Coimisiún na Scrúduithe Stáit
State Examinations Commission

Leaving Certificate 2020

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 ENGINEERING

MATERIALS AND TECHNOLOGY

(Higher Level – 300 marks)

Marking Scheme – Written Examination 2020

Answer Question 1, Sections A and B and **Four other questions.**

Question 1 Section A – 50 marks
Any ten @ 5 marks each.

(a) 5
(b) 5
(c) **Any one** @ 5
(d) 5
(e) 5
(f) 5
(g) 5
(h) 3 + 1 + 1
(i) 5
(j) 3 + 2
(k) 3 + 2
(l) 3 + 2
(m) 3 + 2

Question 1 Section B – 50 marks
Answer **all** of the following.

(n) 5 + 5

(o) 4 + 3 + 3

(p) 5 + 5

(q) **Any two** @ 5 + 5

(r) **Any two** @ 5 + 5

Question 2 – 50 marks

(a) (i) 10
(ii) 2 + 2 + 2

(b) (i) 10
(ii) 2 + 2 + 2
(iii) 2

(c) 16

Question 3 – 50 marks

(a) (i) 10
(ii) **Any two** @ 3 + 3

(b) (i) 2 + 2 + 2 + 2
(ii) 6
(iii) 4

(c) (i) 6
(ii) 10

Question 4 – 50 marks

(a) (i) 4
(ii) 2 + 2
(iii) 4 + 4

(b) (i) 10
(ii) 4
(iii) 4

(c) **Any two** @ 8 + 8

Question 5 – 50 marks

(a) (i) 10
(ii) **Any three** @ 2+2+2

(b) **Any three** @ 6 + 6 + 6

(c) 16

OR

(c) (i) 4 + 4
(ii) 4 + 4

Question 6 – 50 marks

(a) (i) 10
(ii) **Any two** @ 3 + 3

(b) **Any three** @ 6 + 6 + 6

(c) (i) 6
(ii) 10

Question 7 – 50 marks

(a) (i) 5 + 5
(ii) 6

(b) **Any three** @ 6 + 6 + 6

(c) (i) 3 + 3 + 3
(ii) 7

OR

(c) (i) 4 + 4
(ii) 4 + 4

Question 8 – 50 marks

(a) (i) 8
(ii) 4 + 4

(b) **Any three** @ 6 + 6 + 6

(c) (i) 8
(ii) 8

OR

(c) (i) 8
(ii) 4 + 4

Sample Answers and Marking Scheme

Note: The solutions presented are examples only.

All other valid solutions are acceptable and are marked accordingly.

Question1 **(100 Marks)**

Section A – 50 marks

(a) Solar power with storage capacity

5

(b) **Quality control (QC)** is a set of procedures intended to ensure that a manufactured product or a service adheres to a defined set of quality criteria or meets the requirements of the client or customer. Quality control procedures include spot checking finished components, regular tool change and servicing of machines.

5

(c) **(i)** **Mary Anderson**

Mary Elizabeth Anderson (1866 - 1953) was an American real estate developer and inventor of the windshield wiper blade. On November 10, 1903 Anderson was granted her first patent for an automatic car window cleaning device controlled from inside the car, called the windshield wiper.

(ii) **Christopher Cockerell**

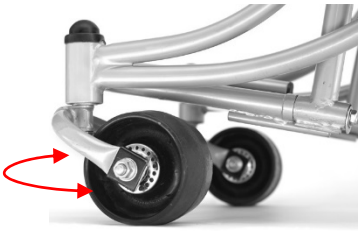
Christopher Cockerell (1910 - 1999) was an English engineer, best known as the inventor of the hovercraft.

(iii) **John P. Holland.**

John P. Holland (1841 - 1914) was an Irish engineer who developed the first submarine to be formally commissioned by the US Navy, and the first Royal Navy submarine called Holland 1. He was originally from Liscannor in Co. Clare.

Any one @ 5

(d) Castors make it easy to manoeuvre the wheelchair as they have the ability to move in different directions and carry heavy loads efficiently.



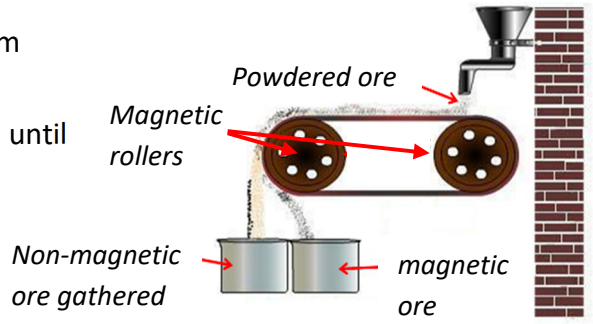
5

(e) Measurement on the wheel rim is from 349.8mm and 350.2mm, tolerance of 0.4mm.

5

(f) **Magnetic Separation**

- Ore is crushed and poured over a rotating drum which contains a fixed magnet.
- The magnetic ore (ferrous) is held to the drum until the waste has fallen off.
- This separation technique can be useful in mining iron as it is attracted to a magnet.



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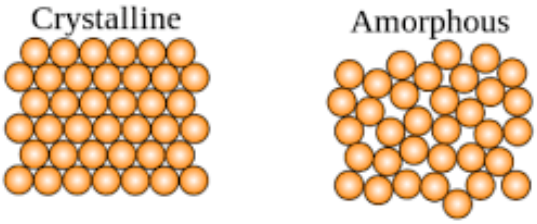
(g) **Crystalline structures** have regular, Geometric and repeating molecular patterns i.e. BCC, FCC CPH. **Amorphous structures** have irregular and non-geometric patterns.



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(h) *Suggestion:* High density polyethylene (HDPE) – *suitable alternatives accepted*

- Does not absorb water.
- HDPE will not rot.
- HDPE netting maintains its colour for the life of the netting.
- HDPE only loses 10% of its strength over its lifetime, thus making it ultimately ideal for outdoor use.

3 + 1 + 1

(i) **UV stabilizers:** Used for the protection of the polymers mechanical properties by absorbing selective UV rays resulting in less degradation.

5

(j) Bronze is widely used in marine applications such as ship propellers because of its resistance to corrosion and because it has good machinability. It is also a very good casting material.

3 + 2

(k) The main benefits of wearable technologies include:

- Activity level: time spent inactive, number of steps taken, etc.
- Sleep patterns and body temperature.
- Resting heart rate and heart rate variability.
- Stress level.

3 + 2

(l) As the Formula E car is battery powered, it is essential it is manufactured from lightweight robust materials. Strength to weight ratio of chosen materials coupled with an ability to withstand impact is crucial in material selection of Formula E cars. This means there will be less battery drain as the battery has less work to do in moving the lighter materials. It also means the car will perform at higher speeds.

3 + 2

(m) The Formula E car has a range of materials such as:

- Carbon Fiber composite.
- Tubular Aluminium.
- Aluminium alloy.
- Kevlar.

3 + 2

Section B – 50 marks

(n) **(i)** **Autonomous Vehicle**

A self-driving car, also known as an autonomous car, driverless car, or robotic car, is a vehicle that is capable of sensing its environment and moving safely with little or no human input.

(ii) **Industry**: Autonomous vehicles have become important in the area of logistics and parcel deliveries. Self-driving carts, often called delivery robots are used extensively by companies such as Amazon, Ailbaba and other sorting and online companies. The carts are given instructions remotely on what parcels to collect and where to drop them. Shipping ports have used autonomous shuttles for repetitive short distance and large volume movements.
Agriculture: Autonomous vehicles for agriculture have been developed using sensors and microprocessors to control tractors for large scale activities such as planting and harvesting huge fields. This frees up famer time to engage in other activities.

5 + 5

(o) **(i)** **Radar sensor**

Radar sensors use radio waves to sense objects. This gives radar the ability to measure velocities of surrounding objects directly and radar can work over long distances. Radar has been traditionally used for airplanes and battleships. Radar maintains functionality across all weather and lighting conditions.

(ii) **Camera**

Reads images and signs for interpretation by computer systems. Cameras are used to detect traffic lights and recognise moving objects such as pedestrians and other road users.

(iii) **LiDAR unit**

Light Detection and Ranging system that senses distances between obstacles and the sensor using light beams. The LiDAR unit sends out rapid pulses of laser light at a surface and a

receiver measures the time to return giving a precise distance measurement. A complex computer map of the area around the LiDAR is generated.

4 + 3 + 3

(p) (i) Artificial intelligence

AI is a major focus for autonomous vehicle testing and development. These vehicles are applying artificial intelligence, a collection of discrete technologies, in new and innovative ways. Deep learning, which mimics neuron activity, supports functions like voice and speech recognition, voice search, image recognition and processing, motion detection, and data analysis. Working together, these functions help the vehicles recognise pedestrian traffic, other vehicles on the road, and traffic signals, and adhere to mapped-out routes.

(ii) Global Positioning Systems

The Global Positioning System is a constellation of satellites orbiting the earth. Wherever the vehicle is on the planet, at least four GPS satellites are 'visible' at any time. Each one constantly transmits its position and the current time. A GPS receiver needs signals from at least three satellites to work. These signals are picked up by the GPS receiver, which calculates how far away each satellite is based on how long it took for the messages to arrive. Once it has information on how far away at least three satellites are, the GPS receiver on the car can pinpoint its location using a process called trilateration.

5 + 5

(q) (i) Level 1 – Driver assistance

The vehicle is controlled by the driver with some assist features (steering or braking) integrated into the vehicle design. Self-parking and lane assistance features are incorporated into this level.

(ii) Level 3 – Conditional automation

The vehicle can monitor its surroundings and control steering, acceleration and braking. The driver must be ready to take control of the vehicle when required.

(iii) Level 5 – Full automation

No human control is necessary; vehicles may not have controls or steering wheel. The vehicle is fully automated and capable of performing all driving tasks whether there is a human or board or not.

Any two @ 5 + 5

(r) (i) Vehicle ownership:

The public may still want to own a car and will buy a self-driving one. But the total number of vehicles on the road is expected to fall by about half from its current level and by 2050 those vehicles will be split roughly equally between robotaxis and privately-owned autonomous vehicles. The robotaxis, being in almost constant use will account for many miles travelled. With fewer private vehicles needing to be parked, large areas of land currently used for parking are likely to be available for other uses, such as housing.

(ii) Traffic management:

In addition to fewer traffic jams, having self-driving cars on the road can reduce the total fuel consumption of all the vehicles driving by 40%.

Autonomous vehicles won't rid the world of gridlock, according to current research. While there will be fewer cars on the road overall, congestion may increase if commuters choose the new vehicles over public transportation.

Autonomous trains and buses systems are in place or planned for implementation in many cities. The Danish metro is completely controlled by sensors and can be controlled remotely, if needed. Full size autonomous buses and taxis, such as the Toyota e-Palette, have been developed and used for large scale events.

Autonomous vehicles are expected to park closer together increasing the number of cars in parking lots. Autonomous vehicles could, in principle, transform parking lots. When people park cars, they need space to open the doors and walk away, but driverless cars do not need such space. Car parks devoted to autonomous vehicles would not require elevators and staircases—the owners could simply be dropped off by the machines at the entrance or some other destination and let the vehicles park themselves.

(iii) Environmental impact:

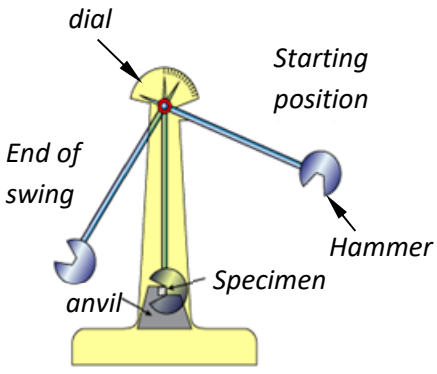
Ultimately, self-driving cars can have immense power to reduce emissions and make the environment a better place if their drivers choose to make it so. Autonomous vehicles are also programmed to operate in a more fuel-efficient manner. There will also be a reduction in noise pollution as a result of the use of electric powered vehicles.

Any two @ 5 + 5

Question 2 (50 Marks)

(a) (i) Impact testing

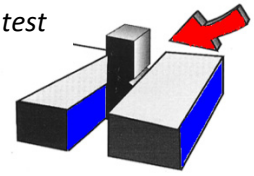
This will determine the toughness of the material which indicates the ability to withstand impact or shock loads. Test pieces are notched and held in the vice associated with the machine. A pendulum strikes the test piece and determines the energy absorbed in breaking the piece. This gives a numerical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



Izod Test

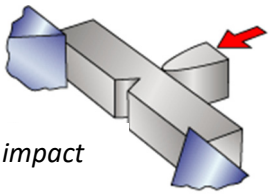
- 167 joules striking energy.
- Test specimen is vertical.
- Test piece is clamped at one end.
- Test piece notch is facing the pendulum.
- The distance the pendulum travels after breaking the piece will give the toughness value.

Izod impact 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.



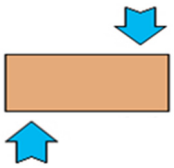
Charpy impact test

10

(ii) **Compressive strength:**
Axial forces that push or press on an object.

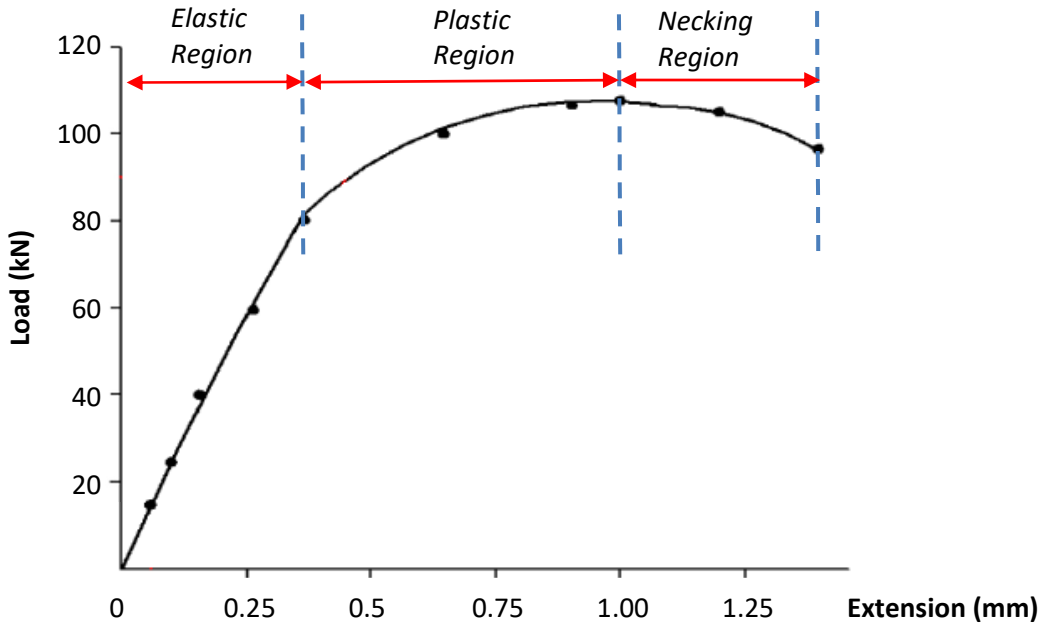
Tensile strength:
Two forces pull or stretch an object in opposite directions.

Shear strength:
Shear is two forces acting parallel to each other but in opposite directions creating a cutting action.



2 + 2 + 2

(b) **(i)**



10

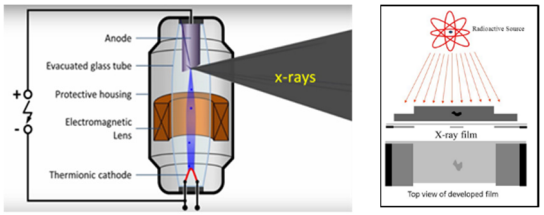
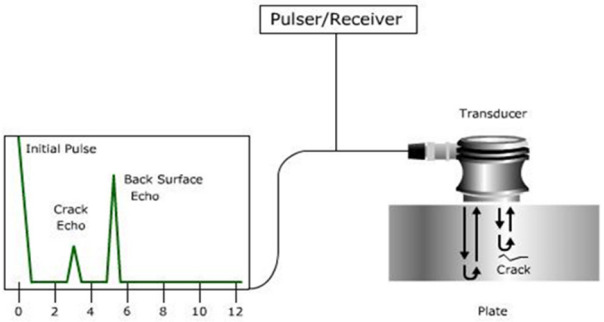
(ii) *Elastic region, plastic region and necking region - shown on graph*

2 + 2 + 2

(iii) **U.T.S. =** $\frac{\text{Max. Load}}{\text{C.S.A.}} = \frac{108\text{kN}}{\pi . (5^2)} =$ **1.38kN/mm²**

2

(c)

X-Ray NDT	Ultrasonic NDT
Equipment used	
	
Method of operation	
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.	A quartz crystal is used to generate high frequency vibrations and passed over the material to be tested. If the material has internal defects, vibrations will be reflected back to the receiver and displayed on a screen. It is used to test thick components such as castings and forgings for defects. It is quick and has the ability to probe deeply without damaging the piece.
Safety considerations	
Proper shielding is necessary when using x-ray equipment as a safety precaution. Prolonged x-ray exposure can be carcinogenic	Ultrasonic wave generation and use is safe for humans therefore no extra safety precautions need to be taken.

16

Question 3 (50 Marks)

(a) (i) **Hardening:**

The steel piece is heated 25˚- 50˚ above the UCT for Hypoeutectoid steels (less than 0.83% carbon) and heated 25˚- 50˚ above the LCT for hypereutectoid steels (greater than 0.83% carbon) and quenched in water**.**

Tempering:

The steel piece is heated to temperatures between 230˚C and 350˚C (although temperatures as high as 550˚C can be used for certain tempering) and then quenched in water.

10

(ii) **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.

Any two @ 3 + 3

(b) (i) **A** = Liquid Steel
B = Pasty stage
C = Austenite
D = Pearlite and Cementite

2 + 2 + 2 + 2

(ii) 0.5% carbon steel is heated 25˚-50˚ above the UCT as it is a Hypoeutectoid steels (less than 0.83% carbon). It is then soaked at this temperature and then allowed to cool gradually in the furnace. During full annealing new grains are formed and this is called recrystallisation. This makes the metal soft, improves ductility, refines the grain size and removes internal stresses.

6

(iii) Cast Iron exists between 2.0% and 4.0% carbon content

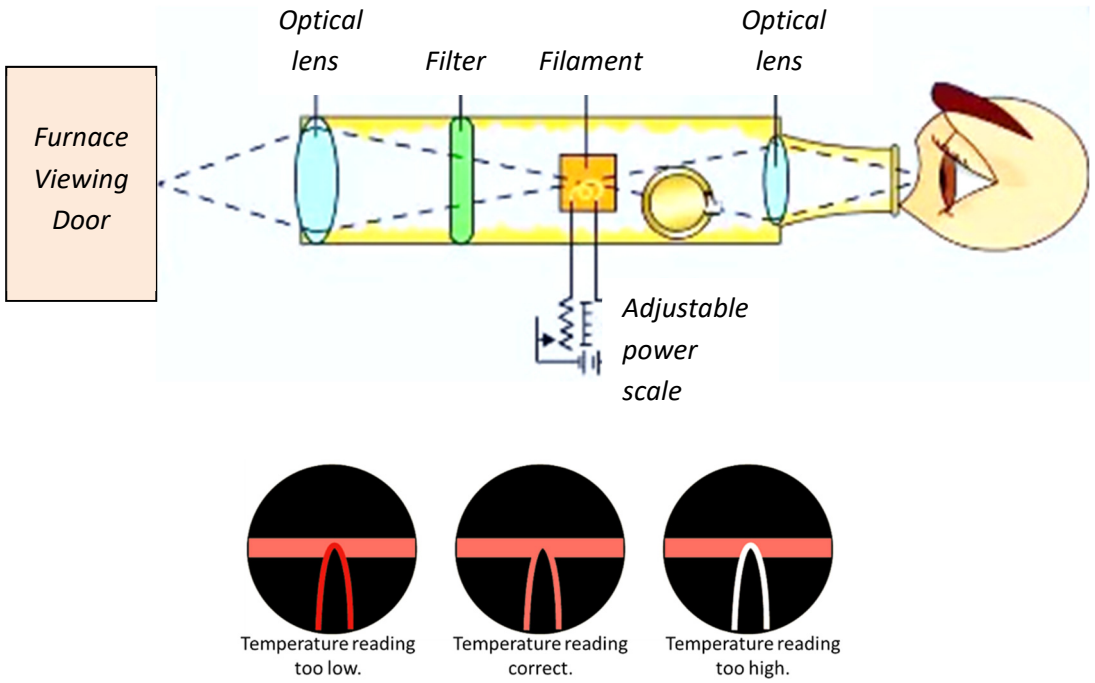
4

(c) (i) Accurate measurement of furnace temperature is very important as various heat treatments have different temperatures required for the material being heat treated. Also, various compositions of steel require different heating zones for the same heat treatment process. Precise temperature measurement will ensure that the correct temperatures are monitored for accurate treatments.

6

(ii) Optical Pyrometer

The optical pyrometer method compares the intensity of light from the filament of a lamp with the colour from the furnace. Current flow from the lamp can be adjusted, using a variable resistor, to match the light from the furnace. There are three possible results with the optical pyrometer: filament too bright, filament not bright enough and filament matching the furnace colour. When the filament seems to 'disappear', the temperature of the filament matches that of the furnace and can thus be taken.



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Question 4 (50 Marks)

(a) (i) Allotrope

The ability of some chemical elements to exist in two or more forms is known as allotropy, e.g. steel can exist in a BBC structure at low temperatures and FCC at 910°C and BCC at 1400°C

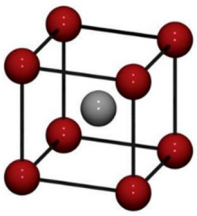
4

(ii) **A:** Body Centre Cubic (BCC)
B: Face Centre Cubic (FCC)

2 + 2

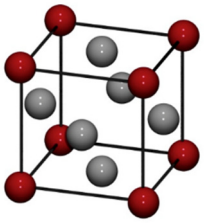
(iii) **BCC Structure**

The body-centred cubic unit cell has atoms at each of the eight corners of a cube, plus one atom in the centre of the cube (total of 9 atoms). BCC metals tend to be strong and brittle. Examples include alpha iron, vanadium and chromium.



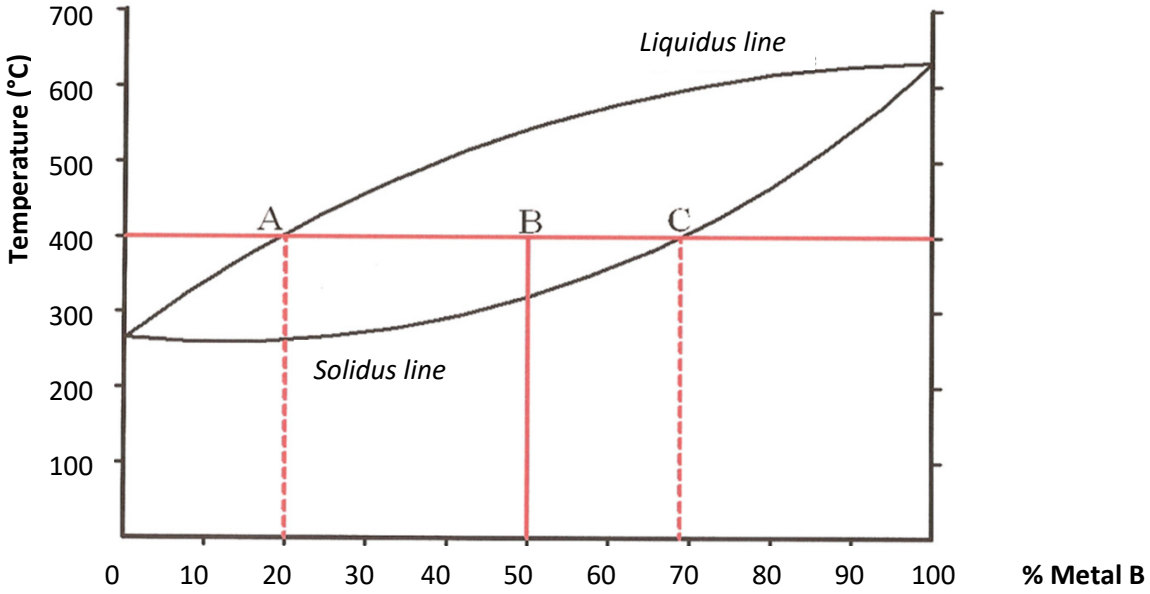
FCC Structure

The face-centred cubic unit cell has atoms at each of the eight corners of a cube with one atom in the centre of each of the cube faces (total of 14 atoms). FCC metals tend to be soft and ductile over a range of temperatures. Examples include gamma iron, aluminium, nickel, silver, copper and gold.



4 + 4

(b) **(i)**



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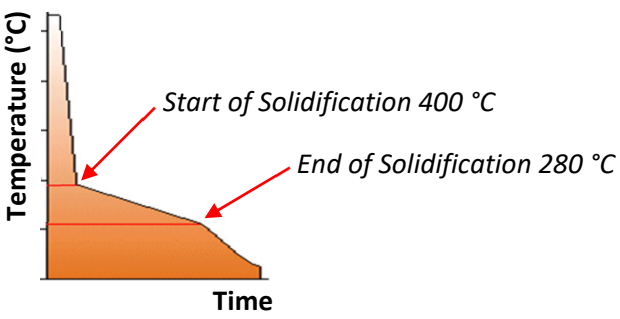
(ii) Ratio of the phases is |AB| / |BC| = 30 / 19

4

(iii) Cooling curve



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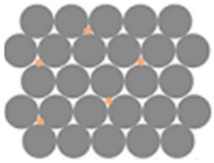
(c) **(i)** **Substitutional Solid Solution**
the alloying atoms replace the parent atoms in the alloy.

Interstitial Solid Solution
the alloying atoms fit in between the parent atoms in the alloy.



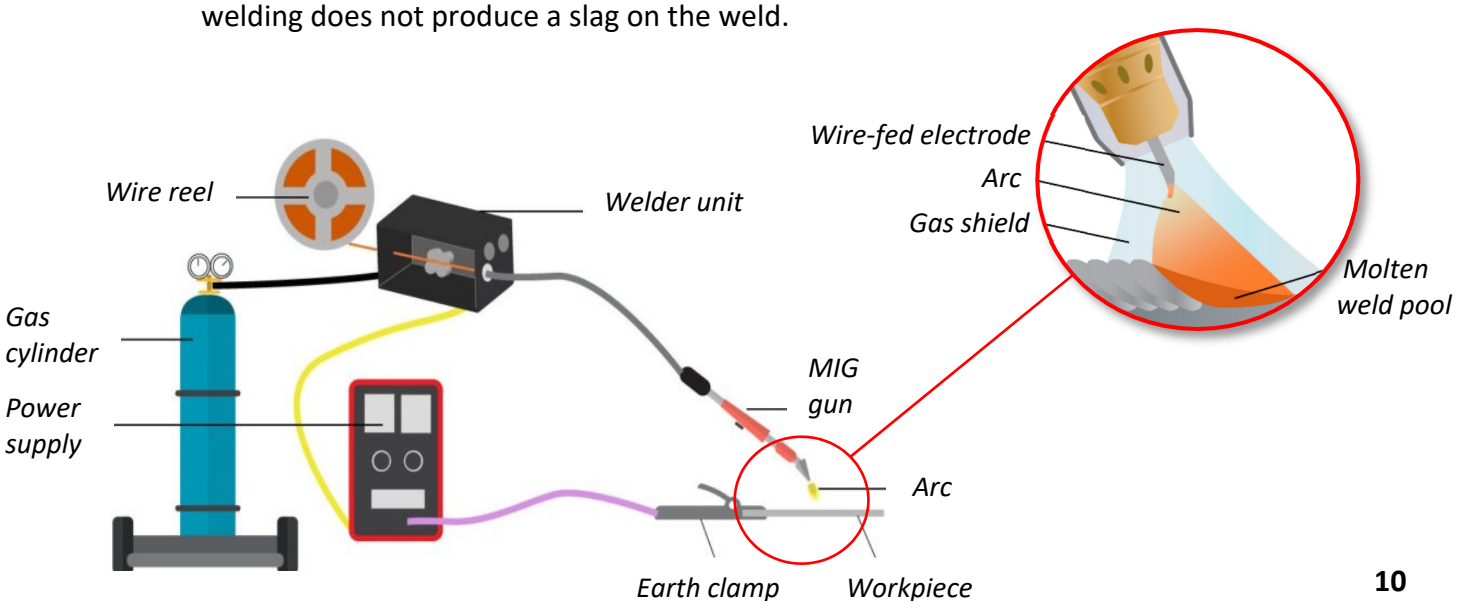
(ii) Metal *macroscopic* examination is a visual inspection process. Physical manufacturing defects can be detected by eye or low powered magnifying glass.
Microscopic examination of metals allows for more detailed examination of grain size and some impurities. An optical microscope is used for this type of inspection.

(iii) **Galvanising sheet steel**
Galvanising is the process of applying a protective zinc coating to steel or iron, to prevent rusting. The most common method is hot-dip galvanising, in which the sheets are submerged in a bath of molten hot zinc.

Any two @ 8 + 8

Question 5 (50 Marks)

(a) **(i)** **MIG Welding:**
MIG Welding is a semi-automatic process. A consumable bare wire electrode is fed continuously into the weld pool area through the welding torch. An inert gas, such as Argon, creates a protective shield around the weld pool giving a fluxing action. The feed rate and flow rate of the gas are set by the operator. This allows the operator to guide the torch along the weld once the arc is generated between the electrode and the work. MIG welding does not produce a slag on the weld.



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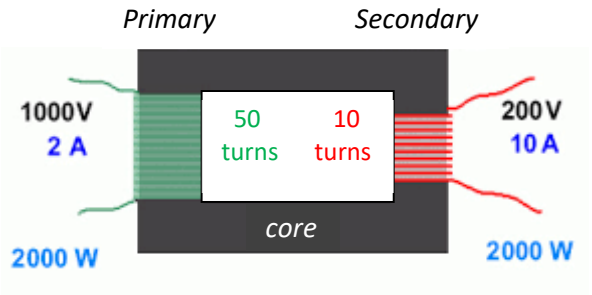
(ii) Safety precautions:

- Wear a welding mask to prevent "arc-eye" and facial burning.
- Wear heavy gloves to prevent hands from being burned.
- Have a ventilation system in place to deal with the toxic fumes.
- Have all electrical units earthed and connections properly insulated.

Any three @ 2 + 2 + 2

(b) (i) 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).

In welding, a variable transformer is used to adjust the output by moving the primary coil towards the secondary coil resulting in a changing voltage.

(ii) Welding defects:

- Porosity in welding can be caused by the presence of moisture
- Welds may lack penetration due when welder settings are incorrectly adjusted or welding torch is moved too quickly
- Welds may be excessively brittle if over-heated and improperly cooled

(iii) **Consumable electrodes** get used up in the welding operations such as MMA, MIG and SAW whereas **non-consumable electrodes** do not melt during the welding operation, such as TIG welding and a filler material is required to fill the weld.

(iv) MIG welding settings

- Select gas type
- Voltage
- Wire feed speed
- Gas flow rate

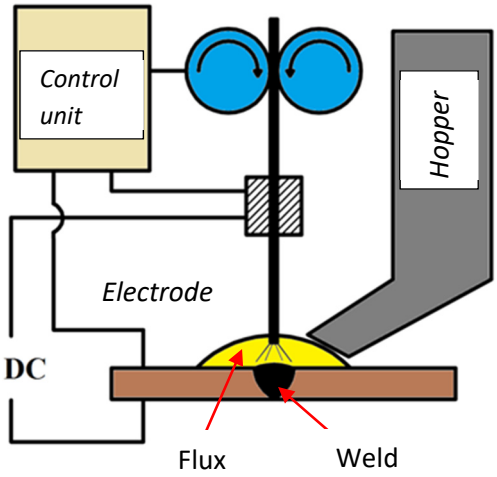
(v) Benefits of inert gas

- No slag formation.
- Less toxic fumes as coating is not being burned.
- Easily contained and refilled when empty.
- Various inert gases can be used.

Any three @ 6 + 6 + 6

(c) Submerged arc welding (SAW):

In submerged arc welding, a bare wire electrode is used. It is fed automatically from a spool and generates an electric arc to heat the metal.
The flux, in powder form, is fed from a hopper to completely cover the joint and the tip of the electrode. The arc creates the heat to melt the joint, flux and electrode. A slag is formed to provide a protective coating for the weld. The excess flux powder can be collected and used again. Submerged arc welding is a fully automated process.
Applications: used for large scale, straight line welds such as steel reinforcing beams, shipbuilding and bridge construction.



16

OR

(c) (i) Proximity Sensors

Proximity sensors are similar to parking sensors on a car. They detect near-by objects and avoid them during the cleaning process.

Navigation Sensors

Navigation sensors rely on GPS and virtual walls to determine where the cleaner has cleaned and where it has yet to clean.

4 + 4

(ii) Advantages of Robotic cleaners over human cleaners.

- Robotic cleaners can work 24/7.
- Cleans better and more consistently than humans.
- The is no down time with these cleaners.
- Reduces fatigue, errors and injuries resulting from repetitive strain.
- It is automated and is better suited than humans for maximum uptime and repeatability.

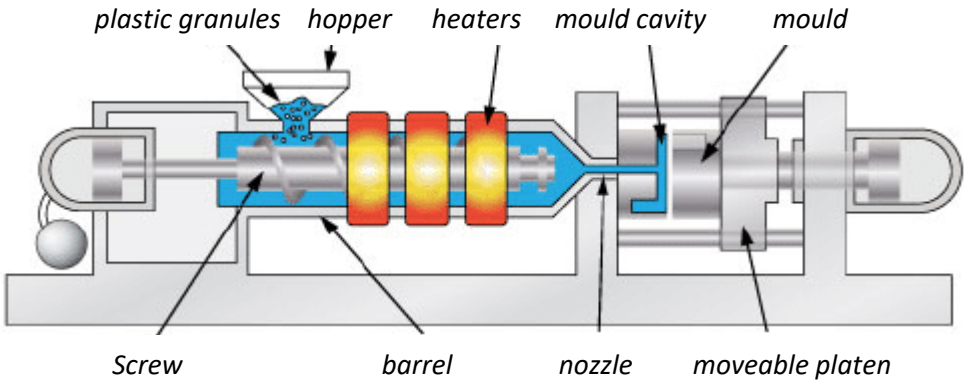
4 + 4

Question 6 (50 Marks)

(a) (i) Injection Moulding:

- Granulated thermoplastic polymer is fed into the barrel from the hopper.
- The screw moves the polymer forward.
- Heaters melt the polymer to liquid.
- When there is enough liquid polymer, the ram will inject the polymer into the mould.
- Typical products include, children's toys, plastic chairs, food boxes, & litter bins.

Injection Moulding Machine



10

(ii) Benefits of Expanded polystyrene:

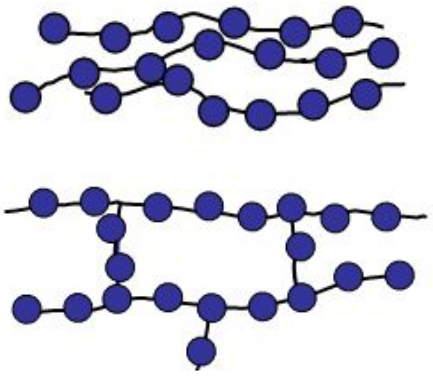
- Dissipates shock.
- Lightweight.
- Thermal insulation. EPS has very low thermal conductivity.
- Moisture resistance.
- Durability.
- Environmental safety.
- Versatile.

Any two @ 3 + 3

(b) (i) Linear and cross-linked structures

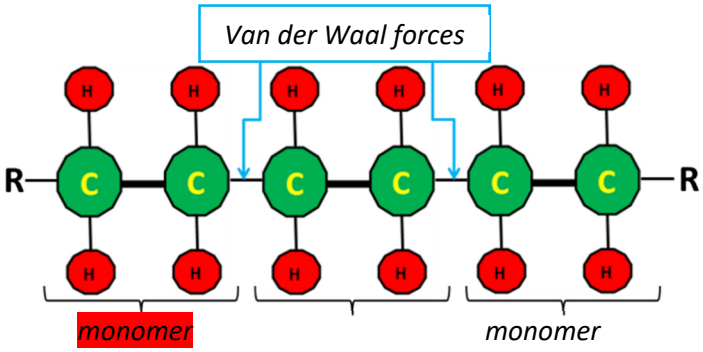
Linear structures are associated with thermoplastics and addition polymerisation. The polymer chain structures are not linked together.

Cross-linked structures are associated with thermosetting polymers and condensation polymerisation. The polymer chains structures are linked together.



(ii) Ethylene monomers are added together in the process of **Addition Polymerisation:**

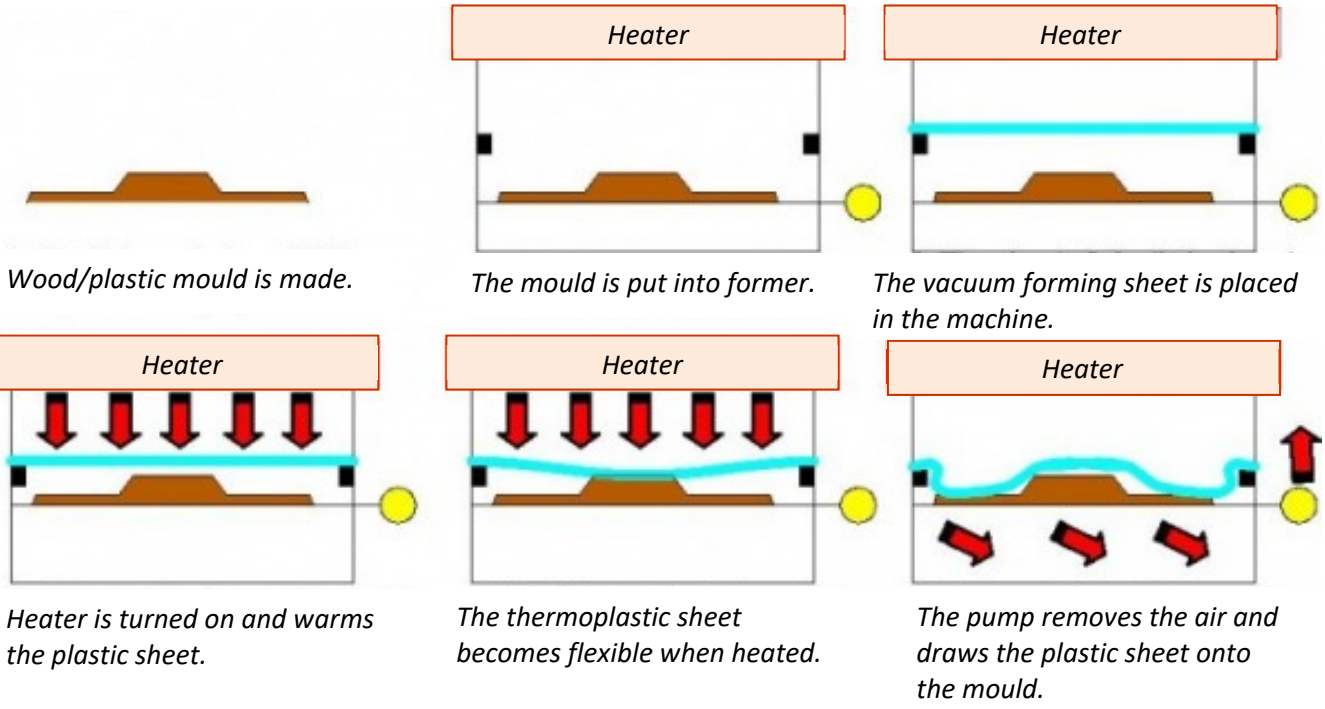
Long chainlike molecules are formed by the addition of large numbers of monomers.
The molecules (or mers) consist of a strong and a weak bond between the carbon atoms.
A catalyst or a free radical, which has an unpaired electron in its outer shell, is released to the molecules.



The weak bond is attached and one of its electrons is taken by the radical leaving the other free. Then those molecules behave like a radical and the process is continuously repeated until termination takes place. Addition polymerisation contains bonds held together by weak van der Waals forces which can be overcome by heat or pressure.

(iii) Thermosetting polymers are insulators and can withstand high temperatures and cannot be re-softened a second time. They are also rigid and hard materials.

(iv) Vacuum forming



Wood/plastic mould is made.

The mould is put into former.

The vacuum forming sheet is placed in the machine.

Heater is turned on and warms the plastic sheet.

The thermoplastic sheet becomes flexible when heated.

The pump removes the air and draws the plastic sheet onto the mould.

(v) Flame Retardants

Flame retardants/Smoke suppressants: A variety of chemicals that can be added to polymers to eliminate its tendency to burn. For polyethylene and similar resins, chemicals such as antimony trioxide and chlorinated paraffin are used.

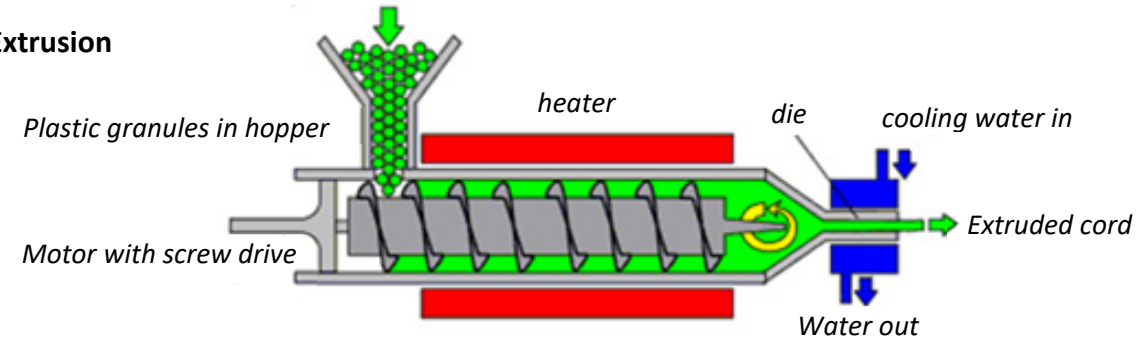
Any three @ 6 + 6 + 6

(c) (i) Elastomer

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.

6

(ii) Extrusion

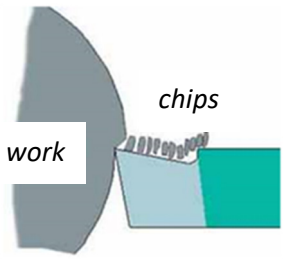


- Granulated thermoplastic polymer is fed into the barrel from the hopper.
- The screw moves the polymer forward.
- Heaters melt the polymer to liquid.
- As the screw continues to rotate, the polymer is pushed out through the die to give the required shape.
- Typical products include, gutters, fascia, pipes, and rods.

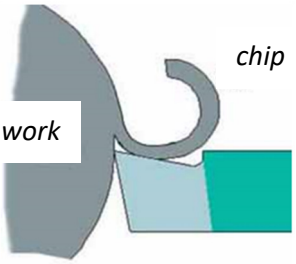
10

Question 7 (50 Marks)

(a) (i) **Discontinuous chips** are small segments produced by metal cutting processes. These chips usually fracture without deformation and are associated with brittle materials such as brass, bronze and cast iron. Discontinuous chips produce effective cutting conditions for brittle materials but may have a tearing action on ductile materials resulting on poor surface finish and excessive wear on tools.



Continuous chips are formed during metal machining in long ribbons without breakage. This chip formation is characterised by high cutting speeds and minimum friction between tool face and metal on ductile materials such as mild steel and aluminium.



5 + 5

(ii) Continuous chips are effectively generated by machining at high speeds and low feed rates, this has the impact of providing a smooth cutting action with minimal wear and tear on the machine. Excessive feed rates can result in excessive heat and the formation of a built-up edge with ineffective cutting. The generation of long cutting swarf can clog automated machines and become a safety hazard when swarf builds up and becomes entangled.

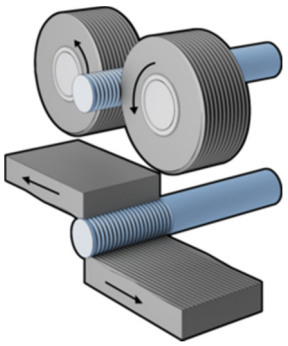
6

(b) **(i)** **Loading:** a grinding wheel becomes loaded with small particles when grinding debris becomes trapped in the space between the abrasive grains and the wheel. This will cause overheating of the work piece.
Glazing: the grinding wheel has a shiny appearance as the abrasive particles have lost their edge and failed to break away from the wheel. The grinding wheel not cut effectively.
These faults are caused by inappropriate choice of grinding wheel for the material being ground.

(ii) Hazards associated with laser cutting:

- Fumes require ventilation.
- Laser light damage to eyes and skin.
- Possibility of fire.
- Noise.

(iii) **Thread rolling** is extensively used to produce screws, bolts and other fasteners. Thread rolling is an automated process suitable for mass production, has a high production rate and has no loss of material. Thread rolling produces a stronger thread than cut threads with increased fatigue resistance due to work hardening. The material grain structure is not cut but strengthened by distorting into the thread shape.



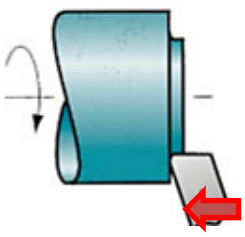
(iv) There are a range of cutting fluids which include petroleum or vegetable oils, soluble oils, oil-water emulsions, mineral oils, synthetic and semi-synthetic fluids, pastes, gels, aerosols (mists) and air or other gases

(v) **Benefits of Tungsten Carbide tips:**

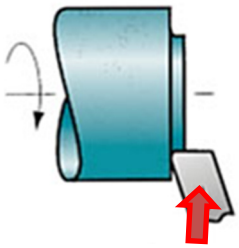
- Tungsten carbide tools will retain their cutting edge at high temperatures more effectively than high speed steel (HSS).
- Experienced operators will ensure longer tool life.
- Tools are not sharpened which is time consuming and dependent on the skill of the operator for effectiveness, inserts are replaced.
- Inserts can have a number of cutting edges integrated into their design.

Any three @ 6 + 6 + 6

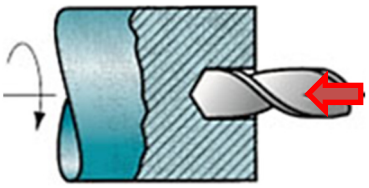
(c) **(i)**



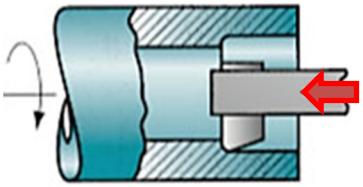
Parallel turning – reducing the metal diameter.



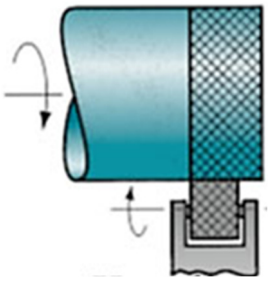
Facing – getting a good finish on the front face.



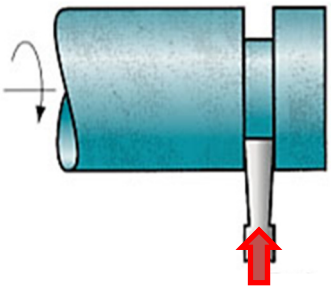
Centre drilling/Drilling - Drilling a hole in the workpiece



Boring / Internal threading Widening the drill hole precisely then creating the internal thread.



Knurling – putting finger grips on the workpiece.

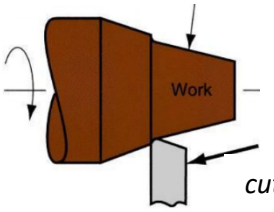


Grooving / Parting-off - cutting the grooves and then cutting the piece to the correct length.

Any three @ 3 + 3 + 3

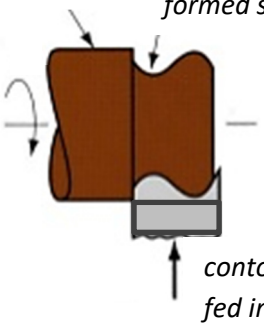
(ii) *Generating* refers to the creation of workpiece due to the feed trajectory of the cutting tool, examples include straight turning, taper turning and profile milling.

taper turning line by line



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

workpiece *formed shape*



7

OR

(c) **(i)** **Machine Tool Calibration** is the process of measuring, diagnosing and correcting the manufacturing error within your Machine Tool or CNC machine. Most large machine tools come directly from the manufacturer with a set of tolerances, calibration is the resetting of machines and tools to agreed dimensions for machining operations.

Closed loop control is a control system with feedback. It continuously measures the output value of the system and compares output value with the desired value. If the value of the output and input are not equal, then an adjustment is made.

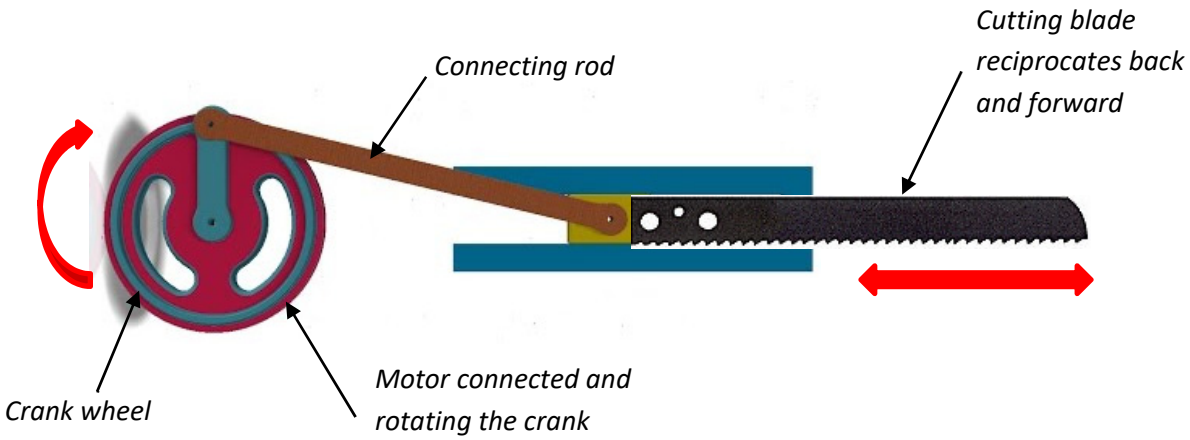
4 + 4

(ii) CNC machining accurately produces piece after piece to the exact same dimensions, this is impractical with handcrafting of instruments. CNC machines repeatedly product object to the same measurements.
While initial set-up time may be long in CNC machines, once the program runs production time is fast and productivity and output is increased.

4 + 4

Question 8 (50 Marks)

(a) **(i)** As the motor rotates the crank wheel the slider will reciprocate back and forward operating the cutting blade.



8

(ii) **Advantages** of cordless power tools:

- No cords to worry about.
- Convenience – Cartridges or batteries will often be the power source of the cordless tool, meaning that there's less equipment to carry.
- Portability.
- No Need of Power Outlet.
- Safety.

Disadvantages of cordless power tools:

- Less power - As the battery power source becomes depleted, the efficiency of the tool may suffer. This can result in subpar work being done by the tool if the charge falls too low.
- Expensive.
- Less reliable.

4 + 4

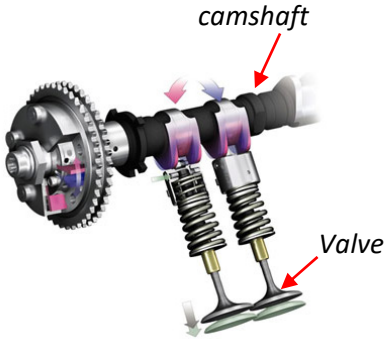
(b) **(i)** Helical gears offer a refinement over straight spur gears. The teeth in helical gears are not parallel to the axis of rotation but are set at an angle. The angled teeth run more smoothly and quietly, giving greater strength also. The teeth on a spur gear are set parallel to the axis of the gear.

Helical gear *spur gear*

(ii) **Advantages of roller bearings in machinery:**

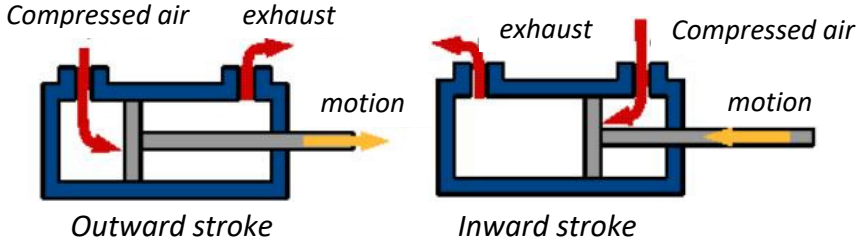
- Reduced friction.
- Smooth running of parts.
- Power saving on machines
- Reliability.
- Lubrication and labour saving.

(iii) The camshaft is a round bar with "egg" shaped cams on it. As the camshaft rotates it will press against the valve tappet which in turn will press the valve downwards and open it. The compressed spring will close the valve when the camshaft rotates further.



(iv) Oil and grease are the most common lubricants used to reduce wear in geared mechanisms.

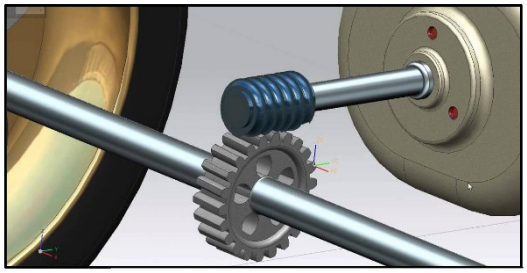
(v) **Double acting pneumatic cylinder.**
The double acting cylinder needs a compressed air supply to move the piston outwards and a second compressed air supply to return the piston inwards.



(Any three) 6 + 6 + 6

(c) **(i)** The use of a worm and worm wheel mechanism would provide the drive for the surveillance vehicle. The drive motor is attached to the worm and the worm wheel and shaft is connected to the drive tracks on both sides. This also provides control for speed reduction and increased torque.

Drive wheel *motor with worm*



Wormwheel on drive shaft

8

(c) **(ii)** Using bevel gear mechanism would provide the possibility of 360° rotation for the camera. This mechanism transmits rotation through 90°. The motor is attached to the top smaller bevel gear and the camera shaft is attached to the larger bevel gear.

8

OR

(c) **(i)** The energy conversion which takes place in a photovoltaic panel is solar energy to electrical energy. Solar battery charging systems can convert solar to chemical energy and then chemical to electrical energy.

8

(ii) **Advantages of photovoltaic (PV) panels**

- Electricity produced by solar cells is clean and silent. As these panels do not use fuel other than sunshine, PV systems do not release any harmful air or water pollution into the environment, deplete natural resources, endanger animal or human health.
- Photovoltaic systems are quiet and visually unobtrusive.
- Small-scale solar plants can take advantage of unused space on rooftops of existing buildings.
- Solar energy is a locally available renewable resource.
- Solar energy can be used to charge battery or capacitor systems and release energy when sun is not available.

Disadvantages of photovoltaic panels

- Some toxic chemicals, like cadmium and arsenic, are used in the PV production process. These environmental impacts are minor and can be easily controlled through recycling and proper disposal.
- Solar energy is somewhat more expensive to produce than conventional sources of energy due in part to the cost of manufacturing PV devices and in part to the conversion efficiencies of the equipment.
- Solar power is a variable energy source, with energy production dependent on the sun. Solar facilities may produce no power at all some of the time, which could lead to an energy shortage if too much of a region's power comes from solar power.

4 + 4

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