MANUFACTURING ENGINEERING TRIPOS PART I

Saturday 28 April 2007 9 - 12

Paper P1

DESIGN AND MANUFACTURE

*Answer not more than **four** questions of which not more than **one** may be taken from each section **A, B, C** and **D**.*

*Answers to sections **A, B, C** and **D** must appear in four separate booklets.*

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
8 page answer booklet x 4
Rough work pad

SPECIAL REQUIREMENTS
Engineering Data Book
P1 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 that you may do so by the Invigilator

Version 7

SECTION A

*Answer **one** question from this section*

1 A long tapered shell structure is to be moulded from composite material in two halves, each weighing over 5 tonnes. Each half has the following dimensions:

Length: 30 m
Width at narrow end: 0.25 m
Width at broad end: 0.75 m
Height: 1.5 m

The structure is assembled by lifting one half-mould, turning it over, and positioning it over the other half and lowering it into place for final assembly. Positioning accuracy is important at this stage.

You are tasked with designing a pair of 'mobile lifting frames', which can be positioned at each end of the structure and will enable the assembly of the two halves.

(a) Identify the degrees-of-freedom required by the lifting frames and the likely range of movement needed in each degree-of-freedom. [20%]

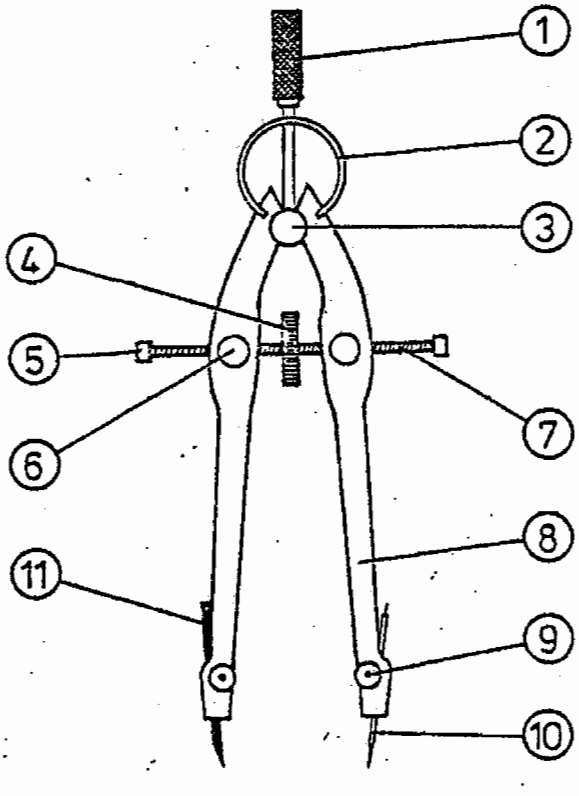
(b) Assuming that the shells are effectively rigid, propose a method of locating these parts for final assembly and discuss the potential sources of inaccuracy. Comment on how you would assess the validity of the assumption that the shell is rigid. [20%]

(c) Using sketches and explanatory notes, suggest a conceptual design for the pair of lifting frames. [50%]

(d) An alternative lifting method is an overhead gantry crane system built into the building. Discuss the advantages and disadvantages of this solution in comparison with the pair of mobile lifting frames. [10%]

2 (a) Describe in detail the functions performed by all the components shown in the drawing of a pair of compasses in Figure 1. Explain the features of each component which enable it to fulfil the necessary functions. [60%]

(b) Develop a new design that reduces the number of parts and explain the reasoning behind your design. [40%]



Ref.	Item	No. off
1	Finger hold	1
2	Spring	1
3	Pivot	1
4	Wheel	1
5	End pieces	2
6	Inserts	2
7	Screwed shaft	1
8	Leg	2
9	Clamping screw and nut	2
10	Point	1
11	Lead	1

Figure 1

SECTION B

*Answer **one** question from this section*

3 You are responsible for the design of a new rugged bicycle light, targeted at off-road cyclists.

(a) Explain the principles of Quality Function Deployment, and use them to explore the potential functionality and technical performance of the new light. [50%]

(b) Using the outputs from the analysis in part (a), develop a technical specification for the light and explain how this technical specification should be used during the design process. [30%]

(c) You have determined that the product will be constructed from an extruded U-shaped main body, two side plates, a front lens, and a mounting bracket as indicated in Figure 2. Locations for controls and a socket for a power cable are not yet determined. Maintaining this basic architecture, you wish to explore aesthetic aspects of the design that would be suitable for different consumers. Sketch some aesthetic concepts that would communicate the following visual values:

> "robust and rugged";
> "fast and fun".

In each case, annotate your sketches to explain how your concept will result in the intended response. [20%]

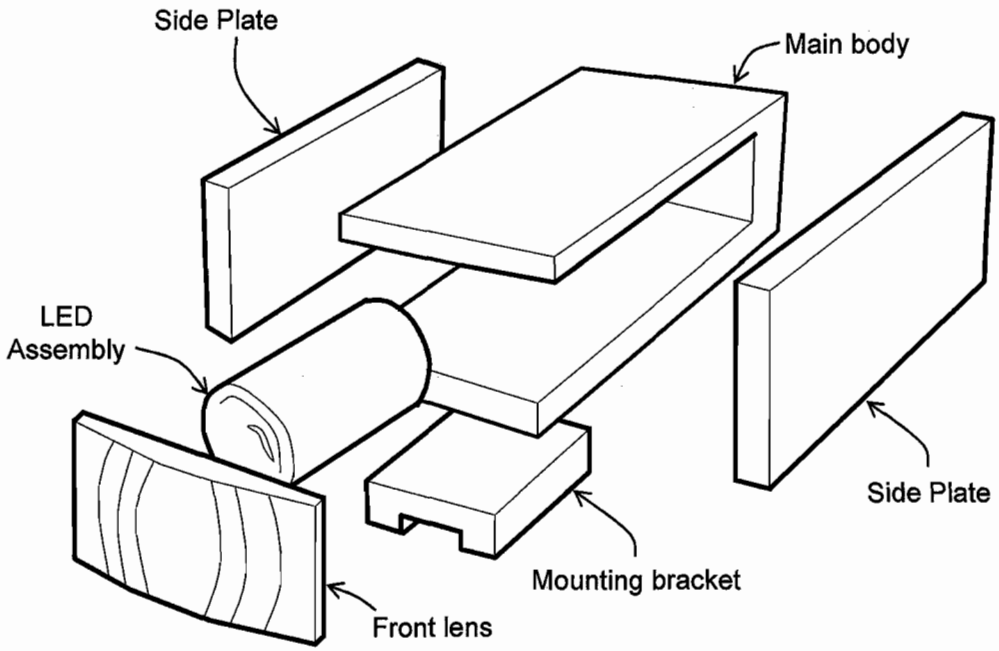

Side Plate
Main body
LED
Assembly
Side Plate
Mounting bracket
Front lens

Figure 2

4 (a) Describe the manufacturing process steps for the Bracket illustrated in Figure 3, assuming it is to be produced from solid in a batch size of 5. Note any design modifications that you would recommend to make production simpler. [25%]

(b) The designer has labelled spigot 'A' as diameter 10h6. Calculate the correct dimensional tolerances for this feature. Comment on the production methods needed to make this feature. [10%]

(c) This spigot fits into a hole of diameter 10H6. Discuss at least three ways in which the geometry of this feature might influence assembly with the mating part. In each case, propose the appropriate geometrical tolerance that you would use to control this potential difficulty, illustrating your answer where appropriate. [30%]

(d) A complete day's production for this part has been completed. The size of Spigot A has been measured on each component and the results are tabulated in Table 1. Calculate the process capability for batches 1 and 3 and compare the results. Discuss the capability of the manufacturing process for the whole day's production and make appropriate recommendations. [35%]

	Batch 1	Batch 2	Batch 3	Batch 4	Lunch	Batch 5	Batch 6	Batch 7	Batch 8
1	9.995	9.994	9.995	9.991		9.997	9.998	9.993	9.999
2	9.996	9.992	9.994	9.987		9.996	9.997	9.996	9.998
3	9.999	9.993	9.996	9.989		9.998	9.999	9.998	9.997
4	10.000	9.992	9.995	9.992		9.999	10.001	9.999	9.999
5	9.992	9.991	9.995	9.994		10.001	10.002	9.991	10.004
Mean	**9.996**	**9.992**	**9.995**	**9.991**		**9.998**	**9.999**	**9.995**	**9.999**
Standard Deviation	**0.003**	**0.001**	**0.001**	**0.003**		**0.002**	**0.002**	**0.003**	**0.003**

Table 1

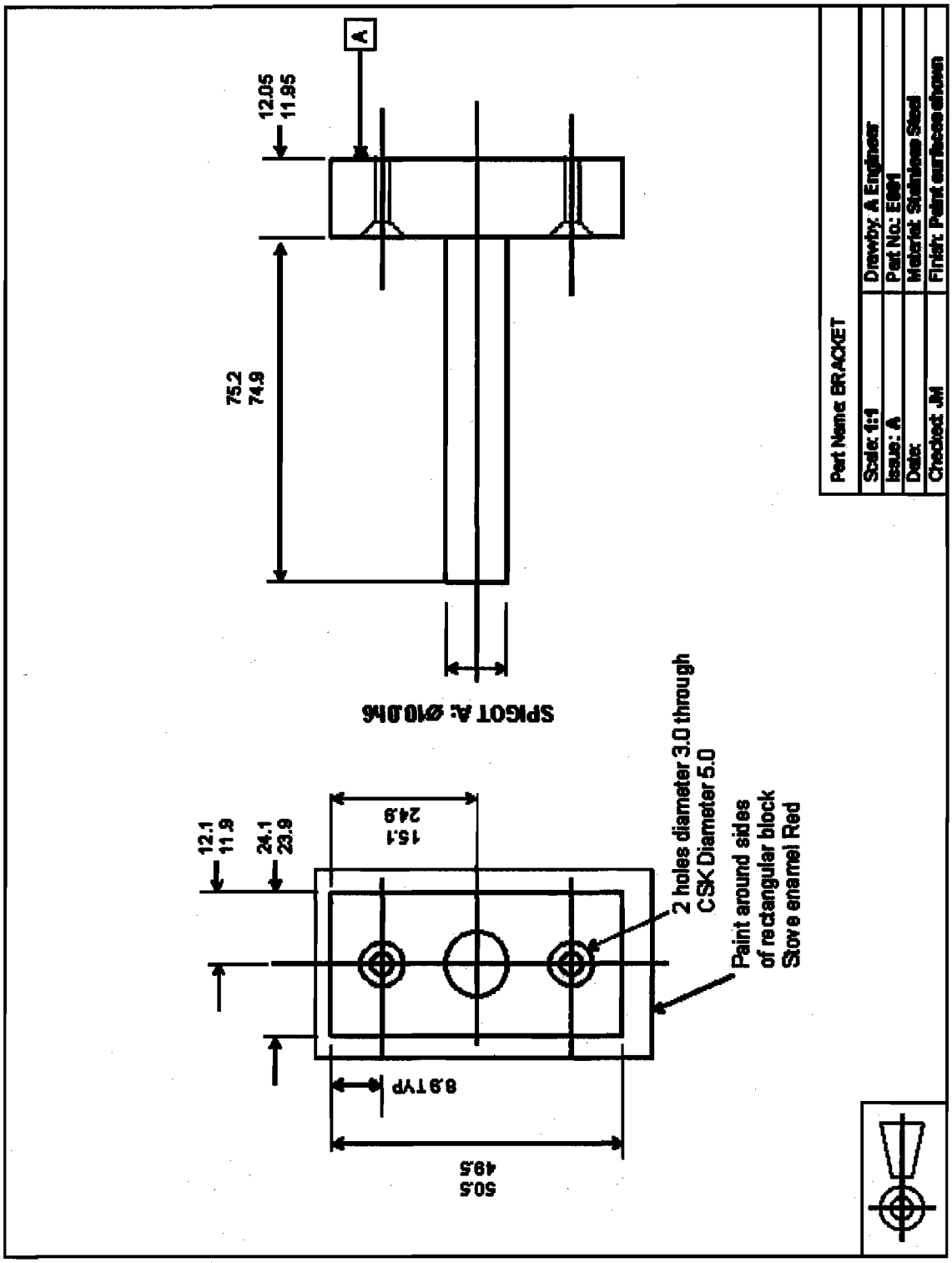

A
12.05
11.95
75.2
74.9
SPIGOT A: Ø10.0h6
12.1
11.9
24.1
23.9
15.1
24.9
2 holes diameter 3.0 through
CSK Diameter 5.0
Paint around sides
of rectangular block
Stove enamel Red
8.9TYP
50.5
49.5
Part Name BRACKET
Scale: 1:1
Drawby: A Engineer
Issue: A
Part No: E001
Date:
Material: Stainless Steel
Checked: JM
Finish: Paint surfaces shown

Figure 3

SECTION C

*Answer **one** question from this section*

5 (a) Briefly discuss the reasons why companies need time standards, illustrating each reason, with examples. [20%]

(b) An operator is part of the way through manufacturing a large batch of components. After 98 components have been manufactured, an engineer measures the time taken for the next three components (i.e. components 99, 100 and 101) with the following results: 59.1 s, 62.2 s, 58.4 s.

Answer the following, stating any assumptions made:

(i) Calculate 95% confidence limits for the basic time for the manufacturing operation. [25%]

(ii) Assuming that this manufacturing operation has a 90% learning curve, calculate the time taken to produce the next 100 components. [35%]

(iii) Discuss quantitatively the applicability of extending the learning curve model to a batch of 500 and a batch of 5000. [20%]

6 (a) Outline briefly the stages of Method Study. [15%]

(b) Describe the principles of Motion Economy. [35%]

(c) Figures 4a and 4b show photographs of the components of a three pin plug and a partially assembled plug. Using the principles of motion economy, or otherwise, design a workstation for the manual assembly of plugs in large batches. For your solution, explain how components are supplied and describe the assembly sequence [50%]

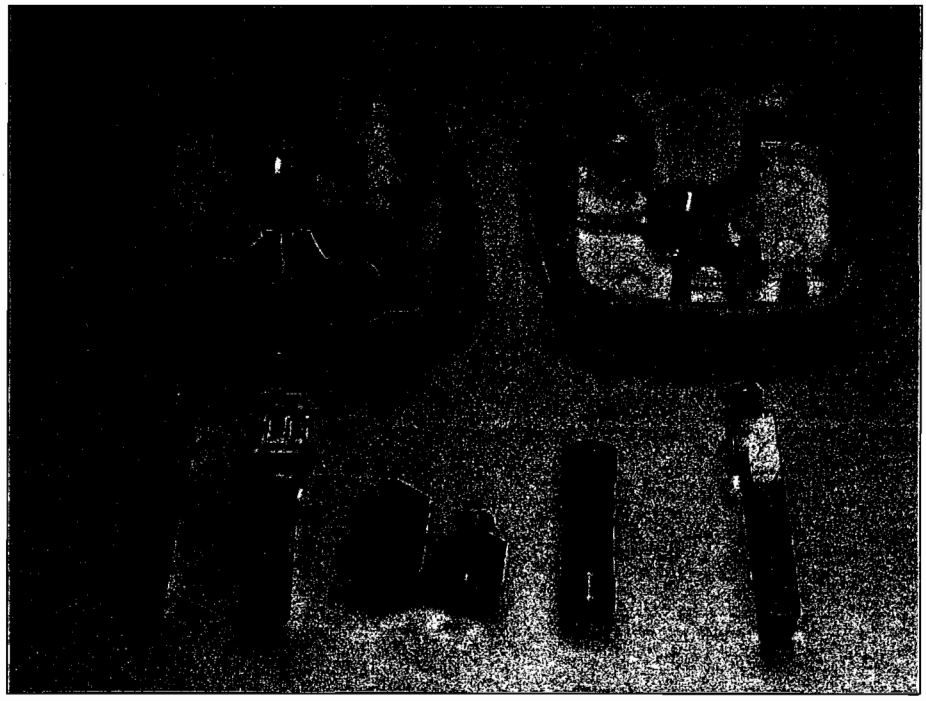


Figure 4a

Figure 4b

SECTION D

*Answer **one** question from this section*

7 (a) For each of the following sheet metal operations describe examples of good practice in the design of components and associated tooling:

(i) blanking;
(ii) bending;
(iii) stamping;
(iv) deep drawing. [40%]

(b) Beverage cans are typically manufactured in two parts from sheet aluminium. As a process engineer, discuss the requirements for fixtures, tooling, lubrication and quality control in sheet metal production, using the beverage can to illustrate your answer. [30%]

(c) Explain the physical mechanisms responsible for non-contact laser bending of sheet metal and briefly describe one application where this technique is used in production operations. [30%]

8 (a) Provide some good-practice guidelines to be used by junior engineers in the design of injection mould tools for precision plastic components. [35%]

(b) How would the design and manufacture of an injection mould tool be influenced by different requirements of production volume and component surface finish. [20%]

(c) Give examples of ways in which the mould-tool might degrade in service, commenting on how the operator might detect this degradation. [20%]

(d) Describe what is meant by the term "Rapid Tooling". Outline four ways of producing such a tool, commenting briefly on the advantages and limitations of each. [25%]

END OF PAPER