Coimisiún na Scrúduithe Stáit

State Examinations Commission

Leaving Certificate 2024

Marking Scheme

ENGINEERING – Materials and Technology

Higher 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, 2024

Marking Scheme

Written Examination and Practical Examination

ENGINEERING –

Materials and Technology

HIGHER LEVEL

Introduction – written examination

In considering the marking scheme, the following should be noted.

1. The solutions presented are examples only. All other valid solutions are acceptable and are marked accordingly.

2. The detail required in any answer is determined by the context and the manner in which the question is asked, and by the number of marks assigned to the answer in the examination paper and, in any instance, therefore, may vary from year to year.

3. Bonus marks at the rate of 5% of the marks obtained will be given to a candidate who answers entirely through Irish and who obtains less than 75% of the total marks. In calculating the bonus to be applied decimals are always rounded down, not up e.g., 4.5 becomes 4; 4.9 becomes 4, etc. The bonus table given on the next page applies to candidates who answer entirely through Irish and who obtain more than 75% of the total marks.

4. The table below contains information about annotations used for marking throughout the exam paper.

Annotation	Meaning
	Blank page
	Page marked by examiner

Coimisiún na Scrúduithe Stáit

Marcanna Breise as ucht freagairt trí Ghaeilge

Léiríonn an tábla thíos an méid marcanna breise ba chóir a bhronnadh ar iarrthóirí a ghnóthaíonn níos mó ná 75% d'iomlán na marcanna.

N.B. Ba chóir marcanna de réir an ghnáthráta a bhronnadh ar iarrthóirí nach ngnóthaíonn níos mó ná 75% d'iomlán na marcanna don scrúdú. Ba chóir freisin an marc bónais sin **a shlánú síos**.

Tábla 300 @ 5%

Bain úsáid as an tábla seo i gcás na n-ábhar a bhfuil 300 marc san iomlán ag gabháil leo agus inarb é 10% gnáthráta an bhónais.

Bain úsáid as an ngnáthráta i gcás 187 marc agus faoina bhun sin. Os cionn an mharc sin, féach an tábla thíos.

Bunmharc	Marc Bónais
226	11
227 – 233	10
234 – 240	9
241 – 246	8
247 – 253	7
254 – 260	6

Bunmharc	Marc Bónais
261 – 266	5
267 – 273	4
274 – 280	3
281 – 286	2
287 – 293	1
294 – 300	0

LEAVING CERTIFICATE

ENGINEERING-MATERIALS AND TECHNOLOGY

(Higher Level – 300 marks)

Marking Scheme 2024

Answer **any six** questions.

Question 1 – 50 marks		**Question 2 – 50 marks**			**Question 3 – 50 marks**		
Any ten @ 5 marks each.		Answer **all** parts of this question			Answer **all** parts of this question		
(a)	3 + 2	**(a)**	**(i)**	3 + 2			
(b)	3 + 2		**(ii)**	3 + 2	**(a)**	**(i)**	2 + 2
(c)	5					**(ii)**	4
(d)	3 + 2	**(b)**	**(i)**	5		**(iii)**	8
(e)	**Any one** @ 5		**(ii)**	5			
(f)	3 + 2				**(b)**	**(i)**	10
(g)	3 + 2	**(c)**	**(i)**	3 + 2		**(ii)**	4
(h)	5		**(ii)**	5		**(iii)**	2 + 2
(i)	5						
(j)	5	**(d)**	**(i)**	5	**(c)**	**(i)**	4 + 4
(k)	5		**(ii)**	5		**(ii)**	8
(l)	3 + 2						
(m)	5	**(e)**	**Any two** @ 5 + 5				

Question 4 – 50 marks			**Question 5 – 50 marks**			**Question 6 – 50 marks**		
Answer **all** parts of this question			Answer **all** parts of this question			Answer (a) and (b) **and** either part of (c)		
(a)	**(i)**	8	**(a)**	**(i)**	8	**(a)**	**(i)**	3 + 3
	(ii)	8		**(ii)**	8		**(ii)**	10
(b)	**(i)**	1 + 1 + 1 + 1 + 1	**(b)**	**(i)**	10	**(b)**	**Any three** @ 6 + 6 + 6	
	(ii)	7		**(ii)**	4			
	(iii)	3 + 3		**(iii)**	2 + 2	**(c)**	16	
						OR		
(c)	**Any two** @ 8 + 8		**(c)**	**Any two** @ 8 + 8		**(c)**	**(i)**	4 + 4
							(ii)	4 + 4

Question 7 – 50 marks			**Question 8 – 50 marks**			**Question 9 – 50 marks**		
Answer **all** parts of this question			Answer (a) and (b) **and** either part of (c)			Answer (a) and (b) **and** either part of (c)		
(a)	**(i)**	3 + 3	**(a)**	**(i)**	3 + 3 + 3	**(a)**	**(i)**	8
	(ii)	8		**(ii)**	4 + 3		**(ii)**	8
	(iii)	3 + 3						
(b)	**Any three** @ 6 + 6 + 6		**(b)**	**Any three** @ 6 + 6 + 6		**(b)**	**Any three** @ 6 + 6 + 6	
			(c)	**(i)**	4 + 4	**(c)**	**(i)**	4 + 4
(c)	**(i)**	6		**(ii)**	4 + 4		**(ii)**	8
	(ii)	2 + 2 + 2	***OR***			***OR***		
			(c)	**(i)**	8	**(c)**	**(i)**	4 + 4
				(ii)	4 + 4		**(ii)**	4 + 4

Marking Scheme

Note: **The solutions presented are examples only.**

All other valid solutions are acceptable and are marked accordingly.

Question 1 (50 Marks)

(a) **Advantages of facial recognition:**

- It can unlock devices and is user friendly.
- Helps find missing people.
- Strengthens security measures and can protect against fraud.
- Reduces the number of touchpoints.
- Improves photo organisation, etc.

Disadvantages of facial recognition:

- Threatens privacy and may impose on personal freedom.
- Misuse causing fraud and other crimes.
- Errors can implicate innocent people.
- Technology can be manipulated, etc.

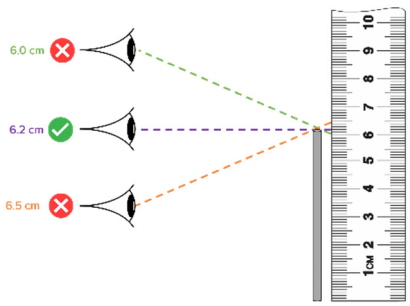
3 + 2

(b) **Safety hazards associated with the use of adhesives** include:

- Avoid contact with skin.
- Avoid inhalation and provide fume extraction.
- Ensure that materials to be joined are adequately supported while the adhesive is curing.
- Eye irritation must be avoided.

3 + 2

(c) Parallax error arises when a change of viewpoint results in an inaccurate reading. Measurements need to read perpendicular to the measuring scale.



5

(d) **Advantages of standing desk:**

- Standing desk have many ergonomic adjustments allowing for various work positions and people of different heights.
- Standing while working can boost your productivity.

- Standing could reduce back pain, help tone muscles and improve posture.

3 + 2

(e) **(i)** **Viktor Kaplan**

Viktor Kaplan (1876 – 1934) was an Austrian engineer and the inventor of the Kaplan turbine, a revolutionary water turbine used to produce electricity from large streams with only a moderate incline.

(ii) **James Watt**

James Watt (1736 – 1819) was a Scottish inventor, mechanical engineer whose improvements in steam engine technology drove the Industrial Revolution. To describe the efficiency of his engines, he coined the term 'horsepower' and devised a rev counter.

(iii) **Gaston Planté**

Gaston Plamté (1834 – 1889) was a French physicist who invented the lead–acid battery. This type of battery was developed as the first rechargeable electric battery marketed for commercial use and it is widely used in automobiles.

Any one @ 5

(f) Material properties should be lightweight, tough, strong, corrosion resistant, non-toxic, biocompatible (not toxic and not rejected by the body), long-lasting, easy to mould, etc.

3 + 2

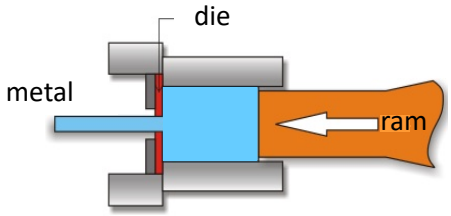
(g) Aluminium has a good strength-to-weight ratio, it will not rust, can be formed into the shape easily, etc.

3 + 2

(h) Elastomers are a group of polymers consisting of linear chains that are coiled, entangled and are subject to minimal cross-linking. This irregular internal structure and bonding arrangement allows these materials to be very elastic at room temperature.

5

(i) Metal extrusion is a forming process in which a metal (either hot or cold) is forced through a die. Due to the high pressures, the metal exits the die through the opening, assuming the die shape in the process.



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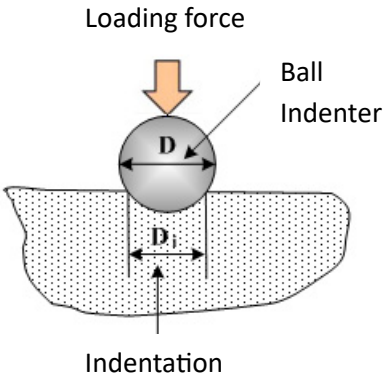
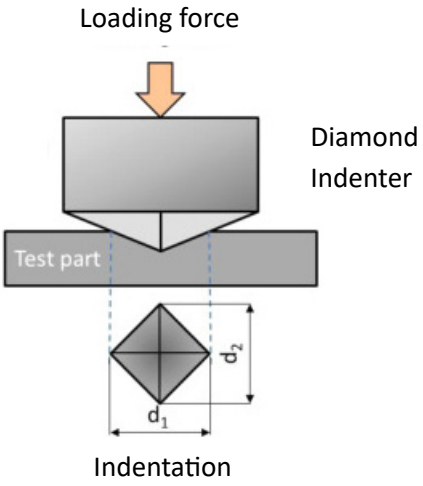
(j) The Brinell hardness test uses a hardened steel ball as an indenter.

The Vickers hardness test uses a diamond, square-based pyramid indenter. It has a point angle of 136°.





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(k) **Pyrometallurgy** is a high-temperature process that involves the heating of ores to extract metals. This process typically involves the use of heat and chemical reactions in a furnace or smelter.

Hydrometallurgy is a process that uses aqueous solutions to extract metals from ores. It involves dissolving the metal compounds in water or acid solutions and then separating and purifying the metal from the solution.

5

(l)

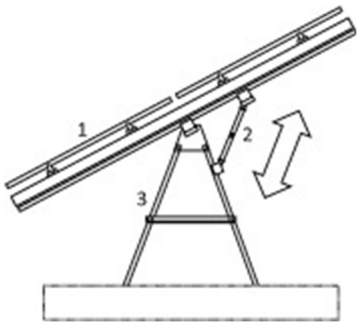
Advantages	Disadvantages
• Offer greater flexibility and portability. • Removes tripping hazard of power cords. • No need for a mains power source, etc.	• Limited battery life. • Expensive to buy. • Corded tools are typically lighter than cordless tools, etc.

3 + 2

(m)

Tilting a solar panel**:**

Suggested solution:



1. Solar panel
2. Tilting mechanism: screw might be automated and driven by a motor to raise and lower the top of the panel creating an adjustable tilt.
3. Panel mount.

   A light sensor tracking circuit can be used to drive the motor and tilt the panel for most effective operation.

5

Question 2 (50 Marks)

(a) (i) Container ships are extensively used in the movement of goods:

- Efficiency and Speed: Container ships can carry large quantities of goods at once, significantly reducing the cost per unit of cargo. They are designed to load and unload quickly at ports, minimising turnaround time and maximising efficiency.
- Standardisation: The use of standardised containers (typically 20-foot and 40-foot long) allows for easy handling, stacking, and transportation across different modes of transport (ships, trains, trucks).
- Cost-Effectiveness: Shipping goods by container ship is generally cheaper than other forms of transportation, especially for long distances.
- Security: Containers provide a secure environment for goods, reducing the risk of damage, theft and loss.
- Flexibility: Container ships can carry a wide variety of goods.
- Global Connectivity: Container shipping networks cover major ports around the world, facilitating global trade.
- Reduced Environmental Impact: While shipping does have environmental impacts, container ships are relatively efficient in terms of fuel consumption and emissions per ton of cargo transported compared to other forms of transport, such as air freight.

3 + 2

(ii) Container ship hazards:

- Weather Conditions: storms, hurricanes, typhoons, rough seas and high winds.
- Piracy and security threats.
- Mechanical failures: engine breakdowns, power outages or other mechanical issues can leave a ship stranded at sea.
- Ships must navigate through narrow straits, congested shipping lanes, icebergs and shorelines where there is a risk of grounding or collision with other vessels.
- Improperly secured or hazardous materials.
- Political instability or conflicts can disrupt shipping routes or lead to blockades.
- Ships can face delays due to port congestion or labour strikes.

3 + 2

(b) **(i)** Twenty Foot Equivalent Unit. Containers are standardised with the agreed standard based on a 20 foot container.

5

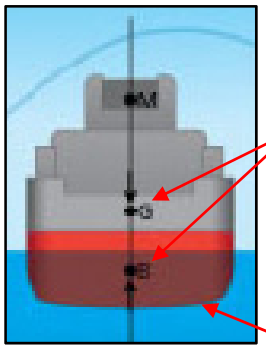
(ii) **Feeder Ships:** relatively small ships, up to 2,500 TEUs, used for short sea and inland port routes where they can feed on to the larger vessels.
Panamax Ships: Medium-sized, up to 5,000 TEUs, designed for the original Panama Canal dimensions, medium to long-haul routes.
Ultra Large Container Vessel (ULCV): Largest ships, over 14,000 TEUs, used for major intercontinental routes and require advanced port facilities.

5

(c) **(i)** Bronze has excellent resistance to corrosion, especially in a seawater environment. Bronze is a strong and wear-resistant material.
It is easy to cast and machine and has effective shock absorption properties, this promotes smoother operation.
It is cost effective due to long life and performance.

3 + 2

(ii) **Centre of gravity:** The centre of gravity is the point where the ship mass is considered to be concentrated. A lower centre of gravity makes the ship more stable. It reduces the risk of capsizing. The cargo must be loaded in a manner that keeps the centre of gravity low and close to the centreline of the ship.
Shape of the Hull: A wider beam (the width of the ship at its widest point) increases stability by providing a larger area for buoyancy forces to act upon. This makes the ship more resistant to rolling (side-to-side motion).



Centre of gravity lowers when laden.

Wide hulled ship

5

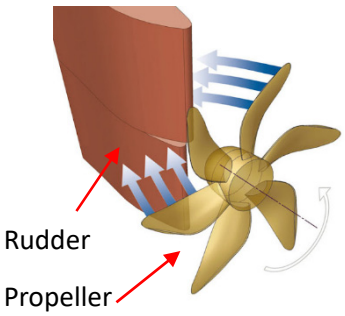
(d) **(i)** **Speed:** two-stroke diesel engines have a high power output at low revolutions per minute (RPM). They are suitable for running in a speed range of 16-25 knots over long periods. These engines are fuel-efficient even at low speeds which minimises environmental impact.
Propulsion: May be directly driven which eliminates the need for complex gear systems as well as reducing mechanical losses. Two-stroke engines are suited to slow speed operation driving large slow-turning propellers to move large volumes of water. Modern two-stroke diesel engines are equipped with turbochargers that improve combustion efficiency and power output.

5

(ii) Steering a container ship

Steering the ship is as important as propulsion and very large forces are required to turn the ship's rudder. This is done by a machine known as the 'steering gear'.
The rudder is like a vertical hinged paddle behind the propellor, it deflects water flow to change the ship direction.

Additional manoeuvrability, may be needed during docking and in confined waters, can be provided by bow and stern thrusters.



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(e) (i) Ballast water management.

Effective ballast water management is crucial for mitigating the environmental impact of container ships. While there are challenges associated with chemical use and energy consumption, the overall benefits of preventing invasive species and protecting water quality are important.

(ii) Oil leakage.

Oil leakage from container ships poses significant immediate and long-term environmental threats including marine pollution, harm to marine life, habitat destruction and ecosystem disruption. However, through design improvements, maintenance practices, effective response plans and regulatory compliance, the risks and impacts of oil leakage can be significantly reduced.

(iii) Emissions.

Reducing emissions from the use of fossil fuels on container ships has predominantly positive environmental impacts such as mitigating climate change, improving air quality, and protecting ecosystems. However, it also presents challenges, such as the environmental impact of alternative fuel production and the energy requirements of emissions reduction technologies.

Any two @ 5 + 5

Question 3 (50 Marks)

(a) (i) Benefits of custom-made carbon fibre shin guard:

- Shin guard is made to suit the player dimensions.
- Carbon fibre has an excellent strength-to-weight ratio and impact resistance.
- Superior impact protection over traditional polymer materials, etc.

2 + 2

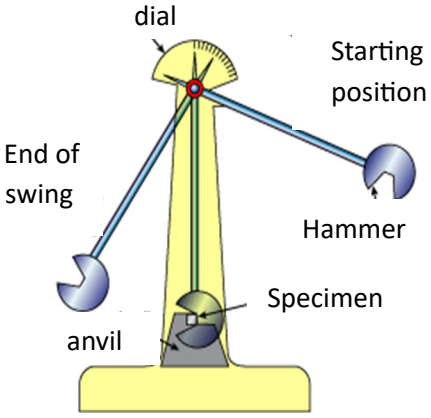
(ii) Toughness definition:

Material toughness is the ability of a material to absorb energy and plastically deform without fracturing. Materials that can absorb a lot of energy before fracturing have high toughness.

4

(iii) Impact testing

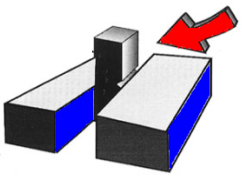
This will determine the toughness of the material which indicates the ability to withstand impact or shock loads. Test pieces are notched and held in the vice associated with the machine.
A pendulum hammer strikes the test piece and determines the energy absorbed in breaking the piece. This gives a numerical value for the toughness of the material.



Izod Test

- 167 joules striking energy.
- Test specimen is vertical.
- Test piece is clamped at one end.
- Test piece notch is facing the pendulum.
- The distance the pendulum travels after breaking the piece will give the toughness value.

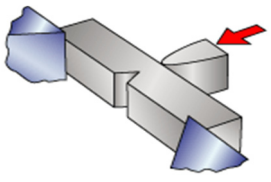
Izod test



Charpy Test

- 300 joules striking energy.
- Test specimen is Horizontal.
- Test piece is clamped at both ends.
- Test piece notch is facing away from the pendulum.
- The distance the pendulum travels after breaking the piece will give the toughness value.

Charpy test



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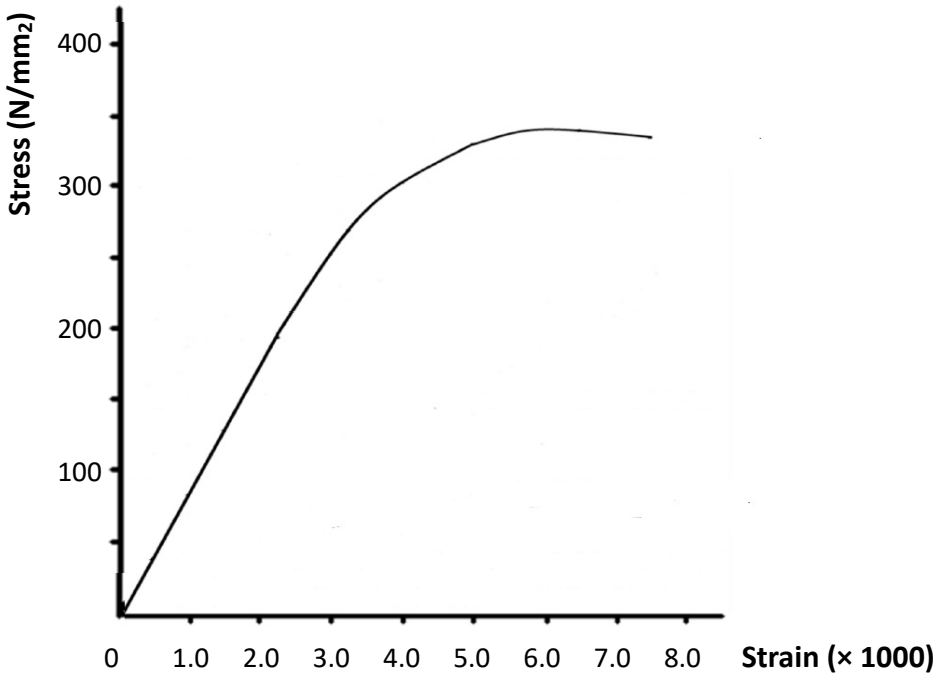
(b) **(i)** **Draw stress-strain graph:**



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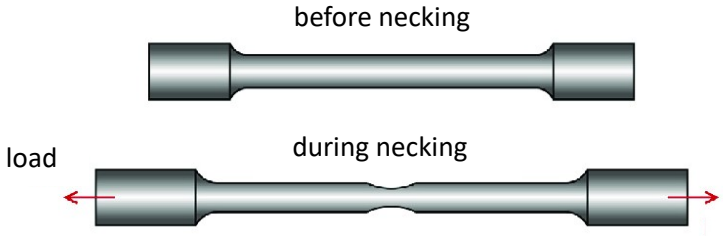
(ii) Young's Modulus of Elasticity = $\frac{\text{stress}}{\text{strain}} = \frac{135}{1.50} =$ 90 kN/mm²

4

(iii) **Necking** is a type of plastic deformation observed in ductile materials subjected to tensile stress. This is where the middle of the specimen is noticeably thinner than the rest of the specimen and with a little more stress the piece is going to fracture.



Cup and cone fracture is a type of failure observed in ductile metals and plastics due to tensile stress. This type of fracture gets its name from the resulting shapes at the end of the broken pieces after a failure has occurred.

2 + 2

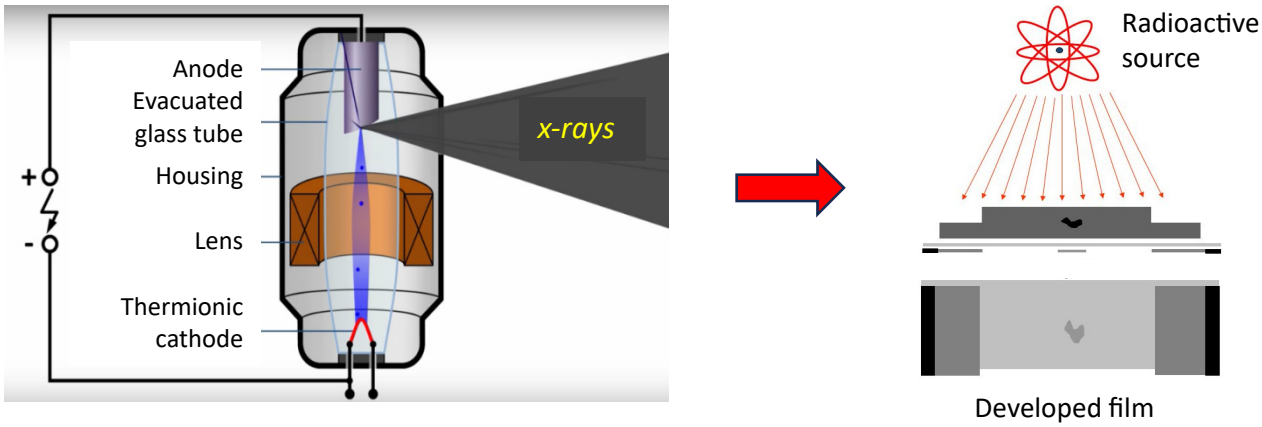
(c) (i) Reasons for non-destructive testing (NDT) of the linkage arm:

- Product will not be destroyed, cost saving.
- Safety and quality control.
- Speed – immediate results can be generated.
- Accuracy – excellent at detecting large and small imperfections.

4 + 4

(ii) Radiography (x-ray) NDT

X-ray radiation penetrates materials and produces an internal photographic image of the test piece. Electrons are released by heating the cathode to high temperature. A high DC voltage speeds up the electrons which are aimed at the anode. The electrons penetrate the anode and the energy is given off as X-rays. The anode reflects the X-rays to the test piece and an image plate is used to capture the internal image. Any flaw or cavity in the test piece will appear dark on the image plate as the radiation will not be absorbed by the flaw. Proper shielding is necessary when using x-ray equipment as a safety precaution. Internal cavities in welded joins can be determined by this NDT method.



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Question 4 (50 Marks)

(a) **(i)** Reasons for hardening:

Metal hardening is a process that strengthens and increases the durability of metals by increasing the hardness of the material. The surface hardness of the brake disc will be improved and the increased wear resistance will result in a longer lasting product.

Reasons for tempering:

Tempering removes some of the hardness, brittleness and strength left by hardening but increases the toughness of the piece and makes it more useful. This will make the brake disc more durable and less likely to fracture due to an impact.

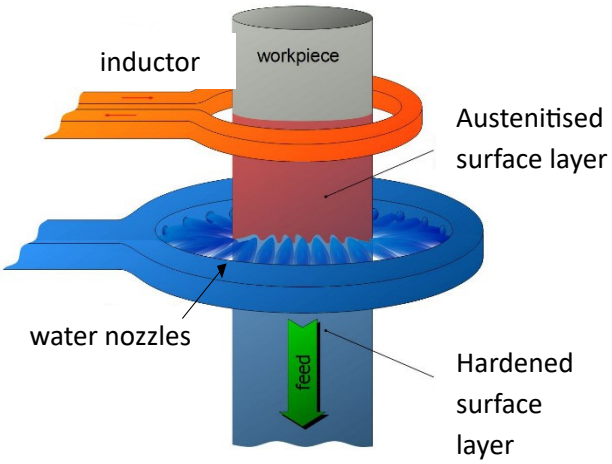
8

(ii) **Induction Hardening:**

Induction hardening is a method of quickly and selectively hardening the surface of a metal part. A copper coil carrying a significant level of alternating current is placed near (not touching) the part.

The workpiece is heated by a high frequency electric current passing through the copper coil to a high temperature (austenite zone) and then quenched with jets of water.

The quenched metal undergoes a martensitic transformation, increasing the hardness of the outer surface while keeping the inner core tough.



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(b) **(i)** **A =** Austenite and Ferrite

B = Austenite

C = Austenite and Cementite

D = Ferrite and Pearlite

E = Pearlite and Cementite

1 + 1 + 1 + 1 + 1

(ii) Annealing 0.6% carbon steel:

The piece is heated 25° - 50° above the UCT for Hypoeutectoid steels (less than 0.83% carbon). It is then soaked at this temperature allowing the whole of the piece to be at the same temperature. It is then allowed to cool gradually in the furnace by reducing the temperature. During full annealing new grains are formed, this is called recrystallisation.

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(iii) This makes the metal as soft as possible, improves ductility, refines the grain size and removes internal stresses.

3 + 3

(c) **(i)** Work hardening, also known as strain hardening or cold working, is the process by which a metal becomes stronger and harder as it is deformed plastically.

- The metal increases in strength and hardness.
- Metals may be more difficult to machine and form.
- Ductility is decreased.
- Residual stresses are introduced from cold working.
- Electrical conductivity and magnetic properties may alter from work hardening.

(ii) **Safety hazards associated with flame hardening:**

- High temperatures associated with the heating process – wear PPE.
- Naked flame is a fire hazard.
- Spitting of the water on impacting the heated surface could lead to burning.
- Fumes could lead to dangerous gas levels in the work area.

(iii) **Eutectic point:** This is a special change point where liquid changes directly to solid without going through a pasty stage.
Eutectoid point: It is a solid-to-solid transformation.
This is where pearlite changes to austenite at 0.83% carbon content at 723°C.

Any two @ 8 + 8

Question 5 (50 Marks)

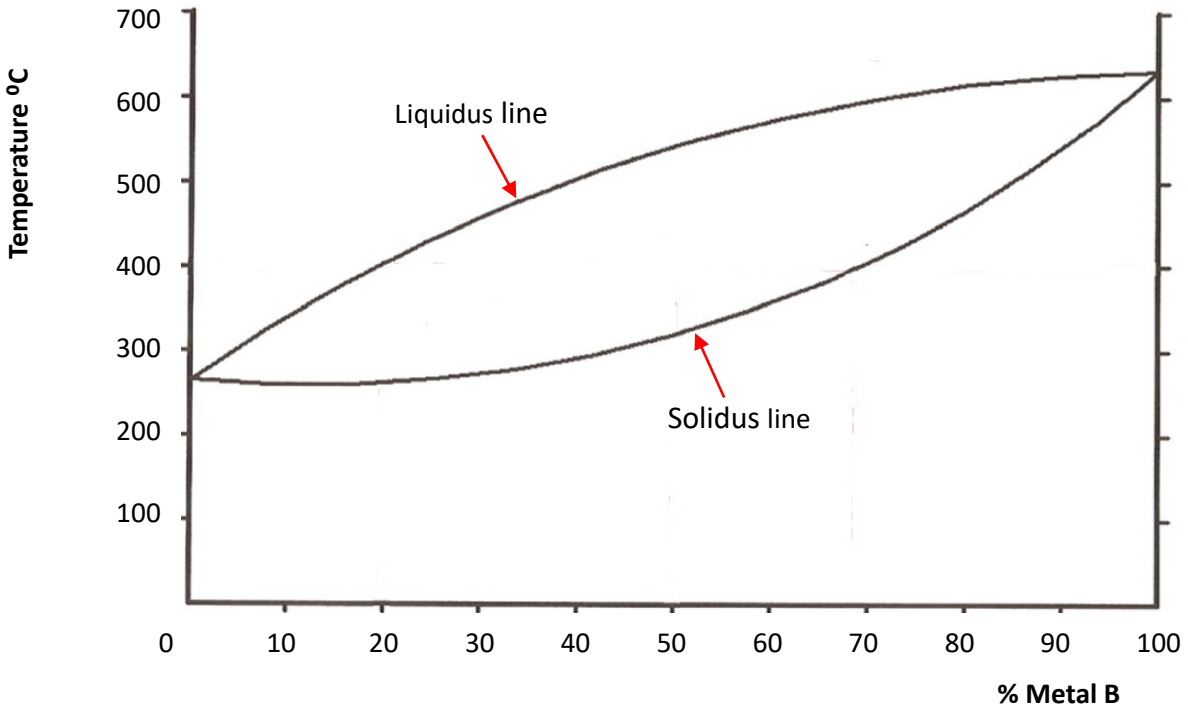
(a) **(i)** **Dendritic growth:**
As a metal reaches its cooling point small particles cool first. Solidification takes place in a pattern. This pattern is called dendritic growth and looks like the branches of a tree.
Each small particle grows to form a crystal or grain. Crystals grow together to form a solid.

8

(ii) **The impact of a line defect in crystal structures.**
Dislocations can move as far as grain boundaries under a shear stress.
Fine grained metals are stronger, stiffer and harder than coarse grained metals.
Dislocations promote material malleability. The motion of dislocations allows slip deformation to occur. Heat treatments can impact on dislocation density caused by cold working.

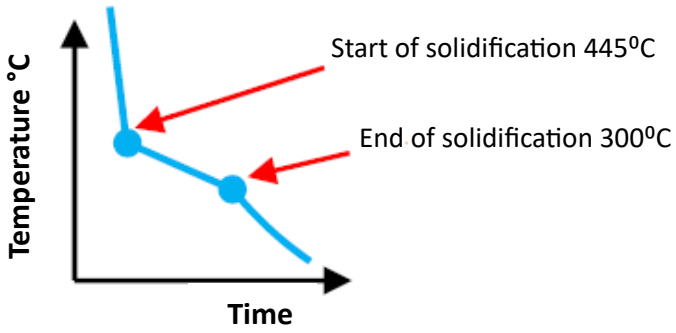
8

(b) **(i)**



10

(ii) Cooling curve for alloy of 30% metal B:



4

(iii) **A** - 270°C
B - 630°C

2 + 2

(c) (i) The principle of sacrificial protection in relation to offshore wind farms.

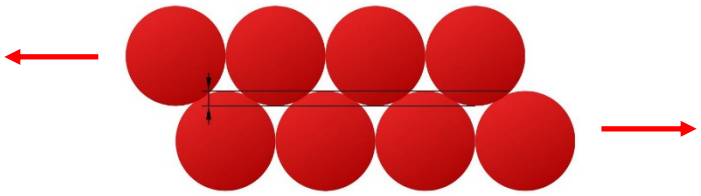
Sacrificial protection is a corrosion protection method in which a more electrochemically active metal is electrically attached to a less active metal. The protection against rust caused by seawater for offshore wind turbine foundations is done by cathodic protection using sacrificial anodes in combination with corrosion protective coatings. A sacrificial anode is a piece of metal made of zinc or aluminium alloy that is attached to a steel structure to protect the steel structure from corrosion.

(ii) Methods to protect steel against the corrosive effects of the environment:

- Barrier coatings like paint, plastic powder/dip coating.
- Galvanising by dipping the steel into molten zinc.
- Alloying with other metals such as corrosion-resistant nickel and oxidation-resistant chromium, etc.

(iii) FCC crystalline structure and ductility:

In the FCC structure atoms are at the corners of a cube and a single atom in the centre of each face of the cube. These atoms are more tightly packed than BCC structures, which allows slip to happen more easily and results in a more ductile metal.



Any two @ 8 + 8

Question 6 (50 Marks)

(a) (i) Reasons for TIG welding stainless steel storage tank:

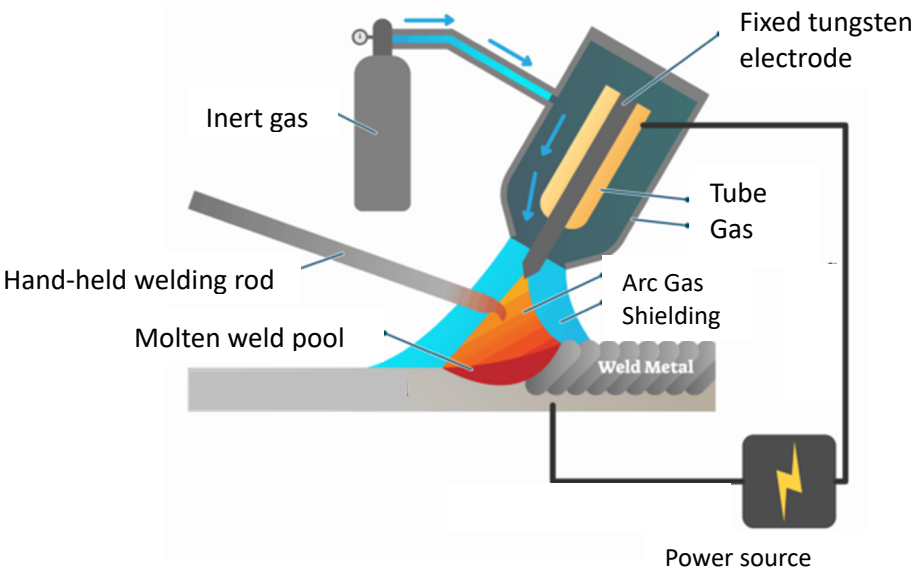
- TIG welding offers more precision.
- Uses a cleaner process, fewer fumes and less smoke when TIG welding.
- Low deposition rates.
- Greater control of heat produced by the welder.
- TIG welding allows you to choose the precise amperage for your work.
- The cost of a TIG welder is comparable to the other methods.

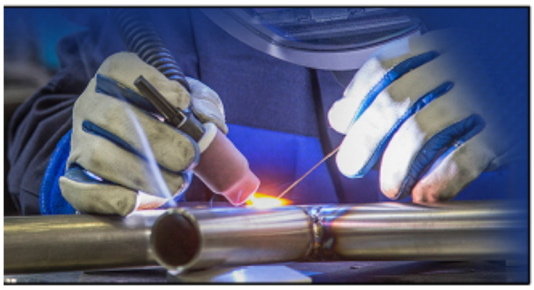
Any two @ 3 + 3

(ii) TIG Welding:

An arc is formed between the non-consumable tungsten electrode and the metal being welded. The inert gas shielded arc is used to flux the joint, argon or helium

are typically used to prevent oxygen getting to the joint area. A filler metal (welding rod) is added manually to the weld pool when necessary. A high frequency generator provides a path for the welding current. Both AC and DC power can be used in TIG welding techniques. TIG welding is a highly skilled welding process and is generally a manual operation.

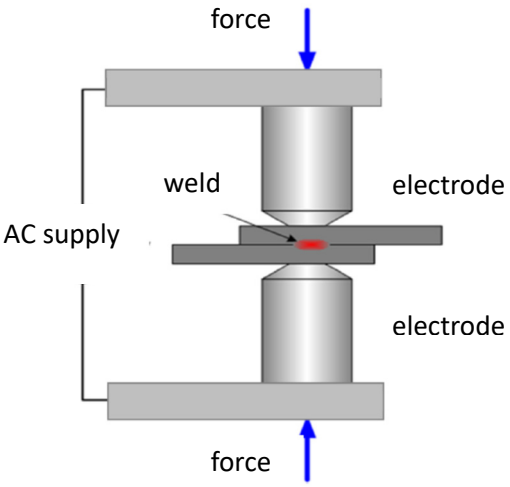




10

(b) **(i)** **Electric shock:** check machine connections, ensure that the working area is not wet, etc.
Intense light from welding: use shield while welding, use a welding bay or welding curtain to protect others.
Welding fumes: ventilation system required to extract fumes.

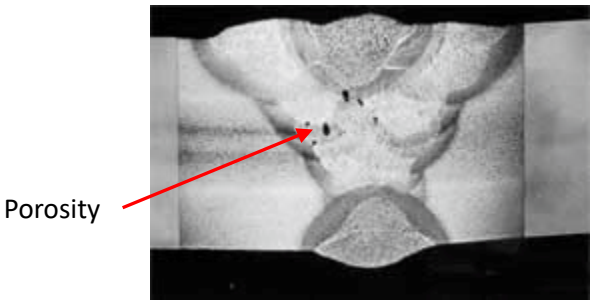
(ii) The electrode is in the shape of a round bar with tapered ends where it contacts the material. The components to be joined are placed between the electrodes and then pressed together. A nugget weld is achieved as current is passed through the electrodes generating a large heat between the metals.
It is effectively used to join sheet metal together and is recognised by the distinctive circular mark left at the site of the weld. It is widely used in the automotive industry for body panel assembly.



(iii) An inert gas such as argon is used in MIG welding to protect the molten weld pool from atmospheric contaminants like nitrogen and hydrogen. Without

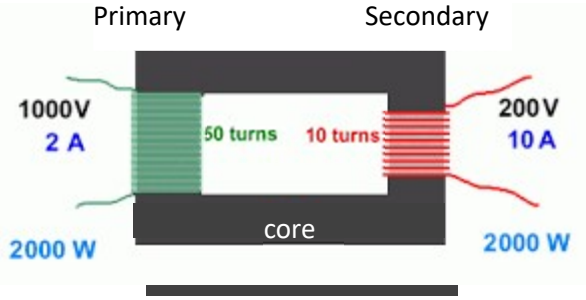
shielding gas, the finished weld would be very weak and subject to porosity. The inert gas results in less toxic fumes compared to using a flux/coating, no slag is formed.

(iv) Radiography (X-ray) NDT can be used to check welds for porosity. The X-Ray test provides a highly sensitive image of the internal structure of the material indicating if porosity is present in the weld.



(v) Transformer:

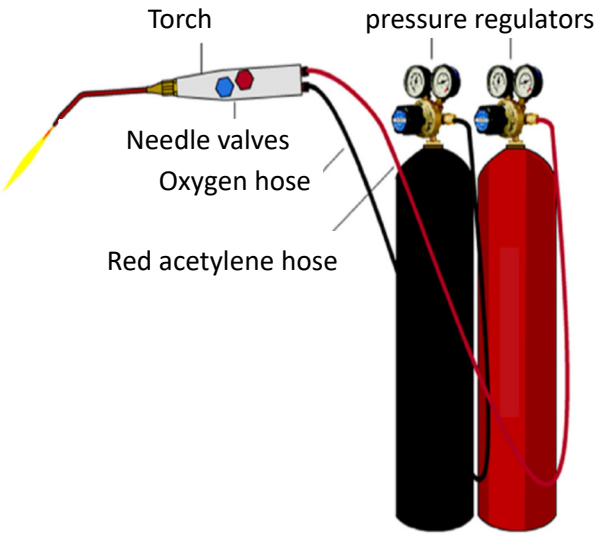
A transformer can either step down or step up the voltage in a circuit. In a step-down transformer, the voltage at the output line (secondary coil) is directly proportional to the voltage at the input line (primary coil).
If the primary coil consists of 50 turns and carries 1000 volts and a secondary coil consists of 10 turns, the secondary voltage is then 200 volts (5 times less).



Any three @ 6 + 6 + 6

(c) Oxy-acetylene equipment include:

- Acetylene cylinder
- Oxygen cylinder
- Oxygen and acetylene hoses
- Welding torch
- Pressure gauges
- Flashback arrestors.



Three flame types:

- Neutral flame - equal portions of both gases
- Oxidising flame - excess oxygen gas
- Carburising flame - excess acetylene gas.

Integrated safety features:

- The colour coding on the cylinders and the hoses helps prevent any possible mix-up of the gases and connections.
- The oxygen cylinder is usually thinner and taller than the acetylene cylinder.
- The connections for the different gases have either left or right-hand thread forms.
- The flashback arrestors prevent the flame returning to the cylinders.
- Cylinders can be turned off when finished operating the equipment.

Applications:

- Oxy-acetylene is used for welding most types of metals depending on which flame type used.
- A neutral flame is used for general steel welding.
- An oxidising flame is used for brass and bronze welding.
- A carburising flame is used for aluminium alloys and alloy steel welding.
- A cutting torch can be attached instead of the welding torch for the process of 'gas cutting'.

16

OR

(c) (i) Benefits of robotic pipe inspection:

Safety: The pipe inspection robot can locate faults in pipelines without putting human lives in danger, making the job safer for employees.

Labour-saving: The pipe inspection robot is small and light and can be operated remotely by a single person. It can enter confined spaces and removes the need to disassemble parts, reducing costs.

Improved efficiency and quality: The inspection robot can provide real-time information such as fault location, crawler inclination (pipeline slope), air pressure, crawling distance (meters of the line), etc.

4 + 4

(ii) Remote visual inspection (RVI) applications:

Building inspectors to attend worksites and perform their standard inspections.

Offshore oil and gas pipelines/structures can be inspected without needing to be on site.

Robotic crawlers are used to inspect structures such as wind turbines and bridges.

A camera drone can be used to inspect places that are hard to reach and could be dangerous, such as the roof of a building, etc.

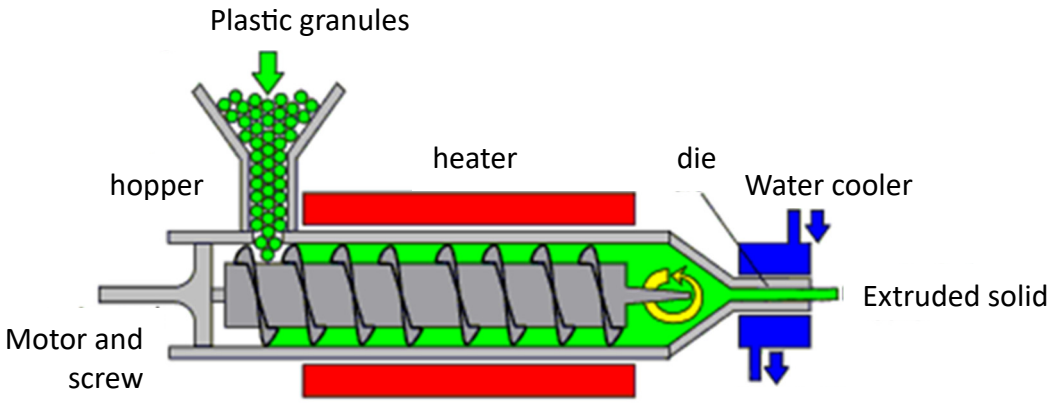
4 + 4

Question 7 (50 Marks)

(a) **(i)** Hose reel - Injection moulding
Hose pipe - Extrusion

3 + 3

(ii) **Extrusion:** Plastic granules are fed from a hopper through a die by a rotating screw. The plastic is heated in the chamber before it enters the die and cooled by air jets or water as it leaves the die. The extruded products can be cut into lengths or coiled. Thermoplastics such as polythene, PVC and nylon are commonly extruded. This process is used to produce items of uniform profile such as curtain rails and plumbing pipes.



8

(iii) Plasticisers are added to improve the flexibility of the polymer material. Stabilisers are used to help resist UV rays and the degrading effects of the environment.

3 + 3

(b) **(i)** Upcycling plastic products generally takes a used low value object and creates a higher value use e.g. Making shoes from recycled PET bottles, shopping bags from recycled bottles, recycled plastic building boards from milk containers, etc.

(ii) **Glass transition temperature:**
Glass transition temperature describes the temperature at which a solid glassy amorphous polymer changes to a rubbery, viscous polymer. It is engineered by altering the degree of branching or cross-linking in the polymer by the addition of plasticisers.

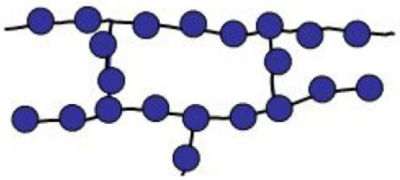
(iii) **Polymer lamination:**
Thin layers of materials bonded together. High strength plastics can be produced by layers of other polymer, fibres, paper or cloth coated with resin being bonded together. Heat and pressure are applied.

(iv) Thermosetting polymer:

Thermosets are plastics that retain their condition and shape after curing due to spatial crosslinking. Once cured, their polymers can no longer be dissolved.

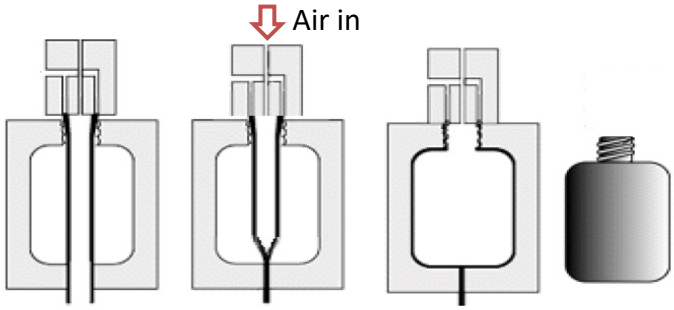
Covalent bonds are formed by condensation polymerisation.

Properties: High melting point, high tensile strength, good thermal insulation and can withstand high temperatures without losing rigidity.



(v) Blow moulding:

1. An extruded plastic parison is clamped in the blow moulder.
2. Air is blown into the heated chamber.
3. The pliable plastic takes the shape of the mould.
4. The finished product is removed.



1. Parison 2. Clamping 3. Moulding 4. Finished bottle

Any three @ 6 + 6 + 6

(c) (i) Bioplastic:

Bioplastics are plastic materials produced from renewable biomass sources, such as vegetable fats and oils, corn starch, straw, woodchips, sawdust, recycled food waste, etc. Bioplastic can be made from agricultural by-products and also from used plastic bottles and other containers using micro-organisms. Bioplastics can be used to reduce the problem of plastic waste that is contaminating the environment.

6

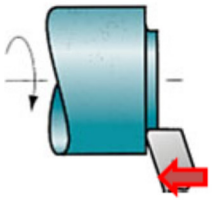
(ii) Advantages of rapid prototyping techniques:

- Quick feedback and early discovery of design problems.
- Estimation of production costs, manufacturing time and material requirements.
- Select machinery required for production.
- Testing to determine fit and durability.
- Receive feedback from customers and end users.
- Cost effective.
- 3-D printed prototypes allow for complex designs to be brought to life relatively quickly.

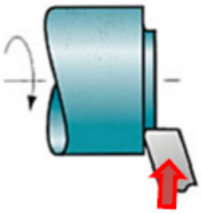
2 + 2 + 2

Question 8 (50 Marks)

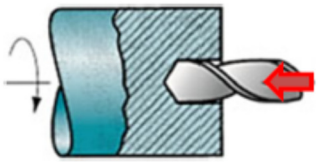
(a) **(i)**



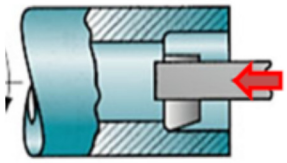
Parallel turning: reduces diameter of workpiece.



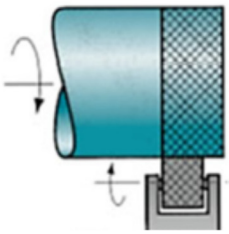
Facing: smooth finish on front face.



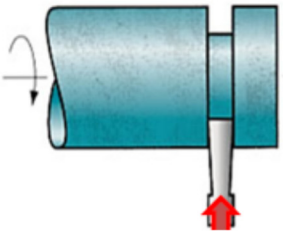
Drilling holes.



Boring / internal threading: widening the hole and creating the thread.



Knurling: adding finger grips.



Grooving / parting-off: creating the grooves and cutting to length.

3 + 3 + 3

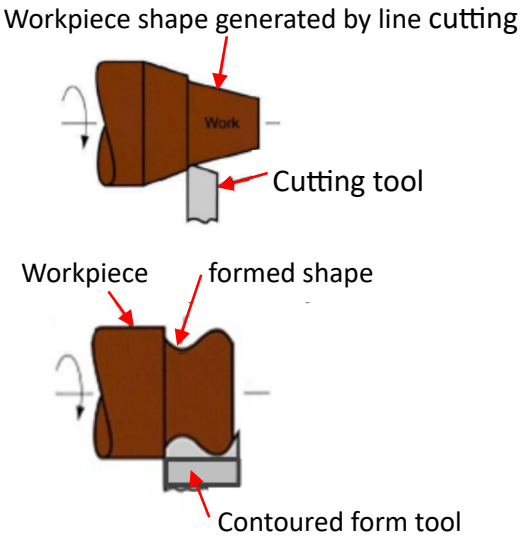
(ii) **Factors affecting material surface finish on a lathe:**

Use of cutting fluids have a lubricating impact and will reduce heat build-up and improve surface finish; the quality of the cutting tool; maintenance of correct cutting angles and a sharp cutting edge; the machine parameters, speed and feed rate, etc.

4 + 3

(b) **(i)** **Generating** refers to the creation of workpiece due to the feed trajectory of the cutting tool, examples include straight turning, taper turning and profile milling.

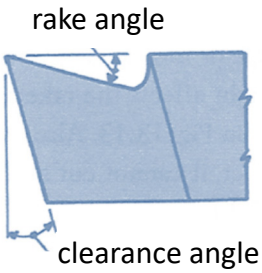
Forming involves the creation of workpiece shape due to the shape of the cutting tool; common examples include form turning and drilling.



(ii) If a grinding wheel is out of balance the spindle will vibrate and a poor surface finish will result. This has consequences for machine safety and surface finish. A wheel is placed on a balancing stand and weights are moved around the flange to balance the wheel. This is similar to balancing a car wheel.

(iii) **Clearance** angle is formed to allow one point of the cutting tool to contact the workpiece**.**

Rake angle is the angle of the cutting face relative to the workpiece. The rake angle facilitates the lifting of the chip during cutting. A rake angle can be positive, negative or zero.



(iv) **Advantages of magnetic chuck:**

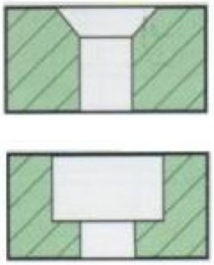
- They provide quick clamping with a firm grip.
- They can accommodate large batches of workpieces.
- They can often accommodate unusual workpiece shapes.

Disadvantages of magnetic chuck:

- The metals need to be magnetic.
- The workpiece must have a flat surface and be able to make good contact with the chuck.

(v) **Countersunk hole:** the enlarging of the mouths of holes to allow countersunk head screws or rivets sit flush with the surface of the piece.

Counterbored hole: is increasing the diameter of the hole to a certain depth to allow a cheese head screw sit flush with the surface of the piece.



Any three @ 6 + 6 + 6

(c) **(i)** **Reasons for sealed lubrication system:**

- Lubrication systems reduce friction between moving parts of machines.
- Machine parts will last longer.
- Heat will be dissipated.
- Sealed systems ensure that lubrication materials do not escape.

4 + 4

(ii) **Lubricating materials:** Oil, grease, graphite, PTFE, etc.

4 + 4

OR

(c) **(i)** CNC milling machines use rotating cutting tools to cut material away from a workpiece. A laser cutting machine uses a high-powered laser beam to cut or engrave material. CNC milling is suited for creating complex 3D shapes with high precision in a variety of materials, while laser cutting excels at fast, detailed cutting and engraving of sheet materials with a clean finish. Choosing between the two depends on the specific requirements of the project, including the type of material, the desired finish and the complexity of the design.

8

(ii) **Safety features integrated into computerised machines:**

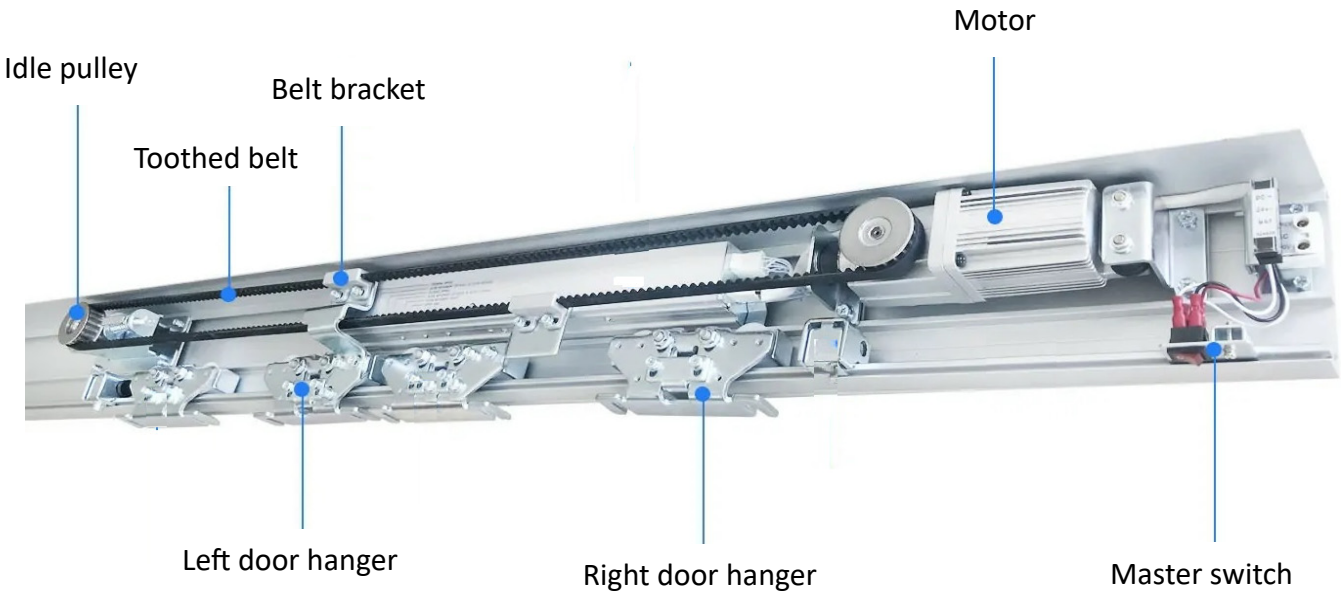
- Cutting tools are guarded.
- Machines will not operate with open guards.
- Programming is designed to avoid collision between materials and tooling.
- Lasers are protected.

4 + 4

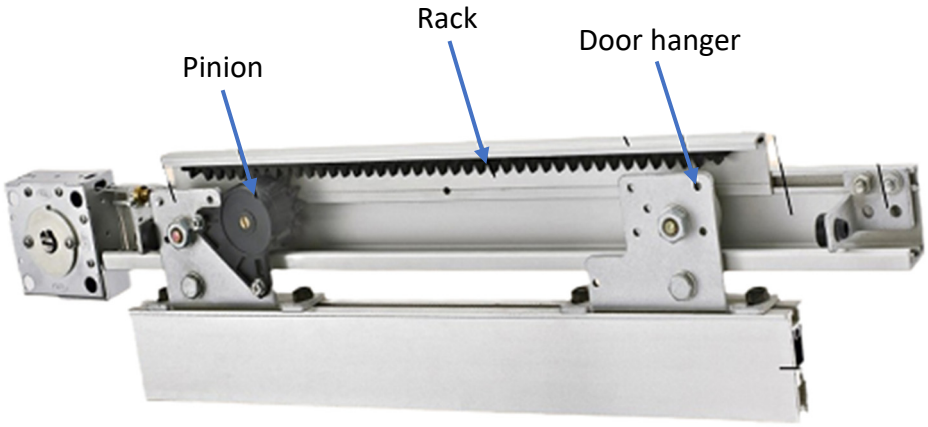
Question 9 (50 Marks)

(a) **(i)** Automatic sliding doors open when the door controller receives an activation signal by the sensor and then activates the gear motor to drive the belt and pulley. When no one is detected inside the activation area, the door starts closing after a designated period. A toothed belt offers excellent transfer of power and reduces the risk of belt slippage.

The left door hanger is attached to the upper section of the belt while the right door hanger is attached to the lower section of the belt, resulting in both doors moving in opposite directions when activated. **8**



(ii) A rack and pinion mechanism could be used, with the pinion being driven and meshing along the rack to open/close the sliding doors.



Suggested solution - other viable solutions are acceptable **8**

(b) **(i)** An LDR or light dependent resistor is a type of resistor whose resistance varies depending on the amount of light falling on its surface. These resistors are often used in circuits where it is required to sense the presence of light/darkness such as garden lights.

(ii) Universal Joint or Coupling, uses include:

- a positive, mechanical connection between rotating shafts, which are usually not parallel, but intersecting.
- used to transmit motion, power, or both.
- found on four-wheel drive (4WD), rear-wheel drive (RWD) and all-wheel drive (AWD) vehicles, agricultural machinery etc.

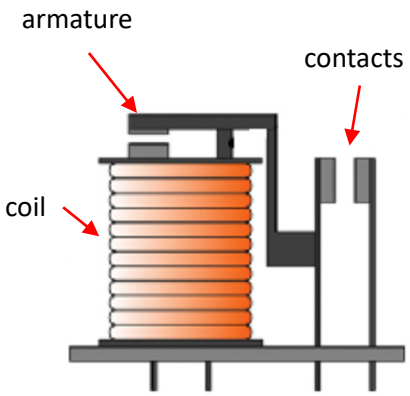
(iii) Helical gears are quieter in operation, have a greater gear meshing area which makes the stronger, helical gear teeth run smoother as they mesh with a number of teeth at the same time while spur gears only mesh one tooth at a time.

(iv) **Operation of a clutch mechanism:**

Clutches are used in devices that have two rotating shafts. One of the shafts is typically driven by a motor or pulley, and the other shaft drives another device. The clutch connects the two shafts so that they can either be locked together and spin at the same speed or be decoupled and spin at different speeds.

When your foot is off the clutch pedal in a manual car, springs push the pressure plate against the clutch disc, which in turn presses against the flywheel. This locks the engine to the transmission input shaft, causing them to spin at the same speed.

(v) A relay is an electromagnetic device that changes switching contacts when it receives an electric signal.
It consists of a wire coil with a soft iron core. If a small current is passed through the coil, the iron core is magnetised and a pivoted armature is attracted towards the magnetised core.
The movement of the armature closes the contacts and may open other contacts. These contacts can be used to control larger currents or a secondary circuit.



Any three @ 6 + 6 + 6

(c) **(i)** Features in the design of a safety harness for a racing car driver:

- Use materials that will withstand levels of stress and strain.
- Materials should be wear resistant.
- The release mechanism should release quickly in case of emergency.
- Configuration of the harness should be adjustable to fit and may have multiple points of attachment.
- Ergonomic design, straps should be wide enough for comfort.
- Harness is required to comply with safety standards.

4 + 4

(ii) *Suggested material* – Nylon
Abrasion resistant material – will wear well.
Strong in tension.
Resistant to moisture and chemicals.
Can be woven and flexible.

8

OR

(c) **(i)** LED lights use less power to run than traditional lighting.
These lights have a long life in operation.
LED lights can be controlled by sensors to turn off or change colour.
They are available in a range of shapes and sizes.

4 + 4

(ii) Advantages of sensor activated lighting:

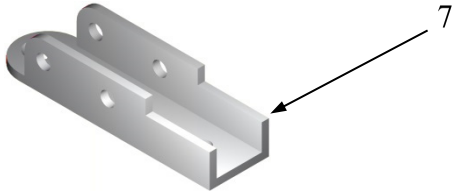
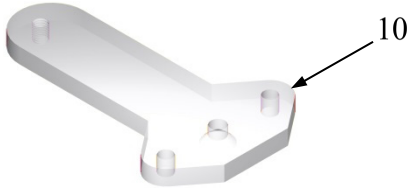
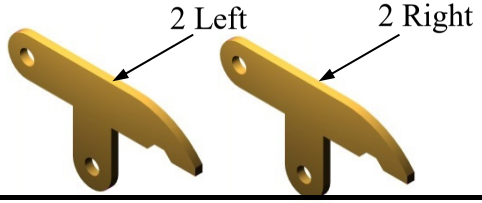
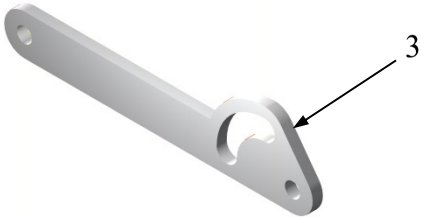
Energy Savings – This system is very efficient as it automatically switches off the lights when there is no presence detected. As a result, the end-user saves on electricity consumption.

Convenience – Turning on/off the lights will be as easy as walking inside the room.

4 + 4

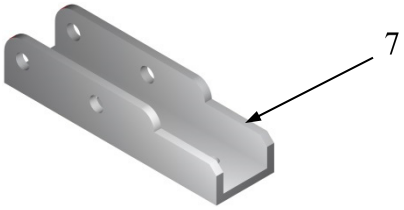
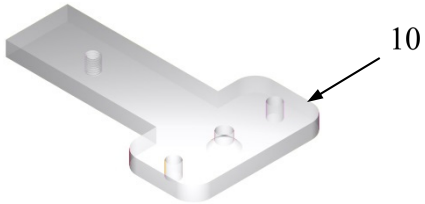
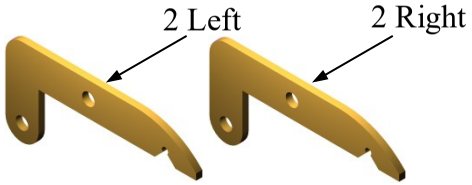
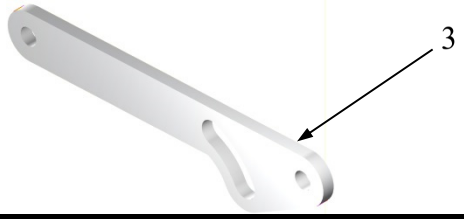
Coimisiún na Scrúduithe Stáit
State Examinations Commission

Leaving Certificate Engineering Practical Marking Scheme 2024 Day 1

Section	Part Number	Pictorial Sketch / Description	Concept		Mark	Mark
1	All Parts of Test-piece		Assembly (5) Function (10) Finish (5)		20	20
2	Part 7		Part 7 20 Marks	Marking Out	5	20
				Ø6 & Ø5.5 mm Holes and Ø5.5 CSK Hole	5	
				Stepped Profile and 12.5 mm Radius	5	
				8 mm Radius Profiles and 93 mm Length	5	
3	Part 10		Part 10 10 Marks	Marking Out	5	20
				Ø5.5 Drilled Holes and Ø5.5 CSK Hole	5	
				25 mm Parallel Base and M5 Drill & Tap	5	
				R7 mm Profiles and 93 mm Length	5	
4	Parts 2		Part 2 Right 10 Marks	Marking Out and Ø6 mm Holes	5	20
				External Profile	5	
			Part 2 Left 10 Marks	Marking Out and Ø6 mm Holes	5	
				External Profile	5	
5	Part 3		Part 3 20 Marks	Marking Out and Ø6 mm Holes	5	20
				8 mm Slot	5	
				Curved Profiles	5	
				Straight Profiles	5	

100 Marks (× 1.5 = 150 Total)

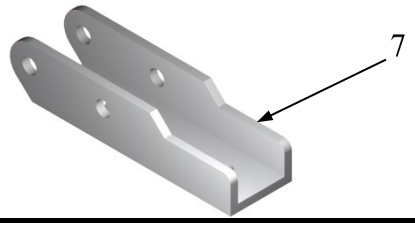
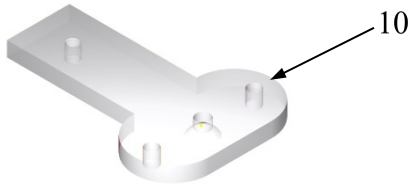
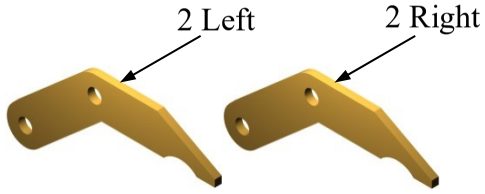
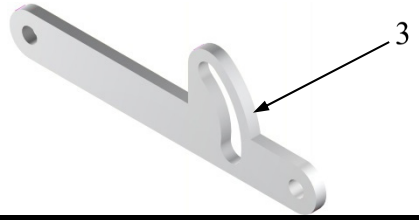
Coimisiún na Scrúduithe Stáit
State Examinations Commission
Leaving Certificate Engineering Practical Marking Scheme 2024 Day 2

Section	Part Number	Pictorial Sketch / Description	Concept		Mark	Mark
1	All Parts of Test-piece		Assembly (5) Function (10) Finish (5)		20	20
2	Part 7		Part 7 20 Marks	Marking Out	5	20
				Ø6 & Ø5.5 mm Holes and Ø5.5 CSK Hole	5	
				Stepped Profile	5	
				8 mm Radius Profiles and 92 mm Length	5	
3	Part 10		Part 10 20 Marks	Marking Out	5	20
				Ø5.5 Drilled Holes and Ø5.5 CSK Hole	5	
				25 mm Parallel Base and M5 Drill & Tap	5	
				R7 mm Profiles and 92 mm Length	5	
4	Parts 2		Part 2 Right 10 Marks	Marking Out and Ø6 mm Holes	5	20
				External Profile	5	
			Part 2 Left 10 Marks	Marking Out and Ø6 mm Holes	5	
				External Profile	5	
5	Part 3		Part 3 20 Marks	Marking Out and Ø6 mm Holes	5	20
				8 mm Slot	5	
				Curved Profiles	5	
				Straight Profiles	5	

100 Marks (× 1.5 = 150 Total)

Coimisiún na Scrúduithe Stáit
State Examinations Commission

Leaving Certificate Engineering Practical Marking Scheme 2024 Day 3

Section	Part Number	Pictorial Sketch / Description	Concept		Mark	Mark
1	All Parts of Test-piece		Assembly (5) Function (10) Finish (5)		20	20
2	Part 7		Part 7 20 Marks	Marking Out	5	20
				Ø6 & Ø5.5 mm Holes and Ø5.5 CSK Hole	5	
				Stepped Profile	5	
				8 mm Radius Profile and 81 mm Length	5	
3	Part 10		Part 10 20 Marks	Marking Out	5	20
				Ø5.5 Drilled Holes and Ø5.5 CSK Hole	5	
				25 mm Parallel Base and M5 Drill & Tap	5	
				R15 mm Profiles and 81 mm Length	5	
4	Parts 2		Part 2 Right 10 Marks	Marking Out and Ø6 mm Holes	5	20
				External Profile	5	
			Part 2 Left 10 Marks	Marking Out and Ø6 mm Holes	5	
				External Profile	5	
5	Part 3		Part 3 20 Marks	Marking Out and Ø6 mm Holes	5	20
				8 mm Slot	5	
				Curved Profiles	5	
				Straight Profiles	5	

100 Marks (× 1.5 = 150 Total)

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