



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

**LEAVING CERTIFICATE EXAMINATION, 2021**

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**ENGINEERING – MATERIALS AND TECHNOLOGY**

(Higher level – 250 marks)

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**THURSDAY 10 JUNE**

**MORNING 9:30 – 12:30**

The 2021 examination papers were adjusted to compensate for disruptions to learning due to COVID-19. This examination paper does not necessarily reflect the same structure and format as the examination papers of past or subsequent years.

## INSTRUCTIONS

1. Answer **any FIVE questions**.
2. All questions carry equal marks.
3. All answers must be written in ink on the answer book supplied.
4. Diagrams should be drawn in pencil.
5. Squared paper is supplied for graphs, as required.
6. Please label and number carefully each question attempted.

**Question 1.**

**(50 marks)**

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

- (a) Describe **two** ways in which wireless headsets have improved the in-game experience of online gaming.
- (b) Briefly describe the principle of operation of *resistance spot welding* and give **one** example of where it is typically used.
- (c) Discuss the contribution that **any one** of the following has made to technology:  
(i) Ferdinand Porsche                      (ii) Hedy Lamarr                      (iii) Nikolaus Otto.



- (d) Water drinkers for cattle are typically manufactured from polyethylene which is UV light and frost resistant. Describe a polymer manufacturing process suitable for a water drinker.



- (e) Give **two** reasons why tubular aluminium is used in scaffolding.
- (f) Describe, with the aid of a diagram, the difference between single-acting and double-acting pneumatic cylinders.
- (g) Explain **two** benefits of using automatic hand sanitisers in schools.
- (h) Outline **two** reasons why it may be necessary to operate drilling machines at different speeds.
- (i) Annealed copper tubing is typically used to replace damaged brake pipes in cars. Briefly describe how copper is annealed.



- (j) Give **two** benefits of using telescopic adjustment on the mobile phone selfie stick shown.



- (k) Explain the significance for having a safety factor of 5 ( $FoS = 5$ ) on a structural beam.
- (l) Identify **two** metals which are commonly used to protect steel from oxidation.

- (m) Outline **two** reasons for the use of composite materials, such as carbon fibre and fibreglass, in the production of modern kayaks.



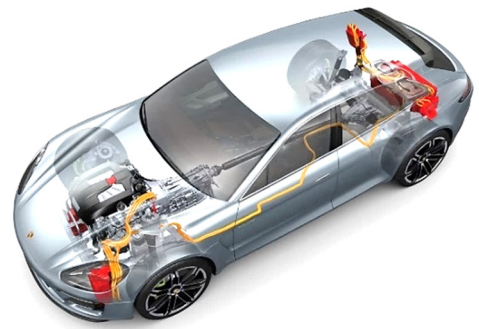
**Question 2.**

**(50 marks)**

Answer **all** of the following:

- (a) Hybrid vehicle technology was first developed at the beginning of the 20<sup>th</sup> century and until recent decades it virtually disappeared from modern transport development.

- (i) Describe the term *hybrid vehicle technology*.
- (ii) Identify **two** benefits of using hybrid vehicles in urban transportation.



- (b) Ireland's National Transport Authority (NTA) has extensively researched different types of hybrid vehicles as it plans to purchase up to 500 hybrid buses over the next five years. Explain **each** of the following types of hybrid vehicle technology:

- (i) Full hybrid;
- (ii) Mild hybrid;
- (iii) Plug-in hybrid.

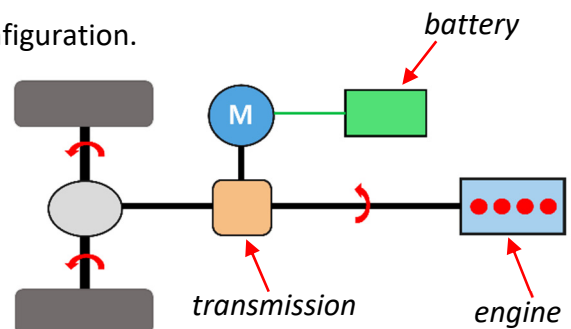


- (c) Describe **any one** of the following in relation to hybrid vehicle technology:

- (i) Regenerative braking;
- (ii) Electric traction motors.

- (d) Hybrid vehicles are categorised by their design configuration.

- (i) Identify the hybrid vehicle configuration shown opposite.
- (ii) Describe, using the given labels, the operation of the hybrid vehicle shown.



- (e) Describe how hybrid vehicle technology may impact on **any two** of the following:

- (i) Vehicle ownership;
- (ii) Environmental considerations;
- (iii) Vehicle maintenance.

**Question 3.****(50 marks)**

- (a) Select **any two** from (a)(i), (ii) or (iii) below and explain the difference between the terms in **each**:

- (i) Brinell hardness test **and** Vickers hardness test;
- (ii) Yield strength **and** ultimate tensile strength;
- (iii) Izod impact testing **and** Charpy impact testing.

- (b) The results shown were obtained from a tensile test on an aluminium alloy specimen.

|                                  |      |      |      |      |      |      |      |      |
|----------------------------------|------|------|------|------|------|------|------|------|
| <b>Stress (N/mm<sup>2</sup>)</b> | 50   | 125  | 195  | 260  | 300  | 330  | 350  | 352  |
| <b>Strain (x1000)</b>            | 0.60 | 1.40 | 2.20 | 3.00 | 3.70 | 5.00 | 7.00 | 8.50 |

- (i) Using the graph paper supplied, plot the stress - strain diagram for the alloy.
  - (ii) Determine the 0.1% proof stress for the alloy.
  - (iii) Calculate Young's Modulus of Elasticity for the alloy.
- (c) Non-destructive testing (NDT) of finished components is an essential part of quality control in engineering manufacture.

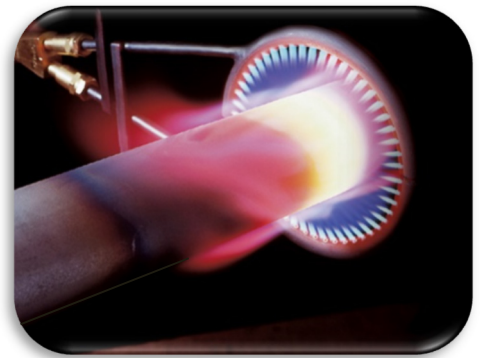
- (i) Describe, with the aid of suitable diagrams, the stages involved in *liquid penetrant* testing.
- (ii) Describe, with the aid of a diagram, a suitable non-destructive test to locate internal cavities in a welded joint.



**Question 4.**

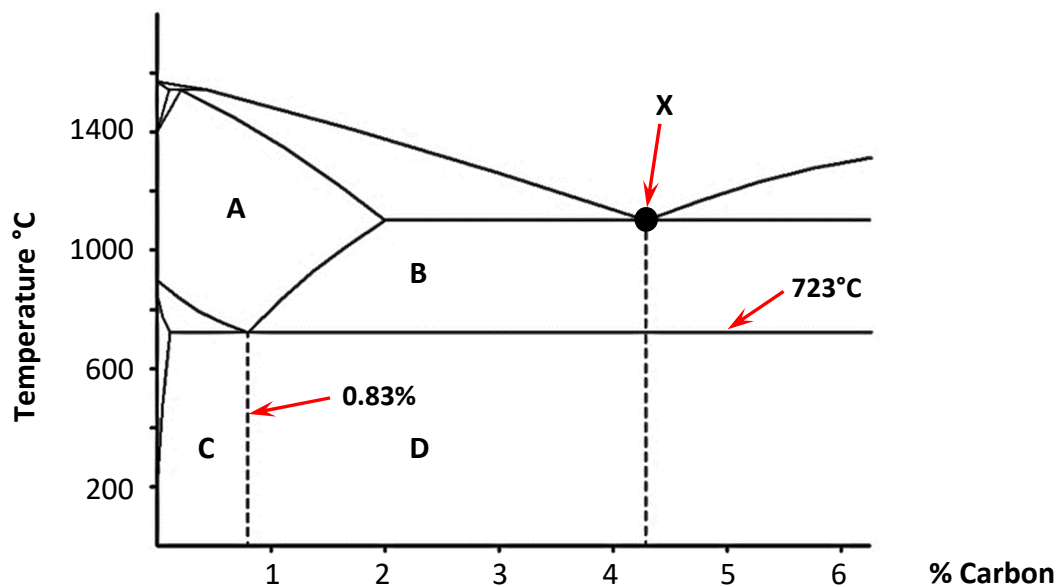
**(50 marks)**

- (a) Heat treatments are performed on steels and other metals to alter their properties. A surface hardening heat treatment process is shown opposite.



- (i) Identify and describe, with the aid of a diagram, the surface hardening process shown.
- (ii) Outline **two** benefits of performing the surface hardening heat treatment shown.

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



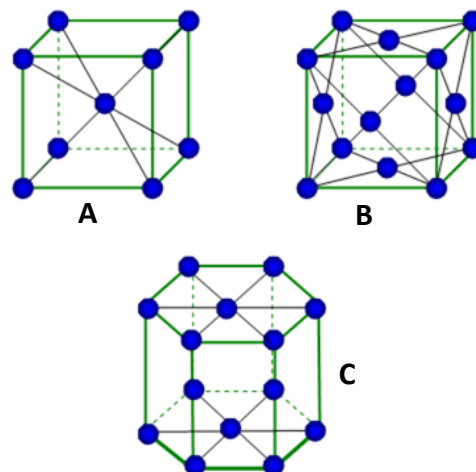
- (i) Identify the regions **A**, **B**, **C** and **D** shown.
  - (ii) Identify and explain the microstructure which is present at **0.83%** carbon steel, up to **723°C**.
  - (iii) Describe the transformation that occurs at point **X**, with reference to temperature, composition and phase change.
- (c) Select **any two** from (i), (ii) or (iii) below and explain the difference between the terms in **each**:
- (i) Optical pyrometer **and** thermocouple pyrometer;
  - (ii) Grey cast iron **and** white cast iron;
  - (iii) Upper critical temperature (UCT) **and** lower critical temperature (LCT).

**Question 5.**

**(50 marks)**

**(a)** The crystal structures of three metals are shown opposite.

- (i)** Identify the crystal structures **A**, **B** and **C**.
- (ii)** Explain why crystal structure **B** is likely to be more ductile than crystal structure **A**.
- (iii)** Describe **two** possible crystal point defects which may occur during metal solidification.



**(b)** The table shows the solidification temperatures for various alloys of Cadmium and Bismuth. The melting temperature of Bismuth is 268°C and the melting temperature of Cadmium is 321°C.

| % of Cadmium in alloy        | 10  | 20  | 30  | 40  | 50  | 60  | 70  | 80  | 90  |
|------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Start of solidification (°C) | 237 | 205 | 175 | 140 | 190 | 235 | 265 | 290 | 310 |
| End of solidification (°C)   | 140 | 140 | 140 | 140 | 140 | 140 | 140 | 140 | 140 |

Using the graph paper supplied:

- (i)** Draw the equilibrium diagram according to the given data, and label the liquidus and solidus lines and the eutectic point.
  - (ii)** For the alloy containing **75%** Cadmium, determine from the diagram the ratio of the phases at **200°C**.
  - (iii)** For the alloy containing **20%** Cadmium, describe, with the aid of a diagram, the cooling curve for the alloy, referring to the solidification temperatures.
- (c)** Select **any two** from **(i)**, **(ii)** or **(iii)** below and explain the difference between the terms in **each**:
- (i)** Solid solution alloy **and** partial solubility alloy;
  - (ii)** Crystalline **and** amorphous solid structures;
  - (iii)** Eutectic **and** eutectoid transformations.

**Question 6.**

**(50 marks)**

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

- (i)** Outline **two** main features of electro-slag welding.
- (ii)** Identify **three** safety features integrated into oxy-acetylene welding equipment.
- (iii)** Explain the function of the earth clamp in arc welding units.
- (iv)** Give **two** benefits of the formation of slag in manual metal arc welding.

**(b)** Steel girders are frequently used to form a structural base in bridge construction. The girders are fabricated from long plates of steel that are continuously welded into the desired shape.

- (i)** Describe, with the aid of a diagram(s), a suitable welding process to manufacture the girders for the bridge shown.
- (ii)** Outline **three** safety precautions to be observed when operating a welding unit.



**(c)** Describe, with the aid of a diagram(s), Tungsten Inert Gas welding (TIG), under **each** of the following headings:

- Principle of operation
- Electrode type
- Method of preventing oxidation
- Applications.

**OR**

**(c)** Robotic assisted surgery (RAS) is the most advanced form of “key hole” surgery now available. The robotic arms and instruments are controlled by the surgeon who is positioned at a console nearby.

- (i)** Explain the following terms in relation to the robotic assisted surgery (RAS):
  - Degrees of freedom
  - Machine vision.
- (ii)** Describe the important role played by stepper motors in the control of robotic arms.

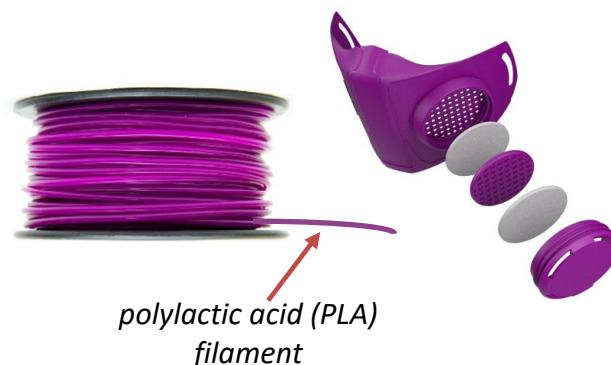


## Question 7.

(50 marks)

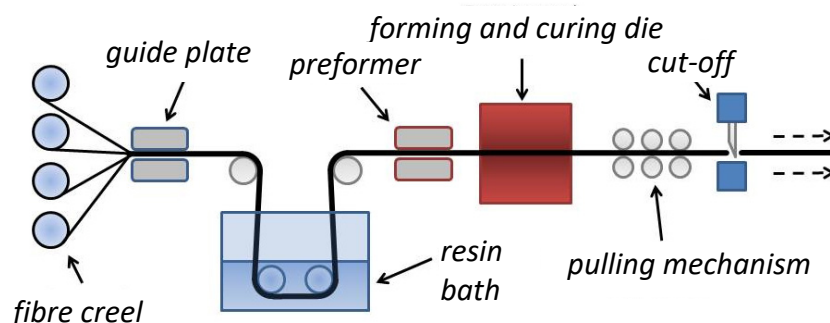
- (a) Polylactic acid (PLA) filament, as shown, is a thermoplastic bioplastic extensively used as a feedstock material in 3-D printing.

- (i) Explain the term *bioplastic*.
- (ii) Name and explain a suitable polymer manufacturing process used to produce the polylactic acid (PLA) filament.
- (iii) Give **two** reasons for the use of polylactic acid (PLA) in 3-D printing.



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

- (i) Describe the main differences between natural rubber and synthetic rubber.
- (ii) Describe the manufacturing process of *plastic pultrusion* shown below.



- (iii) Outline **two** negative effects on the environment of petroleum-based polymer manufacture.
  - (iv) Describe, with the aid of a diagram, the *ethylene monomer*.
  - (v) Explain the polymer manufacturing process of vacuum forming.
- (c) The water dispenser shown has a detachable water bottle made from the thermoplastic Polyethylene terephthalate (PET), which can be replaced when empty.
- (i) Describe, with the aid of a diagram, a suitable polymer manufacturing process to make the water bottle.
  - (ii) Identify and describe **two** polymer additives which may be used during the manufacturing of the water bottle.



**Question 8.**

**(50 marks)**

- (a) A polycarbonate machine guard is fitted to the centre lathe shown. It is used as a safety device to protect the user.

- (i) Outline **three** safety hazards associated with the use of a centre lathe in the engineering classroom.
- (ii) Describe **two** advantages for the use of polycarbonate in the manufacture of machine guards.

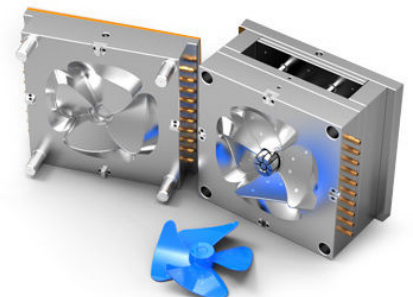


- (b) Answer **any three** of the following:

- (i) Explain the difference between a *clearance hole* and a *tapping size hole* in drilling.
- (ii) Identify **two** safety features incorporated into a horizontal bandsaw.
- (iii) Explain **two** ways in which cutting fluids help the machining process.
- (iv) Describe, with the aid of a diagram, the formation of a *built-up edge* in metal cutting.
- (v) Outline **two** reasons for dressing a grinding wheel.

- (c) Precision surface grinding in plastic injection mould making is essential in order to produce high quality, high volume moulds.

- (i) Explain, with the aid of a diagram(s), the precision surface grinding process.
- (ii) Outline **one** method of securely holding ferrous metals during the surface grinding process.



**OR**

- (c) The vertical CNC milling machine shown is used to produce complex shapes through a process known as a *subtractive manufacturing*.

- (i) Explain the term *subtractive manufacturing* in relation to CNC milling.
- (ii) Describe **each** of the following CNC terms:
- Automatic tool change
  - Tool offsets.

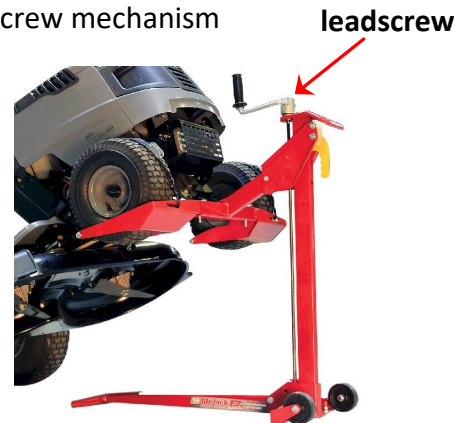


**Question 9.**

**(50 marks)**

- (a)** The hand-operated lifting unit shown opposite uses a leadscrew mechanism to raise and lower ride-on lawnmowers for servicing.

- (i)** Describe, with the aid of a diagram(s), the operation of the leadscrew mechanism in lifting the ride-on lawnmower.
- (ii)** Describe, with the aid of a diagram(s), **one** other method of lifting a ride-on lawnmower safely.



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

- (i)** Suggest **two** benefits of using grease over oil to lubricate mechanisms.
- (ii)** Identify **one** use for the toggle mechanism shown opposite.
- (iii)** Describe, with the aid of a diagram, the operation of an idler gear.
- (iv)** Describe **one** safety precaution that should be incorporated into the design of a gear drive mechanism.
- (v)** Explain, with the aid of a diagram, the operation of a universal joint.



- (c)** *Combilift*, a manufacturing company based in Co. Monaghan, specialise in multi-directional forklifts that are changing the way companies handle and store goods.

- (i)** Describe, with the aid of a diagram(s), a suitable lifting mechanism for the forklift.
- (ii)** Describe how the design of the multi-directional forklift helps to improve workplace safety.



**OR**

- (c)** Offshore wind energy is an ever-increasing form of renewable energy around the coast of Ireland.

- (i)** Describe, with the aid of a diagram(s), how turbines convert wind energy into electrical energy.
- (ii)** Outline **one** advantage and **one** disadvantage of offshore wind energy generation.



Leaving Certificate – Higher Level

## Engineering – *Materials and Technology*

Thursday 10 June

Morning 9:30 – 12:30