Coimisiún na Scrúduithe Stáit
State Examinations Commission

Leaving Certificate 2016

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 2016

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 2016

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) 2 + 2 + 1
(c) 5
(d) **Any two** @ 3 + 2
(e) 3 + 2
(f) **Any two** @ 3 + 2
(g) 5
(h) **Any two** @ 3 + 2
(i) 5
(j) 4 + 1
(k) 5
(l) **Any two** @ 3 + 2
(m) **Any two** @ 3 + 2

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

(n) 4 + 3 + 3

(o) (i) 1 + 1 + 1 + 1
(ii) 4
(iii) 2

(p) (i) 5
(ii) 5

(q) 10

(r) 5 + 5

Question 2 – 50 marks

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

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

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

Question 3 – 50 marks

(a) (i) 10
(ii) 6

(b) (i) 1 + 1 + 1 + 1 + 1 + 1
(ii) 8
(iii) 3 + 2

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

Question 4 – 50 marks

(a) 16

(b) (i) 8
(ii) 4 + 4
(iii) 2

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

Question 5 – 50 marks

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

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

(c) 16

OR

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

Question 6 – 50 marks

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

(b) (i) 2 + 2
(ii) 10
(iii) 4

(c) (i) 4
(ii) 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) 6 + 6 + 4

Question 8 – 50 marks

(a) (i) 8
(ii) 8

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

(c) (i) 8
(ii) 8

OR

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

Sample Answers *and* Marking Scheme, 2016

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) Tensile strength, impact resistance, resistance to corrosion, cost, malleability, etc.

(Any two) 3 + 2

(b) **Quenching media** used in heat treatment of metals include water, brine, oil, lime and air.

(Any three) 2 + 2 + 1

(c) **(i)** **Bill Gates**
Born in October 28th 1955, Gates is an American computer programmer and inventor who co-founded Microsoft, the world's largest PC software company, with Paul Allen in 1975.

(ii) **Charles Hull**
Born May 12th 1939 in America, Hull is the co-founder and chief technology officer of 3D Systems. He is the inventor of the solid imaging process known as stereolithography (3D Printing), the first commercial rapid prototyping technology and the STL file format.

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

(Any one) 5

(d) Lighter structure weight, greater strength to weight ratio, flexibility in design, will not rust, etc.

(Any two) 3 + 2

(e) **Advantages:** Capable of cutting varied materials and thicknesses. It is reliable, fast, easily and accurately repeatable and there is no secondary clean-up process required for most materials.
Disadvantages: High power consumption and can be expensive. Poorly adjusted lasers can cause burning and may have difficulty cutting reflective metals like copper, brass and aluminum.

3 + 2

(f) Prototypes are used to identify weaknesses in product design at an early stage, avoid waste, should make production more efficient, a physical 3D model is produced which provides an appreciation of shape, form and ergonomics, etc.

(Any two) 3 + 2

(g) Expanded polystyrene is a lightweight, easily moulded plastic material that is warm to the touch, this makes it a suitable material for cycling helmets. It can be moulded into intricate and attractive aerodynamic shapes where it will absorb significant initial forces on impact.

5

(h) **Advantages of using pneumatics over hydraulic power:**

- pneumatic power offers a very clean system, it is suitable for food manufacturing processes and other processes which require no risk of contamination
- pneumatics offer rapid movement of cylinders
- available in very small sizes.

(Any two) 3 + 2

(i) **Magnetic separation**

In the separation of ores that have magnetic properties, the ore is ground and passed over a rotating drum. The drum has a magnet inside it which holds the magnetic ore particles as the waste falls outside the screen. The ore held on the drum can be released or scraped off.

5

(j) Malleability is the ability of a material to be flattened out in all directions without fracturing. Pewter is used for statues and ornaments due to its low melting point, casting ability, cost, can be easily engraved and provides a splendid display.

4 + 1

(k) A **factor of safety** is the degree of structural capacity beyond applied loads. In the case of a pedestrian bridge, structural design must take into account excessive weight and weather conditions which leads to the "over design" of the bridge. Failure in this industry could result in loss of life and loss of credibility for manufacturers.

5

(l) Chrome-plating the steel rim will prevent the steel from rusting, allow the rim to be cleaned easily, increase the surface hardness of the rim, provide an attractive aesthetic finish and increase the value of the rim.

(Any two) 3 + 2

(m) The steel spikes would increase traction with the race track for the athlete and the steel spikes would wear at a slower speed compared to plastic spikes. There would be less flexibility with the steel spikes compared to plastic spikes.

(Any two) 3 + 2

Section B – 50 marks

(n) Advantages of using rapid prototyping techniques in the design of new products:

- Almost any shape or geometric feature can be produced.
- Reduction in time and cost.
- Errors and flaws can be detected at an early stage.
- RP can be used in different industries and fields of life (medicine, art and architecture, marketing).
- Discussions with the customer can start at an early stage.
- Assemblies can be made directly in one go.
- Material waste is reduced.
- No tooling is necessary.
- The designers and the machinery can be in separate places.

(Any three) 4 + 3 + 3

(o) **(i)** **A –** Extruder head

B – Heater

C – Nozzle

D – Build platform

1 + 1 + 1 + 1

(ii) **Principle of operation**

In this process, a plastic or wax material is extruded through a nozzle that traces cross-sectional geometry of the part layer by layer.

FDM has become a widely used additive fabrication technologies. A plastic filament is unwound from a coil and supplies material to an extrusion nozzle. The nozzle is heated to melt the plastic and has a mechanism which allows the flow of the melted plastic to be turned on and off. The nozzle is mounted to a mechanical stage which can be moved in both horizontal and vertical directions.

As the nozzle is moved over the table in the required geometry, it deposits a then bead of extruded plastic to form each layer. The plastic cools and hardens immediately after feeding from the nozzle and bonds to the layer below.

4

(iii) Filament materials include Acrylonitrile Butadiene Styrene (ABS), Polylactic acid (PLA), Polycarbonate (PC), Polyamide (PA), Polystyrene (PS), etc.

2

(p) (i) Architecture

Rapid prototyping techniques are very suitable for the production of city and landscapes, this gives an immediate visual representation allowing the impact of new buildings to be analysed. Production time is dramatically reduced in comparison to traditional modelling techniques. 3D models are produced using the same CAD data used for architectural design. Editing and altering aspects of design becomes more efficient with an ultimate saving on building costs.

It is feasible that 3D printing will be a significant production tool in the large-scale building of houses.

5

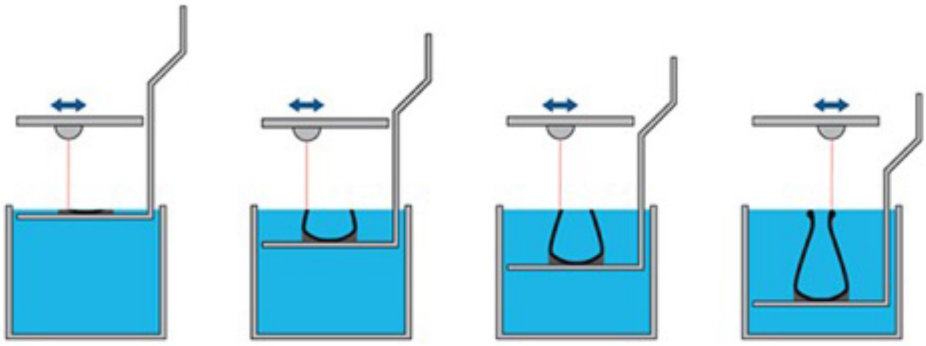
(ii) Medical applications

3D printing has the significant advantage of producing bespoke medical implants customised to each individual in a short space of time. Prosthetic devices are suitable for effective printing. Used in conjunction with 3D scanning, printing can assist with medical diagnosis as well as complicated surgery planning. 3D printing has the potential to create living tissue through bioprinting.

5

(q) (i) Stereolithography (SLA)

Stereolithography is the most widely used rapid prototyping technology. It can produce highly accurate and detailed polymer parts. SLA was the first rapid prototyping process, introduced in 1988, by 3-D Systems Inc. SLA uses a low-power, highly focused UV laser to produce a three dimensional object in a vat of liquid photosensitive polymer.

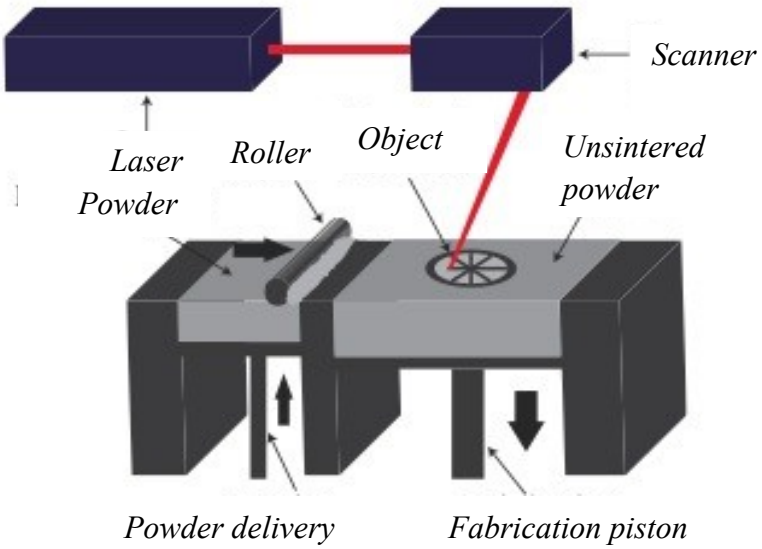


Stereolithography builds plastic parts or objects one layer at a time by tracing a laser beam on the surface of a vat of liquid photopolymer. This class of material originally developed for the printing and packaging industries, it quickly solidifies wherever the laser beam strikes the surface of the liquid. Once one layer is completely traced, it is lowered a small distance into the vat and a second layer is traced right on top of the first. The self-adhesive property of the material causes the layers to bond to one another and eventually form a complete, three-dimensional object after many such layers are formed.

Uncured materials can be toxic with the need for ventilation.

(ii) **Selective Laser Sintering (SLS)**

The basic concept of SLS is similar to that of SLA.
SLS uses a moving laser beam to trace and selectively sinter powdered polymer or metal composite materials. The powder is kept at elevated temperature. Unlike SLA, special support structures are not required because the excess powder in each layer as a support. With the metal composite material, the SLS process solidifies a polymer binder material around steel powder one slice at a time forming the part. The part is then placed in a furnace where the polymer binder is burned away. SLS allows for a wide range of materials, including nylon, glass-filled nylon and metal composites.



Fine particles of some metals can be dangerous to inhale making ventilation systems important in this process.

(Any one) 10

(r) **(i)** Dual extruder

The dual extruder is a printing head which allows two types of material to be used at the same time. The second material can be used to assist in the manufacture of the object or add other colours to the object.

(ii) Additive process

The principle that materials are added together, usually in layers, to make a product. This saves on material used in traditional manufacturing techniques where material is cut away to form an object.

(iii) Support materials

During the printing of some objects it is necessary to use a second material to build up the model. Complex shapes can be created with inclusion of this removable support material.

(iv) The environmental impact of using rapid prototyping techniques:

- Excessive waste of print material is avoided
- Less expensive tooling is used
- Edits and mistakes are reduced producing a reduction in trial products
- Focus on recycled materials for printing.

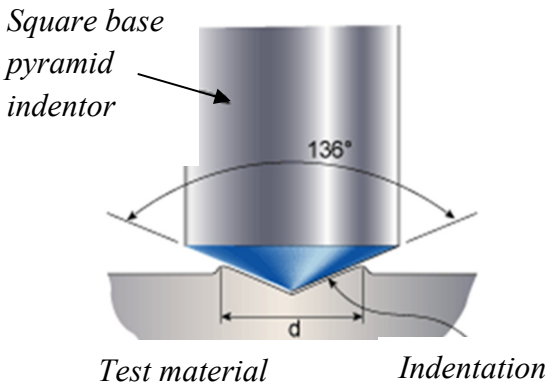
(Any two) 5 +5

Question 2 (50 Marks)

(a) (i) All implant materials need to be biocompatible.
The bearing material needs to be able to withstand impact and shock.
Resistant to wear.
Reduce friction between titanium supports.

4 + 4

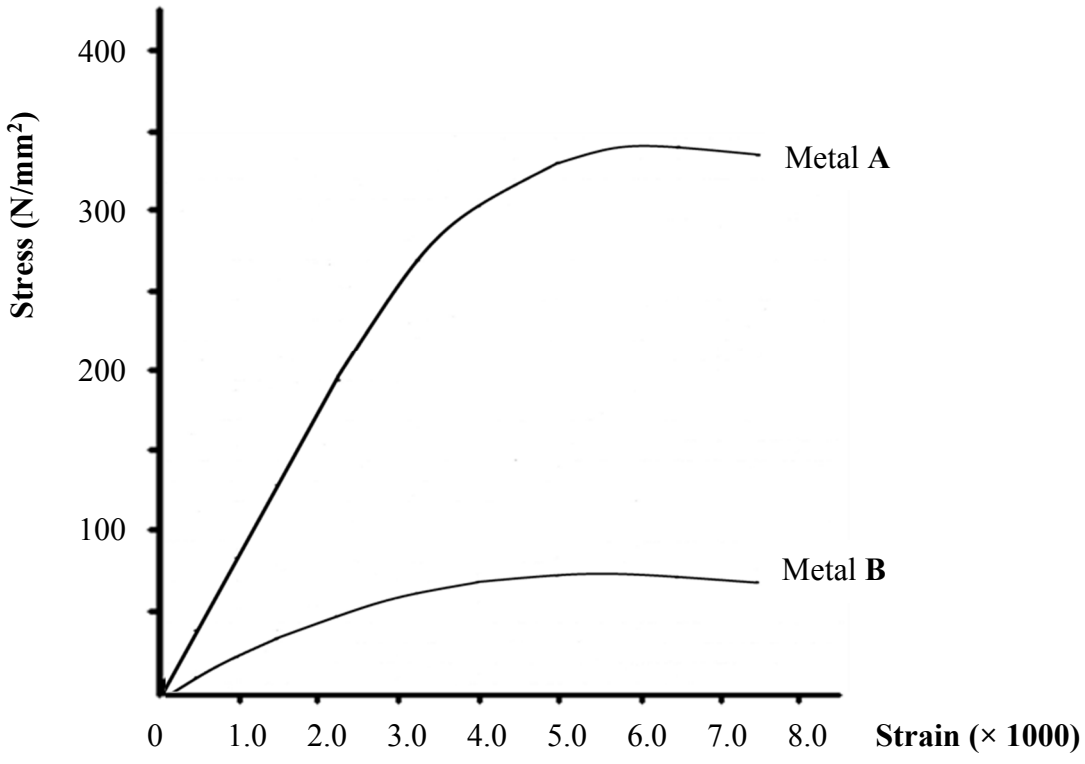
(ii) **Hardness test**



Titanium is a reasonably hard material, a suitable hardness test is the Vickers test. 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.

8

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



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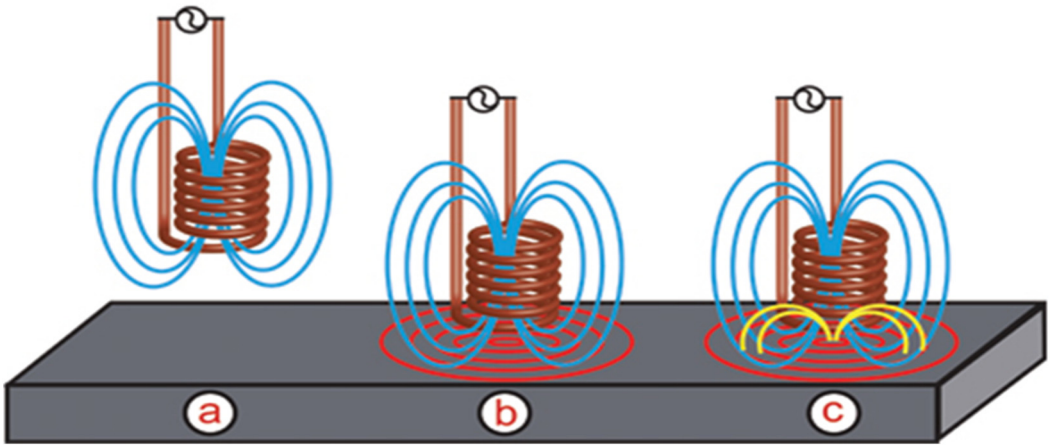
(ii) Tensile Strength of Metal **A** - 345 N/mm²
Tensile Strength of Metal **B** - 79 N/mm²

2 + 2

(iii) Metal **A** shows good elasticity, ductility and a high tensile strength.
Metal **B** has little or no elastic properties, is very ductile and also quite weak as it has a low tensile strength.

2 + 2

(c) **(i)** **Eddy current test**



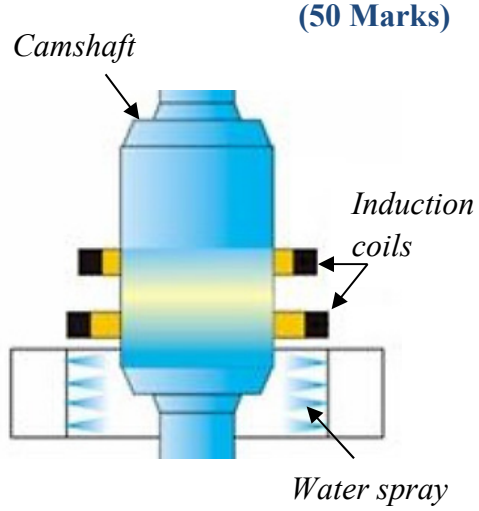
The alternating current flowing through the coil at a chosen frequency generates a magnetic field around the coil. When the coil is placed close to an electrically conductive material, eddy currents are induced in the material.
If a flaw in the conductive material disturbs the eddy current circulation, the magnetic field with the probe is changed and a defect signal can be read by measuring the variation.

8

(ii) Non-destructive testing (NDT) is a wide group of techniques used in science and industry to evaluate the properties of a material or component without causing damage.
Because NDT does not permanently alter the article being inspected, it is a highly-valuable technique that can save both money and time in product evaluation and research. The sample is available afterwards for repeat or additional tests. It enables further use of workpiece and provides cost benefits.

4 + 4

Question 3 (50 Marks)



(a) (i) **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. The frequency of the current determines the depth of heating and the depth of hardening.

10

(ii) Induction hardening the camshaft will increase its surface hardness and wear resistance. It will also increase strength and fatigue life due to the soft core and compressive stress at the surface. It will create relatively minimal distortion to the shaft compared to other hardening processes and induction hardening is frequently less expensive than other heat treatment processes.

6

(b) (i) **1** - Austenite and Ferrite
2 - Austenite
3 - Austenite and Cementite
4 - Ferrite and Pearlite
5 - Pearlite and Cementite

1 + 1 + 1 + 1 + 1

(ii) **Annealing 0.6% carbon steel**
The piece is heated 25º-50º above the UCT for Hypoeutectoid steels (less than 0.83% carbon). It is then soaked at this temperature allowing the whole of the piece to be at the same temperature. It is then allowed to cool gradually in the furnace by reducing the temperature gradually. During full annealing new grains are formed, this is called recrystallisation.

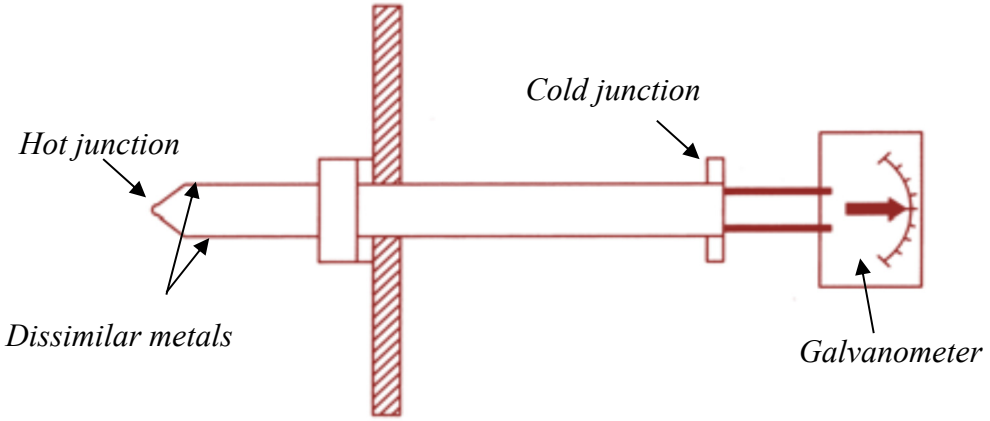
8

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

3 + 2

(c) **(i)** **Thermocouple Pyrometer**

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.



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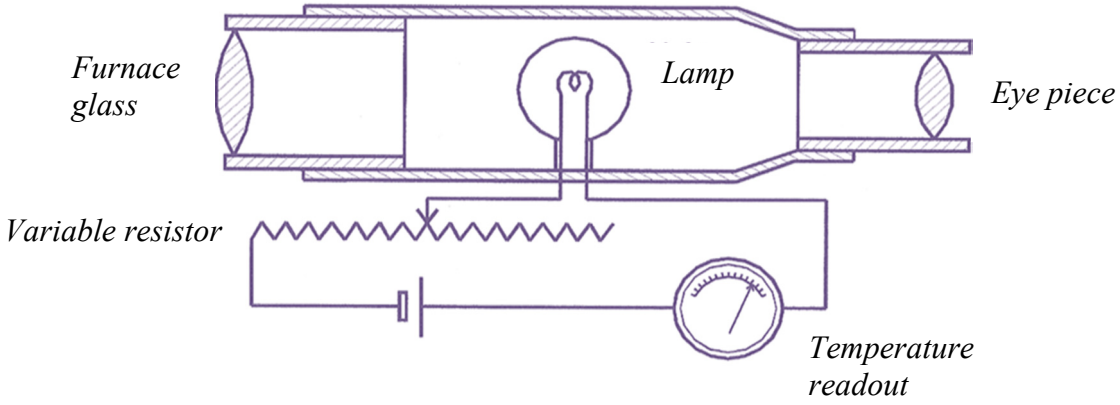
(ii) **Name:** seager cones, optical pyrometer.

Describe: The **optical pyrometer** compares the intensity of light from the filament of a lamp. Current flow from the lamp can be adjusted, using a variable resistor, to match the light from the furnace. When the filament seems to 'disappear', a temperature reading can be taken.

Filament seems to disappear



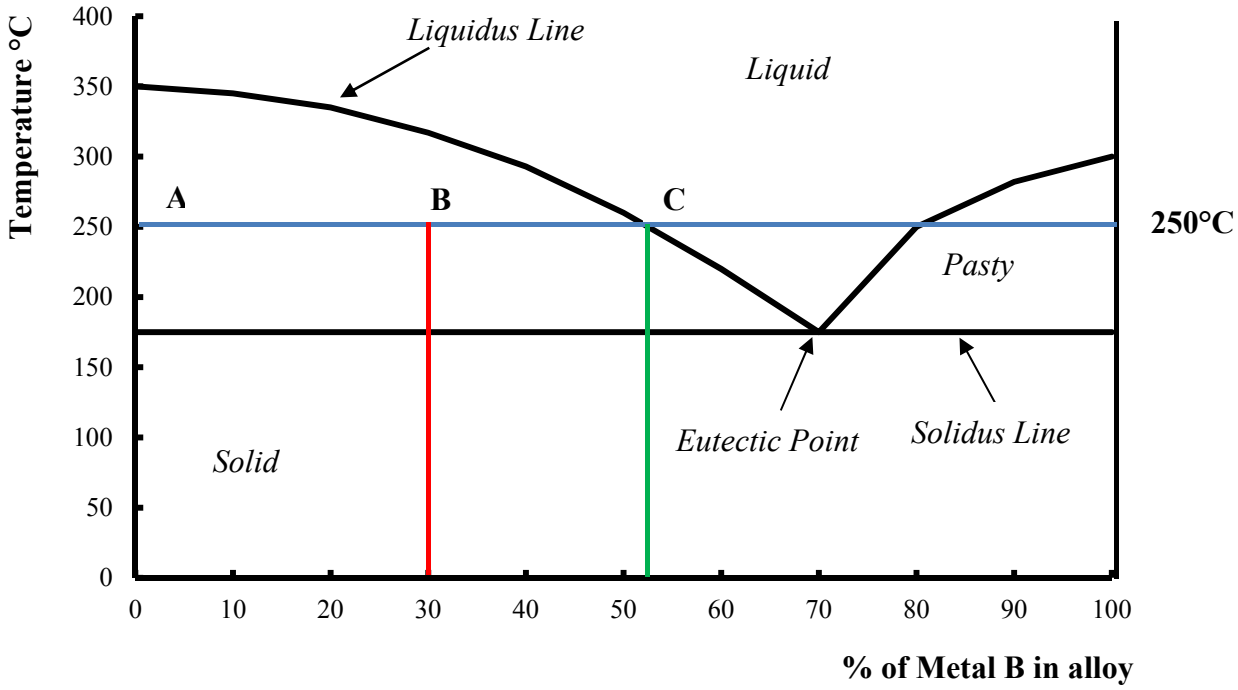
Name 4
Describe 4

Question 4 (50 Marks)

(a) (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.

16

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



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(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.
Solidus line: the change from pasty to solid. Below the solidus line, the alloy is cooling and solid. This is the end of solidification.
Pasty: alloy is in liquid and solid form.
Solid: alloy is in solid form.
Eutectic point: This is a special change point where liquid changes directly to solid without going through a pasty stage.

4 + 4

(iii) Ratio of phases at 1250 °C for 30% metal B:

$$\frac{\text{Mass of solid}}{\text{Mass of liquid}} \text{ is } \frac{30\text{-}00}{53\text{-}30} = \frac{30}{23}$$

2

(c) **(i)** **Point X** = Start of Solidification.
Point Y = End of Solidification.

4 + 4

(ii) Vacancy, substitute defect, interstitial defect and dislocation defect.

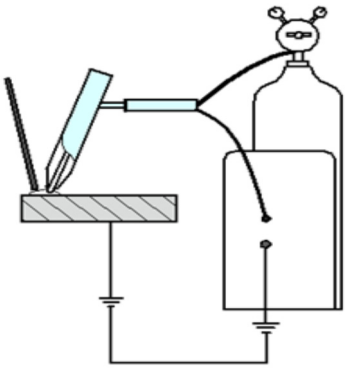
(Any two) 4 + 4

Question 5 (50 Marks)

(a) **(i)** TIG welding is a suitable welding technique for welding the stainless steel drum. It is selected as it produces high quality, clean welds on stainless steel.

4 + 4

(ii) 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.



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(b) **(i)** The flux coating in Manual Metal arc welding:

- Helps to start the arc
- Burns to give off a gas which prevents oxidation
- Helps the formation of a slag on the weld
- Additional alloy material can be part of the coating to improve weld strength.

(ii) **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.

(iii) Hazards using welding equipment in engineering rooms include:

- 'Arc eye' or flash from welding.
- Inhalation of fumes.
- Combustion of flammable materials or liquids in the welding area.
- Damage to face or skin due to welding spatter or handling of hot materials.
- Electric shock.
- UV radiation.

(iv) **Submerged arc welding (SAW)** is suitable for welding steel girders as it will give a long uninterrupted weld. As SAW is an automatic welding process, the weld joint will be of equal quality from beginning to end. SAW is also very suitable for the thickness of the girder material.

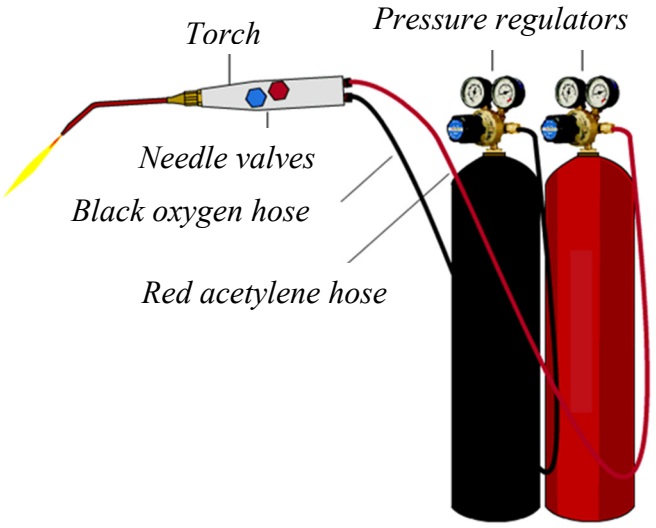
(v) **Advantages of multi-run welds:**

- 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) **Oxy-acetylene equipment include:**

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



Three flame types:
Neutral flame - equal portions of both gases;
Oxidising flame - excess oxygen gas;
Carburising flame - excess acetylene gas.

Integrated safety features:

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

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

16

OR

(c) **(i)** **Advantages of robotic milking machines:**
Elimination of labour - The farmer is freed from the milking process and associated rigid schedule, and labour is devoted to supervision of animals, feeding, etc.
Milking consistency – The milking process is consistent for every cow and every visit, and is not influenced by different persons milking the cows.
Increased frequency – Milking frequency may increase to three times per day, however typically 2.5 times per day is achieved.
Perceived lower stress environment – There is a perception that elective milking schedules reduce cow stress.

Disdvantages of robotic milking machines:
Higher initial cost – Systems can cost upwards in the region of approximately €200,000 per milking unit. Whether it is economically beneficial to invest in robotic milking machines instead of a conventional milking parlor depends on constructions costs, investments in the milking system and cost of labour.
Increased electricity costs - To operate the robots, but this can be more than outweighed by reduced labour input.
Reduced contact between farmer and herd – Effective dairy farming requires that the farmer be fully aware of herd condition. In conventional milking, the cows are observed before milking equipment is attached and ill or injured cows can be earmarked for attention. Automatic milking removes the farmer from such close contact with the animal with the possibility that illness may go unnoticed for longer periods and both milk quality and cow welfare suffer.

4 + 4

(ii) The **working envelope** refers to the defined area of space through which a robot can move.

The **sensors** are laser controlled to identify the location of the teats and a robust robot arm will attach cups individually to each teat from underneath the cow. Swift teat cup attachment is guaranteed even when milking cows with teats missing. Should a cup be kicked off, it is reconnected quickly.

4 + 4

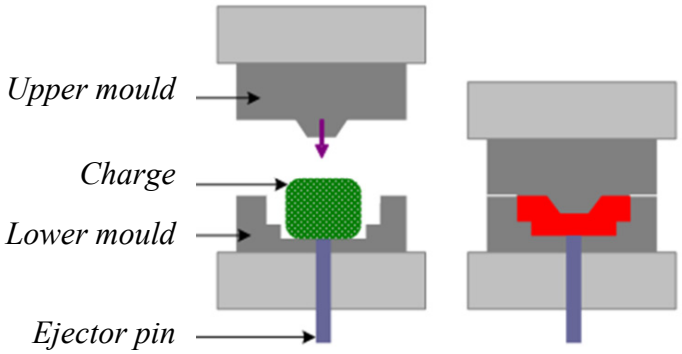
Question 6 (50 Marks)

(a) **(i)** Phenol formaldehyde resin is used for the pool balls because of its ability to absorb impact when the balls collide and when the cue hits the balls. It is also used because of its hardness and ability to withstand chipping and cracking.

4 + 4

(ii) Phenol formaldehyde pool balls can be resin cast. A common method of manufacturing thermosetting products is compression moulding.

Compression moulding: This process 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'. Then 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'.



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(b) **(i)** Injection moulding allows objects of various shapes and cross-sections to be manufactured. It also facilitates mass production of thermoplastic objects. The kicking tee could be manufactured in just two parts.

2 + 2

(ii) 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 mould is opened.
The opening of the mould allows the finished plastic moulding of the casing to be ejected.

10

(iii) The addition of plasticisers will improve flexibility. In the design of kicking tees, the wall thickness could be reduced to make the product more flexible (and weaker).

4

(c) **(i)** **Synthetic Rubber**

Synthetic rubber is rubber processed with sulphur to give cross-links between the folded chains, this is vulcanisation. A stronger bond which is more durable and less flexible than natural rubber is developed.

4

(ii) **Elastomers**

Properties: Elastic at room temperature
Soft, deformable and flexible
Resilience to return to shape when forces of tension, torsion or compression are removed
Low permeability to air, gases, water and steam
Low tensile strength
Recyclability
Good electrical and thermal insulation.

Internal structure - Linear chains that are coiled, entangled and subject to minimal cross-linking.

6 + 6

Question 7 (50 Marks)

(a) **(i)** Safety features integrated into a lathe:

- Emergency stop button.
- Chuck interlocking guard.
- Leadscrew guard.
- Emergency foot brake pedal.
- Screen attached to the main saddle.

(ii) Errors in measurement can occur when using the digital callipers due to the following reasons:

- The callipers maybe "zero" when the jaws are open.
- The battery may be weak.
- Part of the jaws maybe damaged or chipped.
- The locknut may not be tightened and jaw can move.

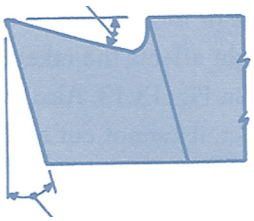
(iii) **Vee block and clamp** are precision metalworking jigs typically used to hold round metal rods or pipes for performing drilling or milling operations.

(iv) **Pilot Hole** is a hole which is drilled prior to a larger hole being drilled. A pilot hole gives the larger hole a centre to start.
Tapping Size Hole is a hole drilled prior to threading. The hole is always smaller than the tap to be used. The pitch of the thread will determine the size of the tapping size hole.

(v) **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

(Any three) 6 + 6 + 6

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

4 + 4

(ii) Oil, grease, graphite, PTFE, etc.

4 + 4

(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.

Disadvantages of using carbide inserts:

- Tungsten carbide inserts are extremely hard and brittle and shatter easily.
- They are expensive to purchase and replace.
- Limited use on materials other than round bars.

4 + 4

OR

(c) **(i)** CNC machining as plumbing fittings are mass produced in high volume.

(ii) Manual machining allows individualised pieces to be produced for each chess set. This demonstration of skill in crafting may make the set more valuable. Accuracy may not be essential.

(iii) Manual machining will be more efficient as wheels may be damaged to a greater or lesser extent. Manual methods will require less setting up for each wheel. In some circumstances, mechanised machining could be employed if large batches of the same wheel are to be machined.

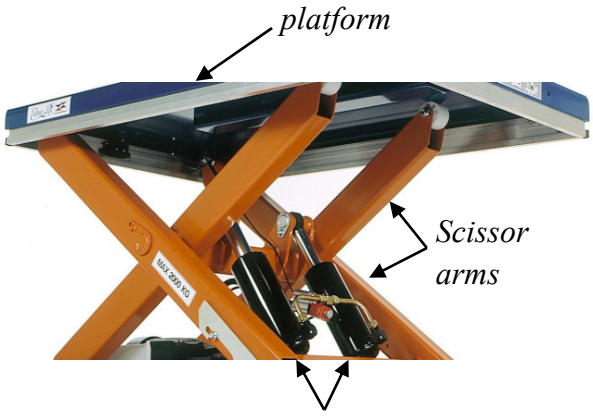
6 + 6 + 4

Question 8 (50 Marks)

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

(i) The most common lift table design incorporates hydraulic cylinders and an electrically powered pump to actuate the scissor lifting mechanism. As the cylinder extends, the scissor arm is pushed upwards raising the platform.

Lift tables can be mounted in a pit for floor-level loading, especially useful for access by wheelchair users.



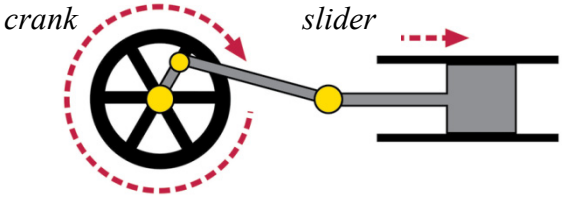
8

(ii) Lift tables can also be driven by pneumatic control or electric motor screw drives. The electric motor drives the screw resulting in raising a platform.

Platform will be raised and lowered

8

(b) **(i)** The **Crank and Slider mechanism** is used to convert rotary motion into reciprocating motion. The crank rotates and the slider reciprocates due to a connecting rod between the crank and the slider.
It is commonly found in standard engine designs, compressors and power hacksaws.



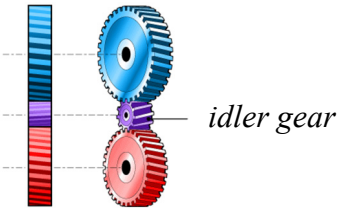
(ii) **Advantages of timing chain over a timing belt:**

- The timing chain provides a stronger drive.
- The chain is less likely to slip.
- Although quieter and smoother in operation, the belt is more likely to break or stretch than the chain.

(iii) A **reservoir** is used to create a time delay in a pneumatic circuit, a larger reservoir will result in a longer time delay as it takes longer to fill with air.

(iv) A **capacitor** is a device that can store electrical charge.

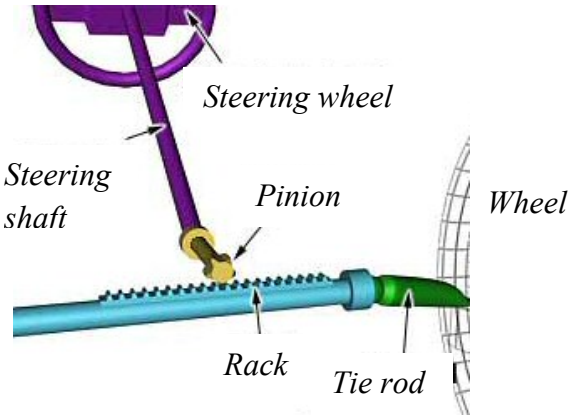
(v) **Idler gears** are used to change the direction of a gear train, it can ensure that driver and driven gears rotate in the same direction.



(Any three) 6 + 6 + 6

(c) **(i)** The use of a linkage system or **rack and pinion** mechanism would be suitable solutions for the steering mechanism of the kart.

The steering wheel can be connected to the pinion and when rotated it will move the rack in a linear manner either left or right.
The wheels in turn are connected via a linkage to the rack and this will allow the wheels turn.



8

(ii) The use toothed belts, gear drive or chain and sprocket would be suitable solutions for the rear wheel drive propulsion unit of the kart.

A **chain and sprocket** would provide a strong drive between the motor and the wheels.
A DPDT switch provides the option for forward and reverse drive of the go-cart.

8

OR

(c) **(i)** Light energy to chemical energy.
Chemical energy to electrical energy.
Light energy to electrical energy.

8

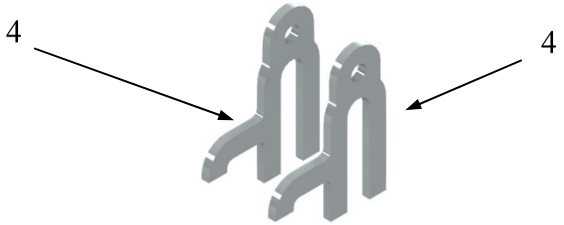
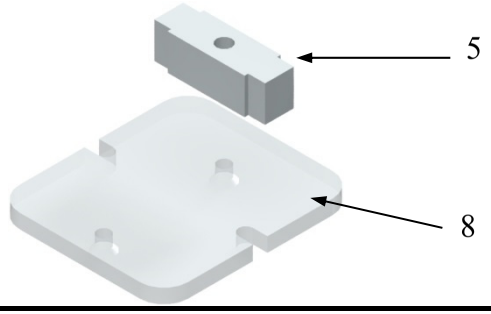
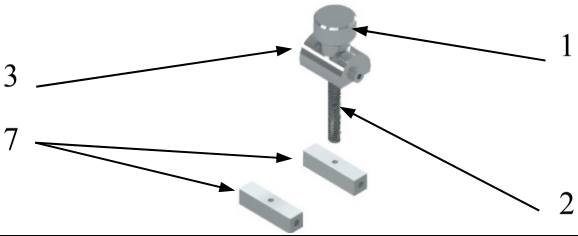
(ii) Mains electrical charger with transformer.
Battery charger.
USB.
Wind-up mechanical charger.

4 + 4

Coimisiún na Scrúduithe Stáit
State Examinations Commission

Leaving Certificate - Engineering Practical - Marking Scheme 2016

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 Project**		Assembly, Function & Finish Subjective Mark 1 – 20		**20**	**20**
2	**Parts 4**		**Parts 4** 20 Marks	Marking Out	**4**	**20**
				External Profiles	**8**	
				12 mm Slots	**6**	
				Ø8 mm Holes	**2**	
3	**Parts 6**		**Parts 6** 20 Marks	Marking Out	**2**	**20**
				External Profiles	**8**	
				15 mm × 12 mm Slots	**6**	
				Ø5.5 mm Holes	**4**	
4	**Parts 5 and 8**		**Part 5** 10 Marks	Mark Out	**2**	**20**
				M8 Tapped Hole	**2**	
				12 mm Spigots	**6**	
			Part 8 10 Marks	Marking Out	**2**	
				Profile and 6 mm Slots	**6**	
				Ø5.5 mm CSK Holes	**2**	
5	**Parts 1, 2, 3 and 7**		**Parts 1, 2 and 3** 10 Marks	Lathe Work	**6**	**20**
				Marking Out and Bench Work	**4**	
			Parts 7 10 Marks	Marking Out and Lengths	**4**	
				6 × M5 Tapped Holes	**6**	

100 Marks (× 1.5 = 150 Total)

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