MANUFACTURING ENGINEERING TRIPOS PART IIB

Wednesday 25 April 2012 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

Final version

1 For each of the applications listed below, two or three possible manufacturing processes are proposed. In each case, briefly describe the processes, compare and contrast them, and discuss their suitability for the application.

(a) Sealing a container for an implanted heart pacemaker, made from thin titanium alloy sheet: adhesive bonding; friction stir welding; laser welding. [35%]

(b) Making a turbine disk for a jet engine from a nickel-based super alloy: hot forging; cold forging; casting. [35%]

(c) Making a container from a thermoplastic polymer for a high-value cosmetic product for retail sale: extrusion blow-moulding; injection stretch blow moulding. [30%]

2 The manufacture of an electro-mechanical consumer product, such as a DVD player, involves assembly processes for electronics components and mechanical components.

(a) Describe the range of electronics components, and related electronics component assembly processes, which may currently be used in building the electronics part of such a product. [50%]

(b) Discuss the range of mechanical assembly and automation methods that could apply over the lifecycle of such a product, and the factors that would determine the most appropriate choice of assembly method. [50%]

3 As the number of internal combustion engines rises steadily in the global economy, there is a compelling impetus to develop clean, efficient, and suitable vehicles for urban transportation. As a result, Hybrid Electric Vehicles (HEV) and Fully Electric Vehicles (FEV) are now joining the product portfolios of many of the world's leading automotive companies.

(a) Describe the basic architectures of both HEVs and FEVs. Discuss the advantages and disadvantages of each, and assess their environmental benefits. [40%]

(b) There are a number of rechargeable battery technologies that have been used or are likely to be used in the future for HEVs and FEVs. The lithium-ion cell has only recently begun to replace the lead-acid cell in transport applications. What are the environmental benefits to the customer in using lithium-ion cells compared to lead-acid cells? [40%]

(c) Given the need to provide safe electrical systems in HEVs and FEVs, explain why the electrical systems run at high voltages instead of low voltages. [5%]

(d) Describe three safety concerns for passengers when using HEVs or FEVs. What measures could be taken to reduce the risks? [15%]

4 (a) Discuss the key issues to consider when designing an asset information management solution. [40%]

(b) In the context of maintenance practices established at ExxonMobil, explain how *response maintenance* is effectively implemented. [60%]

5 As a production engineer, you have been asked to design an automated system that will perform the final assembly of an electronic consumer product. This process is currently carried out by manual labour and involves positioning a lid onto the base of the consumer product and then fastening it in place with three screws. A conveyor system and standardised kitting trays are used to transport the base of the consumer product and its associated lid into the assembly process. The assembled consumer product is transported out of the assembly process using the same kitting trays. Fig. 1 shows an exploded assembly drawing of the electronic consumer product.

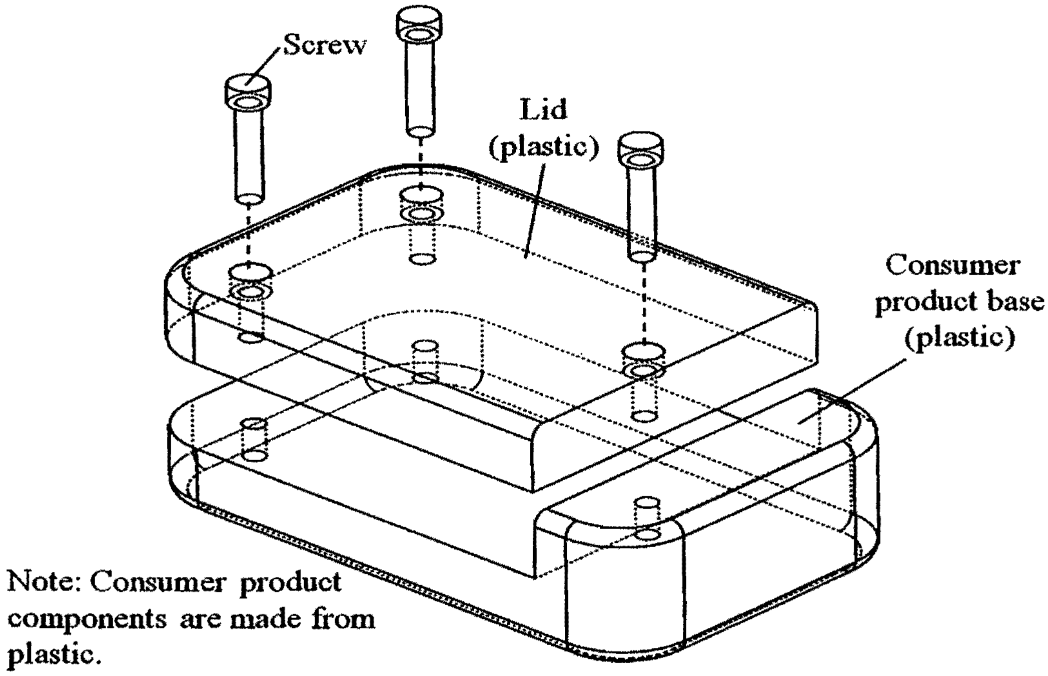


Fig. 1 Exploded assembly drawing of the electronic consumer product.

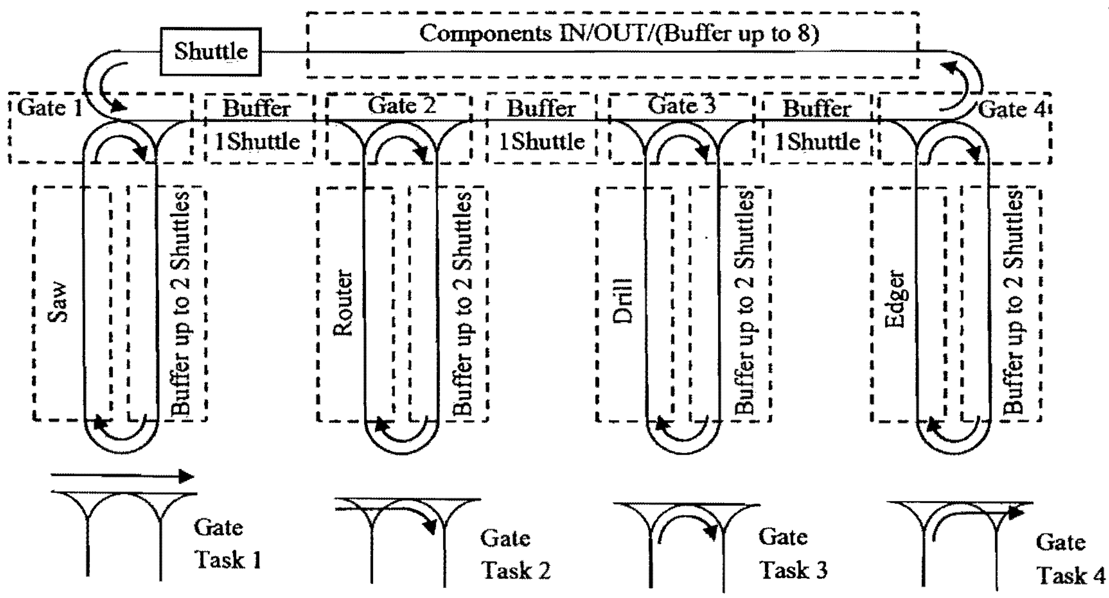
A number of pieces of hardware have been made available to automate this task:
1 x (4 Axis Scara Robot)
1 x (5 Axis Anthropomorphic Robot)
1 x (Bowl Screw Feeder)
1 x (Rotary Turntable, with two operational positions at 180 Deg.)
1 x (Electric Screw Driver, with a vacuum system for picking up individual screws)

(a) Draw a floor layout of the new automated production system making use of the supplied hardware, with additional assembly fixtures and end effectors. The design should make use of the existing conveyor system and kitting trays for transporting parts in and out of the system. Describe the overall operation of the system, listing the specific features of the hardware components that make them suitable for task. [40%]

(b) Provide a detailed design of a fixture that can be used for the assembly/fastening operation of the consumer product. Describe the overall operation of the fixture, listing aspects of the mechanical design that enable it to work reliably. [40%]

(c) Describe the type, location and functionality of sensors required to ensure the reliable operation of the fixture. [20%]

6 A cabinet manufacturing company has developed an automated production system used to machine MDF panels. The panels can be machined to different sizes allowing a wide range of cabinets to be made. The system consists of a number of production resources that can be used to perform tasks such as sawing, routing, drilling and edging. Depending on the style and size of cabinet to be manufactured, these resources can be utilised in different sequences, following different specifications. A new flexible conveyor system has been installed to transport MDF panels through each of the production resources. It is similar to a mono rail, with gates that allow shuttles to be routed in different directions. The sub-loops enable shuttles to pass directly into the work area of the production resources, allowing machining operations to be performed directly on parts located on shuttles. A new control system must be installed and commissioned to control the overall operation of the manufacturing line. Fig. 2 shows the layout of the production system.



Note: The saw, router, drill & edger can carry out two different operational tasks.
The gates can carry out four different routing tasks.
Shuttles will automatically advance unless held at a stop control actuator or are present in a queue.
The conveyor system can accommodate up to eight shuttles.

Fig. 2 Layout of MDF panel production system.

(a) Describe the type of control hardware that would be required to sequence the overall operation of this system. List the features of the hardware that make it suitable for this purpose. Highlight the location of any additional hardware such as sensors, shuttle control actuators or tracking devices required for the purposes of controlling the route of shuttles around the conveyor. [40%]

(b) Draw a system's architecture diagram that shows how the control software could be split into modules. List the functionality of each module and the benefits that this type of modular architecture provides. Discuss the overarching control strategy that could be implemented to ensure individual shuttles are moved via customised routes through the different production resources. [40%]

(c) When planning a systems development/integration project such as this, list the milestones that would be important in ensuring the success of the project. [20%]

END OF PAPER