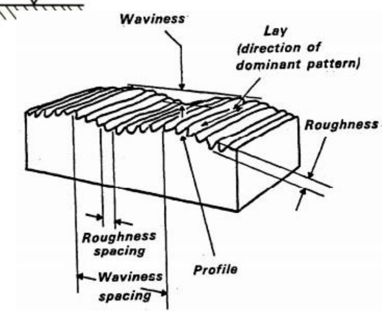
Surface roughness

Surface roughness often shortened to roughness, is a component of surface texture. It is quantified by the deviations in the direction of the normal vector of a real surface from its ideal form. If these deviations are large, the surface is rough; if they are small, the surface is smooth.



Machining symbol:





Knowledge Organiser: KS5 BTEC Engineering

Unit 2 Learning Aim B: Scale and BS 8888

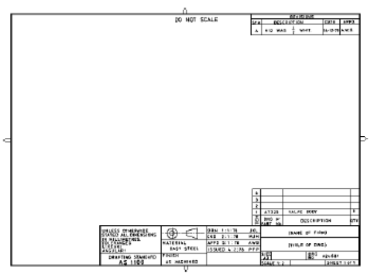
Key skills

Drawing conventions or other relevant international equivalents, including:

- Standards including BS 8888 and BS 60617 or other relevant international equivalents
- Title block/layout – drawing number(s), projection symbols, scale, units, general
- Views – elevation, plan, end, section, hatching style, auxiliary
- Common features, e.g. Screw threads, springs, splines, repeated items, holes, chamfers, radii
- Abbreviations – A/F, CHAM, DIA, R, PCD, M.

Title Blocks

Title Blocks should be at the bottom of any drawing sheet and extend to the lower right-hand corner of the page.



Information that should be contained in a **title block** is the following:-

- Name
- Projection Symbol
- Title
- Date
- Original Scale
- Drawing Number
- Dimensional Tolerance

Drawing Scales

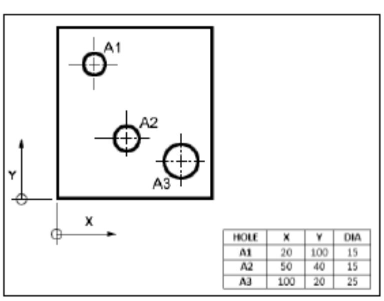
Every technical drawing needs to be drawn in an accurate proportion, also known as **scale**, which is given in ratio format. It is crucial that you aware of the following scales within the Higher course.

Full Size - 1:1

Reduction Scales - 1:2, 1:5, 1:10, 1:20, 1:50, 1:100, 1:200, 1:500 & 1:1000

Enlargement Scales - 2:1, 5:1, 10:1, 20:1 & 50:1

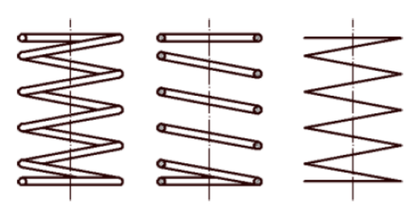
Reduction (1:2) **Full Size (1:1)** **Enlargement (2:1)**



Dimensioning by Coordinates

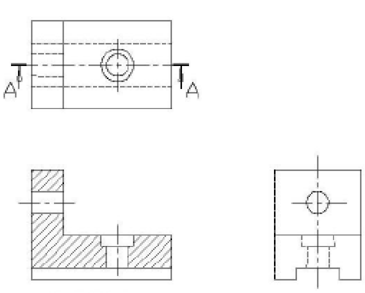
Dimensioning by coordinates uses **running** dimensioning in two directions at right angles, the common origin can be from any datum point stated. This makes it clearer to read and less cluttered on the drawing.

Springs



View **Section** **Simplified**

This is the normal way of cutting a section. The cutting plane lies on a single plane and passes through the entire object. Half of the object is removed to show the internal detail.



Full Section

Abbreviation	Meaning
A/F	across flats
CHAM	chamfer
DIA	diameter
R	radius
PCD	pitch circle diameter

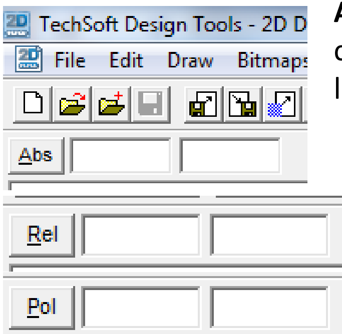
Knowledge Organiser: KS5 BTEC Engineering

Unit 2 Learning Aim B: Layers, Line types and Key terms

Key Knowledge

Using a computer-aided design (CAD) system to produce engineering drawings and circuit diagrams, including:

- **coordinates – absolute, relative, polar**

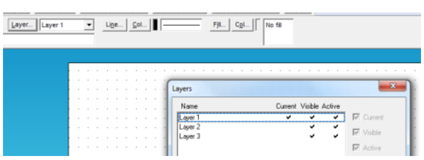


Absolute: These define your position in the drawing using X and Y Cartesian coordinates with reference to a fixed datum point or origin, often the bottom left corner of the drawing.

Relative: These let you choose a position as the origin of a Cartesian coordinate system. This is useful when you are drawing a number of different features on the same diagram.

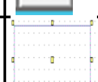
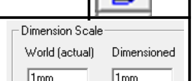
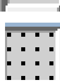
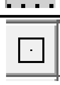
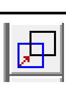
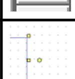
Polar: These are a type of relative coordinate system that is particular useful when positioning features in circular arrays. Instead of using distances along two perpendicular(X and Y) directions, polar coordinates use an angle and a distance from the origin to specify a position.

- **layers – names, line types, colours, visibility**

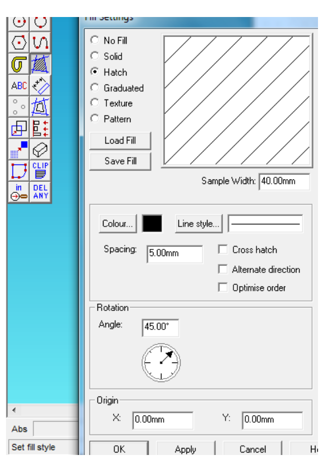


Layers: Layers in a CAD drawing can be used to overlay different information on a common drawing outline. Each feature you add to a drawing will belong to a specified layer and can be moved to a different layer if needed. You can specify any number of layers in a drawing. You can give layers names and colours and control them in different ways. For instance, if the drawing outline and dimensions are on separate layers, then you have the option to hide the dimension layer so that only the drawing outline is visible.

- **commands**

Line		erase	
Circle		stretch	
arc		trim	
polygon		scale	
grid		dimensioning	
snap		text	
copy		zoom-in,	
rotate		zoom-out	

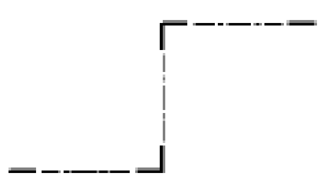
- **cross-hatching** – simple and complex areas, predefined hatch patterns, application to cross-sectioning.



Most CAD packages will have a number of pre-defined hatch patterns that are usually used to denote areas of cross sectioning. Applying cross hatching usually requires an area to be fully bounded by a continuous line.

Knowledge Organiser: KS5 BTEC Engineering

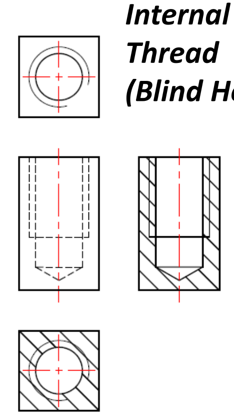
Unit 2 Learning Aim B: Layers, Line types, Key terms and Common Features

Line	Description	Application
	Continuous thick	Visible outlines and edges.
	Continuous thin	Dimensions, projection and leader lines, hatching, outlines of revolved sections, short centre lines, imaginary intersections.
	Continuous thin irregular	Limits of partial or interrupted views and sections if the limit is not an axis.
	Continuous thin with straight zigzags	Limits of partial or interrupted views and sections if the limit is not an axis.
	Dashed thin	Hidden outlines and edges.
	Chain thin	Centre lines, lines of symmetry, trajectories, loci, pitch lines and pitch circles.
	Chain thin thick at ends and changes directions	Cutting planes.
	Double dashed chain thin	Outlines and edges of adjacent parts, outlines and edges of alternative and extreme positions of movable parts, initial outlines prior to forming, bend lines on developed blanks or patterns

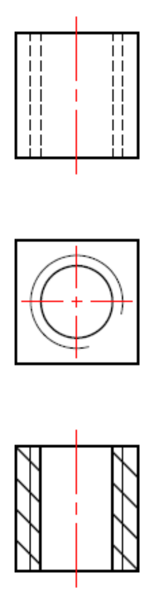
Screw Threads & Other Components

With assembled drawings you may be asked to draw a sectional view of an assembled component that might include a fixing such as a screw, bolt etc… Below are the symbols which represent each possible component:-

Internal Thread (Blind Hole)



Internal Thread (Through hole)



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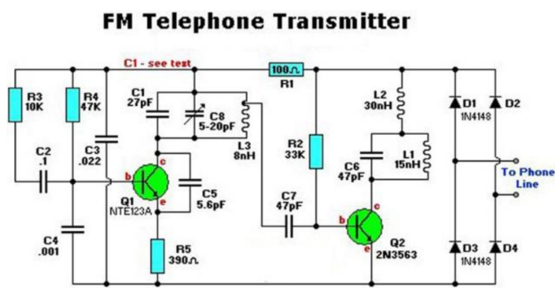
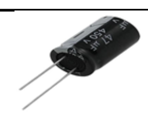
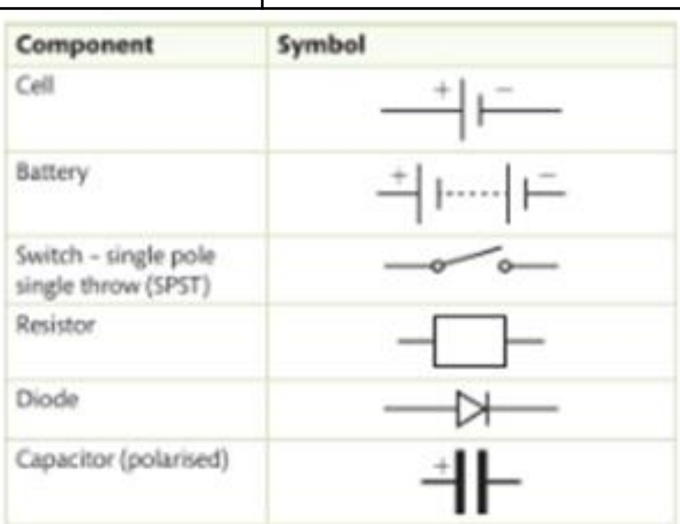
Unit 2 Learning Aim B: Circuit Diagrams, symbols and components

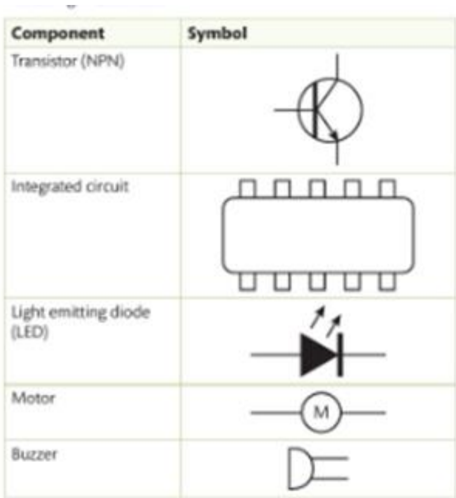
Key knowledge
Electrical symbols and electronic circuit symbols are used for **drawing schematic diagram**. The symbols represent electrical and electronic components. Electrical symbols are simplified and clean representation of circuit components. When drawing circuit diagrams, rather than drawing detailed components, we use simple symbols to represent the different components



Electronic components			**How is the value measured?**
Resistor	**These are used to reduce current flow in a circuit and have differing values**		Ohms
Capacitor	**They smooth out power supplies and can be used to filter signals.**		Farad
Fuse	**A protective safety device that breaks a circuit if too much current is drawn.**		Amps
Diode	**Is used to ensure current flows in the right direction and prevent short circuits and damage to other parts**		Resistance



Component	Symbol
Cell	
Battery	
Switch – single pole single throw (SPST)	
Resistor	
Diode	
Capacitor (polarised)	



Component	Symbol
Transistor (NPN)	
Integrated circuit	
Light emitting diode (LED)	
Motor	
Buzzer	

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Unit 2 Learning Aim C: Good communication, Planning, Team competencies and development

Key Knowledge

Principles of effective teams

• **Good communication**

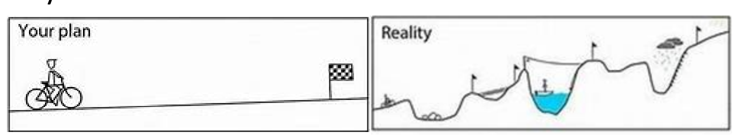
Clear communication with teams and by team members to external stakeholders and interested parties is vital if the project is to be effective. These can take many forms

VERBAL
WRITTEN
EFFECTIVE LISTENING
RESPECTING OTHERS OPINIONS
NEGOTIATION
ASSERTIVENESS
BODY LANGUAGE

• **Planning**

Projects that are successful only do so effectively if they are planned well in order to save time, energy, resources and most importantly money.

SETTING TARGETS
CONSIDERING ALTERNATIVE APPROACHES
ORGANISATION



• **Motivation**

In order to keep your team working together and communicating there needs to be positive motivation. The following are some examples.

SHARED GOALS
COLLABORATION
REACHING AGREEMENTS
FAIRNESS
OPPORTUNITIES TO TAKE RESPONSIBILITIES
CONSTRUCTIVE FEEDBACK

• **Working with others**

People take this for granted but teams can quickly disintegrate and end up finger pointing and members feeling hard done by. Some methods to use are:

BEING A TEAM PLAYER
FLEXIBILITY/ADAPTABILITY
SOCIAL SKILLS
SUPPORTING OTHERS

Team set-up and organisation

• Strengths and limitations of team members
• Allocation of responsibilities
• Timescales
• Objectives

Knowledge Organiser: KS5 BTEC Engineering

Unit 2 Learning Aim C: Preparation for batch manufacture and Manufacture

Key skills

Understanding the requirements of production plans, specifications, engineering drawings

Preparation

Planning operations, health and safety factors, processes, materials, equipment, and quality checks.

Manufacture

- Use of examples of engineered products
- Selecting, setting up and using engineering equipment to manufacture engineered products
- Examples of engineering services, e.g. dismantling/assembly
- Selecting, setting up and using engineering equipment to deliver engineering services

Key knowledge

Risk management is a step-by-step process for controlling health and safety risks caused by hazards in the workplace.

You can do it yourself or appoint a competent person to help you.

- Identify hazards
- Assess the risks
- Control the risks
- Record your findings
- Review the controls

Likelihood		Severity: Minor injury (First aid) 1	Moderate injury (lost time) 2	Serious injury (RIDDOR reportable) 3	Major injury (RIDDOR reportable) 4	Fatality (RIDDOR reportable) 5
Extremely unlikely	1	1	2	3	4	5
Unlikely	2	2	4	6	8	10
Likely	3	3	6	9	12	15
Extremely likely	4	4	8	12	16	20
Almost certain	5	5	10	15	20	25

Materials: What materials will you make each section of the product from? There should be some similar areas (Casing, Handle etc.) but you may have some parts that are individual to your design. Although by this point you may have some basic grasp of possible materials and their properties take some time to research the ones you pick and their benefits/drawbacks.

Processes: The materials used will have to go through some sort of manufacturing process to make them into the product you intend. Again take the time to research the process such as injection moulding, extrusion moulding, casting techniques, welding techniques.

Quality Control: This is a very important area of your design journey, what you decide here will ensure that product is successful and can be produced in large quantities. Just the use of simple things like jigs, measurement templates (Go/No Go) can vastly improve the end product and speed up the whole process.

Knowledge Organiser: KS5 BTEC Engineering

Unit 3 Learning Aim A: Design Triggers and Challenges

Design triggers

Market Pull
- Development based on need
- Aim to meet the needs of the customer to keep them satisfied
- Based on customer feedback
- Need to be aware of accuracy of feedback/market research methods.

Technology Push
- Development due to new technology
- Will cause product to evolve significantly
- Incorporate new features or make product more efficient/work better
- May be limited by demand or customer need/awareness about the new technology

Demand
- How much of a product is required
- Quantity manufactured needs to meet demand
- How long it will be required for
- Lifespan of the product needs to be predicted accurately to meet demand

Innovation
- A step change in product design
- Often as a result as new technology
- Example – touch screen on mobile phone
- Incremental changes are more frequent
- Creates a clear difference between your product and a competitors

Sustainability
- Commercial and environmental driver
- Consumer pressure
- Government targets
- Finite resources are limited

Market research
- Customer input on new products and product development
- Indication of demand
- Opportunity for user feedback
- Identify their priorities
- Limited scope may be an issue

Design challenges

Profitability
- Sales revenue covering cost
- Investment in future products
- Profit margin impacts on quality of materials used and selling price
- Overheads, manufacturing and material costs are ongoing
- Initial set up costs may be high

Commercial risk
- Need to be aware of customer needs and the state of the market
- Adding features may add value but if cost implication is higher than value added then it is not effective
- Viability of products due to external factors such as regulations, suppliers, resources and political changes.

End of life disposal
- Recycling has lower impact, but quality reduces each time
- Recycling parts costly
- Landfill has huge impact on the environment
- Use of recyclable materials may be higher

Designing out risk
- Consider likelihood of an accident and severity of consequence
- Safety is pivotal to product success
- Balance reality of risk i.e. overheating component - burn or fire? With cost of eliminating compared to reducing risk. i.e. could run warm but not hot.
- Physical risk – safety of customer and manufacturer
- Financial risk – installation, use and decommissioning products in cost effective way
- Commercial risk - development of new products/features which need to balance sales potential with risk if unsuccessful.

Performance issues
- Performance issues may mean that a product is too costly, unreliable, requires too much servicing , too short a product life or is unusable.
- Leads to customer dissatisfaction
- May lose market share to competitors
- Poor reputation can cause future issues
- Must take care not to cause further issues e.g. one problem solution may cause another concern.

Knowledge Organiser: KS5 BTEC Engineering

Unit 3 Learning Aim A: Design Triggers and Challenges

<table>
<tr><th colspan="3">Design opportunities</th></tr>
<tr><td>Increase power efficiency</td><td>Less environmental impact due to lower consumption.
More expensive to make products more efficient</td><td>Less use of finite resources for power generation
Improved reputation</td></tr>
<tr><td>Improved product servicing</td><td>Less waste products
Financial cost of providing spares
Longer product life</td><td>Less sales of new products
Improved reputation</td></tr>
<tr><td>Combined power sources</td><td>Electric power -
no pollutants
option of energy recovery through regenerative braking
Limited range
Traditional power
Heavy pollutants
Excellent range</td><td>Hybrid
Less pollutants
Full range
Option for regenerative breaking
Acts as generator so traditional recharges battery</td></tr>
<tr><td>Reducing energy waste during design</td><td>Use of tools to speed up the development process
Tools make the process quicker
Allows concepts to be tested more frequently
Prevents being overtaken by competitors
Brings new products to the market more rapidly</td><td>CAD simulation
Allows designers to visualise ideas much more quickly
Concepts can be tested and compared
Mechanical and physical tests can be simulated.
Reduces waste through not using physical materials and being quicker</td></tr>
<tr><td>Reducing energy waste during operation</td><td>Improved fuel economy or Increased efficiency leads to:
Reduced environmental impact
Increased profitability</td><td>Potentially more expensive
Lower operating costs</td></tr>
<tr><td>Energy from waste</td><td>Regenerative braking
During breaking motor acts as a generator.
Power is returned to battery for later use</td><td>Combined heat and power plants
Water is heated by excess heat from process of electricity generation.
Saves energy heating water separately.</td></tr>
</table>

Knowledge Organiser: KS5 BTEC Engineering

Unit 3 Learning Aim A: Design Triggers and Challenges

High value manufacturing

- Producing high value items in a more cost-effective way
- High level of knowledge and skills
- Efficient to maximise use of resources
- Aerospace, microelectronics, photonics, medical

Design efficiency – product applications

Existing design
- Nails housed in casing
- Screw fitting in casing
- Hole for cable within casing - single part
- Moulding process to allow for shape.
- Electronics housed in casing – not a separate part

Design opportunities

Reduction of mass
- Use LED's
- Smaller housing

Increased component efficiency
- Integrate parts into mounting
- Remove back
- Make mounting smaller
- Reduce/remove cage

Energy efficiency options
- LDR – remove switch
- Solar – remove battery/mains

Knowledge Organiser: KS5 BTEC Engineering

Unit 3 Learning Aim A: Equipment level and system level constraints and opportunities

Product Design Specification Design Constraints
• May be for entire product or different sub systems. • Constraints – appearance, cost, customer demands, environmental factors, size, safety, functionality, materials, manufacturing process. • e.g. material limits process, cost limits materials, safety limits size. • Highest priority – safety, other factors depend on specifics of the product. • Prioritise using cost benefit analysis, also to design out all types of risk.

Design considerations to ensure compatibility			
Electrical products	• Power supply required • AC/DC/3 phase • Single power source or multiple	Pneumatic and hydraulic products	• Connectors used • Pressure • Any ancillaries e.g. filters, regulators, lubrication
Signal transmission	• Voltage used • What sort of coding sensors and actuators to use • Wired or wireless	Control systems	• Sensors/ actuators/motors required. • Controller type • Software required
Mechanical Products	• Engineering standards • Fixings/standard components	• Modular systems – making assembly easy	

Reducing costs in low volume production
• Limit use of custom fixtures/moulds/specialist tools • Use general machinery with interchangeable parts • Flexible machine tools e.g. traditional mills, lathes, CNC.
Using specialist tools for high volume production
• Specialist equipment streamlines the process. • Enables fast, cost effective production. • Requires capital investment but can be shared out when larger production runs. • Specialist fixtures/jigs make it easier to clamp parts and aid processes to be repeatable and accurate. • Time saved to carry out the process likely to return the cost of the specialist part. • Need to factor in set up costs which are fixed whenever manufacturing e.g. loading different polymers. Process takes equal time irrespective of production run size.

Knowledge Organiser: KS5 BTEC Engineering

Unit 3 Learning Aim A: Equipment level and system level constraints and opportunities

Product application

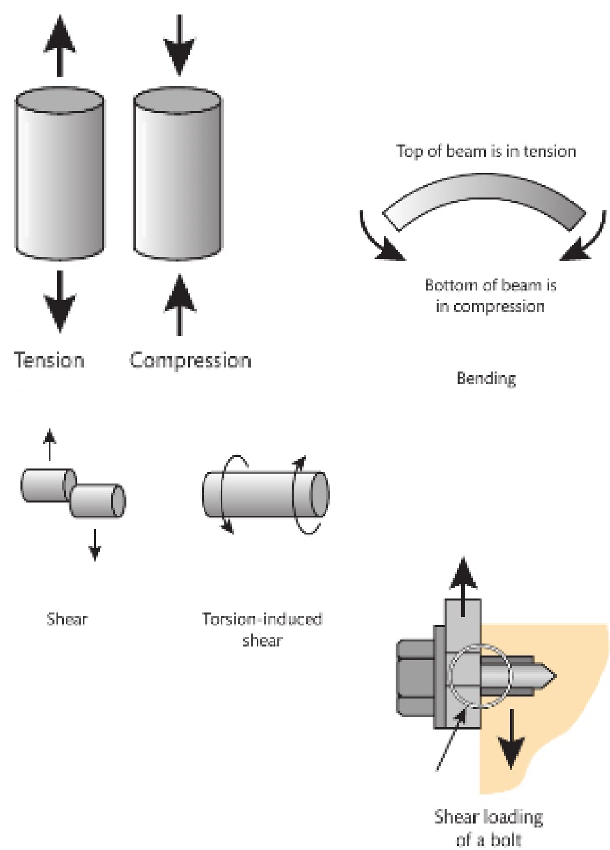
- Physical packaging v component placement
- Consistent voltage for electrics to avoid multiple power packs may mean compromises for circuitry due to flight controls being different to that of camera or sensors.
- Location of fuel tank for stability compromised with length of fuel pipe required
- Consider placement of components which may require cooling or ventilation.
- Consider positioning of parts requiring access.

Knowledge Organiser: KS5 BTEC Engineering

Unit 3 Learning Aim A: Material Properties

Tensile testing	**Point of ultimate tensile strength**
Material held between two jaws and gradually pulled apart.	The material bears the maximum load it can withstand before deforming plastically
Stress	**Yield point**
The force applied divided by the cross-sectional area of the specimen measured in Newtons per metre squared or Pascal	Yield point is where the material is permanently deformed and will not go back Elastic phase – goes back Plastic phase – permanently deformed
Strain	**Ductility**
Measure of deformation of the component under a given load (does not have a dimension)	The ability to be stretched into wires/withstand high tensile stress

Modes of failure



Tension – stresses increase with force applied. If these exceed the yield strength then the component will be permanently stretched. After the load is removed the item will be thinner and longer. Eventually the product will break.

Compression – similar to tension, component will permanently deform and then fail through either bulk or bearing.

Bending – very common mode of failure. Component is in tension on one surface and compression on the other with a neutral axis in the middle. Stresses under bending can be very high and this can lead to early failure under relatively low loads.

Shear – where the component is pulled apart or crushed. Occurs when material is forced to slide over itself.

Fatigue – happens when components are subjected to cyclic loading. Load goes from tension to compression and back again many times. Causes microscopic defects to form at loads much lower than the yield strength.

Buckling – slender components are under a compressive load. Leads to a combination of compression and bending causing instability.

Knowledge Organiser: KS5 BTEC Engineering

Unit 3 Learning Aim A: Material Properties

Property	Symbol	Unit	Description	Example design application
Shear modulus	G	GPa	The stiffness of a material in shear or torsion	Ensuring that a driveshaft in a gearbox does not twist excessively
Poisson's ratio	ν	none	A ratio that measures how much a material thins as it is stretched	Understanding material behaviour in 2D and 3D situations
Density	ρ	$kg\,m^{-3}$	The mass of material per unit volume	Selecting material for a lightweight sports product
Fracture toughness	K_{IC}	$Pa\,m^{1/2}$	The resistance of a material to fracture	Designing a product so that it will be less likely to fracture in areas of stress concentration
Coefficient of thermal expansion	α_L	$m(m\,°C)^{-1}$ or $m(m\,K)^{-1}$	How much a material expands (or contracts) as the temperature changes	Making allowances for parts to expand with temperature and not cause a product to malfunction
Coefficient of thermal conductivity	k	$W(m\,K)^{-1}$	How well a material conducts heat	Designing an air-cooled engine
Melting point		°C or K	Temperature at which a material changes from solid to liquid form	Planning injection moulding or die casting
Specific heat	C	$J\,K^{-1}$	How quickly a material warms when subject to thermal energy	Estimating how quickly a product will take to reach an operating temperature
Electrical resistivity	ρ	Ωm	The resistance of a material to the passage of electricity	Selecting a cover material for a battery terminal connector
Electrical conductivity	σ or κ	$S\,m^{-1}$	The reciprocal of resistivity $\left(\frac{1}{\rho}\right)$; measures a material's ability to conduct electric current	Selecting the appropriate size of electric cable for high-power applications
Permeability	μ	$H\,m^{-1}$	The ability of a material to form a magnetic field	Selecting appropriate materials for magnetic couplings

Use of lubricants

- Liquid, grease or solid
- Circulating, sprayed or dripped on
- Needs to be replaced regularly
- New lubricant should be part of cleaning process
- Grease – moving parts
- Solid – used for high temps where liquid would degrade
- Used so parts do not come in direct contact – reduces friction, wear and heat build up.

Knowledge Organiser: KS5 BTEC Engineering

Unit 3 Learning Aim A: Material Properties

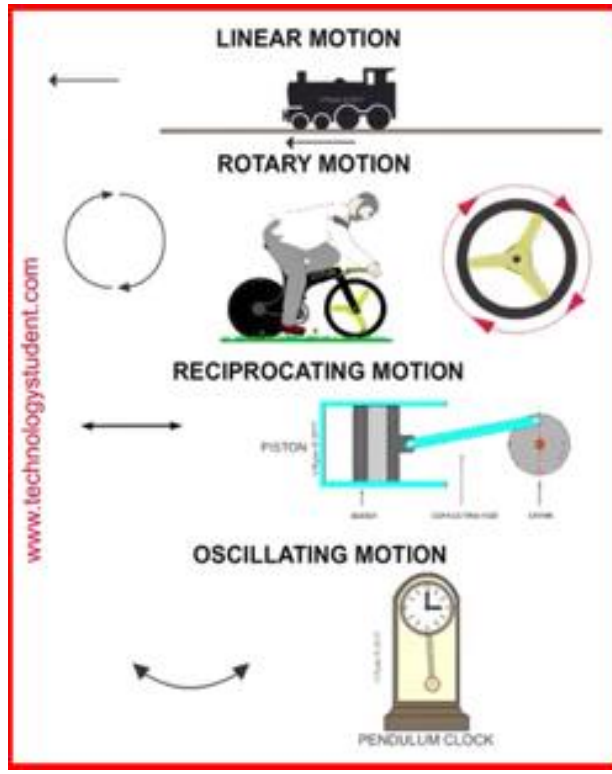
Nanomaterials
• Exist naturally and often developed directly from molecular or crystalline structure. • Have novel properties such as strength, purity or shape of material. • E.g. Fullerenes which are carbon molecules in tubes or ball like structures- very strong and effective conductors. • New technology which is constantly evolving.
Biomaterials
• Used in medical devices and implants • Ceramics, amalgam and cement used in dentistry • Metallic, ceramic and polymer based materials used in replacement • Need to consider strength and wear characteristics and make sure they are biocompatible, so the body does not reject it. • More advanced include miniature scaffolds of bone engineering and hydrogels to grow living tissues and repair the body.
Smart alloys
• Shape memory alloys which when heated above a certain temperature return to their original form. • Can operate as actuators to create simpler, lighter systems • Have super elastic properties so can withstand much greater deformation. • Expensive in bulk and are limited e.g. cannot be used for large parts.

Surface treatments	
Painted coatings • Protect against corrosion • Cosmetic benefits • Conventional brushes or sprayed • e.g. car parts	**Electrodeless plating** • Nickel based compounds used to plate materials to improve wear and corrosion resistance. • e.g. motorcycle bodies
Powder coating • Tougher surface than paint • Powder attracted to metal surface by electrostatic charge • Cured in oven to get a hard surface • e.g. machinery bodies	**Electroplating** • Electrochemical process – base metal surface coated to improve corrosion resistance and wear or cosmetics • e.g. chrome plating used for kitchen ware
Galvanising • Zinc plating on iron or steel • Crystalline spangled finish • Sacrificial protection of the metal through corrosion of the zinc • e.g. railings	**Anodising** • Protect aluminium by artificially increasing the thickness of the aluminium oxide reducing the likelihood of corrosion underneath • Offers option for colourful finishes • e.g. bike brake levers

Knowledge Organiser: KS5 BTEC Engineering

Unit 3 Learning Aim A: Mechanical Power Transmission

Type of motion	Examples
Linear	• A hydraulic ram used in earth-moving equipment • A shock absorber in car suspension • The movement of a seat post to adjust seat height on a bicycle
Rotary	• The main shaft of a jet engine • A drill tip when in use • The rotation of a vehicle wheel
Reciprocating	• A piston in a car engine • A bicycle pump
Oscillating	• A mass on a spring • A pendulum



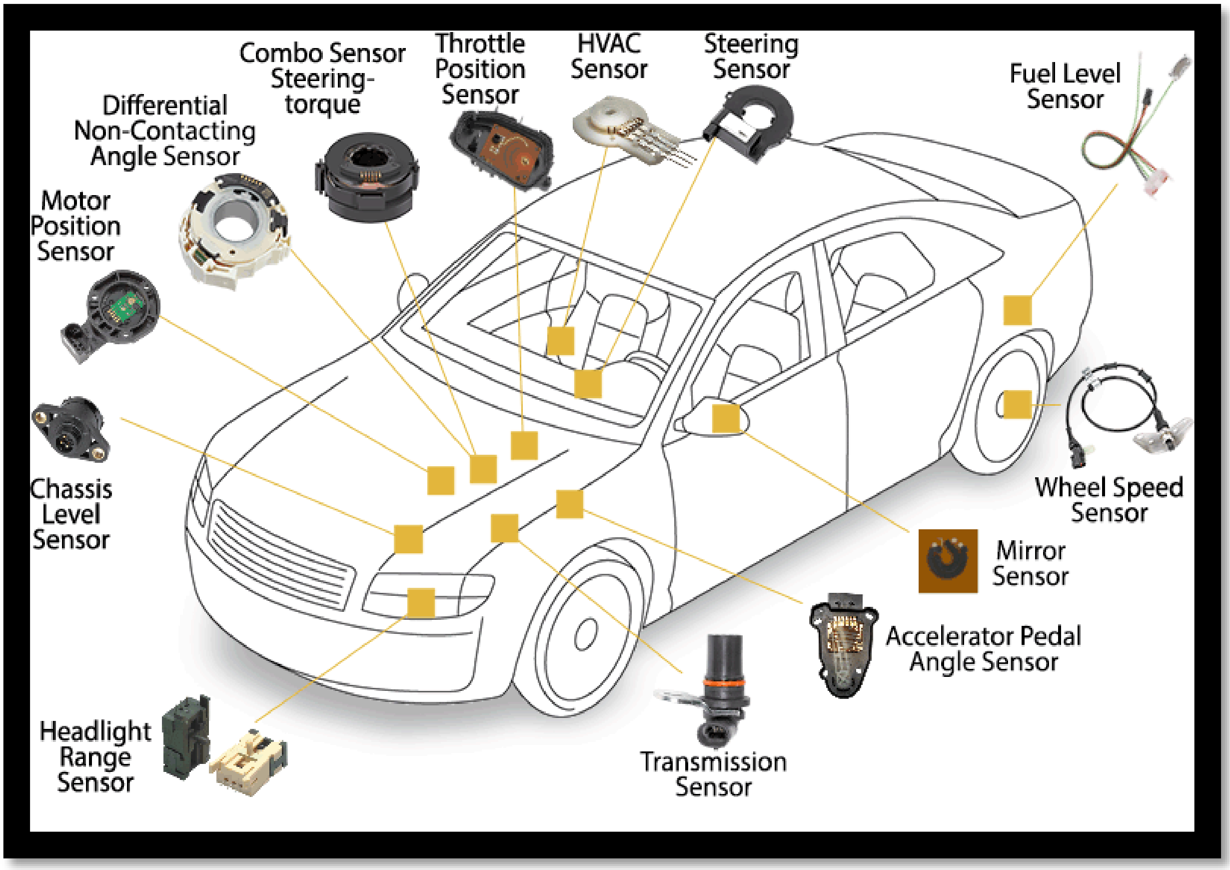
Source	Advantages	Disadvantages
Fossil fuels	Readily available (currently) Portable	Not sustainable Give off particulates and emissions when used
Biofuels	Becoming increasingly available Portable	May still give off emissions when combusted
Mechanical	Have a long history of use – these include flywheels, clockwork and spring-based energy storage, and gravitationally based systems such as pendulums and falling weights	Flywheels have been applied to some specialist transport applications, but these, like springs and gravitational energy-based systems, generally need to be coupled to an additional energy source for effective use
Hydrogen	Can be used in fuel cells, which can then generate electricity Portable and low-emissions (the only emission is water vapour)	There is currently limited infrastructure to supply hydrogen in an accessible form
Electricity – mains	No emissions at point of use Easily accessible	The generation of electricity may produce emissions via the combustion of gas or oil Not portable
Electricity – battery	Portable and easily applied Batteries may be recharged	Batteries may have limited life between recharging cycles Batteries may require special disposal at end of life
Wind and solar power	Renewable source with no emissions Offers electrical power in locations where mains power may not be available	Wind power and solar power are not dependable and may require battery back-up to provide consistent service

Knowledge Organiser: KS5 BTEC Engineering

Unit 3 Learning Aim A: Mechanical Power Transmission

Sensors	Controllers
• Monitor what is happening within a system: • Pressure sensors • Load sensors • Displacement sensors	• Decide what signals need to be executed: • Programmable logic controllers (PLC's) – industrial • Microcontrollers – small chips built into products

Application of sensors and controllers
Commercial greenhouse: • Sensors monitor direct sunlight, temperature and moisture in soil. • Controller sends signals to turn on heaters, open windows, trigger motors to shut blinds and turn on sprinkler systems to water the soil.

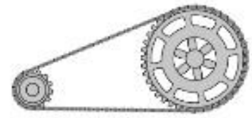


Knowledge Organiser: KS5 BTEC Engineering

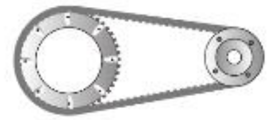
Unit 3 Learning Aim A: Mechanical Power Transmission

Cams usually take rotary motion and convert it into oscillating linear motion. The cam itself is a specially profiled section of the rotating shaft; the profile determines the nature of the reciprocation.

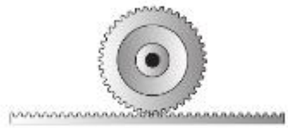
Spur gears



Chain drive



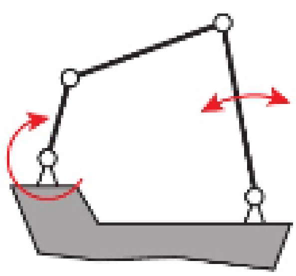
Belt drive



Rack and pinion

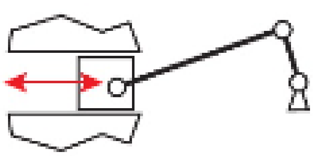
Bevel gears

Four-bar linkages normally consist of three moving links, with the fourth link being a base. This example shows a windscreen wiper-type mechanism. The short link on the left would be driven by a motor and rotate through a full circle, while the link on the right would oscillate left and right through an arc.



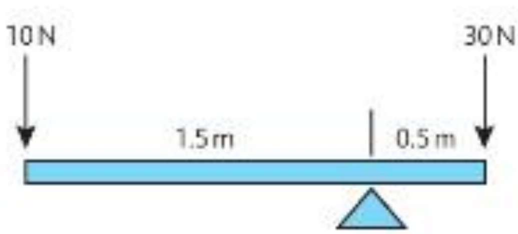
Gears are well suited to power applications. Often, motors and engines run fast and have too little torque to be of direct use. By using gears, the speed of rotation can be reduced and the torque increased. This is effectively another form of leverage. For example, if an 18-tooth pinion running at 3000 rpm is engaged with a 54-tooth gear, the shaft on this gear will run at $\frac{18}{54} \times 3000 = 1000$ rpm, while the torque will increase, nominally, by a factor of three, though in reality a bit less. Note that connecting gears will rotate in opposite directions.

Belt and chain drives also allow speed changes between input and output shafts, based on the number of teeth on their sprockets. Chain drives are commonly used on bicycles. Both chain drives and belt drives feature in car engines to drive cams and ancillary devices, such as alternators and water pumps.



Slider-type linkages are also common. This example is similar to the mechanism of a reciprocating piston in a car engine driving a rotating crankshaft. The same sort of mechanism could run the other way – with a motor driving a rotary crankshaft, which then causes a piston to reciprocate – and could form the basis of a pump or air compressor.

Perhaps one of the most common forms of linkage is the lever (**Figure 3.8**). This gives increased mechanical advantage in a system, allowing a relatively small force to generate a proportionately larger force, depending on the lever proportions.



Applying a 10 N force at a distance, 1.5 m from the pivot will generate 10 x (1.5/0.5) = 30 N at the other end of the lever.

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Unit 3 Learning Aim A: Manufacturing Processes

Scales of production				
Technique	**Description (1 each)**	**Uses (1 each)**	**Advantages (1 each)**	**Disadvantages (1 each)**
One off	Large infrastructure items or small specialist projects	Oil rig, bridge, building,	Very specific bespoke output.	Time consuming and expensive manufacture.
Small batch	Small amounts at any one time but high volume over lifespan.	Machine tool manufacture engines	Well suited to JIT – limited investment in materials and storage	Can incur high set up costs for each batch
Large Batch	Larger number of products made in each run.	Computer software Electrical goods	Lower set up costs as each run is for longer	Storage for finished components and more sales required to get money back.
Mass	Large numbers usually on a production line.	Cars, mobile phones.	Highly cost effective.	Difficult to change products once run is set up.
Continuous	Flow type system which rarely ceases. Highly automated and specialised	Steel, petrochemicals, fertiliser	Very high output to meet demand and very lean for cost effectiveness.	Huge cost implications if system fails.

Joining techniques

Method	Uses, advantages and disadvantages
Screws, nuts	Easily available. Wide range of standard and special types. Allow for disassembly. While screws and nuts are generally metallic, they can be used to join any material.
Rivets	Easily available. Not readily disassembled.
Snap-fit	Allows fast assembly and eliminates the need for separate fasteners. May be difficult to disassemble.
Adhesives	Permanent. May also offer sealant function. Modern adhesives can be particularly strong. Difficult to disassemble.
Welding	Permanent – host material is melted to create join. As strong as host material. Range of different forms of welding available to suit different materials and applications.
Brazing, soldering	Metallic-based connection, but component material is not melted. Variants of these processes can be used for both mechanical and electrical connections.
Interference fits	A component has a hole in it with diameter very slightly smaller than the shaft it will fit on. Using an appropriate press or by heating the component to increase the hole diameter temporarily, the parts can be made to fit and will bind together due to the interference between them.

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Unit 3 Learning Aim A: Manufacturing Processes

Machining

Producing components by cutting material from block or cylinder stock. Can also be a finishing technique e.g. On castings.
Highly flexible and used on many materials including most metals, polymers and woods.

Machining techniques

Drilling is a cutting process that uses a drill bit to cut a hole of circular cross-section in solid materials. The drill bit is usually a rotary cutting tool, often multi-point. The bit is pressed against the work-piece and rotated at rates from hundreds to thousands of revolutions per minute.

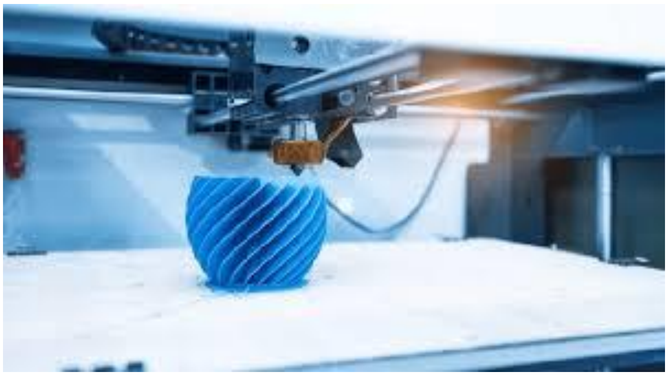
Turning is a machining process in which a cutting tool, typically a non-rotary tool bit, describes a helix toolpath by moving more or less linearly while the workpiece rotates.

Milling is the process of machining using rotary cutters to remove material by advancing a cutter into a work piece. This may be done varying direction on one or several axes, cutter head speed, and pressure.

Additive manufacturing

Additive Manufacturing (AM) is an appropriate name to describe the technologies that build 3D objects by adding layer-upon-layer of material. Otherwise known as 3D printing.

Common to AM technologies is the use of a computer, 3D modeling software (Computer Aided Design or CAD), machine equipment and layering material.



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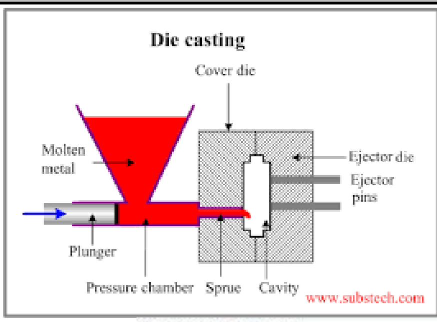
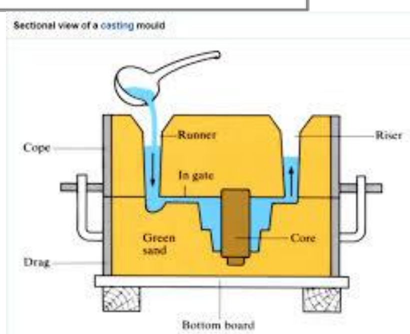
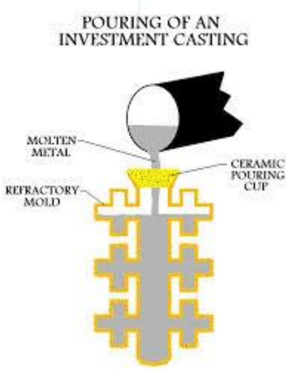
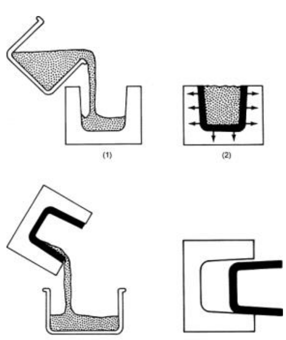
Unit 3 Learning Aim A: Manufacturing Processes

Casting









Die casting is a metal casting process which forces molten metal under high pressure into a mould cavity. The mould cavity is created using two hardened tool steel dies which have been machined into shape and work similarly to an injection mould during the process. Most die castings are made from non-ferrous metals, specifically zinc, copper, aluminium, magnesium, lead, pewter, and tin-based alloys. Depending on the type of metal being cast, a hot- or cold-chamber can be used.

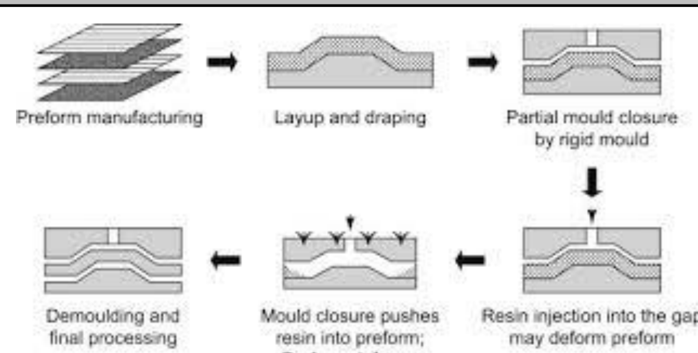
Sand casting uses compressed or compacted sand to create the mold that contains the cavity into which metal is poured. The sand contains oils that encourages it to hold its shape.

Investment casting, or lost wax casting, is a manufacturing process in which a wax pattern is coated with a refractory ceramic material. Once the ceramic material is hardened its internal geometry takes the shape of the casting. The wax is melted out and molten metal is poured into the cavity.

Ceramic casting is when Ceramic slurry is poured over a relief pattern and left to solidify, forming a cavity mould in the shape of the component to be cast. Cope and drag parts are produced. Each ceramic part is hardened by high temperature firing, then fitted together to make one hollow mould in which to cast the molten metal.

Composite manufacture

Composite materials are essentially a combination of two or more dissimilar materials that are used together in order to combine best properties. Composite materials (resin and fibers) are placed in an open mould, where they cure or harden. This may be done by building the material up in layers or within a mould.



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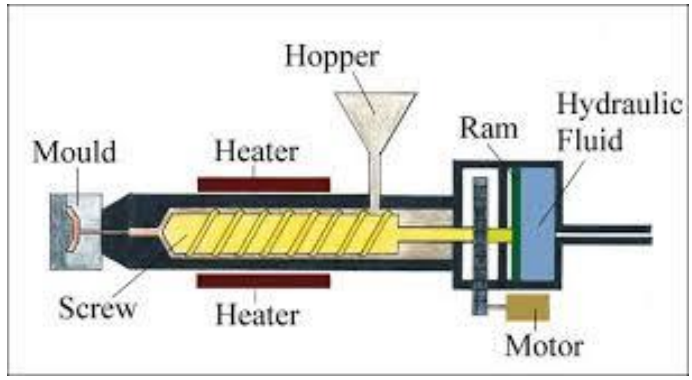
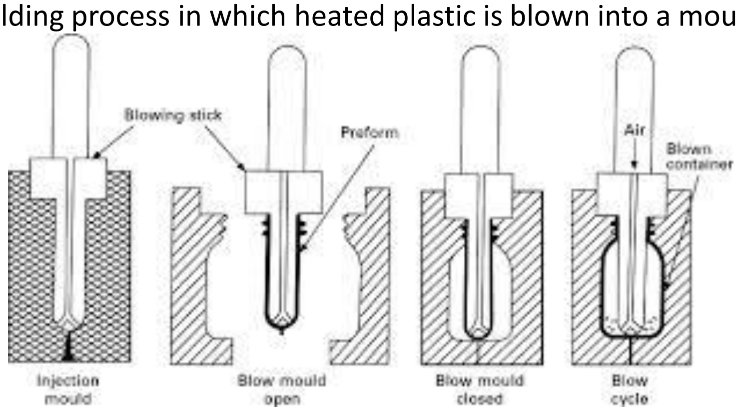
Unit 3 Learning Aim A: Manufacturing Processes

Moulding

Injection moulding is the process of melting plastic pellets (thermosetting/ thermoplastic polymers) that once malleable enough, are injected at pressure into a mould cavity, which fills and solidifies to produce the final product.

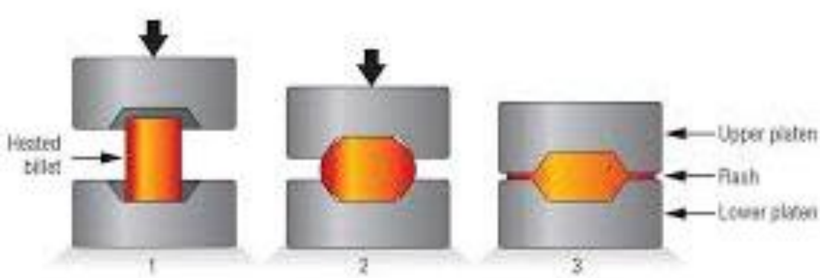


Blow moulding is a molding process in which heated plastic is blown into a mould cavity to create a hollow object.



Heat processes

Forging is a manufacturing process involving the shaping of metal using localized compressive forces. The blows are delivered with a hammer (often a power hammer) or a die. Forging can produce a piece that is stronger than an equivalent cast or machined part. As the metal is shaped during the forging process, its internal grain texture deforms to follow the general shape of the part. As a result, the texture variation is continuous throughout the part, giving rise to a piece with improved strength characteristics.



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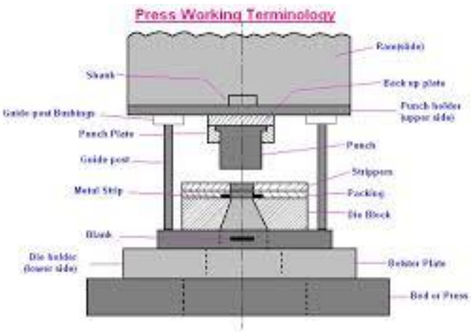
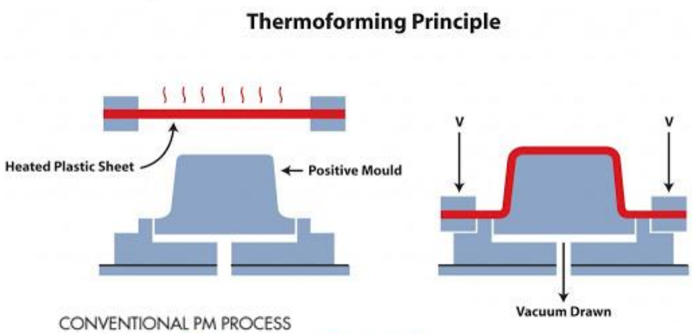
Unit 3 Learning Aim A: Manufacturing Processes

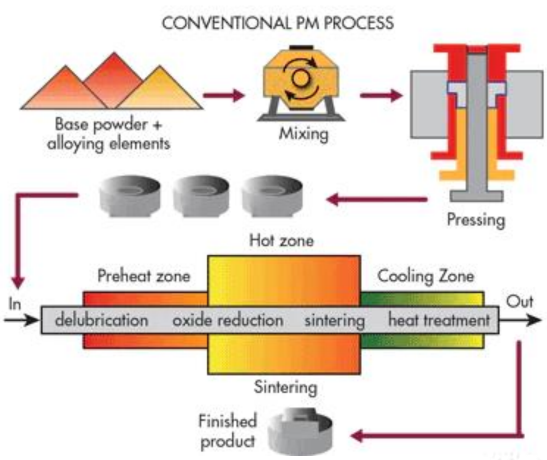
Heat processes



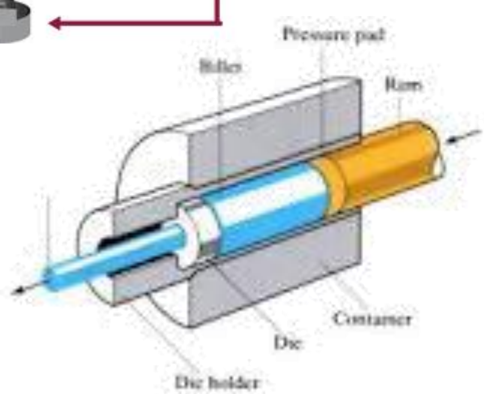
Pressing and punching A punch press is a type of machine press used to cut holes in material. It can be small and manually operated and hold one simple die set, or be very large, CNC operated, with a multi-station turret and hold a much larger and complex die set.



Thermoforming is a manufacturing process where a plastic sheet is heated to a pliable forming temperature, formed to a specific shape in a mould, and trimmed to create a usable product.



Powder metallurgy involves mixing elemental or alloy powders, compacting the mixture in a die, and then sintering, or heating, the resultant shapes in an atmosphere-controlled furnace to metallurgically bond the particles.



Extrusion is a process used to create objects of a fixed cross-sectional profile. A material is pushed through a die of the desired cross-section.

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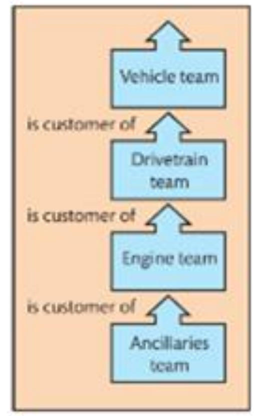
Unit 3 Learning Aim B: Design for a customer

Types of customer	
Internal: •Specialist teams e.g. Design team, engine team, ancillaries team, new car team etc. •Detailed specification of requirements •Work closely with the customer throughout the process External: • Outside the organisation • May be end user • Product usually going onto the open market • Decisions based on product demands • Data from previous experience, market research, focus groups. •Unlikely to have a specific customer to liaise directly with – decisions based on understanding of market/user types and needs.	

Customer considerations	
Performance specifications	Sets out what the user expects the product to be able to do. It is the basic requirements that make the product function. e.g. an engine water pump needs to pump x litres of water an hour (prime performance expectation) but also needs to work in a certain temperature range over a certain period of time (secondary expectations.)
Compliance to operating standards	Products need to adhere to industry standards. Put in place for safety or compliance reasons. e.g. toy safety directive. Makes sure the product complies with essential safety requirements in normal use, a safety assessment is carried out and instructions are included.
Manufacturing quantities	This comes from understanding the size of the market and also the market share that you are likely to be able to get. It impacts on processes and materials used as certain manufacturing techniques are best suited to different volumes of production e.g. injection moulding (large scale) and 3D printing (small scale.)
Reliability and product support	You will need to know what the customer expects from the product in terms of life span. Failure must also be considered as this may have consequences such as injury. Designers also need to think about both support and maintenance. The product will require more support if it is self-assembly or if there are parts that need maintaining or replacing.
Product life cycle	This is considering all the stages of a products life from conception through manufacture, use and then disposal. It is important to consider whether there is opportunity for the product to be re-used, repurposed, recycled or how else it might be disposed of. For example a car tyre could be re-treaded, repurposed as a barrier or recycled into playground surfacing.
Usability	Ease of set up and operation impact on sales. Ideally products should be intuitive a remove the need for complicated instructions. There also might be conventions that need considering (e.g. indicators on the left hand of the steering wheel in most UK cars.) Users may also need it to interface with other products or to be easy to service and maintain.
Anthropometrics	Understanding the physical body measurements of the user e.g. height, eyeline position, weight, arm length. Data is usually taken from tables or databases and converted into computer or physical models of users. Often designers consider the 5th-95th centile which is 90% of users to make sure that the product suits everyone. But sometimes a specific measurement will be required for a certain demographic e.g. pregnant women.

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Unit 3 Learning Aim B: Regulatory constraints and opportunities

Safety considerations
• Is it safe for the user under normal use? • Could it be dangerous to others? • Are there features that will run hot, or are sharp? • Is it excessively noisy? • Will it give off fumes in operation? • Are there any other aspects of the design that are not as safe as they could be? • Can you use guards or **interlocks** to protect the user from any dangerous features? • Is it safe to install – is it heavy or does it have exposed electrical or cutting elements? • Is it easy to clean and maintain? • What instructions should you provide to instruct the user on safe use?
Data protection and data security
Important when designing devices which a user will interact with to access their personal information e.g. cash machines or card readers or when storing personal data e.g. medical information. Devices need to be designed to minimise the risk of interception or capture or data by third parties. May need to consider how data gathered from users might be used. e.g. smart energy meters were rolled out in the Netherlands, but the data also showed when people were home which infringed people's privacy and was also a security risk.
Intellectual property
Patents – protect technical innovations. New manufacturing processes, products or features can all be protected by a patent, but they have to be completely brand new. Patented designs cannot be directly copied by others, but they can be licensed for a fee. Patents are normally region specific and can be valid for up to 20 years. Design rights – focus only on looks e.g. Coca-Cola bottle shape. This prevents people using the specific style as their own. Trademark – conventionally a company name, logo, brand or slogan. e.g. Nike tick and 'Just Do It' They cannot be used by other companies without permission.

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Unit 3 Learning Aim B: Regulatory constraints and opportunities

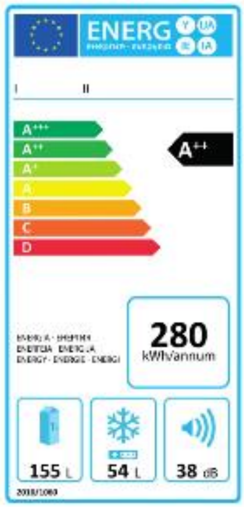
Product or requirement	Standard
Child car seats	ECE R44.03/04
Cycle helmets	BSEN 1078
Safety shoes	ISO 20345:2011
Items to be used in explosive atmospheres (e.g. petrochemical plants, grain silos)	ATEX 2014/34/EU
Electromagnetic compatibility	EMC 2014/30/EU
Boilers and water heater efficiency	EU Directive 2009/125/EC

Regulatory and certification requirements for products

Before sale, products must be checked to make sure they meet relevant regulations or certifications. There may be other standards that are not legally required but might be beneficial. CE marks are used by manufacturers to show that the product meets all the relevant standards, but as a designer you would need to consider each specific standard separately to make sure that your product complies. Standards are very specific to the product and they are extensive. They are also constantly updated so designs must comply to the latest version. Historically, standards were localised e.g. British Standards but now products need to consider national requirements as the marketplace has become more global.

Environmental constraints

Safety and reliability were the initial cause of standards being developed but now they are frequently linked to environmental concerns.
To meet the environmental standards now, many products have to display their energy ratings e.g. washing machines and fridges must have energy labels which show how efficiently they use water and power. Labels may also show other factors such as compliance with noise and electromagnetic regulations.
By complying with these regulations, a manufacturer measures the carbon footprint of the product during use and through its life. Other regulations cover disposal of products and the use of environmentally harmful components or chemicals e.g. the use of certain refrigerants.



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Unit 3 Learning Aim B: Market, Performance and Manufacturing Analysis

Production considerations	
Bespoke products for a specific customer	Customer commissions company to carry out a particular design for them or process is put out to tender so that companies can bid for the work. Designs are very customer specific and bespoke to that situation or environment.
Products for sale on the open market	Customer has a choice of products so ones which are less expensive, more reliable or easy to use will have a competitive edge. Designs are usually aimed at an 'average' customer in order to meet the needs of as many customers as possible.
Unique selling point	USP is usually a feature or performance level which stands out from the competitor products. It makes the product stand out and seem more attractive to the customer. It carries some risk as the cost of the exceptional feature or performance may not be offset by the extra sales if customers are not sold on the idea.
Obsolescence	Where a product is outdated or no longer usable. Can be caused by a range of factors e.g. • Changes in regulations (car engine emissions) • Market disruption due to changes in materials or technology (film cameras replaced by digital) • Replacement products

Factors affecting product lifespan
Customer expectations of lifespan
Establish customer expectations for products. If wear occurs more quickly then this may lead to returns/complaints or impact on future sales.
Servicing and replacement of parts
Moving parts may need inspection, maintenance or replacement to maintain effective use. Estimated points for this should be established to prevent failure. Designs will need easy access to allow this to occur.
Safe failure
Safe failure ensures that the customer is not harmed during product operation even if the product breaks. This is crucial to prevent complaints and maintain companies reputations. Safe failure may mean parts are encased or they have built in fuses to reduce risk.
Environmental sustainability
When choosing materials it is important to consider whether the material is sustainable. Consider whether the source is renewable or if it can be manufactured from recycled materials. The whole life span of the product needs to be analysed, considering usage, consumable items, reduction of energy consumption as well as how the parts can be stripped down and disposed of at end of life.

Knowledge Organiser: KS5 BTEC Engineering

Unit 3 Learning Aim B: Market, Performance and Manufacturing Analysis

Product form and functionality
Physical shape/size/appearance. Often closely linked to function e.g. garden tools shape or aerodynamics of an F1 car. Some products, for example electronics, may have more options for different forms due to changing the shape of the casing. This could be influenced by ergonomics, practicality, style or customer feedback. What the product is expected to do and how it is expected to work. May also cover factors of safety. Functionality will affect cost, materials and manufacturing processes, form and usage. Designers must consider what compromises can be made on function compared with other design criteria.
Impact of manufacturing choices
Manufacturing affects the geometry which can be achieved and the materials which can be used. Some processes are only suited to specific volumes of production and may not be practical or cost effective if used outside of these volumes. The cost implication of manufacturing is considered per part.
The impact of tolerances
Tolerances are used to dictate the minimum and maximum acceptable variation of components. Outside of this level the product may be compromised. Accepting a lower quality finish may mean that the product can be made cheaper, but parts could be less consistent leading to higher failure rates, more waste or lower customer satisfaction. This must all be balanced to ensure the product is financially viable but still acceptable for use.

Welded fabrication
The part is fabricated by two flat laser- or plasma-cut sheets welded together.

Positives:
low set-up costs with minimal specialist tooling;
little waste of material

Negatives:
may lack precision due to thermal distortion;
welding method limits material choice (but as an alternative plastics could be bonded using adhesive)

Machined and assembled fabrication
The part is fabricated from two machined elements screwed together.

Positives:
low set-up costs with minimal specialist tooling;
wide choice of materials;
simple assembly of components

Negatives:
could be wasteful of material if machining from stock;
requires assembly process

Casting or moulding
The part is cast or moulded as a single piece.

Positives:
no assembly needed;
little waste of material;
some features can be moulded in to reduce secondary operations

Negatives:
cost of mould may be significant;
part needs draft angles to allow removal from mould;
limited choice of material

Sheet fabrication
The part is fabricated by folding flat laser- or plasma-cut sheets.

Positives:
low set-up costs with minimal specialist tooling;
little waste of material if parts are nested on sheet

Negatives:
may lack precision due to fold operations;
material choices limited (e.g. thin sheet steel, but may be possible to use plastics with heat-assisted folding)

Knowledge Organiser: KS5 BTEC Engineering

Unit 3 Learning Aim B: Market, Performance and Manufacturing Analysis

Performance considerations	
Strength	Consider the levels of stress that the product will be under and make sure it is always operating below the yield strength. A factor of safety will cover misuse or material faults which could lead to failure. Factor of safety of 3 is 3 times as strong as the anticipated requirement.
Stiffness	Think what will happen if the component flexes. This can be reduced by geometry and also reviewing the young's modulus for the material. The product will determine what level of elasticity can be tolerated.
Fatigue characteristics	Vibration or cyclic operation can reduce durability due to fatigue. Conditions may mean the material is not strong enough due to fatigue even though it is operating well below the yield strength.
Thermal conductivity	If the product is used in a range of temperatures, then thermal conductivity must be considered. Use of a heat sink may be required so the product doesn't overheat.
Thermal expansion	Heat can cause materials to expand. Some products have expansion joints to allow for this.
Density	Dense products are heavier, so should be considered if a product needs to be light. A compromise may be needed between density, strength and rigidity.
Ductility	If the material needs forming, then it will need to be ductile or malleable, so it isn't brittle and snaps
Machinability	Some materials are hard to machine due to work hardening. This is because the vibrations caused by the machining process work harden the materials surface so the next pass is more difficult.
Manufacturing suitability	The geometry required often dictates the process needed. The process required also then limits the materials which are options for the product.
Corrosion resistance	If the environment of use is damp, then corrosion should be considered. Some materials have natural corrosion resistance reducing the need for finishes.
Electrical conductivity	If the product needs to conduct electricity (e.g. a car chassis is used as the earth return) then this limits the material choices. Similarly if the product needs insulating then some materials will be more appropriate.
Price	Material cost, availability and process use impact heavily on the product price. Cost needs to be balanced against the other design criteria to optimise the design.
Choice of components	Components will need a performance specification before designs can be finalised as this will allow the suppliers to source the best fit for the product requirements.

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Unit 3 Learning Aim B: Market, Performance and Manufacturing Analysis

Product applications

- be able to support the weight of users
  - provide adequate back support
  - be such that the chairs can be stored efficiently
  - be easily carried
  - be such that the chair supports do not damage flooring
  - be able to be connected to other chairs to form rows
  - be easy to clean.

Ergonomic interaction	Steering wheel: Indicator positioning Wiper stalks Wheel placement relative to the instrument panel.
Physical interaction	Engine fuel pump: Space available Connecting pipes location Access for changing filters or removal Fasteners that are compatible with the rest of the system
Electrical interaction	Lathe: Voltage need to be compatible with other machinery Digital communication required to be controlled or work with other parts (e.g. CNC)
Thermal and environment interaction	Outdoor security light: Will need to withstand heat, cold and possibly vibration? May require shielding or insulation Could affect other products locally if it generates heat/vibration

Knowledge Organiser: KS5 BTEC Engineering

Unit 3 Learning Aim C: Design Proposals

Key design stages	
Develop an initial product proposal	New product concept. Consider materials, manufacturing processes, technical issues and compromises. Need to turn a basic idea into a viable design.
Redesign a product to resolve a fault	An existing product is failing in use Identify the underlying issue(s) Propose an effective alternative
Redesign a product to reduce costs	Reduce cost to increase profit or reduce sales price Consider modifications which make it cheaper to make, easier to assemble or use fewer materials.
Develop a specialised variant of a product	Consider adapting an existing product to give improved functionality or so it can be used in a new sector. Review power, weight, corrosion resistance or other factors to develop it for this use.
Adapt a product to changing regulations	Alter an existing design which has become obsolete. Modify the existing product to meet the requirements or design an entirely new product.

Critical design considerations	
Aesthetics	• What should it look like? • What environment does it need to fit into? • Are there any conventional colours or shapes people will recognise? • Is there any brand identity to consider?
Ergonomics	• Who are the users? • How will they interact with the product? • What impact do size, strength, weight etc. have on the user? • How can the product be made safe and comfortable to use?
Size	• Does it need to be a certain size? • Is there a standard it needs to meet? • Are there any other components or products it needs to fit with?
Mechanical and electronic principles	• How will it work? • Will it be strong enough? • Are there any parts which move? • How are components connected? • What electronics are required? • How will they be powered?
Materials and manufacture	• What strength and rigidity is required? • What are the consequences of failure • What health and safety impact do the materials/processes have? • Is the product going the be somewhere damp or corrosive? • What coating might be needed?

Knowledge Organiser: KS5 BTEC Engineering

Unit 3 Learning Aim C: Design Proposals

Critical design considerations	
Assembly	• How will it be put together? • Can parts be pre-combined to make the assembly quicker and cheaper? • Is it going to be easy to line up for assembly? • What tools are required? • How will it be joined?
Costing	• What is the estimated cost? • What profit margin will there be after manufacturing costs? • Is it viable for the market? • Can the costs be reduced through redesign?
Factors of safety	• What factor of safety is needed? • How much will need adding for misuse, unexpected loading or variability? • How great is the cost of failure – replacement, reputation, injury? • Does there need to be a safety feature e.g. fuse or back up system?
Which components to buy /how to select them	• What proprietary/standard components are required? • Where will they be sourced? • What limitations are there – size, availability? • Which supplier is preferred - cheapest/most reliable?

Product Application	
Requirement	**Possible solutions**
Protects pelvis from injury	Hard shell Thick layer of protection
Cushions impact	Use a sponge like foam Use expanded polystyrene material
Suits a range of users	Produce a range of sizes Make adjustable through ratchet type adjuster
Can be secured via seatbelt	Buckle Snap fit Stud
Elevates child to correct height for seatbelt	Ergonomic Fits smallest user

Knowledge Organiser: KS5 BTEC Engineering

Unit 3 Learning Aim C: Design Proposals

Choosing information sources for making design decisions
Appropriate sources will be dependent on the product being considered. It may be necessary to look into the machine tools which can be used to make parts so that the cost of them or their availability can be reviewed. Regulatory documentation may dictate certain requirements that the product needs to meet in order to be accepted for sale globally or within certain markets. In addition to written data and that on online data bases, the opinions of other are also valuable especially when using unusual materials or manufacturing processes, or trying to break new ground with a product. Suppliers can give you technical information via their technical support centres and will have specialist knowledge of their sectors which might not be readily available elsewhere.

Information sources	
Materials data	Information of strength, elasticity, density etc. which can be obtained from suppliers or reference books. Data is usually tabulated or graphical in form. Computerised databases allow this data to be accessed easily. Data is used for the identification or appropriate materials and the selection of different materials which they are directly compared with one another.
Manufacturers data	Information on standard or proprietary components such as motors, drive belts, chains, gears etc. Manufacturers will provide datasheets for their products showing things such as dimensions, performance, limitations and fitting instructions. This information is used to select the most appropriate parts and also to compare parts from different suppliers to see their strengths and weaknesses.
Engineering standards	Requirements which govern the geometry of standard components or engineered products. E.g. an M6 screw will have a pitch of 1mm and a head dimension of 10mm across the flats.

Explain how an evaluation matrix can be used to select which initial ideas to develop further. (6)

Each design is compared against the specification criteria. Scores are awarded for each criteria. Criteria might be weighted if they are more important so that the total represents the needs of the customer. The idea with the highest outcome is selected/developed.

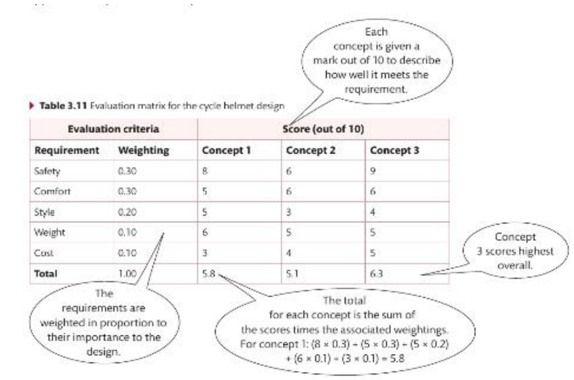


Table 3.11 Evaluation matrix for the cycle helmet design

Evaluation criteria		Score (out of 10)		
Requirement	**Weighting**	**Concept 1**	**Concept 2**	**Concept 3**
Safety	0.30	8	6	9
Comfort	0.30	5	6	6
Style	0.20	5	3	4
Weight	0.10	6	5	5
Cost	0.10	3	4	5
Total	1.00	5.8	5.1	6.3

Knowledge Organiser: KS5 BTEC Engineering

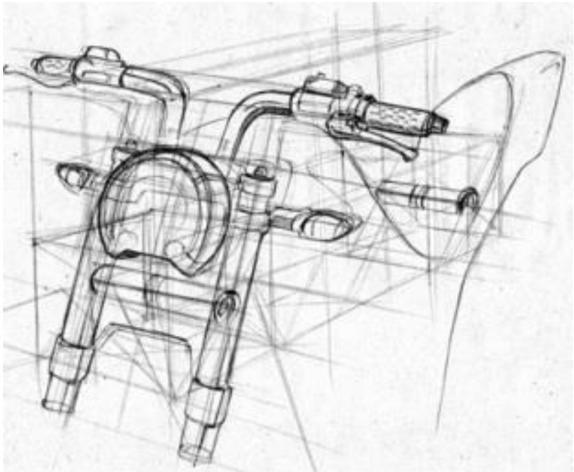
Unit 3 Learning Aim C: Communicating Design

Types of Engineering Documentation	
Technical report	• Formally written in past tense • Describes product development or test/trial results • Clear and concise with correct technical terms
Design log	• Detailed record of the design process • Notes, sketches, block diagrams, test and market data etc • Updated as concepts are generated, ideas proposed, and design decisions made • Reasoning for decisions should be recorded
Design specification	• List of requirements for a product • Considers all design criteria e.g. functionality, cost, weight
Parts list / Bill of materials (BOM)	• List of materials, parts to be manufactured and standard components. • Includes quantity, supplier, part reference number and cost.

The importance of using clear, correct, technical language

- To avoid confusion
- To communicate clearly
- To make work easy to translate or access by others who do not have English as a first language
- To make sure that enough detail is given to allow the information to be understood
- To appear professional and competent
- To communicate accurately – using incorrect terms or grammar can change the meaning of a sentence completely.

Design communication techniques

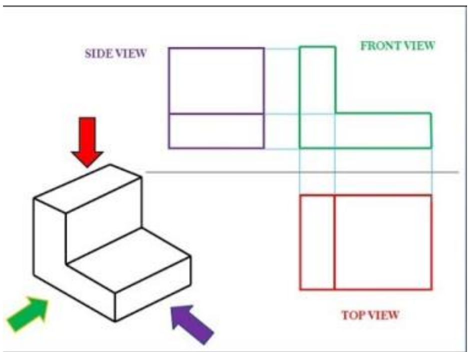


Freehand sketch:
- Rapid communication of ideas
- Show 3D/real presentation of concepts
- Material and manufacturing information may be referenced in annotation but not confirmed

Knowledge Organiser: KS5 BTEC Engineering

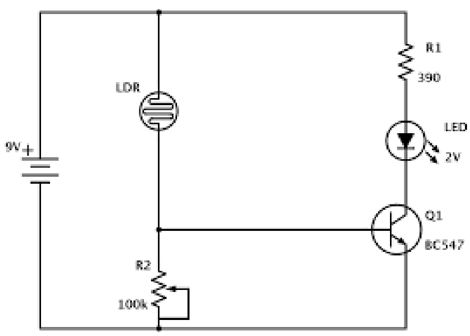
Unit 3 Learning Aim C: Communicating Design

Design communication techniques



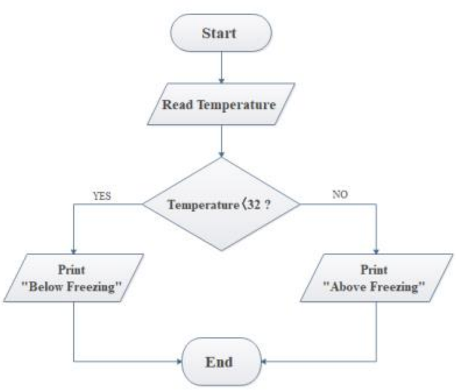
Orthographic and assembly drawings:

- Geometrical and dimensional data
- Used in creation of parts
- Hand generated or using CAD



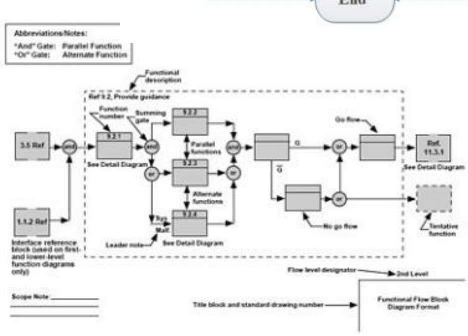
Circuit diagram:

- Electric, hydraulic or pneumatic
- Symbolically represent the layout and operation of a circuit within a product



Flow charts:

- Describe sequences
- Show decisions in systems control
- Represent operation of products or production processes



Block diagrams:

- Main parts and sub functions or assemblies are represented by blocks
- Lines between block represent the relationships between different parts/assemblies.

Knowledge Organiser: KS5 BTEC Engineering

Unit 3 Learning Aim C: Iterative Design Process

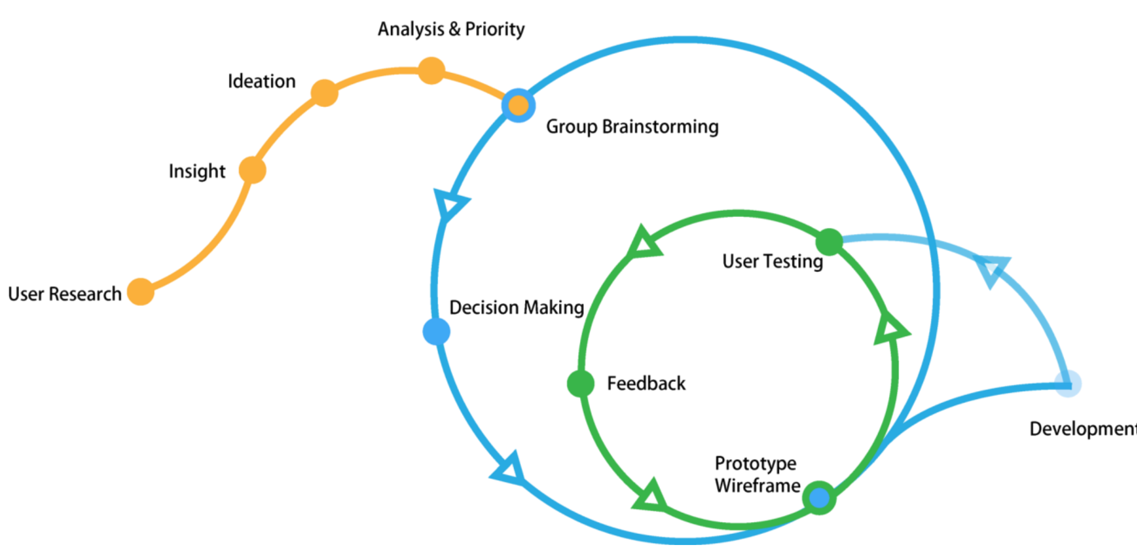
In reality, designing is not an entirely linear process. There is often a need to pause during the development process to review the suitability of the product. This might be to check that it still meets the design specifications, to see if there is scope for enhancement or to adapt the design to widen the market for the product.

A product proposal may initially have fulfilled key functional aspects of the specification but, as the design was further developed to bring in secondary functions, the cost or weight may have drifted up. The development should then be paused to see how to bring the proposal back in line with the specification.

It may also be that as the design has developed, new opportunities have opened up to allow a stronger overall design.

At various points along the design process it may be necessary to carry out tests or trials to evaluate the suitability of the product for its intended purpose. While computer modelling and other analysis techniques may help to validate some aspects of the design, it will often be necessary to build physical prototypes to confirm the suitability of a design.

If the trials have revealed any issues with the design, you may then have to go back a stage or more and repeat the development steps to address these issues before you can move forward.



Knowledge Organiser: KS5 BTEC Engineering

Unit 3 Learning Aim D: Statistical Methods

Key terms	
Mean	Sum of all values in the data set divided by the number of data items.
Median	The middle value when all the data values are arranged in order.
Mode	The most commonly occurring data value in the data set.
Variance	The mean of the squared differenced between the data values and the mean of the data set.
Standard deviation	The square root of the variance
REMEMBER: Hey diddle diddle, the median's the middle, you add and divide for the mean. The mode is the one that appears the most and the range is the difference between!	

Data types	
Ergonomic data	• Data relating to safety and comfort. • Often concerned with making a product fit e.g. crash helmet – head size
Competitor data	• Information relating to competitors and where the product will place on the market • May be investigating sales costs or functionality of other products
Market data	• Contacting potential customers to find out their requirements and priorities for the product
Historic data	• Looking at the current or previous performance of existing products in order to design a developed item which improves on these
Experimental or trial data	• Gained from testing prototypes or CAD models to determine successes and failures within the design.

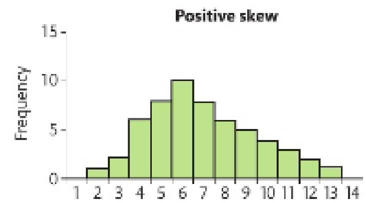
Importance of reliable data
If there are errors due to collection methods then the data may not represent the reality of what is being investigated. If there is insufficient data gathered, then the data may show an incomplete or simplified picture and prevent drawing meaningful conclusions. Data which is not repeatable or reliable could lead to design decisions which are ineffective for use.
Considering extremes of data
Extremes of data need to be considered when looking at sizes where ingress needs to be allowed or prevented. E.g. guillotine blade guard – needs to block the smallest fingers whilst still allowing material through. Designing for the average user would allow those below average to be at potential risk and meant that the safety feature design was not effective.

Knowledge Organiser: KS5 BTEC Engineering

Unit 3 Learning Aim D: Statistical Methods

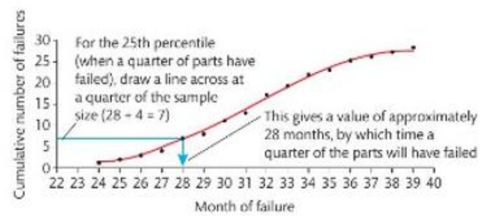
Skewed Data

Data is not always symmetric about the mean value. It can be skewed to one side or the other. Example – weight of an adult male has a positive skew. There are not the same number of men weighing 120kg as 40kg. In cases like this the median may be more representative for designing.



Cumulative frequency diagrams

- Plots a running total.
- Usually an S shaped curve
- Useful to estimate a percentile in a data set



Using pie charts to represent data

Useful where data comes in distinct categories rather than discrete or continuous numerical values. Each slice represents a portion of the data set. It can be easily read to establish proportion and preference. A slice can be extracted to make the specific data referenced clear and draw attention to it.

Data types	
Ergonomic data	• Data relating to safety and comfort. • Often concerned with making a product fit e.g. crash helmet – head size
Competitor data	• Information relating to competitors and where the product will place on the market • May be investigating sales costs or functionality of other products
Market data	• Contacting potential customers to find out their requirements and priorities for the product
Historic data	• Looking at the current or previous performance of existing products in order to design a developed item which improves on these
Experimental or trial data	• Gained from testing prototypes or CAD models to determine successes and failures within the design.

Knowledge Organiser: KS5 BTEC Engineering

Unit 3 Learning Aim D: Validating Designs

Design for manufacturing
Products which are difficult to make are unnecessarily expensive and may lead to higher levels of waste due to scrap or rejected parts. Need to consider; • Whether materials can be reduced? • If multiple parts can be made into a single component using a different process? • Can any parts be simpler or removed? • Are the processes suited to the volume and materials required? • Are there any issues with complex geometry? Designs are selected on their ease of manufacture.
Balancing benefits and opportunities with constraints
Need to consider the benefits of improving certain aspects of the product and whether that will lead to a trade off in another functional aspect such as strength v weight. All constraints have to be considered as they will need to be met regardless of what opportunities there are. Designs are considered on balance with constraints being given priority of potential benefits and opportunities.
Referencing against the product design specification
• Checking the design against the specification criteria to establish whether it meets all the requirements. • If some requirements are not met then the design can be altered or an alternative considered. • If all requirements are met then the design is accepted, although there may be opportunities for further development or improvement • Changes should be considered in relation to the full PDS as an improvement with one criteria may lead to issues elsewhere. • Designs are selected on the basis of the number of criteria they address.
Evaluating proposals in a weighted matrix
Using a weighted matrix allows designs to be compared against the specification in a more sophisticated way. Through weighting criteria can be given priority based on their impact on user satisfaction or functionality. This allows changes to be considered more holistically and the knock-on impacts of different criteria to be reported. High scoring proposals can also be evolved using successful features of other high scoring concepts to maximise the potential outcome of the product.
Considering indirect benefits and opportunities
Intended outcomes are direct benefits, but there may be improvements to designs which were unintentional benefits as a result of another alteration. There may also be opportunities to evolve and improve the product which were not originally anticipated by carrying out minor tweaks. For example a casing might be able to be developed to also provide some form or water resistance. This was not part of the initial intended design development but is an opportunity to improve the design to add a benefit to the user. Designs are selected considering additional benefits which were not part of the original PDS.
Considering future modifications
Technology and market demands may move during the design process for a new product. Particularly if development is over a longer period of time. During designing, regular checks should be made into whether there are new materials, components, manufacturing techniques or technologies which could be used to further improve your product or render your current design obsolete. Designs are selected for their future proofing and readiness for market.

Knowledge Organiser: KS5 BTEC Engineering

Unit Exam Skills: Success Criteria

PART A	
Content to consider:	**What to include:**
Range of materials	These should link together and be appropriate for the product
Range of manufacturing processes	
Existing products	Considering form and function for the product being investigated. Costing information. Mechanical parts Specialist materials or processes
Key stages of the LCA	Material sourcing, Design, Prototyping, Packaging, Transportation, Manufacture, Use, Maintenance, Disposal.* *May not all be relevant to all products
Sketching aids	Outline shapes, key mechanisms, existing products to copy or trace.
Technical information	Mechanical parts or fixtures - how they work including diagrams. Key technical words Standard rules for drawings e.g. BS 8888
Initial design considerations	Initial ideas in rough draft Key criteria from the Part A you need to remember or address
Success Criteria	Things you need to remember to do in each activity which might not be explicit from the question wording e.g. ACCESS FM criteria, decision matrix or SWOT analysis.
Stem word reminders	Definitions or prompts for any key words you find tricky to recall.

PART B

ACTIVITY 1 — **What to include:**

- Activity list with descriptions
- Timings
- Reflections at the end of each session
- Clear, prioritised plan for the next session (action points)
- Description of the changes made at each stage (designs as well as timings)
- Justification for the changes made at each stage

ACTIVITY 2 — **What to include:**

- Overview of opportunities, constraints, data calculations and findings, health and safety considerations, regulations, legislation and sustainability including life cycle analysis.
- Summary of the impact each of these elements will have on the final design proposal (product requirements) considering all design criteria (ACCESS FM)

Knowledge Organiser: KS5 BTEC Engineering

Unit Exam Skills: Success Criteria

PART B	
ACTIVITY 3	**What to include:**
• 3-4 design concepts sketched out clearly that address the product issues raised. • Additional views to show operation/function or to clarify specific parts. • Dimensions • Full annotation relating to the product requirements from Activity 2. • Technical information such as specific materials, processes, design considerations.	
ACTIVITY 4	**What to include:**
• Decision matrix of initial ideas • Justification of chosen idea with changes that will be made to improve it (modifications) • Idea is significantly different to the original product and shows improvement. • Existing products are discussed and the features that have been used from them are clearly referenced. • A range of materials are considered and then the most effective selected. • A range of processes (which suit the materials) are considered and the most effective selected. • Materials and manufacturing processes are appropriate for each other. • Material and process decisions are fully justified. • Sustainability is considered through a full life cycle analysis of the product. • How the product is safe is clearly explained and justified. • Designing out all risk is considered – commercial (will it sell?), performance (will it work?) and physical (will it hurt anyone?).	
ACTIVITY 5	**What to include:**
• Compare design to the requirements in activity 2. • Discuss successes and limitations • Describe indirect benefits and opportunities • Describe the impact of design constraints • Fully justify why your solution is better than the original and why your chosen proposal is the best of all your ideas. • Identify how technology could make your product/design more efficient • Explain how the technology would work and justify the use of it to make your solution more effective.	

Knowledge Organiser: KS5 BTEC Engineering

Unit Exam Skills: Materials and Manufacturing Matrix

Level 3 Engineering – Unit 3

Materials and Processes Matrix	Injection Moulding	Die Catsing	Blow Moulding	Casting	Drilling	Turning	Milling	3D printing	Forging	Pressing/Punching	Extrusion	Drape forming	Vacuum forming	Powder metallurgy	Composite manufacture	Processing - Recrystallisation	Processing - Work hardening	Processing - Blending	Processing - Alloying	Processing - Machining	Automated fibre placement
Cast iron	N	N	N	Y	Y	Y	Y	N	N	N	N	N	N	N	N	N	N	N	Y	Y	N
Mild steel	N	Y	N	Y	Y	Y	Y	N	Y	Y	Y	N	N	N	Y	Y	Y	Y	Y	Y	N
Tool steel	N	Y	N	N	Y	Y	Y	N	Y	N	N	N	N	N	N	Y	Y	N	Y	Y	N
Stainless steel	N	Y	N	N	N	N	N	N	N	Y	N	N	N	N	N	Y	Y	Y	Y	Y	N
Aluminium	N	Y	N	Y	Y	Y	Y	N	Y	Y	Y	N	N	Y	Y	Y	Y	Y	Y	Y	N
Brass	N	Y	N	Y	Y	Y	Y	N	Y	Y	Y	N	N	N	N	Y	Y	Y	Y	Y	N
Copper	N	Y	N	Y	Y	Y	Y	N	Y	Y	Y	N	N	Y	N	Y	Y	Y	Y	Y	N
Tin	N	Y	N	Y	Y	Y	Y	N	Y	Y	Y	N	N	N	N	Y	N	Y	Y	Y	N
Zinc	N	Y	N	N	Y	Y	Y	N	N	Y	Y	N	N	N	N	Y	N	Y	Y	Y	N
Acrylic	Y	N	Y	N	Y	N	N	N	N	N	Y	Y	Y	N	Y	N	N	N	N	N	N
HDPE	Y	N	Y	N	Y	N	N	N	N	N	Y	Y	Y	N	Y	N	N	N	N	N	N
PET	Y	N	Y	N	Y	N	N	Y	N	N	Y	Y	Y	N	Y	N	N	N	N	N	N
HIPS	Y	N	Y	N	Y	N	N	Y	N	N	Y	Y	Y	N	Y	N	N	N	N	N	N
PVC	Y	N	Y	N	Y	N	N	N	N	N	Y	Y	Y	N	Y	N	N	N	N	N	N
PP	Y	N	Y	N	Y	N	N	N	N	N	Y	Y	Y	N	Y	N	N	N	N	N	N
Epoxy Resin	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	Y
Urea Formaldehyde	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N
Phenol Formaldehyde	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N
Polyester resin	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N
Alumina	N	Y	N	Y	Y	Y	Y	N	N	Y	Y	N	N	N	N	N	N	N	Y	Y	N
Beryllia	N	Y	N	N	Y	Y	Y	N	N	N	Y	N	N	Y	N	Y	N	N	Y	Y	N
Magnesia	N	Y	N	N	Y	Y	Y	N	N	Y	Y	N	N	Y	N	Y	N	N	Y	Y	N
Zirconia	N	Y	N	N	Y	Y	Y	N	N	N	N	N	N	Y	N	Y	N	Y	Y	Y	N
Boron Carbide	N	Y	N	N	Y	Y	Y	N	N	N	N	N	N	Y	N	Y	N	Y	Y	Y	N
Silicon Carbide	N	Y	N	N	Y	Y	Y	N	N	N	N	N	N	Y	N	Y	N	Y	Y	Y	N
Silicon Nitride	N	Y	N	N	Y	Y	Y	N	N	N	N	N	N	Y	N	Y	N	Y	Y	Y	N
Zirconium dioxide	N	Y	N	N	Y	Y	Y	N	N	N	N	N	N	Y	N	Y	N	Y	Y	Y	N
GRP	N	N	Y	Y	Y	N	N	N	N	N	N	Y	Y	N	Y	N	N	N	N	N	N
CRP	Y	N	N	Y	Y	N	N	N	N	N	N	Y	Y	N	Y	N	N	N	N	N	Y
Kevlar	N	N	N	N	N	N	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N
Reinforced concrete	N	N	N	N	N	N	N	N	N	N	N	N	N	N	Y	N	N	Y	N	N	N
Tufnols	Y	N	N	N	Y	Y	Y	N	N	N	Y	N	N	N	Y	N	N	N	N	Y	N
Plastic laminates	N	N	Y	N	Y	N	N	N	N	N	N	Y	Y	N	Y	N	N	N	N	N	N
Cermets	N	Y	N	N	Y	Y	Y	N	N	N	N	N	N	Y	Y	Y	N	Y	N	Y	N

Knowledge Organiser: KS5 BTEC Engineering

Unit 9 Learning Aim A: Own skills and attributes and clarifying expectations for employment in engineering

Key skills

Identifying the skills you have in engineering - practical, communication, listening skills, problem solving, engineering knowledge, teamwork, developing ideas, researching skills, resilience, leadership

Rights & Responsibilities

Diversity, equality, dignity and confidentiality

Preparation for employment in engineering – organisation, punctuality, appropriate dress, enthusiasm, interested and have an inquiring mind, ability to follow instructions, appropriate attitude, listening skills, interpersonal skills, being proactive

Key words

Professionalism
Communication
Interpersonal
Organisational
Technical
Problem solving
Team work
Confidence
Proactive
Resilience
Diversity
Equality
Dignity
Confidentiality
HASAWAR
RIDDOR
PPE
COSHH
MHOR

What are 21st century skills?

- **Problem solving skills** are about using a structured process to analyse tricky problems, consider logical solutions, and then evaluate the result. This can be done alone or as a collaboration with other people
- **Creativity** is the ability to come up with inventive ideas that will help you complete a task or solve a problem in a new or interesting way
- **Communication and interpersonal** skills are the verbal and physical skills that we use every day to explain what we're thinking and feeling to other people
- **Leadership** is the ability to get the best out of a team of people as you collectively work to tackle a task, or reach an objective
- Being **proactive** means that you think ahead, take the initiative and make things happen, instead of always reacting to what happens around you
- **Resilience** is the ability to cope with challenges or setbacks and turn them into positive, valuable learning experiences

Knowledge Organiser: KS5 BTEC Engineering

Unit 9 Learning Aim A: Own skills and attributes and clarifying expectations for employment in engineering

Key skills

Professionalism: Being able to act in a way that is appropriate and proficient	Its important because it show people you are serious about a role and you will carry out a task in the correct manner and with the right attitude.
Communication: Being able to effectively communicate with the people around you	It is important because you need to understand what your role is and how to carry it out correctly and efficiently. It also makes the work of others around you much easier to complete.
Interpersonal skills: Being able to interact with other people and understand body language and cues	This is important because you need to be able to work in a team situation. You and your colleagues need to be able to understand each other so that there is a healthy workplace environment. If everyone understands each other you will all be able to carry out your work more easily
Organisational skills: Being able to manage tasks and meet deadlines and stay focussed on the task until completed.	This is important because if workers are organised they can complete their best work for the company and will be able to prioritise tasks. You will also feel more comfortable and capable if you are organised.
Technical skills: Having the knowledge and abilities to accomplish a task. Understanding how processes work.	This is important because a person can not complete tasks if they don't know how to do it or can not do it very well. Having no technical skills will mean you will need lots of training which will use the time of the company

Rights and responsibilities

Your rights and responsibilities

- Fully understand what I am doing in the workplace so that things are less likely to go wrong
- Report if I feel like I am being bullied or discriminated against
- If someone is acting in a dangerous manner, reports it for the safety of other workers
- Make sure that I get the correct amount of breaks
- Make sure I am properly trained before using equipment
- Be responsible for carrying out tasks when I am asked or follow instructions correctly
- Make sure I am aware of any risks or hazards so I can avoid them
- Wear the correct PPE when working on something that requires it so that I am protected from harm
- If someone is doing something incorrectly help them out so they can learn
- Be responsible for being on time

Your employer's rights and responsibilities

- Make sure the correct PPE is provided to the employees so they don't get injured
- Make sure tools and equipment like machinery are up to standard and safe to use
- Make sure employees are well educated in health & safety so they know how to prevent accidents
- Make sure employees have correct training and qualifications to work on tasks so they can be carried out safely and correctly
- Carry out a risk assessment so the employee is aware of hazards and how to avoid them
- To provide an atmosphere where employees feel respected and valued and allowing statutory breaks

Knowledge Organiser: KS5 BTEC Engineering

Unit 9 Learning Aim A: Own skills and attributes and clarifying expectations for employment in engineering

Key knowledge	
Health , safety and security	
HASAWA 1974	The Health and Safety at Work Act 1974 (HASAWA) lays down wide-ranging duties on employers. Employers must protect the 'health, safety and welfare' at work of all their employees, as well as others on their premises, including temps, casual workers, the self-employed, clients, visitors and the general public. HASAWA allows the government to issue regulations, guidance and Approved Codes of Practice (ACOPs) for employers. These set out detailed responsibilities for your employer in every aspect of workplace health and safety, from working safely with computers, to stress and hazardous chemicals.
RIDDOR 2013	*RIDDOR stands for the Reporting of Injuries Diseases and Dangerous Occurrences Regulations.* Under the RIDDOR regulations, employers, the self-employed and people in control of work premises have a legal duty to report certain serious workplace accidents, occupational diseases and specified dangerous occurrences (near misses). **RIDDOR**, then, is in place to keep you and your colleagues safe at work. The legislation is **important** because it holds employers responsible for negligence or bad working behaviours. In practice, this encourages people to follow health and safety procedures in the workplace, which helps to prevent accidents.
PPE at work regulations 1992	If you employ workers in an environment where there may be a risk to their health and safety, you are legally required to provide personal protective equipment (PPE) to help keep them safe at work. The type of equipment required will depend on a range of factors, including the working environment, the hazards faced and the specific roles being carried out. Examples can include Safety helmets Eye protection Hearing protection Safety gloves Respiratory protection Safety footwear Protective clothing
COSHH 2002	COSHH is the law that requires employers to control substances that are hazardous to health. You can prevent or reduce workers exposure to hazardous substances by: finding out what the health hazards are; deciding how to prevent harm to health (risk assessment); providing control measures to reduce harm to health; making sure they are used ; keeping all control measures in good working order; providing information, instruction and training for employees and others; providing monitoring and health surveillance in appropriate cases; planning for emergencies.
MHOR 1992	Manual Handling Operations Regulations 1992 The Regulations define manual handling as: "*...any transporting or supporting of a load (including the lifting, putting down, pushing, pulling, carrying or moving thereof) by hand or bodily force*". The load can be an object, person or animal. The MHOR 1992 set out a clear ranking of measures for dealing with risks from manual handling, these are: **first** : avoid hazardous manual handling operations so far as is reasonably practicable; **second** : assess any hazardous manual handling operations that cannot be avoided; and **third:** reduce the risk of injury so far as is reasonably practicable.

Knowledge Organiser: KS5 BTEC Engineering

Unit 9 Learning Aim A: Own skills and attributes and clarifying expectations for employment in engineering

Key knowledge
What is the equality at work act?
The equality at work act legally protects people from discrimination in the workplace. It sets out the different ways in which it is unlawful to treat someone. It prevents discrimination against disabilities, gender, age, class, culture and race by setting down laws that people have to abide by and follow or face dismissal or a fine.
Why is diversity in the workplace good for a business?
People from different cultural and ethnic backgrounds can bring different skill sets and knowledge to a business. Different age groups can create a wider range of ideas for a business as each generation have different experiences. For example people who are multilingual can help communication for a company that is international. Some countries may train their workers in a way that is superior and this experience and knowledge can be shared within a business

Knowledge Organiser: KS5 BTEC Engineering

Unit 9 Learning Aim A: Exploring career options

Key knowledge
Engineering sectors
Aerospace - Aerospace engineering is concerned with the development of aircraft and spacecraft. It has two major and overlapping branches: aeronautical engineering (study design and manufacturing of flight capable products) and astronautical engineering (study of the practice of travel not in earths atmosphere). Avionics engineering is similar, but deals with the electronics side of aerospace engineering. Maintain aircrafts, measure and improve the performance of aircraft, components and systems, research and develop design specifications and use computer-aided design (CAD) software to create plans.
Manufacturing - Manufacturing engineering requires the ability to plan the practices of manufacturing; to research and to develop tools, processes, machines and equipment; and to integrate the facilities and systems for producing quality products with the optimum expenditure of capital. Designing the layout of the plant using computer-aided design/manufacturing (CAD/CAM) software to build 3D models, calculating production costs that include equipment, time and labour,
Electrical - is an engineering discipline concerned with the study, design and application of equipment, devices and systems which use electricity, electronics, and electromagnetism.
Biomedical - medical engineering is the application of engineering principles and design concepts to medicine and biology for healthcare purposes (e.g. diagnostic or therapeutic). This field seeks to close the gap between engineering and medicine, combining the design and problem solving skills of engineering with medical biological sciences to advance health care treatment, including diagnosis, monitoring, and therapy. Include job roles like researcher, arranging clinical trials, conducting mathematical modelling, training technical or clinical staff.
Mechanical - is an engineering discipline that combines engineering physics and mathematics principles with materials science to design, analyse, manufacture, and maintain mechanical systems. Maintenance engineer, vehicle mechanic, CAD technician, civil engineer, nuclear engineer.

Key words
Aerospace Manufacturing Biomedical Electrical Mechanical Apprenticeship Eng Tech/ IEng/ CEng

IN ASSOCIATION WITH TTE TRAINING

APPRENTICESHIP vs DEGREE

FACTS AND FIGURES SUPPLIED BY THE TELEGRAPH WEBSITE

Apprenticeships

University Degree

APPRENTICESHIP:

- LEARNING
- WORKING AND EXPERIENCE
- EARNING BASIC WAGE

DEGREE:

- LEARNING
- STUDYING
- SOCIAL SCENE

COURSE FEES & DEBT

FREE

FREE TRAINING AND EARN A LIVING DURING COURSE - RESULTING IN NO STUDENT DEBT!

PAY FOR FEES UNLESS SPONSORED RESULTING IN A FINAL DEBT OF APPROX 40-50 THOUSAND POUND

EMPLOYMENT STATISTICS *

- 83% IN EMPLOYMENT
- 11% IN PART TIME ROLES
- ALL EARN AVERAGE WAGE AND ABOVE

72% FULL TIME

- 87% IN EMPLOYMENT
- 26% IN PART TIME ROLES
- 27% EARN LESS THAN AVERAGE WAGE

61% FULL TIME

END RESULT

- WORK PLACEMENTS = EXPERIENCE & KNOWLEDGE
- FOOT IN THE DOOR WITH REAL COMPANYS

- DEGREE CERTIFICATE
- MAJOR DEBT

* POST QUALIFICATION

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Knowledge Organiser: KS5 BTEC Engineering

Unit 9 Learning Aim A: Exploring career options

Key knowledge
Eng Tech/ IENG/ CENG
Engineering Technicians in the Aerospace, Aviation, Automotive, Maritime Defence and wider Advanced Manufacturing and Engineering Sector are predominantly involved in highly skilled, complex work and must, as a minimum be able to: Apply safe systems of working, Make a technical contribution to either the design, development, quality assurance, manufacture, installation, commissioning, decommissioning, operation or maintenance of products, equipment, systems, processes or services. Apply proven techniques and procedures to solve engineering/manufacturing problems. Demonstrate effective interpersonal skills in communicating both technical and non-technical information. Have a commitment to continued professional development. Engineering Technicians take responsibility for the quality and accuracy of the work they undertake within the limits of their personal authority. They also need to be able to demonstrate a core set of behaviours in order to be competent in their job role, complement wider business strategy and development. This will enable them to support their long term career development. Engineered and manufactured products and systems that Engineering Technicians work on could involve mechanical, electrical, electronic, electromechanical and fluid power components/systems.
Incorporated Engineers (IEng) maintain and manage applications of current and developing technology, and may undertake engineering design, development, manufacture, construction and operation. Incorporated Engineers (IEng) need to demonstrate - The theoretical knowledge to solve problems in developed technologies using well proven analytical techniques successful application of their knowledge to deliver engineering projects or services using established technologies and methods. Responsibility for project and financial planning and management together with some responsibility for leading and developing other professional staff. Effective interpersonal skills in communicating technical matters. Commitment to professional engineering values.
CEng is an international recognised level of professional registration for Engineers. It is a formal recognition of your engineering skills and competence. Chartered Engineers develop answers to engineering problems using new or existing technologies in creative and innovative ways. You might be developing these technologies, promoting advanced designs and methods, introducing more efficient production techniques or pioneering engineering services. Chartered Engineers (CEng) develop solutions to engineering problems using new or existing technologies, through innovation, creativity and change and/or they may have technical accountability for complex systems with significant levels of risk.

Knowledge Organiser: KS5 BTEC Engineering

Unit 9 Learning Aim B: Preparation for work experience and setting goals and learning objectives

Key knowledge

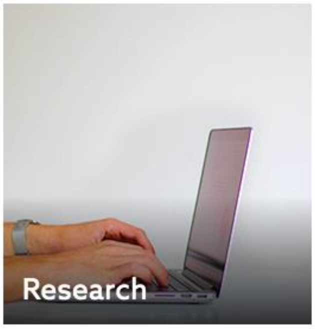
The role of a supervisor

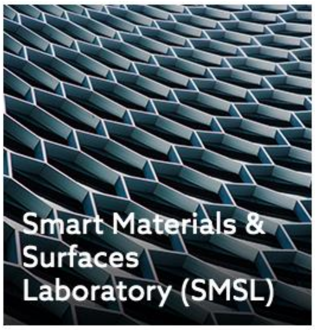
The role of a supervisor/mentor
Set goals for performance and deadlines in ways that comply with company's plans and vision and communicate them to subordinates
Organize workflow and ensure that employees understand their duties or delegated tasks
Monitor employee productivity and provide constructive feedback and coaching
Receive complaints and resolve problems
Maintain timekeeping and personnel records
Pass on information from upper management to employees and vice versa
Prepare and submit performance reports
Decide on reward and promotion based on performance
Hire and train new employees
Ensure adherence to legal and company policies and procedures and undertake disciplinary actions if the need arises

A supervisor is important to my professional development because they can answer any questions I have about the industry or placement. They can guide me in the placement and expose me to diferent roles in the industry. They can model behaviour and give me knowledge based on years of experience in the field of engineering. They can demonstrate using machinery or equipment and explain why things are done in a certain way. They can teach me and evaluate my progress. They can assess my strengths and weaknesses and make suggestions as to what I can do next in my career. They know lots of different people in industry and could recommend me for apprenticeships/jobs if I make a good impression.

Key words

Supervisor
Mentor
SMART
Professional body





Knowledge Organiser: KS5 BTEC Engineering

Unit 9 Learning Aim B: Preparation for work experience and setting goals and learning objectives

Key knowledge – Professional bodies	
Function	**Entry requirements**
IMechE	
IMechE strive to improve the world through engineering by: Developing engineers Promoting engineering Informing opinion Encouraging innovation They also provide Professional registration which gives you the chance to benchmark your skills against a global standard Recognition of your experience and better career prospects Transferability of your skills to other roles or organisations Improved job satisfaction and ongoing development	CEng: Accredited BEng (Hons) degree plus appropriate Masters degree or Accredited BEng (Hons) degree plus approved Further Learning to Masters level or Accredited Meng Accredited Bachelor's degree or HND/Foundation degree plus approved Further Learning to Bachelor's level
IET	
The IET represents the engineering profession in matters of public concern and assists governments to make the public aware of engineering and technological issues. It provides advice on all areas of engineering, regularly advising Parliament and other agencies. They also provide personal and professional support, career management and the latest engineering trends/solutions	Anyone can join the IET. You may be working in a related field, studying towards an engineering qualification or simply have a passion for engineering and technology. There is a category of membership for everyone. For more information, please visit the Join the IET page.

Professional bodies maintain and improve standards, not just practical standards, but those of ethics and behaviour. Professional bodies can act to encourage fairer access, whether social, gender or race, and discourage discrimination.

Institution of MECHANICAL ENGINEERS

The Institution of Engineering and Technology

Knowledge Organiser: KS5 BTEC Engineering

Unit 9 Learning Aim C: Work experience tasks, work shadowing and observation

Task examples

Engineering tasks
1 Asked to detect a fault in the machine press
2 Organised a range of die plates so they were more efficient to access
3 Complete research in to cameras for the conveyor belt
4 Used CAD application to model options on a component
5 Asked to redesign a small component
Non Engineering tasks
1 Cleaning up a spillage
2 Giving my opinion on a problem
3 Organising work into folders and filed it and kept it updated
4 Observed a response to a complaint
5 Analysing data

Skills used as a team

Analysis and problem-solving skills, communication, listening skills, collaboration, creativity,

Shadowing and observation

Ask questions about the tasks being completed, make notes so you are well organised. Listen to instructions and feedback. Build confidence when speaking to new people by asking them to talk about their role or their entry pathway.

Knowledge Organiser: KS5 BTEC Engineering

Unit 9 Learning Aim D:Reviewing personal and professional development, using feedback and action planning

Key skills

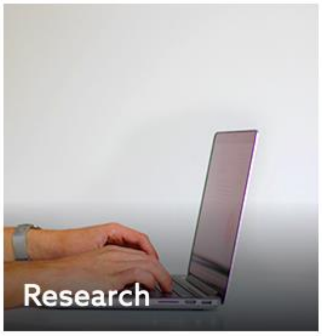
Examples of reflection and review and use of literature to support statements:

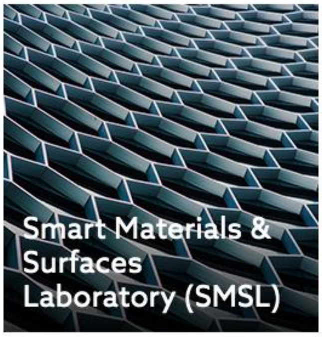
“I now feel that my communication skills have improved as I am quite capable of talking to people I don’t know. Although I have always thought I am shy I have found out that if you ask people questions about themselves and their work they quite enjoy talking about themselves and I learned a lot about how the team entered the engineering sector. I felt confident with the clocking in of the job system and the morning staff briefing.”

“I need more training on the industry standard programmes that are used as they are different to the ones we use in school. I would like to get more hands on knowledge of mechanical engineering as I feel this is the sector I identify most with but lack experience.”

Rolfe et al (2001)
“Rolfe et al.’s (2001) reflective model is based upon three simple questions: What? So what? Now what?
What? Specific tasks were shared out amongst members of my team. Initially, however, the tasks were not seen as equally difficult by all team members.
So what? Cooperation between group members was at risk because of this perception of unfairness.
Now what? Ultimately, our group achieved a successful outcome, but to improve the process, we perhaps needed a chairperson to help encourage cooperation when tasks were being shared out. In future group work, on the course and at work, I would probably suggest this.”

Gibbs reflective cycle (1988)
Description of the experience
Feelings and thoughts about the experience
Evaluation of the experience, both good and bad
Analysis to make sense of the situation
Conclusion about what you learned and what you could have done differently
Action plan for how you would deal with similar situations in the future, or general changes you might find appropriate.





Structuring your answers in Engineering

P.E.E Chains

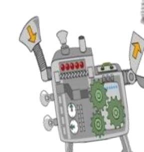
In Technology we use PEE chains to expand our answers so we are communicating our thoughts and ideas clearly. This makes sure that we say what we think and then back up, or justify, our thoughts with explanations and evidence from research which support them.

POINT	Say WHAT you think.	*I think the product should be…*
EXPLAIN	Say WHY you think it.	*This is because…*
EVIDENCE	Say what RESEARCH you've done to back this up.	*I know this from my research into…*

ACCESS FM

ACCESS FM is an analysis and annotation tool which makes sure we consider all the important design criteria and the impact they have on products we are investigating, designing or evaluating,

A	Appearance	Where did the designer get their inspiration? Could the product look better? Do you think it looks attractive or ugly, Why? What does the product look like? *THINK* shape, form, materials, size, beauty, ugliness.
C	Cost	Is it affordable to your customer? Will it make a profit? Is it value for money? How much does it cost to make?
C	Customer	What impact would it have on a customers life? Why would a customer buy it? What makes it suitable for them? Who would buy it? Who would use it?
E	Environment	What is the products impact on the environment? *THINK* batteries, rethink, refuse, reduce, reuse, recycle, lifecycle. How would the product be disposed of? Is the product needed or wanted? How long will it last?
S	Safety	Is the product high quality? Does it meet safety standards? How has the designer considered safety? Could the product hurt anyone? Are there any sharp edges?
S	Size	Is it an appropriate size? Would it work better if it was bigger or smaller? Does it come in different sizes? How big is it?
F	Function	Does the product work? Could the product work better? How does the product work? Why is the product needed? What does the product do? Is it easy to use?
M	Materials/ Manufacture	What impact could the designer's choice of material have on the environment? Would a different material make it better? What material has it been made from? What process would be used to make it?



Structure Strips in Engineering

State			Pass
Example Question State two reasons why corrugated cardboard is used as packaging for cooked pizzas.			
1	Reason 1 (1 mark)	It is a rigid material that won't flex and bend as easily as other types of cardboard which offers protection to the pizza.	
2	Reason 2 (1 mark)	The thermal properties of the material as cavities in the cardboard keep the pizza warm.	
Give			**Pass**
Example Question In 2010 the use of renewable energy in the UK accounted for 6.5% of total energy usage. By 2015 this figure had increased to 25%. Give two reasons for the increase in the use of renewable energy sources.			
1	Reason 1 (1 mark)	The Government set specific targets to reduce CO2 emissions.	
2	Reason 2 (1 mark)	People now have an increased awareness of environmental issues and are more conscientious about them.	
Describe			**Pass**
Example Question Describe two ways that materials and/or products are strengthened or reinforced. Give examples in your answer.			
1	Description 1 (1 mark)	Layering materials can make materials stronger as you can lay them with their grain in different directions. This ensures the weak lines of the grain are strengthened.	
2	Example (1 mark)	Plywood is created in layers to strengthen the material.	
3	Description 2 (1 mark)	Laminating is adding a plastic coating to a material to make it more rigid, tougher and weather resistant.	
4	Example (1 mark)	Plastic coating is added to card and paper to make the materials more wear resistant and rigid, for example a restaurant menu.	

Explain (written)			**Pass**
Example Question Explain what is meant by the term 'anthropometrics' and why it is important for designers to consider.			
1	Define key word (1)	Anthropometrics is the study of human measurements.	
2	Give 3 reasons why (3)	Designers need to consider anthropometric data in order to: • ensure that wearable items fit • ensure that products are comfortable • ensure that products are easy to use	

Explain (notes and sketches)			**Merit**
Example Question Name one industrial process used in the manufacture of a polymer toy musical instrument. In the box below, use notes and/or sketches to explain this process in detail.			
1	Identify (1)	A suitable process would be Injection Moulding	
2	Describe (2)	A polymer is placed in the hopper and enters the chamber of the injection moulding machine. The chamber is heated until the plastic melts. The plastic is then forced in to a mould where it cools to create the shape of the object.	
3	Sketches to help with description (2)	*Sketch of injection moulding machine and movement of plastic.*	
4	Explain why (1)	Injection moulding is suitable because it is quick and cheap for mass produced parts and it does not require finishing.	

Evaluate			**Merit**
Example Question Evaluate the Apple watch in terms of its suitability for the user.			
1	Positives / Advantages (1-2)	• Waterproof which allows for use when outdoors and does not absorb sweat. • Clear display screen which is easy to read even when moving.	
2	Negatives / Disadvantages (1-2)	• Flat screen susceptible to reflection • Screen can scratch easily	
3	Summary (1)	Overall the watch is well suited to the user as it has a range of specific features which are suited to the environment in which it will be used and the negative design features are minimal.	

<table>
<tr><th colspan="3">Justify</th><th>Distinction</th></tr>
<tr><td colspan="3"><u>Example Question</u>
Justify the design decisions which have been made to make the Apple watch more aesthetically appealing and gender neutral for the user.</td><td>Q:</td></tr>
<tr><td>1</td><td>Identify / underline each key word</td><td>• Aesthetically appealing
• Gender neutral</td><td></td></tr>
<tr><td>2</td><td>Define each key word (2)</td><td>• An aesthetically appealing product is one which looks attractive to its specific target market.
• A gender neutral product is not aimed specifically at one gender, but it may have options to target each gender.</td><td></td></tr>
<tr><td>3</td><td>Promote Positives / Advantages (2)</td><td>• Black in colour which is neutral and sophisticated which will appeal to an adult target market.
• A plain colour that will not date/go out of fashion and appropriate for a wide range of settings
• Brightly coloured icons on the screen that are attractive and easy to recognise
• Geometric, simple styling that can be worn by men or women.</td><td></td></tr>
<tr><td>4</td><td>Discount Negatives / Disadvantages (2)</td><td>• Black is a boring colour that will not excite, but you can purchase alternative straps to make it more personalised.
• Square shape face may not appeal to all users or may appeal masculine, however, this has featured on previous products and they have sold well.</td><td></td></tr>
<tr><td>5</td><td>Summary (2)</td><td>Previous sales show that the latest Apple watch is appropriate for the target market as it sells in high volumes. As it can be personalised through different straps, the customer can tailor the watch to their personal style which makes it more aesthetically appealing to them and the original watch being gender neutral allows this to be done effectively.</td><td></td></tr>
</table>

<table>
<tr><th colspan="3">Evaluate</th><th>Distinction</th></tr>
<tr><td colspan="3"><u>Example Question</u>
Designers sometimes choose materials according to their impact on society and the environment.
Examples include the use of fair trade cotton, recycled components and biodegradable packaging. Evaluate how the use of such materials might be seen as the ethical choice.</td><td></td></tr>
<tr><td>1</td><td>Identify / underline each key word</td><td>• Biodegradable Packaging
• Fair trade Cotton
• Recycled components
• Ethical choice</td><td></td></tr>
<tr><td>2</td><td>Define each key word (3 marks)</td><td>• Biodegradable Packaging is made from materials which decompose much more quickly so that less waste is left in landfill
• Fair trade Cotton is produced by cotton farmers who are paid a living wage which allows them to survive and earn enough money to feed their families
• Recycled Components are made from waste products where the material has been melted down and reformed.
• An ethical choice is one which avoids harm to people, animals and the environment.</td><td></td></tr>
<tr><td>3</td><td>Positives / Advantages (3 marks)</td><td>Biodegradable packaging:
• Require less energy to process into a useable material.
• Are easier to recycle/use less energy to recycle.
• Are non-toxic when they break down.
Fair trade Cotton:
• Ensures workers / farmers get a fair price for their labour / products.
• It gives small scale farmers access to global markets.
• Buying this product shows your support for these communities.
Recycled components:
• Often contain valuable materials such as gold, copper, aluminium.
• Saves landfill space.</td><td></td></tr>
<tr><td>4</td><td>Negatives / Disadvantages (3 marks)</td><td>Biodegradable packaging:
• Are relatively new materials and not currently widely used.
• May be more expensive.
Fair trade Cotton:
• Paying a higher wage results in products having a higher overall cost/price.
Recycled components:
• Are non-renewable and are becoming more difficult and costly to find.</td><td></td></tr>
<tr><td>5</td><td>Summary (1 mark)</td><td>Overall, the main disadvantage of choosing these materials seems to be cost. However, I think that they are ethically right as they reduce the impact on the environment and are more socially acceptable as well and I think this is more important than the fact that products will be more expensive.</td><td></td></tr>
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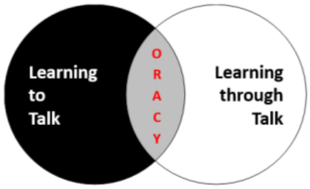
Oracy in Engineering



Oracy means being able to express yourself clearly using spoken language. We build oracy tasks into Engineering lessons to help you develop the technical language and understanding that you need to be able to communicate your ideas and opinions effectively to others. These are some of the activities which we use in lessons, but you can try them out at home too!

RANT

You need to discuss and explain all the negatives you can think of on the topic you have been given.

Success Criteria	Sentence Starters
• Consider all the potential negatives • State your opinion clearly • Take turns with your partner / group • Explain your reasons • Give examples • Don't lose your temper!	• The problems are… • I disagree with you because… • The effects of that are… • That's true but have you considered… • I hear what you are saying but…

RAVE

You need to discuss and explain all the positives you can think of on the topic you have been given.

Success Criteria	Sentence Starters
• Consider all the potential positives • State your opinion clearly • Take turns with your partner / group • Explain your reasons • Give examples • Be enthusiastic!	• The benefits of this are… • I feel this is positive because… • The effects of that are… • That's true but have you considered… • I hear what you are saying but…

Talk Detective

You need to observe conversations and identify examples of good oracy.

Success Criteria	• Look for what people are doing well • Record specific phrases and names • Give praise in your feedback • Use positive body language when you feedback

Things to look for:

✓ **Invited someone else to contribute** ✓ **Challenged someone's opinion** ✓ **Summarised their thinking or the group opinion** ✓ **Clarified someone's idea**	✓ **Gave a good example** ✓ **Used appropriate body language** ✓ **Used technical language / key words**

Revision Strategies in Engineering

Technique	Difficulty	Description	Used
Revision Cards	Hard Challenge	Write out 'flash cards' which have questions on the front and answers on the back which can be used for testing yourself/each other.	
Memory Map	Challenge	Mind map all the key points and key words related to the topics. Use images as appropriate.	
mnemonics	Hard Challenge	Use the first letter of key words to spell out a word or phrase to remember lists or large chunks of information e.g. Richard of York gave battle in vain (colours of the rainbow: red, orange, yellow, green, blue, indigo, violet) or ACCESS FM.	
Self Test	Challenge	Use flash cards or the practice questions in the book to test your knowledge of topics.	
	Hard Challenge	Designing your own question and mark scheme for the topic	
	Extreme Challenge	Create a model answer for the question you designed.	
Smartass Lists	Extreme Challenge	Write down impressive/unusual key words or expressions which you could use to answer a question on that topic	
Example Q&A	Hard Challenge	Make up an example exam question on the topic and write a mark scheme for it using the revision guide. Then test a peer with the question, mark their work and work in pairs to develop the mark scheme.	
Songs/Poems	Hard Challenge	Write a poem or a rhyme (you could even include a tune) which will help you to remember the key words or points for a topic.	
Pictograms	Challenge	Draw images surrounded by key words which will remind you of the key information or help to summarise the topics. This may be a single image (e.g. materials/tools) or a story board (e.g. processes)	
Bullets/Lists	Challenge	Number or bullet point the key information on a topic. Try and list them in order of importance.	
Audio Tape	Challenge	Create an audio account of the key information which you can then play back to yourself to help you remember the key points.	
	Hard Challenge	In pairs write and record an interview which includes the key information about a topic and requires the interviewee to explain and justify the information being covered.	
Physical Map	Challenge	Put key points about a topic around the room. Move to that point and either read out loud or write down the fact/point/information. This means that the information then becomes associated with this specific place and thinking about the place should trigger the recall of information.	
Round Robin	Challenge	In teams of 3-4, take it in turns to relay the information about a topic until you run out of key points. Then check that you covered all the information by using the revision guide/notes as a checklist.	
Quiz Quiz Trade	Hard Challenge	Create quiz, quiz, trade cards and use them in small groups to cover the information for a topic. Each card should feature a question and a sub-question or hint on one side, with the answer on the reverse.	
Talk Pair Share/speed dating	Hard Challenge	Talk in pairs and cover the main points of a topic (make a note of what you remember together in your revision books) Then pair up with someone else and add to your notes, repeat this until you think you have all the information – then check against the revision guide.	
Talking Tables	Challenge	Similar to Talk, Pair, Share - working in teams of 3-4 cover the main points of a topic (make a note of what you remember together in your revision books) and then move teams and add to your notes, repeat this until you think you have all the information – then check against the revision guide.	
Consensus	Hard Challenge	Useful for key words. Independently define a key word, then in teams of 3-4 bring definitions together and synthesise the information to create the best definition possible. Can also be used to develop responses to exam questions.	

Personalised Learning Checklist: KS5 BTEC Engineering

Complete the revision PLC booklet section for each topic below and check your work using the mark scheme to prove you can do each one.

- If you can definitely do the full task, tick green.
- If you can do some of the task, tick amber.
- If you can do less than half of the task, tick red.

If you have not ticked green, spend some extra time revising that area, go back through the examples or produce a revision aid! What's a revision aid? This could be revision notes, a mind map, a list, flashcards. Whatever works for you! Look at the revision strategies page for more ideas.

BTEC Engineering REVISION PLC

UNIT 1			
Topic	**R**	**A**	**G**
Learning Aim A			
Algebraic methods			
Trigonometric methods			
Learning Aim B			
Static engineering systems			
Loaded components			
Learning Aim C			
Dynamic engineering systems			
Learning Aim D			
Fluid systems			
Learning Aim E			
Static and direct current electricity			
Direct current circuit theory			
Direct current networks			
Target Topics:			

BTEC Engineering REVISION PLC

Topic	R	A	G
Learning Aim F			
Magnetism			
Learning Aim G			
Single-phase alternating current theory			
Target Topics:			

RED TOPIC STRATEGIES

Topics I need to review and practice more:	Topics I need peer support or to attend a DIG session for:	Topics I need 1-2-1 teacher support with:

Personalised Learning Checklist: KS5 BTEC Engineering

Complete the preparation tasks for each topic below and check your work using the knowledge organiser and your class work booklet to prove you can do each one.

- If you can definitely do the full task, tick green.
- If you can do some of the task, tick amber.
- If you can do less than half of the task, tick red.

If you have not ticked green, spend some extra time revising that area, go back through the examples or produce a revision aid! What's a revision aid? This could be revision notes, a mind map, a list, flashcards. Whatever works for you! Look at the revision strategies page for more ideas.

BTEC Engineering REVISION PLC

UNIT 2			
Topic	**R**	**A**	**G**
Learning Aim A			
Pick three engineered products identify the methods used to manufacture them and be able to suggest alternative methods of production.			
Name all the headings of human factors and explain how each affects performance.			
Understand and explain the purpose of the following legislation and where it would be implemented, H&S at work act, RIDDOR, PPE at work act, COSHH, and MHOR.			
Learning Aim B			
Draw a 1st angle projection drawing of an engineered product using the conventions that apply.			
Draw a 3rd angle projection drawing of an engineered product using the conventions that apply.			
Dimension an engineering drawing correctly including radius and tolerances			
Set up a drawing template with full border, grid and title block			
Identify the basic electrical components and their symbols			
Effectively use layers to include additional drawings/dimensions			
Learning Aim C			
Name all the principles that make an effective team			
How would you set up a team and ensure motivation, what methods would you use?			
What are the 5 areas that are used when risk assessing			
Complete a full risk assessment of a manufacturing process			
Pick an engineered product and name 4 quality tests that could have been carried during its production.			

Personalised Learning Checklist: KS5 BTEC Engineering

Complete the revision tasks for each topic below and check your work using the knowledge organiser and your class work booklet to prove you can do each one.
- If you can definitely do the full task, tick green.
- If you can do some of the task, tick amber.
- If you can do less than half of the task, tick red.

If you have not ticked green, spend some extra time revising that area, go back through the examples or produce a revision aid! What's a revision aid? This could be revision notes, a mind map, a list, flashcards. Whatever works for you! Look at the revision strategies page for more ideas.

BTEC Engineering REVISION PLC

UNIT 3			
Topic	**R**	**A**	**G**
Learning Aim A			
Choose an engineered product and answer the following questions about it:			
• Explain the design triggers which led to the product being designed and/or developed.			
• Identify the design challenges which the designer have had to overcome in order to be able to produce successful concepts for this product. • Explain what design criteria would have been most important and any compromises that they would have had to make.			
For a complex engineered product, consider: • What constraints and opportunities would the design team have faced at an equipment level? • What constraints and opportunities would the design team have faced at a system level?			
Select a component from your chosen engineered product and carry out the following analysis: • Identify the material(s) which have been used to manufacture the component. • Justify the material selection considering the physical and mechanical properties required of the component. • Compare the material used to a possible alternative and evaluate the strengths and weaknesses of each material.			
Mechanical Power Transmission Analyse the mechanical systems within an automotive vehicle. • Identify an example of each of the following: Sensor, controller, actuator, cam system, gear system, linkage system • Describe the different possible fuel sources which could be used to power the vehicle. • Evaluate each fuel source and explain which you would select as a designer, justifying your decision.			
Manufacturing Processes Select a component from your chosen engineered product and carry out the following analysis: • Identify the scale of manufacture and the manufacturing process(es) which have been used to make the component. • Justify the process selection considering the physical and mechanical properties required of the component. • Compare the process used to a possible alternative and evaluate the strengths and weaknesses of each technique.			

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UNIT 3			
Topic	**R**	**A**	**G**
Learning Aim B			
Design for a customer • Identify the key design criteria which must be considered when generating a product design specification. • For a chosen product, justify which criteria are most important and how you would make systematic compromises in the design.			
Regulatory constraints and opportunities • Outline the legislative and data protection issues which would affect a company designing a new electronic device • Explain the environmental considerations for this product and how they might affect the other design decisions being made.			
Market Analysis • Identify the different markets where a product can be targeted. • Explain what factors can affect the lifespan of a product. • Give an example of an effective unique selling point and explain why it makes the product more successful.			
Performance Analysis • Define each of the following performance considerations and explain how each one impacts on the performance of a product: Strength, Stiffness, Fatigue characteristics, Thermal conductivity, Thermal expansion, Density, Ductility, Machinability, Manufacturing suitability, Corrosion resistance, Electrical conductivity, Price, Choice of components.			
Manufacturing Analysis • Explain the effect of the following manufacturing methods on product form when designing: Welded, machined, cast or sheet fabricated			
Learning Aim C			
Design Proposals • For a chosen product, identify the key product requirements and a range of possible solutions which would meet each requirement. • Explain why designers use decision matrices to evaluate proposals. • Outline what material sources a design team may need to use when designing a new product.			
Communicating Designs • Give examples of five different design communication techniques and where they would be used. • Produce a report justifying the importance of using clear and correct technical language, both written and spoken, when communicating in engineering,			
Iterative Design Process • Explain how the iterative design process works and justify its use as an effective strategy.			

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UNIT 3			
Topic	**R**	**A**	**G**
Learning Aim D			
Statistical Methods • Define each of the following key terms: Mean, Median, Mode, Variance, Standard deviation. • Explain where each of the following data sets might be used when designing: Ergonomic data, Competitor data, Market data, Historic data, Experimental or trial data. • Explain the importance of reliable data for designers and identify when extremes of data may need to be considered for designs to be effective.			
Validating Designs Justify the use of each of the following techniques and explain where in the design process they might be most appropriate: Design for manufacturing, Balancing benefits and opportunities with constraints, Referencing against the product design specification, Evaluating proposals in a weighted matrix, Considering indirect benefits and opportunities, Considering future modifications			
Target Topics:			

RED TOPIC STRATEGIES

Topics I need to review and practice more:	Topics I need peer support or to attend a DIG session for:	Topics I need 1-2-1 teacher support with:

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Complete the preparation tasks for each topic below and check your work using the knowledge organiser and your class work booklet to prove you can do each one.
- If you can definitely do the full task, tick green.
- If you can do some of the task, tick amber.
- If you can do less than half of the task, tick red.

If you have not ticked green, spend some extra time revising that area, go back through the examples or produce a revision aid! What's a revision aid? This could be revision notes, a mind map, a list, flashcards. Whatever works for you! Look at the revision strategies page for more ideas.

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UNIT 9			
Topic	**R**	**A**	**G**
Learning Aim A/B			
Before work experience:			
Explain how to meet own specific personal and professional development goals while on work placement			
Explain own responsibilities and limitations on work experience in engineering			
Discuss ways in which work experience can inform own career choices and help prepare for employment in engineering			
Explain how work experience can support the development of own professional skills and personal attributes for work in engineering			
Assess the importance of own work experience plan to support own learning and development			
Analyse how work experience can provide support in gaining a realistic understanding of the engineering sector			
Justify the benefits of preparation in supporting own understanding of the expectations of work experience			
Target Topics:			

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UNIT 9			
Topic	**R**	**A**	**G**
Learning Aim C/D			
During/after work experience:			
Produce a personal development plan which identifies improvements to own personal and professional skills for the future			
Review own strengths and areas for development in response to feedback on work experience placement			
Discuss ways in which work shadowing and observation can support development of own skills while on work placement			
Demonstrate work related skills to meet set objectives for work experience tasks			
Assess how self-reflection can contribute to personal and professional development in work experience placement			
Demonstrate work-related skills with confidence and proficiency to meet objectives in different situations			
Justify how planning for and reflecting on skills developed during own work experience placement have informed future plans for personal and professional development			
Demonstrate work-related skills proficiently, taking the initiative to carry out activities according to own responsibilities and setting’s procedures, selecting appropriate skills and techniques for different situations			

Target Topics: