Coimisiún na Scrúduithe Stáit
State Examinations Commission

Leaving Certificate 2015

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, 2015

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 2015

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

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

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

(o) (i) 1 + 1 + 1 + 1 + 1
(ii) 5

(p) (i) 1 + 1 + 1
(ii) 7

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

(r) 5 + 5

Question 2 – 50 marks

(a) (i) 6
(ii) 10

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

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

Question 3 – 50 marks

(a) (i) 8
(ii) 8

(b) (i) 2 + 2 + 2 + 2
(ii) 5 + 5

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

Question 4 – 50 marks

(a) 8 + 8

(b) (i) 8
(ii) 3 + 3
(iii) 4

(c) (i) 2 + 2
(ii) 8
(iii) 2 + 2

Question 5 – 50 marks

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

(b) (i) 6
(ii) 10

(c) 16

OR

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

Question 6 – 50 marks

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

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

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

Question 7 – 50 marks

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

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

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

OR

(c) (i) 2 + 2 + 2 + 2
(ii) 4 + 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, 2015

Note: **The solutions presented are examples only.**
All other valid solutions are acceptable and are marked accordingly.

Question 1 (100 Marks)

Section A – 50 marks

(a) **Advantages:** Touchscreen devices have limited buttons, have a simpler user interfaces, easy to navigate, fast to use with a simplified interface, easy to clean.
Disadvantages: The screen has to be big enough to be able to touch the buttons without missing. In direct sunlight it may be difficult to read the screen. The screens can get very dirty. User has to be within arms-reach of the device.

3 + 2

(b) Safety precautions when using cutting fluids:

- Avoid splashes on skin, wash immediately, use skin barrier cream, can cause irritation
- 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, etc.

(Any two) 3 + 2

(c) **Flotation separation** is used for concentrating the metal-bearing mineral in an ore. The metal is ground to a fine powder and mixed with water, frothing reagents, and collecting reagents. When air is blown through the mixture, mineral particles cling to the bubbles, which rise to form a froth on the surface. The waste material settles to the bottom. This froth is skimmed off. This process is used for a number of minerals, especially silver.

5

(d) Lighter structure weight, greater strength to weight ratio, flexibility in design, aesthetics, non-corrosive, etc.

(Any two) 3 + 2

(e) Stainless steel is a material which has excellent resistance to corrosion, is very hard and tough and has a bright shiny appearance.

(Any two) 3 + 2

(f) 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 angle, when reheated it will return to its original shape.

5

(g) **(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) **Ivan 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) **Jonas Hesselman**
Jonas Hesselman (1877 – 1957), was a Swedish engineer. He built the first spark ignition engine with direct injection of fuel into the cylinder.

(Any one) 5

(h) **Advantages of using pneumatics over electrical power**

- Can be employed in hazardous situations where electric spark might be a danger
- Air can be stored and used when needed
- Strong and precise action, non toxic
- Range of applications in a production situation
- Can be easily programmed for a sequence of actions, etc.

(Any two) 3 + 2

(i) Provides a fuel for the incineration process, removes long life plastic material from landfilling, expanded polystyrene is not suitable for recycling, packaging materials are moulded into specific shapes minimising the possibility of reusing, etc.

(Any two) 3 + 2

(j) Taper turning, copy turning, CNC machining, knurling, grooving, drilling, threading, etc.

5

(k) MIG, Submerged Arc Welding, resistance welding, electro-slag welding, robotic welding, etc.

(Any one) 5

(l) Ratchet and pawl, electro-magnetic switch, etc,

5

(m) Galvanising, painting, metal cladding, plastic coating, etc. These methods will prevent the oxygen in the air attacking the metal surface.

(Any two) 3 + 2

Section B – 50 marks

(n) The benefits of fuel injection systems:

- Precise and variable fuel metering assists in the efficient use of fuel and reduces waste
- Superior throttle response gives the engine an increase in efficiency
- Improved cold start ability reduces the amount of fuel needed to get the vehicle moving
- Better fuel efficiency and economy has a saving in the amount of fuel used
- Lower emissions than carburettors has a positive environmental impact
- Increased horse power due to the efficient use of fuel
- Decreased vibration due to improved engine efficiency.

(Any two) 5 + 5

(o) (i) **A –** Fuel pump with filter
B – Fuel pressure regulator or filter
C – High pressure fuel line
D – Fuel rail
E – Injector

1 + 1 + 1 + 1 + 1

(ii) Principle of operation:
This contains a small particle filter (in addition to the strainer), pump, electronic pressure regulator, fuel level sensor and a sound isolation system within one unit of the submersible fuel pump (A). An electronic pressure regulator (B) allows the pressure to be increased under acceleration conditions and the pump's output can be adjusted to suit the engine's fuel demand. This prolongs the pump life as it is does not need to provide a larger than required output delivery to the fuel rail (D) and fuel injectors (E). To compensate for the changing viscosity of the fuel with changing fuel temperature, a fuel rail temperature sensor is installed.

5

(p) (i) **F –** Solenoid windings / electromagnetic coil
G – Magnet
H – Needle valve

1 + 1 + 1

(ii) Principle of operation:
The fuel supplied to the injector is filtered through the fuel filter. When the electromagnetic coil is energised this attracts the magnet which opens the needle valve allowing the fuel to pass through it. This action has a reaction time of around one millisecond. The spring closes the valve when the energy is removed from the coil.

7

(q) **(i)** **Throttle position sensor**
This sensor monitors the throttle valve position, which determines how much air goes into the engine. The ECU can respond quickly to changes, increasing or decreasing the fuel rate as necessary.

(ii) **Lambda sensor**
The exhaust gas oxygen sensor (EGO or O2), or lambda sensor, is the key sensor in the engine fuel control feedback loop. The computer uses the O2 sensor input to balance the fuel mixture, leaning the mixture when the sensor reads rich and richening the mixture when the sensor reads lean.

(iii) **Crankshaft position sensor**
The crankshaft position sensor provides information on the speed and position of the crankshaft. This is used to determine firing order and cylinder recognition, timing and crank position, spark ignition timing and fuel injection timing.

(iv) **MAP sensor**
The Manifold Absolute Pressure Sensor or MAP is located in the intake manifold. This sensor is used to measure manifold pressure which informs the ECU of the engine load, this information is needed to work out how much fuel to inject. In order to work out the air mass the ECU also needs to know the air temperature and the engine speed.

(Any two) 5 + 5

(r) Direct fuel injection is a fuel-delivery technology that allows petrol engines to burn fuel more efficiently, resulting in more power, cleaner emissions, and increased fuel economy. Traditional fuel injection systems pre-mix the petrol and air in a chamber just outside the cylinder called the intake manifold. In a direct-injection system, the air and petrol are not pre-mixed. Air comes in via the intake manifold while the petrol is injected directly into the cylinder.

Mixture formation
The theoretical ideal ratio of 14.7 air to 1 part petrol is generally achieved with a homogenous mixture which can rise close to 20:1, this gives good economy and low emissions. Maximum torque and power are achieved at a richer ratio of around 12:1. Homogenous mixture has all the mixture volume at the same ratio.
The mixture can be stratified where pockets of air : fuel mixture is created within the cylinder and surrounded by air, this gives a ratio of up to 40:1 with reduced fuel consumption and less power generated.

Injection timing
Most direct injection petrol engines operate with stratified and homogenous mixture formations depending on operating conditions. This is achieved by controlling the injection timing. Direct injection systems generally have two distinct timing periods, which provide different characteristics for mixing the air and fuel.
One timing period is during the induction (intake) stroke where the homogenous mixture formation is close to 14.7:1 giving good power production and low emissions. At the end of the compression stroke, a smaller amount of petrol is injected to promote a localised turbulence and directed to the spark plug for ignition.
The exact time of injection can be electronically adjusted to account for driving conditions such as speed, temperature, etc.

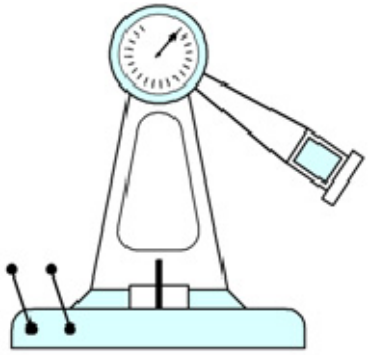
5 + 5

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.

6

(ii) **Impact test**



This will determine the toughness of the material which indicates the ability to withstand impact or shock loads.
Test pieces are notched and held in the vice associated with the machine. A pendulum strikes the test piece and determines the energy absorbed in breaking the piece. This gives a numerical value for the toughness of the material.
There are a number of toughness tests available including the izod impact test which has a striking energy of 167 joules and a vertical test specimen notched on the front face.

10

(b) (i) **A –** Upper yield point.
B – Ultimate Tensile Strength.
C – Fracture point.

2 + 2 + 2

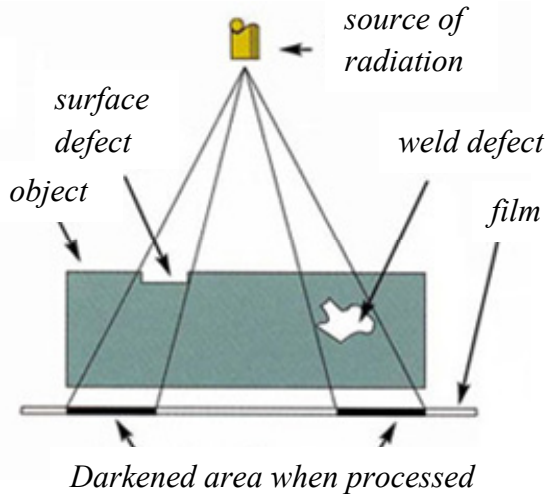
(ii) Up to **point B**, the specimen will have thinned uniformly as the load increased. At this point, the specimen will begin to 'neck' as it elongates with applied force.
At **point C**, the specimen is likely to have fractured with the distinctive 'cup and cone' fracture. One side of the specimen has a rough cone shape and the other has a hollow cup shape.

6 + 6

(c) (i) **Surface Flaws** – Liquid penetrant, visual inspection, etc.
Internal Flaws – Ultrasonic test, x-ray, eddy current test, etc.

4 + 4

(ii) **X-ray / Radiography testing:**
Radiation from an x-ray tube is passed through the weld. If no defects are present, the amount of absorption is uniform across the area exposed to the x-ray beam. If a defect is present in the weld, a smaller amount of rays is absorbed giving a variation in the intensity of the emergent beam. This can be detected by placing a photographic film on the side of the material opposite the radiation source. On a negative film, the defect shows as a dark spot.



8

Question 3 (50 Marks)

(a) (i) This screwdriver is prone to damage from usage as the blade is small and thin. It has an intricate shaped tip which may break if brittle or bend if too soft. **8**

(ii) Medium carbon steel can be hardened and tempered to a reasonable extent, especially when close to 1% carbon. Higher carbon content steels will harden more effectively. The hardening process entails heating to a red colour and quenching quickly.

When hardened, the screwdriver blade needs to be tempered to reduce brittleness. The blade is cleaned and then heated slowly and carefully until it reaches tempering temperature (220-300ºC) this is usually indicated by colour changes form straw through to blue.

8

(b) (i)

A - Liquid
B - Austenite
C - Ferrite and Pearlite
D - Pearlite and Cementite

2 + 2 + 2 + 2

(ii)

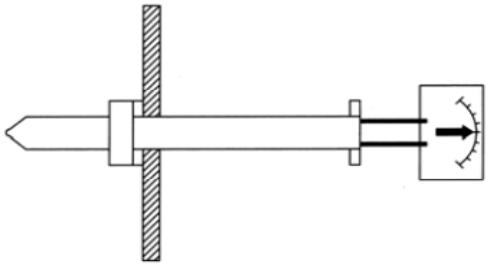
	Point X	**Point Y**
Name:	Eutectoid point	Eutectic point
Phase change:	solid austenite changes to solid pearlite	Liquid to solid
Composition:	0.83% carbon	4.3% carbon
Temperature:	723^{o}C	1147^{o}C

5 + 5

(c) (i) **Optical pyrometer:** this method 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.

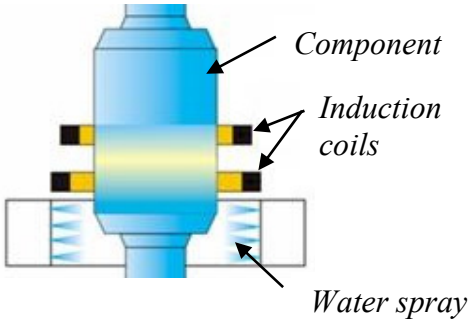
Temperature is taken at this stage

Thermocouple Pyrometer:
A galvanometer measures the electrical current generated by a rise in temperature of two dissimilar metals joined together. A temperature output is converted from the electrical units.



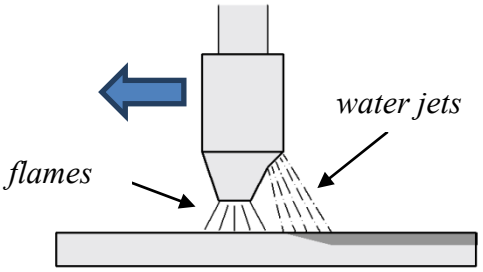
(ii) **Induction hardening:**

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.



(iii) **Ferrite** is iron that contains less than 0.02% carbon dissolved in solution, it is almost pure iron. It has a body centred cubic structure.

Pearlite is 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.

(iv) The holding of a metal at a suitable heat treatment temperature is called **soaking**. The object of heat treatment is to bring about changes in the properties of a metal. To accomplish this, the metal must be heated to a temperature at which structural changes will take place within the metal as the constituents go into solution. With such slow cooling, grain structure will be refined and internal stresses will be relieved.

Quenching in water will result in an increase in hardness and brittleness with greater prospects of cracking or warping.

(Any two) 8 + 8

Question 4 (50 Marks)

(a) (i) Substitution

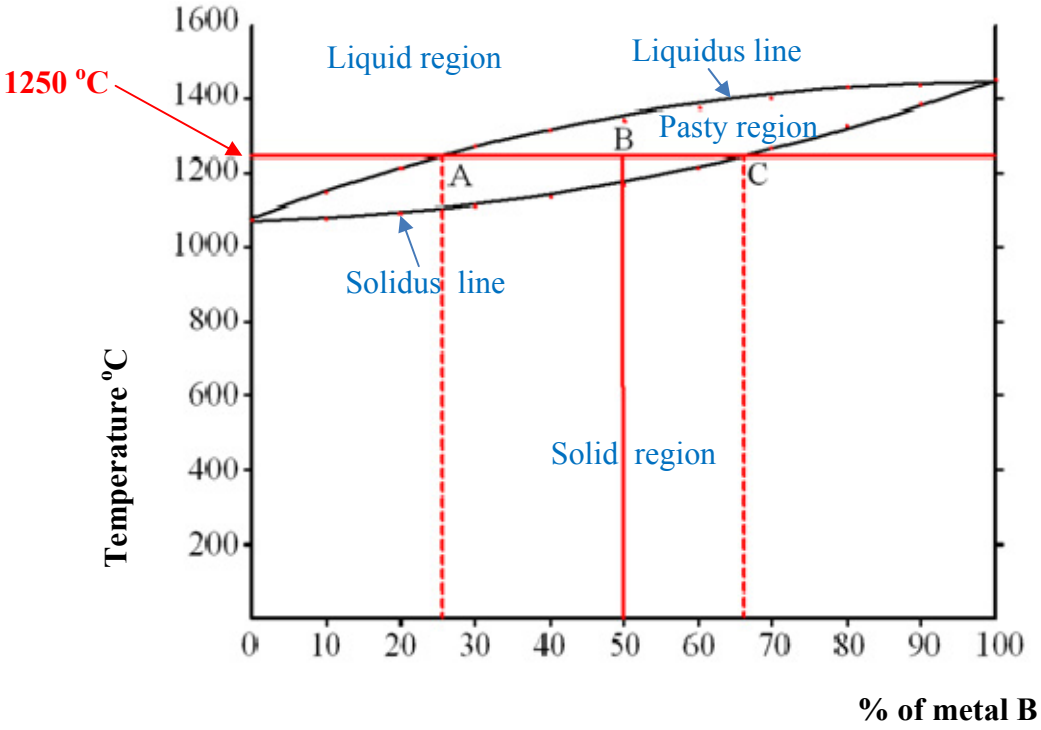
An atom of another element is present in the crystal lattice.
Distortion occurs if this atom is larger or smaller than the parent element.
When atoms of similar size are present one type of crystal is may be formed and the mixture looks like a pure metal. The copper-nickel alloy is an example.

Interstitial

An atom from another element moves into the space between the atoms of the parent metal lattice. This causes compression of the surrounding atoms and will strengthen the material as it takes a higher stress to cause deformation.

(Name) 4 + 4
(Describe) 4 + 4

(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.

(Any three labels) 3
(Any three descriptions) 3

(iii) Ratio of phases at 1250 °C for 50% metal B

$$\frac{\text{Mass of solid}}{\text{Mass of liquid}} \text{ is } \frac{50-26}{66-50} = \frac{24}{16} = \frac{3}{2}$$

4

(c) (i) Structure **X** = Body Centre Cubic (BCC)
Structure **Y** = Face Centre Cubic (FCC)

2 + 2

(ii) In the BCC structure, the structure is arranged with the atoms further apart at the corner of a cube and an atom in the centre of the cube. This structure is associated with brittleness. However, in the FCC structure, atoms are at the corners of a cube and a single atom in the centre of each face of the cube. Atoms are more tightly packed which allows metals to be more ductile hence allowing slip to occur.

8

(iii) **BCC** metals include iron, vanadium and chromium.
FCC metals include aluminium, nickel, silver and copper.

2 + 2

Question 5 (50 Marks)

(a) (i) Porosity in welding can be prevented in the following ways

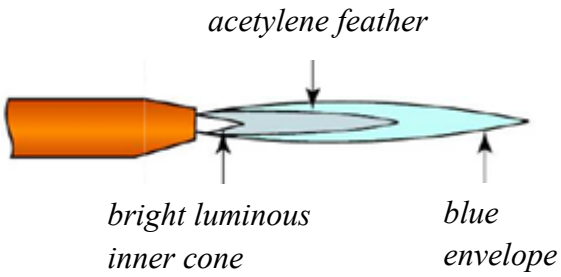
- Make sure the gas tank is not empty
- Clean the material surfaces thoroughly removing surface coatings, oil and grease
- Eliminate moisture – the prime cause of weld porosity
- Make sure gas flow is at correct pressure
- Eliminate drafts and air
- Proper use of anti-spatter compounds, sprays or gels, etc.

(ii) In **MIG** welding the electrode is a bare wire electrode supplied in a reel which is fed through the gun when the trigger is pulled. Typical size electrodes range from 0.6mm to 1.6mm diameter. The electrode is said to be consumable. The electrode is coated with a corrosion resistant metal to prevent it for rusting.

In **TIG** welding the electrode is made from tungsten. It is non-consumable and its purpose it to maintain the welding arc while a filler rod is applied to the weld pool. The tungsten electrode must not touch the weld pool as this will contaminate the electrode.

(iii) Carburising flame:

- Contains excess acetylene
- It has a working temperature of 3150^{o}C
- Used to weld aluminium and alloy steel where it gives protection against oxidation
- Large flame with the distinctive acetylene feather.



(iv) **Electric shock** can be prevented by making sure all electrical connections are secure and insulated and that dampness is not an issue in the welding area. The correct size fuse and a proper earth should also be maintained.

Other operators must be shielded from the **intense welding light** from welding bays using welding curtains. 'Arc eye' can be prevented by using a face mask with the correct filtering lens in the helmet. Cracked or damaged lens should be replaced immediately. An auto-darkening lens helmet will also prevent the operator from flash as it will darken the moment the arc starts.

Welding Fumes can be prevented by in the following ways;

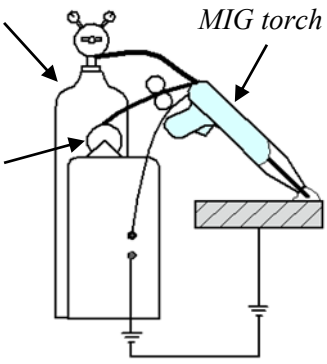
- a hood which captures the contaminant at its point of generation
- a duct system with appropriate airflow
- an air cleaning system to prevent pollution of the general atmosphere
- an exhaust fan.

(Any three) 6 + 6 + 6

(b) (i) **Metal inert gas welding**, MIG, MAGS – *other appropriate methods accepted.*
MIG is an effective method of welding mid steel even in light tubular form.
It is relatively easy to set up and use.
Mild steel welding wire is commonly used.
MIG welding torch can be manoeuvred easily.

(Name) 3
(Reason) 3

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



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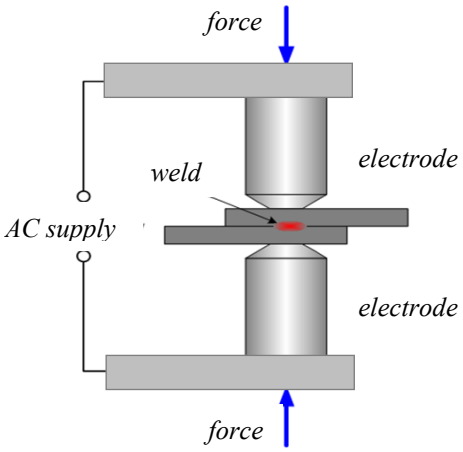
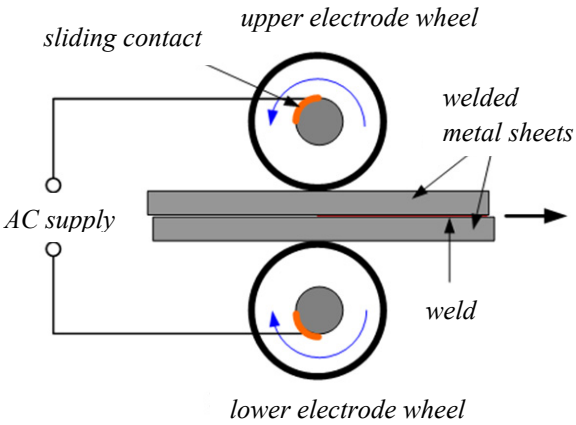
(c)

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.

Principle of operation

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.

Weld joint

The weld is a single nugget weld at various intervals.	There is an overlapping of nuggets by approximately one third to create the continuous seam.

Applications

Used in the automotive industry for body panel assembly.	Used when continuous tight weld is required eg fuel tanks, drums, domestic radiators.

16

OR

(c) **(i)** **Degree of freedom**
A description of the number of axes the robot arm can move. A single joint will provide one degree of freedom. To provide a variety of degrees of freedom, different robotic joints can be used such as rotary or linear joints. The degrees of freedom will determine how the robocoaster will move and are normally programmed in a series of motions.

Working Envelope
The defined area of space through which a robot can move. This is also known as the work cell. The robocoaster must ensure that the working envelope for each device is safe for passengers.

4 + 4

(ii) Programmable robots allow for very precise movements.
Motions are accurate, consistent and repeatable.
Speed of movements can be adjusted and controlled.
Movements can be reprogrammed and adjusted to change sensation of thrill machines.
Similar drive mechanisms can be used on a variety of machines.

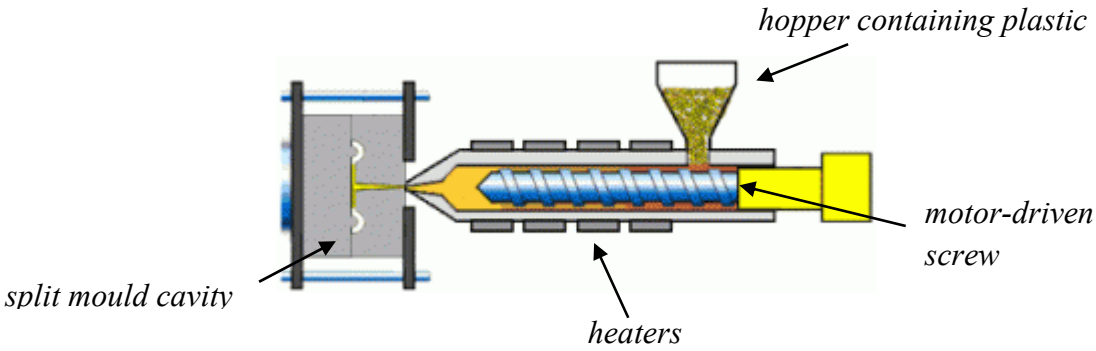
4 + 4

Question 6 (50 Marks)

(a) **(i)** EVA is a soft and flexible copolymer. The material has good clarity and gloss, low-temperature toughness, stress-crack resistance, waterproof and resistance to UV radiation. It is inert and biocompatible.

4 + 4

(ii) Injection moulding - there are different types of injection moulding machines.
A screw-type is described.



The mould has a hollowed out shape of the casing.
With the split mould firmly clamped under pressure, plastic granules are fed from the hopper.
These plastic granules are 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 mouthguard to be ejected.

8

(b) **(i)** **Amorphous polymers** do not have a pattern in the arrangement of their atoms but are a more random structure.
Crystalline polymers have atoms that are bonded together in a pattern that is repeated.

(ii) **Natural rubber** is the sap from the rubber tree. It has folded polymer chains which are bonded by weak Van der Waals forces. It is both plastic and elastic.

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.

(iii) **Foaming agents** are substances which add bubbles to a polymer. They increase the bulk of the polymer making it lighter. Examples include sponges and buoyancy aids.

Fillers: These additives control the mechanical properties, such as material strength, of the polymer. They reduce the amount of expensive polymer used. Fillers such as chalk, wood flour and glass fibre can be used.

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

Inhibitor: Prevent certain chemical combinations from happening or slow down reactions.

(Any two) 8 + 8

(c) **(i)** **Thermoplastics**
Can have linear or branched structure.
Properties: Low melting point
Allows for easy moulding
Easily disrupted by heat
Low tensile strength
Branched structures have higher tensile strength than linear
Ideal for recycling.

Thermosetting plastics
Have a cross-linked structure.
Properties: High melting point
High tensile strength
Good thermal insulation
Can withstand high temperatures without losing rigidity
Stiff and less flexible.

Elastomers
Linear chains that are coiled, entangled and subject to minimal cross-linking.
Properties: Elastic at room temperature
Soft and deformable
Resilience to return to shape when forces of tension, torsion or compression are removed
Low permeability to air, gases, water and steam
Good electrical and thermal insulation.

4 + 4 + 4
(For each: Structure @ 2, Property @ 2)

(ii) Polymers exhibit a significant range of properties making them useful for a variety of applications. They can be easily moulded into shape and mass produced using an extensive range of machines such as injection moulders.
The properties of polymers can be enhanced using co-polymers and strengthening techniques such as the addition of fibres, designers can select suitable polymers for most applications.
Rapid prototyping techniques allow polymers to create models directly from a drawing without further processing.

6

Question 7 (50 Marks)

(a) **(i)** Oil, grease, graphite, etc.

(ii) The function **Plug gauge** is to accurately determine if a selected hole is within a specific range of limits.
The function of a **Gap gauge** is to accurately check if an external diameter is within a specific range of limits.

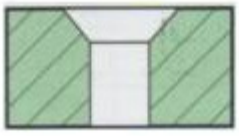
plug gauge

gap gauge

(iii) **Functions of chuck guard on the lathe:**

- Protect user from cutting chips and swarf
- Interlock guards will prevent the machine operating when not in place
- Allows a viewing window to safely monitor machining
- Protects the user from rotating chuck
- Keeps hair and clothing separated from the machining process.

(iv) **Countersinking** is the enlarging of the mouths of holes to allow countersunk head screws or rivets sit flush with the surface of the piece.

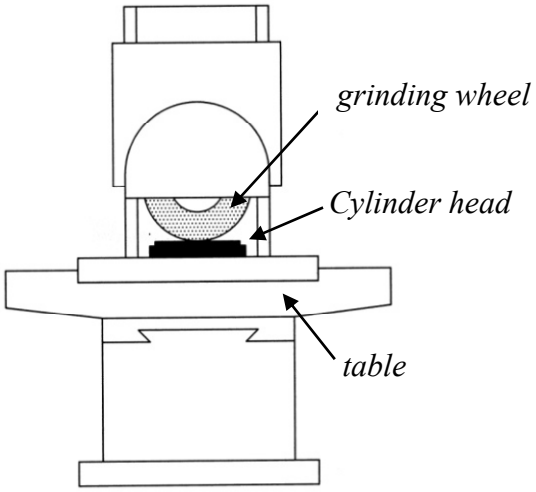


Counterboring is increasing the diameter of the hole to a certain depth to allow a cheese head screw sit flush with the surface of the piece.

(v) Cutting tools must be harder than the material being machined.
Cutting tools must maintain a sharp edge at high temperatures generated by the machining process.
Cutting tools need to have the ability to be sharpened or replaced easily.
Able to withstand the shock loads of machining processes.

(Any three) 6 + 6 + 6

(b) **(i)** **Surface grinding:** A metal cutting process in which flat and extremely smooth surfaces are produced. The grinding wheel rotates and the cylinder head, usually held in a magnetic chuck, is fed to and fro continuously. At the end of each stroke, the table is moved across the wheel by a small amount. The grinding wheel can be lowered to take a new cut.



8

(ii) **Hazards using a grinding machine:**

- All grinding processes produce small metal particles that are emitted at high speed, eye protection is critical
- Grinding wheels rotate at high speeds, they need to be correctly mounted and balanced to avoid vibration
- The wheels are guarded with small gaps between guard and wheel, caution needs to be exercised as loose clothing may get trapped
- Tools and metals must be gripped tightly.

4 + 4

(c) **(i)** **A** – Continuous chip
Soft, ductile material such as aluminium.
B – Discontinuous chip
More brittle materials with brass as an example.

(Name) 2 + 2
(Distinguish between) 2 + 2

(ii) As the built-up edge enlarges, the cutting edge will not cut effectively as the tool cutting angles are compromised. The surface finish will deteriorate and machining will not be smooth. The machine is likely to be subjected to excess vibration.

4 + 4

OR

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

- They repeatability produce parts to maximum accuracy
- CNC machines allow multiple axes of simultaneous motion, resulting in 2D and 3D machining ability
- CNC machines allow for efficient mass production
- Minimal setting-up between batch productions of components
- Multi-tool loading for complex components
- Once the first piece has passed inspection, minimal inspection is required on subsequent parts
- Enables the operator to make changes or improvements with a minimum of delay.

2 + 2

Disadvantages:

- More expensive to purchase and repair.
- Requires more space, electricity and maintenance than manual machines
- Slower and more expensive for making one simple part
- CNC machining does not eliminate the need for expensive tools
- Parts (machines and tooling) are costly and their purchase requires extensive justification.

2 + 2

(ii) Factors for CNC machining of chess pieces:

- Choice of material to manufacture pieces
- Size of pieces
- Volume of pieces to be manufactured in this batch
- Design shape and detail.

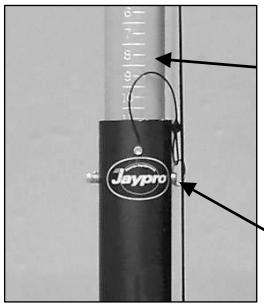
4 + 4

Question 8 (50 Marks)

(a) **(i)** The worm and wheel mechanism will provide adjustment of net tightness.
The tensioning handle will be attached to the worm mechanism with the gear wheel driving the net cord. As the handle is turned, the worm will rotate, this drives to gear wheel and tightens the net cord.

8

(ii) The height of the net can be adjusted using a pin which fits into the tubular frame.
The outer tube is drilled in the position shown.
The inner tube has a series of holes drilled which allow for the height to be adjusted.



Suggested solution - other viable solutions are acceptable.

8

(b) **(i)** A **thermostat** is a component of a control system which senses the temperature of a system so that the system's temperature is maintained near a desired set-point. The thermostat does this by switching heating or cooling devices on or off, or regulating the flow of a heat transfer fluid as needed, to maintain the correct temperature.

(ii) **Advantages of roller bearings**

- Roller bearings typically have higher load capacity than ball bearings
- Gives a smoother drive
- Are generally easy to replace and maintain
- Are designed in a range of sizes in both length and diameter
- Tapered roller bearings support both radial and axial loads.

(iii) A **Double Pole Double Throw** switch may be used to turn a circuit on or off.
DPDT switches are commonly used to operate a motor both forward and reverse.

(iv) **The advantages of helical gears:**

- Allow a number of teeth to mesh at the same time providing a strong drive
- Shafts need not be parallel for transferring power
- Quieter in operation then straight spur gears.

(v) A **double acting cylinder** needs compressed air to move the piston but will stay in this position if the air is turned off. It needs air to return the piston to its original position.

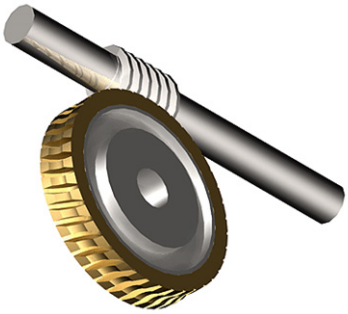
(Any three) 6 + 6 + 6

(c) There are a variety of ways of providing movements to the robot shown.

Suggested solution - other viable solutions are acceptable.

(i) Mechanism to move the robot's arm

The worm wheel will rotate precisely. This will give a swiveling action at the shoulder or elbow joints. This mechanism will provide a slow, deliberate motion to the robot arm.

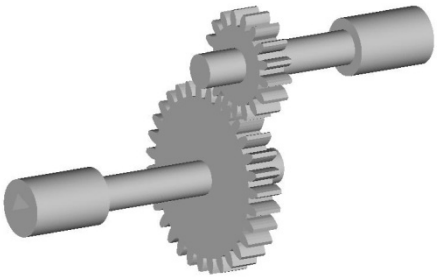


Worm is connected to a driver motor

8

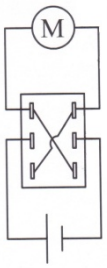
(ii) Mechanism to allow robot to travel on a flat surface

Gear directly connected to the wheels



Gear connected to a driving motor.
This arrangement will give a reduced speed for the movement of the robot.

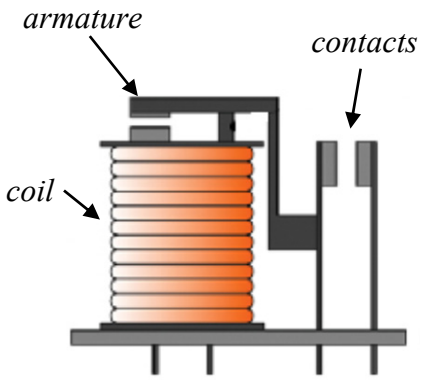
The motor can be controlled by switching that allows the motor to reverse as well as drive forward, speed control is also feasible. A DPDT switch can be used



Servo motors and Stepper motor could also be considered.

8

(c) **(i)** A **relay** is an electromagnetic device that changes switching contacts when it receives an electric signal. It consists of a wire coil with a soft iron core. If a small current is passed through the coil, the iron core is magnetised and a pivoted armature is attracted towards the magnetised core. The movement of the armature closes the contacts and may open other contacts. These contacts can be used to control larger currents or a secondary circuit.
The relay is a switch and changes electrical energy into mechanical energy.



8

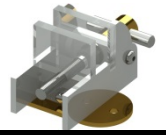
(ii) Relays are used in the following areas:

- Controlling a high-voltage circuit with a low-voltage signal, such as in audio amplifiers
- Controlling a high-current circuit with a low-current signal, as in the starter solenoid of a vehicle
- It is used in an electric door chime
- Switching from dip lights to head lights
- Relays are quite common in home appliances where there is an electronic control such as turning on a motor or a light.

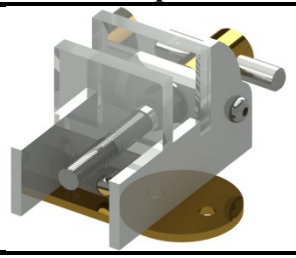
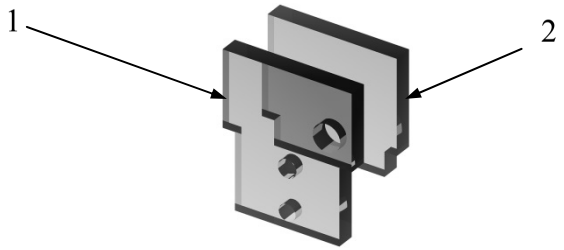
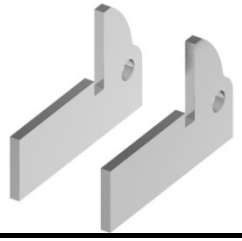
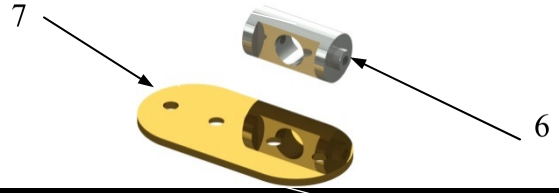
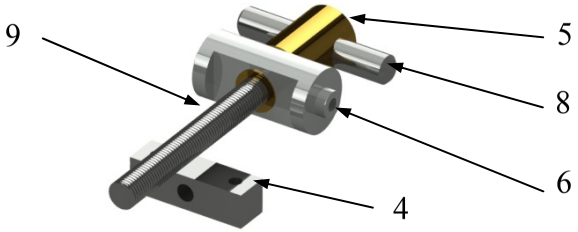
4 + 4

Coimisiún na Scrúduithe Stáit
State Examinations Commission

Leaving Certificate Engineering - Practical Marking Scheme 2015



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 1 and 2**		**Part 1** 12 Marks	Marking Out	**3**	20
				25 mm × 4 mm Steps	**6**	
				M8 Tapped Hole	**2**	
				Ø5.5 mm Hole	**1**	
			Part 2 8 Marks	Marking Out	**2**	
				8 mm × 4 mm Steps	**5**	
				Ø9 mm Hole	**1**	
3	**Part 3 × 2**		**Part 3 × 2** 20 Marks	Marking Out	**4**	20
				Rear Profiles	**6**	
				6 mm Slots	**4**	
				Lengths & Heights	**4**	
				Ø9 mm Holes	**2**	
4	**Parts 6 and 7**		**Part 6** 8 Marks	Marking Out	**2**	20
				26 mm × 4 mm Slots	**6**	
			Part 7 12 Marks	Marking Out	**4**	
				Drill, CSK & Profile	**8**	
5	**Parts 4, 5, 6, 8 and 9**		**Part 4** 8 Marks	Mark Out	**2**	20
				3 × M5 Tapped Holes	**6**	
			Parts 5, 6, 8 & 9 12 Marks	Lathe Work	**12**	

100 Marks (× 1.5 = 150 Total)

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