Coimisiún na Scrúduithe Stáit
State Examinations Commission

LEAVING CERTIFICATE 2009

MARKING SCHEME

ENGINEERING - MATERIALS AND TECHNOLOGY

HIGHER LEVEL

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Written Examination and Practical Examination

ENGINEERING - MATERIALS AND TECHNOLOGY

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ENGINEERING - Materials and Technology

(Higher Level – 300 marks)

Written Examination Marking Scheme 2009

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) 5 (d) **Any two @** 3 + 2 (e) 5 (f) 5 (g) 5 (h) 5 (i) **Any two @** 3 + 2 (j) 5 (k) 5 (l) **Any one** @ 5 (m) 5	**Question 1 Section B – 50 marks** Answer **all** of the following. (n) (i) 2 + 2 + 2 (ii) 4 (o) 4 + 3 + 3 (p) 4 + 3 + 3 (q) 4 + 3 + 3 (r) **Any two** @ 5 + 5	**Question 2 – 50 marks** (a) (i) 4 (ii) 12 (b) (i) 2 + 2 + 2 (ii) 6 + 6 (c) (i) 4 + 4 (ii) Describe 4 Diagram 4
Question 3 – 50 marks (a) **Any two** @ 8 + 8 (b) (i) 5 + 5 (ii) 8 (c) (i) 6 (ii) 10	**Question 4 – 50 marks** (a) **Any two** @ 8 + 8 (b) (i) 4 (ii) 2 + 2 + 2 + 2 + 2 (iii) 4 (c) 8 + 8	**Question 5 – 50 marks** (a) (i) 3 + 3 (ii) 10 (b) **Any three** @ 6 + 6 + 6 (c) **Any one** @ Describe 8 Diagram 8 **OR** (c) (i) 8 (ii) 8
Question 6 – 50 marks (a) (i) 2 + 2 (ii) 2 + 2 (iii) 8 (b) Identify @ 4 Describe @ 12 (c) **Any three** @ 6 + 6 + 6	**Question 7 – 50 marks** (a) **Any three** @ 6 + 6 + 6 (b) (i) 4 + 4 (ii) 4 + 4 (c) Describe 8 Diagram 8 **OR** (c) (i) 8 (ii) 8	**Question 8 – 50 marks** (a) **Any one** @ Name 8 Application 8 (b) **Any three** @ 6 + 6 + 6 (c) Describe 8 Diagram 8 **OR** (c) (i) 2 + 2 + 2 + 2 (ii) 4 + 4

Sample Answers and Marking Scheme

Question1 (100 Marks)

Section A – 50 marks

(a) **(i)** thread rolling
(ii) casting
(iii) grinding / stamping / profile key cutting.

(Any two) 3 + 2

(b) Safety precautions when using cutting fluids:

- Avoid splashes on skin, wash immediately, use skin barrier cream,
- Wear eye protection,
- Remove spilt cutting fluids from floor to prevent slipping,
- Renew cutting fluid to prevent rancidity,
- Cutting fluids need to be filtered and cleaned.

(Any two) 3 + 2

(c) After mining, as much metal is removed from the ore as possible in the processes of ore concentrating. This increases the percentage of useful mineral through processes such as magnetic separation, flotation and gravity concentration. Metal extraction, through furnaces, leaching, electrolysis, etc., seeks to remove the metal from the concentrates.

5

(d) Fatigue failure is influenced by:

- Nature and size of loading force;
- Length of time the component is subjected to loading force;
- Rough surface finish;
- Component with sharp corners;
- Corrosion on surface.

(Any two) 3 + 2

(e) **A single acting cylinder** is a pneumatic output device that requires compressed air to make the piston move. If the air is removed the piston will return.
A double acting cylinder needs compressed air to move the piston but will stay in t his position if the air is turned off. It needs air to return the piston to its original position.

5

(f) A vee block may be used for holding round materials for marking out or drilling.

5

(g) Young's Modulus is the ratio that indicates the stiffness a material displays in use. It is represented by E and expressed in kN/mm^2.

$$E = \frac{\text{stress}}{\text{strain}}$$

5

(h) A heat sink is used in electronics to conduct away heat generated by a component. These heat sinks are normally corrugated or finned to dissipate heat to the surrounding air and protect components such as transistors.

5

(i)
(i) Printed circuit board.
(ii) unplasticised Polyvinyl Chloride.
(iii) Single pole, single throw switch.
(iv) High speed steel.

(Any two) 3 + 2

(j) Safety signs are designed to an international standard to include shape and colour. The following colours are used:

- Red is prohibition signs to include danger and fire safety;
- Yellow alerts to a caution or possible danger;
- Green is a positive action to safe condition, emergency exit or first aid;
- Blue denotes mandatory or information signage.

The standardisation of colour codes allows workshop users to be uniformly aware of hazards in the workplace.

5

(k) Elastic memory refers to the ability of a plastic to return to its original shape and size after a load is removed. Most plastics may also be heated, shaped and cooled to retain new shape. If heated again, it reverts to the original shape.

5

(l)
(i) **James Dyson:** Born in Norfolk in England in 1947, he invented the use of cyclone technology in vacuum cleaners. This bagless system does not clog or lose suction. The Dyson Airblade hand dryer was launched in 2006.
(ii) **Igor Sikorsky:** Russian born in 1889, he had an interest in aviation with his most important contribution in helicopter design especially his single rotor design.
(iii) **Chester Carlson:** in 1939, he developed the photocopier on a Xerox machine.

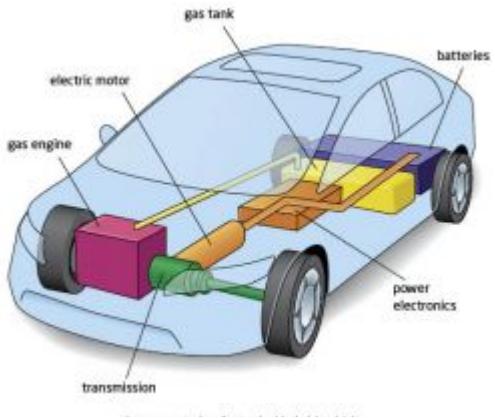
(Any one) 5

(m) Sea water will attack and corrode the bronze propeller of a boat which is expensive to replace. A plate of zinc, aluminium or magnesium is attached to the hull of the boat near the propeller. This attached metal acts as an anode in an electro-chemical action with the propeller as the cathode. The anode will be 'sacrificed' and will need to be replaced periodically.

5

Section B – 50 marks

(n) **(i)** **A** – Fuel engine.
B – Electric motor.
C – Batteries.



2 + 2 + 2

(ii) A hybrid electric vehicle (HEV) combines a conventional propulsion system with a rechargeable storage system to achieve better fuel economy than a conventional vehicle. This hybrid vehicle has a battery powered system with a fuel (petrol) engine to extend the range of operation.
The engine management system will control the operation of the fuel engine, electric motor or both to determine the most efficient driving condition. Extra power can be provided by running the electric motor in parallel with the engine. If stopped, the engine can be switched off and can be driven by the electric motor at lower speeds.
Batteries can be charged by capturing kinetic energy through regenerative braking or by spinning an electric generator. HEV engines are generally smaller than the vehicle with a traditional petrol engine giving an increase in efficiency.

4

(o) Power sources to power a hybrid vehicle include:

- Fossil fuels such as petrol or diesel,
- Battery or electrical power source,
- Biodiesel,
- Ethanol,
- Gas,
- Hydrogen, etc.

4 + 3 + 3

(p) Environmental consequences of the use of hybrid vehicles:

- Hybrid vehicles can significantly lower fossil fuel consumption. In the burning of fossil fuels, CO2 is released into the atmosphere with consequences for global warming.
- The fossil fuel that is used in hybrid technology is processed more efficiently than in traditional car engines. Fossil fuels are non-renewable and reserves are dwindling.
- Less toxic emissions are produced and released into the atmosphere.
- Particularly suited to short trips where petrol engines are least efficient.

- Lower noise emissions.
- Energy that is normally lost is captured and used.
- Batteries may be constructed from toxic materials (lead, nickel, etc.) that will need to be disposed of or recycled at the end of vehicle life cycle.
- Tracts of land can be used to produce raw material for fuel with greater profit than producing food, this can create food supply issues for some third world countries.

4 + 3 + 3

(q) (i) Regenerative braking

When accelerating, energy is drawn from the batteries to power the motor. If the brakes are applied, the motor starts to act as a generator and charges the batteries as the electronic controls switch power away from the engine.

(ii) Battery capacity

The ability of a battery to store energy varies with the different types of battery. Nickel metal hydride and lithium ion are most commonly used as hybrid car batteries.

(iii) Fuel-engine shut down

This drives the vehicle from the power source that is most efficient. At low speeds, the electric motor is driven by batteries. The power split device will transfer power to the engine as the main driving source as the vehicle accelerates. When the vehicle is not moving, both fuel engine and electric motor will switch off and restart when the accelerator is pressed.

4 + 3 + 3

(r) (i) PHEV

Plug in Hybrid Vehicles have a gasoline electric hybrid with a battery pack that is upgraded to a larger capacity. The battery pack can be recharged by connecting to the national grid. The car will run on battery power for the first 15 to 100 km with the petrol engine available for fast acceleration. The car can be run on the petrol engine as the battery nears discharge or, more efficiently, can be returned to its charging station.

The fundamental issue is developing a good, cheap high-energy battery pack to improve range of operation. PHEV's have the option of charging at off-peak time late at night and have some practical uses as most travel is about 50 km per day. It could be the cleanest personal transport available especially if the national grid relies on renewable sources for generating electricity.

There are few PHEV vehicles available but some can be converted from existing hybrids.

(ii) Hybrid vehicle incentives

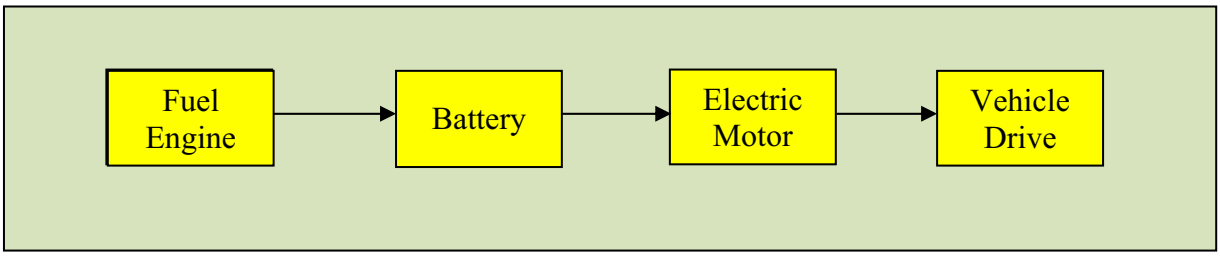
In order to encourage the purchase of hybrid vehicles, a range of incentives have been introduced in Ireland and many other countries, including:

- The Irish government offer a 50% reduction in Vehicle Registration Tax (VRT) since 2008, this reduces the car price by up to 25%.
- Motor tax rates have been changed to reflect CO_2 emissions, this has significantly reduced motor tax for hybrid vehicles.
- Reduced insurance premiums are offered to hybrid car owners.
- In the Netherlands, VRT is payable when the car is sold to its first buyer and can earn a hybrid owner up to €6,000.

- Congestion charges in London exempt hybrid cars.
- The US offers federal income tax credit up to $3,400 for hybrid car purchasers.
- Free car parking is offered to hybrid car owners in some American cities including Los Angeles.
- Some Canadian cities offer tax rebates on purchase or lease of hybrid cars.

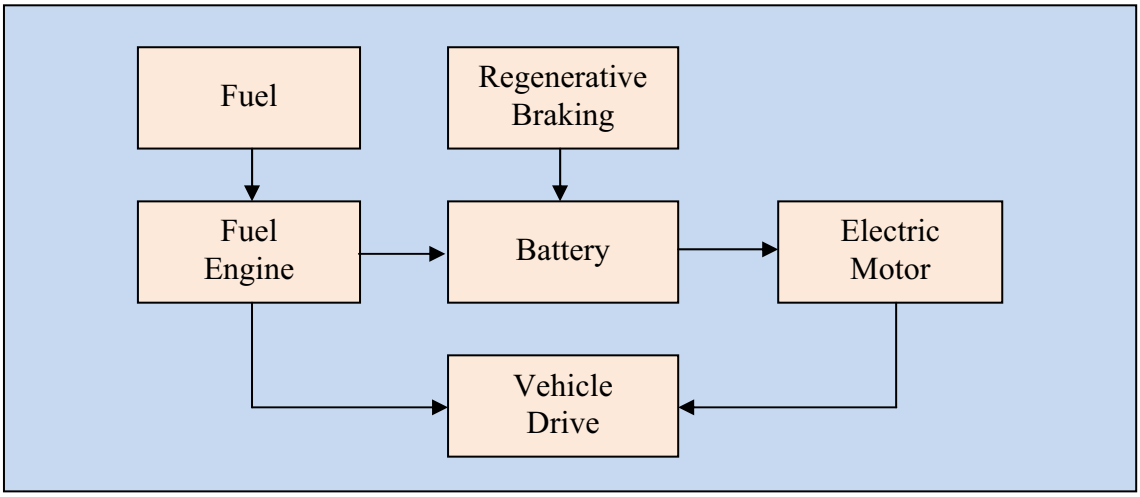
(iii) Series and parallel hybrid vehicles

Series hybrid vehicles are used to overcome limitations by particular engine types. Modern trains use diesel-electric hybrids where a diesel engine drives a generator to charge batteries for powering an electric motor. This allows a very heavy train to move and then travel at speed.



Series Hybrid Vehicle layout

In parallel hybrid vehicles, the engine is assisted by a secondary system to drive the road wheels. For example, a fuel engine or battery powered electric motor or a combination of both can be used to drive the vehicle. The engine and regenerative braking may be used to charge the batteries.



Parallel Hybrid Vehicle layout

(Any two) 5 + 5

Question 2 (50 Marks)

(a) **(i)** Vickers hardness test

4

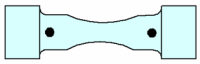
(ii) A hard metal point, called an indenter, is pressed into the surface of the material being tested with a measured force. Softer materials will produce a deeper indentation. The test piece is considerably thicker than the indentation The test material is placed on a table, which can be adjusted for height.
The Vickers hardness test uses a diamond, square-based pyramid indenter. It has a point angle of 136°. The hardness value for a Vickers hardness test is converted from the length of the diagonal produced by the indenter.
It is suitable for testing hard materials with a good degree of accuracy.

12

(b) **(i)** **A** – Upper yield point
B – Tensile strength
C – Fracture point

2 + 2 + 2

(ii) Up to **point B**, the specimen will have thinned uniformly as the load increased. At this point, the specimen will begin to 'neck' as it elongates with applied force.



At **point C**, the specimen will have fractured with the distinctive 'cup and cone' fracture. One side of the specimen has a rough cone shape and the other has a hollow cup shape.

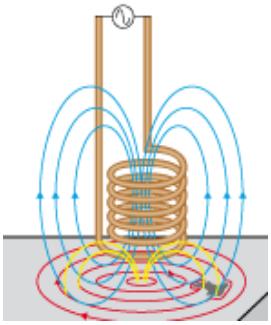
6 + 6

(c) **(i)** Reasons for using non-destructive tests (NDT):

- Casting engines is a costly process. NDT's allow testing for quality yet will ensure that each acceptable component can be used.
- NDT's can be employed on each engine.
- The final product will not be destroyed in the testing process.
- Cost effective.

4 + 4

(ii) Penetrant tests or eddy current tests can be used for testing for surface imperfections.
Eddy current tests are most effective for testing non-ferrous metals of uniform section.
A coil, energised with high frequency alternating current, is placed close to a conductive material producing eddy currents on the material. A magnetic field is produced in the test specimen by the currents. A defect will distort this magnetic field which will then be located by a search coil which records electronically and displays the imperfection.



Describe 4
Diagram 4

Question 3 (50 Marks)

(a) (i) Quenching media:

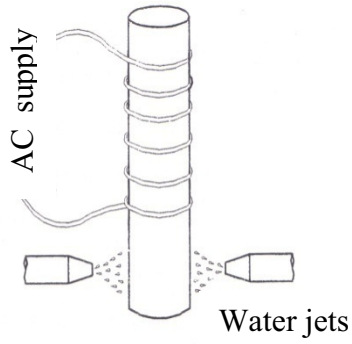
- Water
- Oil
- Brine
- Air

(ii) Safety hazards in case hardening:

The main concerns centre around the use of high temperatures over a period of time.
The heat source must be heated to over 900^{o}C for up to 12 hours for 1mm depth of a carbon-rich layer. Hot furnaces must be isolated or have warning signs for this type of activity.
Case hardened components are prone to cracking.
Some forms of gas carburising and nitriding must be carried out in specially sealed furnaces due to the toxic materials used.

(iii) Induction hardening

The steel component is placed inside a coil, which carries a high frequency current. Eddy currents are induced on the surface of the component causing a rapid rise in temperature. This allows a change to austenite in the surface layers of the component. Water jets then cool the steel transforming the austenite to martensite. This leaves the outer surface hard. The frequency of the current determines the depth of heating and the depth of hardening. Induction hardening is used on the slideways of a lathe.



(iv) Pearlite

A mixture of alternate layers of ferrite and cementite. It is mostly ferrite and gives off a sheen similar to mother of pearl. Pearlite is formed at 0.83% carbon.

(Any two) 8 + 8

(b) (i) **A –** Annealing or hardening
B – Stress relieving or spheroidising or process annealing
C – Tempering

(Any two) 5 + 5

(ii) Allotropy in carbon steel:

The ability of a material to exist in more than one crystalline form. Steel has a BCC form when cold but exists as FCC austenite when heated above the upper critical temperature.

8

(b) **(i)** A thermoelectric pyrometer.

6

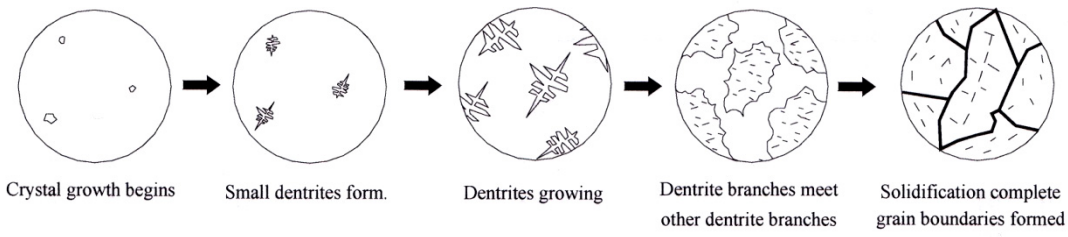
(ii) Principle of operation: Two dissimilar metals are joined together with a galvanometer placed at the cold junction. A rise in temperature at the hot junction produces an electrical current which is recorded by the galvanometer. This galvanometer is calibrated to read in degrees of temperature rather than indicating electrical units.

10

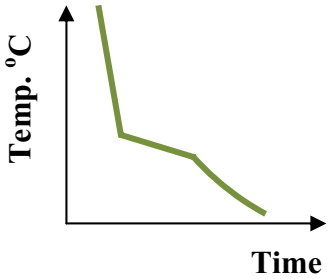
Question 4 (50 Marks)

(a) **(i)** **Crystalline structures** have atoms that are bonded together in a pattern that is repeated. Metals with bcc and fcc unit cells are examples of a crystalline structure.
Amorphous structures do not have a pattern in the arrangement of their atoms but are a more random structure. Pitch, glass and some plastics have this type of structure.

(ii) The stages of crystal solidification of a metal from the liquid phase are known as **dendritic growth**. As the metal cools, solidification starts from cells and begin to grow to form a dendrite. These have a tree-like formation with branches reaching out in all directions. Grain boundaries with solid metal crystals are formed.



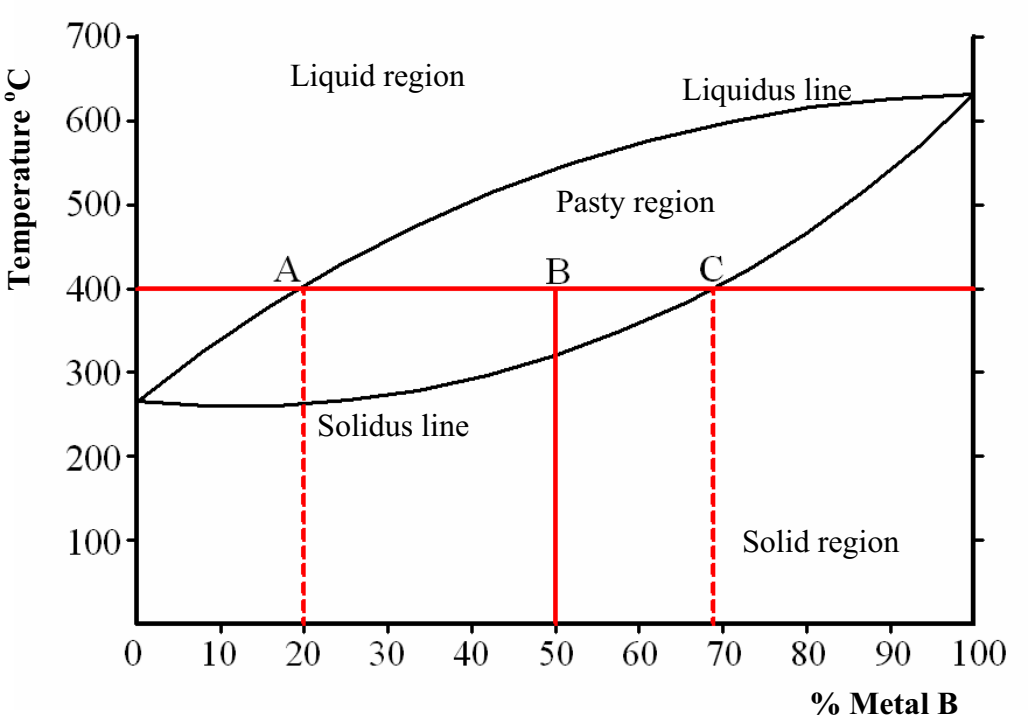
(iii) **Cooling curve:**
When the temperature of a cooling molten metal alloy is plotted against time, a cooling curve is formed.



(iv) **Brittleness in crystal cells:**
In a comparison of body-centred cubic (BCC) and face-centred cubic (BCC) unit cell structure, FCC is more closely packed. Atoms in the FCC structure are more likely to slip and move across each other than the more loosely packed BCC. This slippage promotes ductility while the BCC unit cell structure more likely to exhibit brittleness.

(Any two) 8 + 8

(b) **(i)** Draw diagram:



4

(ii) **Liquidus line:** for the alloy system this line represents the boundary between the fully liquid state and the beginning of solidification.

Solidus line: the boundary line that determines the end of solidification. Below this line, the alloy is completely solid.

Liquid region: the two metals are soluble in a liquid state.

Solid region: the two metals are soluble in a solid state.

Pasty region: between the liquidus and solidus lines, the alloy system is in a partly liquid and a partly solid state.

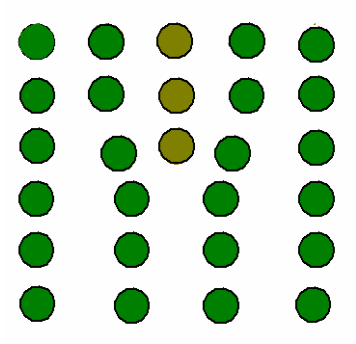
10

(iii) Ratio of solid to liquid:

$$\frac{\text{Weight of solid}}{\text{Weight of liquid}} = \frac{AB}{BC} = \frac{30}{19}$$

4

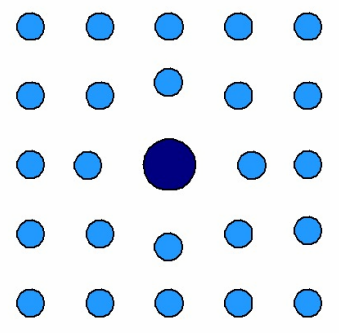
(c) (i) Dislocation:



This line defect results from an incomplete layer of atoms in a crystal structure. Dislocations can cause a weakening of the structure as the application of a stress will move the dislocation and result in early failure.

8

(ii) Substitute defect:



An atom of another element is present in the crystal lattice. Distortion occurs if this atom is larger or smaller than the parent element. When atoms of similar size are present one type of crystal is may be formed and the mixture looks like a pure metal. The copper-nickel alloy is an example.

8

Question 5 (50 Marks)

(a) (i) A – Resistance seam welding
B – Resistance spot welding

3 + 3

(ii) A – **Resistance seam welding**
A form of resistance welding that uses copper roller electrodes to provide a continuous run of overlapping spot welds as the current is activated at set intervals. One of the electrodes may be driven by an electric motor. The workpiece is moved between the rollers and pulses of current are supplied. Each pulse is set to last long enough to produce a spot weld. The time interval is controlled so that these spots overlap by approx. 40% of their length along the seam.

B – **Resistance spot welding**
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 very effectively used to join sheet metal together and is recognised by the distinctive circular mark left at the site of the weld.
Spot welding gives a lower strength joint than other forms of welding but it is energy efficient, giving little work deformation, it can be easily automated and does not require a filler metal. It is commonly used in sheet metal applications such as presses, filing cabinets and car body panels.

(Any one) 10

(b) **(i)** **MIG (MAGS) welding** is a very versatile process and can be used to weld light sheet metal as well as heavy plate. It can also be automated for welding by robots on car and other assembly line products.
TIG (TAGS) welding is a more specialised welding process, that features a non-consumable electrode and demands the feeding of a filler metal, it has made the welding of aluminium and stainless steel feasible.

(ii) **Functions of the electrode coating include:**

- To generate a shield of carbon dioxide gas to protect welded joints from contamination by oxygen and nitrogen in the air.
- To form a slag coating which protects the weld from oxidation and ensures a slow cooling rate for the weld, this prevents cracks and brittleness.
- Facilitates the striking action of the arc between the work and electrode.

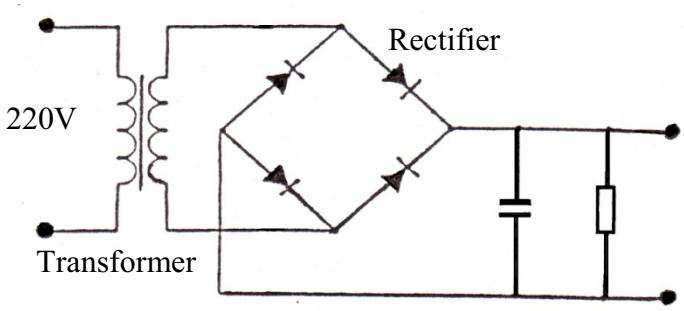
(iii) **Installing a school welding station:**

- A ventilation system must be incorporated to efficiently remove the gases produced by welding.
- The welding station should be shielded to protect others in the workshop from the intense light produced by welding.
- Personal safety equipment (masks, apron, gloves, etc.) must be available.
- The hazards of the area must be highlighted by signs.

(iv) **Multi-run welding:**
A series of welds are run across the metals to be joined in multi-run welding. A superior weld is produced as each weld has a post heating effect on the previous run. The finished weld is stronger and more refined in structure than single run welds.

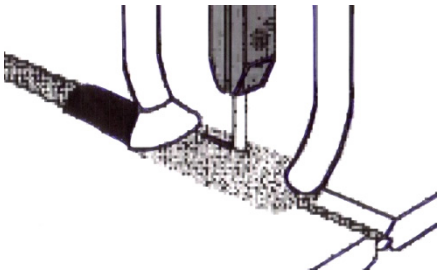
(Any three) 6 + 6 + 6

(c) (i) Transformer circuit:



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.
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.
The capacitor is employed to provide a smooth supply of low voltage DC.

(ii) Submerged arc welding:



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.

(Any one) Describe 8
Diagram 8

OR

(c) (i) Pneumatic control will provide a very strong method of powering the robots used in heavy duty work.
A high degree of automation can be integrated into pneumatic control.
Once set-up, control is reliable and precise with minimal maintenance.

8

(ii) Robots can be controlled from a distance which allows the operator to be out of the hazardous environment.
The robotic control machines can be shielded from hazardous substances or plated to absorb most environmental factors.
Robots can be replaced or repaired.

8

Question 6 (50 Marks)

(a) **(i)** A – Calendering.
B – Extrusion.

2 + 2

(ii) A – sheets of acrylic, mats and floor coverings, etc.
B – thermoplastic products with uniform section such as pipes, curtain rails, tubes, gutters, etc.

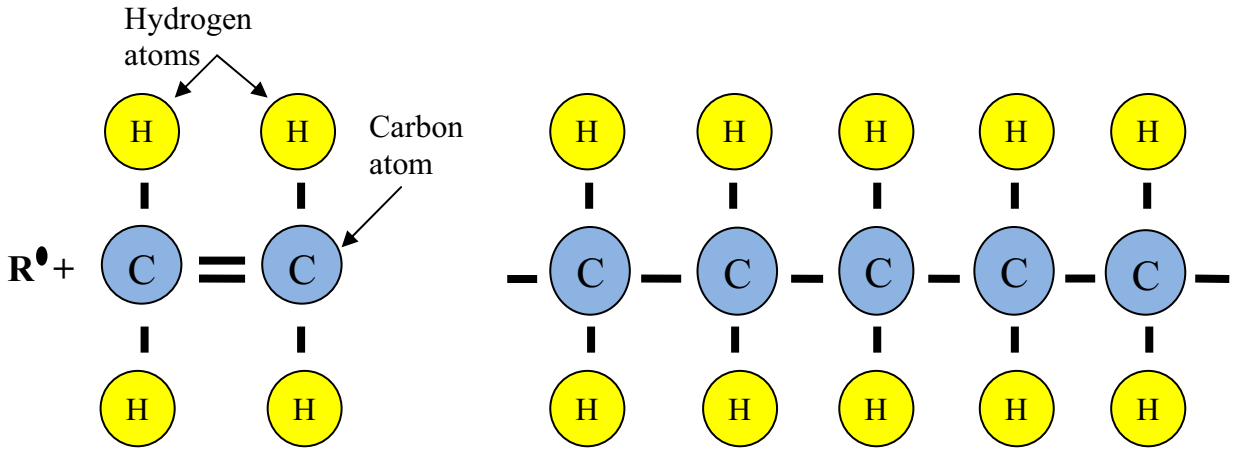
2 + 2

(iii) A **– Calendering:**
Continuous lengths of sheets are produced in thermoplastics by calendaring. 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.

B – **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. Polythene, PVC and nylon are commonly extruded.

(Any one) 8

(b) **Addition polymerisation.**
Polyethylene is produced by addition polymerisation. Long chainlike molecules are formed by the addition of large numbers of mers.

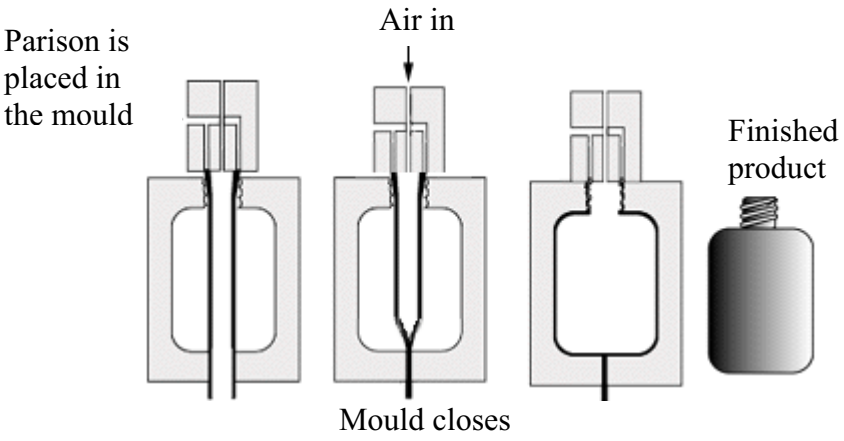


The ethylene molecule (or mer) consists of a strong and a weak bond between the carbon atoms. A catalyst or a free radical which has an unpaired electron

in its outer shell is added to the ethylene molecule. The weak bond is attached and one of its electrons is taken by the radical leaving the other free. Then the attached ethylene molecule behaves 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.

16

(c) (i) Blow moulding:
A moulding process used to create hollow shapes, such as bottles.



An extruded thick-walled tube, called a parison, is placed in the mould. The mould closes and air is blown into the parison. The parison takes the shape of the mould.

(ii) Elastomers:
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.

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

(iv) Co-polymer:
This 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.

(v) Thermosetting plastic:
These are polymers that are moulded once and cannot be remoulded or will not recycle. Thermosets tend to have a high melting point, are rigid and have a high tensile strength. They include polyester resin which is used with fibre glass to make canoes.

(Any three) 6 + 6 + 6

Question 7 (50 Marks)

(a) **(i)** **Dovetail cutter** is used to machine dovetail slides on machine slideways.

(ii) The surface of a material is given a roughened surface in order to improve the grip on it. Angled teeth are cut into the wheels of a knurling tool which are fed into the surface of the work.

(iii) **Safety features on a pedestal grinder:**

- A face guard is supplied with the machine to protect against grinding debris.
- Easily accessible switches allow the machine to be turned off quickly.
- Modern machines are designed to stop quickly.
- The machine should be firmly attached to the ground.

(iv) **Height gauge:**

- Provides an accurate method of marking out metals and plastics.
- Relatively easy to use once reading a vernier scale is mastered.
- Can be used with vee blocks on round materials.
- Can have a digital readout for increased accuracy.

(v) **Direct measurements** are taken by instruments that have a scale and the size of a component is read from the scale, an engineers rule is an example of a direct measuring instrument.
Comparative measurements are taken by gauges that compare component dimensions against standard gauges. Limit gauges and dial indicators are examples of comparative measuring tools.

(Any three) 6 + 6 + 6

(b) **(i)** A – Tungsten carbide.
B – High speed steel.

4 + 4

(ii) **Prolonging tool life:**

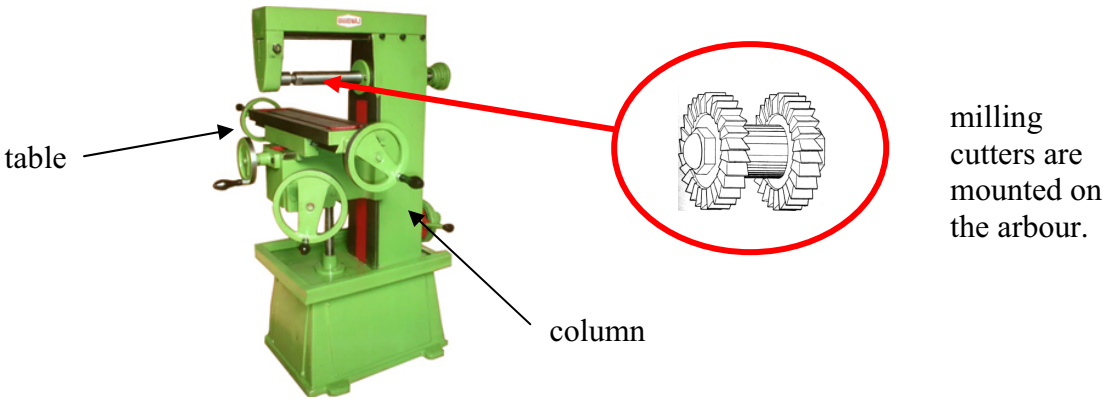
- Use cutting fluids when machining.
- Choose suitable cutting tools for each machining process.
- Run the machine at the correct speed to prevent heat build-up.
- Ensure that the machine is in good condition and not prone to excessive vibration.
- Use the correct cutting speed and cutting feed for the material.

4 + 4

(c) **The milling machine:**
Milling is the machining of a surface using a cutter which has a number of teeth. A flat surface may be produced or special cutters can be used to form profiled surfaces. The most common type of milling machine is the knee and column type. The spindle is fixed in the column or main body and the table is mounted on a knee. These

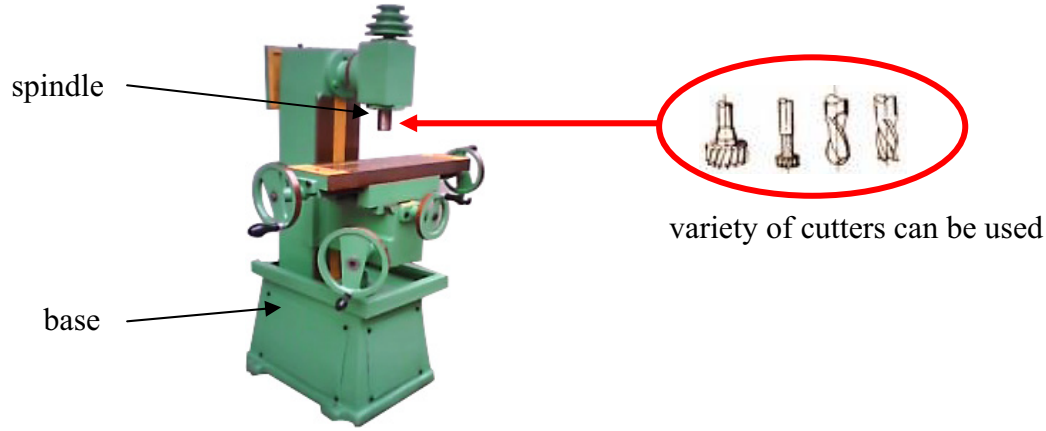
machines are capable of movement in the longitudinal, transverse and vertical directions. The main parts of these machines include:
Base: cast iron base houses the cutting-fluid reservoir and has a rigid construction to prevent vibration.
Column: mounted on the base, the column contains the spindle.
Knee: allows for vertical movement of the table.
Saddle: provides transverse movement of the table.
Table: workpieces and workholding equipment are located and clamped.
Spindle: provides the drive for the milling cutters.

Horizontal milling machine:



The main spindle is mounted horizontally near the top of the column. The machine capacity is determined by the maximum distance from the table to the spindle as well as working surface size and travel in all directions. The milling cutters have a hole in them in order to be mounted on an arbour. The cutters are usually large in diameter and are found in a range of types including slab, side and face, saw, angle and form cutters.

Vertical milling machine:



The spindle is mounted vertically in a head at the top of the column. The milling cutters are generally mounted in a chuck. There are a range of end mills, slot drills and profiled cutters (angle, ball-nose, dovetail, tee-slot, corner-rounding, etc.)

Describe 8
Diagram 8

OR

(c) **(i)** CAD – Computer Aided Design/Drawing/Drafting is the process of inputting design data in a system with a graphical output.
CAM – Computer Aided Manufacture uses the CAD output to produce components in a variety of computerised machines including lathe, milling machines, etc.

8

(ii) **Safety features** include:

- Large clear guard encloses machining.
- Machine will not run when guard is not in place.
- Emergency stop on the front of the machine.
- Programme must have test run before machining.

8

Question 8 (50 Marks)

(a) **(i)** **Name:** Ratchet and pawl.
Ratchet is used to allow the socket to turn and lock in either direction due to the design of the locking pawl.

(ii) **Name:** Toothed belt and pulley.
Toothed pulley and belt gives an effective grip drive for car timing belts, motorcycle drive and CNC lathes.

(Any one) Name 8
Application 8

(b) **(i)** **The advantages of helical gears:**

- Allow a number of teeth to mesh at the same time providing a strong, continuous drive
- Quieter in operation then straight spur gears.

(ii) **Preventing pulley belt slip:**

- Maintain tautness with a jockey wheel
- Use toothed belt
- Vee-belts are less prone to slip than flat belts.

(iii) **Crank and slider:**
A mechanism used to convert rotary movement to reciprocating movement. An air compressor has a motor that turns a crankshaft and the piston (slider) moves up and down to compress the air.

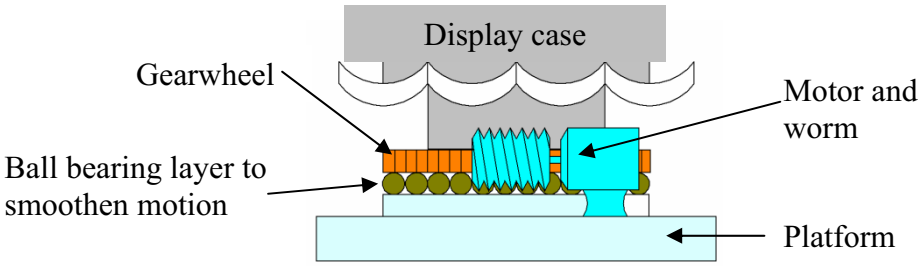
(iv) **Integrated circuit:**
An electronic circuit containing components such as transistors, resistors, capacitors, etc. which is produced onto a small piece of semi-conducting material. Commonly known as a 'silicon chip' due to material it is sourced from, these circuits are used to control electrical appliances.

(v) **Solenoid:**
An electrical device where a coil of wire, wound around a soft iron core, is energised. The magnetic force induced by the current pulls the bar towards the centre. A solenoid spring will return the bar to its original position.

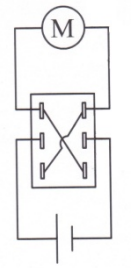
(Any three) 6 + 6 + 6

(c) There are a variety of ways that the rotating display could be automated.
Suggested solution is based on the principle of the 'lazy susan' or turntable mechanism.

The display is driven by a worm and wheel. A gearwheel is mounted on the bottom of the display case. This gearwheel is driven by an electric motor with a worm attached. The motor is securely fixed to the platform base.
In between the gearwheel and the base, a layer of ball bearings sits in a circular grooved track which allows the display case to rotate freely on its centre axis.



The motor is activated with a control switch and power supply and can be made to rotate clockwise and anticlockwise with the use of a DPDT centre/off switch connected as shown in the circuit diagram.



The main advantage of this solution is that a smooth, slow motion can be achieved in an easily constructed mechanism.

Describe 8
Diagram 8

OR

(c) **(i)** A – Capacitor (polarised)
B – Light emitting diode (LED)
C – Push to make switch
D – On/off switch.

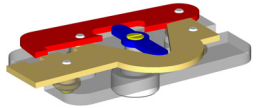
2 + 2 + 2 + 2

(ii) Capacitor will store electric charge.
LED will light up when current is passed through it.

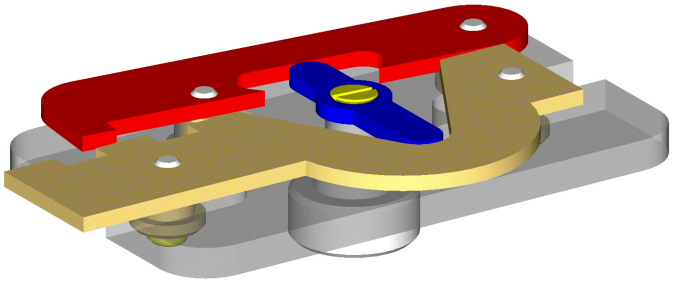
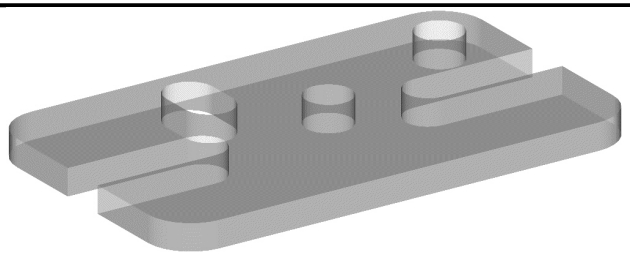
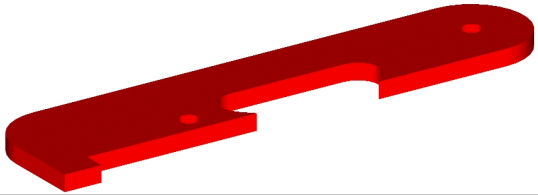
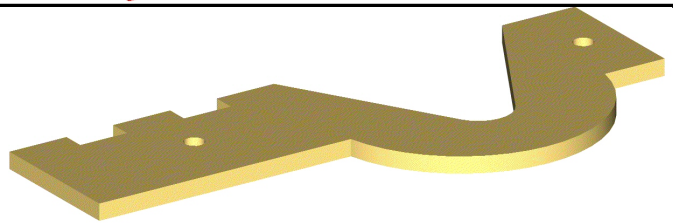
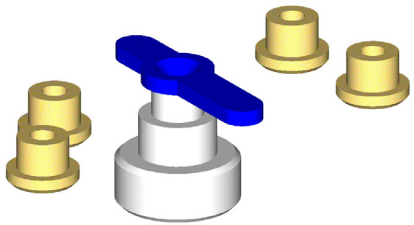
4 + 4

Coimisiún na Scrúduithe Stáit
State Examinations Commission

Leaving Certificate Engineering Practical, Marking Scheme 2009



Subjective Grading 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 Mechanism**		Assembly, Function & Finish Subjective Grade 1-20	20	20
2	**Part 1**		Marking Out	4	20
			10mm Radii	4	
			10.5mm Slots	6	
			11mm Slot	4	
			Drill 10.5mm Holes	2	
3	**Parts 2**		Marking Out	4	20
			10mm Radii	3	
			M5 Tapped Holes	2	
			90º Angle and Slot Profile	7	
			General Profile	4	
4	**Part 3**		Marking Out	4	20
			Vee Slot	4	
			9mm Slots	4	
			M5 Tapped Holes	2	
			25mm Radius	2	
			General Profile	4	
5	**Parts 4, 5 and 6**		Part 4 Lathe Work	6	20
			Part 5 × 4 Lathe Work	4	
			Part 6 Bench Work	10	

100 Marks
(× 1.5 = 150 Total)