



# **Coimisiún na Scrúduithe Stáit State Examinations Commission**

**LEAVING CERTIFICATE EXAMINATION, 2018**

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**ENGINEERING – MATERIALS AND TECHNOLOGY**

(Higher level – 300 marks)

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**THURSDAY, 7<sup>th</sup> 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:

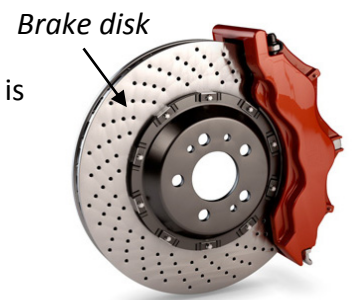
- (a) Car parking sensors use ultrasonic waves to assist in the parking and navigation of vehicles. Explain how the ultrasonic sensors operate.



- (b) Explain the term *factor of safety*.

- (c) Explain **two** reasons why titanium metal is used in surgical applications, such as in joint replacements and tooth implants.

- (d) Modern motor vehicles use a disk braking system, where a brake pad is pressed against the rotating disk to slow the vehicle upon braking. Suggest a suitable metal for the manufacture of the brake disk.



- (e) Outline **two** reasons for the holes on the design of the brake disk.

- (f) The thickness of the brake disk is 22 mm with a tolerance of +/- 0.15 mm. State the maximum acceptable thickness of the brake disk.

- (g) The shell of the American football helmet shown is manufactured from carbon fibre and must resist impact. Describe **one** suitable impact test.



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

- (i) James Dyson                      (ii) Charles Parsons                      (iii) Eileen Gray.

- (i) Lead is used in roof flashings but is subject to metal creep. Explain the term *metal creep*.

- (j) Explain the term *elastic memory* with reference to thermoplastics.

- (k) Aluminium is often the material of choice for outdoor TV antennas because of its ability to resist corrosion. Give **two** other reasons for the use of aluminium for outdoor TV antennas.



- (l) Outline **two** reasons why cast iron is used to make garden ornaments.

- (m) The use of electric vehicles is increasing, especially in urban areas. State **one** advantage and **one** disadvantage for the use of electric vehicles.



**Section B – 50 marks**

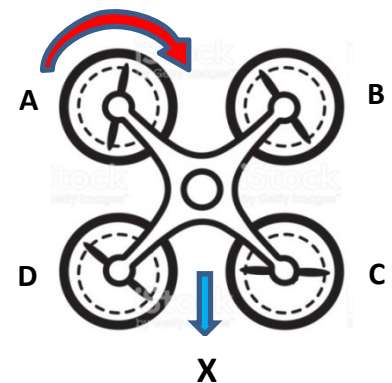
Answer **all** of the following:

- (n) Unmanned aerial vehicles (UAV) or drones, as they are commonly known, have a varied range of use from the military to the enthusiast. List **two** popular drone applications in each of the categories below:



- (i) Sporting and recreational activities;
- (ii) Agriculture.

- (o) The propeller layout of a typical drone quadcopter is shown. Drone movement is dependant on both propellor rotation *and* appropriate speed. Describe both the rotation **and** associated speed for each propellor **A, B, C** and **D** for the following flight operations:



- (i) Hovering in a fixed elevated position;
- (ii) Forward movement in the direction of arrow X.

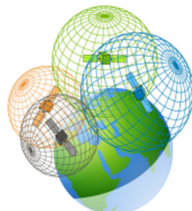
- (p) The flight control system includes a range of sensors, mainly to achieve smooth and stable flight. Explain the function of any **two** of the following in relation to flight control:

- (i) Accelerometer;
- (ii) Gyroscope;
- (iii) Electronic speed controller.



- (q) Drone navigation systems are normally reliant on a Global Positioning System (GPS) for safe guidance. Describe briefly any **two** of the following in relation to navigation:

- (i) Trilateration;
- (ii) Autonomous flight;
- (iii) Auto return home;
- (iv) FPV flying.



- (r) Describe any **two** methods used to address security and privacy issues with regard to drone usage.

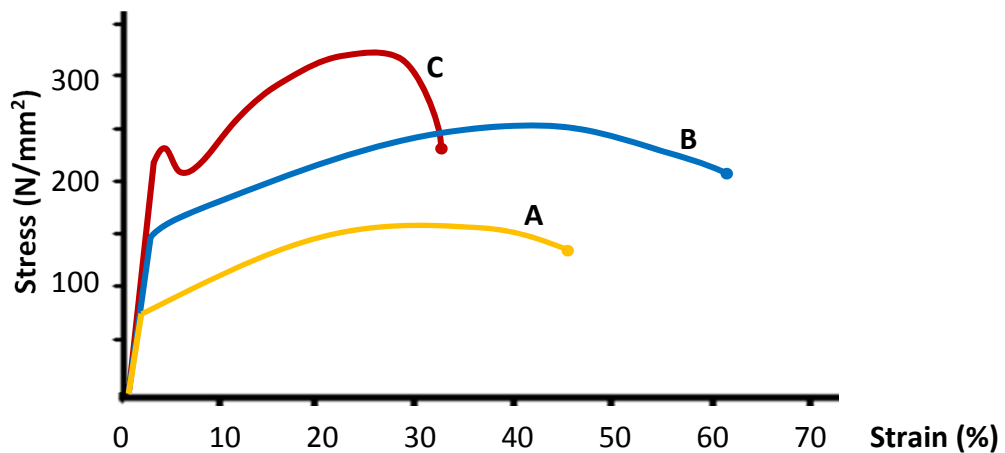
**Question 2.**

**(50 marks)**

- (a) The Mary McAleese Boyne Valley Bridge on the M1 motorway uses steel cables in tension to suspend the bridge.
- (i) Outline **one** method which may be used to protect the steel cables on the bridge from corrosion.
- (ii) Describe, with the aid of a diagram(s), the principles of tensile testing.



- (b) The graphs **A**, **B** and **C** shown below were produced following tensile tests on three metals – copper, low carbon steel and stainless steel.



- (i) State which one of the three metals – copper, low carbon steel or stainless steel – is most suitable for **each** of the graphs **A**, **B** and **C**.
- (ii) Compare graph **A** and graph **C** with reference to **each** of the following:
- the shape of the graph
  - material properties.
- (iii) Determine, from graph **B**, the ultimate tensile stress for metal **B**.

- (c) Bronze alloys are used to cast propellers for large ships. As part of a quality control procedure, the bronze propeller shown is non-destructively tested before use.

- (i) Outline **one** economic benefit and **one** safety benefit of using non-destructive testing for ship propellers.
- (ii) Describe, with the aid of a diagram, **one** suitable non-destructive test to examine the propeller for flaws near the surface of the bronze casting.

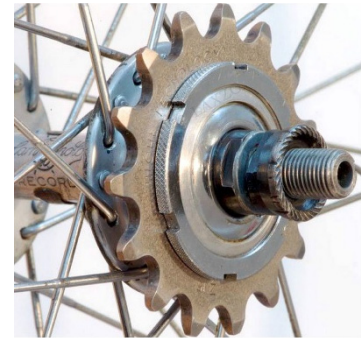


Question 3.

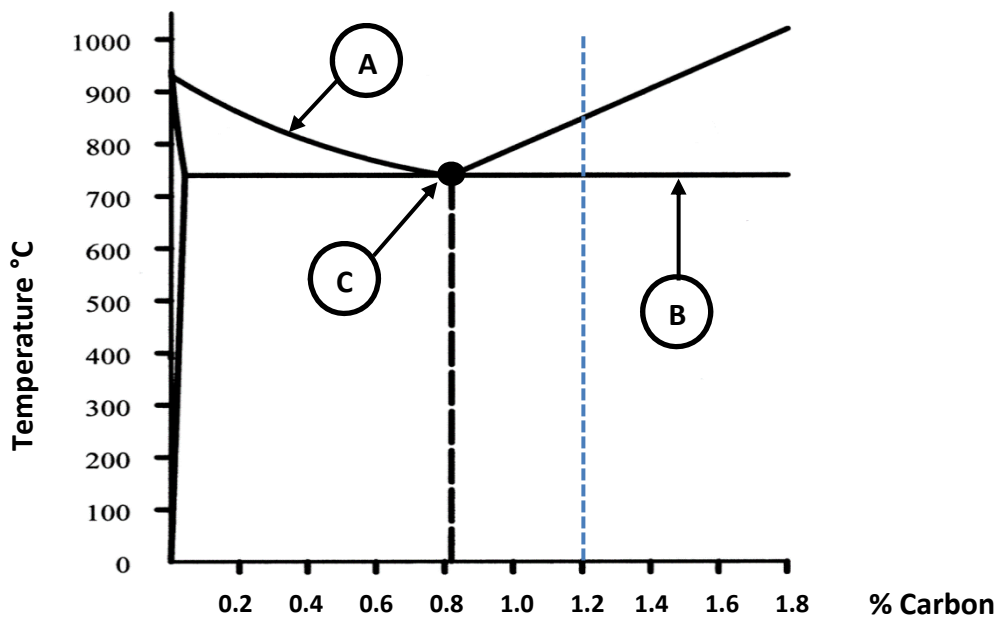
(50 marks)

(a) The teeth on the sprocket shown are surface hardened during manufacture.

- (i) Describe, with the aid of a diagram, a suitable heat treatment process for the teeth of the sprocket.
- (ii) Outline **two** faults that might cause the sprocket to fail during the heat treatment process.



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

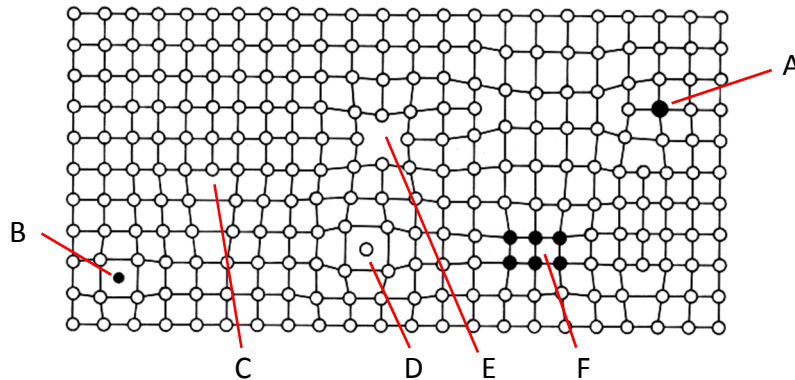


- (i) Explain the transformation that occurs along line **A** and along line **B**.
  - (ii) Name point **C** and describe the transformation which occurs at this point.
  - (iii) Describe the annealing of 1.2% carbon steel under the following headings:
    - Temperature
    - Cooling process
    - Effects on the steel.
- (c) Describe, with the aid of a diagram(s), **one** method of measuring furnace temperature, using the following guidelines:
- Equipment used
  - Principles of operation
  - Accuracy of results.

**Question 4.**

**(50 marks)**

**(a)** A range of crystal defects is shown in the lattice below.



- (i)** Name and describe **three** crystal point defects in the lattice.
- (ii)** Outline, with the aid of a diagram, the impact of a line defect.

**(b)** The table shows the solidification temperatures for various alloys of Cadmium and Zinc. The melting temperature of Zinc is 419°C and the melting temperature of Cadmium is 321°C.

% of Zinc in alloy	10	14	20	30	40	50	60	70	80	90
Start of solidification (°C)	290	266	275	293	310	328	345	362	380	401
End of solidification (°C)	266	266	266	266	266	266	266	266	266	266

Using the graph paper supplied:

- (i)** Draw the equilibrium diagram according to the information given above and the data in the table.
  - (ii)** Label the liquidus line, the solidus line and the eutectic point.
  - (iii)** For the alloy with **60% Zinc**, determine from the diagram the ratio of the phases at **300 °C**.
- (c)** Select **any two** from **(i)**, **(ii)** or **(iii)** below and explain the difference between **each** term:
- (i)** Partial solubility alloy and solid solution alloy;
  - (ii)** Work hardening and age hardening;
  - (iii)** Ductility in BCC structures and ductility in FCC structures.

Question 5.

(50 marks)

(a) The tubular frame for the roadster shown is formed using mild steel.

- (i) Describe, with the aid of a diagram(s), a suitable welding process to manufacture the mild steel frame shown.
- (ii) Outline **three** safety features integrated into the welding technique selected.



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

- (i) Describe how multi-run welding can positively affect the quality of a weld.
- (ii) Outline the principles of submerged arc welding.
- (iii) Give **two** benefits of the formation of slag in manual metal arc welding.
- (iv) Describe **two** safety hazards associated with resistance spot welding.
- (v) Outline **three** ways in which oxidation may be prevented during welding.

(c) Describe, with the aid of suitable diagrams, the **three** flame types associated with oxy-acetylene welding with reference to **each** of the following:

- Constituents of each flame
- Ratio of oxygen to acetylene gases in each flame
- Temperature of each flame
- Uses of each flame.

OR

(c) The robotic lawn mower shown is guided by a boundary wire and uses a combination of battery and solar power to move during operation.

- (i) Explain the following terms associated with robotic lawn mowers:
  - Self-docking;
  - Robotic sensors.
- (ii) Outline **one** positive environmental impact of robotic lawn mowers.





Question 6.

(50 marks)

(a) The vehicle roof box shown is designed to carry luggage and is manufactured from the thermoplastic copolymer, Acrylonitrile Butadiene Styrene (ABS).

(i) Name and describe, with the aid of a diagram, a polymer manufacturing process suitable for the manufacture of the roof box.

(ii) Outline a suitable polymer additive which is used to improve the roof box for **each** of the following:

- to increase flexibility
- to provide greater resistance to UV rays.



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

- (i) Calendering;
- (ii) Addition polymerisation;
- (iii) Glass transition temperature;
- (iv) Van der Waal forces;
- (v) Rotational moulding.

(c) Some windscreens on vehicles are held in place by extruded elastomer seals. The car windscreen shown is held in place by a silicone rubber elastomer.

- (i) Explain the term *elastomer*.
- (ii) Explain the polymer manufacturing process of extrusion and give **one** reason for using this process to produce elastomer seals.
- (iii) Explain **two** reasons why elastomer seals are used to hold glass panels in frames.



**Question 7.**

**(50 marks)**

- (a)** A continuous chip formed during parting-off is shown.
- (i)** Identify **two** materials which may produce a continuous chip formation when machined.
- (ii)** Explain the impact of continuous chip formation on:
- Surface finish
  - Automated machinery.



- (b)** Answer **any three** of the following:
- (i)** Explain the difference between a dovetail cutter and a slot drill in milling.
- (ii)** Outline **one** reason for balancing a grinding wheel.
- (iii)** Explain why a three-jaw chuck is not suitable for holding a square bar.
- (iv)** Describe **one** method of holding a work piece securely when surface grinding.
- (v)** Describe the use of a fixed steady when operating a lathe.
- (c)** Grinding wheels are subject to conditions such as loading and glazing which affects the cutting ability of the grinding wheel.
- (i)** Explain, with the aid of a diagram(s), the differences between loading and glazing of grinding wheels.
- (ii)** Describe a suitable wheel dressing process used to repair a grinding wheel.

**OR**

- (c)** In modern CNC systems, CAD software is used to define the dimensions of a part while CAM software is used to control the machine.
- (i)** Explain **two** of the following terms in relation to CNC technology:
- Machine tool envelope
  - Software simulation
  - Closed loop control.
- (ii)** Identify **two** safety features incorporated into modern CNC machines.



**Question 8.**

**(50 marks)**

- (a)** Hospital beds have special features both for the comfort of the patient and for the convenience of health care workers. Common features include adjustable height for the entire bed and collapsible side rails.

- (i)** Describe, with the aid of a diagram, how the mechanism shown may raise and lower the height of the bed.
- (ii)** Explain, with the aid of a diagram, how the side rails may be collapsed to allow a patient ease of access to the bed.



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

- (i)** Explain how a stepped cone pulley can change the speed of a machine.
- (ii)** Outline how a cam and follower mechanism may be used in a child's toy.
- (iii)** Give **two** applications for a universal joint.
- (iv)** Explain how a crank and slider mechanism may operate an electric knife.
- (v)** Outline the operation of a single acting pneumatic cylinder.

- (c)** The 3-wheel electric-motor golf cruiser shown opposite has given people with reduced mobility the opportunity to continue to play golf.

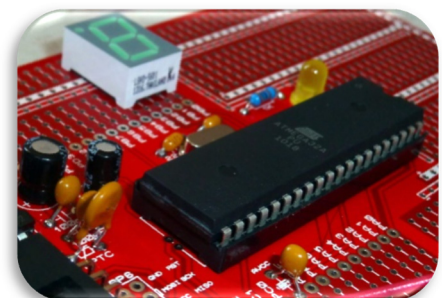
- (i)** Describe, with the aid of a diagram, a suitable steering mechanism for the golf cruiser shown.
- (ii)** Describe **two** advantages for having a single rear wheel cruiser over a single front wheel cruiser.



**OR**

- (c)** Integrated Circuit (IC) chips are used in many electronic devices.

- (i)** Describe **two** benefits of using IC chips.
- (ii)** Outline the importance of using a heat sink in the soldering of IC circuits.
- (iii)** State **two** common output components used in electronic circuits.



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