ENGINEERING TRIPOS PART IIA
ENGINEERING TRIPOS PART IIB

Tuesday 10 May 2011 2.30 to 4

Paper 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.*

Attachments: Supplementary sheet – blank copy of Fig. 1.

STATIONARY REQUIREMENTS
Single-sided script paper

SPECIAL REQUIREMENTS
Engineering Data Book
CUED approved calculator allowed

You may not start to read the questions printed on the subsequent pages of this question paper until instructed that you may do so by the Invigilator

pjc02

1 An outdoor sports company is considering the design of a mountaineering backpack (rucksack). Market research and user testing on competitive products has generated a list of customer attributes. Discussions amongst the design team have identified the most relevant engineering characteristics of the product. This information can be seen in the 'customer attributes matrix' and 'engineering characteristics matrix' of the partially completed *House of Quality* chart shown in Fig. 1.

(a) Explain the basic principles of Quality Function Deployment's (QFD's) *House of Quality*. [10%]

(b) The 'relationships matrix' of the chart in Fig. 1 is considered to be complete, but a transcription error has occurred by which three of the symbols have been incorrectly placed in cells adjacent to those that were intended. Locate these three errors, and thereby produce a correct version of the 'relationships matrix' on the separate sheet supplied. Provide justification for the three corrections you have made. [20%]

(c) Calculate the 'priority scores' for each item in the 'technical matrix' and add these to your chart. [10%]

(d) Complete the technical correlations matrix of your chart. Note that not every cell of the matrix need be filled in. [10%]

(e) From your completed technical correlations matrix identify what you consider to be the two most important design challenges to address. Justify your choices and discuss possible design solutions to address those challenges. [30%]

(f) Suggest five additional 'customer attributes' that you believe should have been included on the QFD chart. [10%]

(g) Outline the potential benefits and drawbacks of employing QFD for a design project such as this. [10%]

A blank copy of Fig 1. is provided on a separate sheet. This should be handed in with your answers.

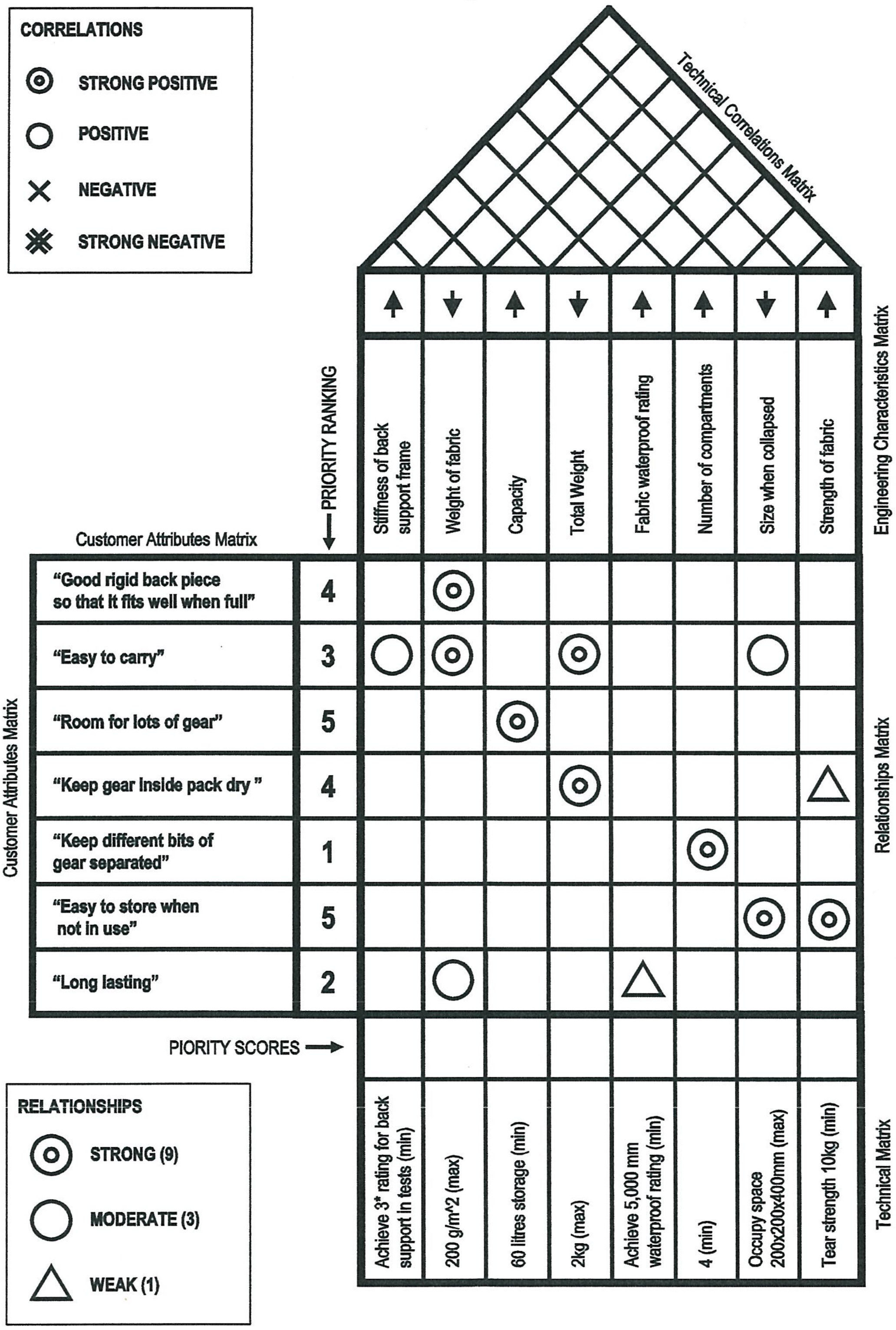
CORRELATIONS
STRONG POSITIVE
POSITIVE
NEGATIVE
STRONG NEGATIVE
Technical Correlations Matrix
Engineering Characteristics Matrix
PRIORITY RANKING
Stiffness of back support frame
Weight of fabric
Capacity
Total Weight
Fabric waterproof rating
Number of compartments
Size when collapsed
Strength of fabric
Customer Attributes Matrix
"Good rigid back piece so that it fits well when full"
4
"Easy to carry"
3
"Room for lots of gear"
5
"Keep gear inside pack dry"
4
"Keep different bits of gear separated"
1
"Easy to store when not in use"
5
"Long lasting"
2
Relationships Matrix
PIORITY SCORES
RELATIONSHIPS
STRONG (9)
MODERATE (3)
WEAK (1)
Achieve 3* rating for back support in tests (min)
200 g/m^2 (max)
60 litres storage (min)
2kg (max)
Achieve 5,000 mm waterproof rating (min)
4 (min)
Occupy space 200x200x400mm (max)
Tear strength 10kg (min)
Technical Matrix

Fig. 1

2 A large camera company has identified a market opportunity for a new digital camera model that contains a built-in miniaturised inkjet printer that provides near-instant prints. The main application for the camera is expected to be amateur use at social events such as parties and weddings. This new product would use three main consumables; batteries, ink cartridges and blank paper cards.

(a) Produce a requirements specification for the product structured under at least ten headings. [20%]

(b) Draw a diagram indicating the overall function for the camera. Use appropriate conventions to represent the main flows of energy, signals and materials. [10%]

(c) List up to ten sub-functions and arrange these into a product function structure. Make the drawing large and clear. Again, use appropriate conventions to represent the main flows of energy, signals and materials. [30%]

(d) Sketch and annotate a design that could meet the requirements listed in part (a) and also perform the functions listed in part (c). [30%]

(e) Comment on the strengths and weaknesses of your design. [10%]

3 A pharmaceutical company with long experience of supplying pressurised metered-dose inhalers (pMDIs) wishes to develop a novel dry-powder inhaler (DPI), following the lead of their competitors. This represents a significant shift from the use of a liquid drug formulation to a powder drug formulation. They have identified a number of possible concepts for the new device and associated manufacturing systems, two of which are shown in functional form in Fig. 2. They have concerns relating to both concepts and are keen to evaluate the risk associated with further development of each.

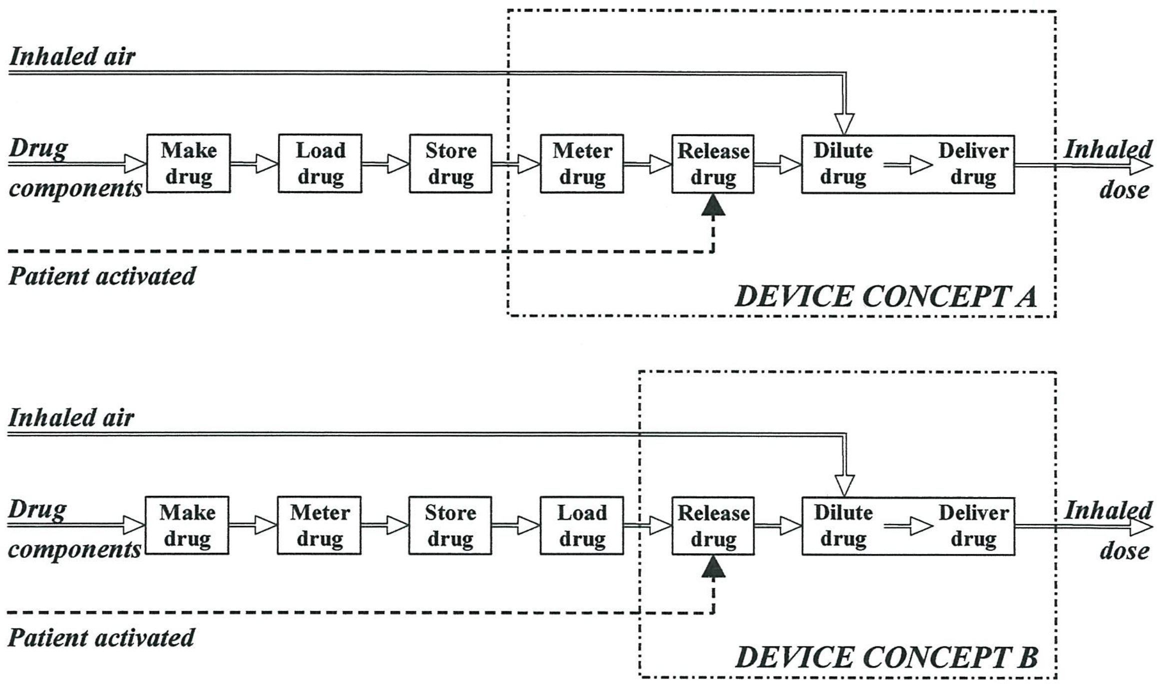

Fig. 2

(a) Describe the role of *evaluation* in design with reference to verification, validation and review activities. [20%]

(b) Describe the role of *risk management* in design with reference to the key activities involved. [30%]

(c) Sketch a fault tree for each concept, where the top event is the failure to deliver the correct dose of drug to the patient, and comment on the relative safety of each concept. [40%]

(d) Discuss the potential for developing a breath-operated DPI, i.e. one where the "Patient activated release" is triggered automatically by the "Inhaled air" flow. [10%]

4 Figure 3 shows a typical pressurised metered-dose inhaler (pMDI). To trigger the release of a dose the patient depresses the can within the body. A single aerosol dose is then 'fired' via the stemblock out of the mouthpiece. The stem of the can assembly needs to be an interference fit in the stemblock to ensure that the can does not fall out of the pMDI body. The mean external diameter of the stem is 3.0 mm with a standard deviation of 0.05 mm

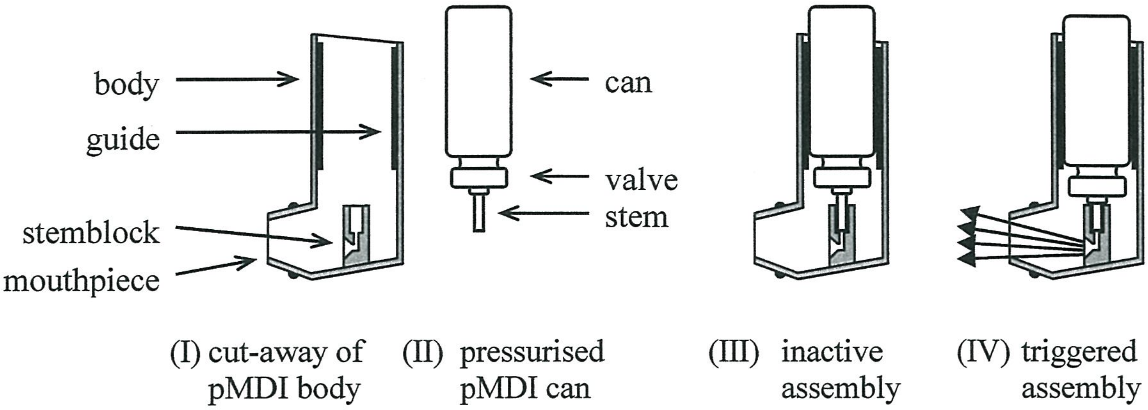

Fig. 3

(a) Given that the mean internal diameter of the stemblock is 2.9 mm with a standard deviation of 0.05 mm, calculate the percentage of pMDIs where an interference fit will not be achieved. [30%]

(b) Given the percentage of clearance fits calculated in part (a) is unacceptable, what is the maximum mean diameter required for the stemblock, assuming the same standard deviation, to achieve a percentage of interference fits in excess of 99.9%? [30%]

(c) If the interference between the stem and stemblock diameters exceeds 0.4mm, an interference fit is not achievable. For the maximum mean stemblock diameter identified in part (b), what is the maximum acceptable standard deviation for the stemblock diameter to achieve a total percentage of fits in excess of 99.9%? [40%]

END OF PAPER

4C4 DESIGN METHODS Candidate Number:

Supplementary sheet: Blank copy of Fig. 1.