MANUFACTURING ENGINEERING TRIPOS PART II

Wednesday 22 April 2009 9 to 12

PAPER 1

*Answer not more than **four** questions.*

Answer each question in a separate booklet.

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.*

There are no attachments.

STATIONERY REQUIREMENTS	SPECIAL REQUIREMENTS
8 page answer booklet x 4	Engineering Data Book
Rough work pad	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

Version 6

1 The density of transistors within integrated circuits has increased considerably over the last 45 years.

(a) Explain the law that describes this phenomenon, including its name, origin and what it predicts. [20%]

(b) The consequences of this law have had a major impact on the manufacturing processes for many electronic components and circuits, including application specific integrated circuits (ASICs).

(i) Briefly describe the principal stages in ASIC manufacture. [30%]

(ii) Discuss the consequences of the law explained in (a) for these manufacturing stages, and the effect on the overall yield of the ASIC manufacturing process. [30%]

(c) Discuss the limits to the application of this law and the degree to which it might apply in future to circuits based on organic rather than on silicon semiconducting materials. [20%]

2 'The ability to model both manufacturing processes and component behaviour, for example the effects of mechanical stress or temperature, is essential to the achievement of high yields of high performance components for safety-critical applications'.
Discuss this statement in the context of the following products:

(i) Thermoplastic drug-delivery devices, produced in high volumes.
(ii) Wheels for large agricultural vehicles.
(iii) Hollow-core, wide-chord fan blades for aero-engines.

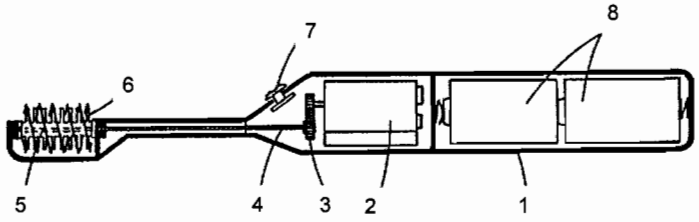
In your answer, for each case: indicate why the product can be regarded as 'safety-critical'; outline the manufacturing processes and materials involved; identify the attributes of the product and/or process which might be optimised by appropriate modelling. [100%]

3 Figure 1 shows a schematic drawing of a proposed new design for a motorised toothbrush. The novel step is that the bristles (parts 5 and 6) rotate, driven by the motor and gearbox (parts 2 and 3). The production engineering department has estimated that this design will cost £3.50 per item to produce, in production volumes of one million per year. Detailed costings are provided in table 1.

(a) Briefly outline the origins and purpose of Value Analysis/Value Engineering (VA/VE), indicating the difference between Value Analysis and Value Engineering. [15%]

(b) Describe the main stages of VA/VE, and analyse the toothbrush design, to highlight opportunities for improving its value to customers. [70%]

(c) Discuss the effectiveness of VA/VE Engineering as a design tool. [15%]



1 Housing
2 Motor
3 Gearbox
4 Drive shaft
5 Bristle-shaft
6 Bristles
7 Switch
8 Batteries

Fig. 1

	Unit cost
Housing	£0.80
Motor	£0.50
Gearbox	£0.30
Drive shaft	£0.20
Bristle-shaft	£0.20
Bristles	£0.30
Switch	£0.20
Batteries	£1.00
Total unit cost	£3.50

Table 1: Unit costs

4 Manufacturing industry is coming under pressure to reduce its carbon footprint.

(a) Define what is meant by 'carbon footprint'. [5%]

(b) Explain, with examples, why it is important to define system boundaries in assessing environmental impacts. [15%]

(c) With specific reference to a company which manufactures mass-market car body panels, discuss the factors which contribute to the carbon footprint. How can the carbon footprint be minimised? In defining your system boundary, you should include all operations within the factory together with distribution of manufactured goods from the factory to the assembly plant. [60%]

(d) For the system defined in (c), identify other environmental considerations which are not addressed by the carbon footprint. What strategy would you propose to reduce their impact? [20%]

5 Process Intensification (PI), has been described as a strategy for the next generation of process plant operations. In this strategy, large industrial plants are replaced by a collection of smaller plants located closer to the point of use, or the point of need.

(a) Describe how the following process industries could usefully implement PI strategies and give examples of any new technology that will be required.

i) Chemical Production.
ii) Power Generation. [60%]

(b) Provide a detailed discussion of the problems and benefits of implementing PI in the Power Generation industries. [40%]

6 A factory is implementing a new production line for the manufacture and assembly of a small electronic consumer product. The product consists of an electronic circuit board enclosed within a plastic box as shown in figure 2. The first stage of the assembly will be performed manually, taking 15 seconds to secure the electronic circuit board inside the lower body of the box. The second stage will be fully automated and will locate a lid on the top of the box, and then secure it in place with four screws in the corners of the box.

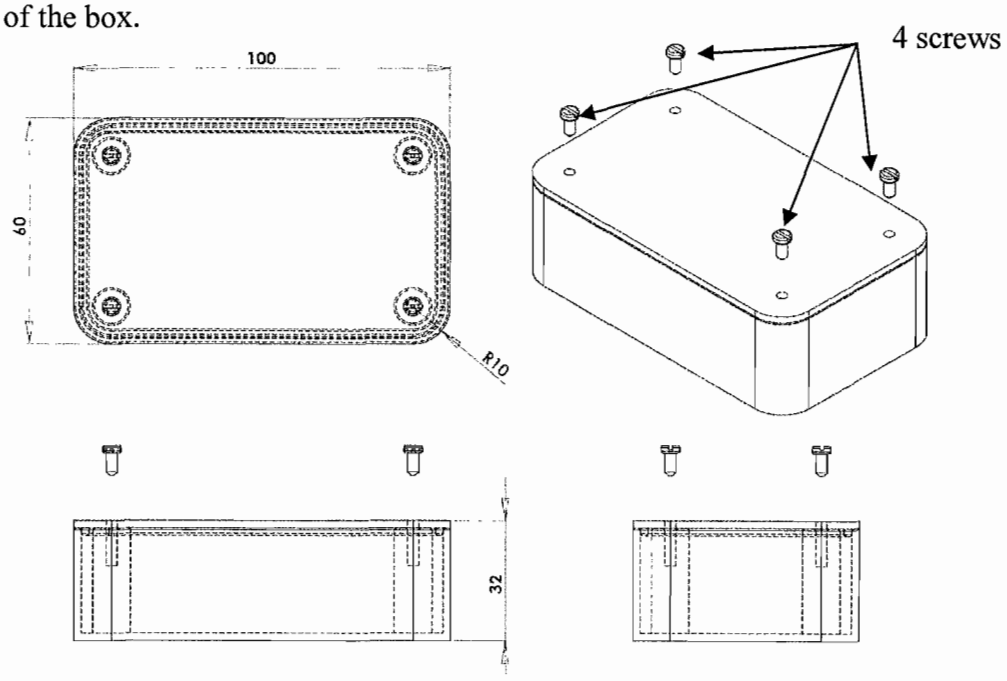


Fig. 2 Drawing of Box and Lid Assembly (Dimensions in mm.)

(a) Discuss how a robot and an automated screw driver could be used to perform the automated assembly process. What factors would you need to consider in linking the initial manual process and the secondary automated process? [50%]

(b) Sketch a fixture that could be used to locate and hold the box components during the assembly process. Discuss briefly the main features of the design. [25%]

(c) Discuss the types and location of sensors that would be needed in the automated assembly process. Provide examples of error conditions that could be identified with the sensors used. [25%]

END OF PAPER