Version AP/6

MET2
MANUFACTURING ENGINEERING TRIPOS PART IIA

Thursday 28 April 2016 9 to 12

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
Engineering Data Book
CUED approved calculator allowed
3P5 Data Sheet

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.

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SECTION A

1 A major electrical equipment manufacturer headquartered in the UK has developed a new lighting product based on a technology that is innovative and unique in the market. The company currently operates 4 distribution centres (DCs) in the country. Fig 1. shows the location coordinates (X_i, Y_i) of the DCs from a reference location, and the anticipated monthly demand (N_i) for the new product at each DC.

Distribution Centre	X_i [miles]	Y_i [miles]	N_i
A	200	200	75
B	100	500	105
C	250	600	135
D	500	300	60

Fig. 1: Distribution Centre location and anticipated monthly demand

The CEO is exploring the option to invest in a new factory to manufacture the new product, and a search for its location has yielded three possible options whose locations are given in Fig. 2. These locations were identified on the basis of land availability and cost.

	X_i [miles]	Y_i [miles]
Option 1	360	180
Option 2	420	450
Option 3	250	400

Fig. 2: Location options for new factory

(a) (i) Determine which of the three location options is most suitable in terms of transportation cost for locating the new factory. State any assumptions you make. [20%]

(ii) Discuss the practical limitations of using this approach for locating the new factory. [20%]

(Cont.

(b) The company currently operates three factories (F1, F2, and F3) with monthly spare capacities of 125, 150, and 120 units respectively. The spare capacity could be used to manufacture the new product. The CEO is exploring this option since the market demand for the new product is unclear. Considering the costs of production and transportation, the profit (per unit) the company can make through different factory-DC shipment combinations are shown in Fig. 3. Determine the shipments between each factory and DC so as to maximise profit. [40%]

Factories	Distribution Centres			
	A	B	C	D
F1	160	410	430	180
F2	330	320	220	170
F3	210	180	200	260

Fig. 3: Profit per unit (£) of shipment between factories and distribution centres

(c) The CEO also has the option to outsource manufacturing of the product to a company based in China. Discuss the key factors that will influence the CEO's decision whether to manufacture in-house or to outsource. [20%]

2 (a) Discuss, using examples, scenarios under which the following inventory control models are appropriate:

(i) fixed time-period inventory model;

(ii) fixed-quantity inventory model.

[25%]

(b) The annual demand, D, for a product that a retailer sells is deterministic and constant. The retailer uses an order quantity of Q = 1,000 units. The retailer's annual inventory holding cost is £500 and their annual setup cost is £700. Is the order quantity that the retailer uses appropriate? Explain the rationale for your answer. [15%]

(c) A phone manufacturer makes two kinds of smartphones, A and B. The company has the option of setting up the order for A and B separately (separate setups) or at the same time (common setup). If the company chooses separate setups, the setup costs for each kind of smartphone is given by K_i, where $i \in \{A, B\}$. If the company chooses common setup, owing to the economy of scale, the setup costs it will incur will be $\alpha(K_A + K_B)$, where $0 < \alpha < 1$. Regardless of the setup choice, the annual holding cost per unit is h_i and the annual demand is λ_i, where $i \in \{A, B\}$.

(i) For separate setups, in terms of λ_i, K_i, and h_i, write the expressions for the economic order quantity, EOQ_i, for each smartphone, and determine the corresponding optimal total annual cost (ordering cost + holding cost). [10%]

(ii) For common setup, derive an expression for the total annual cost in terms of the time between orders T and the parameters λ_i, K_i and h_i. [20%]

(iii) In terms of λ_i, K_i, h_i, and α, determine the optimal time between subsequent orders, T^*, and the corresponding optimal total annual cost. [15%]

(iv) In terms of λ_i, K_i, and h_i, determine the range of values for α such that you would prefer a common setup. [15%]

SECTION B

3 (a) Briefly outline the basic procedure for *Method Study*. [10%]

(b) A male worker works an eight-hour shift consisting of performing a repetitive task with a 6-min work cycle. During each cycle, his energy expenditure rate is 9 kcal/min for 1/3rd of the time, and 5 kcal/min for the remaining 2/3rd. Suggest a suitable schedule for rest breaks. [10%]

(c) Briefly discuss the following terms, describing their use in the design and operation of a manufacturing system:

(i) SMED;
(ii) Poka-yoke;
(iii) 5-S;
(iv) Overall Equipment Effectiveness (OEE). [20%]

(d) An activity sampling study is required to determine the utilisation of a machine to an accuracy of +/- 5 %, with 90% confidence. A pilot study shows the utilisation to be around 75%. How many observations should be planned for the study? [10%]

(e) A manufacturing process has a defect rate of 15 percent, based upon 50 samples of 25 data points each. Calculate the control limits for a *p*-chart, and explain how it would be used to detect changes in the process performance. [15%]

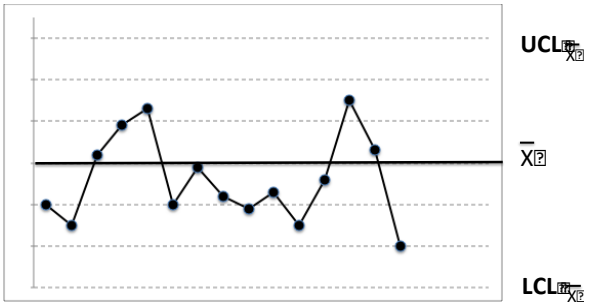
(f) Explain Taguchi's '*Loss to Society*' notion contrasting it to Juran's '*Cost of Quality*' model. [15%]

(g) Control charts (I)-(IV) in Fig. 4 have been collected from 4 manufacturing processes. For each chart:

(i) State whether the process is in control
(ii) Indicate on the figures any points showing special cause variation, stating the rule that you have used to identify this. [20%]

An additional copy of Fig.4 is attached to the back of this paper. It should be detached and handed in with your answers

(I)



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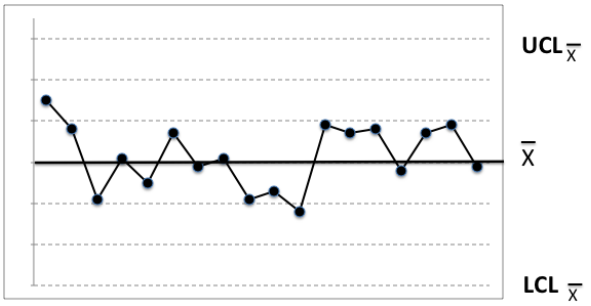

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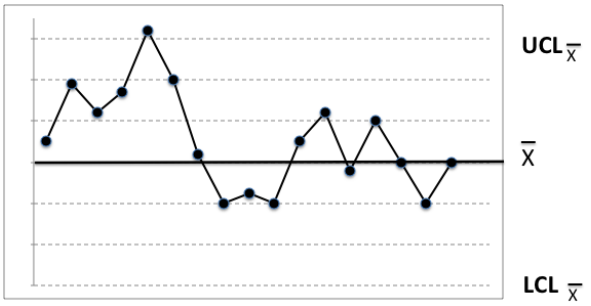

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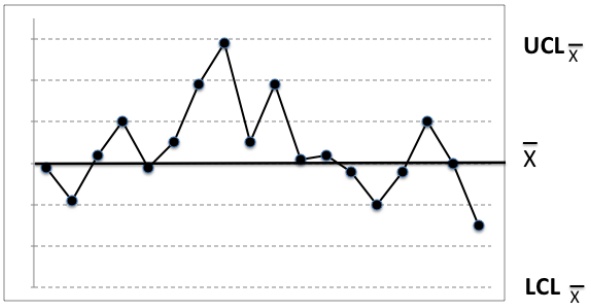

Fig. 4

4 A factory, working 75 hours/week, manufactures a product with a demand of 5000 per week. One component of the product is an item which is produced on two identical machines, each with its own operator. The company is anticipating an increase in demand to 6000 items/week, but does not want to increase working hours. An engineer is asked whether this increase could be accommodated by simply buying a third identical machine.

The engineer studies this operation over the production of 5 components and observes the following times: 81.1 s; 85.6 s; 84.2 s; 83.8 s; 80.2 s. He estimates the workers rating at 110, and assesses the total allowances to be 17%.

(a) Calculate 95% confidence limits for the observed times. [25%]

(b) Calculate the basic time and the standard time for the operation, and explain the meaning of these terms. [20%]

(c) By comparing this with the current and anticipated TAKT times for the product, comment on how robustly the current capacity can cope with:

(i) the current demand;

(ii) the anticipated demand. [25%]

(d) The machines are located in a workshop with a background noise of 70 dBA. The noise from each machine when working is 82 dBA. Considering the noise implications quantitatively, discuss whether simply purchasing a third machine to be co-located in the workshop is a feasible solution to the demand increase. [20%]

(e) Assuming a 3rd machine is purchased, what options are available to meet noise regulations? [10%]

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Candidate Number:

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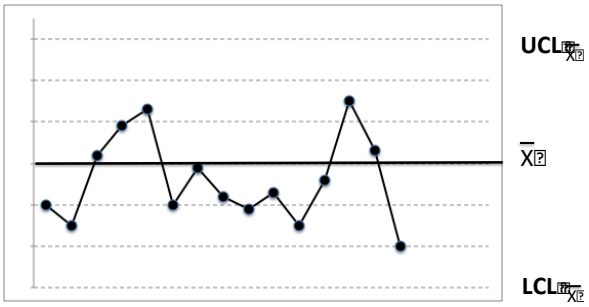
Thursday 28 April 2016, Module 3P4 & 3P5, Question 3

(I)



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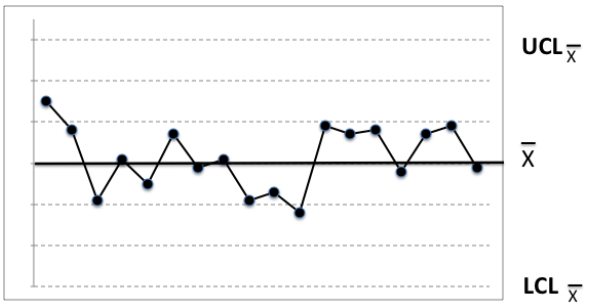

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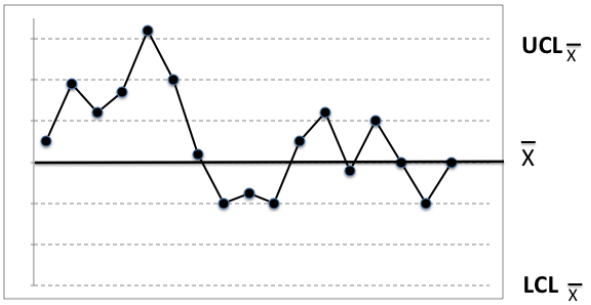

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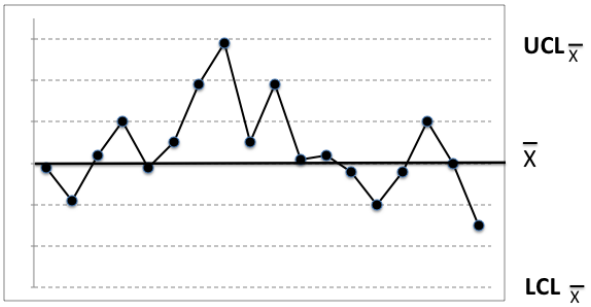

Extra copy of Fig. 4 Control charts for Question 3