Version MDV/3

MET3
MANUFACTURING ENGINEERING TRIPOS PART IIB

Wednesday 26 April 2017 9 to 12

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.

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

1 (a)

(i) Define what is meant by the term *biopolymers*. Include specific examples of two different biopolymers in your answer. For each biopolymer, give two examples of typical applications, explaining why the biopolymer is particularly suited to that application. [20%]

(ii) Why is there an interest in moving from standard petroleum-based polymers to biopolymers? What barriers may hold back such a move? [10%]

(iii) What are the challenges when attempting to carry out and analyse Life Cycle Assessments of biopolymers? [20%]

(b) (i) Define the term *High Performance Material*. [15%]

(ii) Ball rolling bearings are an example of an application that requires high performance materials. For this example, explain what material requirements must be taken into account and note any details about the processing of the materials that will help achieve these requirements. [35%]

2 (a)

(i) Describe the key advantages to manufacturing by additive techniques. Include three example applications of additive manufacturing and explain why additive manufacturing is a good choice for each of these examples. [15%]

(ii) There are a wide range of techniques for additive manufacturing. Briefly describe any two different additive manufacturing technologies and highlight any significant benefits or constraints in each technique. [15%]

(b) (i) Define the term *micro-manufacturing*. [10%]

(ii) Your company manufactures a very large number of gears using injection moulding of a thermoplastic polymer. Describe the differences between manufacturing parts that are 100 mm in diameter and manufacturing parts that are 1 mm in diameter, when using injection moulding. [20%]

(iii) Describe three different micro-manufacturing processes you may choose if you need to manufacture only a small number of micro-gears. Include details about suitable materials, advantages over other methods, or process constraints. [40%]

3 (a) For complex automation projects it is common practice during the planning stages of a project for both the end user and the system integrator to develop a functional specification. This increased complexity also results in the need for structured system testing procedures.

(i) Describe the purpose of a functional specification and list the types of information that should be contained within this documentation. [20%]

(ii) Outline the reasons for the introduction of structured testing and describe an approach for testing an automation solution. [20%]

(b) A UK based valve manufacturing company is going to enhance one of its semi-automated assembly production lines. Most of the assembly processes on the line are automated except for the installation and fastening of removable plastic covers used to protect the valve ports during shipping and installation.

The valve manufacturing company will take the lead role in the automation project, managing the overall project, modifying the existing line to accommodate new equipment provided by two specialised suppliers and then integrating the developed automation solution.

A Japanese injection moulding supplier has been selected to provide equipment for producing the plastic port covers, although they have never made equipment to produce port covers of this size before. A German robot supplier has been selected to provide the material handling solutions. They have produced many systems of this type and the solution required is readily available.

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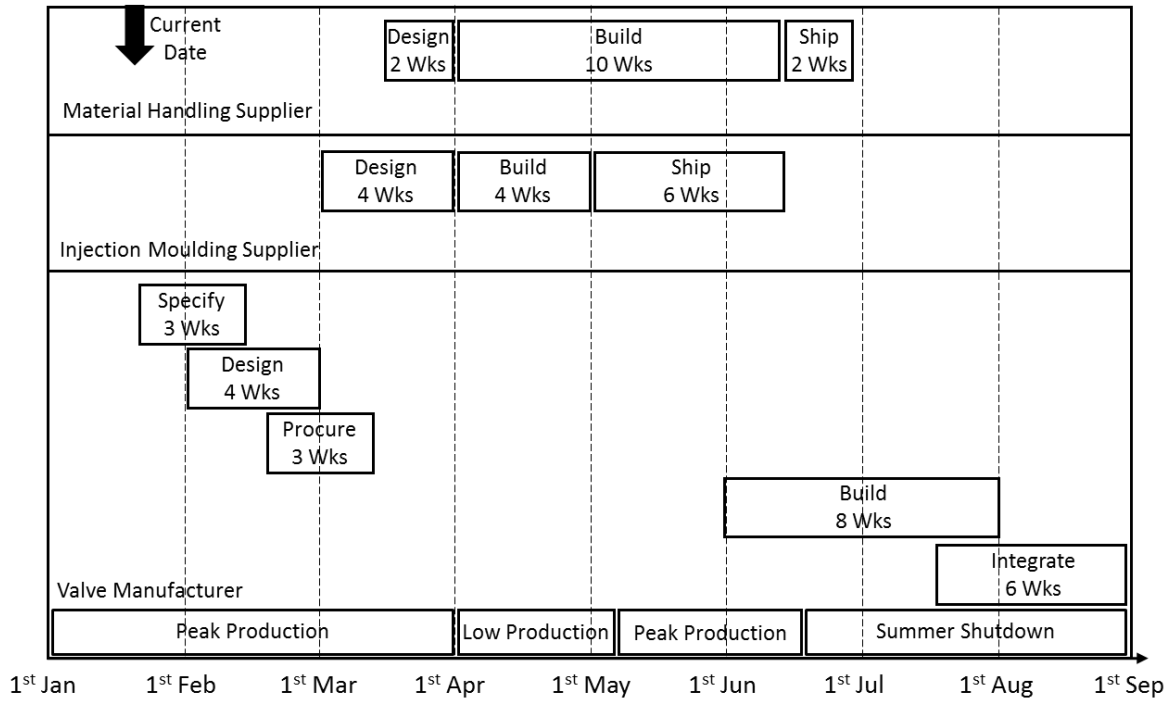

Fig. 1

The project manager has proposed a draft project plan as shown in Fig.1. The plan shows production loads within the factory and some of the key activities that need to be undertaken by the different parties involved in the automation project.

(i) Consider both the project and supplier information provided and critique the draft project plan shown in Fig.1. Identify the weaknesses in the plan and discuss how they could be addressed. [30%]

(ii) Produce a revised project plan to ensure that the project is successfully implemented during the summer shutdown and ensure that peak production periods are protected. Include in your plan measures to address key risks in the successful execution of the plan. [30%]

4 A motion picture industry analyst obtains data on a random sample of 20 Hollywood movies made within the last five years. The sample contained the following data: EARN – Gross earnings; COST – Production cost of the movie; PROM – Total costs of all promotional activities; BOOK – Binary variable for whether or not the movie is based on a book (BOOK = 1 if the movie is based on a book, and 0 otherwise). EARN, COST and PROM are given in millions of pounds (£m). This data is given in shown in Table 1.

EARN	COST	PROM	BOOK
28	4.2	1	0
35	6	3	1
50	5.5	6	1
20	3.3	1	0
75	12.5	11	1
60	9.6	8	1
15	2.5	0.5	0
45	10.8	5	0
50	8.4	3	1
34	6.6	2	0
48	10.7	1	1
82	11	15	1
24	3.5	4	0
50	6.9	10	0
58	7.8	9	1
63	10.1	10	0
30	5	1	1
37	7.5	5	0
45	6.4	8	1
72	10	12	1

Table 1.

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In order to estimate the gross earnings of a movie, the analyst performs multiple regression on the sample data with EARN as the dependent variable, and COST, PROM and BOOK as independent variables. The resulting regression model is given in Table 2.

Dependent variable: EARN				
Parameter	Coefficients	Standard Error	T-statistic	P-Value
Intercept	7.836199	2.333802	3.3583	0.0039967
COST	2.847692	0.392339	7.2582	0.0000019
PROM	2.278237	0.253437	8.9894	0.0000001
BOOK	7.166093	1.817964	3.9418	0.0011664
Adjusted R square: 0.9605, Standard Error = 3.689501, Mean Absolute Error = 2.596636				

Table 2.

(a) Explain the regression results in Table 2 describing the meaning of the intercept, coefficients, standard error and t-statistic. Comment on the usefulness of this regression model. [30%]

(b) Calculate the estimated gross earnings of a movie costing £6m, with a promotion cost of £3m based on a book, and that of a movie with identical costs, but not based on a book. [20%]

(c) Using the data given in Table 1 test whether solely basing a movie on a book has a statistically significant impact on the movie's gross earnings (use a 95% confidence level). State your assumptions. Use the following formula for standard error:

$$\sqrt{(sterror_1)^2 + (sterror_2)^2} = \sqrt{\frac{stdev_1^2}{n_1} + \frac{stdev_2^2}{n_2}}$$

[30%]

(d) Estimate the gross earnings for a movie that costs nothing to produce or promote, and that is not based on a book. Comment on the meaningfulness of the answer you have obtained. [20%]

5 (a) *Life Cycle Analysis* (LCA) is a powerful tool for assessing the environmental impact of an activity or product. Discuss the following with reference to the production, use and disposal of an electric kettle.

(i) Define what an LCA might aim to achieve. [10%]

(ii) Outline the outputs that will be generated from such an analysis. What are the difficulties with using these outputs? [15%]

(iii) The environmental impact of this appliance will be dominated by the *use* phase. What are the factors that would affect the environmental impact of this stage? What is the significance of considering different geographical areas in which the kettle is used? [20%]

(iv) For all the other stages of the kettle lifecycle, suggest ways in which the environmental impact of an electric kettle might be minimised. Indicate which measures will be expected to have the biggest impact. [15%]

(b) Factories making the same product can show large variation in operational efficiencies. Outline the factors which may influence variations in *resource efficiency*. Suggest ways in which resource efficiencies may be improved. Use specific examples, from module presentations or from your own experience, to illustrate your answer.

[40%]

6 (a) Describe using examples, the terms *vulnerability*, *risk* and *resilience* in the context of supply chains. [30%]

(b) Company A is a car manufacturer that serves four markets – USA, EU, China and India. The company has 500 suppliers around the world. One of its tier 2 suppliers (Company C) is based in the Fukushima province in Japan and supplies critical and unique parts worth £100,000 per year to a tier 1 supplier (Company B) located in India on a Just-In-Time basis. Company B is the sole supplier of a part to Company A's India operations, supplying parts worth £600,000 per year. Company B carries a safety stock of 2 days inventory of their finished parts in their warehouse. Company A's India operations are worth £2 Million/day. The annual probability of a typhoon affecting Fukushima is 0.3 and the impact of such a typhoon is to disrupt operations of Company C for 5 days.

(i) Quantify the annual typhoon risk exposure to Company A and B. State any assumptions you make. [20%]

(ii) Identify at least three other risks facing Company A's supply chain. [20%]

(iii) Outline and discuss mitigation measures to protect Company A from the identified risks using examples to illustrate each mitigation measure. [30%]

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