



Coimisiún na Scrúduithe Stáit State Examinations Commission

LEAVING CERTIFICATE EXAMINATION, 2020

ENGINEERING – MATERIALS AND TECHNOLOGY

(Higher level – 300 marks)

3 hours

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) Traffic speed monitoring signs are used in urban areas to alert motorists of their speed. Identify **one** environmentally friendly energy source suitable for the speed monitoring unit.
- (b) Explain the process of *Quality Control* (QC) in manufacturing technology.
- (c) Discuss the contribution that **any one** of the following has made to technology:
(i) Mary Anderson (ii) Christopher Cockerell (iii) John P. Holland.
- (d) Modern motorised wheelchairs are being developed to help improve the mobility of the user. Describe the function of castors on the motorised wheelchair shown.
- (e) The wheel rim of the motorised wheelchair is manufactured to a diameter measuring 350 ± 0.20 mm. State the tolerance of the wheel rim.
- (f) Describe, with the aid of a diagram, the process of magnetic separation.
- (g) Outline the difference between amorphous structures and crystalline structures.
- (h) Suggest a polymer material suitable for the manufacture of football nets. Identify **two** properties of this material.
- (i) Identify **one** polymer additive which could extend the lifespan of the football net.
- (j) State **two** properties of bronze which make it suitable for ship propellers.
- (k) Discuss **two** benefits associated with the use of wearable technologies such as fitness trackers and smart watches.
- (l) Describe **two** factors to be considered when selecting appropriate materials for the electric-powered Formula E car shown.
- (m) Identify **two** materials suitable for manufacturing the body of the Formula E car.



Section B – 50 marks

Answer **all** of the following:

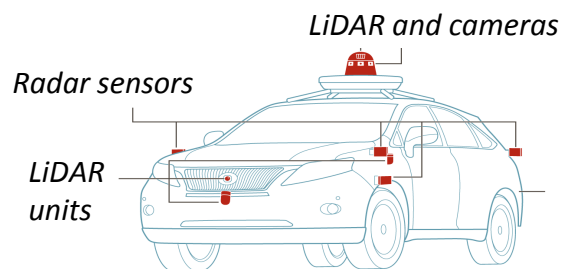
- (n) Experiments to develop autonomous vehicles have been taking place since the late 1920s. Today, most modern vehicle manufacturers are actively developing autonomous vehicles and conducting extensive on-road testing.



- (i) Describe the term *autonomous vehicle*.
- (ii) Outline, with examples, the use of autonomous vehicles in industry **and** in agriculture.

- (o) Explain the function of **each** of the following autonomous vehicle features:

- (i) Radar sensor
- (ii) Camera
- (iii) LiDAR unit.



- (p) Describe **each** of the following with regard to the efficient and safe operation of autonomous vehicles:

- (i) Artificial intelligence (AI)
- (ii) Global Positioning Systems.

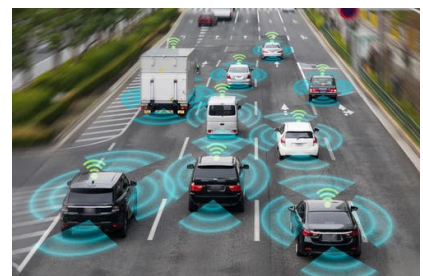


- (q) Designated levels of Vehicle Automation exist, ranging from level 0 to level 5. Describe the main features of **any two** of the following:

- (i) Driver assistance (level 1)
- (ii) Conditional Automation (level 3)
- (iii) Full Automation (level 5).

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

- (i) Vehicle ownership
- (ii) Traffic management
- (iii) Environmental impact.



Question 2.

(50 marks)

- (a) The hull of a personal watercraft, as shown, more commonly called a *jet ski*, is subject to wave-impact damage as it slams across the water when in use.

- (i) Describe, with the aid of a diagram(s), a testing procedure to determine the impact resistance of a material.

- (ii) Material strength may be partly described in terms of the following properties:

- Compressive strength
- Tensile strength
- Shear strength.

Describe **each** of these properties.



- (b) The results shown below were obtained from a tensile test on a non-ferrous alloy with a 10 mm diameter and 50 mm gauge length.

Load (kN)	15	25	40	60	80	100	107	108	105	96
Extension (mm)	0.06	0.10	0.16	0.26	0.38	0.65	0.90	1.0	1.2	1.4

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

- (ii) Indicate **each** of the following regions on your graph:

- Elastic region
- Plastic region
- Necking region.

- (iii) Determine the ultimate tensile strength (UTS) of the alloy in kN/mm^2 .

- (c) Both X-Ray and Ultrasonic testing of materials are non-destructive tests (NDT) used to find internal flaws in aircraft engine components. Compare X-Ray NDT and Ultrasonic NDT under the following headings:

- Equipment used
- Method of operation
- Safety considerations.

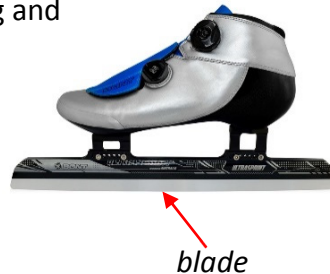


Question 3.

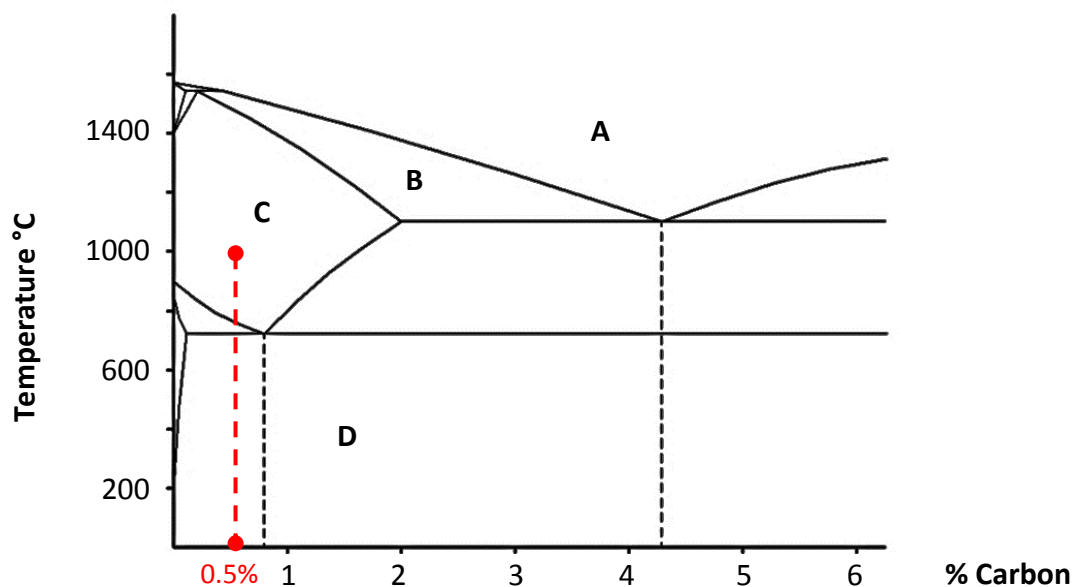
(50 marks)

- (a) The specialised skate shoes used in the sport of speed skating have hardened and tempered steel blades attached to the skate shoe.

- (i) Describe the processes of hardening and tempering the steel blade.
- (ii) Outline **two** reasons for tempering the steel blade of the skate.



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



- (i) Identify the regions **A**, **B**, **C** and **D** shown.
 - (ii) For **0.5%** carbon steel shown, describe in detail the heat treatment process of annealing.
 - (iii) Name the material which commonly contains between 2.0% and 4.0% carbon content.
- (c) An optical pyrometer is used to accurately measure the temperature of a furnace when a range of different heat treatment processes is being carried out.
- (i) Explain the importance of accurately measuring furnace temperature when heat treating steel.
 - (ii) Describe, with the aid of a diagram(s), the operation of an optical pyrometer.

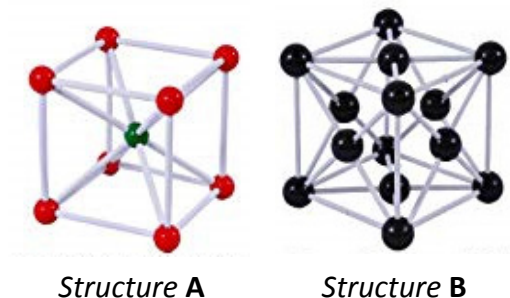


Question 4.

(50 marks)

(a) Metals can exist in a range of forms including allotropes and alloys.

- (i) Explain the term *allotrope*.
- (ii) Identify structure **A** and structure **B**, shown.
- (iii) With reference to the allotropy of iron, outline the difference between the properties of structure **A** and the properties of structure **B**.



(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 ($^{\circ}\text{C}$)	270	332	400	445	492	524	552	580	603	618	630
End of solidification ($^{\circ}\text{C}$)	270	272	280	300	318	340	368	404	449	510	630

Using the graph paper supplied:

- (i) Draw the equilibrium diagram according to the given data **and** label the liquidus and solidus lines.
- (ii) For the alloy with **50%** metal **B** determine, from the diagram, the ratio of the phases at **400 $^{\circ}\text{C}$** .
- (iii) Sketch the cooling curve for the alloy with **20%** metal **B**, referring to the solidification temperatures in the table above.

(c) Explain **any two** of the following:

- (i) The difference between substitutional solid solution **and** interstitial solid solution
- (ii) Metal *macroscopic* examination **and** metal *microscopic* examination
- (iii) The process of galvanising sheet steel.

Question 5.

(50 marks)

- (a)** A roll cage is a specially engineered tubular steel frame built into the passenger cabin of vehicles to protect the occupants.

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



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

- (i)** Describe the operation of a transformer in electric arc welding.
- (ii)** Outline **two** welding defects that may arise in manual metal arc welding.
- (iii)** Explain the difference between a consumable and a non-consumable electrode.
- (iv)** Identify **any three** control settings used in metal inert gas (MIG) welding.
- (v)** Outline the benefits of using an inert gas to prevent oxidation in welding.

- (c)** Describe, with the aid of a diagram(s), the features of the submerged arc welding process shown, with reference to equipment, operation and applications.



OR

- (c)** Robotic floor cleaners are widely used in areas such as airports and shopping centres utilising a variety of sensors to accurately navigate in such spaces.

- (i)** Explain the difference between *proximity sensors* and *navigation sensors* in relation to the operation of the robotic cleaner.
- (ii)** Outline **two** advantages the robotic cleaner has over human-based cleaning operations.



Question 6.

(50 marks)

- (a) Modern American football helmets generally have a thermoplastic polycarbonate outer shell. They also have an expanded polystyrene foam (EPS) internal liner. These help protect players from impact forces.

- (i) Name and describe, with the aid of a diagram, a polymer manufacturing process suitable for the mass production of the polycarbonate outer shell of the helmet.
- (ii) Outline **two** benefits of the use of expanded polystyrene foam (EPS) as a material for the inside liner of the helmet.



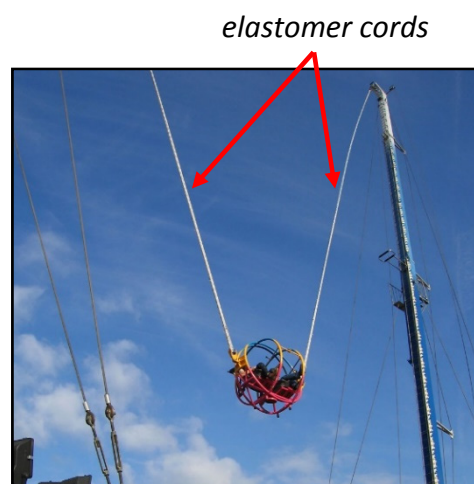
- (b) Answer **any three** of the following:

- (i) Explain the difference between *linear* and *cross-linked* polymer structures.
- (ii) Explain how ethylene monomers are added together to produce polyethylene.
- (iii) Outline **two** reasons for the use of thermosetting polymers in electrical products.
- (iv) Describe, with the aid of a diagram, the vacuum forming process.
- (v) Describe the importance of adding flame retardants to specific materials.

- (c) Fairgrounds often include thrill rides such as the “Slingshot bungee”.

These bungee cords, which catapult the occupants vertically into the air, are usually made from a neoprene elastomer.

- (i) Explain the term *elastomer*.
- (ii) Name **and** explain a polymer manufacturing process that could be used to make the bungee cord.

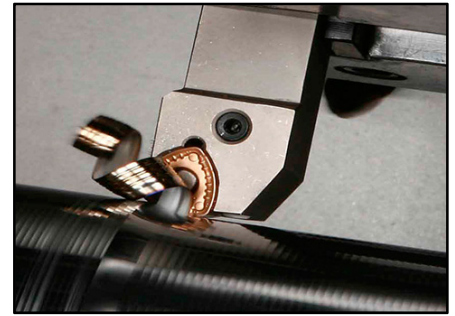


Question 7.

(50 marks)

(a) Answer **each** of the following:

- (i)** Distinguish, with examples, between continuous and discontinuous chips produced by metal cutting.
- (ii)** Explain the impact of a continuous chip on an automated machining process.



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

- (i)** Explain the difference between *loading* and *glazing* of grinding wheels.
- (ii)** Describe **two** hazards associated with the process of laser cutting.
- (iii)** Outline the advantages of thread rolling.
- (iv)** Name **two** types of cutting fluids used in modern machining.
- (v)** Outline **two** benefits of using tungsten carbide cutting tips.

(c) A prototype of the camera handle shown is turned on a centre lathe.

- (i)** Describe, with the aid of diagrams, **three** operations used in making the camera handle on a centre lathe.
- (ii)** Explain, with the aid of diagrams, the differences between *generating* and *forming* in machining processes.



OR

(c) Manufacturing companies use CNC technology to mass produce musical instruments such as electric guitars.

- (i)** Explain **each** of the following in relation to CNC technology:
 - Machine tool calibration
 - Closed loop control.
- (ii)** Explain the benefits of using CNC technology over the hand crafting of musical instruments.



Question 8.

(50 marks)

- (a)** The cordless reciprocating saw shown uses a motorised crank and slider mechanism to activate the cutting blade.

- (i)** Describe, with the aid of a diagram, how a motorised crank and slider mechanism activates the cutting blade.
- (ii)** Identify **one** advantage **and one** disadvantage of cordless power tools.

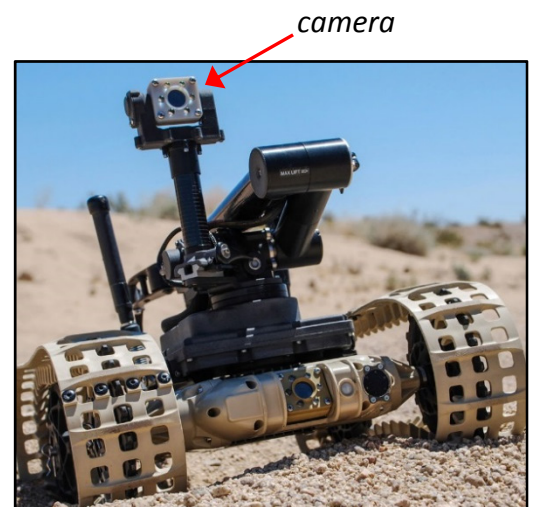


- (b)** Answer **any three** of the following:

- (i)** Explain the difference between helical gears and spur gears.
- (ii)** Give **two** advantages of the use of roller bearings in machinery.
- (iii)** Describe how the camshaft opens the valves in a four-stroke engine.
- (iv)** Identify **two** lubricants which reduce wear in geared mechanisms.
- (v)** Explain how a double acting pneumatic cylinder operates.

- (c)** The all-terrain surveillance vehicle shown opposite operates on tracks and has a camera capable of rotating through 360°.

- (i)** Describe, with the aid of a diagram, a suitable drive mechanism for the surveillance vehicle.
- (ii)** Describe, with the aid of a diagram, a suitable mechanism which will rotate the camera through 360°.



OR

- (c)** Photovoltaic (PV) panels are often used to power flashing beacons at pedestrian and train crossings.

- (i)** Outline **one** energy conversion that takes place in the photovoltaic panels.
- (ii)** Describe **one** advantage **and one** disadvantage of the use of photovoltaic panels.



Leaving Certificate – Higher Level

Engineering – *Materials and Technology*

3 hours