Version AB/01

MET 2
MANUFACTURING ENGINEERING TRIPOS PART IIA

Tuesday 6 May 2025 9:00 to 12:10

Paper 3

MODULE 3P4: OPERATIONS MANAGEMENT
MODULE 3P5: INDUSTRIAL ENGINEERING

*Answer ALL questions from sections **A** and **B.***
Start each question in a new 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 of each booklet.

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
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.
You may not remove any stationery from the Examination Room.

SECTION A

Answer all questions from this section.

Question 1

The Ink Store stocks and sells a common brand of a home printer for £125 at a margin of 25%. The store manager estimates that the total annual demand for home printers will be 5000 units. It costs the store £1 each time it places an order for the home printers with the manufacturer. Orders are received within five days of being placed from the nearby warehouse maintained by the manufacturer. Storage space in the store is limited and the costs of carrying one printer in inventory for a year is £30. The firm operates 6 days a week – equivalent to 312 days per year.

(a) Determine the following:

- Economic order quantity for the Ink Store.
- Total annual inventory costs.
- Number of orders to place per year.
- Number of operating days between orders based on the order quantity.

[20%]

(b) What are the assumptions of the *Economic Order Quantity* model, and to what extent do these assumptions limit the usefulness of this model's application in the real world?

[20%]

(cont.

The store manager has noted a 40% increase in sales during the last quarter of the year. In addition, a few small business customers buy in bulk – up to 12 printers at a time, resulting in a standard deviation of 25% of average daily demand. Although the stock from the manufacturer is received within five days of the order being placed, the standard deviation is two days. The manager is therefore considering holding some safety stock.

(c) Discuss the implications of the Ink Store holding safety stock for the upstream printer manufacturer.

[20%]

(d) How would holding safety stock impact a company's environmental sustainability?

[20%]

(e) Given the above considerations, would you recommend that the Ink Store starts holding safety stock? Justify your answer.

[20%]

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Question 2

A law firm specialises in five types of civil court cases. The firm has been given one of each type of case with due dates shown on Table 1. The firm has been having staffing issues, and estimates current processing times as shown in Table 1.

Table 1

Case types	A	B	C	D	E
Processing Time (weeks)	3	3	4	5	6
Due Date (week)	9	8	16	9	12

(a) Create schedules to minimise *(i) maximum lateness*, and *(ii) average tardiness*, when undertaking all cases. After scheduling, clearly state the cases that are late and by how much.

[10%]

(b) The firm is considering subcontracting one or more cases to another law firm. Assume each case can be subcontracted with the same cost regardless of its processing time. Use a scheduling algorithm to identify which cases could be subcontracted.

[10%]

(c) Discuss the considerations the firm should be taking into account when making an outsourcing decision.

[20%]

(d) To plan for their next planning horizon, the firm estimated demand, staff time required, as well as profits per case. Due to administrative overhead, staff have 25 hour per week availability to process cases. Can all cases be processed in the time available? Follow the theory of constraints approach to discuss how the firm should prioritise the cases.

(cont.

Table 2

Case types	A	B	C	D	E
Staff 1 (hours)	1	2	1	1	3
Staff 2 (hours)	3	1	2	4	2
Staff 3 (hours)	5	4	3	2	2
Demand	1	2	2	3	2
Profit per case (£, 000s)	95	195	260	425	110

[40%]

(e) Under what circumstances should the company consider adding further staff capacity

(i) before demand has increased?

(ii) after demand has increased?

[20%]

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SECTION B

Answer all questions from this section.

Question 3

(a) A major automotive manufacturer has employed a team of multi-skilled workers on one of their assembly lines. The line manager has approached you to carry out a 6-week project aimed at analysing how the workers spend their time in the factory.

(i) Describe the approach you would take to perform this analysis.

[20%]

(ii) State the limitations of your approach.

[20%]

(b) The company wants to establish a standard time for a repetitive task on the assembly line. The following data is collected during the time study:

Observation	1	2	3	4	5	6	7	8	9	10
Time	5.6	5.2	4.9	6.2	6.5	4.5	5.9	5.5	4.9	5.8

The company uses a performance rating of 110% and allowance factor of 15%.

(i) Calculate the normal time and the standard time for the task.

[10%]

(ii) If the company wants a 95% confidence level with an accuracy of ±5% of the mean, how many additional observations should be made?

[30%]

(c) During the time study, the observed times for the task were seen to vary significantly. Discuss potential causes of variability in observed times and propose methods to reduce this variability when conducting future time studies.

[20%]

Question 4

(a) Discuss the concept of *burn-in* in the context of equipment reliability.

[20%]

(b) An electronic component manufacturer has performed reliability testing on one of their products and it was found that the product's lifetime distribution $f(t)$ can be modelled as a function of time *t* using a *Weibull Distribution* as follows:

$$f(t) = \frac{\beta}{\eta}\left(\frac{t}{\eta}\right)^{\beta-1} e^{-(t/\eta)^{\beta}}$$

where the shape parameter $\beta = 0.4$ and the scale parameter $\eta = 10$ years.

(i) Show that the reliability of the product after a burn-in period of t_b is given by:

$$R(t|t_b) = e^{-((t+t_b)/\eta)^{\beta}+(t_b/\eta)^{\beta}}$$

[20%]

(ii) The manufacturer wishes to offer a warranty period of 2 years for the product and subjects all manufactured items to a burn-in process of one month. Determine the percentage improvement in reliability at 2 years due to the burn-in process.

[20%]

(iii) If the burn-in cost per unit time for an item is £1, the cost per failure during burn-in £10 and the cost per operational failure is £100, determine whether the burn-in process is cost-effective. Explain the rationale for your answer.

[40%]

END OF PAPER

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