Version Final

MET3

MANUFACTURING ENGINEERING TRIPOS PART IIB

Wednesday 23 April 2014 9 to 12

PAPER 1

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

Answer ***each*** *question in a separate booklet.*

All questions carry the same percentage 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 coversheet.

STATIONERY REQUIREMENTS

8 page answer booklet x 4

Rough work pad

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 to do so.

1 Discuss the concept of a '*high-performance material'*. [25%]

Describe three examples of how materials can be processed to achieve '*high performance*'. For each example:

(a) identify a practical application of the material in a manufactured product;

(b) explain how the production process is used to enhance the properties of the material; and

(c) describe how the enhanced properties are relevant to the performance of the product in the identified application. [75%]

2 (a) Micro Electrical Mechanical Systems (MEMS) have been identified as one of the most promising technologies for the 21st Century and have the potential to revolutionize both industrial and consumer products. Discuss the main technical and operational attributes of typical MEMS devices. Give specific examples of MEMS devices and applications to support your answer. [30%]

(b) In order to manufacture and apply a successful MEMS device, basic physics and operating principles, including scaling laws, need to be fully understood and appreciated at both macro and micro levels. What are the issues with scaling laws when designing and manufacturing MEMS devices? [30%]

(c) Although MEMS and Nanotechnology are sometimes cited as separate and distinct technologies, in reality the distinction between the two is not so clear-cut. In fact, these two technologies are highly dependent on one another, particularly in terms of production methods. Semiconductor and MEMS device fabrication routes are constantly seeking higher resolutions that go beyond the limits of typical semiconductor fabrication technologies. Explain the factors that limit the current resolution and describe two emerging production technologies that could be applied in the realisation of device resolutions that go below 35nm. [40%]

3 The environmental impact of polymer packaging in the food and drink industry is the subject of some controversy. Public perception is based on information which is often incomplete, even when it comes from reputable sources.

(a) The main functions of packaging in the food and drink industry may be summarised under the headings of product handling, mechanical protection, barrier function, provision of information, and tamper-evidence. Give examples of how these functions are achieved, and discuss their resulting environmental implications. [25%]

(b) How may polymers be recycled at end-of-life? Why is recycling of post-consumer polymer packaging generally regarded as problematic? What are the environmental consequences (benefits and penalties) of the different end-of-life disposal options for polymer packaging? [30%]

(c) Bio-polymers may be defined as polymers originating from renewable feedstock. One of the commonest bio-polymers is PLA (polylactic acid), which is derived from corn. What are the advantages and disadvantages of using PLA for food packaging? To what extent can the environmental impact of biopolymers be assessed using Life Cycle Analysis (LCA)? [30%]

(d) What steps can be taken to minimise the environmental impact of packaging? [15%]

 (TURN OVER

4 A consumer electronics company is launching a new tablet based computer. You have been asked to design an automated system that will perform the final assembly of the product. The assembly process will require an electronics module comprising a Liquid Crystal Display (LCD) and an integrated single board computer to be positioned in a plastic tablet casing and fastened in place with four screws. A snap-fit plastic bezel will then be positioned and pushed into place on the front of the tablet. This will form an attractive front for the tablet casing, framing the edge of the LCD and concealing the inner workings of the tablet. Fig. 1 shows an exploded assembly drawing of the tablet.

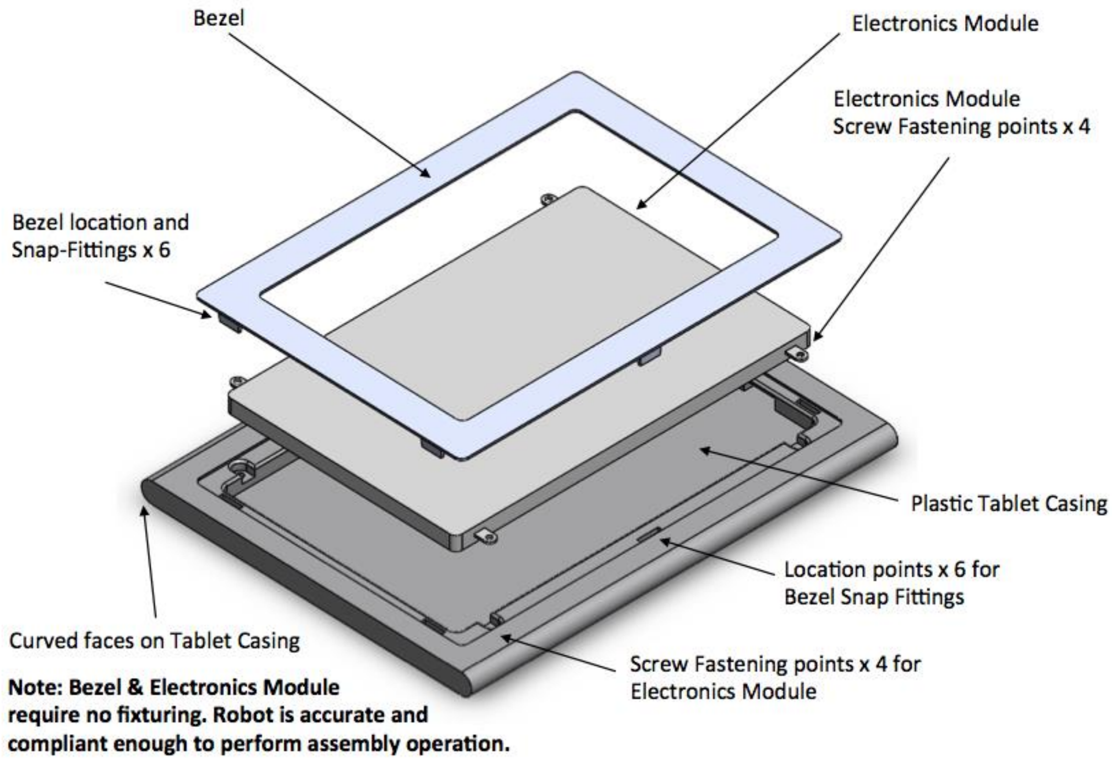

Fig. 1 Exploded assembly drawing of tablet.

The assembly station will consist of two SCARA Robots and a single assembly fixture. One SCARA robot will manipulate in-coming parts (tablet casing, electronics module and bezel) and out-going parts (assembled tablet) between kitting trays on a conveyor and the assembly fixture. The second SCARA robot will perform the screw fastening operation.

(a) Provide detailed designs of the fixture and robot end effector used to manipulate parts during the assembly of the tablet. Describe the overall operation of the fixture and end effector, listing aspects of the mechanical design that enable them to work reliably. [40%]

(b) Describe the type, location and functionality of sensors required to ensure the reliable operation of the fixture and both end effectors. [40%]

(c) Describe the approach that should be taken to test the assembly station. Discuss details of the different test phases and types of tests that should be carried out in each phase. [20%]

 (TURN OVER

5 (a) Describe the basic principles that underpin *design for assembly*. [30%]

A company is proposing to manufacture large area lightweight aluminium flooring for the next generation of high-speed train. The design requirements are that the floor must be light, stiff, have surfaces that remain flat with no protrusions, and must not contain adhesives. A section of the initial design is presented in Fig. 2. It consists of top and bottom plates made from aluminium sheet that are secured to a series of extruded aluminium spacers that run the length of the floor section. Both top and bottom plates are secured to the spacer at intervals with screw fixings.

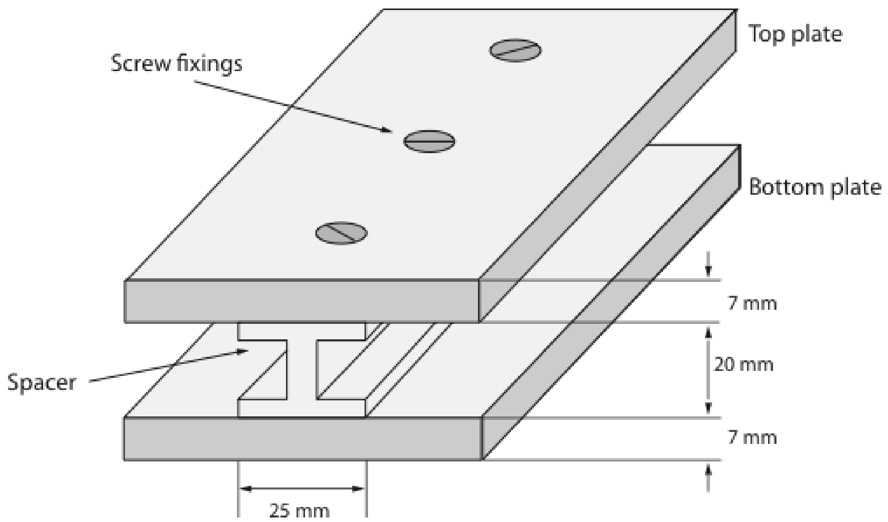

Fig. 2 Floor section

(b) Discuss the extent to which this design and manufacturing route align with the principles outlined in section (a). [30%]

(c) Develop an improved design and suggest three alternative manufacturing routes. Select your preferred route and provide a detailed description of the manufacturing processes and operations employed. [40%]

6 A manufacturing company underwent inspection by the Health and Safety Executive (HSE) and was found to be in violation of a number of safety regulations. The HSE ordered the company to do the following: alter some existing machinery to make it safer; purchase new machinery to replace old machinery; and relocate machinery to make safer passages within the factory. The HSE gave the company 33 weeks to make the changes. Failure to meet these changes within the timescale would result in the company being fined £300,000. The company prepared a project plan identifying the activities required and the estimated completion times. This data is shown in Table 1.

Table 1

Activity	Description	Predecessor	Time estimate (weeks)		
			Minimum (l)	Most Likely (m)	Maximum (h)
a	Order new machinery	-	1	2	3
b	Plan new physical layout	-	2	5	8
c	Determine safety changes	-	1	3	5
d	Receive equipment	a	4	10	25
e	Hire new employees	a	3	7	12
f	Make plant alterations	b	10	15	25
g	Make changes in existing machinery	c	5	9	14
h	Train new employees	d, e	2	3	7
i	Install new machinery	d, e, f	1	4	6
j	Relocate old machinery	d, e, f, g	2	5	10
k	Conduct employee safety orientation	h, i, j	2	2	2

Project crashing is a method for shortening project duration by reducing the time of one or more of the project activities to less than its normal activity time. After implementing project crashing, the project manager has calculated the cost of each activity, and estimated the mean duration of activities and their costs. This data is shown in Table 2.

 (Cont.

Table 2

Activity	Activity duration after crashing (weeks)	Cost	
		Normal (£)	After crashing (£)
a	1	100,000	101,000
b	2	1,000	3,000
c	1	500	750
d	4	500	1,500
e	3	1,500	1,800
f	10	5,000	8,000
g	5	500	1,500
h	2	2,500	3,000
i	1	5,000	6,000
j	4	5,000	5,500
k	2	1,000	1,000

(a) Construct the project network and determine the expected project duration without project crashing. [40%]

(b) Calculate the risk to the company arising from missing the deadline posed by the HSE without crashing the project. [30%]

(c) Assuming that the variances of activity duration remain the same after crashing the project, identify the activities that must be crashed to achieve the best cost-risk balance. [30%]

END OF PAPER