Version WON/4

MET3
MANUFACTURING ENGINEERING TRIPOS PART IIB

Tuesday 23 April 2019 9.00 to 12.10

PAPER 1

*Answer not more than **four** questions.*

Answer each question in a separate booklet.

All questions carry the same number of marks.

*The **approximate** percentage of marks allocated to each part of a question is indicated in the right margin.*

*Write your candidate number **not** your name on the cover sheet.*

STATIONERY REQUIREMENTS
8 page answer booklet x 4
Rough work pad

SPECIAL REQUIREMENTS TO BE SUPPLIED FOR THIS EXAM
CUED approved calculator allowed
Engineering Data Book

10 minutes reading time is allowed for this paper at the start of the exam.

You may not start to read the questions printed on the subsequent pages of this question paper until instructed to do so.

1 (a) What is a *high performance* ceramic? Give reasons why manufacturing industries are increasingly turning towards these materials in place of conventional structural materials such as metals and polymers. [20%]

(b) Discuss the range of high performance ceramic materials that are currently available and highlight their particular characteristics. [20%]

(c) Outline the process steps used to manufacture high performance ceramic components. [40%]

(d) Describe three example applications in which high performance ceramic materials are used instead of conventional materials. In each case highlight the operational and economic benefits of using high performance ceramics. [20%]

2 (a) Define a *composite material* and give examples to illustrate your answer. [10%]

(b)

(i) Why are carbon fibre composite materials increasing in popularity across a range of industrial sectors?

(ii) Discuss the types of carbon fibre composites that are available including their general characteristics and particular advantages.

(iii) How does the magnitude of global carbon fibre production compare with steel and concrete? What are the barriers to increasing the global production of carbon fibre composites? [35%]

(c) What is carbon fibre *Prepreg*? Describe the process steps employed in Prepreg manufacture. [35%]

(d) Formula 1 racing teams have applied carbon fibre composites in the production of a number of vehicle components. Describe two components in which traditional manufacturing materials have been replaced with carbon fibre composites and state the reasons why. [20%]

3 A small job shop manufacturing company is bidding for a contract to produce a critical component for the Bloodhound Supersonic Car. A major criterion for selecting the winning bid, besides low cost, is the time required to produce the part. However, if the company is awarded the contract, it will be held strictly to the completion date specified in the bid, and any delays will result in a penalty of £200,000 in addition to the loss of the contract. In order to determine the completion time and price to put in its bid, the company has identified the activities, precedence relationships, activity times, and costs as shown in Table 1. In order to develop a competitive bid, the company decided to specify a contract price of £125,000 and a manufacturing time of 25 days.

Table 1

Activity	Predecessor	Time estimate (days)			Expected cost of activity (£)
		Minimum	Most likely	Maximum	
A	-	5	8	11	10,000
B	-	7	9	17	18,000
C	A	3	5	7	17,500
D	A	3	5	13	30,000
E	B, C	4	6	8	12,000
F	B, C	4	5	6	2,500
G	D, E, F	3	4	5	10,000

(a) Prepare a Gantt Chart for the project. [20%]

(b) Which activities should the company be particularly diligent in monitoring for any delays? Explain the rationale for your answer. [10%]

(c) Has the company specified a reasonable price and time frame for the contract? Explain the rationale for your answer. [30%]

(d) The bid was successful, and the progress of the project in the first 15 days is shown in Table 2.

(cont.

(i) Carry out an Earned Value Analysis and calculate the schedule variance and cost variance on Day 15. Assume that the activity costs are evenly distributed across its duration.

(ii) Comment on the progress of the project and suggest any corrective actions that are necessary. [40%]

Table 2

Day	Activity							
	A	B	C	D	E	F	G	Expenditure to date (£)
1	Started	Started	-	-	-	-	-	3,200
3	Ongoing	Ongoing	-	-	-	-	-	9,600
6	Completed on Day 5	Ongoing	Started today	-	-	-	-	20,900
9	-	Ongoing	Ongoing	-	-	-	-	35,300
12	-	Ongoing	Completed on Day 10	Started today	-	-	-	58,000
15	-	Completed today	-	Completed today	-	-	-	78,000

4 For a manufacturer of a high-volume consumer product, such as a 3-pin electrical power socket, it is critical that the manufacturing processes chosen allow individual components and their assemblies to be produced whilst meeting changing market demands.

(a) Injection moulding is commonly used to produce the main housing for such a product. Describe the basic principles of this process, the main operating parameters, and the common defects that affect the quality of the parts produced. [50%]

(b) What types of mechanical assembly and automation methods could be applied over the lifetime of the product in the market? Discuss the factors that influence their selection. [50%]

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(a) (i) What are bio-based polymers?

(ii) For one specific material, describe briefly a typical manufacturing route for the polymer and suggest two applications for the material.

(iii) For which petroleum-based polymer would this material provide a substitute?

(iv) What end-of-life processes are appropriate for bio-based polymers?

. [25%]

(b) (i) What are the functions of food packaging, and what properties of the polymer are being used? [20%]

(ii) How would you assess the environmental impact of polymers for food packaging? Discuss the factors that should be included in this assessment and explain how the system boundary should be defined. What would you expect your analysis to reveal for packaging for the three different food types, meat, cheese, salad? [35%]

(iii) Bio-based polymers are being promoted as an environmentally beneficial solution for future food packaging, substituting for petroleum-based polymers. Discuss the validity of this claim. What are the prospects for the future of bio-based polymers? [20%]

6 A system integrator has been tasked with developing a new pick and place solution using a SCARA robot fitted with a parallel pneumatic gripper. The pneumatic gripper has an integral double-acting cylinder that opens and closes the gripper fingers symmetrically around a centre location. The gripper is also fitted with two magnetic switches. Switch 1 has a closed-circuit state when the gripper fingers are in a fully open position. Switch 2 has a closed-circuit state when the gripper fingers are at a part clamped position. Details of the pneumatic components can be seen in Fig.1. In Fig.1, (a) shows the physical configuration of the parallel pneumatic gripper and associated cylinder logic, (b) shows the ISO symbol for a double acting cylinder and (c) shows the ISO symbol for a 5 Port/2 Position valve with spring return and electrical coil operation.

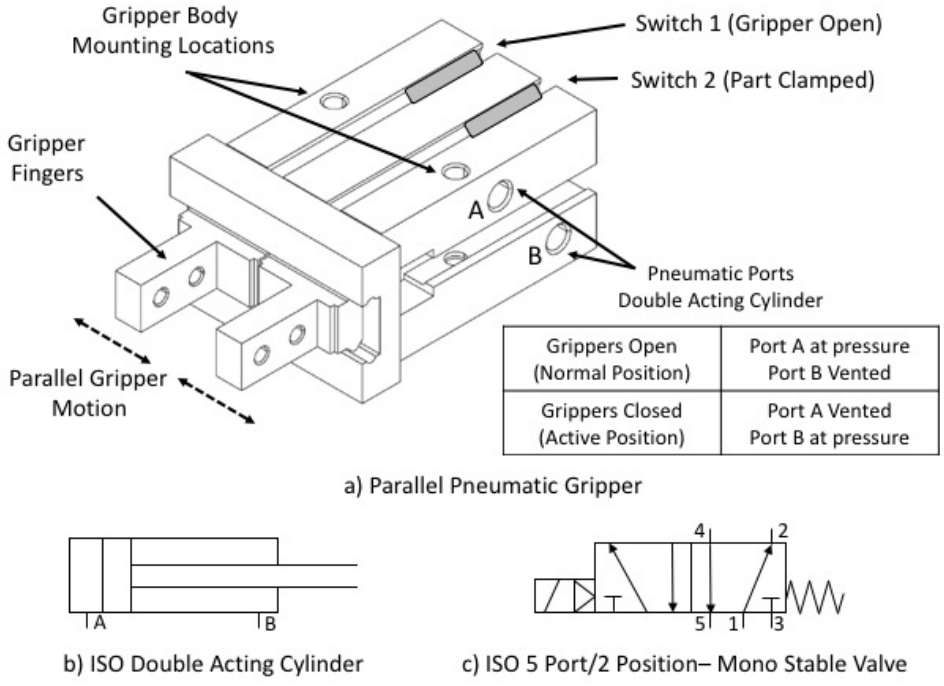

Fig.1

 (cont.

(a) Design a pneumatic circuit that will enable the parallel gripper to be controlled using a 5 port/2 position valve. Include in your design the components required to vary the speed of both the gripper's opening / closing motions and the force that will be applied to components being gripped. Justify your selections. [40%]

(b) Draw a flowchart that depicts the high-level logic required to control the operation of the robot and the parallel gripper when performing a pick and place operation. The flowchart should include the following robot motions: initial position; pick location; place location; and continued operations via the pick location. For each of these motions provide details around the operation of the 5 port/2 position valve and the switches used to sense gripper position. State any assumptions you make. [40%]

(c) The finished system will be delivered to a new company location. Describe the infrastructure components that should be installed to ensure safe operation of the robot. [20%]

END OF PAPER

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