



**Coimisiún na Scrúduithe Stáit  
State Examinations Commission**

**LEAVING CERTIFICATE EXAMINATION, 2016**

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**ENGINEERING – MATERIALS AND TECHNOLOGY**

(Higher level – 300 marks)

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**THURSDAY, 9 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) State **two** factors to be considered in the selection of materials for the manufacture of a safety crash barrier for a motorway.
- (b) Identify **three** quenching media that can be used in the heat treatment of metals.
- (c) Outline the contribution that **any one** of the following has made to technology:  
(i) Bill Gates                      (ii) Charles Hull                      (iii) Theodore Maiman.



- (d) The *selfie stick* shown opposite is constructed mainly from aluminium. Give **two** reasons why aluminium tubing is used in the selfie stick.
- (e) Give **one** advantage and **one** disadvantage of laser technology in metal cutting.



- (f) Explain **two** reasons why models or prototypes are developed in the early stages of the design process.
- (g) Evaluate the use of expanded polystyrene as a material in the manufacture of cycling helmets, as shown.



- (h) Outline **two** advantages of pneumatic power over hydraulic power.
- (i) Describe magnetic separation as a method of ore separation.

- (j) The malleable metal alloy, pewter, is used to make the statue shown opposite. Explain the term *malleable* and give **one** other reason why pewter is used in the making of statues and ornaments.



- (k) Explain the term *factor of safety* with reference to the design and manufacture of a pedestrian foot bridge.
- (l) Outline **two** reasons why a chrome-plated finish is often applied to the steel rim of a car wheel.

- (m) The running shoes shown opposite have steel spikes fitted to the soles of the shoes. Give **two** advantages of using steel spikes over plastic spikes for the running shoes.



**Section B – 50 marks**

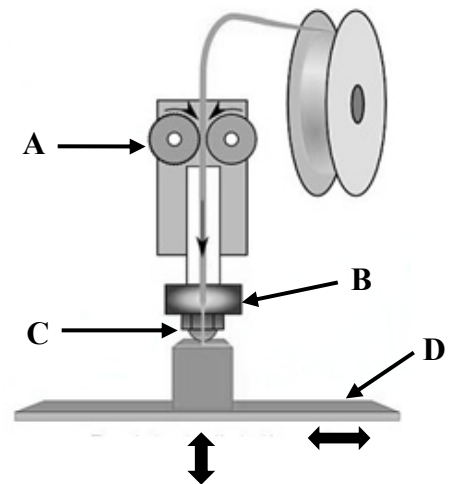
Answer **all** of the following:

- (n) Rapid Prototyping is used extensively to create components and model items prior to manufacture. In recent years the development of this technology has brought the process of 3D printing to a wide range of users.



Describe **three** advantages of using rapid prototyping techniques in the design of new products.

- (o) A simple diagram of a 3D fused deposition modelling (FDM) printer is shown.
- (i) Name the parts **A**, **B**, **C** and **D**.
- (ii) Describe the principle of operation.
- (iii) Identify **one** suitable filament material.

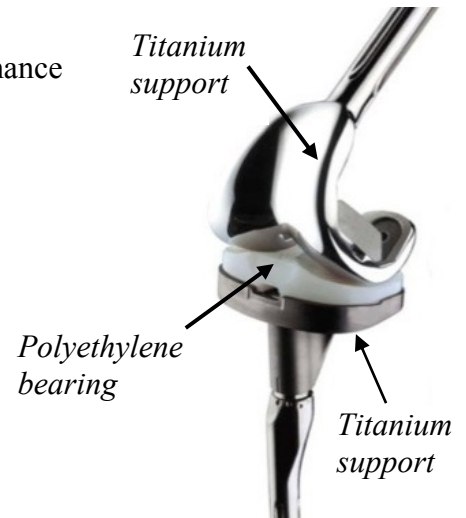


- (p) Give examples of the use of 3D printing to enhance product development in **each** of the following:
- (i) Architecture
- (ii) Medical applications.
- (q) Stereolithography and Selective Laser Sintering are two forms of Rapid Prototyping. Explain **one** of these processes with regard to:
- Materials
  - Principle of operation
  - Safety.
- (r) Describe **any two** of the following in relation to the process of Rapid Prototyping:
- (i) Dual extruder
- (ii) Additive process
- (iii) Support materials
- (iv) The environmental impact of using rapid prototyping techniques.

**Question 2.**

**(50 marks)**

- (a) The prosthetic knee joint shown opposite uses a high-performance polyethylene bearing between the titanium metal supports.
- (i) Describe **two** critical properties to be considered in the selection of polyethylene as a bearing material in this prosthetic device.
- (ii) Describe, with the aid of a diagram(s), a mechanical test suitable for measuring the hardness of titanium.



- (b) The results shown below were obtained from tensile tests on two non-ferrous metals, **metal A** and **metal B**.

<b>Metal A: Stress (N/mm<sup>2</sup>)</b>	45	90	135	200	275	308	335	345	340
<b>Metal B: Stress (N/mm<sup>2</sup>)</b>	16	28	40	53	68	75	79	78	75
<b>Strain (×1000)</b>	0.50	1.00	1.50	2.25	3.25	4.00	5.00	6.50	7.50

- (i) Using the graph paper supplied, plot the stress-strain diagram for **metal A** and the stress-strain diagram for **metal B** using the same graph axes, as shown opposite.
- (ii) Find the ultimate tensile strength value for **metal A** and the ultimate tensile strength value for **metal B**.
- (iii) Compare **metal A** and **metal B** under the following headings:
- Ductility
  - Tensile strength.



- (c) An eddy current non-destructive testing device is shown.

- (i) Describe, with the aid of a diagram(s), the principle of eddy current testing.
- (ii) Outline **two** reasons why non-destructive tests are used during the manufacture of an engine crankshaft.



**Question 3.**

**(50 marks)**

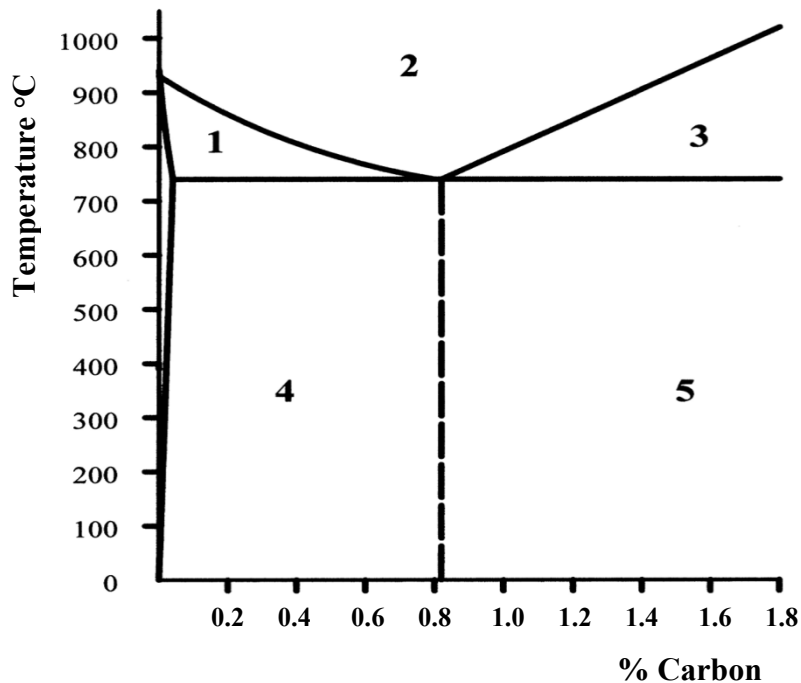
(a) The camshaft shown opposite is to be induction hardened as part of a heat treatment procedure.



(i) Describe, with the aid of a suitable diagram(s), the process of induction hardening.

(ii) With reference to the camshaft, outline the benefits of induction hardening.

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



(i) Identify the regions 1, 2, 3, 4 and 5 shown.

(ii) Explain how steel containing 0.6% carbon is annealed.

(iii) Outline **two** benefits of annealing 0.6% carbon steel.

(c) A thermocouple pyrometer as shown opposite, is used to accurately measure furnace temperature during heat treatment.



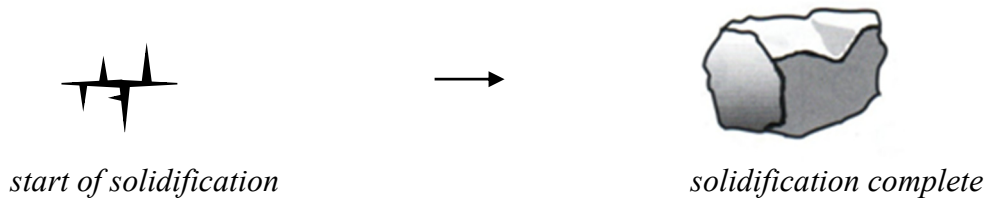
(i) Explain, with the aid of a diagram(s), the principle of operation of a thermocouple pyrometer.

(ii) Name and describe **one** alternative method of measuring furnace temperature.

**Question 4.**

**(50 marks)**

- (a) Describe, with the aid of diagrams, the various stages of dendritic growth during the process of metal solidification.



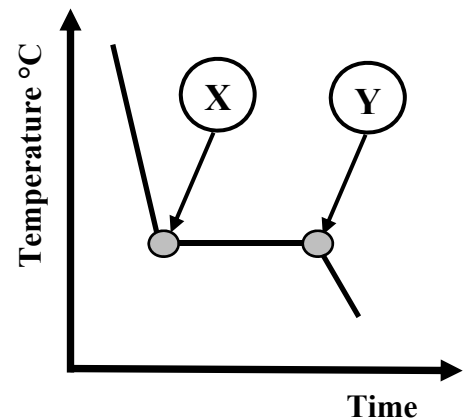
- (b) The table shows the solidification temperatures for various alloys of metal A and metal B.

% of metal B in alloy	0	10	20	30	40	50	60	70	80	90	100
Start of solidification (°C)	350	345	335	317	293	260	220	175	250	282	300
End of solidification (°C)	175	175	175	175	175	175	175	175	175	175	175

Using the graph paper supplied:

- (i) Draw the equilibrium diagram according to the given data.
  - (ii) Label the diagram and describe its main features.
  - (iii) For the alloy with **30% metal B**, determine from the diagram the ratio of the phases at **250 °C**.
- (c) A diagram of a cooling curve for a pure metal is shown.

- (i) Identify **point X** and **point Y** labelled on the diagram.
- (ii) Identify **two** possible defects which may occur during the solidification process.



**Question 5.**

**(50 marks)**

- (a) The drum set shown is fabricated from sheet stainless steel which is rolled and welded. The resultant weld on the drum shell is smoothly finished.

- (i) Select a suitable welding process used in the manufacture of the stainless steel drum and outline **one** reason for your selection.
- (ii) Describe, with the aid of a diagram(s), the key principles of the welding process selected.



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

- (i) Outline **two** functions of the flux coating used in manual metal arc welding.
- (ii) Describe the principle of resistance spot welding.
- (iii) Describe **three** hazards associated with the use of welding equipment in a school engineering room.
- (iv) Explain why submerged arc welding (SAW) is suitable for welding steel girders.
- (v) Outline **two** advantages of multi-run welds.

- (c) Describe, with the aid of a suitable diagram(s), oxy-acetylene welding with reference to **each** of the following:

- equipment used
- flame types
- integrated safety features
- applications.

**OR**

- (c) Many dairy farmers in Ireland are investing in robotic milking machines such as that shown opposite.

- (i) Discuss **one** advantage and **one** disadvantage of robotic milking machines in modern dairy farming.
- (ii) Explain the importance of the *working envelope* and the *sensors* in the operation of a robotic milking machine.





**Question 6.**

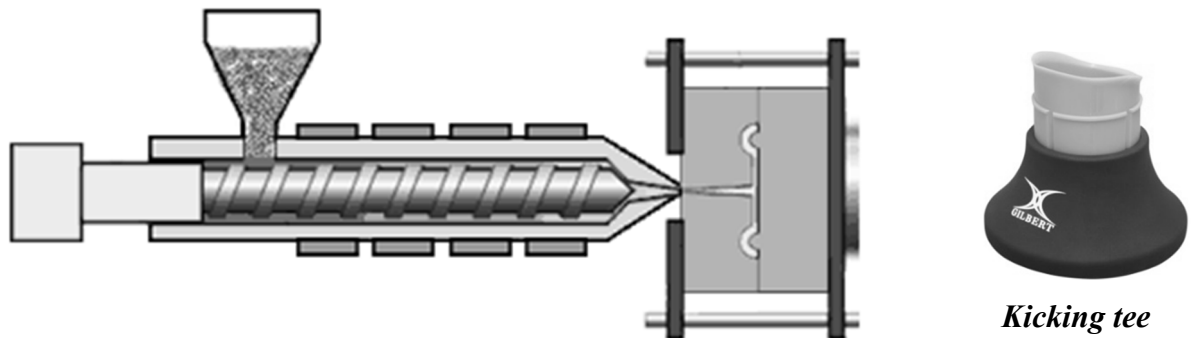
**(50 marks)**

(a) The pool balls shown are manufactured from the thermosetting polymer phenol formaldehyde resin (PF).

- (i) Give **two** reasons why the thermosetting polymer phenol formaldehyde resin is suitable for the manufacture of pool balls.
- (ii) Describe, with the aid of a diagram, a suitable process to manufacture thermoset products.



(b) The injection moulding machine shown is used to produce products such as a kicking tee.



- (i) State **two** reasons why injection moulding is suitable for the manufacture of a kicking tee.
- (ii) Explain the principle of operation of an injection moulding machine.
- (iii) Describe briefly how the flexibility of a kicking tee can be improved during the moulding process.

(c) The Formula 1 race tyre shown is manufactured from the synthetic rubber elastomer *polybutadiene*.

- (i) Explain the term *synthetic rubber*.
- (ii) Describe the basic properties *and* internal structure of elastomer materials.



**Question 7.**

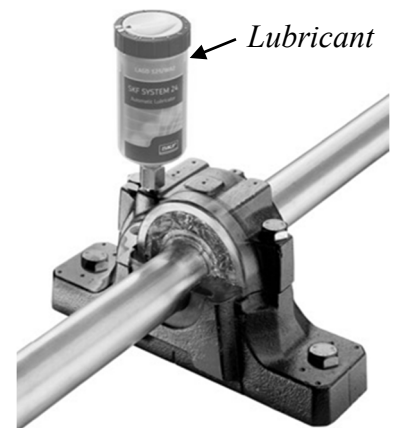
**(50 marks)**

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

- (i)** Identify **three** safety features integrated into a lathe.
- (ii)** Explain how measurement errors may occur when using digital vernier calipers.
- (iii)** Outline **one** use of a vee-block and clamp.
- (iv)** Distinguish between a *pilot hole* and a *tapping size hole*.
- (v)** Explain the difference between a rake angle and a clearance angle in cutting tools.

**(b)** A sealed system for lubrication is shown for the rotating shaft in a metal cutting machine.

- (i)** Outline **two** reasons why a sealed lubrication system is used in engineering machines.
- (ii)** Identify **any two** lubricating materials commonly used in engineering machines.



**(c)** The face milling cutter shown, is fitted with interchangeable tungsten carbide inserts.

- (i)** Describe briefly how the tungsten carbide inserts are manufactured.
- (ii)** Outline **two** advantages and **two** disadvantages of an interchangeable tungsten carbide insert.



**OR**

**(c)** Indicate whether CNC machining **or** manual machining is most suitable for **each** of the following applications. Justify your selection in each case:

- (i)** The production of plumbing fittings;
- (ii)** Customised pieces for a chess set;
- (iii)** Repair of damaged alloy car wheels.

**Question 8.**

**(50 marks)**

- (a) Lifts which are suitable for wheelchair users are often provided in both public and private buildings to improve accessibility. The scissor lift mechanism shown can be used to operate a wheelchair lift.

- (i) Describe, with the aid of a diagram(s), the operation of this type of lift mechanism.
- (ii) Outline **one** other mechanism that could be used to operate a wheelchair lift.



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

- (i) A crank and slider mechanism;
- (ii) The advantages of a timing chain over a timing belt;
- (iii) The use of a reservoir in a pneumatic circuit;
- (iv) The function of a capacitor;
- (v) The use of an idler gear.

- (c) The kart shown opposite is designed to reach high speeds and also to perform quick turning movements.

- (i) Describe clearly, with the aid of a diagram(s), a suitable steering mechanism for the kart shown.
- (ii) Describe, with the aid of a diagram(s), a rear wheel drive propulsion unit for the kart.



**OR**

- (c) The mobile phone shown has a solar charger.

- (i) Outline **one** energy conversion that takes place as the phone charges.
- (ii) Identify **two** other methods for charging a mobile phone.



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