Coimisiún na Scrúduithe Stáit
State Examinations Commission

LEAVING CERTIFICATE EXAMINATION, 2017

ENGINEERING – MATERIALS AND TECHNOLOGY

(Higher level – 300 marks)

THURSDAY, 8th JUNE MORNING 9:30 – 12:30

INSTRUCTIONS

1. Answer **Section A** and **Section B** of **Question 1** and **FOUR** other questions.

2. All answers must be written in ink on the answer book supplied.

3. Diagrams should be drawn in pencil.

4. Squared paper is supplied for graphs, as required.

5. Please label and number carefully each question attempted.

Question 1. **(100 marks)**

Section A – 50 marks

Give **brief answers** to **any ten** of the following:



(a) Outline **two** advantages of LED car headlights over traditional car headlights.

(b) Identify **two** metals commonly used to protect steel from corrosion.

(c) Outline **two** safety devices integrated into modern motor vehicles.



(d) The cardboard EcoHelmet for cyclists, designed by Isis Shiffer, was awarded the 2016 International James Dyson award. Outline **two** advantages of this design, shown opposite.

(e) Give **two** reasons why stainless steel is suitable for the manufacture of surgical devices.

(f) Explain **two** methods of quality control which may be carried out during manufacture.

(g) Discuss the contribution that **any one** of the following has made to technology:
(i) George Devol **(ii)** Marie Curie **(iii)** Dugald Clerk.



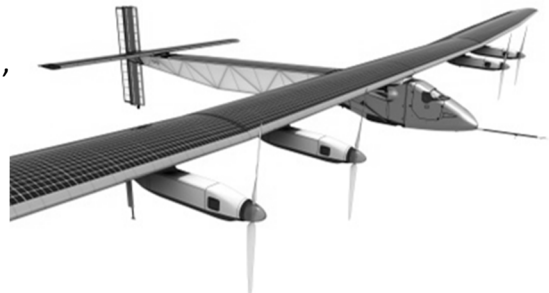
(h) Most golf clubs are manufactured with either steel or carbon-fibre (graphite) shafts. Describe **two** benefits of using carbon-fibre (graphite) shafts over steel shafts.

(i) Wireless technologies such as Wi-Fi and Bluetooth are widely used nowadays. Outline **one** advantage and **one** disadvantage of wireless technology.

(j) The rotor blades of a helicopter are subjected to high speeds and varying weather conditions, which could lead to fatigue failure. Explain the term fatigue failure.

(k) Explain the difference between a gap gauge and a plug gauge.

(l) Describe the principle of operation of a double acting hydraulic ram.



(m) The first flight around the world without using fossil fuel, was completed in July 2016 by the *Solar Impulse 2*. Describe briefly how this could be achieved.

Section B – 50 marks

Answer **all** of the following:

(n) The advanced technological development of robotic control has greatly improved many aspects of automobile manufacture.

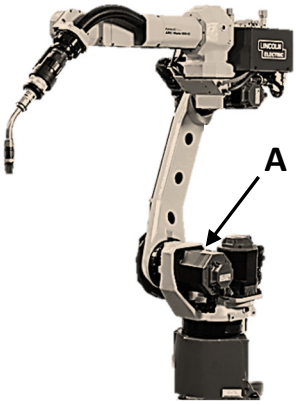


(i) Explain briefly what you consider to be the main advantages of using robotic control systems to aid manufacture.

(ii) Other than for welding, list **two** applications where robots are used in motor vehicle manufacture.

(o) Describe, with the aid of a diagram(s), **one** method of robotic welding commonly used in the automotive industry.

(p) Robotic joints are mainly powered by electric motors, as shown opposite.



articulated robotic arm

(i) Identify a type of motor suitable for Part **A**;

(ii) Describe the main features of this motor;

(iii) Name a suitable drive mechanism for a Cartesian Robot.

(q) Describe in detail any **one** of the following processes:

(i) Lead by nose;

(ii) Teach pendant;

(iii) Off-line programming.

(r) Describe **any two** of the following in relation to robotic control in motor vehicle manufacture:

(i) Closed loop control;

(ii) Degrees of freedom;

(iii) Working envelope;

(iv) **Any two** safety features of a robotic system used in automobile manufacture.

Question 2. **(50 marks)**

(a) The construction of Formula One cars and the materials used are strictly controlled by regulations to maximise the safety of the cars. Front, side and rear impact tests focus on the car's survival cell (cockpit), which must be designed to withstand high impact.



(i) Name and describe, with the aid of a diagram(s) a suitable impact testing procedure to examine the suitability of the material used in the survival cell.

(ii) Outline, with sketches, the expected results of impact tests on brittle materials **and** on tough materials.

(b) The results shown below were obtained from a tensile test on a **carbon steel** specimen of 12 mm diameter and 80 mm gauge length.

Load (kN)	30	80	126	146	153	147	152	162	181	174
Extension (mm)	0.2	0.5	0.8	0.9	1.5	2.0	2.5	3.0	5.6	8.0

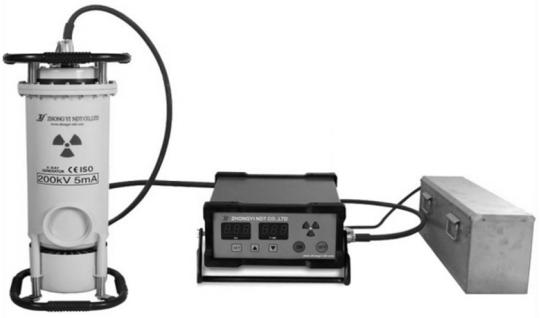
(i) Using the graph paper supplied, plot the load-extension diagram.

(ii) Indicate the following points on your graph:

- Elastic limit
- Start of necking
- Fracture point.

(iii) Find the ultimate tensile strength (UTS) of the material.

(c) A portable X-ray testing device is shown.



(i) Describe, with the aid of a diagram, the principles of X-ray testing.

(ii) Outline **two** safety hazards associated with the use of X-ray testing equipment.

Question 3. **(50 marks)**

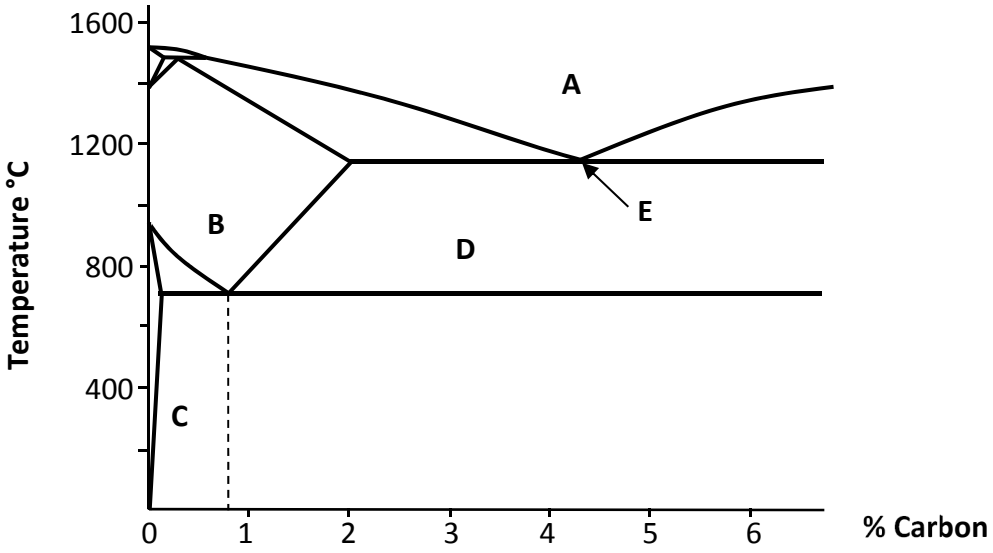
(a) Pizza ovens can be constructed from a variety of materials such as brick, clay, steel and cast iron. The pizza oven shown is manufactured from cast iron.



(i) Explain **two** reasons why cast iron is used in the manufacture of this pizza oven.

(ii) Distinguish between the composition of cast iron and the composition of low carbon steel.

(b) A simplified portion of the iron-carbon equilibrium diagram is shown.



(i) Identify the regions **A**, **B**, **C** and **D** shown.

(ii) Name and describe the significance of point **E**.

(iii) Explain the process of normalising **1.5%** carbon steel.

(c) Surface hardening techniques, such as case hardening and induction hardening, are often used as heat treatment processes for drive and transmission systems.



(i) Outline **two** reasons for surface hardening the teeth of the gear wheels.

(ii) Describe a case hardening process.

Question 4. **(50 marks)**

(a) The compression spring shown is made from a Beryllium-Copper alloy and is age hardened.



(i) Describe the process of age hardening.

(ii) With reference to the spring shown, outline **two** benefits of the age hardening process.

(b) The table shows the solidification temperatures for various alloys of metal **A** and metal **B**.

% of metal B in alloy	**0**	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**
Start of solidification (°C)	270	332	400	445	492	524	552	580	603	618	630
End of solidification (°C)	270	272	280	300	318	340	368	404	449	510	630

Using the graph paper supplied:

(i) Draw the equilibrium diagram, using the given data, **and** label the liquidus and solidus lines.

(ii) For the alloys containing 0% metal **B** and 100% metal **B**, explain why the start of solidification and the end of solidification are at the same temperature.

(iii) For the alloy with **50%** metal **B** determine, from the diagram, the composition of the phases at **400 °C**.

(c) Select **any two** from **(i)**, **(ii)** or **(iii)** below and differentiate between the terms in **each**:

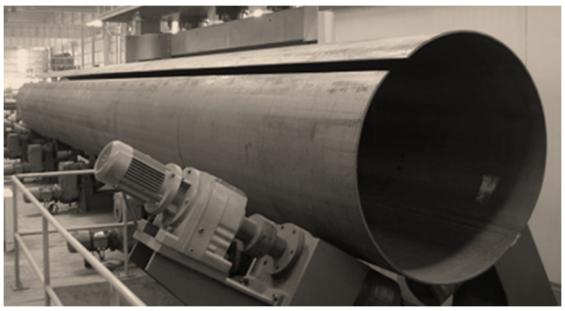
(i) *Amorphous* solid structures and *crystalline* solid structures;

(ii) *Solvus* and *solidus*;

(iii) *Body Centre Cubic* (BCC) and *Face Centre Cubic* (FCC) structures.

Question 5. **(50 marks)**

(a) The heavy steel pipe shown is first rolled into shape and is to be completed by welding.



(i) Select a suitable automated welding process for joining the seams along the length of the heavy steel pipe. Justify your selection.

(ii) Describe, with the aid of diagram(s), the main principles of operation for the selected welding process.

(b) Answer **any three** of the following:

(i) Describe the term *dissolved acetylene*.

(ii) Outline the reasons for *porosity* in welding.

(iii) Describe **two** hazards which may be encountered in underwater welding.

(iv) Outline **three** safety features integrated into oxy-acetylene welding equipment.

(v) Give **two** benefits of using resistance seam welding in the production of house radiators.

(c) Describe, with the aid of a suitable diagram(s), **any one** of the following:

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

(ii) The essential differences between Metal Inert Gas (MIG) welding and Tungsten Inert Gas (TIG) welding.

OR

(c) The Dyson 360 Eye™ robot vacuum cleaner uses battery power to operate and also incorporates link app technology.

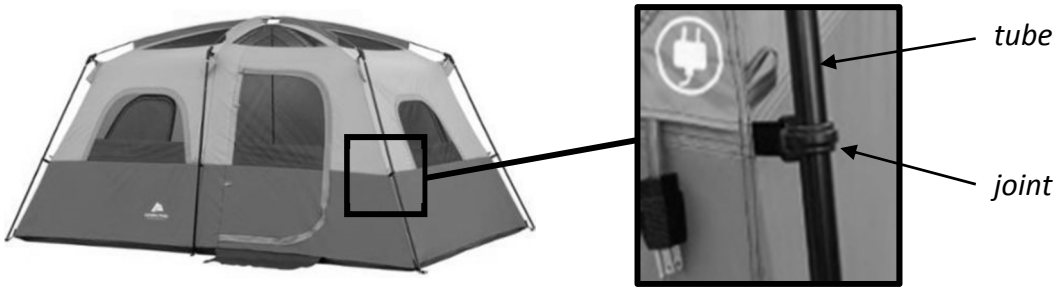


(i) Outline **one** advantage and **one** disadvantage of robotic vacuum cleaners linked to mobile apps.

(ii) Describe the importance of the 360° camera incorporated in the vacuum cleaner.

Question 6. **(50 marks)**

(a) Camping tents, canopies and promotional marquees are often constructed using interlocking flexible tube framing and moulded joints.



(i) Name a process used to manufacture the thermoplastic tubes **and** a process used to manufacture the thermoplastic joints.

(ii) Describe the principle of operation for the manufacturing process used to make the thermoplastic tubes.

(iii) Select a suitable thermoplastic for the frame tubing and give **one** reason for your selection.

(b) Many toys, including Lego® bricks, are manufactured from the copolymer Acrylonitrile Butadiene Styrene (ABS).



(i) Explain the term *copolymer.*

(ii) Outline **two** reasons for the use of ABS in the manufacture of toys.

(iii) Explain the polymerisation process used to produce ABS.

(c) Describe **any three** of the following:

(i) Calendering;

(ii) Plastic pultrusion;

(iii) Monomer;

(iv) Catalyst;

(v) Compression moulding.

Question 7. **(50 marks)**

(a) Answer **any three** of the following:

(i) Explain the term *tolerance* used in metrology.

(ii) Outline the difference between loading and glazing of grinding wheels.

(iii) Describe the function of a *reamer* in machining.

(iv) State **two** advantages of a keyless chuck.

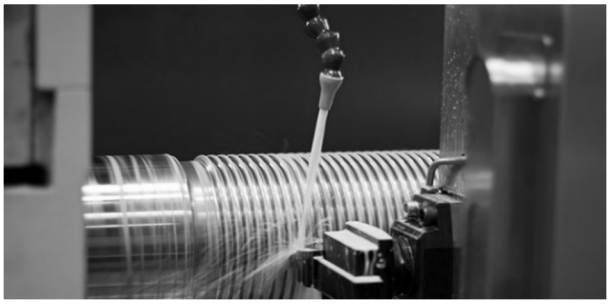
(v) Explain the term *rancidity* in relation to cutting fluids.

(b) Cutting fluids are commonly used in metal cutting machines.

(i) Identify **two** types of cutting fluids.

(ii) Describe the impact of cutting fluids on:

- metal cutting machines **and**
- metal cutting efficiency.



(c) Magnetic chucks, similar to the one shown, are used to hold workpieces during various machining processes.

(i) Explain, with the aid of a diagram(s), the basic operation of a magnetic chuck.

(ii) State **one** advantage and **one** disadvantage of magnetic chucks.



OR

(c) The use of 3-D printers, similar to the one shown, is rapidly growing in schools and in industry. These 3-D printers are operated by computer numerical control (CNC).

(i) Explain why stepper motors are used to control movements in CNC machines.

(ii) Identify **two** other modern manufacturing machines which can be operated using CNC.



Question 8. **(50 marks)**

(a) Entrance turnstiles are used to control access to train stations and sports stadiums.



(i) Describe, with the aid of a diagram, a suitable mechanism which allows a turnstile to rotate in one direction only.

(ii) Other than a turnstile, identify **two** applications for the mechanism described by you in **Q8(a)(i)** above.

(b) Answer **any three** of the following:

(i) Describe a mechanism that transmits motion through 90°.

(ii) State **two** advantages of helical gears over spur gears.

(iii) Outline a suitable use for a cam and follower mechanism.

(iv) Give **two** uses for a cylindrical roller bearing.

(v) Describe the operation of a capacitor.

(c) A car suitable for wheelchair users is shown opposite.

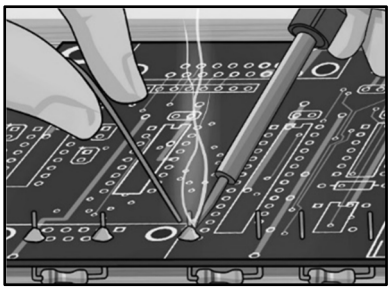


(i) Describe, with the aid of a diagram, a suitable mechanism to allow the sliding door to open.

(ii) Describe, with the aid of a diagram, a mechanism which will allow the ramp be automated.

OR

(c) The electronic circuit shown has components, including ICs, soldered on to a PCB.



(i) Explain the terms IC and PCB.

(ii) Outline the procedure for soldering the PCB shown, making reference to equipment, safety and to ensuring a high quality joint.

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