



**Coimisiún na Scrúduithe Stáit  
State Examinations Commission**

**LEAVING CERTIFICATE EXAMINATION, 2015**

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**ENGINEERING – MATERIALS AND TECHNOLOGY**

(Higher level – 300 marks)

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**THURSDAY, 4 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:

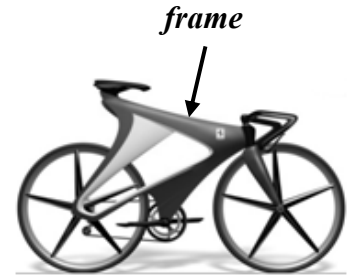
- (a) The computer tablet shown uses touchscreen technology. Give **one** advantage and **one** disadvantage of touchscreen technology.



- (b) State **two** safety precautions to be observed when using cutting fluids.

- (c) Describe the flotation process as a method of ore separation.

- (d) A concept bicycle shown opposite has a frame constructed from the composite material *carbon fibre*. Outline **two** material properties of carbon fibre which makes it a suitable material for bicycle frames.



- (e) Outline **two** reasons why stainless steel is widely used in jewellery making.

- (f) Describe the term *elastic memory* with reference to thermoplastics.

- (g) Discuss the contribution that any **one** of the following has made to technology:

- (i) James Dyson                      (ii) Ivan Sikorsky                      (iii) Jonas Hesselman.

- (h) State **two** advantages of using pneumatic power over electrical power for certain processes.

- (i) Describe **two** advantages of incineration as a means for the disposal of expanded polystyrene packaging.

- (j) Outline the main processes used to manufacture the tungsten barrel of a dart, as shown.



- (k) Identify **one** automatic welding process.

- (l) The roller coaster seat shown opposite is fitted with a safety harness, to securely hold an individual when the roller coaster is in use. Identify a suitable mechanism which will ensure that the safety harness remains in a closed position when in use.

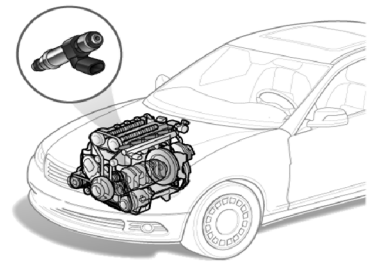


- (m) Outline **two** ways in which the steel structure of the roller coaster seat may be protected from corrosion.

**Section B – 50 marks**

Answer **all** of the following:

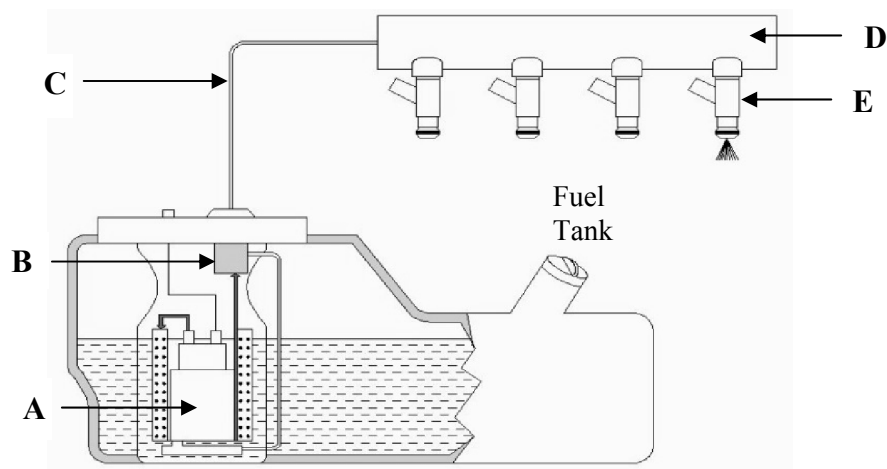
- (n) Fuel injection systems have replaced the traditional carburettor as a means of fuel delivery in petrol-powered cars. Indirect injection and direct injection are now a standard feature in modern engines.



Describe **any two** benefits of fuel injection systems.

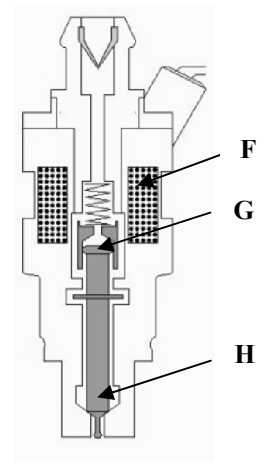
- (o) A simple diagram of a return-less fuel injection system is shown below.

- (i) Name the parts **A, B, C, D** and **E**.  
 (ii) Describe briefly the principle of operation of the system shown.



- (p) The diagram opposite shows the components of a typical fuel injector.

- (i) Identify the components **F, G** and **H**.  
 (ii) Explain the function and operation of the injector.



- (q) Modern fuel injection systems rely on multiple components and sensors. Describe briefly the function of **any two** of the following:

- (i) Throttle position sensor;  
 (ii) Lambda sensor;  
 (iii) Crankshaft position sensor;  
 (iv) MAP sensor.

- (r) Discuss the main features of Direct Injection, with reference to:

- Injection timing
- Mixture formation (air : fuel ratio).

**Question 2.**

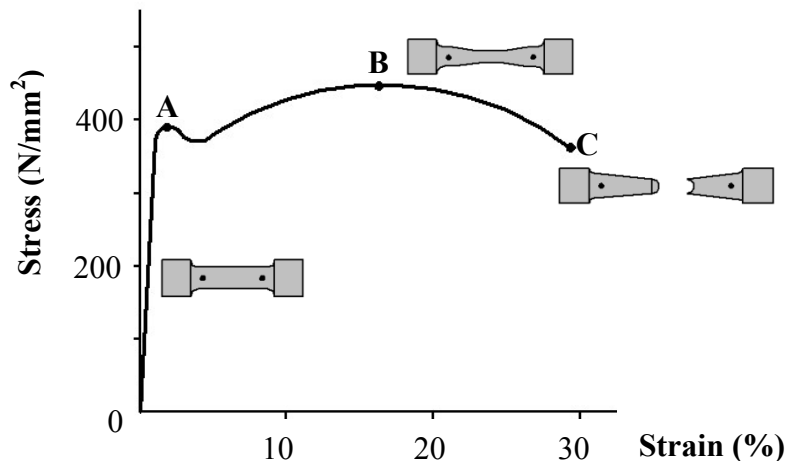
**(50 marks)**

- (a) The aluminium alloy wheel of a car, as shown, is subject to *fatigue* and must therefore be able to withstand shock and impact loads, such as striking kerbs and poor road conditions.



- (i) Explain the term *metal fatigue*.
- (ii) Describe in detail a suitable mechanical test to determine the aluminium alloy's ability to withstand shock or impact loads.

- (b) The Stress-Strain graph and the test specimen used in a tensile test are shown.



- (i) Identify the points labelled **A**, **B** and **C** on the Stress-Strain graph.
- (ii) Analyse the effects of the tensile test on the shape of the test specimen shown at **both B** and **C**.
- (c) Casting is the method used to manufacture the aluminium alloy wheel shown. As part of quality control, the wheel is examined for flaws, checked for porosity and for other possible defects in the casting.



- (i) Identify **one** non-destructive test to examine the wheel for surface flaws and **one** non-destructive test for internal flaws.
- (ii) Describe, with the aid of a diagram, the non-destructive test to examine for internal flaws identified at (c) (i) above.

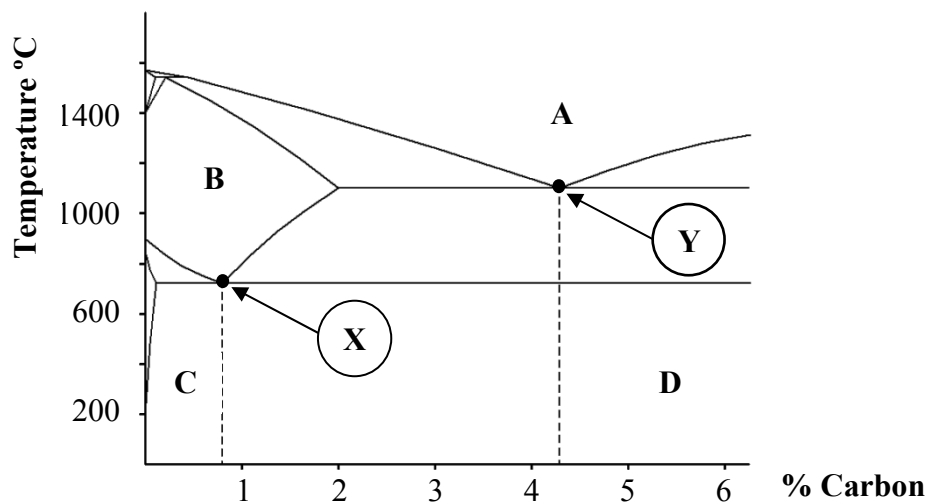
**Question 3.**

**(50 marks)**

- (a) Precision screwdrivers are used in the disassembly of modern smart phones.
- (i) Why is it necessary to carry out a heat treatment procedure on a precision carbon steel screwdriver?
- (ii) Describe in detail the heat treatment procedure required for a precision carbon steel screwdriver.



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

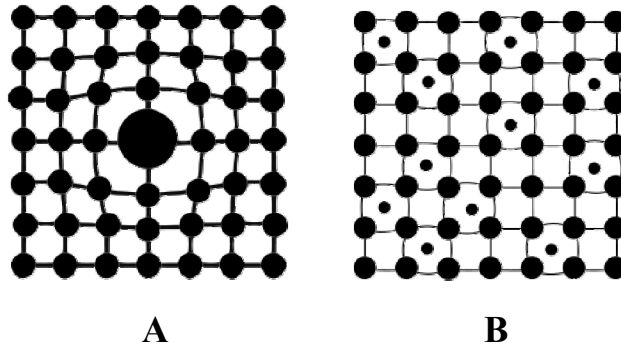


- (i) Name the regions **A**, **B**, **C** and **D** shown.
- (ii) Describe in detail point **X** and point **Y**, with reference to **each** of the following:
- Phase change
  - Composition
  - Temperature.
- (c) Select **any two** of the following and distinguish between:
- (i) Optical pyrometer and thermocouple pyrometer;
- (ii) Induction hardening and flame hardening;
- (iii) Ferrite and pearlite;
- (iv) Soaking and water cooling in heat treatment.

Question 4.

(50 marks)

- (a) Identify and describe the crystal point imperfections shown at **both A and B**.

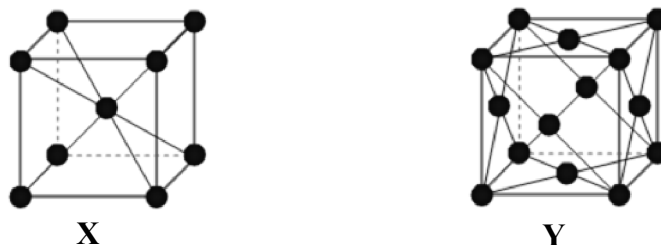


- (b) The given table shows the solidification temperatures for various alloys of metal **A** and metal **B**.

| % of metal B in alloy        | 0    | 10   | 20   | 30   | 40   | 50   | 60   | 70   | 80   | 90   | 100  |
|------------------------------|------|------|------|------|------|------|------|------|------|------|------|
| Start of solidification (°C) | 1083 | 1160 | 1220 | 1270 | 1320 | 1350 | 1380 | 1400 | 1430 | 1440 | 1453 |
| End of solidification (°C)   | 1083 | 1080 | 1090 | 1110 | 1140 | 1170 | 1220 | 1270 | 1330 | 1380 | 1453 |

Using the graph paper supplied:

- (i) Draw the equilibrium diagram according to the given data;
  - (ii) Label the diagram and describe the main features;
  - (iii) Determine from the diagram, the ratio of the phases at **1250 °C** for the alloy with **50% B**.
- (c) Two crystalline solid structures are represented at **X** and **Y** in the diagrams below.



- (i) Identify the **two** crystal structures **X** and **Y** shown.
- (ii) Explain why structure **X** is most associated with brittleness in metals.
- (iii) Name **one** metal based on structure **X** and **one** metal based on structure **Y**.

**Question 5.**

**(50 marks)**

- (a) Answer **any three** of the following:
- (i) Outline **two** methods used to prevent porosity occurring in welds.
  - (ii) Compare the electrode used in MIG welding and the electrode used in TIG welding.
  - (iii) Describe the carburising flame used in oxy-acetylene welding.
  - (iv) Suggest a suitable method to protect against **each** of the following when welding:
    - Electric shock
    - Intense light from welding
    - Welding fumes.

- (b) The kart shown has a welded mild steel frame.
- (i) Select a suitable welding process for joining the frame and outline **one** reason for your selection.
  - (ii) Describe in detail the key principles of the welding process selected.



- (c) Using the following guidelines, compare resistance seam welding **and** resistance spot welding:
- Electrode shape
  - Principle of operation
  - Weld joint
  - Application.

**OR**

- (c) (i) Explain the importance of **each** of the following in relation to the Robocoaster device shown opposite:
- Degrees of freedom
  - Working envelope.
- (ii) Outline **two** reasons why programmable robots are used in the on-going development of compact mechanised thrill machines for amusement parks.





**Question 6.**

**(50 marks)**

- (a) For safety reasons, mouthguards are widely used in sport. The mouthguard shown is manufactured from the thermoplastic copolymer, ethylene-vinyl-acetate (EVA).

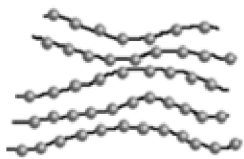
- (i) Outline **any two** reasons why EVA is suitable for the manufacture of a mouthguard.
- (ii) Describe, with the aid of a diagram, a suitable polymer manufacturing process to mass-produce a thermoplastic mouthguard.



- (b) Select **any two** of the following and distinguish between:

- (i) Amorphous and crystalline polymer;
- (ii) Natural and synthetic rubber;
- (iii) Foaming agents and fillers;
- (iv) Catalyst and inhibitor.

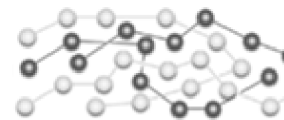
- (c) (i) Discuss the main properties **and** the internal structures of **each** of the following:



*Thermoplastics*



*Thermosetting plastics*



*Elastomers.*

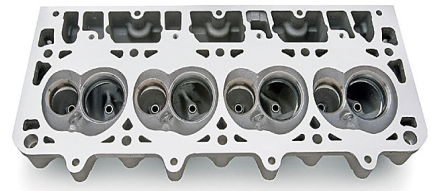
- (ii) Describe how the variety of polymers currently available has influenced modern design technology.

**Question 7.**

**(50 marks)**

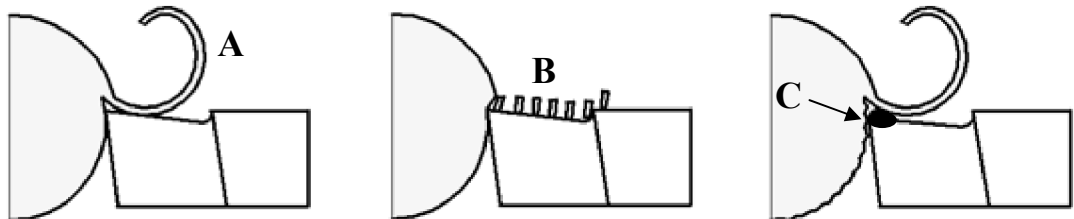
- (a) Answer **any three** of the following:
- (i) Identify **any two** lubricating materials used in engineering machines;
  - (ii) Distinguish between the use of a plug gauge and the use of a gap gauge;
  - (iii) State **two** uses for a chuck guard on the lathe;
  - (iv) Distinguish between countersink and counterbore holes;
  - (v) Name **two** important properties of cutting tool materials.

- (b) The surface of the cylinder head in an engine, as shown, has to be ground flat and smooth before assembly.



- (i) Describe, with the aid of a suitable diagram, a surface grinding process for a cylinder head.
- (ii) Outline **two** safety hazards associated with using a grinding machine.

- (c) Machining on the lathe can produce metal chips such as those illustrated at **A**, **B** and **C** below.



- (i) Identify the metal cutting chips shown at **A** and **B** and distinguish clearly between them making reference to material properties.
- (ii) Analyse the impact on safety **and** surface finish of the chip formation shown at **C**.

**OR**

- (c) CNC machining has many applications in engineering manufacture.

- (i) Give **two** advantages and **two** disadvantages of CNC machining.
- (ii) Identify **two** factors to be taken into account when selecting CNC machining for the manufacture of the chess pieces shown opposite.



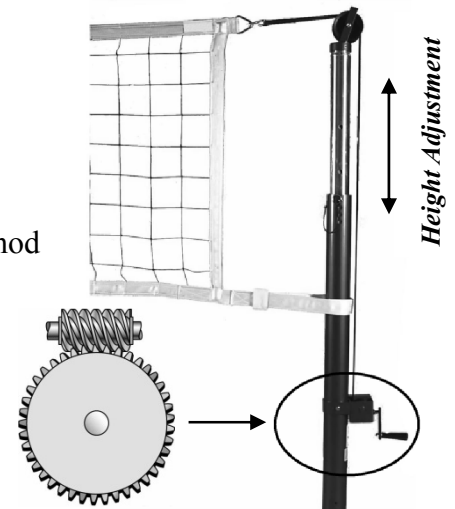
**Question 8.**

**(50 marks)**

(a) A worm and worm wheel mechanism is used to tension the volleyball net shown opposite.

(i) Describe, with the aid of a diagram, how the worm and worm wheel mechanism shown may be operated to tension the net.

(ii) Describe, with the aid of a diagram, a suitable method for adjusting the height of the net shown.

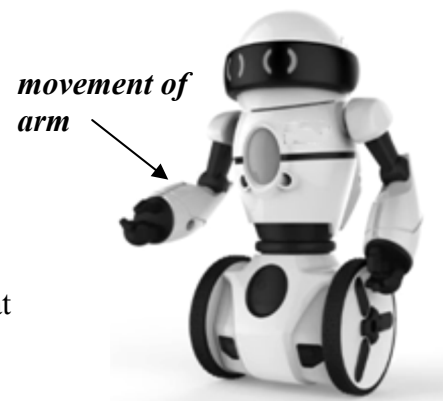


(b) Explain **any three** of the following:

- (i) The function of a thermostat;
- (ii) The advantages of roller bearings;
- (iii) **One** application of a DPDT switch;
- (iv) **Two** advantages of helical gears over spur gears;
- (v) The operation of a pneumatic double-acting cylinder.

(c) The robot shown is capable of moving in a number of different directions. With the aid of suitable diagrams, identify and describe clearly **each** of the following:

- (i) a mechanism to move the robot's arm;
- (ii) a mechanism to allow the robot to travel on a flat surface.



**OR**

(c) Relays are used in numerous electrical circuits, usually allowing low voltage circuits to drive higher voltage circuits.

- (i) Describe, with the aid of a diagram, the principle of operation of a relay.
- (ii) Identify **two** applications for relays.



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