Version AP/4

MET2

MANUFACTURING ENGINEERING TRIPOS PART IIA

Monday 29 April 2019 9.00 to 12.10

Paper 3

Module 3P4: OPERATIONS MANAGEMENT
(Section A)

Module 3P5: INDUSTRIAL ENGINEERING
(Section B)

*Answer all questions from sections **A** and **B**.*

*Answers to section **A** and **B** must appear in two separate booklets.*

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 coversheet.*

STATIONERY REQUIREMENTS
20 page answer booklet x 2
Rough work pad

SPECIAL REQUIREMENTS TO BE SUPPLIED FOR THIS EXAM
CUED approved calculator allowed
Engineering Data Book
3P5 Data Sheet

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.

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SECTION A

1 Your company has a daily demand of 5 business cards, and you are currently ordering your business cards from a supplier, who charges £2 per card in addition to a fixed ordering cost of £55 per order. For the calculation of your holding cost an annual interest rate of 30% is applicable.

(a) (i) In order to minimize your average total cost how many cards should you order in each batch. [15%]

(ii) Explain why the actual order quantity for business cards might differ from that calculated in (i). [30%]

(b) You can rent a machine to make your business cards in-house. The rental cost of the machine for 2 days is £80. The cost of the required material is £1.95 per card. You can produce up to 400 business cards per day using this machine. In order to minimize your average total cost how many cards should you produce in each batch? [25%]

(c) For what values of the ordering cost is it economical to keep ordering cards from the supplier instead of making them in-house? State any assumptions you make. [30%]

2 (a) Measurement has revealed the following information on a manufacturing operation. Design capacity is 100 units per hour, planned losses are 15 units per hour, and actual output is 78 units per hour. What are the utilisation and efficiency of the operation? Briefly explain the meaning of these measures. [10%]

(b) What are the key short-term options for a manufacturer in order to address a mismatch between its capacity and forecasted demand? Outline the advantages and disadvantages of each of the options. Provide examples to illustrate. [20%]

(c) Discuss the challenges of capacity management. Provide examples to illustrate. [30%]

(d) Fig. 1 provides the per unit cost of transportation of a product (in Pounds Sterling) from four factories to three distribution centres. The figure also shows the quantity of products that can be supplied from each of the factories as well as the demand at each distribution centre. Assume that this is a balanced transportation problem. Also, it is known that the initial solution given by the North West Corner method is degenerate.

	Distribution Centres			
Factories	**L**	**M**	**N**	**Supply**
P	3	5	6	**22**
Q	4	3	7	*a*
R	6	4	8	**11**
S	8	2	5	*b*
Demand	**15**	**17**	**20**	

Fig. 1

(i) Use the above information to determine the values of *a* and *b*. [10%]

(ii) Calculate the total cost of transportation of the initial degenerate solution. [10%]

(iii) Can the initial degenerate solution be improved? Justify your answer by performing a single iteration. [20%]

SECTION B

3 (a) Work sampling is a statistical technique for determining the proportions of time spent by workers and machines in various defined categories of activity.

(i) What are the characteristics of work situations for which work sampling is most suited? [15%]

(ii) What are the limitations of work sampling? [25%]

(b) A work sampling study was performed on four sales executives in a company who make all their sales through telephone solicitations. A total of 500 observations were made over a period of one week (seven hours per day, five days per week). The categories of activity and number of observations per category are given in Fig. 2.

Category	Description	Number of observations
1	telephone calls	164
2	filing and sorting	150
3	reading and research	101
4	personal and non-productive time	85

Fig. 2

Previous analysis has shown that total sales is proportional to the time spent on the telephone. Total sales during this period were £525,000 and the company earned a profit of 4% on these sales.

(i) Estimate how many hours were spent on the telephone by the four sales executives during the one-week period. [10%]

(ii) Construct a 97% confidence interval on the proportion of time spent on telephone calls during the one-week period. [20%]

(iii) The company is considering hiring a clerk at £800/week to do the filing and sorting. This would reduce the time spent by the sales executives on these

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activities since the clerk will do filing and sorting for 7 hours every day. It is anticipated that the sales executives will spend this extra time on phone calls to increase sales. Will the increase in profit cover the cost of employing the clerk? Explain the rationale for your answer. [30%]

 (TURNOVER

4 (a) Explain the term *bathtub curve* in the context of equipment reliability. [15%]

(b) A device is made of seven components, and its reliability block diagram is in Fig. 3. Components a_1, a_2, a_3 and a_4 have a reliability of 0.80, components b_1 and b_2 have a reliability of 0.85 and component c has a reliability of 0.98.

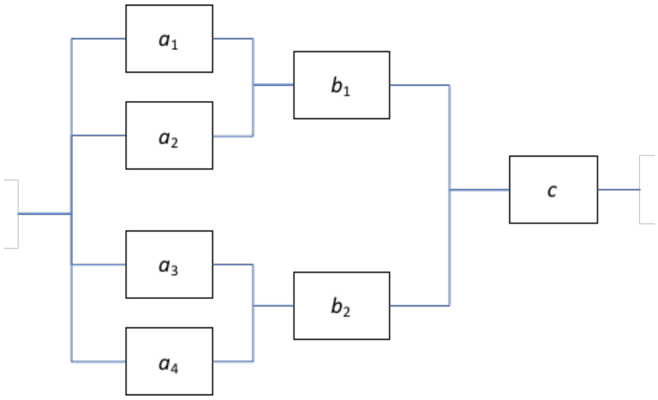

Fig. 3

(i) Calculate the reliability of the device. [20%]

(ii) Without further calculations, suggest the component to which adding redundancy would provide the maximum increase in the reliability of the device. Justify your answer. [15%]

(c) A device has a failure rate $\lambda(t)$ as a function of its age t characterised by the following equation.

$$\lambda(t) = \frac{m}{\theta}\left(\frac{t}{\theta}\right)^{m-1}$$

Where Weibull parameters $\theta = 180$ years and $m = {}^{1}/_{2}$.

The device is required to have a design-life reliability of 0.90.

(i) Calculate the design-life assuming there is no burn-in period. [15%]

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(ii) Calculate the design-life if the device is subject to a burn-in period of one month before being put into service. [20%]

(iii) Describe how you would determine the optimal burn-in period for the device. [15%]

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