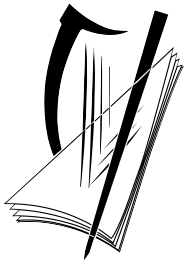


Coimisiún na Scrúduithe Stáit
State Examinations Commission

Leaving Certificate 2017

Marking Scheme

ENGINEEERING –
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 2017

MARKING SCHEME

Written Examination and Practical Examination

ENGINEERING –
MATERIALS AND TECHNOLOGY

HIGHER LEVEL

LEAVING CERTIFICATE

ENGINEERING - Materials and Technology

(Higher Level – 300 marks)

Written Examination Marking Scheme 2017

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

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

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

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

(n) (i) 6
(ii) 2 + 2

(o) 10

(p) (i) 2
(ii) 6
(iii) 2

(q) **Any one** @ 10

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

Question 2 – 50 marks

(a) (i) 8
(ii) 8

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

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

Question 3 – 50 marks

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

(b) (i) 1 + 1 + 1 + 1
(ii) 4 + 4
(iii) 6

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

Question 4 – 50 marks

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

(b) (i) 8 + 1 + 1
(ii) 4
(iii) 4

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

Question 5 – 50 marks

(a) (i) 2 + 6
(ii) 8

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

(c) 16
OR
(c) (i) 4 + 4
(II) 8

Question 6 – 50 marks

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

(b) (i) 4
(ii) 3 + 3
(iii) 4

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

Question 7 – 50 marks

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

(b) (i) 4 + 4
(ii) 4 + 4

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

OR

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

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) Advantages of LED headlights:

- Small size, allow great manipulation for various shapes.
- Very low energy consumption.
- Brighter than halogen headlights.

(Any two) 3 + 2

(b) Zinc, tin, copper, chromium, gold, silver, etc.

(Any two) 3 + 2

(c) Use of airbags, traction control, impact resistant windscreen, computerised monitoring of vehicle condition, etc.

(Any two) 3 + 2

(d) Capable of folding easily for storage, layers of cardboard are reasonably strong when subject to impact, lightweight, ergonomic design, etc.

(Any two) 3 + 2

(e) Hard material capable of retaining a sharp edge, non-toxic, tough, does not contaminate, etc.

(Any two) 3 + 2

(f) Sample checking of finished product for dimensional accuracy, x-ray testing for internal faults, mechanical testing for material properties of hardness and toughness, stress testing of finished product to maintain standards, statistical analysis of product failure, etc.

(Any two) 3 + 2

(g) **(i)** **George Devol**

Born in 1912, he was an American inventor who was awarded the patent for Unimate, the first industrial robot. Devol's patent for the first digitally operated programmable robotic arm represented the foundation of the modern robotics industry. He died in August, 2011.

(ii) **Marie Curie**

Marie Curie (1867 – 1934) was a Polish and naturalised-French physicist and chemist who conducted pioneering research on radioactivity and discovered two elements - polonium and radium. She was the first woman to win a Nobel Prize and the only person to win in multiple sciences.

(iii) **Dugald Clerk**
Scottish engineer who designed the world's first successful two-stroke engine in 1878 and patented it in England in 1881.

(Any one) 5

(h) Graphite is much lighter than steel. A light club can be swung faster than a heavy one means more distance.
A graphite shaft will not rust compared to a steel shaft and will have more flexibility in it.
Graphite tends to have a softer, more dampened feel.

(Any two) 3 + 2

(i) Advantages: ease of connection, no physical connection required, etc.
Disadvantages: concern over security for sensitive information, limited connectivity in remote areas, etc.

3 + 2

(j) Metal fatigue is failure due to on/off loading or cyclic stressing. Fatigue failure begins as a minute crack which grows under the action of fluctuating stress.

5

(k) Gap gauge 

Used to determine the limits of a round bar.

Plug gauge 

Used to test the dimensions of holes.

5

(l) A double-acting hydraulic ram has a port at each end, supplied with hydraulic fluid for both the retraction and extension of the piston. It is used where high force is required in both directions of travel.

5

(m) Using improved motors and a large number of solar cells, *Solar Impulse 2* generated enough power to take off without assistance and circumnavigate the world. This was achieved in stages with a single pilot.

5

Section B – 50 marks

(n) **(i)** **Main advantages of using robots:**

- Consistency of quality and output
- Greater efficiency
- Reduced labour costs
- Less labour intensive
- Greater level of safety for workers – not exposed to hazardous processes

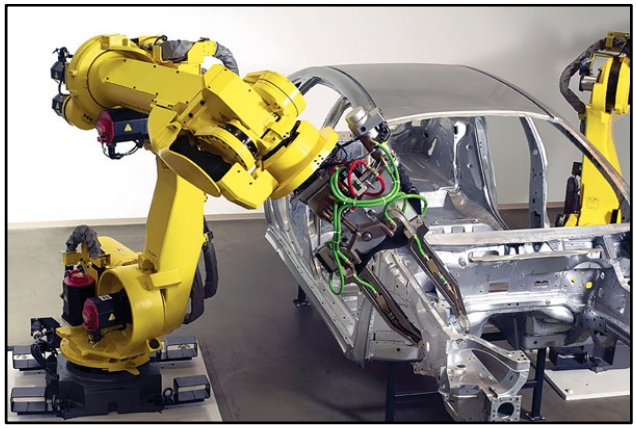
6

(ii) **Main applications of robots in motor vehicle manufacture:**

- Panel punching and pressing
- Adhesive application
- Panel and glass fitting
- Spray Painting
- Fitting of pre-assembled units – engine/gearbox, dash, doors, front bumper units etc
- Wheel fitting and stud tensioning
- Vehicle testing – simulation of road variations

2 + 2

(o) Resistance spot welding and MIG welding are commonly used in the manufacture of cars.



Resistance Spot Welding is a welding process in which work pieces are welded due to a combination of a pressure applied to them and heat generated by a high electric current flowing through the contact area of the weld.
Heat produced by the current is sufficient for local melting of the work piece at the contact point and formation of small weld pool called a 'nugget'. The molten metal then solidifies under a pressure and joins the pieces.

Time, pressure and current, required for the formation of a reliable joint, are determined by dimensions of the electrodes and the work piece metal type. Robots can move quickly from weld to weld to give precise control.

10

(p) **(i)** **Suitable type of motor for Part A**

- Servo Motor
- Stepper Motor

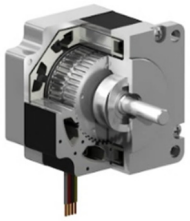
2

(ii) Main features of Servo Motor:

- Provides smooth control with high torque (full at high speed)
- Can rotate to a specific point with great accuracy – up to ten times finer than a stepper motor
- Provides **feedback** and can correct if position is distorted due to built-in encoder – corrective
- Only use power as required – load dependant
- Self-cooling, fully enclosed, ideal for robot arms
- More accurate than stepper motor
- Not suitable for continuous rotation

Main features of Stepper Motor:

- Digital input allows motor shaft to move in discrete steps
- Does not have corrective capacity
- Very high holding torque. Also at start up and low speeds
- Require high currents, even when stationary
- Simple drive electronics
- Good accuracy and excellent repeatability
- Excellent reliability
- Rugged – will work in any environment
- Control and torque are reduced at high speed



6

(iii) Toothed belt and pulley or leadscrew, depending on load.

2

(q) (i) Lead by Nose:

In this method, one user holds the robot's manipulator, while another person enters a command which de-energizes the robot causing it to go into limp. The user then moves the robot by hand to the required positions and/or along a required path while the software logs these positions into memory. The program can later run the robot to these positions or along the taught path. This technique is popular for tasks such as spray painting.

(ii) Teach Pendant:

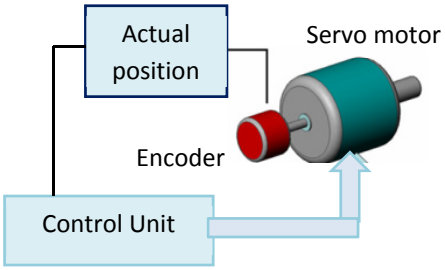
This is the most common method of programming robots. It is a hand-held device with push buttons/ joystick to control the robot movements and speed. The programmer can move each axis to create the desired path for the specific operation. They are fitted with a large emergency stop button and can be wired or wireless.

(iii) Off-Line Programming:

This technique uses 3D software to graphically simulate the robotic movement around a cell or manufacturing line. The simulation process saves time in the design of robotic applications and increases the level of safety as potential problems can be addressed before the system is activated.

(Any one) 10

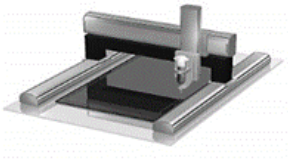
(r) **(i)** **Closed Loop Control:**



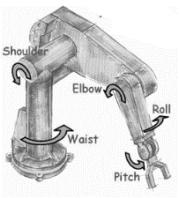
Used on servo motors. This facility allows feedback to the unit indicating the exact position of the motor shaft. Achieved with the use of an encoder which indicates actual position and compares with programmed. Adjustment then made if necessary. Result is a very high degree of accuracy.

(ii) **Degrees of freedom:**

A description of the number of axes the robot arm can move.
A single joint will provide one degree of freedom.
The greater the range of movement, the greater the number of joints either linear or rotary or combinations.



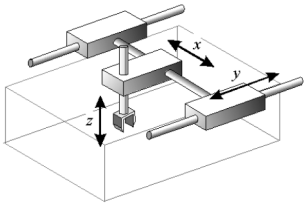
Cartesian robots have three degrees of freedom in the X, Y, Z axis which makes them ideal for pick and place tasks.



Revolute / Polar type have more joints, 6 or more axes similar to the human arm – ideal for spraying and welding operations.

(iii) **Working Envelope:**

This is the three-dimensional volume of space that a robot/arm/end effector will occupy in performing the task.



(iv) **Safety features of a robotic system used in automobile manufacture**

- Robots and human operators have traditionally been kept apart in case of collision, potentially causing serious injury.
- The working envelope is enclosed or screened-off in automated environments – no humans in the vicinity. If the area is entered accidently, sensors can effect a shutdown of the operation.
- Modern systems allow humans to work collaboratively by using sensitive robots that incorporate a variety of sensors that allow the operator to work hand in hand with the robot sharing the same workspace.
- Artificial intelligence includes force sensors and 2D/3D vision systems allowing them to see and feel, thus preventing collisions or injuries.
- Some will respond to voice command or can be gesture controlled.
- These robots can perform many of the complex tasks that are repetitive and can help to eliminate injuries such as R.S.I.

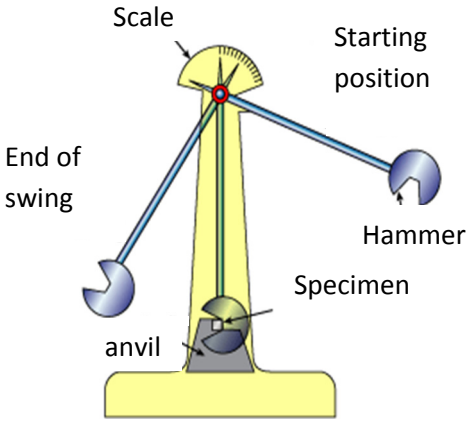
(Any two) 5 +5

Question 2 (50 Marks)

(a) (i) Izod or Charpy notched bar tests are suitable test for toughness.
Descriptions of car impact tests will be accepted.

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.



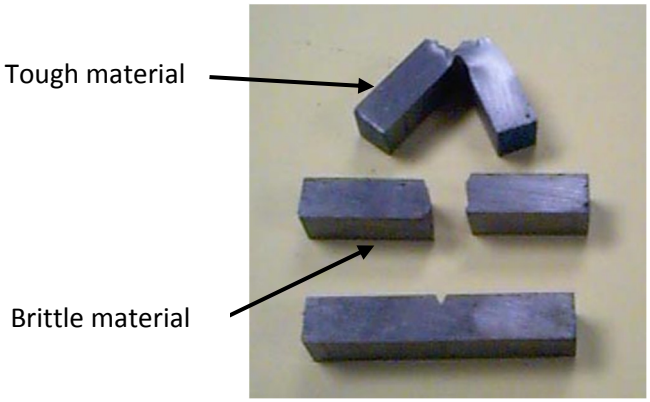
Charpy Test

- 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.

8

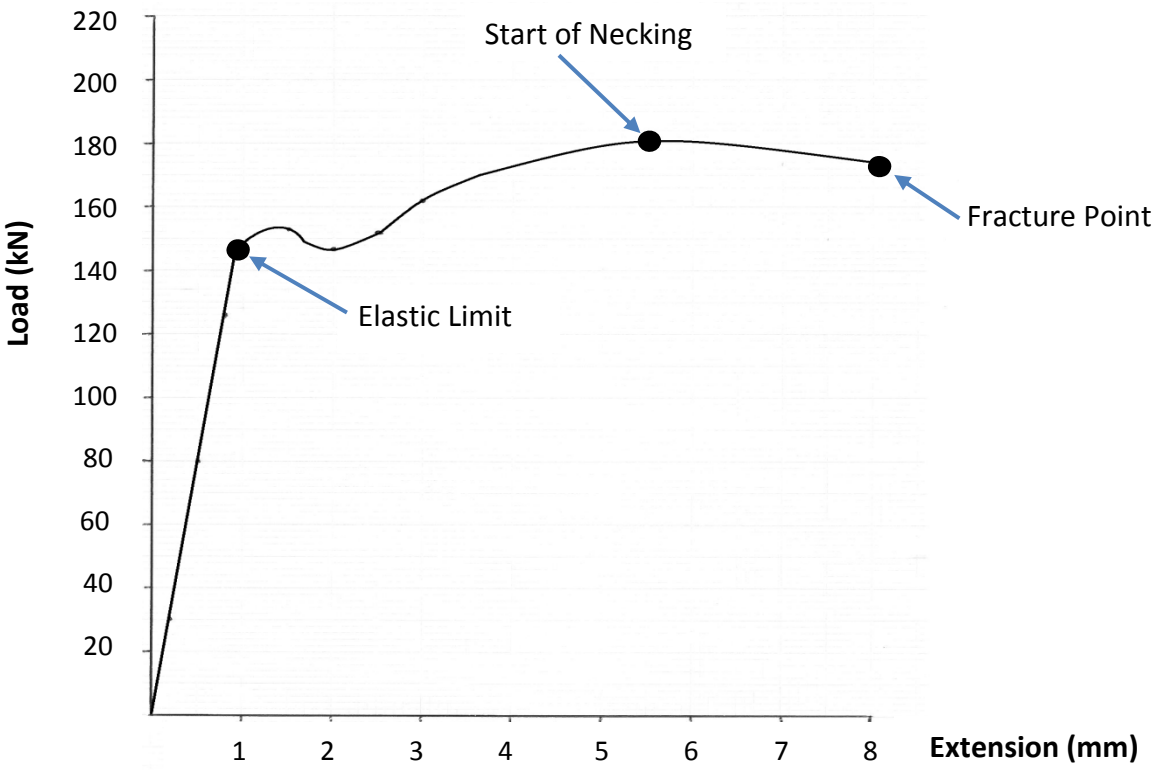
(ii) Tough material:
Expect to be more ductile with more plastic deformation and stretching would be expected at the fracture point.

Brittle material:
A brittle material would expect to be broken or snapped straight across at the notch point.



8

(b) **(i)** Plot the stress-strain graph



10

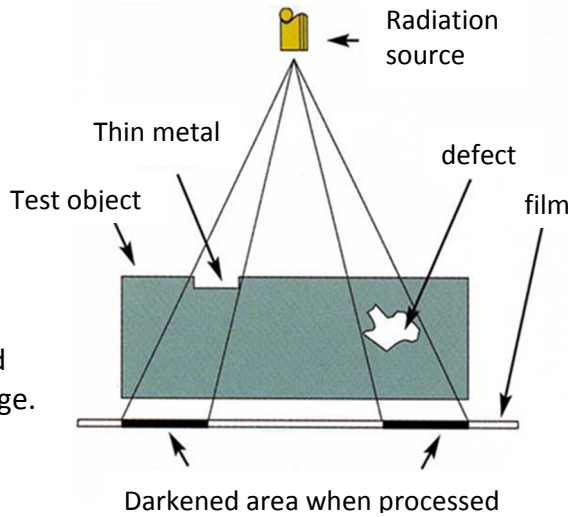
(ii) *On graph* **2 + 2 + 2**

(iii) Ultimate tensile strength = Max load/C.S.A.
= 181 kN / 113.1 mm²
= 1.6 kN/mm² **2**

(c) **(i)** **X-ray test**

X-ray radiation penetrates materials and produce an internal photographic image of the test piece. Electrons are released by heating the cathode to a 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.

Used for the inspection of welds.



8

(ii) Safety hazards associated with the use of x-ray testing equipment would include the following:

- **Shielding:** Use appropriate shielding at all test sites and on all persons.
- **Distance:** Maintain adequate distance between radioactive sources and persons.
- **Duration:** Minimize time spent near or within radiation fields.
- **Quantity:** Utilise the smallest amount of radioactive material possible to accomplish the job at hand.

4 + 4

Question 3 (50 Marks)

(a) **(i)** **Use of Cast iron for stoves**

- The cast iron is much denser and heavier than steel and therefore it takes more time for the fire to heat the metal before the heat can then be radiated out.
- Cast iron holds the heat for longer than steel and takes longer to cool once the fire has been extinguished.
- Cast iron stoves are generally more expensive than steel stoves.

4 + 4

(ii) Most cast irons have a chemical composition of 2.5 – 4.0% carbon with varying amounts of silicon, manganese, sulphur, etc. Most cast irons are brittle, have a relatively low melting point, resist wear with excellent casting properties.
Low carbon steels contain up to 0.3% carbon with a range of properties including good machinability, welds easily, malleable, ductile, etc.

8

(b) **(i)** **A** - Liquid
B - Austenite
C - Ferrite and Pearlite
D - Austenite and Cementite

1 + 1 + 1 + 1

(ii) **Eutectic point** **4**

At 4.3% Carbon and 1147°C, the liquid solidifies to form austenite and cementite phases.

4

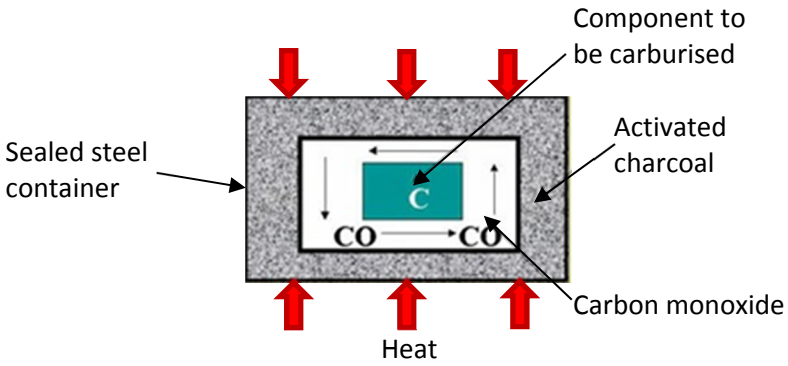
(iii) **Normalising 1.5% carbon steel:** The piece is heated 25˚-50˚ above the UCT (austenite region) for all steels (Hypoeutectoid and hypereutectoid steels).
It is soaked at this temperature and then allowed to cool at room temperature.
Normalising removes internal stresses and refines abnormal grain structures which occur during hot or cold rolling and forging.
This improves machinability. Normalised steel has higher strength and lower ductility than full annealed steel.

6

(c) **(i)** Surface hardening the gear wheel teeth will prolong the life of the gears as they will not wear as easily.
The surface of the gears will be hard with a softer inner layer to reduce the impact of the brittle outer layer.
Gear teeth will maintain their shape longer.

4 + 4

(ii) **Pack Method Carburising**



The piece is packed in a box with a carbon rich material such as charcoal and placed in a furnace at 920˚C (above UCT). This allows the carbon to diffuse into the piece.
The longer the component is in the furnace the greater the depth of penetration of carbon.
The result is a very hard coarse outer shell.
Grain refining is necessary to prevent cracking and this is done by putting the piece into a bath of molten salt at 780˚C for half an hour and then quenching it in water.

8

Question 4 (50 Marks)

(a) (i) Age Hardening

Age Hardening occurs in certain non-ferrous alloys of aluminium, copper and nickel, as well as some ferrous alloys. The work piece is heated and allowed to soak to dissolve the alloyed particles. Ageing then occurs at room temperature or elevated temperatures depending on the piece. Precipitation of the dissolved particles in the alloy cause distortion of the material lattice thus resulting in the hardening of the metal.

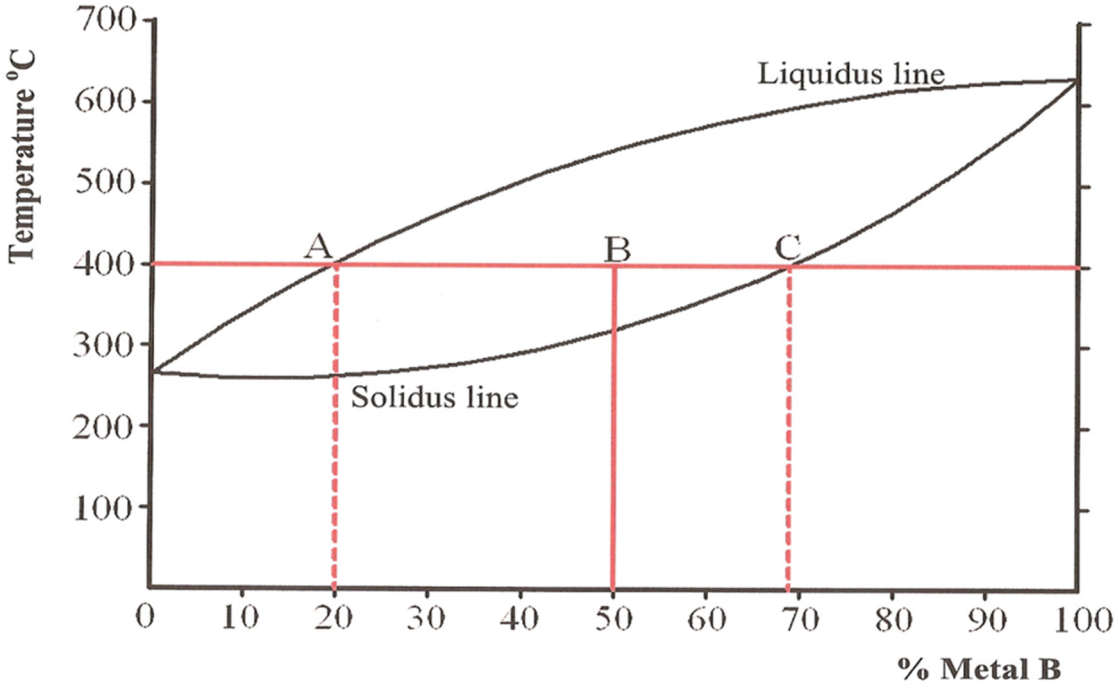
8

(ii) Age hardening of the Beryllium-Copper alloy will provide:

- High strength,
- Corrosion resistance,
- Stability,
- Conductivity,
- Low creep.

4 + 4

(b) (i) Draw the thermal equilibrium diagram: **8**



Label: 1 + 1

(ii) Pure metals do not change temperature when going from liquid to solid.
0% Metal B is 100% Metal A and 100% Metal B is a pure metal also.

4

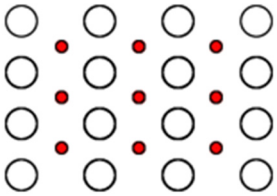
(iii) Composition of the phases:

Point A = 20% Metal B – 80% Metal A

Point C = 69% Metal B – 31% Metal A **4**

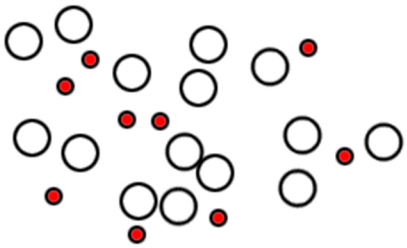
(c) **(i)**

Crystalline solid structures



Crystalline atoms are arranged in a pattern.

Amorphous solid structures

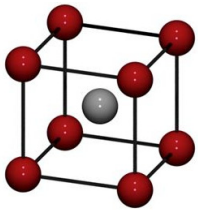


Amorphous atoms are arranged randomly.

(ii) A solvus line is the boundary between a solid solution solid and a eutectic alloy and is shown on the lead-tin diagram.
A solidus line represents the end of solidification in an alloy.

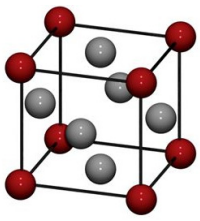
(iii)

Body Centre Cubic (BCC)



BCC structures are generally harder and more brittle

Face Centre Cubic (FCC)



FCC structure materials are usually more ductile

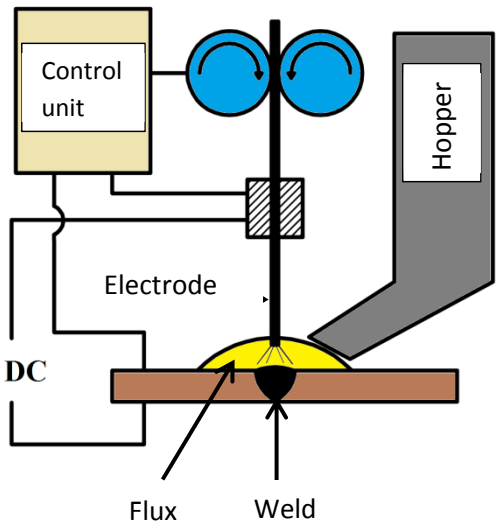
(Any two) 8 + 8

Question 5 (50 Marks)

(a) **(i)** Submerged arc welding (SAW) is a suitable welding technique for the steel pipe as SAW is an automated process used for long uninterrupted welding.

2 + 6

(ii) 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.



8

(b) **(i)** If acetylene is compressed into a cylinder, it would explode under high pressure. Acetylene cylinders are packed with a porous material that is filled with acetone, this can absorb 25 times its own volume of acetylene.
Dissolved acetylene is the name given to this form of acetylene fuel.

(ii) Porosity in welding:

- The presence of moisture in the weld
- Cylinder out of gas
- Presence of paint, oil or grease
- Weld nozzle is not close enough to weld
- Shielding gas has been blown away due to drafts.

(iii) Hazards of welding underwater:

- Underwater welding adds the danger of being shocked, or producing a mixture of oxygen and hydrogen together in bubbles in the arc, which can lead to an explosion.
- If a diver surfaces too fast, he is always in danger of getting the bends (severe pain in joints that is caused by not properly depressurizing).
- Sharks and large ocean predators are always a potential threat when welding underwater, as well as the diving suit becoming damaged or the oxygen tanks becoming loose or emptied.
- The ocean current can actually carry a welder off, which can result in disastrous consequences.
- Nitrogen can build up in the diver's blood and create deposits.
- Of course, there is the most common death involved with water - drowning.

(iv) Safety features integrated into oxy-acetylene welding equipment:

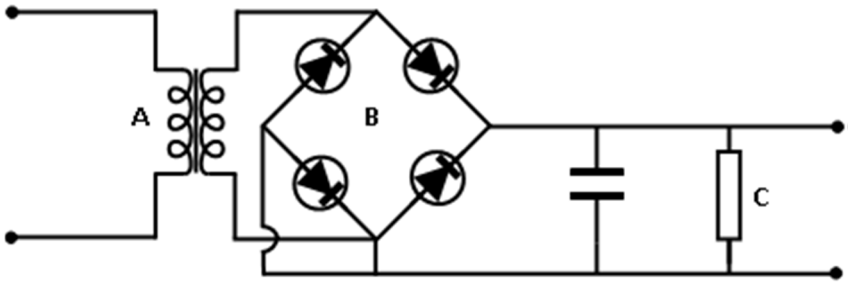
- The colour coding on the cylinders and the hoses helps prevent any possible mix-up of the gases and connections.
- The oxygen cylinder is usually thinner and taller than the acetylene cylinder.
- The connections for the different gases have either left or right-hand thread forms.
- The flashback arrestors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

(v) Benefits of seam welding domestic radiators:

- Creates a sealed unit
- High speed welding
- Easily automated
- Suitable for high rate production
- Economical.

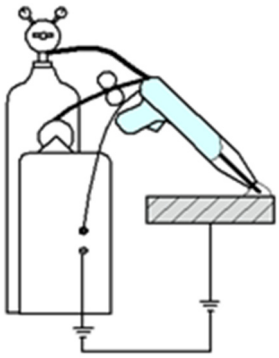
(Any three) 6 + 6 + 6

(c) (i) The transformer-rectifier circuit used in manual metal arc welding.



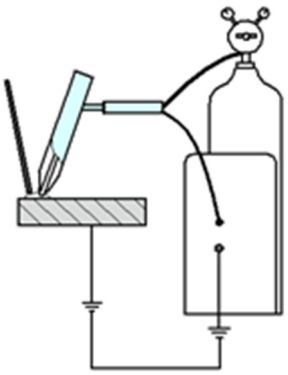
A - Transformer: A step-down transformer is used to change the mains voltage from 220V to a suitable level (80-100V) for welding. This will provide the high current needed for welding. This type of transformer has more turns on the primary coil than the secondary coil and will induce alternating current (AC) at a lower voltage.
B - Rectifier: The rectifier changes alternating current (AC) to direct current (DC). It consists of four diodes which allows two of the diodes to conduct on each half-cycle of the AC supply.
C - Capacitor: The capacitor is employed to provide a smooth supply of low voltage DC.

(ii) MIG welding:



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.

Tungsten inert gas welding, TIG, TAGS.



An arc is formed between the non-consumable electrode and the metal being welded. The inert gas shielded arc is used to flux the joint, argon is often used to prevent oxygen getting to the joint area. A stainless steel filler metal is added manually to the weld pool when necessary. A high frequency generator provides a path for the welding current.

(Any one) 16

OR

(c) **(i)** **Advantages:**

- The robotic vacuum cleaner will clean when the householder is away from the premises.
- The owner can view on the app, the area that is cleaned and not cleaned.
- It has a very low noise output.
- Its size means a large storage area is not required when idle.

Disadvantages:

- The vacuum cleaner may have an electrical malfunction and need to be rebooted.
- If the internet connection is down the cleaner will not communicate with the app.

4 + 4

(ii) The Dyson 360 Eye™ robot constantly observes and interprets its surroundings. It sees all around the room at once.
This unique 360° vision system uses complex mathematics, probability theory, geometry and trigonometry to map and navigate a room. So it knows where it is, where it's been and where it's yet to clean.
It uses this technology also to locate its docking station and recharge the battery.

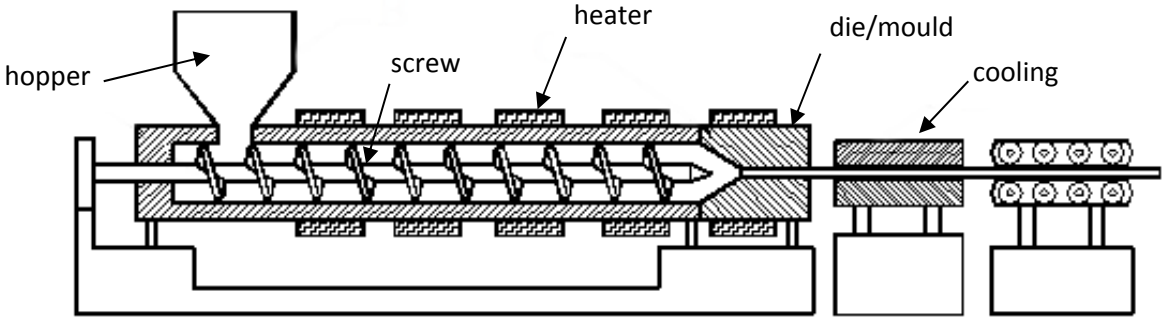
8

Question 6 (50 Marks)

(a) **(i)** thermoplastic tubes – extrusion
thermoplastic joints – injection moulding

2 + 2

(ii) **Extrusion**



This process is used to produce items of uniform profile such as curtain rails and plumbing pipes. 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.

10

(iii) Nylon is strong, difficult to break and lightweight

2 + 2

(b) **(i)** Copolymer is a polymer formed when two different mers are linked together in the same polymer chain. This new polymer may have a mixture of new improved properties, it is similar to alloying in metals.

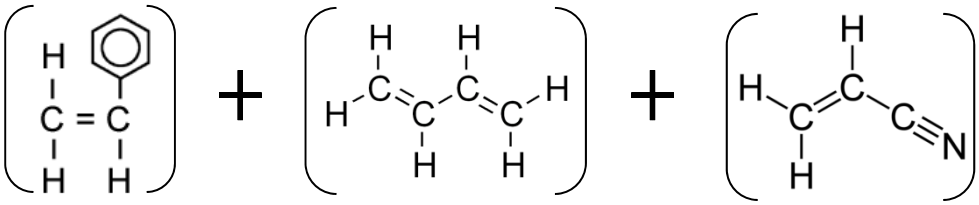
4

(ii) In the manufacture of toys, the polymer has properties such as:

- Light weight copolymer.
- It has the ability to be injection moulded and extruded which makes it useful in manufacturing products such as protective headgear, protective carrying cases, small kitchen appliances, and toys, including Lego.
- Polymers such as ABS have excellent impact resistance.
- It also facilitates mass production of thermoplastic objects.

3 + 3

(iii) ABS is produced by addition polymerisation. Long chainlike molecules are formed by the addition of large numbers of mers. The three molecules (or mer) 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.



4

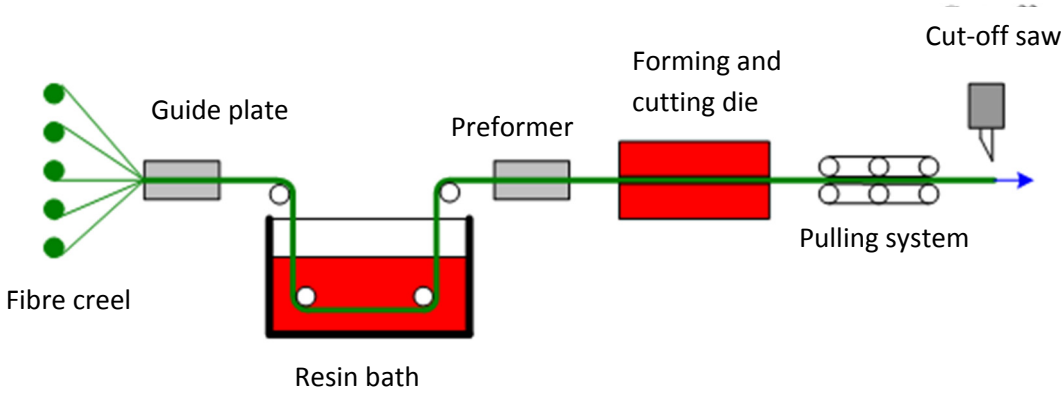
(c) **(i)** **Calendering**

Continuous lengths of sheets are produced in thermoplastics by calendering. The material passes through a series of heated rollers to gradually produce the desired thickness of material. These sheets may then be cut to size or collected in a roll.

(ii) **Plastic Pultrusion:**

Plastic Pultrusion is similar to extrusion and is associated mainly with thermosetting polymers. In the standard Pultrusion process the reinforcement materials like fibers are impregnated with resin, possibly followed by a separate preforming system, and pulled through a heated stationary die where the resin undergoes polymerization. The impregnation is either done by pulling the reinforcement through a bath or by injecting the resin into an injection chamber which typically is connected to the die. Many resin types may be used in Pultrusion including polyester, polyurethane, vinylester and epoxy. Resin provides the resistance to the environment, (i.e., the corrosion resistance, the UV

resistance, the impact resistance, etc.) and the glass provides strength, in addition to safety from fire.



(iii) Monomer a molecule of a compound which can react with other molecules to form a polymer.

(iv) Catalyst will speed up or slow down a chemical reaction, they are used to initiate the polymerisation process.

(v) Compression Moulding is suitable for thermosetting plastics. It uses a split mould formed to the shape of the object to be moulded. The combination of heat and pressure allows a measured amount of polymer to be shaped. The polymer can be in powder or 'slug' form. As the mould closes, the application of heat triggers the chemical reaction of 'cross-linking' and the object sets (curing). The mould is opened and the object is removed. These mouldings can have a high quality finish requiring only the removal of 'flash'.

(Any three) 6 + 6 + 6

Question 7 (50 Marks)

(a) **(i)** **Tolerance**
A tolerance is the extent by which a dimension is allowed to deviate from the nominal or basic size. If a nominal size of an object is 20.00mm with a tolerance of ±0.15 then the upper limit is 20.15mm and the lower limit is 19.85mm.

(ii) **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 will not cut effectively. These faults are caused by inappropriate choice of grinding wheel for the material being ground.

(iii) A reamer is a type of rotary cutting tool used in metalworking.
Precision reamers are designed to enlarge the size of a previously formed hole by a small amount but with a high degree of accuracy to leave smooth sides. The process of enlarging the hole is called reaming.

(iv) Keyless chucks eliminate the need for a chuck key to open and close the jaws of the chuck. You simply hand tighten the chuck after inserting the drill bit or cutting tool into the space between the three jaws. Machinists and others who use drill chucks have a tendency to lose chuck keys, so this prevents that from happening; you do not use a chuck key to open or close the jaws of a keyless chuck.
Over time the teeth of a keyed chuck can break or chip, making the process of opening and closing a traditional chuck difficult, but keyless chucks do not suffer this fate.

(v) Rancidity of the cutting fluid is caused by bacteria and other microscopic organisms, growing and eventually causing bad odors to form. Most cutting fluids contain bactericides that control growth of bacteria and make fluids more resistant to rancidity. Other ways of preventing rancidity include continuous filtering of the cutting fluid to keep it clean and by keeping the fluid at proper strength.

(Any three) 6 + 6 + 6

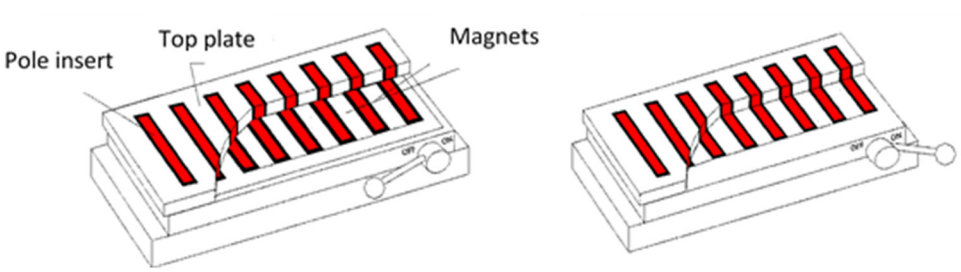
(b) **(i)** Soluble oils, pastes, synthetic fluids, oils, etc.

4 + 4

(ii) Metal cutting machines: prolong machine life, reduces vibration, maintains tool sharpness, etc.
Metal cutting efficiency: makes metal cutting more effective, reduces heat generated, improves finish, etc.

4 + 4

(c) **(i)** **Magnetic chuck**



Traditionally associated with grinding machines, the magnetic chuck has been adapted for use with other machines. Used for holding ferromagnetic workpieces, a magnetic chuck consists of an accurately centered permanent magnet face. Electromagnets or permanent magnets are brought into contact with fixed ferrous plates, or pole pieces, contained within a housing. These pole pieces are usually flush with the housing surface. The part (workpiece) to be held forms the closing of the magnetic loop or path, onto those fixed plates, providing a secure anchor for the workpiece. There are two basic types of magnetic

chucks now available (electromagnetic and permanent), but they come in a variety of sizes, shapes and modifications to suit many different applications. Electromagnetic chucks are charged by an electrical current while permanent-type magnetic chucks are based on permanent magnets. Both types can be turned on and off.

8

(ii) **Advantages of using magnetic chucks:**

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

Disadvantages of using magnetic chucks:

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

4 + 4

OR

(c) **(i)** Incremental movement allows for precision control of cutting.
Reliability of operation.
Good power output to give torque required for operation.

8

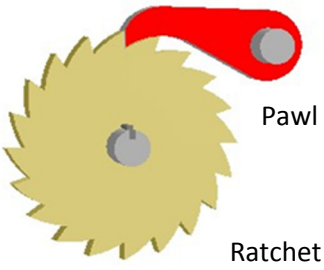
(ii) CNC lathe, CNC Milling,. CNC Router.

4 + 4

Question 8 (50 Marks)

(a) *Suggested solutions - other viable solutions are acceptable.*

(i) A Ratchet and Pawl is a device that allows continuous linear or rotary motion in only one direction while preventing motion in the opposite direction.



This would be a suitable mechanism for the operation of the turnstile.

8

(ii) Other uses for a ratchet and pawl mechanism include:

- Clothes line
- Ratchet straps
- Hoists

4 + 4

(b) **(i)** Mechanisms which will transmit motion through 90° include:

- Worm and worm gear
- Bevel gears

(ii) Helical gears offer a refinement over spur gears. The teeth 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. Uses include High Speeds needed, large power transmission and low noise.

(iii) The cam and follower converts rotary motion into reciprocating motion. Uses include camshaft and valves in engine.

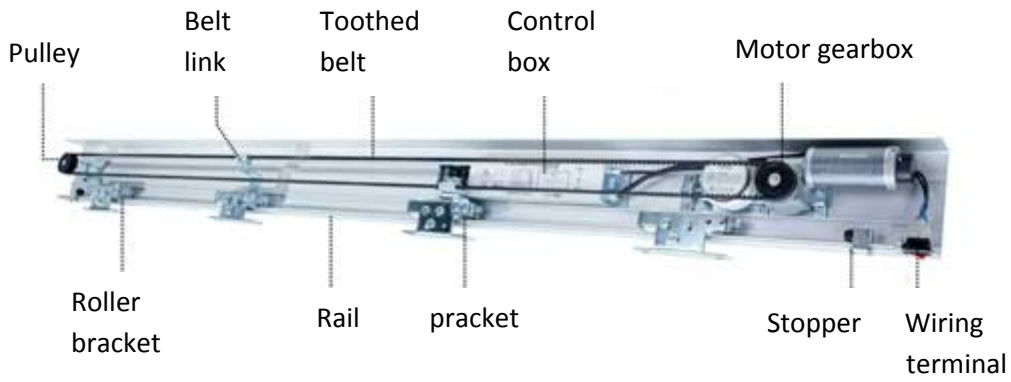
(iv) Cylindrical roller bearings are used for applications with high radial load capacity such as mining, construction crushers, machine tools, traction motors, fans, etc.

(v) A capacitor is used to store charge which can be released when needed. They are used for timer circuits, power supplies, etc.

(Any three) 6 + 6 + 6

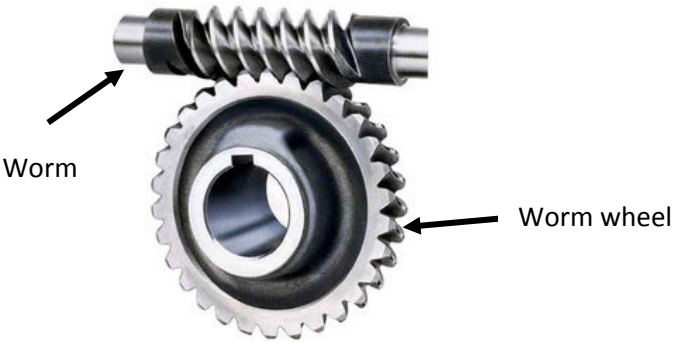
(c) *Suggested solutions, suitable alternatives are considered*

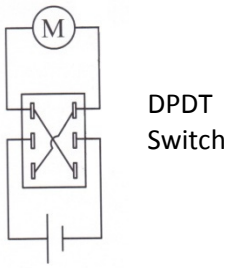
(i) The use of a **toothed belt and pulley** mechanism could operate a sliding door(s) for the car. As the motor rotates the belt will also rotate on the pulleys and link assembly brackets attached to the top and bottom of the belt will move the doors in opposite directions.



8

(c) **(ii)** The use a **worm and worm wheel** drive would be a suitable solution for the automatic ramp of the car. This would provide an increase in torque and a speed reduction. A low-cost motor could also be used with this mechanism. The worm wheel could be attached to the pivot hinge of the ramp allowing it to be rotated into position. A DPDT switch would provide the option for forward and reverse drive of the ramp while a variable resistor could be used to vary the speed of the drive.





Servo motors and Stepper motor could also be considered for both parts of the question.

8

OR

(c) **(i)** IC – Integrated Circuit
PCB – Printed Circuit Board

4 + 4

(ii) Safety: hot electric soldering iron, control of fumes, use of lead in solder, cleaning agents
Equipment: solder, soldering iron, stand with sponge, clamping equipment.
Procedure:

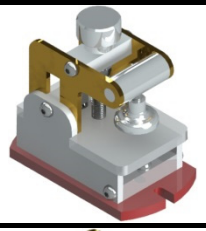
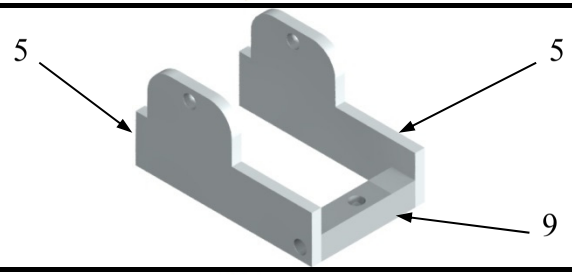
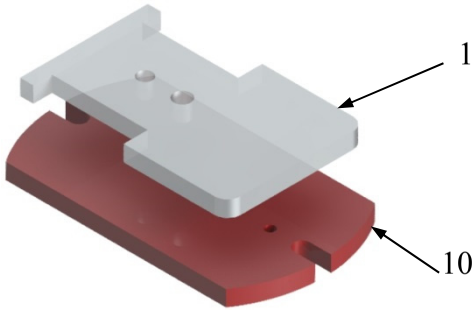
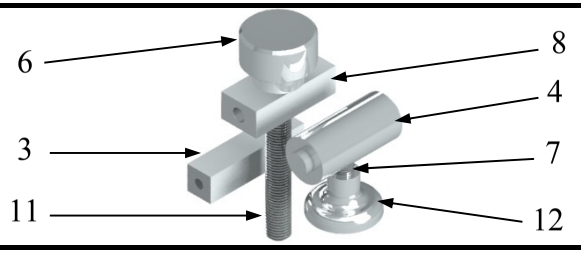
- Ensure soldering iron tip is clean, tin with solder.
- Hold soldering iron at an angle to the PCB heating the component and pad simultaneously.
- Touch the solder wire between the iron and component lead allowing the solder to melt.
- Remove the soldering iron allowing the solder to cool.
- Continue for each component to be soldered.
- Check that each joint is effectively soldered.

8

Coimisiún na Scrúduithe Stáit
State Examinations Commission

Leaving Certificate - Engineering Practical - Marking Scheme 2017

Subjective Marking 1 - 20 17 - 20 Excellent 13 - 16 Very Good 9 - 12 Good 5 – 8 Poor 1 - 4 Very Poor

Section	Part Number	Pictorial Sketch / Description	Concept		Mark	Mark
1	**All Parts of Test-piece**		Assembly, Function & Finish Subjective Mark 1 – 20		**20**	**20**
2	**Parts 2**		**Parts 2** 20 Marks	Marking Out	**4**	**20**
				External Profiles	**6**	
				10 mm Slots	**6**	
				Ø8 & Ø5.5 mm Holes	**4**	
3	**Parts 5 and 9**		**Parts 5** 16 Marks	Marking Out	**4**	**20**
				External Profiles	**8**	
				Ø5.5 mm Holes	**4**	
			Part 9 4 Marks	2 × M5 Holes & Length	**3**	
				Ø5.5 mm Hole	**1**	
4	**Parts 1 and 10**		**Part 1** 10 Marks	Marking Out	**2**	**20**
				M8 Tapped Hole & Ø5.5 mm Hole	**2**	
				7 mm × 38 mm Slots	**6**	
			Part 10 10 Marks	Marking Out	**2**	
				M5 Tapped Holes	**2**	
				Profile and 6 mm Slots	**6**	
5	**Parts 3, 4, 6, 7, 8, 11 and 12**		**Parts 4, 6 and 12** 10 Marks	Lathe Work	**6**	**20**
				Marking Out and Bench Work	**4**	
			Parts 3, 7, 8 and 11 10 Marks	Marking Out and Lengths	**5**	
				4 × M5 Holes & Ø10 mm Hole	**5**	

100 Marks (× 1.5 = 150 Total)

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