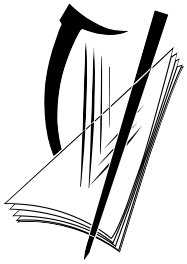


Coimisiún na Scrúduithe Stáit
State Examinations Commission

Leaving Certificate 2019

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 2019

MARKING SCHEME

Written Examination and Practical Examination

ENGINEERING –
Materials and Technology

HIGHER LEVEL

LEAVING CERTIFICATE ENGINEERING

MATERIALS AND TECHNOLOGY

(Higher Level – 300 marks)

Marking Scheme 2019

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

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

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

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

(n) 5 + 5

(o) 10

(p) 4 + 3 + 3

(q) (i) 4
(ii) 2 + 2 + 2

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

Question 2 – 50 marks

(a) (i) 3 + 3
(ii) 10

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

(d) (i) 2 + 2 + 2+ 2
(ii) 8

Question 3 – 50 marks

(a) (i) 6
(ii) 10

(b) (i) 3 + 3
(ii) 6
(iii) 6

(c) 16

Question 4 – 50 marks

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

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

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

Question 5 – 50 marks

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

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

(c) 16
OR
(c) (i) 4 + 4
(ii) 4 + 4

Question 6 – 50 marks

(a) (i) 3 + 3
(ii) 10

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

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

Question 7 – 50 marks

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

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

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

Question 8 – 50 marks

(a) (i) 8
(ii) 8

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

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

Sample Answers *and* Marking Scheme

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

All other valid solutions are acceptable and are marked accordingly.

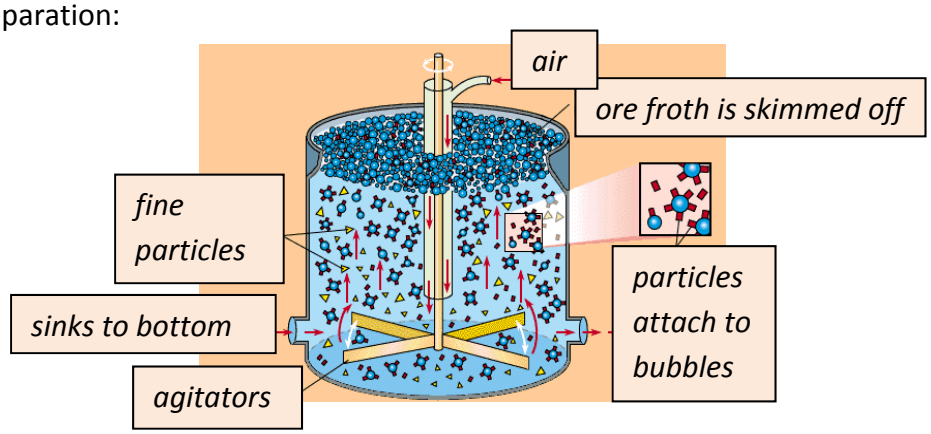
Question1 **(100 Marks)**

Section A – 50 marks

(a) Strength of material, lightweight, resistance to impact, can be painted, corrosion resistant, etc.

3 + 2

(b) Flotation separation:



The fine particles of ore are swirled around in large tanks with air blown in and flotation agents added. The particles attach to the bubbles and float to the surface where this froth is skimmed off.

5

(c) Strong power transmission, can be used in hostile or dangerous environments, unlikely to generate excessive heat or sparks, etc.

Any two @ 3 + 2

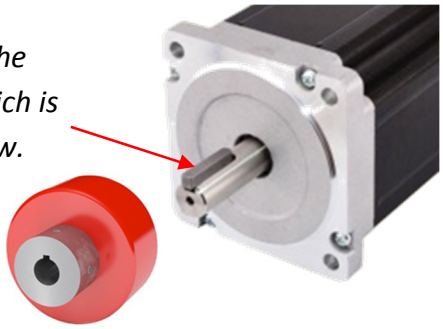
(d) **(i)** **Robert Boyle:** (1627 – 1691) born at Lismore Castle, Co. Waterford, he was a natural philosopher, chemist, physicist and inventor. Boyle is largely regarded today as the first modern chemist, and therefore one of the founders of modern chemistry, and one of the pioneers of modern experimental scientific method. He is best known for Boyle's law which describes the inversely proportional relationship between the absolute pressure and volume of a gas, if the temperature is kept constant within a closed system**.**

(ii) **Kim Eric Drexler:** (born April 25, 1955) is an American engineer best known for seminal studies of the potential of molecular nanotechnology (MNT), from the 1970s and 1980s.

(iii) **Theodore Maiman** (1927-2007) was an American engineer and physicist credited with the invention of the first working laser.

Any one @ 5

(e) *Use a key way to attach the wheel onto the motor which is secured using a grub screw.*



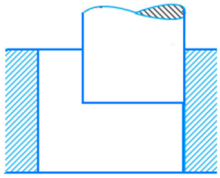
Alternative suggestions accepted

5

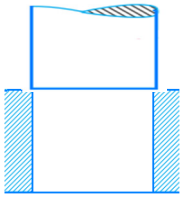
(f) Will turn well into shape, wear resistant, range of colours, will not crush under pressure, etc.

3 + 2

(g) **Clearance fit** has the shaft made smaller than the part it fits into, there is a space to allow the parts to fit together easily.
Interference fit has the shaft made larger than the part it is intended to fit. The parts will have to be forced together.



Clearance fit



Interference fit

5

(h) Oil, water, brine, air cooling, furnace cooling, lime, etc.

Any three @ 2 + 2 + 1

(i) Anodising aluminium can increase corrosion resistance, improve wear resistance, can absorb colour dyes and provide better adhesion for paint primers and adhesives.

5

(j) *Suggested solution, other feasible solutions accepted:*
The shaft can have a series of holes drilled, this allows a threaded or spring-loaded pin to set the height**.**
Tubular shafts fit into each other.

Tightening pin

5

(k) **Semi-conductor:** A material that is neither a good conductor of electricity nor a good insulator but has properties of electrical conductivity somewhere between the two. Silicon and germanium are good semiconductor materials. **5**

(l) Shape of each part, dimensions, assembly details, type of materials, location of drill holes, etc.

Any three @ 2 + 2 + 1

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

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

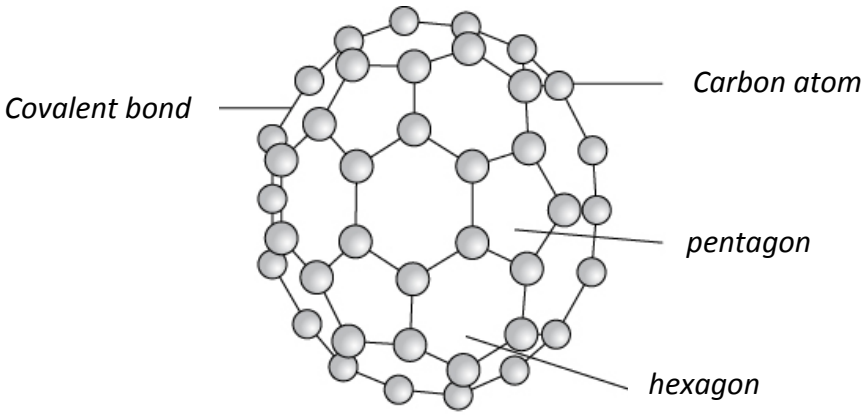
The standardisation of colour codes allows workshop users to be aware of hazards in the workplace.

5

Section B – 50 marks

(n) **(i)** **Nanotechnology** is a part of science and technology about the control of matter on the atomic and molecular scale - this means things that are up to about 100 nanometres. Nanotechnology includes making products that use parts this small, such as electronic devices, catalysts, sensors, etc.

(ii) **Structure:** Buckyballs are composed of carbon atoms linked to three other carbon atoms by covalent bonds. However, the carbon atoms are connected in the same pattern of hexagons and pentagons you find on a soccer ball, giving a buckyball the spherical structure as shown.

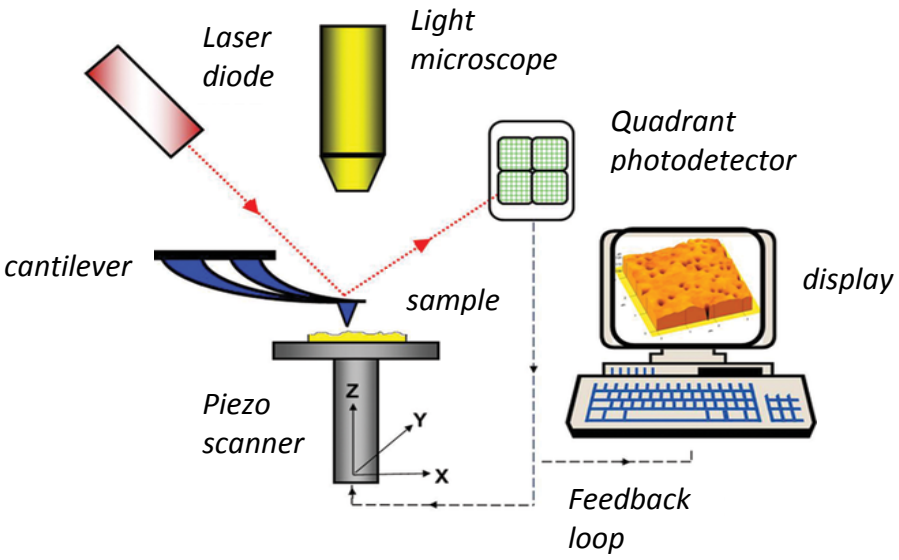


The most common buckyball contains 60 carbon atoms and is sometimes called C60. Other sizes of buckyballs range from those containing 20 carbon atoms to those containing more than 100 carbon atoms.

Properties: The covalent bonds between carbon atoms make buckyballs very strong and the carbon atoms readily form covalent bonds with a variety of other atoms. Buckyballs are used in composites to strengthen material. Buckyballs have the interesting electrical property of being very good electron acceptors, which means they accept loose electrons from other materials. This feature is useful, for example, in increasing the efficiency of solar cells in transforming sunlight into electricity.

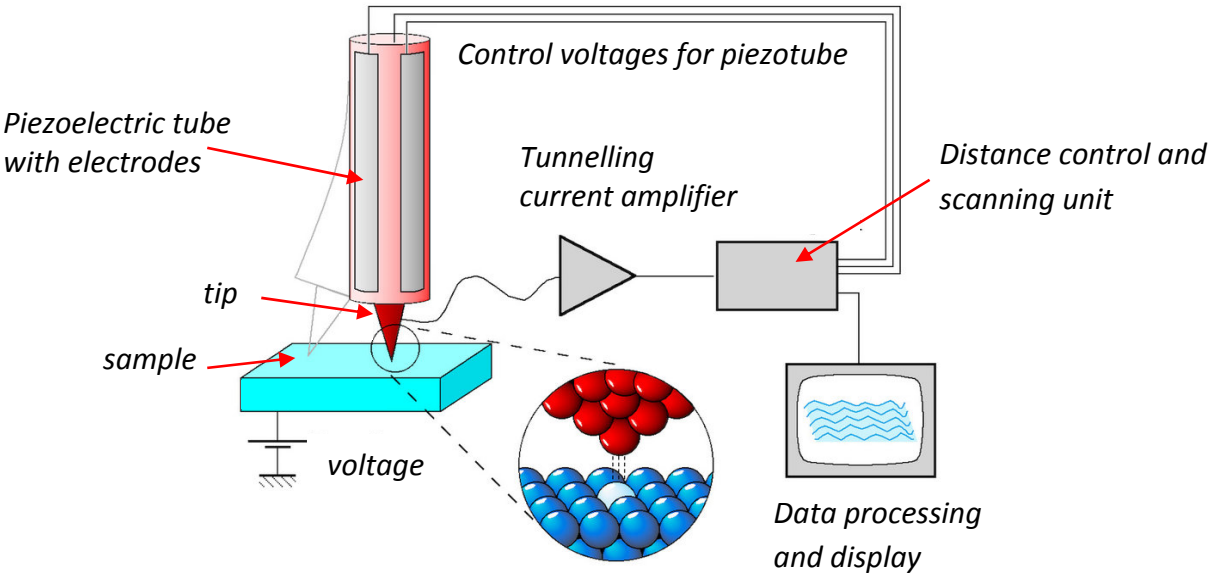
5 + 5

(o) (i) Atomic Force Microscope (AFM).



The free end of the probing cantilever is attached with an atomically sharp tip which is then brought into contact with the surface. The sharper the tip, the better is the resolution. The extent of interactions between the surface and the tip is measured in terms of cantilever displacements. These deflections are monitored using a laser attached to the back of the cantilever, whose beam is detected on a segmented photodetector.
A computer display may be created revealing the configuration of the molecules being imaged by the machine.

(ii) Scanning Tunneling Microscope (STM)



The scanning tunneling microscope (STM) works by scanning a very sharp metal wire tip over a surface. In bringing the tip very close to the surface and applying an electrical voltage to the tip or sample, the surface can be imaged at an extremely small scale. The measuring of changes in current creates the image of the surface at the atomic level.

Any one @ 10

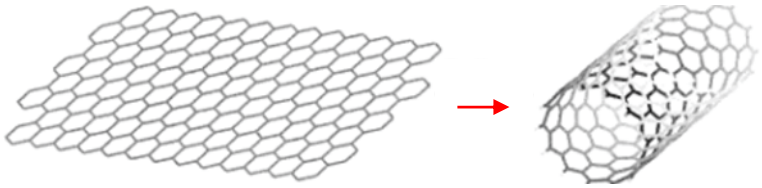
(p) **Diagnosis of medical conditions:** Every disease has a specific biomarker or genetic pattern that nanotechnology can be used to find. This can help doctors identify the disease and by using nanoparticles that bind to that specific tumour, find out where it is located and thus quickly decide on the correct treatment for the disease. This should lead to a less invasive, less painful, quicker and less traumatic experience for the patient.

Delivery of drugs: Nanotechnology can deliver medicine or drugs into specific parts of the human body, thereby making them more effective and less harmful to the other parts of the body.

Prevention of superbugs: Nanoparticles have been developed which target the MRSA bug, latch onto it and are small enough to penetrate its cell membrane, destroying it from within before it develops resistance.

4 + 3 + 3

(q) **(i)** **Construction of carbon nanotubes**



Graphene sheets *carbon nanotubes*

Carbon nanotubes (CNTs) are cylindrical molecules that consist of rolled-up sheets of single-layer carbon atoms (graphene). They can be single-walled (SWCNT) with a diameter of less than 1 nanometer (nm) or multi-walled (MWCNT), consisting of several concentrically interlinked nanotubes, with diameters reaching more than 100 nm. Their length can reach several micrometers or even millimetres. **4**

(ii) **Mechanical properties of graphene sheets:**

- graphene is the extremely stiff
- exhibits very high thermal conductivity
- has virtually zero effective mass
- is impermeable to gases
- displays high mobility of charge carriers
- it is optically transparent. **2 + 2 + 2**

(r) **(i) Electronics**

Increasing the available power from a battery and decreasing the time required to recharge a battery. These benefits are achieved by coating the surface of an electrode with nanoparticles. This increases the surface area of the electrode thereby allowing more current to flow between the electrode and the chemicals inside the battery. This technique could increase the efficiency of hybrid vehicles by significantly reducing the weight of the batteries needed to provide adequate power. Nanotechnology research is currently working with existing battery materials to improve their effectiveness while also examining alternatives such as ultracapacitors to store charge more effectively.

'Quantum dots' nanotechnology create energy efficient LEDs in almost any colour, much closer to our eyes' natural range than existing technology.

(ii) Environmental protection.

The ambition of nanomaterials in agriculture is to reduce the amount of spread chemicals, minimise nutrient losses in fertilization and increased yield through pest and nutrient management. Graphene surface coatings are developed to absorb and release energy like solar panels. Smart glass can alter reflective properties of glass to reduce energy use.

(iii) Clothing.

Engineers in Shanghai Jiao Tong University, China have created a chemical coating that causes cotton materials to clean themselves of stains and remove odours when exposed to sunlight. The researchers say the treatment is cheap, nontoxic and ecologically friendly. This nanotechnology is also used in odour-free socks.

(iv) Water purity

Portable water purifiers like the Lifesaver bottle can be used to collect any available water. Once the bottle is full, it is tightly closed and then pumped. The pressure that builds up by pumping will make the water to pass through a filter, purifying it. This bottle's interchangeable filter can purify up to 6,000 litres. It filters out objects bigger than 15 nm, including viruses, bacteria etc. 0.7 litres of water can be filtered in 20 seconds. Soldiers use this Lifesaver bottle for drinking water.

Any two @ 5 + 5

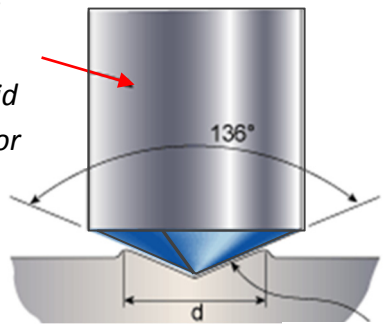
Question 2 (50 Marks)

(a) **(i)** 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.

Hardness is the property of the material which enables it to resist plastic deformation, usually by penetration or by indentation. Hardness is also referred to as temper or the resistance to bending, scratching or abrasion.

3 + 3

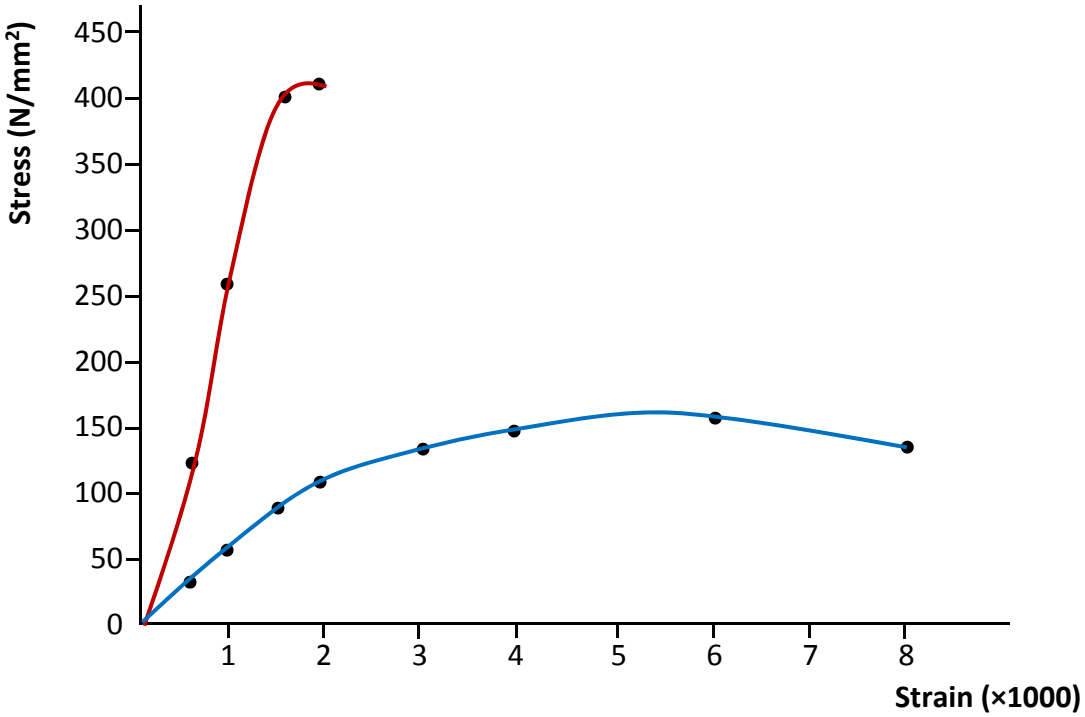
(ii) *Any suitable hardness test, Vickers test is shown.*



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.

10

(b) **(i)** Draw graphs on same axes

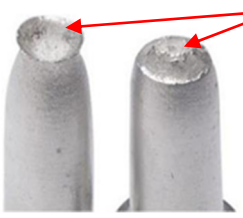


10

(ii) Metal A is likely to fracture with a brittle facture, metal B is likely to exhibit a ductile fracture.

Brittle fracture

Ductile fracture



2 + 2

(iii) **A:** cast iron
B: aluminium, copper, etc.

2 + 2

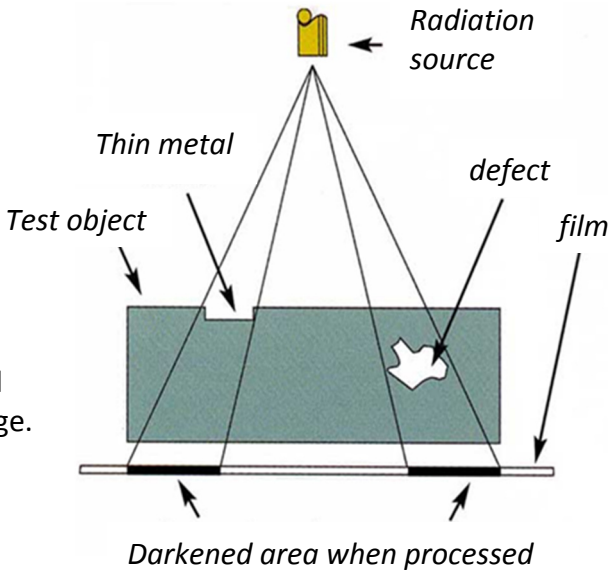
(c) **(i)** Visual inspection: sizeable surface defects.
Dye penetrant testing: surface defects.
Magnetic particle test: surface cracks on ferrous metal objects.
Eddy currents: non-ferrous metals where the flaw is near the surface.

2 + 2 + 2 + 2

(ii) Radiography (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

Question 3 (50 Marks)

(a) **(i)** Annealing the centre hub is carried out to make a metal softer, it also improves machinability, ductility, refines grain size and minimises internal stresses. **6**

(ii) Higher carbon content steels will harden more effectively. The hardening process entails heating to a red colour and quenching quickly.
When hardened, the wheel needs to be tempered to reduce brittleness. The object is cleaned and then heated slowly and carefully until it reaches tempering temperature (220-300^{o}C) this is usually indicated by colour changes form straw through to blue.

10

(b) **(i)** **A:** Austenite
B: Pearlite and Cementite **3 + 3**

(ii) **X:** Low carbon steel with 0.2% carbon.

- Lower hardness
- Reduced strength
- Fabricates and cuts well
- Will cold form, bend and press
- Tough and ductile
- Malleable
- Will weld well

Y: Medium carbon steel with 1.5% carbon.

- Higher hardness
- Stronger
- Can be used after cold forming
- Will harden further by heat treatment
- More brittle
- Poor welding performance

6

(iii) **Eutectoid point**

Phase change: solid austenite changes to solid pearlite

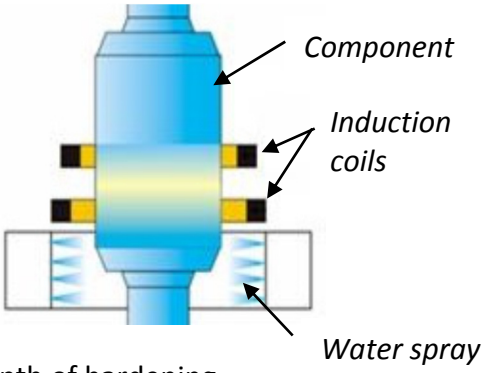
Temperature: 723^{o}C

Composition: 0.83% carbon

6

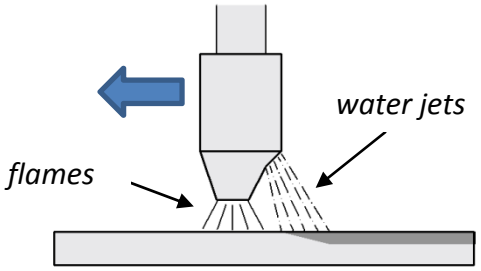
(c) **Induction hardening**

A coil carries high frequency currents which 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 while the inner core is tough. The frequency of the current determines the depth of heating and the depth of hardening.



Flame hardening

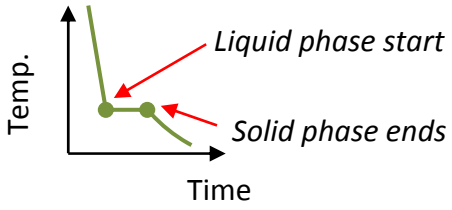
The surface of the steel object is heated to 850˚C with an oxy-acetylene flame and quenched quickly. This creates a hard outside layer as the heated austenite structure changes to hard martensite. The depth of hardening depends on the rate of heating.



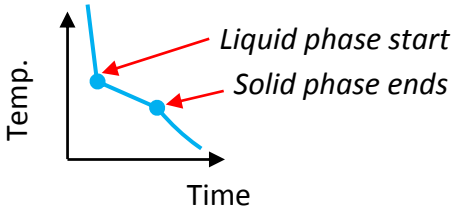
16

Question 4 (50 Marks)

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



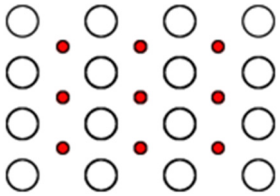
Cooling curve for a pure metal



Cooling curve for an alloy

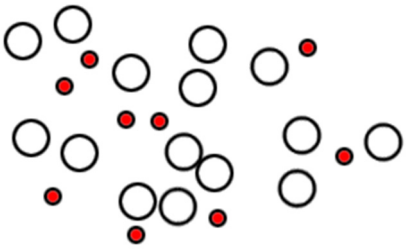
(ii) Crystalline solid structures

Crystalline atoms are arranged in a pattern



Amorphous solid structures

Amorphous atoms are arranged randomly

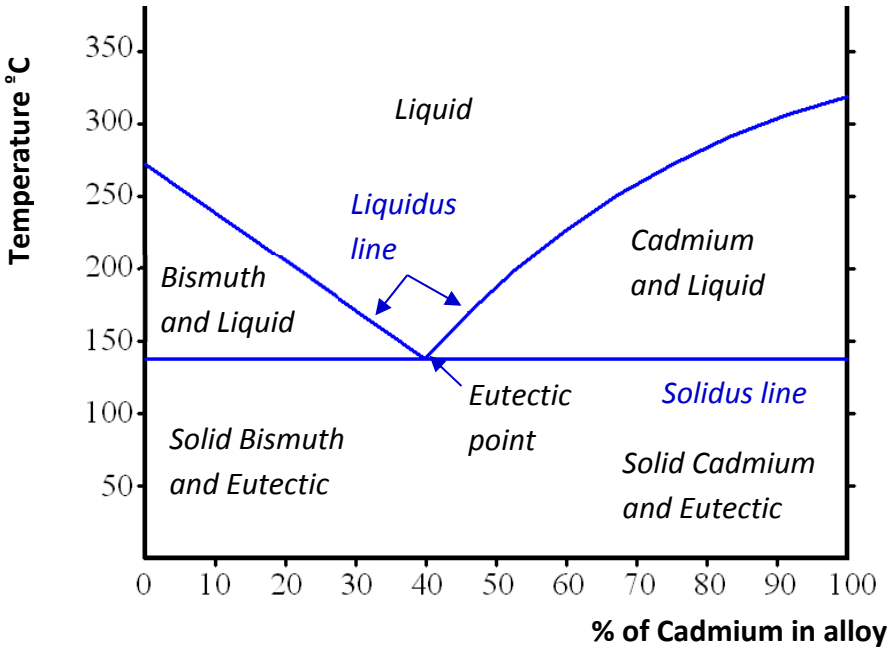


(iii) Eutectic point is the point in a phase diagram indicating the chemical composition and temperature corresponding to the lowest melting point of a mixture of components. The eutectic point occurs at 4.3% carbon and 1147 °C.

When the solution above the transformation point is solid, rather than liquid, a eutectoid transformation can occur. For instance, in the iron-carbon system, the austenite phase can undergo a eutectoid transformation to produce ferrite and cementite, often in lamellar structures such as pearlite. This eutectoid point occurs at 723 °C and 0.83% carbon.

Any two @ 8 + 8

(b) (i) Draw the thermal equilibrium diagram



10

(ii) **Liquid:** the two metals are soluble in each other in the liquid state.
Liquidus line: the change from fully liquid to pasty state. Above the liquidus line, the alloy is liquid. This is the beginning of solidification.
Liquid and bismuth: solid bismuth and liquid.
Liquid and cadmium: solid cadmium and liquid.
Solidus line: the change from pasty to solid. Below the solidus line, the alloy is cooling and solid. This is the end of solidification.
Solid Cadmium and eutectic: at 100% Cadmium, there is a large amount of solid Cadmium. This decreases in the alloys found nearer to the eutectic. This also applies for Bismuth.
Solid: alloy is in solid form.
Eutectic point: a change point in which the alloy changes from liquid to solid without going through a pasty phase.

Any three @ 2 + 2 + 2

(iii) **Eutectic alloy:** A mixture of metals that is completely soluble in the liquid state but insoluble in the solid state.

2

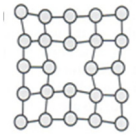
(c) (i)

As a metal reaches its cooling point small particles cool first. Solidification takes place in a pattern. Each small particle grows to form a crystal or grain. Crystals grow together to form a solid. This process is known as dendritic growth from Greek word “dendron” for treelike.

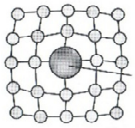
8

(ii) **Crystal point defects**

Vacancy: if there is an atom missing from the lattice, the other atoms are forced towards the vacant space.

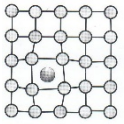


Substitution: if atoms from another element have taken the place of atoms of the parent metal. These atoms may not be the same size and may cause a distortion of the lattice.



Larger atoms can distort lattice

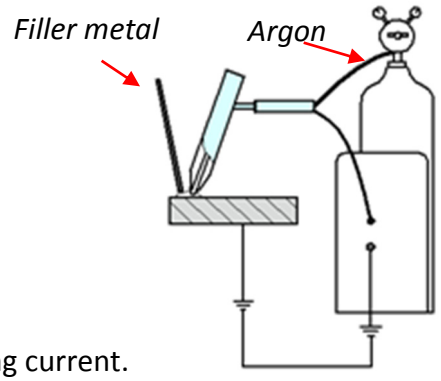
Interstitial: an atom from another element moves into the space between the atoms of the parent metal lattice.



Any two @ 4 + 4

Question 5 (50 Marks)

(a) **(i)** **Tungsten inert gas (TIG) welding**:



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.

8

(ii) Tungsten inert gas (TIG) welding is used as:

- A stronger, more durable weld is produced
- As the metal is prone to oxidation, Argon gas acts as a shielding gas
- A neat, spatter-free weld is usually produced

4 + 4

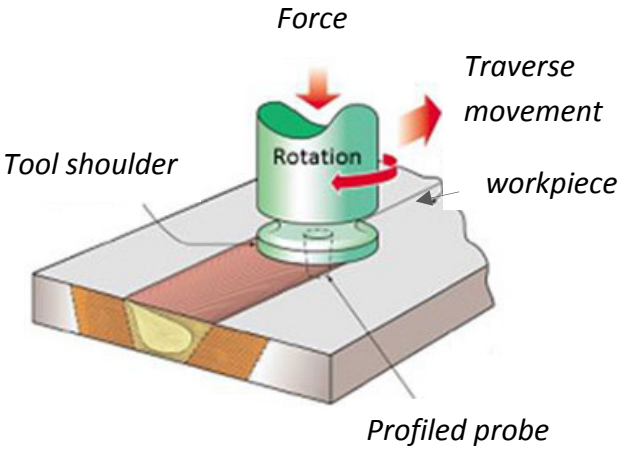
(b) **(i)** **Rectifier:**

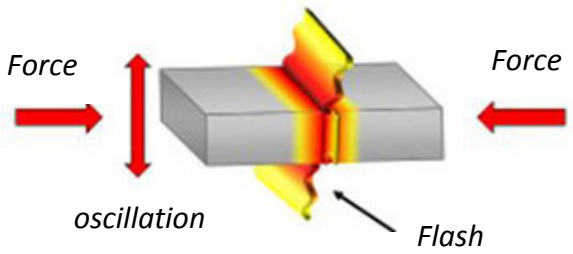
Used to convert mains supply alternating current (AC) to the direct current (DC) needed for welding.

(ii) 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.

(iii) Friction welding is solid-state joining technique that welds workpieces by generating heat through mechanical friction.

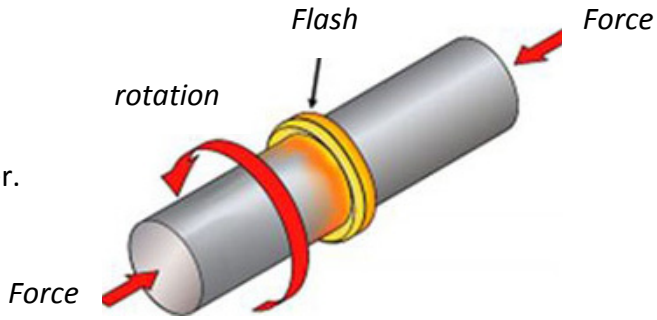
Friction Stir Welding (FSW) works by using a non-consumable tool, which is rotated and plunged into the interface of two workpieces. The tool is then moved through the interface and the frictional heat causes the material to heat and soften.





Linear Friction Welding (LFW) works by linearly oscillating one workpiece relative to another while under a compressive force. The friction between the oscillating surfaces produces heat, causing the interface material to soften and mechanically mix.

Rotary Friction Welding (RFW) is similar to LFW except that the workpieces are often round and are rotated relative to each other.



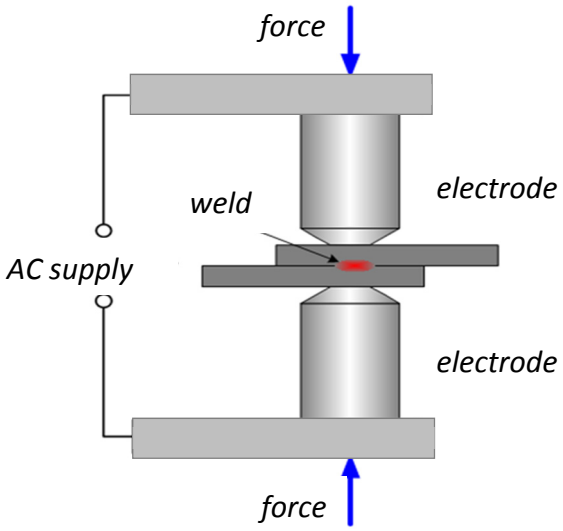
(iv) In manual metal arc welding (MMA), the flux electrode coating melts and gives off a gas to protect the weld from the surrounding air, a protective slag coating forms on top of the weld.

(v) Hazard of bright light from welding for user and others in the workshop.
Danger of fumes from welding and burning coatings on metals.
MIG welding produces hot metals.
Inexperienced users need to be supervised.
Weld Splatter.
Electric Shock.

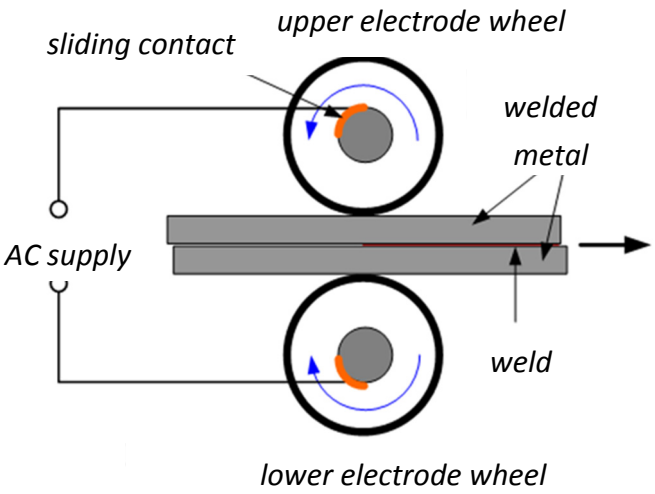
Any Three @ 6 + 6 + 6

(c)

Resistance spot welding



Resistance seam welding



Electrode shape:

The electrode is in the shape of a round bar with tapered ends where it contacts the material.

The electrodes are disc shapes as they need to rotate during the process.

Welding procedure:

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.

A form of resistance welding that uses copper roller electrodes to provide a continuous run of overlapping 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 weld.

Applications:

Used in the automotive industry for body panel assembly.

Used when continuous tight weld is required e.g. fuel tanks, drums, domestic radiators.

Safety Considerations:

Electrical equipment needs to be maintained. Localised spots of weld will be hot after welding, metal must be handled with care.

Process tends to be more automated allowing sheet metal to move through the machine.
A strip of hot metal is created while welding.

16

OR

(i) **Assisting a person with a disability:** can compensate for inactive or missing limbs, movement can be sensed and activated by robotic suit, etc.
Rehabilitation due to injury: exoskeleton suit can support site of injury, allow exercise to start before healing is complete, can monitor progress, virtual reality can be incorporated to improve balance, walking, etc.

4 + 4

(ii) Remote surgery, microsurgery, telepresence allows a specialist to use robots to treat patients in remote locations, medical transportation robots can navigate through large facilities, robots can be used to sanitise and disinfect rooms from infections, prescription dispensing systems etc.

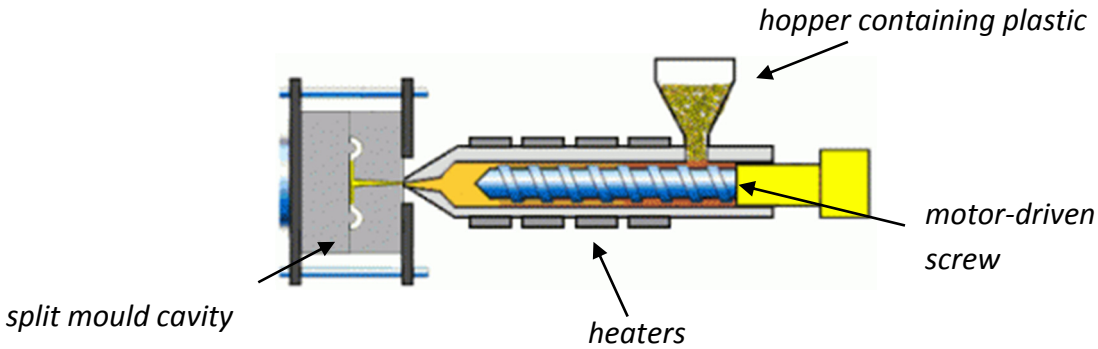
4 + 4

Question 6 (50 Marks)

(a) **(i)** **Properties:** tough impact-resistant polymer, wear-resistant, ultra-violet resistance, resistant to water and salt-water, capable of machining and moulding to shape.

3 + 3

(ii) **Injection Moulding:**
This is an efficient method of shaping thermoplastics of complicated shapes and various cross sections in large quantities.



The mould has a hollowed out shape of the oarlock body.

With the split mould firmly clamped under pressure, plastic granules are fed from the hopper. These plastic granules are then made into a molten plastic liquid using heat, friction and force.
Pressure is applied after the molten plastic material has been injected into the mould to make sure that all of cavities and spaces have been filled.
In the final stage of the process as the screw begins moving back for the next moulding the tool is opened. The opening of the tool allows the finished plastic moulding of the oarlock body to be ejected.

10

(b) (i) **Copolymerisation:**
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. Many commercially important polymers are copolymers including polyethylene-vinyl acetate (PEVA), nitrile rubber and acrylonitrile butadiene styrene (ABS).

(ii) **Elastic memory** in thermoplastics is the ability of the polymer to return to its original state from a deformed state. If a thermoplastic has been bent to a specific shape, when reheated it will return to its original shape.
Elasticity is displayed when a load is applied to a polymer to cause the object to change shape. When the load is removed, the polymer will return to its original shape.

(iii) Lubricants make the polymer easier to mould. Various types of waxes are used in small amounts for this purpose.

(iv) Most plastic materials have a long life and will degrade slowly.
A large proportion of polymers are used for convenience applications (bags, bottles, etc.) due to their ease of mass production. Plastic objects are currently cost-effective to use in this way with limited taxing of single-use objects.
A small proportion of plastic objects are recycled, remoulded or reused. Plastic objects are frequently sent to landfill, incinerated or discarded into the seas or environment, this has implications for marine and wildlife.

Any three @ 6 + 6 + 6

(c) (i) **Lamination:** Thin layers of materials bonded together. High strength plastics can be produced by layers of paper or cloth coated with resin being bonded together. Heat and pressure can be used.

Carbon fibre: The addition of glass or carbon fibre greatly increases the strength of plastic materials, commonly polyester resins are used. Boats and storage tanks are commonly made from these materials

4 + 4

(ii) The honeycomb structure adds strength, stiffness and thickness to the boat structure. The racing boat remains light with excellent strength-to-weight properties.

8

Question 7 (50 Marks)

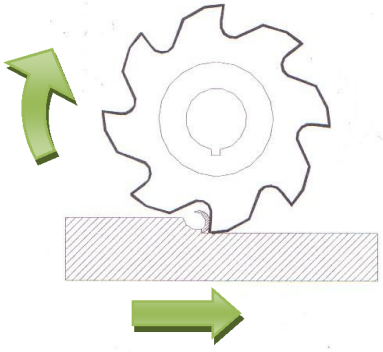
(a) (i) **Material surface finish**: reduces vibration, maintains tool sharpness, the reduction in heat improves surface finish, cutting fluids have a lubricating impact, etc.
Cutting tool life: tool stays sharp for longer which makes metal cutting more effective, reduces heat generated, higher machine speeds can be used, etc.

4 + 4

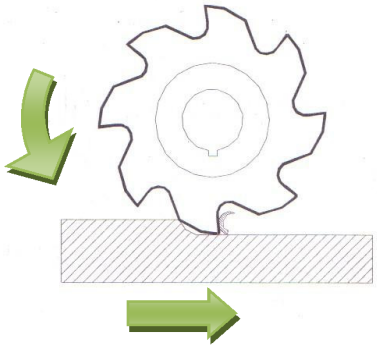
(ii) Rancidity of the cutting fluid is caused by bacteria and other microscopic organisms growing and eventually causing bad odors to form. Most cutting fluids contain bactericides that control growth of bacteria and make fluids more resistant to rancidity. Other ways of preventing rancidity include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

8

(b) (i) **Up-cut milling:** The conventional milling method. In this process the milling cutter is rotating against the direction of the workpiece. There is a danger of the workpiece lifting out of the vice, therefore effective clamping is necessary. A smoother cutting action is achieved.
Down-cut milling:
The milling cutter rotates in the same direction as the workpiece movement, it is also known as 'climb milling'. A 'blacklash' eliminator should be fitted to the machine for this type of milling to allow heavier cuts to be taken without the tendency to lift. It produces a finish with less defined cuter marks.



Up-cut milling



Down-cut milling

(ii) **Safety features on a bench grinder:**

- A face guard is supplied with the machine to protect against grinding debris.

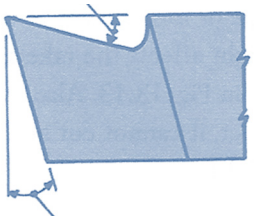
- Easily accessible switches allow the machine to be turned off quickly.
- Modern machines are designed to stop quickly.
- The machine should be capable of being securely attached to the bench.

(iii) A drill bit is used to cut a round hole in a material.
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.

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

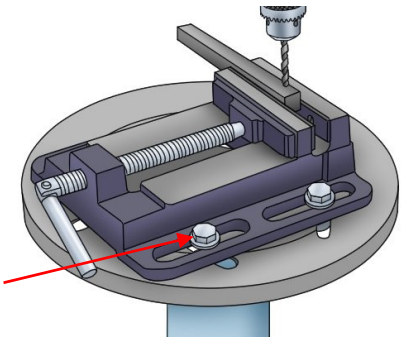
Clearance angle is formed to allow one point of the cutting contact the workpiece.

Rake angle



Clearance angle

(v) The drill vice may be bolted securely to the drill table using the slots in the table.



Nut and bolt on vice

Any three @ 6 + 6 + 6

(c) **(i)** During the production of tungsten carbide cutting tool inserts, cobalt and tungsten powder are mixed with cemented carbide and pressed into shape.

The process:

Carbon black, tungsten metal and metal oxides are mixed and heated until the carbon bonds with the tungsten (carburises).
Mix the tungsten carbide powder with wax and cobalt.
This is mixed very thoroughly using a ball mill to give you a final powder.
This final powder is put in a mould and pressed to the desired shape.
Heat (pre-sinter) the pressed, final powder enough so that is sticks together and shapes like soft chalk.
Put the soft chalk pieces in a very hot, high pressure, special atmosphere oven and do the final sinter where the powder cooks, shrinks and gets very hard, this is the final piece of tungsten carbide.

8

(ii) **Advantages of using carbide inserts:**

- Tungsten carbide tools will retain their cutting edge at high temperatures more effectively than 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. **4 + 4**

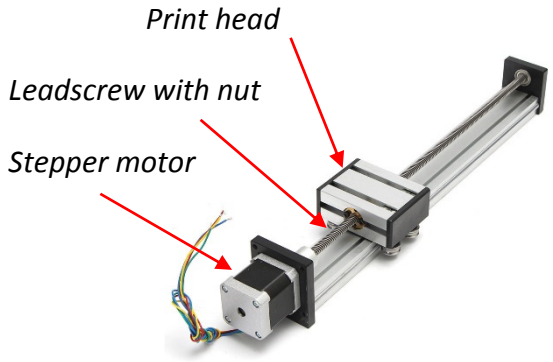
OR

(c) **(i)** **Impact on productivity:** products can be manufactured precisely at greater speeds than by using traditional technology, less expertise is required, machines will run without interruption, tool changes are automated, etc.
Reliability: CNC machines will produce high quality products on a consistent basis, accuracy is assured, etc. **4 + 4**

(ii) **Automatic tool change:** It allows the machine to work with a large number of tools without an operator. When required, stored tools will assume a fixed position (tool change position) to allow the machine pick up the required tool.
Test run: the machine will simulate the cutting operations of a designed workpiece to ensure that the CNC machine will produce a suitable workpiece in the most efficient method. **4 + 4**

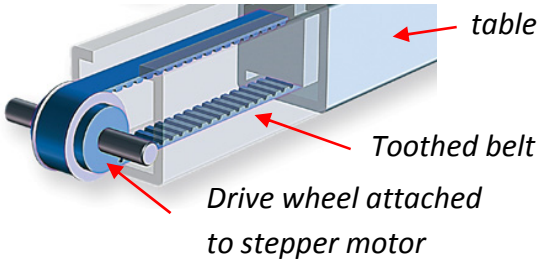
Question 8 (50 Marks)

(a) **(i)** The leadscrew will translate turning motion into linear motion. The pitch or lead is the distance the nut travels along the screw for every complete revolution. The stepper motor will rotate the leadscrew precisely to ensure that the printing head will raise and lower the correct distance.



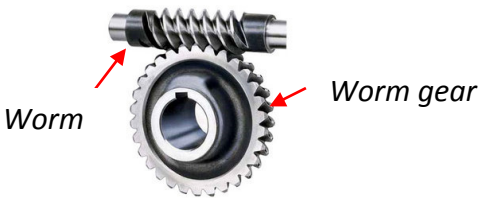
8

(ii) The table can be precisely controlled by a toothed belt (or plastic chain) driven by a stepper motor and gear. This will produce a precise and quiet drive.



8

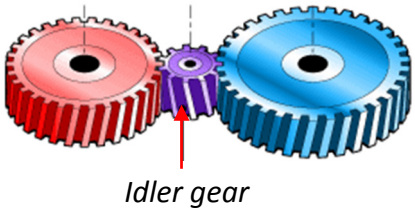
(b) **(i)** As the worm moves forward for a full revolution, the gear will move forward by one tooth. The shaft of the worm gear is mounted at 90° to the shaft of the worm.



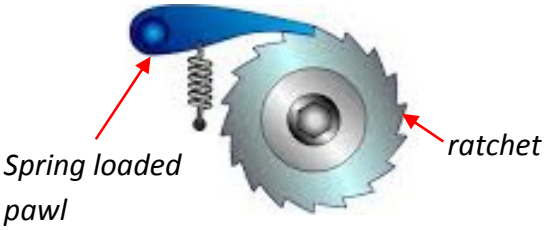
(ii) Chemical energy to electrical energy.

(iii) The toothed belt drive motion is quieter in operation than the chain drive.
The toothed belt can absorb shock through slip, the chain is more likely to break or damage the mechanism when shock load occurs and it does not require lubrication.
Toothed belts are easier to change.

(iv) **Idler gears** are used to change the direction of a gear train, it can ensure that driver and driven gears rotate in the same direction.

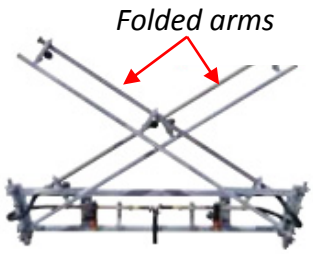


(v) The lifting winch allows a ratchet wheel to turn in one direction only and prevents it slipping back. The pawl locks into the ratchet teeth preventing movement in the opposite direction.



Any three @ 6 + 6 + 6

(c) **(i)** The boom arms can retract into a storage position by folding the linkages, this can be powered by hydraulics or manually folded and locked into position.



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(ii) **Advantages:** provides a large spraying area making the process faster, boom stores more efficiently when folded, product can easily be transported, etc.
Disadvantages: lightweight arms can damage if obstacles catch it, the rear facing arms demand driver concentration as the arms are considerably wider than the vehicle, need to be folded when going through narrow gaps, etc. **4 + 4**

OR

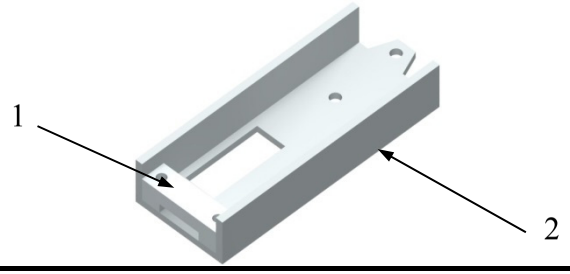
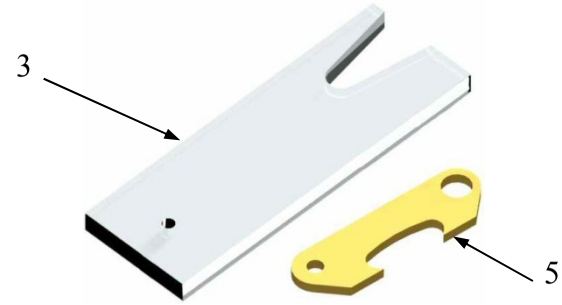
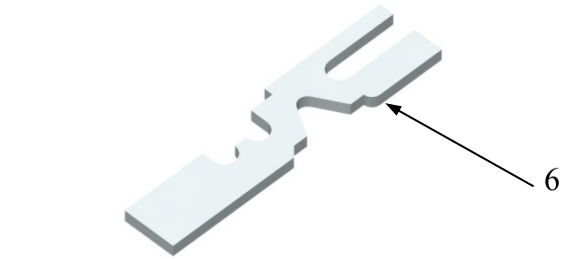
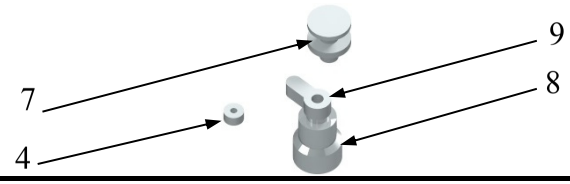
(c) **(i)** A transformer will reduce the voltage in a power supply circuit usually from 240 V mains supply to 6-12 V. **8**

(ii) PCB, capacitors, diode, bridge rectifier, inductor coil. **8**

Coimisiún na Scrúduithe Stáit
State Examinations Commission

Day 1 - Leaving Certificate Engineering - Practical Marking Scheme 2019

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

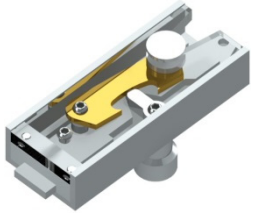
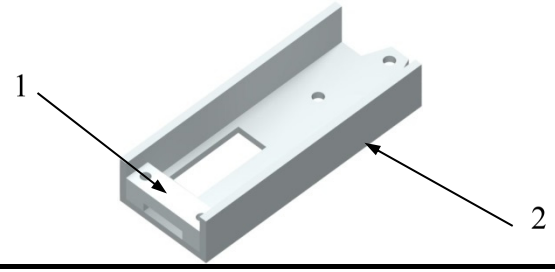
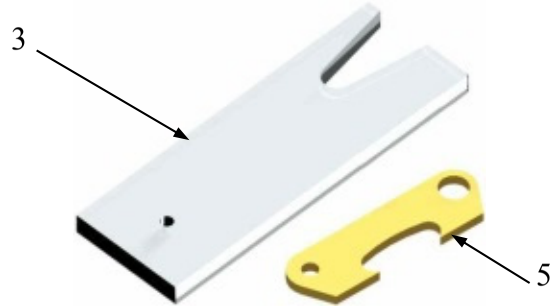
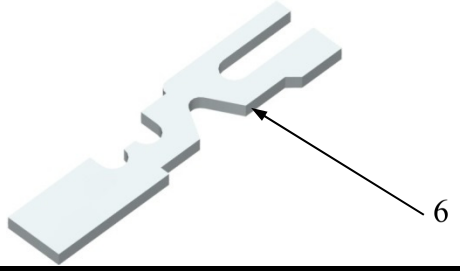
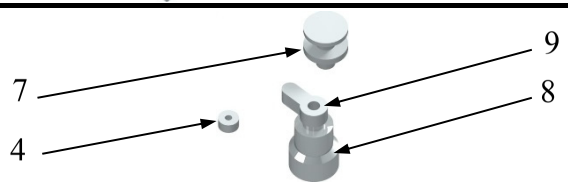
Section	Part Number	Pictorial Sketch / Description	Concept		Mark	Mark
1	**All Parts**		**Assembly** **Function** **Finish** Subjective Mark 1 – 20		**20**	**20**
2	**Parts 1 and 2**		**Part 1** 5 Marks	Pre-Prepared Work	**2**	**20**
				18mm × 4mm Slot	**3**	
			Part 2 15 Marks	Pre-Prepared Work	**2**	
				Ø4.5mm & Ø8mm Holes	**5**	
				Rectangular Slot	**4**	
				End Tab	**4**	
3	**Parts 3 and 5**		**Part 3** 6 Marks	Marking Out	**2**	**20**
				Profile	**3**	
				Drill and Tap	**1**	
			Part 5 14 Marks	Marking Out	**4**	
				Ø4.5mm & Ø8mm Holes	**2**	
				External Profile	**4**	
				Internal Profile	**4**	
4	**Part 6**		**Part 6** 20 Marks	Marking Out	**4**	**20**
				8mm Guiding Slot	**3**	
				Tapered Slot Profile	**4**	
				16mm Locking Slots Profile	**4**	
				3mm Step, Taper and Radius	**3**	
				18mm Bolt Profile	**2**	
5	**Parts 4, 7, 8 and 9**		**Parts 4, 7 & 8** 10 Marks	Turning, Drilling and Tapping	**5**	**20**
				Knurling	**5**	
			Part 9 10 Marks	Marking Out and Ø4.5mm Hole	**2**	
				External Profile	**8**	

100 Marks (×1.5 = 150 Total)

Coimisiún na Scrúduithe Stáit
State Examinations Commission

Day 2 - Leaving Certificate Engineering - Practical Marking Scheme 2019

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

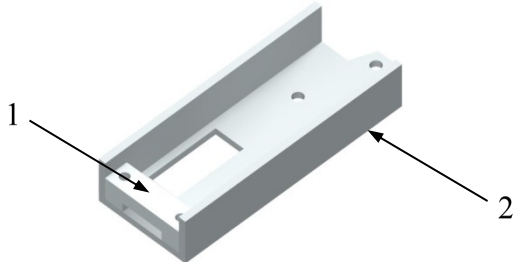
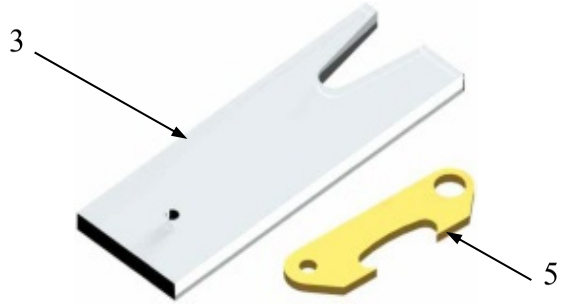
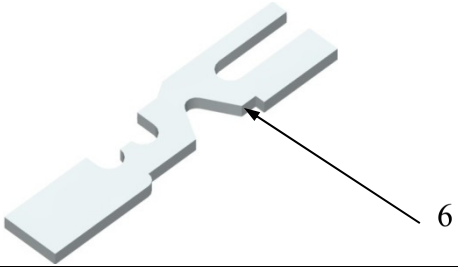
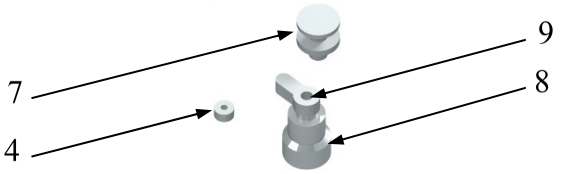
Section	Part Number	Pictorial Sketch / Description	Concept		Mark	Mark
1	**All Parts**		**Assembly** **Function** **Finish** Subjective Mark 1 – 20		**20**	**20**
2	**Parts 1 and 2**		**Part 1** 5 Marks	Pre-Prepared Work	**2**	**20**
				18mm × 4mm Slot	**3**	
			Part 2 15 Marks	Pre-Prepared Work	**2**	
				Ø4.5mm & Ø8mm Holes	**5**	
				Rectangular Slot	**4**	
				End Tab	**4**	
3	**Parts 3 and 5**		**Part 3** 6 Marks	Marking Out	**2**	**20**
				Profile	**3**	
				Drill and Tap	**1**	
			Part 5 14 Marks	Marking Out	**4**	
				Ø4.5mm & Ø8mm Holes	**2**	
				External Profile	**4**	
				Internal Profile	**4**	
4	**Part 6**		**Part 6** 20 Marks	Marking Out	**4**	**20**
				8mm Guiding Slot	**3**	
				Tapered Slot Profile	**4**	
				16mm Locking Slots Profile	**4**	
				3mm Step, Taper and Radius	**3**	
				18mm Bolt Profile	**2**	
5	**Parts 4, 7, 8 and 9**		**Parts 4, 7 & 8** 10 Marks	Turning, Drilling and Tapping	**5**	**20**
				Knurling	**5**	
			Part 9 10 Marks	Marking Out and Ø4.5mm Hole	**2**	
				External Profile	**8**	

100 Marks (×1.5 = 150 Total)

Coimisiún na Scrúduithe Stáit
State Examinations Commission

Day 3 - Leaving Certificate Engineering - Practical Marking Scheme 2019

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**		**Assembly** **Function** **Finish** Subjective Mark 1 – 20		**20**	**20**
2	**Parts 1 and 2**		**Part 1** 5 Marks	Pre-Prepared Work	**2**	**20**
				18mm × 4mm Slot	**3**	
			Part 2 15 Marks	Pre-Prepared Work	**2**	
				Ø4.5mm & Ø8mm Holes	**5**	
				Rectangular Slot	**4**	
				End Tab	**4**	
3	**Parts 3 and 5**		**Part 3** 6 Marks	Marking Out	**2**	**20**
				Profile	**3**	
				Drill and Tap	**1**	
			Part 5 14 Marks	Marking Out	**4**	
				Ø4.5mm & Ø8mm Holes	**2**	
				External Profile	**4**	
				Internal Profile	**4**	
4	**Part 6**		**Part 6** 20 Marks	Marking Out	**4**	**20**
				8mm Guiding Slot	**3**	
				Tapered Slot Profile	**4**	
				16mm Locking Slots Profile	**4**	
				3mm Step, Taper and Radius	**3**	
				18mm Bolt Profile	**2**	
5	**Parts 4, 7, 8 and 9**		**Parts 4, 7 & 8** 10 Marks	Turning, Drilling and Tapping	**5**	**20**
				Knurling	**5**	
			Part 9 10 Marks	Marking Out and Ø4.5mm Hole	**2**	
				External Profile	**8**	

100 Marks (×1.5 = 150 Total)

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