MANUFACTURING ENGINEERING TRIPOS PART II

Wednesday 27 April 2005 9 to 12

PAPER 1

*Answer not more than **four** questions. Answer **each** question in a separate script paper 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.

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

1 (a) A plant is being set up to manufacture 100mm diameter wheels for supermarket trolleys. These will have an internal bore to carry bearings, and an external rim to carry a rubber tyre.

(i) List the required attributes of the wheels.
[10%]

(ii) Present a reasoned argument for two possible alternative materials types for the wheels. Your answer should address a range of factors including: economics; lifecycle (e.g. anticipated lifetime, degradation mechanisms, recyclability, possibility of replacement or repair); and mechanical properties.
[30%]

(iii) Briefly describe the processes which could be used to manufacture the wheels for each of your two alternative materials, identifying the advantages and disadvantages of each process.
[20%]

(iv) What differences would you anticipate in the criteria for selection of materials and manufacturing processes for the front wheels for wheelchairs?
[10%]

(b) "To obtain the required properties for a component, it is not enough to specify only the composition of the material. It is also necessary to take account of the influence of the manufacturing process on the microstructure." Discuss the implications of this statement with reference to any two of the following: the casting of light alloys; the processing of starch-based snack foods; surface coating.
[30%]

2 (a) Explain what is meant by the term *embedded software*, giving examples of characteristics of such software.

[15%]

(b) The terms *desktop*, *real time* and *non-real time* are also used to describe software. A characterisation of software types in these terms is illustrated in Fig. 1.

	Embedded software	Desktop software
Non-real time	1	2
Real time	3	4

Fig. 1 Characterisation of software types

Give at least one example of the type of software application that you would expect to find in each of these quadrants.

[15%]

(c) What characteristics distinguish software system elements from hardware system elements?

[20%]

(d) What is meant by a *safety critical system*, and what design and development practices might be adopted to create software suitable for such systems?

[25%]

(e) Companies frequently lack the skills to develop the embedded software that provides essential functionality in their products. Discuss the issues a company should

consider when sourcing embedded software from an external supplier.
[25%]

3 Fig. 2 shows a simple mousetrap. This product is currently assembled by hand.

(a) Briefly describe the main elements of a systematic approach to Design for Assembly. Using a systematic approach to Design for Assembly, analyse the mousetrap shown in Fig. 2 and comment on opportunities for design improvement. Briefly describe another method by which this design could have been assessed for assembly improvements.

[30%]

(b) Analyse the design of this mousetrap using Value Analysis techniques. A list of parts and costs is given in Table 1. Using a value matrix, suggest ways in which you would improve the value of the existing design. You may need to make estimates of sensible values for any additional information required.

[40%]

(c) In the light of your answers to (a) and (b), and other relevant considerations, discuss what factors should be taken into account when reviewing the practical and economic viability of automating the assembly of the mousetrap.

[30%]

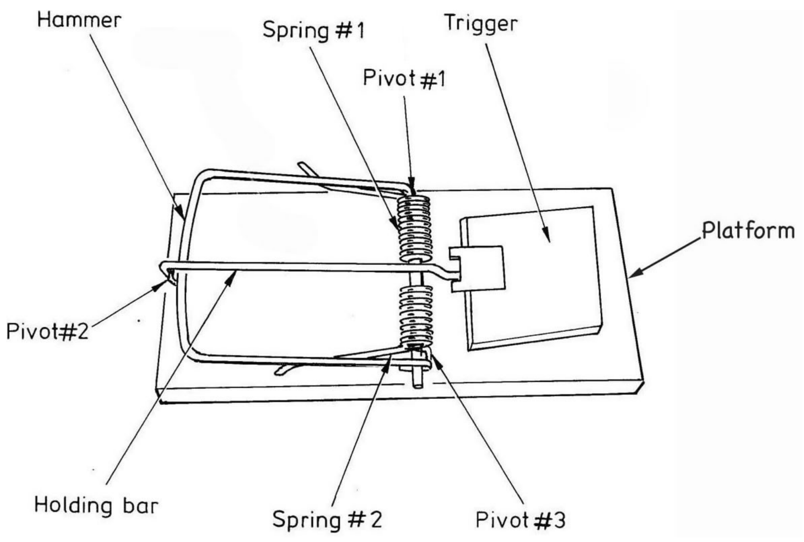

Fig. 2 Mousetrap

	Cost per 1000 units
Platform (wood)	£60
Hammer	£50
Trigger (plastic)	£90
Spring #1	£80
Spring #2	£80
Holding bar	£30

Pivot (x3)	£30
Assembly	£80
	Total cost per 1000 = £500

Table 1 Mousetrap parts and costs

4 (a) High out-of-stock levels are a major concern for many retailers. Describe what is meant by *shelf out-of-stock* for a supermarket and identify the main causes of high shelf out-of-stock levels. Why is this such a critical issue?

[20%]

(b) Discuss the role of the manufacturer in minimising a retailer's shelf out-of-stock levels for its product range? Your discussions should address:

(i) the roles of sales forecasting, information sharing, inventory management and production flexibility

(ii) the limitations a manufacturer faces in attempting to reduce a retailer's shelf out-of-stock levels

[30%]

(c) You are employed by a major beverage company as account manager for their largest retail customer. It is late February 2005. You have just attended a meeting with the retailer's planning team to discuss plans for the summer of 2005 which addressed issues such as possible product promotions (dates not given) and shelf out-of-stock target levels for the summer period. It has been emphasised to you that unavailability of your company's products in summer 2004 had a major impact on the retailer's profitability in that period. Your company requires you to develop a plan for meeting the retailer's requirements. Outline the key elements of this plan and, in particular, address:

(i) information that you would need from both the retailer and your organisation

(ii) key decisions that need to be considered in determining production plans and building stock levels

(iii) possible difficulties that might occur in the execution of the plan and how you might prepare for these.

[50%]

5 (a) (i) Define a bottleneck; a process batch; and a transfer batch.

(ii) Give a very brief explanation of the drum / rope / buffer concept.
[15%]

(b) A small company manufactures flooring boards in two lengths (full lengths and half lengths). There are three operations, as shown in Fig. 3.

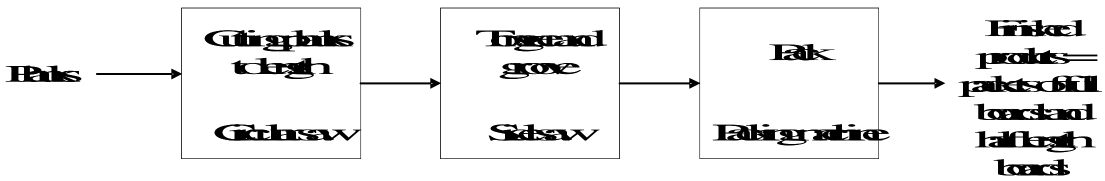

Fig. 3 The three operations

Planks are fed, one at a time, into the circular saw which cuts them to length. One plank makes one full length board or two half length boards. A changeover is required when switching between full length boards and half length boards, and vice versa.

Each board is then fed into a side saw that can only handle one board at a time, irrespective of length. The side saw puts a tongue and groove along each board. Here too a changeover is required when switching between full length and half length boards, and vice versa.

In the final stage, the boards are packed into bundles of five, ready for selling.

Table 2 shows, the set-up and make times for full and half length boards. In the case of the packing machine, the numbers refer to the time to bundle the boards into packets of five.

(cont.

	Changeover from full length to half length (minutes)	Changeover from half length to full length (minutes)	Make time for full length board (minutes)	Make time for half length board (minutes)
Circular saw	30	16	1	0.6
Side saw	20	20	3	2.5
Packing machine	-	-	2	2

Table 2

The factory sells everything it can produce. It sells two half length boards for every full length. The factory makes a schedule just for the week ahead each Monday. The factory runs an eight hour working day, five days per week. One week's finished stock can be stored on site.

(i) What is the maximum weekly output that could be obtained from each of the three resources, assuming they were able to produce at their full rate? State your assumptions regarding the calculation for the output of the packing machine. Which resource is therefore the bottleneck?

[25%]

(ii) Produce a schedule for a week that aims to maximise output while minimising the build up of work between resources. Your schedule should list the hours on each resource for each day. Assume that there is no shortage of labour.

[30%]

(iii) What are the process batch sizes on the circular saw?

[5%]

(c) Explain to what extent your schedule incorporates the drum / rope / buffer concept particularly describing the function of the buffer.

[25%]

6 You have to design the sensing and control logic for a simple inspecting and sorting station to sit on the end of an automated production line. The system is required to detect an incoming product, inspect for quality, and pass the item down Conveyor 1 or Conveyor 2 accordingly. The general arrangement is shown in Fig. 4.

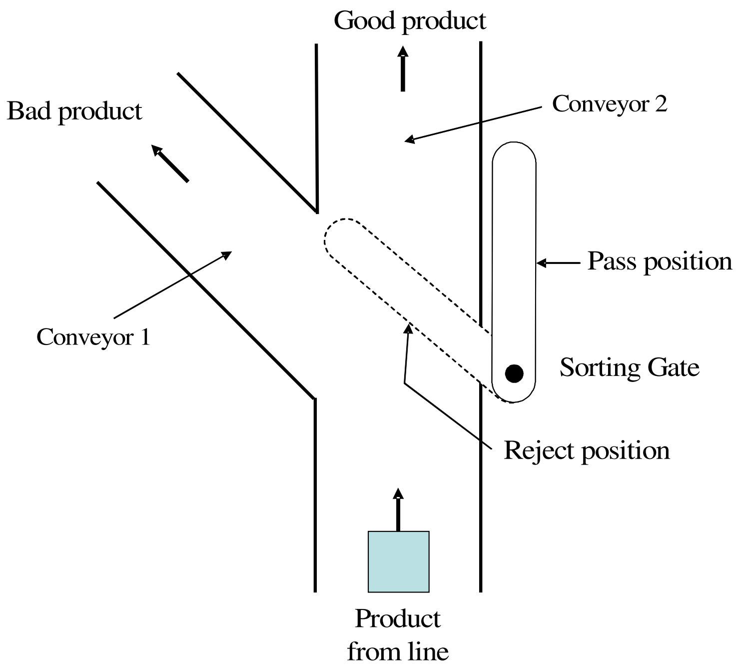

Fig. 4

The inspection operation is controlled from a single industrial PLC.

(a) Discuss the sensing and actuation requirements to allow robust operation of the station. Suggest the types of sensor and actuator that might be used and sketch the location of the sensors. State any assumptions you make.
[40%]

(b) The sensors and actuators represent inputs and outputs to the control system respectively. Construct a table of the places and transitions and then draw a Petri-net for the control of the operation.
[30%]

(c) From the Petri-net, or otherwise, develop a ladder logic diagram for the PLC controlling the operation.
[30%]

END OF PAPER