

MET3
MANUFACTURING ENGINEERING TRIPOS PART IIB

Wednesday 20 April 2016 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.*

*Write your candidate number **not** your name on the cover sheet.*

STATIONERY REQUIREMENTS

8 page answer booklet x 4

Rough work pad

SPECIAL REQUIREMENTS TO BE SUPPLIED FOR THIS EXAM

CUED approved calculator allowed

Engineering Data Book

10 minutes reading time is allowed for this paper.

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

- 1 (a) Define the process of *welding*. List five advantages and five disadvantages of such an operation. [15%]
- (b) Describe the essential characteristics of the following three processes for joining metals: arc welding; laser welding; and friction welding. [30%]
- (c) For each of the following applications, suggest, with a reasoned explanation, which of the three welding processes listed in part (b) would be the most appropriate choice.
- (i) Joining a heat resistant steel engine valve head to a mild steel shank for an automotive application.
 - (ii) Forming a butt joint between two mild steel plates of thickness 50 mm for fabrication of large structures.
 - (iii) Joining a titanium alloy blade and disk for an aerospace application. [40%]
- (d) Describe the key features of the ultrasonic bonding process and discuss three possible applications of this technique. [15%]

2 (a) You are asked to select a structural adhesive to bond an internal support to the inside of a hollow wind turbine blade. Discuss in detail the technical considerations that would lead you to choosing the correct adhesive for this structural application.

Include within your answer notes on: (i) the appropriate properties of the adhesive prior to bonding; (ii) application-specific considerations; and (iii) validation/testing.

Provide specific examples and additional considerations where appropriate. [50%]

(b) Discuss the future challenges and opportunities faced by the carbon fibre composites industry as it tries to drive growth. As part of the discussion, include specific points on industry trends, production technology challenges and material challenges. [50%]

- 3 (a) Describe the construction and operation of:
- (i) An anthropomorphic (articulated) robot;
 - (ii) A SCARA robot; and
 - (iii) A DELTA robot.

Explain the advantages and disadvantages of each and give examples of tasks that they would be best suited to perform. [60%]

- (b) A robot is to be used to assemble a plastic lid to a plastic box, as shown in Fig. 1, and to secure it with 4 steel screws.

Provide labelled concept sketches for a suitable assembly fixture, clearly indicating methods of location and clamping. State what type of robot and end effector you would use, giving the reasons for your choice. Discuss errors that might be encountered in the assembly and screwing operations and describe what sensors you would use to identify each error condition. [40%]

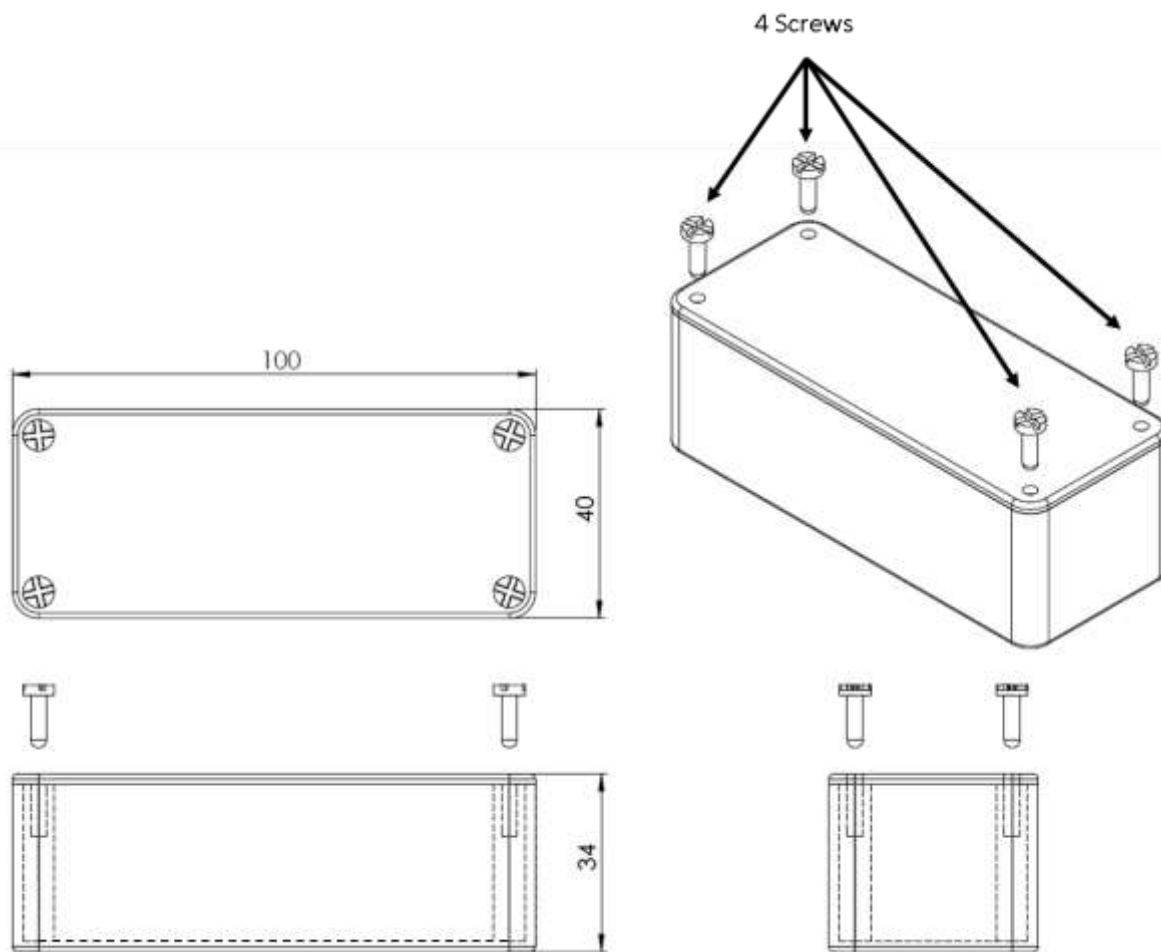


Fig. 1. Plastic Box and Lid Assembly (Dimensions in mm)

4 (a) Maintenance is one of the key factors that influence profitability of operations in the oil industry. *Response maintenance* describes a particular strategy for maintenance in the oil industry. Contrast *standard* and *imperative* response maintenance procedures, and describe how a decision is made as to whether or not a maintenance task requires an imperative response. [40%]

(b) A major oil company is planning its regular shutdown maintenance, and is conducting a risk analysis to decide whether it should replace a particular piece of equipment. The equipment meets all current regulations. However, if a fire occurs due to a fault in the equipment, it will affect production. In addition, the fire will also result in contamination that can cause harm to neighbouring farms and the environment. Recent court cases have shown that simply meeting regulations does not relieve a company of liability if an incident causes harm to others. Also, courts have been awarding large damages to individuals and businesses harmed by hazardous incidents.

If the company replaces the equipment, fires due to equipment faults will not occur because the new model has additional protection built in. The cost of replacing the equipment is £30,000.

If the company decides to keep the existing equipment, the management estimates that there is a 0.001 probability that a fire due to equipment fault will occur sometime during the remaining life of the equipment. If a fire occurs, there is a 0.20 probability that it will be bad and the company will incur a very high cost of £90 million for the clean-up, and a 0.80 probability that the fire will be minor and a clean-up can be accomplished at a low cost of £8 million. Moreover, there is a 0.10 probability that the effect of the fire on production will be high and the resulting losses will amount to £10 million, and a 0.90 probability that the effect on production will be low with a resulting loss of £100,000.

- (i) Determine whether the company should replace the equipment on an economic basis. [40%]
- (ii) Do you believe the company should make the decision according to your calculations in part (i)? Explain your reasons. [20%]

5 Polymer based food packaging is very widespread in the food industry, and has both positive and negative environmental impacts. In assessing the environmental impact of polymer food packaging, a range of considerations must be included.

(a) Food packaging can provide a chemical *barrier* between the product and its surroundings.

- (i) Describe, using three different examples, the functions of such barriers and explain what materials properties are required.
- (ii) Discuss the impacts on the lifecycle (positive and negative) of including a barrier function in packaging.

[25%]

(b) What is a *system boundary*? Discuss what factors should be considered when defining a system boundary for environmental analysis of plastic film packaging for cheese produced and consumed in the UK.

[15%]

(c) Briefly describe how an eco-audit of a plastic film packaging for cheese would be carried out. What are the outputs of such an analysis? What assumptions might you expect to make in carrying out the assessment? How would you use the analysis to propose reduction in the environmental impact of the packaging? Identify any additional factors relevant to environmental impact assessment which should be considered that are not included in this analysis.

[40%]

(d) With reference to plastic packaging for takeaway foods (e.g. clamshell packaging for prepared salads) discuss how the environmental impact of the packaging can be minimised.

[20%]

6 A large job shop manufacturing company is bidding for a contract to produce a component part for the fuselage assembly in a new space shuttle. A major criterion for selecting the winning bid besides low cost is the time required to produce the part. However, if the company is awarded the contract, it will be held strictly to the completion date specified in the bid, and any delays will result in a penalty of £200,000 in addition to the loss of the contract. In order to determine the completion time and price to put in its bid, the company has identified the activities, precedence relationships, activity times and costs as shown in Table 1. In order to develop a competitive bid, the company decided to specify a contract price of £120,000.

Activity	Predecessor	Time estimate (days)			Cost (£)
		Minimum	Most Likely	Maximum	
1	-	5	8	17	10,000
2	-	7	10	19	18,000
3	1	3	5	7	17,500
4	1	1	3	5	30,000
5	3, 2	4	6	8	12,000
6	2, 3	3	3	3	2,500
7	4, 5	3	4	5	10,000

Table 1.

- (a) Which activities should the company be particularly diligent in monitoring for any delays? Explain the rationale for your answer. [40%]
- (b) If the company wants to be 90% certain that it can deliver the component without incurring the penalty, what time frame (in days) should it specify in the bid? [40%]
- (c) Has the company specified a reasonable price and time frame (calculated in part (b)) for the contract? Explain the rationale for your answer. [20%]

END OF PAPER