

ENGINEERING - MATERIALS AND TECHNOLOGY
(Higher Level - 300 marks)

FRIDAY, 21 JUNE - AFTERNOON, 2.00 to 5.00

Answer Question 1, Sections A and B, and Four other questions

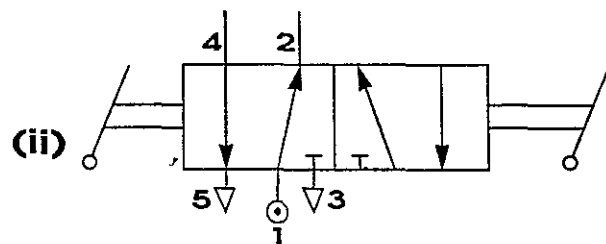
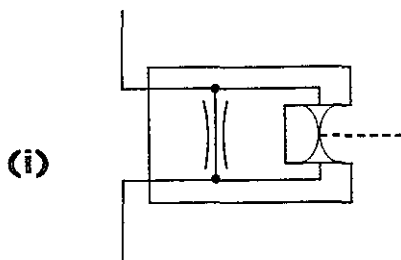
1.

(100 marks)

SECTION A - 50 marks

Give brief answers to any ten of the following:

- (a) What health hazards are associated with the use of cutting fluids?
- (b) Differentiate between hydrometallurgy and pyrometallurgy.
- (c) Explain the difference between a substitutional and interstitial solid solution.
- (d) Name processes used to manufacture (i) uPVC window frames; (ii) automobile distributor caps and (iii) ball pein hammers.
- (e) State two factors that affect the fatigue properties of a material.
- (f) Explain the difference between (i) primary bonding and (ii) secondary bonding in polymers.
- (g) In relation to the prevention of corrosion, explain what is meant by sacrificial protection.
- (h) Explain the type of bonding which occurs in (i) polymers and (ii) metals.
- (i) State two advantages of adhesives relating to the joining of engineering materials.
- (j) Differentiate between (i) a line defect and (ii) a point defect in a crystal structure.
- (k) In relation to computers distinguish between parallel and serial transmission.
- (l) Identify the pneumatic symbols (i) and (ii) shown.



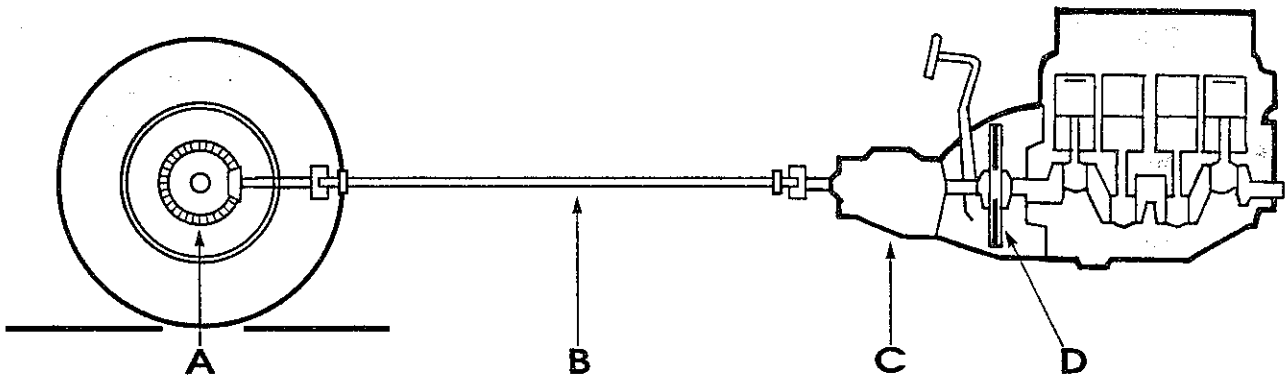
- (m) Indicate the contribution of any one of the following to technology:
- (i) Dugald Clerck or
 - (ii) Louis Bonneville or
 - (iii) Eli Whitney.

OVER →

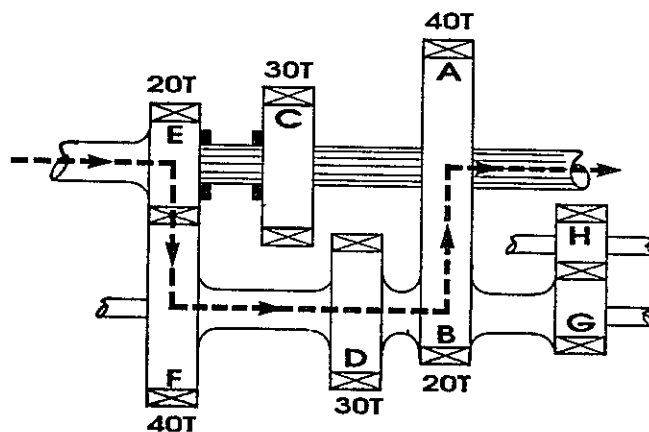
SECTION B - 50 marks

Answer **all** of the following:

- (n) Identify and state the function of each of the components marked A, B, C and D.



- (o) Name **two** types of transmission system and explain the principle of any **one** of the types you have selected.
- (p) What is an overdrive transmission? State **two** advantages of this system.
- (q) Explain the basic difference between a manual and an automatic transmission system.
A first gear selection in a transmission system is shown. What is the first gear ratio and state its significance.



- (r) List **three** functions served by fitting a gearbox in a transmission system.

2.

(50 marks)

- (a) (i) Distinguish between macroscopic and microscopic examination of metallic materials.
- (ii) Explain any two of the following terms: elastic limit; tensile strength; proof stress.

- (b) A tensile test on an alloy gave the following results:-

Stress (N/mm ²)	68	135	200	275	308	325	338	350
Strain (x 1000)	0.75	1.50	2.25	3.25	4	4.75	5.5	7.25

Plot the stress-strain graph and use the graph to find:-

- (i) 0.2% proof stress;
- (ii) Young's Modulus of elasticity for the alloy.
- (c) Explain the principle of any two of the following non-destructive tests:
- (i) liquid penetrant test;
- (ii) radiography test;
- (iii) eddy-current test.

In each case state whether the test is suitable for detecting internal or external flaws.

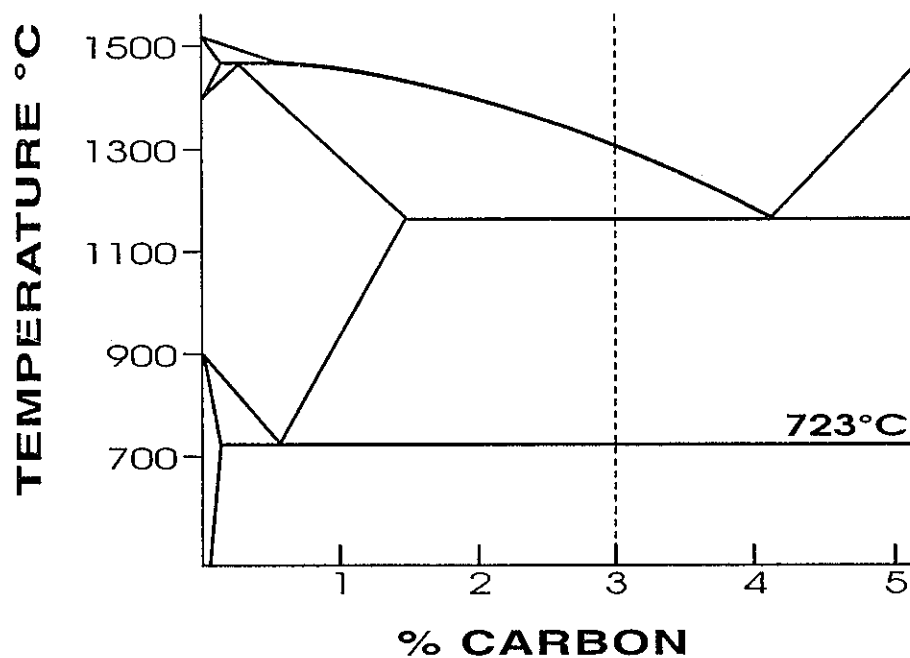
3.

(50 marks)

- (a) (i) State two factors that affect the state of the carbon in cast iron.
- (ii) Explain any two of the following:
white cast iron; grey cast iron; spheroidal graphite cast iron.

(b) With reference to the given iron-carbon diagram:

- (i) Explain the solidification of cast iron with 3% carbon under quick cooling conditions from 1400°C.
- (ii) Indicate clearly on a diagram the phases of ferrite, pearlite and austenite.



- (c) (i) Describe, with the aid of diagrams, two methods for the surface hardening of plain carbon steels.
- (ii) Why do these steels become hard when quenched rapidly?
- (iii) State two factors that affect the depth of hardening of a steel.

4. (50 marks)

- (a) (i) What basic information can be obtained from a thermal equilibrium diagram?
(ii) Explain, using diagrams, the various stages of solidification of a metal from the liquid phase.
- (b) The melting points of two metals A and B are 500°C and 700°C respectively. The given table shows the solidification temperatures for various alloys of the two metals.

Amount of B in alloy (%)	0	10	30	50	70	90	100
Temperature at start of solidification (°C)	500	545	610	650	670	690	700
Temperature at end of solidification (°C)	500	510	530	550	585	650	700

- (i) Using the graph paper supplied, draw the thermal equilibrium diagram according to the given data.
(ii) Label the diagram and discuss its main features.
- (c) For the alloy with 40% B at 590°C, determine from the diagram:
(i) the composition;
(ii) the ratio of the phases which exist.

5.

(50 marks)

- (a) (i) State two important functions of the slag produced in manual metal-arc welding.
- (ii) State two precautions which should be taken in order to eliminate the hazards associated with mains operated metal-arc welding equipment.
- (b) In manual metal-arc welding explain, using suitable diagrams, the principle of operation when using:
- (i) Alternating Current (AC);
- (ii) Direct Current (DC).
- (c) Describe with the aid of a diagram the main features of an automatic welding process.

OR

In relation to the use of robots in welding explain:

- (i) how control of the robot is affected;
- (ii) what is meant by degrees of freedom?

6.

(50 marks)

- (a) Name and explain the main polymerisation mechanisms when forming polymers.
- (b) Explain any three of the following terms:
glass transition temperature; crystalline; promoters and copolymer.
- (c) With reference to (i) chemical bonding and (ii) structure; name and explain the three main polymer groups.
- (d) Describe using diagrams, the production processes for any two of the following plastic products:
- (i) refuse bins;
- (ii) bottle caps;
- (iii) garden hose.
- Indicate the nature of the plastic used in each case.

7.

(50 marks)

- (a) State three factors which affect the amount of heat generated during a cutting operation.
- (b) (i) Explain the basic metal cutting theory of chip formation.
(ii) What conditions influence the formation of a continuous chip?
- (c) Answer any two of the following:
- (i) With the aid of diagrams, differentiate between gang and straddle milling;
- (ii) Explain the principle of the quick return mechanism of the shaping machine;
- (iii) In relation to the grinding wheel specification shown, explain any three codes

39 C 60 J 5 V

OR

- (i) In relation to a CNC machine, list three safety features incorporated in its design.
- (ii) Explain what is represented by the lines 200, 210 and 220 in the part CNC program shown in the table.

N	G	M	X	Z	I	K	S
200	00	05	30	10			
210		06			11		
220	00	04	22	-11.6			2500

8.

(50 marks)

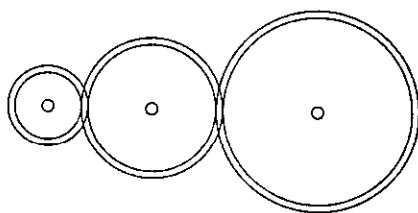
(a) Describe the principal function of any three of the following:

- (i) throttle valve;
- (ii) thermistor;
- (iii) heat pump;
- (iv) solar panel;
- (v) dividing head.

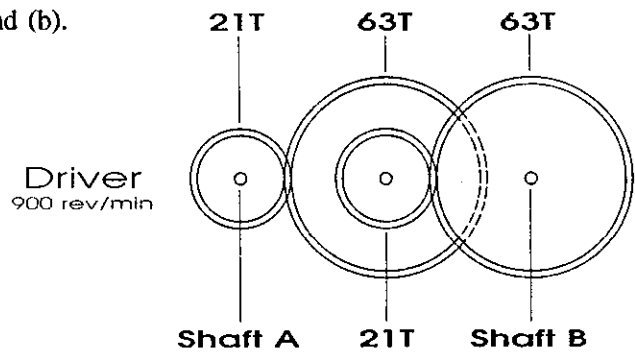
(b) Explain clearly the function of any two of the following:

- (i) strain gauge;
- (ii) a non-return valve;
- (iii) integrated circuit.

(c) (i) Name the gear trains shown in (a) and (b).



(a)



(b)

- (ii) Calculate the speed in rev/min of shaft B in (b) when the driver is rotating at 900 rev/min.
- (iii) Sketch and explain the principle of a worm and wormwheel mechanism.

OR

Identify the different stages marked A, B, C and D in the given electronic circuit.
What is the function of this circuit?

