Version JMC/3

EGT2
ENGINEERING TRIPOS PART IIA
EGT3
ENGINEERING TRIPOS PART IIB

Monday 4 May 2026 9.30 to 11.10

Module 4C4

DESIGN METHODS

*Answer not more than **three** questions.*

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.*

STATIONERY REQUIREMENTS
Single-sided script paper

SPECIAL REQUIREMENTS TO BE SUPPLIED FOR THIS EXAM
CUED approved calculator allowed
Supplementary page: one extra copy of Fig. 1 (Question 1)
Engineering Data Book

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.

1 A partially completed QFD (House of Quality) chart for a domestic vacuum cleaner is shown in Fig. 1.
An additional copy of Fig. 1 is attached to the back of this paper. It should be detached and handed in with your answers.

(a) Comment on the strengths and weaknesses of using QFD for product design. [20%]

(b) Using the additional copy Fig. 1 provided, add four additional Engineering Characteristics and their corresponding Technical details. Complete the Relationships Matrix by filling in an appropriate symbol for each relevant cell. [20%]

(c) Calculate the priority scores for each Engineering Characteristic. Which Engineering Characteristic does the QFD suggest is most important? Comment on what factors influence this answer. [20%]

(d) Complete the Technical Correlations Matrix. Which three negative (or strong negative) correlations do you consider to be the most important? Justify your answer. [20%]

(e) Select one of the negative (or strong negative) correlations discussed in part (d) and suggest design solutions to this problem. [20%]

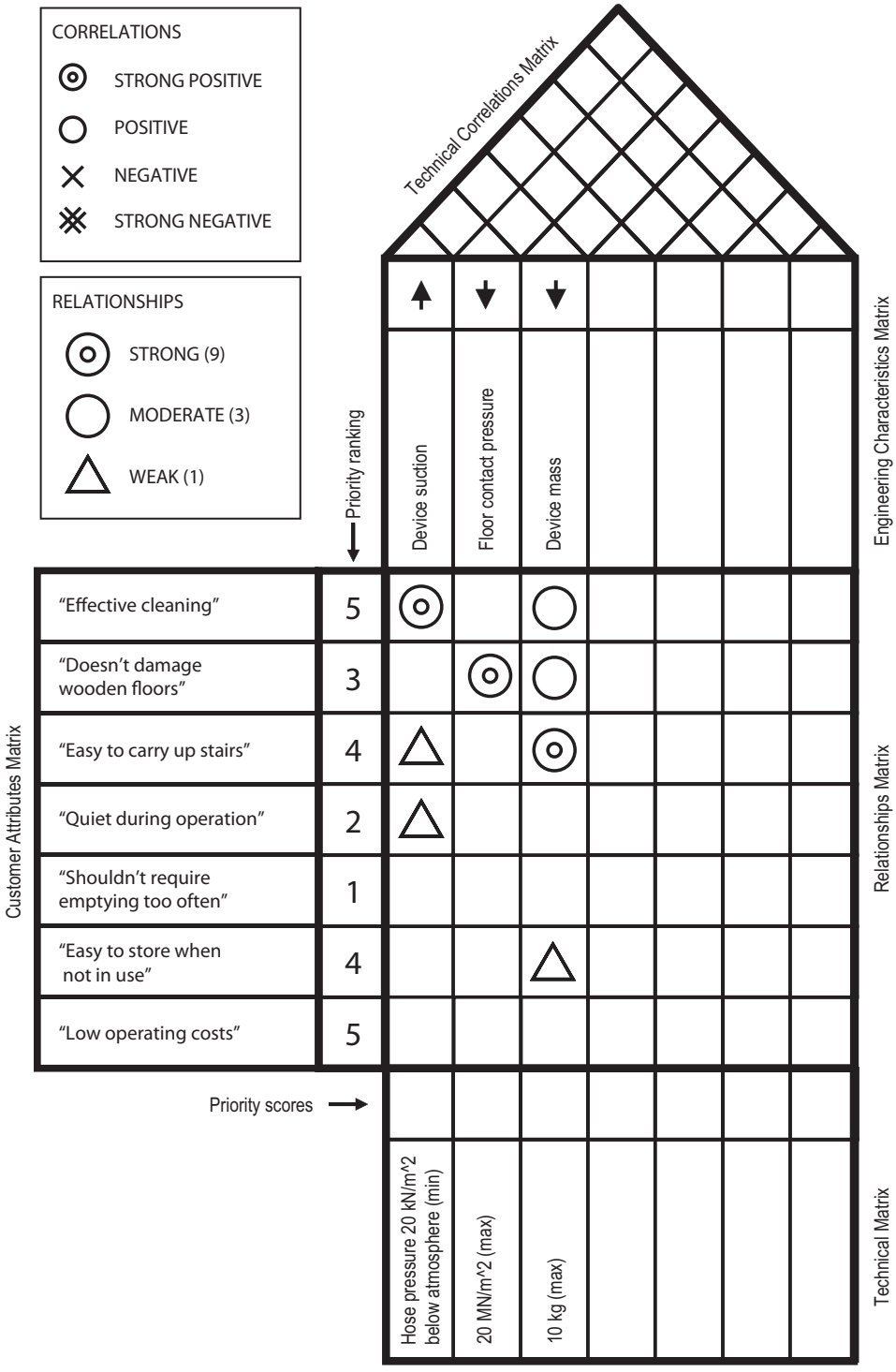


Fig. 1

(TURN OVER

2 Guide canes (or white canes) enable people with visual impairment to navigate safely and independently by sweeping or tapping the ground ahead to detect obstacles and surface texture changes.

Your company has been asked to design a new "smart guide cane" that enhances the functionality of a traditional guide cane with digital sensing, feedback and navigational assistance.

(a) Provide a solution-neutral problem statement for the "smart guide cane". [10%]

(b) Identify the key functions that might be realised by the system. Briefly describe each function's relevance to the design. [20%]

(c) Use a morphological chart to explore alternative function carriers for the functions identified in part (b). [20%]

(d) Provide annotated sketches for two very different conceptual designs, showing the key features. Comment on the relative strengths and weaknesses of the designs, and indicate your preferred design. [40%]

(e) Write a requirements specification with four key requirements for your preferred conceptual design identified in part (d). [10%]

3 A corridor is to be illuminated using five lights that have individual and independent probabilities of failure. Each light is assumed to have a constant failure rate and the probability of failure of each individual light is the same. The mean time between failures for a light is 2 000 hours. The price to wire the lights in series will cost £10, while to wire the lights in parallel will cost £20.

(a) Calculate the reliability R_c of an individual light for use over a time period of 500 hours. [10%]

(b) Find the probability of failure (i.e. of no light in the corridor) assuming the lighting system has either (1) series redundancy, or (2) parallel redundancy. [20%]

(c) Calculate the gain in value provided by the redundancy solution resulting in the lowest probability of failure. [20%]

(d) An alternative solution is proposed in the form of a k-out-of-n system.

(i) Find expressions for the probabilities of failure when $k = n$ and $k = 1$. [10%]

(ii) It is decided to set $k = 2$ and $n = 5$, where the reliability structure function is given by

$$R_{kn} = 1 - \sum_{m=0}^{k-1} \binom{n}{m} p^m (1-p)^{n-m}$$

where p is the individual component reliability. Calculate the gain in value and compare with the system resulting in the highest probability of failure in part (b). Assume the reliability of an individual light is the same as in part (a) and use a cost of £15 for the 2-out-of-5 system. Comment briefly on this result. [30%]

(iii) Comment briefly on the similarities between the reliability of a system in part (b) and the combinational logic used in fault-trees. [10%]

4 A UK consortium proposes to design and build a new factory to manufacture batteries for electric vehicles. A battery factory is seen as strategically important for the UK for several key reasons, including automotive industry competitiveness, supply chain security, economic growth and net-zero commitments.

Building a battery factory requires large capital investment and potential subsidies from the UK Government. The consortium appreciates there is considerable risk in developing this project and aims to utilise good risk management practice during the project delivery.

(a) Describe the elements of good risk management practice that will increase the consortium's chance of successfully delivering the battery factory. [30%]

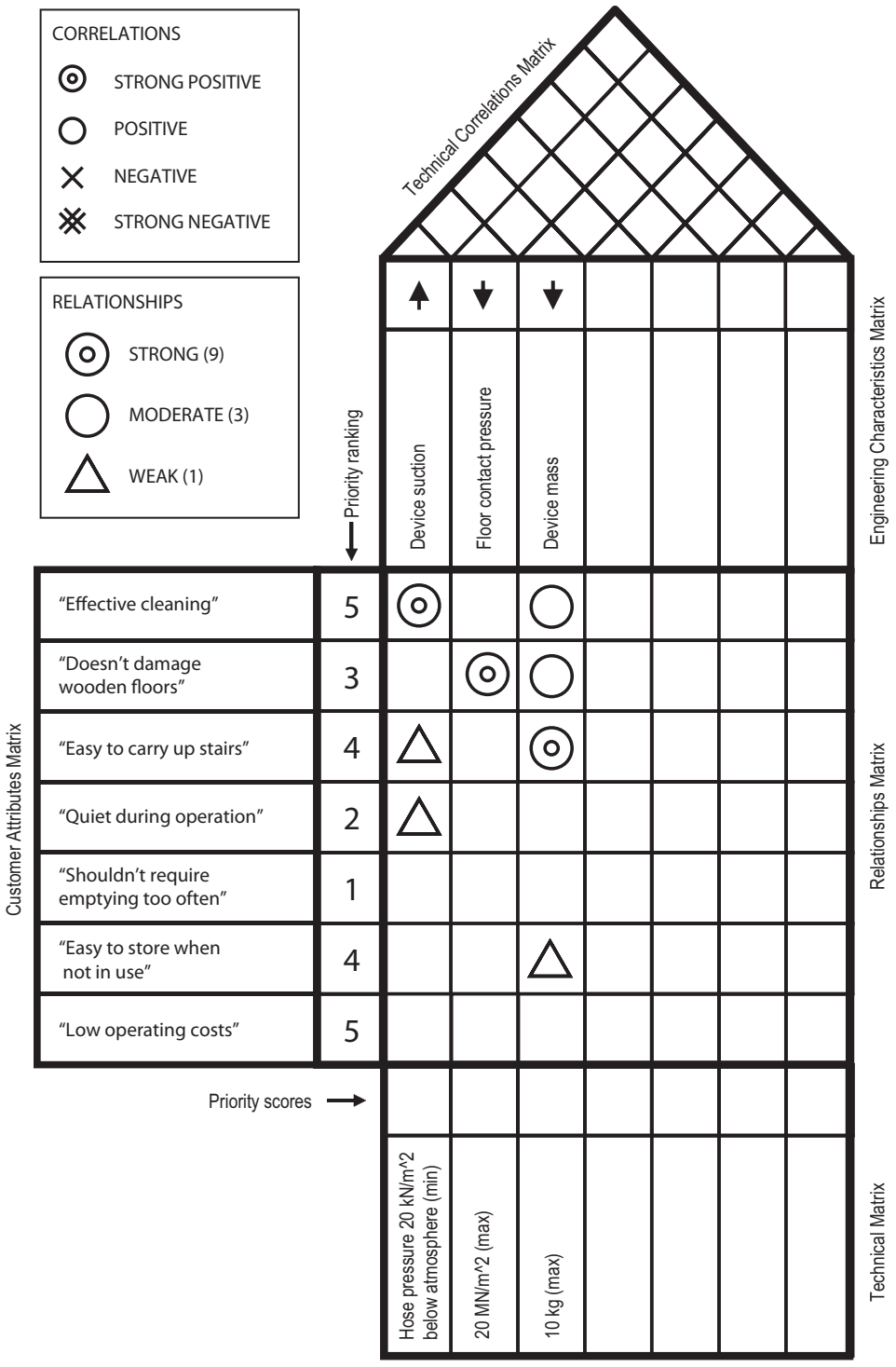
(b) Create a list of ten risks associated with the design and build of the battery factory, and group these by the type of risk. Prioritise the risks, explaining your rationale, and suggest an action for mitigating each of the risks. [30%]

(c) The consortium is considering the use of three risk assessment techniques: HAZOP, FMEA and FTA. Describe each technique and comment on its suitability for assessing risks for the design and build of the battery factory. [20%]

(d) Discuss the claim that a UK based battery factory is important for the delivery of the UK's net-zero commitments, with reference to the five principles for sustainable systems thinking, where appropriate. [20%]

END OF PAPER

Version JMC/3 Candidate Number:



Extra copy of Fig. 1: QFD (House of Quality) chart for Question 1.

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