Version FE/03

MET 2

MANUFACTURING ENGINEERING TRIPOS PART IIA

Tuesday 2 May 2023 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 books

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

(a) There are two fundamental approaches to scheduling production operations, pull and push scheduling.

(i) Discuss the key differences between pull and push scheduling.

[10%]

(ii) What is the role of inventory in a pull-scheduled production system?

[10%]

(iii) What is the role of inventory in a push-scheduled production system?

[10%]

(b) (i) What are the main inputs to a Material Requirements Planning (MRP) system? How is a Bill of Materials (BOM) used in MRP calculations?

[20%]

(ii) Discuss the limitations of MRP. How do extensions to MRP address these limitations?

[10%]

(c) The product structure for an end item is described below. The number in parentheses indicates the lead time (in weeks) for making or purchasing each item.

End item: Composed of 2 units of item A, 2 units of item B and 3 units of item C.

Item A (1 week): Composed of 2 units of item B and 1 unit of item D.

Item C (2 weeks): Composed of 1 unit of item B and 2 units of item D.

CONT)

Item B has a lead time of 2 weeks and item D has a lead time of 4 weeks. What is the lead time for making the end item from scratch (i.e., order-to-delivery lead time)?

[10%]

(d) Three refineries with maximum daily capacities of 6, 5, and 8 million gallons of oil supply three Distribution Centres (DCs) with daily demands of 4, 8, and 7 million gallons.

Oil is transported to the three DCs through a network of pipes. The transportation cost is 1 pence per 100 gallons per mile. Refinery I is not connected to DC3. Table 1 shows the mileage among refineries and DCs.

	DC1	**DC2**	**DC3**	**Capacity (in million gallons)**
Refinery I	120	180	-	6
Refinery II	300	100	80	5
Refinery III	200	250	120	8
Demand (million gallons)	4	8	7	19

Table 1

(i) State the basic principles of the North West Corner approach for allocating supply to demand. What are the limitations of the approach?

[10%]

(ii) Find an initial North West corner allocation for the configuration in Table 1 and calculate the total distribution cost associated with that allocation.

[10%]

(iii) Is the solution in part (ii) optimal? If yes, explain why. If no, find an improved solution.

[10%]

TURN OVER

Question 2

Yummy Treats is a London-based candy store famously known for their exceptionally fresh Turkish delight. The store is reviewing its order policy for this product.

In the past year, average sales for the Turkish delights have been 1000 boxes per month. The store purchases them from a producer in Turkey. The fixed cost of ordering is £3500. The cost per box is £15. The cost of keeping the product in stock is 25% of its value per year.

(a) Find the optimal order quantity for this product. How frequently must Yummy Treats place an order?

[25%]

(b) Write the total cost function. How much does Yummy Treats spend per year for this product?

[25%]

(c) State all your modelling assumptions in (a). Discuss how each of these assumptions might be unrealistic compared to the situation faced by the store.

[25%]

(d) Recently, Yummy Treats executives are considering alternative sourcing options for Turkish delight. Discuss key advantages and disadvantages of moving the production in-house rather than outsourcing.

[25%]

SECTION B

Answer all questions from this section.

Question 3

(a) A new operator is part of the way through manufacturing her first batch of components. After 98 components have been manufactured, the time taken for the next three components is measured; see Table 2.

Component	99	100	101
Production time (in seconds)	59.1	62.2	58.4

Table 2

(i) Calculate 95% confidence limits for the basic time for the manufacturing operation. State any assumptions made.

[25%]

(ii) Assuming that this manufacturing operation has a 90% learning curve, calculate the time taken to produce the next 100 components.

[25%]

(iii) Calculate and discuss whether this learning curve model can be applied to a batch of 500 and a batch of 5000.

[25%]

(b) Outline the three main principal groups of motion economy used in the Develop Step of the Method of Study. Identify three examples of good practices per group.

[25%]

TURN OVER

Question 4

(a) Discuss the concept of *bathtub curve* in the context of equipment reliability.

[30%]

(b) A petrochemical plant operates a fleet of seven desalination tanks in its effluent treatment plant. Each tank has the same capacity, and the failure probability $f(t)$ as a function of time t is given by

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

where $\beta = 3$ and $\eta = 3500$ days.

(i) Calculate the optimal preventive replacement age of each tank if the cost of preventive replacement is £20,000, and the cost incurred for replacement after an unexpected failure is £320,000.

[20%]

(ii) At least five of the tanks must function for the system to operate properly. Assuming the tanks are operated on a hot standby basis, calculate the reliability of the system at the end of three years of continuous operation.

[30%]

(iii) Describe how you would evaluate the reliability of this system if the tanks were run on warm/cold standby basis.

[20%]

END OF PAPER