Version PJC/3

EGT2
ENGINEERING TRIPOS PART IIA
EGT3
ENGINEERING TRIPOS PART IIB

Friday 25 April 2014 2 to 3:30

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.*

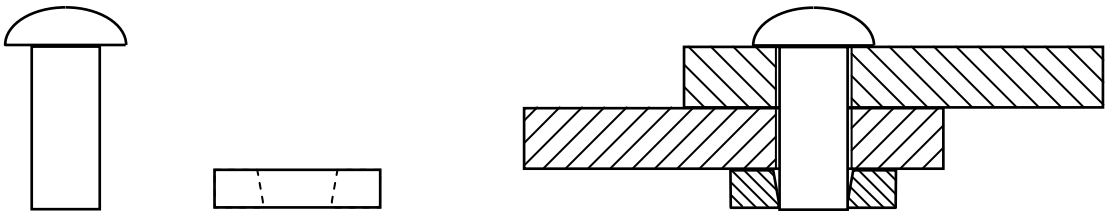
STATIONERY REQUIREMENTS
Single-sided script paper

SPECIAL REQUIREMENTS TO BE SUPPLIED FOR THIS EXAM
CUED approved calculator allowed
Engineering Data Book

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

1 A peg is to be inserted through two plates and into a shaped retaining washer, as shown in Fig. 1. The peg is to have a clearance fit (where the peg will always fit in the hole) through the plates and an interference fit (where the peg will not, without sufficient force applied, fit in the hole) with the retaining washer.

The peg, ignoring its head, has a diameter of 10 ± 0.1 mm and a length of 21.5 ± 0.5 mm. The hole in each plate has a diameter of 10.2 ± 0.2 mm and the plates are of thickness 8 ± 0.25 mm. The retaining washer has a nominal thickness of 5 mm and internal diameter 9.8 ± 0.1 mm. If the washer is to be able to retain the peg, there must be an interference fit between the washer and the peg and the length of longitudinal overlap between the peg and washer must exceed 5 ± 1 mm.



Peg Retaining Washer Cross-section of peg/plate/washer assembly

Fig. 1

You may assume that the plates are free to move in a plane perpendicular to the longitudinal axis of the peg, enabling alignment of the peg and the holes. You may also assume that in all cases the range from minimum to maximum represents six standard deviations, and that the plates are randomly chosen from the same batch.

(a) What are the failure modes for this assembly approach? [20%]

(b) What is the likelihood that any randomly selected peg/plate/plate/washer assembly will fail to assemble correctly? [40%]

(c) Show how it is possible, in principle, to limit the failure rate to 0.15% by making dimensional changes to the peg alone, assuming that the variations in size cannot be reduced? [30%]

(d) What other practical considerations are necessary to determine whether additional changes to the plates or washer are required to meet the target given in (c)? [10%]

2 Accident and Emergency departments in UK hospitals are becoming increasingly overwhelmed by the number of people who arrive seeking medical attention that could adequately be provided by their community doctor (General Practitioner). A particular healthcare provider is developing a novel approach to the initial assessment (triaging) of patients entering their Accident and Emergency department, with the intention of identifying those 'patients' who should be referred directly back to their community doctor without further assessment or treatment.

(a) Describe the elements of good risk management that enable the successful delivery of a new service to market. [50%]

(b) Identify five risks that might inhibit the provider's ability to launch a new, safe, and cost effective service within six months. [20%]

(c) Devise a risk management strategy that will improve the provider's chances of achieving a successful launch, indicating how the most critical risks identified in (b) might be avoided. [30%]

3 An increasing number of supermarket products have tamper resistant and/or child resistant closures. However, it is evident that the latter not only exclude younger users, but also older or less able users. For example, a child resistant closure on a bottle of household bleach should stop young children from opening the bottle, but it may also present a significant challenge for older adults. A particular supplier of liquid household chemicals has decided to develop a new range of easy-to-open products.

(a) Use a solution-neutral problem statement to describe the overall function of the new packaging. [10%]

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

(c) Define a process function structure for the safe use of the new packaging. [20%]

(d) Identify solution principles for the critical functions identified in (c), and describe a packaging concept that will ensure safe and economic use of liquid household chemicals in the home. [50%]

4 (a) Describe the purpose and form of the Function Analysis System Technique (FAST) diagram. [20%]

(b) An auto-injector, a device to allow an individual to self administer an injection of a liquid medication, comes with the following draft instructions:

- Step 1: Gather and inspect the supplies for your injection
  - 1.1 Gather an alcohol swab, a cotton wool ball and an auto-injector from the fridge
  - 1.2 Check the expiration date
  - 1.3 Check the security seal
  - 1.4 Wait 30 minutes
  - 1.5 Check the liquid in the auto-injector

- Step 2: Choose and prepare the injection site
  - 2.1 Choose the injection site
  - 2.2 Prepare the injection site

- Step 3: Injecting using the single dose auto-injector
  - 3.1 Remove the cap
  - 3.2 Push the open end of the auto-injector firmly against the skin
  - 3.3 Press button to inject
  - 3.4 Wait for second "click"

- Step 4: After the injection
  - 4.1 Check the viewing window
  - 4.2 Dispose of the used auto-injector
  - 4.3 Use the cotton wool ball

Draw a FAST diagram for the use of the auto-injector. Indicate on the diagram the critical functions from the point of view of the safety of the user. [20%]

(c) Draw a fault tree where the 'top event' represents the failure of the user to inject the medication effectively. [30%]

(d) Identify six areas of clarification required in the instructions presented in (b) to improve the safety of the device. Present the list in the form of questions to be addressed to the device designers. [30%]

END OF PAPER