



Coimisiún na Scrúduithe Stáit
State Examinations Commission

Leaving Certificate 2021

Marking Scheme

ENGINEERING –
Materials and Technology

Ordinary Level

Note to teachers and students on the use of published marking schemes

Marking schemes published by the State Examinations Commission are not intended to be standalone documents. They are an essential resource for examiners who receive training in the correct interpretation and application of the scheme. This training involves, among other things, marking samples of student work and discussing the marks awarded, so as to clarify the correct application of the scheme. The work of examiners is subsequently monitored by Advising Examiners to ensure consistent and accurate application of the marking scheme. This process is overseen by the Chief Examiner, usually assisted by a Chief Advising Examiner. The Chief Examiner is the final authority regarding whether or not the marking scheme has been correctly applied to any piece of candidate work.

Marking schemes are working documents. While a draft marking scheme is prepared in advance of the examination, the scheme is not finalised until examiners have applied it to candidates' work and the feedback from all examiners has been collated and considered in light of the full range of responses of candidates, the overall level of difficulty of the examination and the need to maintain consistency in standards from year to year. This published document contains the finalised scheme, as it was applied to all candidates' work.

In the case of marking schemes that include model solutions or answers, it should be noted that these are not intended to be exhaustive. Variations and alternatives may also be acceptable. Examiners must consider all answers on their merits, and will have consulted with their Advising Examiners when in doubt.

Future Marking Schemes

Assumptions about future marking schemes on the basis of past schemes should be avoided. While the underlying assessment principles remain the same, the details of the marking of a particular type of question may change in the context of the contribution of that question to the overall examination in a given year. The Chief Examiner in any given year has the responsibility to determine how best to ensure the fair and accurate assessment of candidates' work and to ensure consistency in the standard of the assessment from year to year. Accordingly, aspects of the structure, detail and application of the marking scheme for a particular examination are subject to change from one year to the next without notice.

LEAVING CERTIFICATE EXAMINATION

ENGINEERING - Materials and Technology

(Ordinary Level – 150 marks)

Written Examination Marking Scheme 2021

Answer any **THREE** questions.

Question 1: 50 Marks

Any eight.

Two @ 7 marks, six @ 6 marks.

(Two-part answers @ 4(3) + 3 marks)

Question 2: 50 Marks

- (a) – Three parts @ 3 marks
Three parts @ 2 marks (15)
 - (b) – One part @ 6 marks
Two parts @ 3 marks (12)
 - (c) – Three parts @ 3 marks
Three parts @ 2 marks (15)
 - (d) – Two parts @ 4 marks (8)
-

Question 3: 50 Marks

- (a) – Two parts @ 7 marks (14)
 - (b) – Two parts @ 8 marks (16)
 - (c) – Two parts @ 4 marks (8)
 - (d) – Two parts @ 6 marks (12)
- Or**
- (d) – Two parts @ 6 marks (12)
-

Question 4: 50 Marks

- (a) – (i) Three parts @ 3 marks
(ii) Two parts @ 3 marks (15)
 - (b) – Three part @ 4 marks (12)
 - (c) – Three parts @ 5 marks (15)
 - (d) – Two parts @ 4 marks (8)
-

Question 5: 50 Marks

- (a) – (i) Two parts @ 5 marks
(ii) One part @ 10 marks (20)
 - (b) – Two parts @ 6 marks (12)
 - (c) – Two parts @ 5 marks (10)
 - (d) – Two parts @ 4 marks (8)
-

Question 6: 50 Marks

- (a) – One part @ 6 marks
Two parts @ 5 marks (16)
 - (b) – One part @ 6 marks
Two parts @ 5 marks (16)
 - (c) – Three parts @ 6 marks (18)
- Or**
- (c) – Three parts @ 6 marks (18)
-

Question 7: 50 Marks

- (a) – Three parts @ 4 marks (12)
 - (b) – Four part @ 5 marks (20)
 - (c) – Three parts @ 6 marks (18)
- Or**
- (c) – (i) One part @ 5 marks
One part @ 4 marks
(ii) One part @ 5 marks
One part @ 4 marks (18)
-

Sample Answers *and* Marking Scheme

Note: The solutions presented are examples only.

All other valid solutions are acceptable and are marked accordingly.

Question 1

(50 Marks)

- | | |
|--|---|
| <p>(a) Personal Protective Equipment (PPE) must be worn when:
(i) Operating machinery such as the lathe / pillar drilling etc.
(ii) Using oxygen acetylene gas welding equipment i.e. leather gloves / apron / welding goggles must be worn.</p> <p>(b) Permanent joint.
A permanent joint is a joint that cannot be disassembled without destroying the parts or damaging the surfaces i.e., a pop riveted joint.</p> <p>(c) A chain and sprocket mechanism can be used as part of a driving mechanism in a bicycle.</p> <p>(d) Two forms of renewable energy:
(i) Solar energy.
(ii) Wind energy.</p> <p>(e) Tool A is an adjustable spanner.
An adjustable spanner is used to loosen or tighten a nut or bolt.</p> <p>(f) (i) Steel is a ferrous metal. (ii) Brass is a non-ferrous metal.</p> <p>(g) Name: The electronic component shown is a Light Emitting Diode (L.E.D.).

Application: Light Emitting Diodes can be used as indicators on TV's / PC's / electrical kettles etc. to show they have been turned on.</p> <p>(h) Engineering continues to contribute to the development of electrical and hybrid vehicles for the transport industry.</p> | <p>4 (3) + 3 Marks</p> <p>7 (6) Marks</p> <p>7 (6) Marks</p> <p>4 (3) + 3 Marks</p> <p>4 (3) + 3 Marks</p> <p>4 (3) + 3 Marks</p> <p>4 (3) + 3 Marks</p> <p>7 (6) Marks</p> |
|--|---|

(i) Any one:

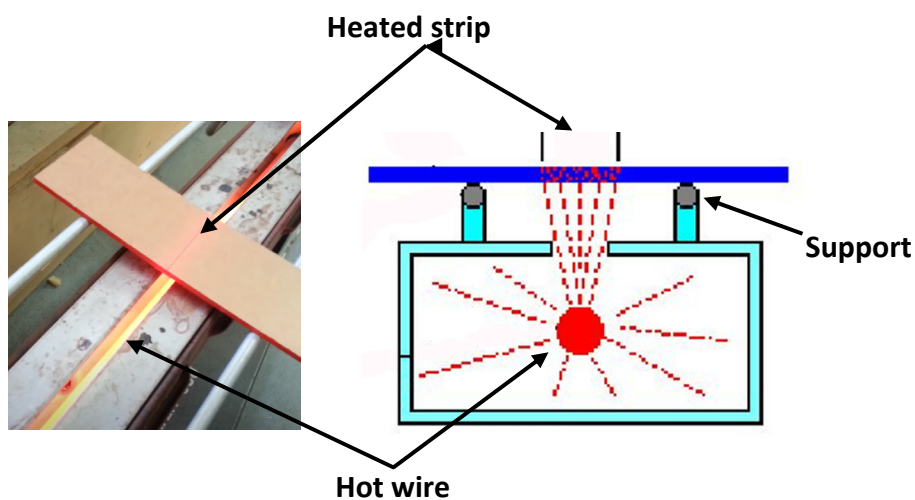
Air compressor:

The compressor shown has an electric motor, a compressor unit, and a storage tank. The electric motor drives the compressor unit which sucks air into a cylinder through an inlet valve. The air is then squashed (compressed) by a piston and forced into the storage tank. As the compressor continues to run, pressure builds up inside the storage tank. When it reaches a set level the electrical motor cuts off, stopping the compressor. The storage tank now stores the compressed air for use. When the pressure drops inside the storage tank, the electric motor starts again to bring up the level of pressure inside the storage tank.



Strip heater:

A strip heater is used to form straight or small curvature bends in thermoplastic sheet material. An electric element or hot wire is enclosed in a channel which has an opening at the top. Thermoplastic sheet is placed across supports above the opening. By adjusting the height of the supports the width of strip to be heated can be altered. The supports are set to a low height for tight bends. If a more gradual bend is required, the heated area is widened by setting the supports higher. Different thicknesses of sheet may be formed by controlling the heating temperature.

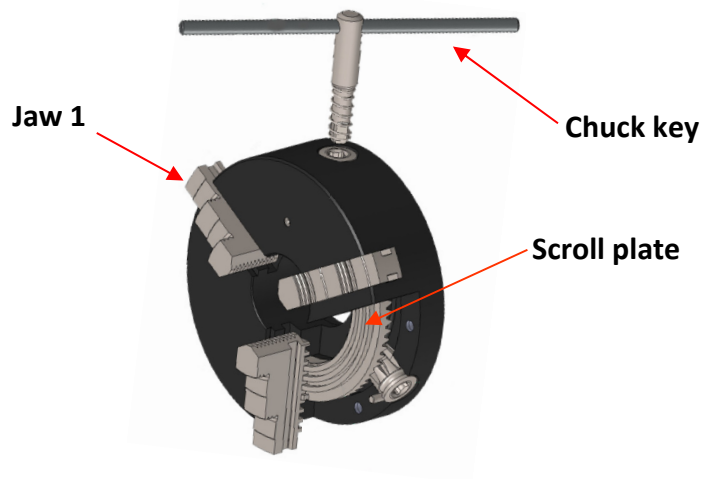


Describe

Award 7 (6) Marks

3 Jaw chuck:

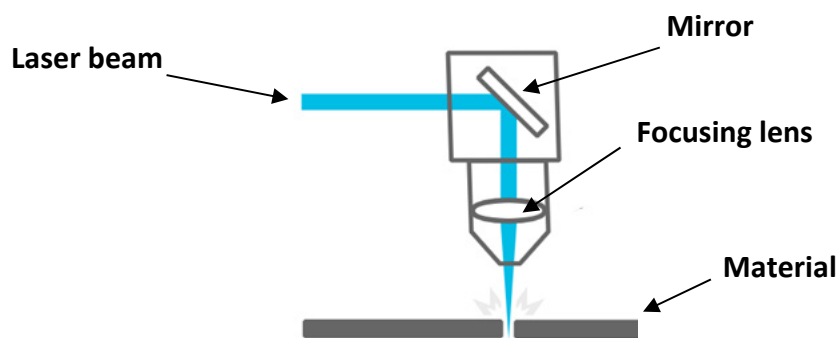
A 3-jaw chuck is used for holding round or hexagonal work. The chuck has three jaws which are located on a scroll plate. When the chuck key is used, the scroll plate rotates moving all three jaws together, automatically centering the work when the chuck is closed (self-centering). Two sets of jaws are supplied with these chucks. One set for gripping small diameter and hollow work. The other for gripping large diameter work. The jaws of each set are stamped 1, 2 and 3 and corresponding numbers are stamped beside each slot on the chuck. This is to ensure that each jaw is returned to its proper slot after removal.



(j) Any one:

Laser cutting:

Laser cutting is a technology that uses a laser to slice materials. Laser cutting works by directing the output of a high-power laser most commonly through mirrors. Laser mirrors and CNC (computer numerical control) are used to direct the laser beam generated onto the material. The laser beam is directed at the material through a focusing lens, which then either melts, burns or vaporizes away the material. This leaves an edge with a high-quality surface finish.



Explain

Award 7 (6) Marks

Bluetooth:

Bluetooth is a wireless technology which allows mobile devices to be connected over short distances. Bluetooth is used as a short-range wireless interconnection of mobile phones, computers, sound systems, game controllers, printers, and other electronic devices.

**Drone:**

A drone may be explained as any unmanned robot either preprogrammed or remotely controlled. This includes robots designed for water, land and air use. The most common drone is an aerial one, either an RPA (remote piloted aircraft) or UAV (unmanned/unpiloted aerial vehicle). A remote-piloted aircraft, RPA, is controlled remotely either by a short-range remote control or from a more sophisticated remote base station. Used in both commercial and military applications, these drones are often like a helicopter and can come with more than one rotor blade. An unmanned aerial vehicle, UAV, is preprogrammed prior to flight to do a specific set of tasks on a specific flight path.



(k)

Definition:

A brittle material can be fractured easily by an impact. Brittleness is the opposite to toughness.

Name:

Glass / Hardened Steel / Cast iron is an example of a brittle material.

Definition

Award 4 (3)

Name

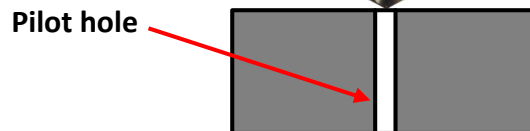
Award 3

Total 7 (6) Marks

(l) **Any one:**

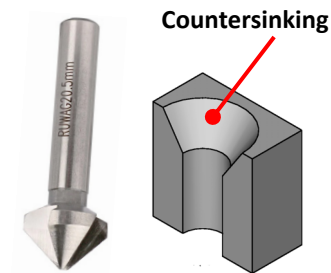
Pilot hole:

A pilot hole must be drilled before using a large drill. This keeps the large drill central as it guides the drill through the piece when drilling.



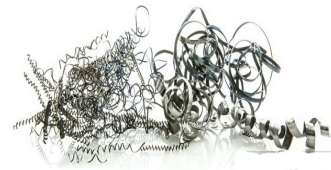
Countersinking bit:

A countersinking bit is used to enlarge the mouths of holes to accommodate the heads of countersunk head screws / rivets or fixings. Countersinking allows the fixing to be sunk below the surface of the hole.



Swarf:

Swarf is the waste material produced when the chip is cut from the workpiece.



Explain

7 (6) Marks

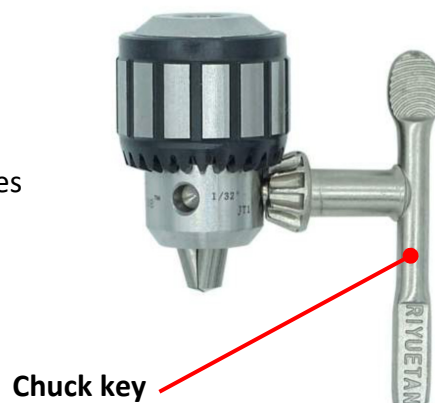
(m)

Name:

Chuck key.

Function:

A chuck key is used to open and close drill chucks found on a range of machines such as pillar drills, hand drills or lathe tailstocks.



Name

Award 4 (3) Marks

Function

Award 3 Marks

Total 7 (6) Marks

Question 2

(50 Marks)

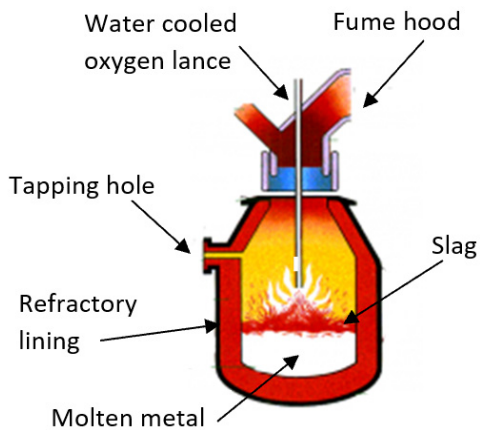
(a)

- A - **Name:** Basic Oxygen furnace **Function:** Produces steel
B - **Name:** Blast furnace **Function:** Produces Pig iron
C - **Name:** Electrical Arc furnace **Function:** Produces High grade steel

Name
Award 3 @ 3 Marks
Function
Award 3 @ 2 Marks
Total (15) Marks

(b) Any one:

(i) **A - Diagram & labeled parts:**



A - Basic oxygen furnace

(ii) **Materials used in the charge**

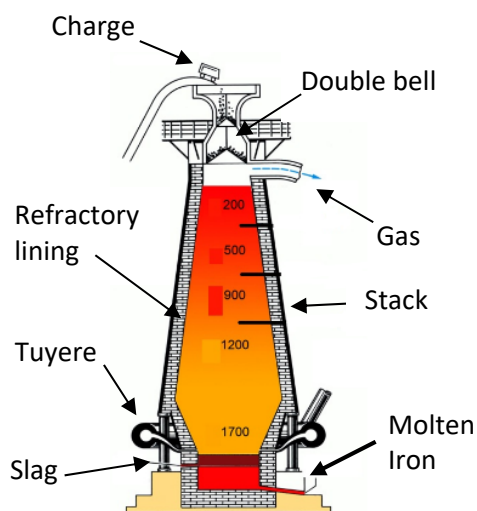
Molten iron / scrap metal, lime, carbon

(iii) **How the charge is heated**

Oxygen blown onto the surface of the molten metal produces intense heat which burns unwanted impurities from the charge.

(i) Diagram & Labels
Award 6 Marks
(ii) Materials
Award 3 Marks
(iii) Heat charge
Award 3 Marks
Total (12) Marks

(i) **B - Diagram & labeled parts:**



B - Blast furnace

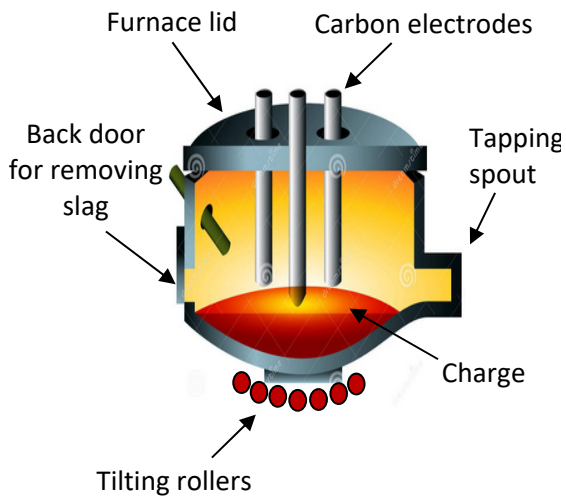
(ii) **Materials used in the charge**

Iron ore, coke & limestone

(iii) **How the charge is heated**

As the coke burns it provides heat to melt the charge. To support the burning process air is blown into the charge through the tuyere.

(i) **C** - Diagram & labeled parts:



(ii) **Materials used in the charge**

Pig iron, scrap metal & carbon.

(iii) **How the charge is heated**

The charge is heated by an electric arc created by current flowing between the carbon electrodes and the charge.

C - Electric arc furnace

(c)

(i) **Rotary handrail**

Material: Aluminium / Tubular steel

Reason: Light & strong

(ii) **Seat cover**

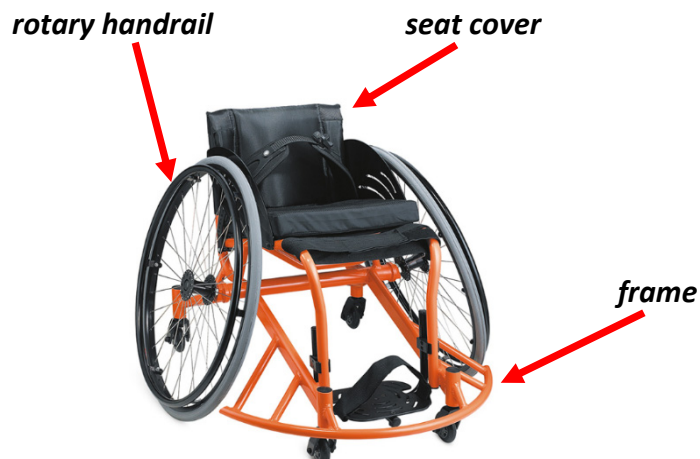
Material: Leather / Nylon

Reason: Resistant to wear & durable

(iii) **Frame**

Material: Tubular steel / Aluminium / Carbon fiber

Reason: Strong & light



(i) **Material**

Award 3 @ 3 Marks

(ii) **Reason**

Award 3 @ 2 Marks

Total (15) Marks

(d) Any two:

(i) Solder: Lead & Tin

(ii) Bronze: Copper & Tin

(iii) Brass: Copper & Zinc

Metals

Award 2 @ 2+2 Marks

Total (8) Marks

Question 3

(50 Marks)

(a) Any two:

(i) Quenching:

Quenching is when a hot metal is cooled very quickly i.e. when a cherry red metal is moved about when dipped into cold water.

(ii) Case hardening:

Case hardening is a method of making low carbon steel very hard on the outside while leaving its centre tough. Low carbon steel may be case hardened by first increasing the amount of carbon in the outer surface by 'carburising'. Carburising is carried out by heating the steel to a cherry red and allowing it to cool in a carbon rich material. The steel part will now have a skin or 'case' rich in carbon. The part is then heated to a cherry red and quenched, producing a hardened skin with a tough core.

(iii) Annealing:

Annealing is a heat treatment process used to soften metals. To anneal steel, it is heated to a cherry red colour, approx. 900°C and allowed to cool down as slow as possible. This can be achieved by leaving the metal in the furnace while the furnace is cooling down.

(iv) Work hardening:

Work hardening is when a metal becomes hard and brittle because of been hammered or shaped when cold. Some metals are more prone to work hardening, than others. Copper and aluminum are typical examples and need to be continually annealed if subjected to a lot of cold shaping or forming.

Explain

Award 2 @ 7 Marks

Total (14) Marks

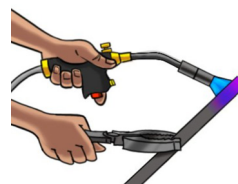
(b)

(i) To harden point A of the centre punch:

Point A of the centre punch is hardened by heating the point to approx. 800°C, i.e. a cherry red color, or until the point loses its magnetic properties. The point is then immediately quenched in water or oil.

(ii) To temper the cutting edge B of the cold chisel:

Following the hardening process, the cutting edge is reheated to a suitable temperature, which is below the reddening temperature and then cooled in oil or water. The correct temperature is often displayed by a colour i.e. blue / purple is a suitable indicator for the cutting edge of a chisel.



(i) Harden

Award 8 Marks

(ii) Temper

Award 8 Marks

Total (16) Marks

(c) Two safety precautions:

- Wear heat resistant gloves when performing heat treatment of metals.
- Do not leave hot metals lying around in case people accidentally pick up the piece.

Safety precautions
Award 2 @ 4 Marks
Total (8) Marks

(d)

Any two:

(i) Malleability:

The ability of a material to be hammered and/or formed without breaking.

(ii) Compressive strength:

The ability of a material to withstand being squashed or pushed together.

(iii) Ductility:

A material is said to be ductile when it can be permanently stretched, without fracture. It must be plastic enough to allow deformation and strong enough not to fracture. A metal must be ductile to enable it to be stretched / drawn into wire.

(iv) Tensile strength:

The ability of a material to withstand being pulled apart or stretched.

Explain
Award 2@ 6 Marks
Total (12) Marks

OR

(d)

(i) Two advantages:

- Robotics offer precision placement of components in manufacturing.
- Robotics offer precision when performing manufacturing processes such as welding & paint spraying.

(ii) Two safety improvements:

- Robotic technology can reduce the number of injuries associated with lifting heavy objects. Robotics can also be used to reduce the need for workers to lift or carry heavy objects.
- The use of exoskeleton robots can reduce the need for workers to perform repetitive motion tasks, which often lead to musculoskeletal disorders (MSDs).

(i) Advantages
Award 2 @ 3 Marks
(ii) Safety improvement
Award 2 @ 3 Marks
Total (12) Marks

Question 4

(50 Marks)

(a)

(i) **Flames produced:**

Excess acetylene: Carburising flame

Excess oxygen: Oxidising flame

Equal amounts: Neutral flame

(ii) **Successful soldered joint:**

- The surfaces to be joined must be perfectly clean and coated with flux.
- A good flow of heat to the joint is essential. Before applying the solder, the joint must be brought to the temperature at which the solder melts.



(i) Flame names

Award 3 @ 3 Marks

(ii) Steps

Award 2 @ 3 Marks

Total (15) Marks

(b)

Any three

(i) **Flux:**

Flux protects the weld area and prevents oxidation during welding.

(ii) **Earth clamp:**

The earth clamp forms the circuit when welding. It clamps onto the material being welded and when the electrode creates the arc the clamp closes the circuit.

(iii) **Function of slag:**

When manual arc welding, slag forms on top of the weld helping to pull impurities out of the weld. The slag also forms a shield from the atmosphere reducing oxidation of the weld. The shield also slows down the cooling rate of the weld when solidifying.

(iv) **Two safety precautions:**

- Always wear correct PPE such as a face welding mask.
- Ensure the area is dry and all electric cables are in good condition.



Award 3 @ 4 Marks

Total (12) Marks

(c)

Any three:

(i) Tool B

Name: Tap wrench

Purpose: The tap wrench is used to hold a threading tap when cutting an internal thread.



(ii)

Plug tap:

A plug tap has only a short taper across one or two threads. It is used for finishing the thread at the bottom of a deep or blind hole.

Tapered tap:

A tapered tap has a taper across the first 8 to 10 threads, allowing it to enter the hole and gradually cut to the full thread depth.

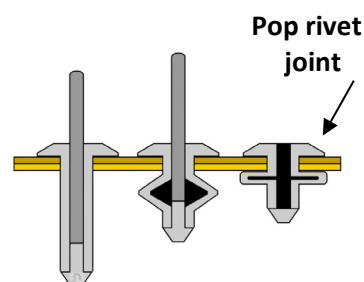


Plug
tap

Tapered
tap

(iii) **Method to join light gauge aluminium:**

A pop rivet can be used to join light gauge aluminium.



(iv) **Two advantages:**

- A spot-welding machine does not require a high level of skill to operate.
- Spot welding does not require flux or a filler material.

(d)

Two safety precautions:

- Avoid leaving a hot soldering iron on a desk after use.
- Avoid touching your hand or skin with the hot tip of the soldering iron when in use.

Award 3 @ 5 Marks
Total (15) Marks

Safety precautions
Award 2 @ 4 Marks
Total (8) Marks

Question 5

(50 Marks)

(a)

(i) Name any two:

A: Vacuum forming

B: Injection moulding

C: Blow moulding

(i) Name

Award 2 @ 5 Marks

(ii) Describe

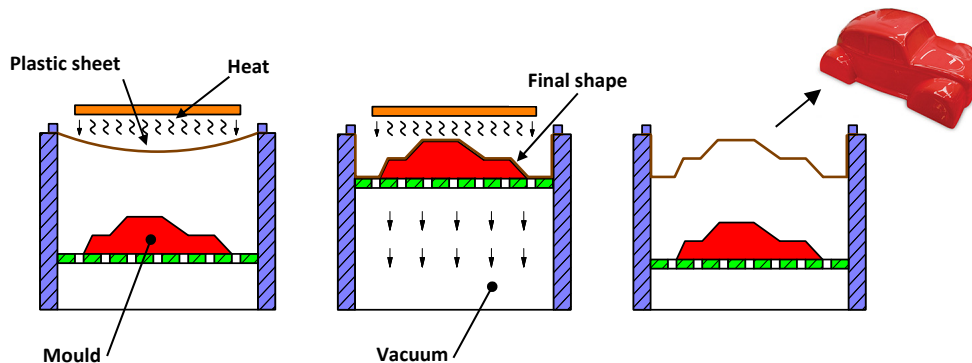
Award 1 @ 10 Marks

Total (20) Marks

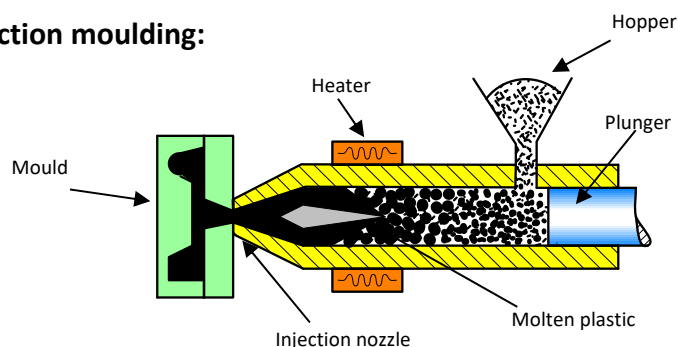
(ii) Describe any one plastic manufacturing process:

A - Vacuum forming:

A thermoplastic sheet is clamped in a frame and heat is applied until the sheet begins to sag. At this stage, the mould is lifted up into the plastic sheet and vacuum pressure is applied. This causes the plastic sheet to pull against the mold and form the final shape. After cooling, the mould is lowered and the plastic part is removed from the frame. Excess material is trimmed away.

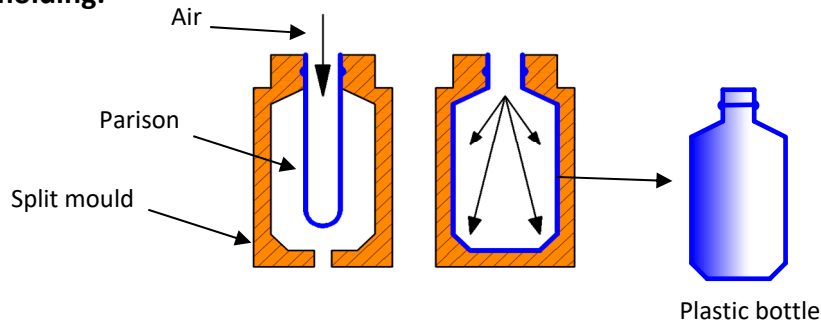


B - Injection moulding:



Thermoplastic is softened by heating it inside an injection nozzle. The softened plastic is forced by a plunger into a cold mould where it hardens rapidly and is then ejected. Injection moulding is used for the rapid molding of components.

C - Blow molding:



Used to produce articles from a heated thermoplastic tube called a parison. The mould closes around the extruded parison and air is blown inside forcing the parison out against the wall of the mould. The article is moulded by the internal shape of a split mould. The component is allowed to cool before being removed from the opened mould.

(b)

Any two:

(i) Thermoplastic is a plastic which softens when heated.

(ii) **Elastic memory:**

This describes the ability of a plastic to return to its original shape after being formed. The plastic remembers its original shape and will return to this shape if heated i.e. it is a smart material.

(iii) Thermosetting plastic is a plastic which remains hard when heated.

Award 2 @ 6 Marks

Total (12) Marks

(c)

Any two:

(i) **Basin:** Polypropylene (PP)

(ii) **Toothbrush:** Nylon

(iii) **Shampoo bottle:** Polyvinylchloride (PVC)

Name

Award 2 @ 5 Marks

Total (10) Marks

(d)

Safety precautions:

- Always work in a well-ventilated area.
- Wear protective goggles / gloves to protect from adhesive sticking to the skin.

Safety Precautions
Award 2 @ 4 Marks
Total (8) Marks

(a) Any three:

- (i) **Knurling tool**
Used to apply a grip on the surface of a piece such as a scribe or centre punch.
- (ii) **Tailstock**
Facilitates drilling, tapping, reaming or supporting the end of long work on the centre lathe.
- (iii) **Four-way toolpost**
Holds up to four cutting tools and allows each to be used as needed by rotating the tool post through 90°.
- (iv) **Chuck**
Used to secure / hold a drill or tap.

Identify any three
Award 1 @ 6 Marks
Award 2 @ 5 Marks
Total (16) Marks

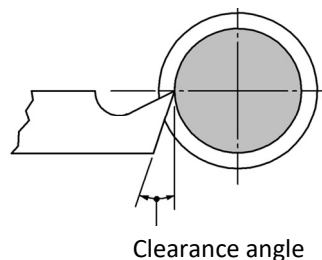
(b) Any three:

- (i) **Cutting fluids**
Cutting fluids are used when machining metals to improve tool life, reduce the buildup of heat, improve surface finish and flush away chips from the cutting zone.



- (ii) **Clearance angle**

Without a clearance angle, no cutting would take place. The clearance angle ensures that only the cutting edge of a tool contacts a piece. It provides clearance between the cutting tool face and the workpiece.



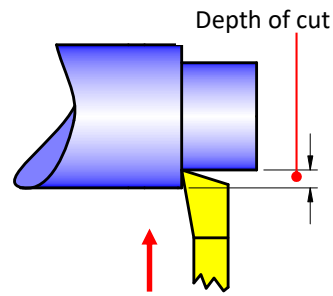
- (iii) **Chuck key**
Used to open and close a 3 / 4 jaw chuck on a centre lathe.



Describe any three
Award 1 @ 6 Marks
Award 2 @ 5 Marks
Total (16) Marks

(iv) **Depth of cut**

This is the distance the cutting tool is moved into the workpiece when cutting.



(c)

(j) Slocombe or centre drill bit

(i) A slocombe or centre drill bit is used for drilling countersunk holes to accommodate lathe centres and for starting the holes on centre when drilling on the lathe.

(ii)

- Wear correct PPE i.e. goggles.
- Ensure the drill is secured correctly before drilling.

(i) Name

Award 1 @ 6 Marks

(ii) Describe

Award 1 @ 6 Marks

(iii) Safety precautions

Award 2 @ 3 Marks

Total (18) Marks

OR

(c)

Any three:

(i) **Protective screen**

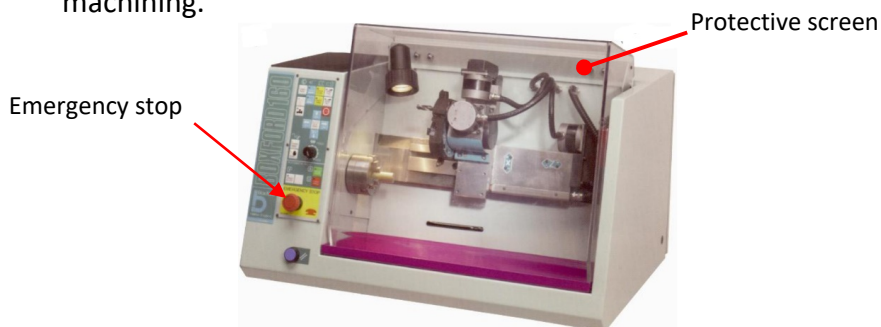
The protective screen covers the machining area when the CNC lathe is in operation. If the screen is lifted, the machining process stops.

(ii) **Emergency stop button**

If the emergency stop button is pressed the machining process will stop.

(iii) **Simulation**

The CNC software allows the user to simulate a part program before machining.



Identify

Award 3 @ 6 Marks

Total (18) Marks

Question 7**(50 Marks)****(a)**

(i) A Clearance fit, Interference fit or Transition fit

(ii) **Clearance fit** - The shaft is always smaller than the hole.
Interference fit - The shaft is always larger than the hole.

Or

Transition fit - The shaft can be larger or smaller than the hole.

(i) Name

Award 2 @ 4 Marks

(ii) Describe

Award 1 @ 4 Marks

Total (12) Marks

(b)

(i)	Nominal diameter of the hole;	30.00 mm
(ii)	Largest diameter of the shaft;	30.08 mm
(iii)	Smallest diameter of the hole;	29.94 mm
(iv)	Type of fit;	Interference fit.

Calculations

Award 4 @ 5 Marks

Total (20) Marks

(c)

Any three:

- (i) **Engineering protractor** - Used for checking or accurately marking out angles on material.
- (ii) **Digital Vernier calipers** - Used for accurately measuring the diameter of round bars or internal diameters of holes. Measurement can be read directly from a digital display.
- (iii) **Vee block & clamp** - Used of holding round bars when drilling or marking out.
- (iv) **Feeler gauges** - Used to check the gap between two parts.

Name

Award 3 @ 3 Marks

Application

Award 3 @ 3 Marks

Total (18) Marks

OR

(c)

(i) Any two electronic components:

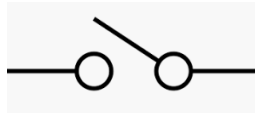
- Motor
- Switch

(ii) Electronic symbol:

Motor:



Switch:



(i) Name

Award 1 @ 5 Marks

Award 1 @ 4 Marks

(ii) Symbol

Award 1 @ 5 Marks

Award 1 @ 4 Marks

Total (18) Marks

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