



EXAMINATION SOLUTIONS

(to accompany the examination paper sent to the external examiner
but NOT to be seen by students)

Programme:	BEng Mechanical Engineering, BEng Mechanical and Manufacturing Engineering, BEng Energy and Environmental Engineering, BEng Extreme Sports Engineering, BEng Motorsport Engineering, BEng Automotive Engineering and BEng Motorcycle Engineering	Level:	5
Module:	Management Innovation and Sustainability		
Author:	Andrew Thorn & Mark Sandford	Page:	

Q 1	Question	Marks
a)	Candidates are required to calculate the break-even point. $\text{Break-even point} = \frac{\text{Fixed costs}}{\text{Selling price per unit} - \text{Variable costs per unit}}$ $\text{Break-even point} = \frac{£500,000}{£20 - £7}$ $\text{Break-even point} = 38,462 \text{ units}$	4 marks
b)	Candidates are required to draw a break-even chart that shows the firms current position (3 marks) for labelling lines (1 mark) for adding figures (fixed costs and output at break-even point) (1 mark) for labelling axis	5 marks



c)	Candidates are required to calculate the margin of safety at 45,000 units. Margin of safety = Current output – Output at break-even point Margin of safety = 45,000 – 38,462 Margin of safety = 6,538 units	4 marks
d)	Candidates are required to calculate the profit if output falls to 75% Output at 75% = 60,000 x 0.75 = 45,000 units Now calculate the contribution and profit using the following formula Contribution = Sales revenue – Variable costs Profit = Contribution – Fixed costs Contribution = 45,000 x £20 = 45,000 x £7 Contribution = £900,000 - £315,000 Contribution = £585,000 Profit = Contribution – Fixed costs Profit = £585,000 - £500,000 Profit = £85,000	2 marks 3 marks 2 marks
e)	Candidates are required to discuss the limitations of using break-even analysis • It depends on the quality and accuracy of the data used to construct cost and revenue functions. If the data is poor and inaccurate, the conclusions drawn on the basis of the data are flawed. • It assumes that all output is sold and no stocks are held. Many businesses hold stocks of finished goods to cope with changes in demand • The break-even chart is drawn for a given set of conditions. It cannot cope with a sudden increase in wages and prices or changes in technology • Throughout the analysis it has been assumed that the total cost and total revenue functions are linear. This may not always be the case.	5 marks

Q 2	Question	Marks
a)	Candidates are required to calculate the payback in years and months for each project.	



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Project A

Year	Net Cash flow (£)	Cumulative Cash flow (£)
0	(200,000)	(200,000)
1	80,000	(120,000)
2	50,000	(70,000)
3	45,000	(25,000)
4	40,000	15,000

Payback = 3 years X months

Calculation of month of payback

$$= \frac{\text{Income required}}{\text{Contribution per month}}$$

Monthly contribution = £40,000 /12
= £3,333.33

Month of payback = £25,000 / £3,333.33
= 8 months

Payback = 3 years and 8 months

**3
marks**

Project B

Year	Net Cash flow (£)	Cumulative Cash flow (£)
0	(200,000)	(200,000)
1	60,000	(140,000)
2	50,000	(90,000)
3	50,000	(40,000)
4	60,000	20,000

Payback = 3 years X months

Calculation of month of payback

$$= \frac{\text{Income required}}{\text{Contribution per month}}$$

Monthly contribution = £60,000 /12
= £5,000

Month of payback = £40,000 / £5,000
= 8 months

Payback = 3 years and 8 months

**3
marks**

Project C

Year	Net Cash flow (£)	Cumulative Cash flow (£)
0	(200,000)	(200,000)
1	70,000	(130,000)
2	60,000	(70,000)
3	50,000	(20,000)
4	60,000	40,000



Payback = 3 years X months

Calculation of month of payback

$$= \frac{\text{Income required}}{\text{Contribution per month}}$$

$$\text{Monthly contribution} = £60,000 / 12 \\ = £5,000$$

$$\text{Month of payback} = £20,000 / £5,000 \\ = 4 \text{ months}$$

Payback = 3 years and 4 months

**3
marks**

b)

Candidates are required to calculate the net present value using a discount factor of 10%

Project A

Year	Cash flow (£)	Discount factor	Present value (£)
0	(200,000)	1.000	(200,000)
1	80,000	0.9091	72,728
2	50,000	0.8264	41,320
3	45,000	0.7513	33,809
4	40,000	0.6830	27,320

Total cash flow £175,177

$$\text{Net present value} = \text{Total cash flow} - \text{Initial investment} \\ = £175,177 - £200,000 \\ = -£24,823$$

**3
marks**

Project B

Year	Cash flow (£)	Discount factor	Present value (£)
0	(200,000)	1.000	(200,000)
1	60,000	0.9091	54,546
2	50,000	0.8264	41,320
3	50,000	0.7513	37,565
4	40,000	0.6830	27,320

Total cash flow £174,411

$$\text{Net present value} = \text{Total cash flow} - \text{Initial investment} \\ = £174,411 - £200,000 \\ = -£25,589$$

**3
marks**

Project C

Year	Cash flow (£)	Discount factor	Present value (£)
0	(200,000)	1.000	(200,000)
1	70,000	0.9091	63,637
2	60,000	0.8264	49,584
3	50,000	0.7513	37,565
4	60,000	0.6830	40,980

Total cash flow £191,766

**3
marks**

	Net present value = Total cash flow – Initial investment = £191,766 - £200,000 = -£8,234	
c)	Candidates are expected to comment on their findings. All of the projects give a negative net present value which means over time the projects will not give a return on their investment in real terms. Project C provides the best payback of 3 years and 4 months which is only slightly better than the 2 projects. While project C provides the best net present value at - £8,234. It would therefore be a good idea to select project C.	3 marks
d)	When making capital investment decisions candidates are required to evaluate two factors that should be considered as part of the decision making process. These include; motives, return, confidence and external factors. <u>Motives:</u> - to begin with, firms must have a reason to invest. • All firms have to replace worn out equipment • To be competitive on costs, price and quality, firms may have to invest or risk losing customers to their rivals • The availability of new technology may persuade firms to invest. When technology becomes available, firms are often keen to use it if they can afford to • Firms may wish to grow, to be more profitable or to increase their market influence. Growth involves investment in more plant, equipment and other productive assets. <u>Return:</u> - if firms have a reason to invest, they must then decide whether it is worthwhile. There are three major costs. Capital costs might be the cost of a new factory. Opportunity costs are the foregone alternatives the investment funds might have been used for. Direct variable costs include the running costs of the project. Calculating the expected revenue is not easy. Expected sales are hard to predict with accuracy because many factors affect them. Sales can also be influenced by the price set by the business in the future and by rivals' behaviour. <u>Business confidence:</u> - may be influenced by a range of factors. These include whether or not previous investment has been success, the state of the economy, the existing level of capacity and future order levels. <u>External factors:</u> - can be direct or indirect. High interest rates may directly affect the cost of investment. If money, is borrowed the business will pay back more. This can indirectly affect confidence. Inflation could affect costs, revenue and confidence. World affairs, such as problems in other economies, or rising exchange rates may make investment abroad seem less attractive. Up to (4 marks) for evaluating any two factors that should be considered as part	4 marks 4 marks 4 marks 4 marks



	of the decision-making process.																																																													
Q 3	Question	Marks																																																												
a)	Candidates are required to discuss what factors need to be considered when evaluating where the location for a new warehouse/factory should be. These include: - • Short-term benefits, such as development grants, temporary rent reductions, or tax grants, such sweetners can be attractive, but they rarely form the basis of good decisions • Location decisions are invariably difficult, and organisations have to consider many factors; such as operating costs, wage rates, taxes, number of competitors, distance from current locations and reliability of suppliers • Other factors include quality of the infrastructure, political stability if in a foreign country, industrial relations and future developments of the economy, and so on. • Cultural issues, environmental issues, operating restrictions and power supply. This is not an exhaustive list and credit will be given for relevant answers.	13 marks																																																												
b)	Candidates are required using the centre of gravity technique to calculate the best possible area in which to locate the facility. In order to determine this values for the X weights and Y weights need to be calculated for each location. The X and Y weights are calculated by multiplying the demand by X and Y coordinates. For example, Supplier 1. X weight = $91 \times 40 = 3,640$ Y weight = $18 \times 40 = 720$ This process is now repeated for all other locations and the results are shown in the table below. <table><tr><th>Location</th><th>X</th><th>Y</th><th>Demand</th><th>X Weight</th><th>Y Weight</th></tr><tr><td>Supplier 1</td><td>91</td><td>18</td><td>40</td><td>3,640</td><td>720</td></tr><tr><td>Supplier 2</td><td>93</td><td>25</td><td>90</td><td>8,370</td><td>2,250</td></tr><tr><td>Supplier 3</td><td>4</td><td>46</td><td>60</td><td>240</td><td>2,760</td></tr><tr><td>Customer 1</td><td>83</td><td>26</td><td>24</td><td>1,992</td><td>624</td></tr><tr><td>Customer 2</td><td>89</td><td>24</td><td>86</td><td>7,654</td><td>2,064</td></tr><tr><td>Customer 3</td><td>63</td><td>57</td><td>32</td><td>2,016</td><td>1,824</td></tr><tr><td>Customer 4</td><td>11</td><td>85</td><td>78</td><td>858</td><td>6,630</td></tr><tr><td>Customer 5</td><td>9</td><td>27</td><td>92</td><td>828</td><td>2,484</td></tr><tr><td>Customer 6</td><td>44</td><td>57</td><td>48</td><td>2,112</td><td>2,736</td></tr></table> Now calculate the totals for demand, X weight and Y weight Total Demand = 550 Total X weight = 27,710 Total Y weight = 22,092 The coordinates for the centre of gravity techniques are calculated using the		Location	X	Y	Demand	X Weight	Y Weight	Supplier 1	91	18	40	3,640	720	Supplier 2	93	25	90	8,370	2,250	Supplier 3	4	46	60	240	2,760	Customer 1	83	26	24	1,992	624	Customer 2	89	24	86	7,654	2,064	Customer 3	63	57	32	2,016	1,824	Customer 4	11	85	78	858	6,630	Customer 5	9	27	92	828	2,484	Customer 6	44	57	48	2,112	2,736
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	formula below $X_o = \frac{\sum X_i W_i}{\sum W_i} \quad Y_o = \frac{\sum Y_i W_i}{\sum W_i}$ $X_o = \frac{27,710}{550} = 50.4$ $Y_o = \frac{22,092}{550} = 40.2$ A good place to start looking for locations is around (50.4; 40.2)	3 marks
Q 4	Question	Marks
a)	Candidates are required to explain seven reasons why change can fail in organisations. These include: - (i) Allowing too much complacency and making assumptions that people will willingly follow what is proposed (ii) Failure to generate sufficient resources to see the proposed changes through (iii) Failure to communicate effectively and continuously with everyone involved (iv) Lack of honesty and integrity especially when further changes are required (v) Becoming side tracked into operational problems and issues (vi) Failure to create or publicise short term advantages, wins and successes (vii) Failure to reward people for their efforts (viii) Failure to deliver to people those rewards which were promised or strongly indicated (ix) Top management is frequently unreasonable in its expectations and timescale, forgetting the process it went through when it decided to make the change Credit will be given for relevant answers.	14 marks
b)	Candidates are required to analyse what factors drive change and those factors that restrain change. Factors driving change include the following: - • Inefficiency • Loss of competitive edge • Product and service obsolescence of ageing • Response to competitors' initiatives • Need for investment • Need to improve financial performance • Influence of stakeholders Factors restraining change include: • Location/area site/factory is in • Size and suitability of premises for current operations • Workforce structure and expertise • Familiarity of present ways of doing things	11 marks



	History and tradition Credit will be given for relevant answers	
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Q5	Question	Marks
5 a	Q5 a) Generate an RFQ for the autoclave. Briefly explain the reasoning behind the inclusion of each of your criteria. (8 marks) Physical internal size – to ensure the biggest panel can fit or batches of panels can be accommodated External dimensions and weight for shipping Ex works and delivery charge Warranty terms and conditions Operational software Software maintenance and support facilities Power consumption/efficiency Pressure&heat up/ depressurize times Additional service equipment supplied or required Service contract conditions. Sketty sportcars are concerned about the initial purchase price and operating costs for the autoclave.	8 marks
5 b	b) Explain the concept of life style costing. (2 marks) The student should define/discuss life cycle costing ☐ The practice of obtaining over their lifetime the best use of the physical assets at the lowest cost to the organisation. This is achieved through a combination of management, financial, engineering and other disciplines. ☐ Discuss the advantages Accurate comparison of competing options (broad options buy v lease days) Good awareness of total costs (ref total cost of project) Accurate forecasting of cost patterns (cash flow esp, running costs) Allows assessment of performance trade off against cost ☐ Outline the main disadvantage of not really knowing what will happen in the future.	2marks
5 c	c) Critically evaluate the factors that should be considered to generate a life style cost for the Autoclave. (10 marks) The students should analyse important factors, which could include: ☐ LCC gives two main costs ☐ Acquisition costs	



	■ Initial cost ■ Transports costs (i.e. ex works) ■ Installation / commissioning costs, □ esp building changes, floor strengthening etc □ provision of electrical power ■ Cost of necessary peripherals □ Cooling towers □ Special freezers for material storage etc ■ Spares packages ■ Training costs ■ The time cost of money □ Running costs ■ Operation, fill time, cycletime. ■ Energy costs ■ Material/consumable costs ■ Insurance – pressure vessel ■ Servicing ■ Raw material availability. ■ Maintenance and inspection costs, □ Disposal Costs or Residual Value ■ Lifetime prediction, depreciation. ■ Disposal – residual value (depreciation factors) or costs of removal and scrapping.	10 marks

Q6	Question	Marks
6 a	<u>Question 6</u> Explain the concept of Total Quality Management The students should discuss: Fitness for Purpose or use, (Dr. Joseph Juran) Or Meeting (exceeding)the Customer's Requirements Requirements include:- ❖ Reliability ❖ Cost ❖ Function ❖ Delivery ❖ Life ❖ Aesthetics Customers are both internal and external to an organisation Total Quality Embraces ❖ BS/ISO – Quality accreditation ❖ Company Culture ❖ Individual Attitudes ❖ Continuous Improvement ❖ Commitment – ownership of problems	5 marks



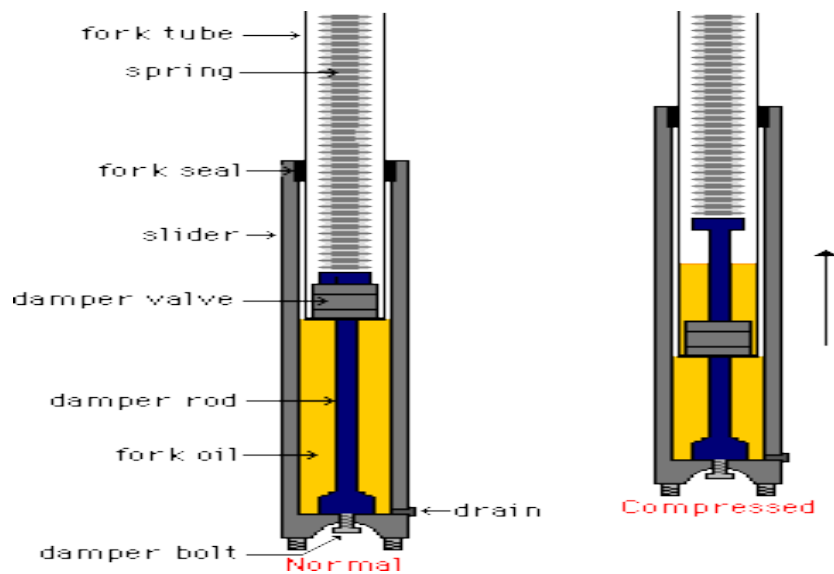
	❖ Relationships (with suppliers and customers) And applies to all parts of the organisation “Quality is both thinking why something is done, and why it is done that way: Then thinking differently to improve” Mr Ohno, Chairman of Toyota.	
6 b	Outline a total Quality Management Strategy. Refer to Juran’s 10 steps. The student should discuss: ❖ TQM Must be owned by senior management ❖ TQM requires continuous improvement ❖ TQM involves everybody ❖ TQM applicable to all parts of the company <i>design, production, purchase, finance</i> ❖ TQM means satisfying your customers Juran’s 10 steps ❖ Build awareness of the need and opportunity for improvement ❖ Set goals for improvement ❖ Organise to meet goals ❖ Promote training ❖ Carry out projects to solve problems ❖ Report progress ❖ Give recognition ❖ Communicate results ❖ Keep score ❖ Maintain momentum. Make annual improvement part of regular systems of company continuous improvement	6 marks
6 c	What are the potential effects of not having a robust engineering quality system? Cost arises from ❖ Error ▪ Eg. Scrap, rework, waste in any form ❖ Policing ❖ Loss of reputation ❖ Loss of market share Costs can be as high as 40% of sales turnover, and are typically as high as 15-25% of sales. 80-85% of quality problems originate in areas other than manufacture. Examples of waste: ❖ Service/warranty costs FRACAS reporting/investigations ❖ Customer dissatisfaction – loss of reputation, leading to loss of market share. ❖ Redesign ❖ Shortages	3 marks



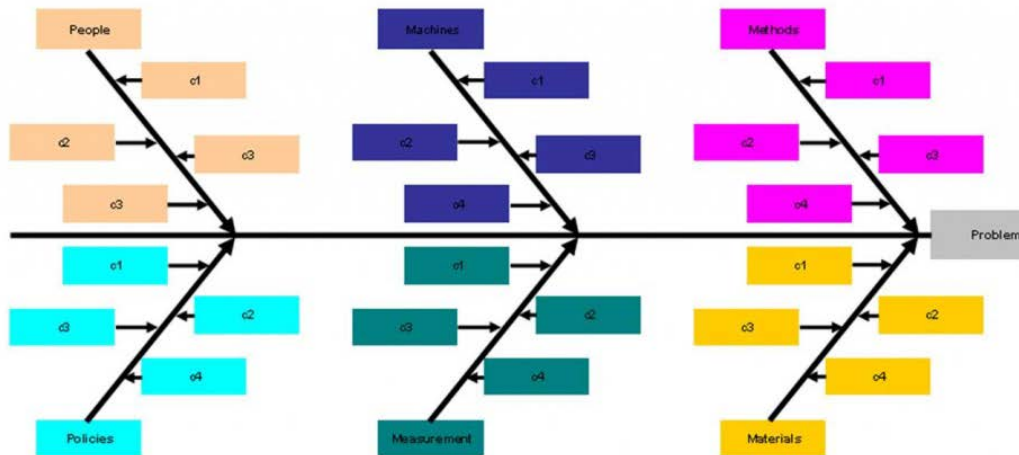
- ❖ Incorrect deliveries
- ❖ Material handling damage
- ❖ Lack of information. Unclear communication
- ❖ Rework
- ❖ Excess inventory
- ❖ Time wasting

6 d

Many engineering organizations utilize Fault Reporting And Corrective Action Systems (FRACAS). Imagine that you are working for a volume motorcycle engineering manufacturer. It has been reported that some telescope damper fork seals are leaking regularly on a recently released motorcycle. (see below)



You have been asked to identify any possible causes of this failure. Create an Ishikawa (herring bone) diagram of possible causes. Explain significant design error potential causes that may require more detail investigation. Use diagrams as required.



FISHBONE DIAGRAM

Check design intent, usage and life. Velocity and fluid pressures

The back bone (or trunk) is the error state eg leaking seal, branches and twigs off that.

Design branch

- Limits and fits (identify critical dimensions) esp seal housing
- Surface finish esp shaft.
- Dimensional tolerances etc
- Material selection, fluid compatibility, shore values
- Lifing, recommended service intervals etc.

Environmental branch

- Ingress IP rating, fluid and grit etc
- Temp, humidity
- Vibration

Manufacturing branch

- Seal insertion, process, mandrels and tooling, lubrication
- System assy procedure,
- Training.

Material management branch.

- Purchase systems, identification of critical items.
- Supplier quality assessment.
- Storage, time . temp humidity, stock control etc.

11
marks



Q7	Question	Marks
7 a	The candidate should discuss the potential adoption these technologies: The reduction of fuel costs, carbon footprint and pollution The seeing to be 'green' and improved public image, potential sponsorship The technology – size, relevance, safety and complexity, maintenance requirements. Improved passenger comfort, reduced noise and improved Noise Vibration and Harshness	4 marks
7 b	The candidate should perform a PEST analysis on the marco environment. The list bellows is not exhaustive but provides examples. Political Supporting the political agenda Seen to be green Supporting government agendas Green pressure groups appeased Emissions legislation CO2, noxious gasses Economic Expensive to design and develop Extra spares required Extra safety regulations Potential new sponsorship avenues. Additional staff & facilities required for maintenance. Social Consumer buying/travel patterns Satisfying consumers green agenda Fashion for vehicle downsizing Increased passenger comfort Technological Effect brake stability Effect on vehicle mass Effect on servicing requirements and safety Ease of installation OEM's offering more base vehicles with hybrid capability – technology transfer Competing technologies such as flywheels batteries, supercaps. Possibilities to 'down size' IC engine. Ever more complex donor vehicle engine management systems making KERS/hybrid integration more complex	16marks
7 c	An open question for the candidate, suggestions could include: Improve the green credentials	



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	Target for smaller engines, promote concept of downsizing More potential sponsorship/advertising Probably need market survey, sound out travellers expectations etc Technical and cost impact on teams – study required Safety considerations – study required. Diversify within technology and equipment	5 marks
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