MANUFACTURING ENGINEERING TRIPOS PART I

Saturday 30th April 2005 9 to 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.*

Attachments:
Log-log paper (1 sheet)

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

SECTION A

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

1 (a) What key attributes of static functionality does a primary component provide to a mechanical assembly? What additional attributes does the component need to have to make the production of these components sustainable over a long period of time?

[10%]

(b) A wind turbine tower carries a large horizontal load at the top which can be applied in any direction. Deflection and strength are two main criteria. Consider three designs of tower as follows:

- A vertical tube;
- A four-legged framework;
- A vertical tube supported by guy ropes at its mid point.

(i) Sketch a design of tower based on each concept. Discuss the advantages and disadvantages of each design and explain how shape can be adapted to match the bending moment distribution efficiently in these three kinds of tower.

[40%]

(ii) Three materials have been suggested for the tower construction. These are steel, glassfibre composites and composites using wood (Birch). Figures for strength, density and energy used per kilogram to produce these materials are as follows:-

(cont

	Strength (MPa)	Density (kg/m^3)	Energy/kg (kWh/kg)
Steel	275	7850	11.50
Glassfibre	150	1950	26.40
Wood (Birch)	80	700	1.33

Write down a merit index that establishes energy used per unit of load carried. Determine the value of this index for each material and suggest which material you would propose for further consideration. Explain your reasoning.

[30%]

(iii) Discuss other practical issues that must be considered before implementing your design.

[20%]

2 You work for a UK company and have been asked to develop a base of expertise, material supply chains and manufacturing capacity in China in order to supply products to the local Chinese market. Your first task is to establish a partnership with a suitable Chinese manufacturing company.

(a) Outline the approach that you will take in the initial analysis of a potential partner company. How do you propose to deal with the linguistic and cultural differences between your company and a potential partner company?

[20%]

(b) Describe three levels of trust that it is important to establish within the partnership. Outline the three rules of fair play necessary to develop trust.

[30%]

(c) Concerning the evaluation of potential partners, itemise three detailed questions for each of the three issues of trust outlined above. Explain what these tell you about the companies concerned.

[30%]

(d) As the project manager, what measures would you take to ensure that the project objectives are reached?

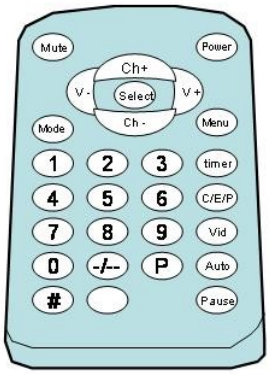
[20%]

SECTION B

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

3 Figure 1 shows a sketch design of a remote control for a specialist Hi-Fi.

(a) The remote control has ten components, four of them are sub-contract injection moulded, three are manufactured in house and three are purchased. Describe how you would calculate the unit cost for the remote control, commenting on the information you would need and the assumptions that you would have to make.



[25%]

Figure 1

(b) You have been given three options for the production of the 'Case Moulding':

1 Injection moulded polyethylene – tooling cost £20,000, material cost £0.5 per part, tooling life 40,000 units;

2 Die cast aluminium – tooling cost £15,000, material cost £2.00 per part, tooling life 20,000 units;

3 Low pressure reaction moulded polyurethane – tooling cost £5000, material cost £5.00 per part, tooling life 5000 units.

Outline the relative merits of each production method. Using graphs where appropriate, recommend the most appropriate option for a production run of 4000 per annum. How would your recommendation change as the production volume changed?

[40%]

(cont

(c) Some basic anthropometric data is provided in Table 1. How would you use this information to ensure that the remote control is usable? What other ergonomic issues would you take into consideration?

[35%]

	Percentiles – Male (mm)			Percentiles – Female (mm)		
	5th	50th	95th	5th	50th	95th
Hand length	175	190	205	160	175	190
Hand breadth	80	85	95	70	75	85
Index finger breadth	19	21	23	16	18	20
Thumb breadth	20	23	26	17	19	21

Table 1: Anthropometric data

4 (a) When dimensioning a component, why is it important to specify geometry in addition to size?

[10%]

(b) Figure 2 illustrates a simple bearing assembly. The outer race of the bearing remains stationary and the shaft rotates. With the aid of sketches, show how you would design the shaft and housing to locate the bearing. Calculate the tolerances that you would apply to the housing and to the shaft to achieve an appropriate fit with the bearing, explaining your assumptions.

[30%]

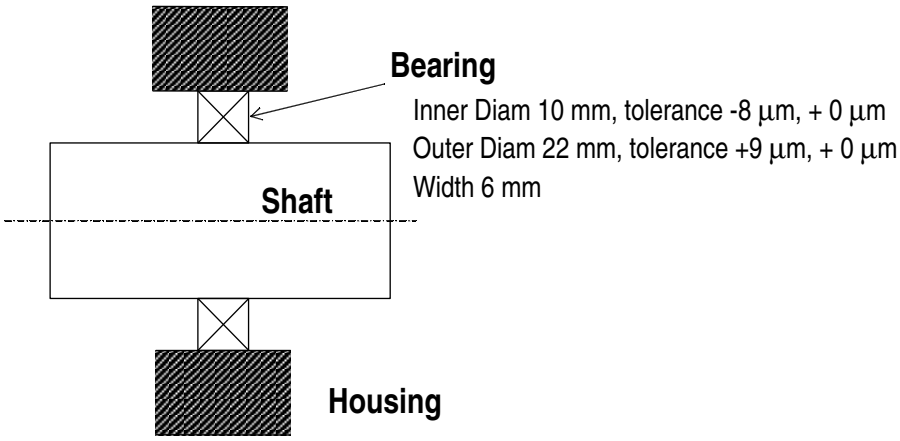


Figure 2

(c) **Figure 3 shows a sketch of a stainless steel spacer. The inner bore must be concentric with the outer bore and the two end faces must be parallel. Using sketches show how you would tolerance these features and explain what the tolerance zones mean in practice. In each case indicate what your choice would mean for the production process.**

[30%]

(i) The spacer has four holes for M4 cap head screws on a 55.0 mm pitch circle. These holes are offset by 30 degrees from three location holes. Using the positional tolerances, show how you would dimension these features.

[20%]

(ii) Explain how would you measure the roundness of a component and how this measurement differs from ‘run-out’.
[10%]

(cont

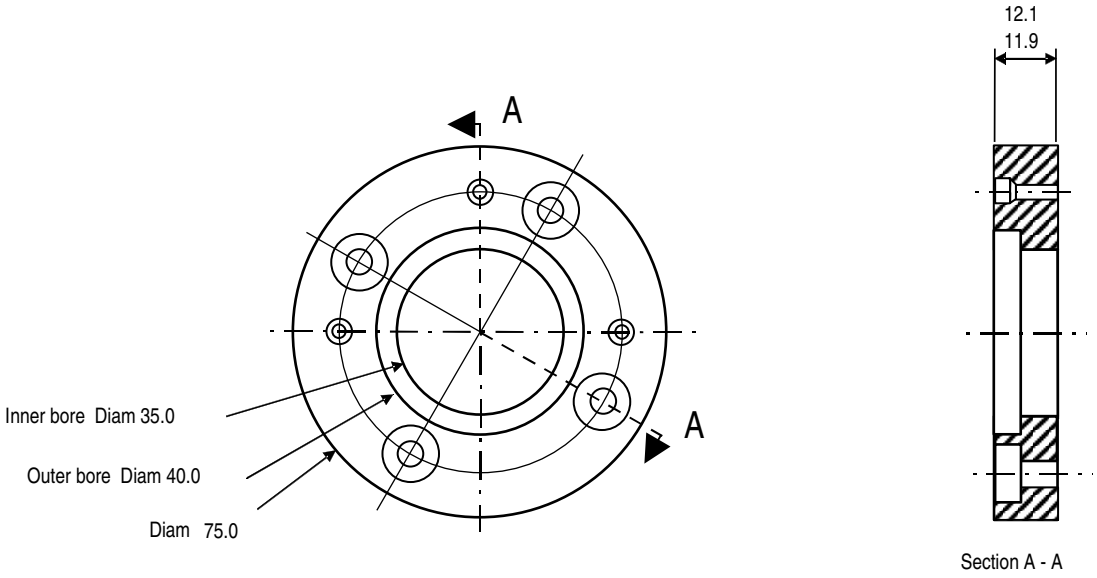


Figure 3 Spacer (dimensions in mm).

SECTION C

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

5 (a) Discuss the reasons why time standards are required for manufacturing operations.

[20%]

(b) 'Work measurement is the application of techniques designed to establish the time for a *qualified worker* to carry out a *specified job* at a *defined level of performance.'*

Discuss the terms: *qualified worker*; *specified job*; and *defined level of performance.*

[20%]

(c) An engineer measures the time for five repetitions of a manufacturing operation with the following results:

1st observed time	2 min 38 s.
2nd observed time	1 min 49 s.
3rd observed time	2 min 42 s.
4th observed time	2 min 12 s.
5th observed time	1 min 59 s.

(i) Explain carefully what is meant by a 95% confidence interval. Calculate 95% confidence limits for the observed time.

(ii) Explain, in detail, the steps required to convert observed time to standard time.

(iii) Discuss the main sources of error in time study.

[60%]

6 (a) Briefly discuss the factors that affect *individual learning* and *group improvements* in manufacturing operations.

[20%]

(b) Briefly describe how Predetermined Time Standards can be used to establish a standard time for an operation.

[20%]

(c) Figure 4 shows a smooth learning curve for a manufacturing operation. An MTM analysis gives the operation time as 558 TMU. Assuming that learning continues at the same rate until the MTM time is reached, and then the operation time remains constant, calculate the total time taken for 2000 operations. Comment on whether the assumption is sensible.

[60%]

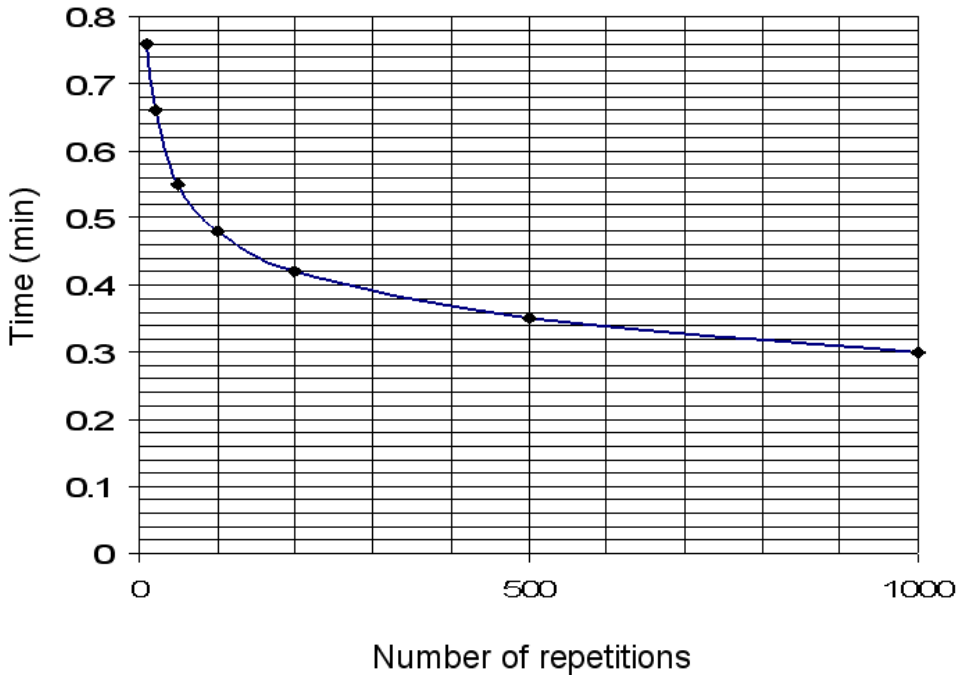


Figure 4

SECTION D

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

7 (a) A design house has secured a contract to design the next generation of fully automatic machining centres. The design brief states that it must achieve a 'best in class' award if it is going to take a significant share of this very competitive marketplace. Describe the elements of such a machining centre capable of producing high precision prismatic parts, paying particular attention to those design features that will minimise static errors and dynamic errors.

[30%]

(b) Describe the four principal means of tool wear.

[20%]

(c) What are the four main differences between *high speed machining* and *conventional machining*? List four advantages and four disadvantages of high speed machining.

[30%]

(d) Taylor's tool life equation is given as $C = VT^n$ where C is a constant, T is time, V is linear cutting speed, and n is an exponent that depends on cutting conditions. Under particular cutting conditions $n = 0.5$ and $C = 400$. What is the percentage increase in tool life when the cutting speed is reduced by 50%?

[20%]

8 (a) A traditional route to manufacture requires extensive pre-production activities that involve all aspects of the manufacturing operation from marketing, to design and prototyping. Suggest how the process of product development can be accelerated in order to reduce time to market. What other benefits might such a system provide to the manufacturing company?

[30%]

(b) Describe the basic operating mechanism of the selective laser sintering process (SLS). What benefits do technologies such as this bring to the manufacturing engineer?

[40%]

(c) A prestige car manufacturer is in the process of developing an innovative injection manifold for their new V6 engine. The manifold is to be made from magnesium, is very intricate and has large internal volumes for weight reduction.

(i) Briefly describe a method of manufacturing a working prototype for this component. Your method must be fast and low cost.

[15%]

(ii) Briefly describe a method for manufacturing this component in high volumes. Your method must be cost effective in volumes greater than 200,000.

[15%]

END OF PAPER