ENGINEERING TRIPOS PART IIA/IIB

Wednesday 25 April 2012 9 to 10.30

4C4

DESIGN METHODS

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

*The **approximate** percentage of marks allocated to each part of a question is indicated in the right margin.*

Answers to questions in each section should be tied together and handed in separately.

There are no attachments

STATIONERY 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 The government has approached a company that specialises in the development of vending machines and have asked them to develop a new machine for providing healthy fruit snacks in schools. The only power source available at all the required locations will be an electric wall outlet. The company are instructed to

"*develop a product that dispenses fresh fruit in return for students' coins, that is the same size and shape as standard vending machines (approximately 1 m wide, 1 m deep and 2 m high), and that contains an electrically powered refrigerator.*"

The company identify that the main challenge facing the development of the new product is the problem of efficiently dispensing fruits such as apples, peaches and oranges without bruising or damaging them.

(a) Describe three potential means of solving this mechanical problem and comment on the strengths and weaknesses of each one. Your three potential solution principles should demonstrate something of the breadth of solutions that are possible. Provide annotated sketches to illustrate your ideas. [30%]

(b) Choosing one of your solutions from (a), develop a design that would satisfy the problem statement specified in the quotation above. Provide annotated sketches to illustrate your ideas and comment on the strengths and weaknesses of the design. [30%]

When working on the design of the machine, the company becomes increasingly concerned that the problem has been too narrowly defined.

(c) Working from the quotation above, derive a set of three to five increasingly solution-neutral problem statements that are still within the scope of what the company could address. After each statement indicate what solution-specific assumptions have been removed. [10%]

(d) Through a further process of abstraction, derive a set of three to five increasingly solution-neutral problem statements that continue from those provided in response to (c) but are beyond the scope of what the company would typically address. After each statement indicate what solution-specific assumptions have been removed. [10%]

(e) Using the statements that you prepared for (d), make suggestions for what other approaches the government might take beyond commissioning the development of a new vending machine. [20%]

2 A company that specialises in the production of power tools wants to develop an electric drill that (i) drills holes, and (ii) collects the dust that is generated. In order to achieve this they are going to combine a battery-powered drill with a small battery-powered vacuum cleaner.

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

(b) Describe the difference between a product's sub-functions and a product's components. [10%]

(c) Identify five or six product sub-functions that collectively define all the essential roles that the machine should perform. Arrange all these sub-functions 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. [20%]

(d) Sketch and annotate a design solution for a highly *modular* product that can perform all the functions that you identified in (c). [20%]

(e) Sketch and annotate a design solution for a highly *integrated* product that can perform all the functions that you identified in (c). [20%]

(f) Comment on the relative strengths and weaknesses of the design solutions that you have presented in (d) and (e). [20%]

3 A pharmaceutical company has developed a novel concept for an inhaler to deliver oral medication. It is based on the use of an existing dry powder formulation which will be stored in the inhaler as a series of 120 discrete doses. They appreciate that there is some considerable risk in delivering such a novel technology to market and aim to utilise good risk management practice during the development of the new inhaler.

(a) Describe the elements of good risk management practice that will increase the company's chances of delivering the new inhaler to market. [40%]

(b) List the key requirements for the new inhaler. [20%]

(c) Outline a possible verification and validation approach to support the timely delivery of the new inhaler. [20%]

(d) Sketch a fault tree highlighting events that may lead to the patient not receiving the correct medication whilst using the new inhaler. [20%]

4 A new product, comprising 50 nominally identical parts, is to be sold in a simple heat-sealed plastic pack. It is proposed to check-weigh the pack to ensure that the correct number of parts is supplied, where each part weighs 10±1 g. The packaging line cannot put more than 50 parts in a pack, but within any given production batch of 10,000 packs, typically 100 packs will contain 49 parts and 1 pack will contain 48 parts. You may assume that the range from minimum to maximum weight for each part is equivalent to six standard deviations (σ), that the weight of the plastic pack is negligible and that the typical distribution of parts in packs is observed.

(a) If the packs that weigh less than 495 g are rejected, how many good packs will be rejected and how many short packs (those with less than 50 parts) will be accepted within a single batch? [30%]

(b) What weight limit is required if only one good pack per batch is to be rejected? How many short packs will then be accepted? [30%]

(c) If the weight limit is set to 493 g, what tolerance on the part weight is required if only one good pack per batch is to be rejected? How many short packs will then be accepted? [20%]

(d) What is the relationship between a reduction of the number of short packs per batch and the number of packs accepted? Comment on this result. [20%]

END OF PAPER

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