STAFFORDSHIRE UNIVERSITY
School of Engineering

Staffordshire
UNIVERSITY

Session 1992/93

BEng(Hons) in Mechanical Engineering (BM4MH)
BEng(Hons) in Computer Aided Engineering (BM4CH)
BEng(Hons) in Manufacturing Engineering with Business (BM4BH)
BEng Degree in Mechanical Engineering (BM2P)

Systems Engineering

DATE: 16th June 1993

TIME: 2.00 pm - 5.00 pm

DURATION: 3 Hours 1, 3, 5, 6.

EXAMINER: D Link

Ext No: 5284

Instructions to Candidates:

This paper contains six questions.
Candidates should answer Question One which carries 40% of the total marks and three other questions only, each of which carries 20% of the total marks.

Students Will Require:

1. Jeeves Plc, the subject of a case study which has been analysed as part of the course, manufactures and sells an electronic consumer durable product which was launched five years ago. Reliability has proved to be poor and warranty claims consume a high percentage of sales revenue. Your task was to investigate the existing problems within the company and propose a Total Quality Management (TQM) strategy to overcome any deficiencies.

(i) Produce a discursive report on the problems within Jeeves Plc and expound your approach to implementing TQM within that company.

(20 marks)

(ii) Critically appraise the TQM philosophy with reference to other examples of its implementation which are available in the open literature and which you were encouraged to study.

(20 marks)

2. (a) Explain what is meant by "the transformation process" in the context of production systems. Using a practical example show how the concept of an engineering production function emerges from the consideration of the transformation process.

(8 marks)

(b) A construction company is to lay a railway track using a combination of manual labour and machines. A study has shown that the length of track, T miles, is related to the number of thousands of man-hours (L) and machine-weeks (M) by a production function of the form:-

$$T = 2.84\,(L)^{0.33}\,(M)^{0.67}$$

Given that the cost of labour is £4.00 per man-hour and the total hire cost of machines is £4,800 per week, determine the optimum values of L and M to be used in laying 25 miles of track. Briefly justify your solution at each stage of the process.

(12 marks)

3. (a) Dynamic programming is concerned with time-staged or cost-staged decision processes. Identify five typical areas in engineering where dynamic programming decision models have been applied successfully and state the Principle of Optimality upon which dynamic programming algorithms are based.

(6 marks)

(b) A manufacturing organisation owns three factories, A, B and C, all of which produce light alloy castings. The management has decided to invest a total of £6.0 x 10^6 between the three factories to achieve expansion. Table Q3 below shows the estimated returns over a five-year planning period which would result from various levels of investments for each factory. Subdivisions of investment under £1.0 x 10^6 have been ruled out.

Determine, using dynamic programming techniques, the investment allocation to be made to each factory so that the total return will be maximised.

Unit = £1.0 x 10^6

Investment	0	1	2	3	4	5	6
Return from A	0	3	4	14	17	19	22
Return from B	0	12	14	16	17	18	19
Return from C	0	4	8	12	16	20	24

(14 marks)

Table Q3

4. A firm of heating engineers has been asked to design and install a refrigeration tank to be used for the low temperature storage of chemicals. The tank, due to holding requirements for the chemical, must have a capacity of 1000 m^3 and, because of space restrictions, must take the form of a right circular cylinder, of diameter D and length L.

The metallic ends of the cylinder will cost £1/m^2, whilst the unit cost of the cylindrical walls will be exactly half of this cost. The refrigeration costs over the useful life of the tank are estimated as being £5/m^2 of surface area. The design engineer is required to satisfy the condition of maximum volume for minimum cost.

(i) Using the Lagrange multiplier method determine the dimensions D and L to maximise the enclosed volume at minimum cost.

(15 marks)

(ii) Determine the value of the multiplier, λ, and interpret its meaning in this application.

(5 marks)

5. (a) Briefly describe a case study, with which you are familiar, which deals with the applicability of Weibull analysis to the maintenance decision making process in an industrial environment. Discuss some of the major conclusions derived from the investigation, paying particular attention to the advantages of planned maintenance policies.

(9 marks)

(b) The performance of ten similar machines has been monitored over a long period of time by a company's maintenance engineering department. As a result, identical failures in a particular component have been identified and the following Table Q5 lists the first eight failures to be noted, together with their failure times.

Failure Number	1	2	3	4	5	6	7	8
Failure Time (hours)	192	525	1030	2020	3400	5000	8000	11800

Table Q5

The Chief Maintenance Engineer decides to utilise a Weibull analysis of the data which has been collected and, hence, prepare a report suggesting potential failure causes and possible remedies.

(i) Simulate the engineer's action by undertaking a Weibull analysis on the given data and derive as much information from the analysis as possible.

(6 marks)

(ii) Discuss some of the salient points which would be required in the report with regard to possible causes and any further investigation.

(5 marks)

Figure Q5 is a sheet of Weibull Graph paper. This is to be used for part of your solution and should be submitted with your script.

6. (a) An engineering company has been presented with a proposal for a new product, and must decide whether or not to develop it. The cost of the development project is £200,000; the probability of success is 0.70. If development is unsuccessful, the project will be terminated. If it is successful, the company must then decide whether to begin manufacturing the product at a high level or at a low level. If demand is high, the incremental profit given a high level of manufacturing is £700,000; given a low level it is £150,000. If demand is low, the incremental profit given a high level of manufacturing is £100,000; given a low level it is £150,000. All of these incremental profit values are gross figures. The probability of high demand is estimated as P = 0.40, and of low demand as P = 0.60. Construct the decision tree for this situation and determine whether or not the company should proceed with the attempt to develop this product.

(10 marks)

(b) The same company are considering the purchase of a large quantity of steel piling for a factory extension project. The average depth to rock is uncertain but, based on previous experience of working in the same area, the firm assigns subjective probabilities of 0.4 and 0.6 to depths of 13 metres and 17 metres respectively. The firm have arranged for sonic tests to be carried out as an indication of depth. The tests are not wholly reliable and can only provide probabilistic data. Table Q6(i) lists the relevant conditional probabilities based on previous experience. Table Q6(ii) also lists the relevant outcomes. A sonic test was carried out, the result indicating a depth to rock of approximately 13 m.

Determine whether 13 metre or 17 metre piles should be purchased and comment on the result.

(10 marks)

 (Question 6 continued overleaf)

(Question 6 continued)

Sonic Test Indication	True State 13 m T_1	True State 17 m T_2
E_1 (13 m depth)	0.8	0.28
E_2 (17 m depth)	0.2	0.72

Values of conditional probabilities, $P(E_i/T_j)$

Table Q6(i)

Decision	True Depth	
	13 m	17 m
Use 13 m pile	0	-300
Use 17 m pile	-130	0

Outcomes in monetary units

Figure Q6(ii)