THE OPEN UNIVERSITY OF SRI LANKA

FACULTY OF ENGINEERING TECHNOLOGY 032

DIPLOMA IN TECHNOLOGY – LEVEL 04

FINAL EXAMINATION 2006/2007

MEX4231/MED2202 – ELEMENTARY MACHINE DESIGN – PAPER I

DATE *: 23rd April 2007*
TIME *: 1430 hrs – 1630 hrs*
DURATION : Two Hours

READ THE FOLLOWING INSTRUCTIONS CAREFULLY BEFORE ANSWERING THE QUESTION PAPER

1. *This question paper has Two parts.* **Part A** *and* **Part B***. Part A has* **three (03)** *questions and Part B* **five (05)** *questions. Answer* **only four (04)** *questions* **selecting at least one (01)** *question from Part A, but* **not more than Two (02)** *questions from Part B.*

2. *All questions carry equal marks.*

3. *Read the questions carefully before you start answering each question.*

4. *Write the relevant question number at the beginning of the answer.*

5. *Before submitting your answer script fill the box on the front page by writing the question numbers for which you have answered.*

6. *Some questions require design data. They are provided to you separately.*
   Do not write anything on these data books.

7. *Assume any missing dimensions or design data. All such assumptions should be clearly stated appropriately in the relevant answers.*

8. *Any sketches that you provide to explain your answer should be neatly drawn and labeled.*

9. *Use the charts, catalogues, data sheets and tables available and return them to the supervisor at the end of the examination.*

PART A

Question 1:

i) Answer the questions given below. Use relevant examples to make your answer clear.

a) What is ergonomics? Discuss its scope in Machine Design.

b) Discuss the ergonomic considerations in design of displays and controls in machines.

c) Compare Design Synthesis with Design Analysis.

[10 marks]

ii) There are two schools of thought in Engineering Design. They are briefly as follows:

- Design a product and explore the market.
- Explore the market and design the product.

(a) Explain the major differences of the two schools of thought.

(b) Which one you think is the most desirable from the present day context? Give reasons for your answer. [10 marks]

Question 2:

i) What is meant by "Service Factor?" Explain the statement, "a 1 kW motor with 1.15 safety factor can operate at 1.15 kW." [5 marks]

ii) Explain as to why should the designer specify an optimum surface finish in a design? [5 marks]

iii) Two plates A and B are assembled by two bolts with a nominal centre-to- centre distance of a and a tolerance of $\pm x$. An exaggerated view of this assembly is shown in Figure Q2. If the smallest size of the hole is D_{min} and largest size the bolts is d_{max}, show that $x = (D_{min} - d_{max})$.

Two bolts, with a centre distance of 50 mm, are used to assemble two plates as shown in the Figure. The recommended class of fit between bolts and holes is $\phi 12 \frac{H_{11}}{d11}$. Determine the magnitude of x. Specify the centre-to-centre distance between bolts with the tolerance. *Use the tolerance tables for shafts and holes.*

[10 marks]

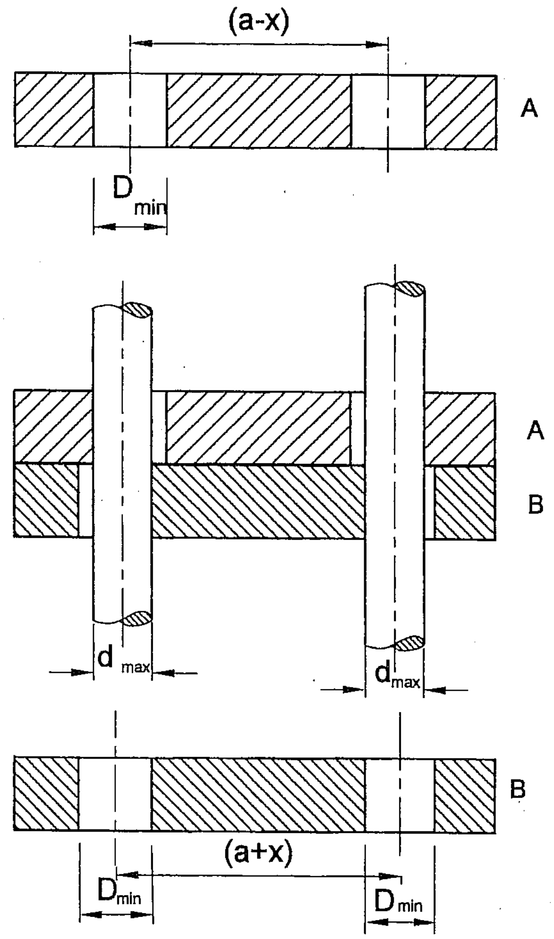

Figure Q2 NOT TO SCALE

Question 3

i) Compare and contrast rolling contact bearings, hydrodynamic bearings and hydrostatic bearings taking into consideration the load carrying capacity, frictional loss, space requirement, and cost. [6 marks]

ii) Explain why majority of internal combustion engines use hydrodynamic bearings to support their crankshafts. [4 marks]

iii) What is the most important advantage gained by using a needle bearing? [3 marks]

iv) Explain the following parameters with particular reference to rolling element bearings.

- Basic static load rating
- Basic dynamic load rating
- Life
- Rating life

[7 marks]

PART B

Question 4

Views of the layout of a wall crane and the pin-joint connecting the tie-rod to the crane-post is shown in Figure Q4 (a) and (b). The tension in the tie-rod is maximum when the load of 50 kN is at a distance of 2 m from the wall. The tie-rod and pin are made of steel with yield strength of 250 MPa. Considering the safety factor as 3, calculate the diameter of the tie-rod and the pin. Shear stress and allowable bearing pressure for pin material are 0.3 x Yield strength and 200 MPa respectively. [20 marks]

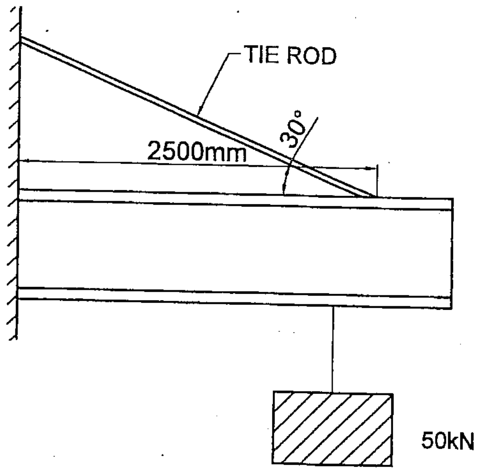

Figure 4(a)

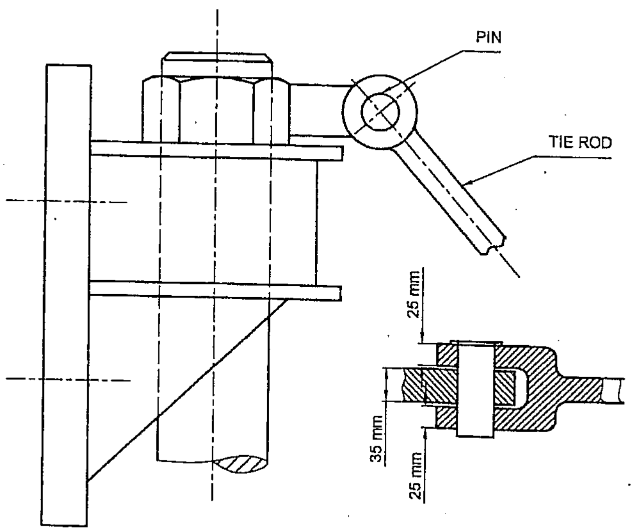

Figure 4(b)

CRANE POST

Figure Q 4

NOT TO SCALE

Question 5

The following data are given for a V-belt drive connectng a 20 kW motor to a compressor.

Data	Motor Pulley	Compressor Pulley
Pitch diameter (mm)	150	300
Coefficient of friction	0.2	0.2
Centre distance (mm)	1,000	
Groove angle	40-deg	
Maximum permissible tension (N)	750	
Mass of the belt (kg/m)	0.25	

i) Calculate the maximum power transmitted by the belt and the corresponding velocity. [13 marks]

ii) As the belt speed increases, can the belt tension of both high and low tension sides become equal? Explain your answer. If it is possible, at what speed does it occur. [7 marks]

Question 6

i) What is a flexible shaft? Give two applications of flexible shafts. [3 marks]

ii). Shafts should be designed, so that they have natural frequency far away from their operational speeds. Explain. [3 marks]

iii) A pinion of a water pump is rigidly attached to the shaft, which is supported on two rolling element bearings A and B, 200 mm apart as shown in Figure Q6. The pinion bas 15 teeth, and a module 5 and rotates at speed of 1,200 rpm. It requires 37kW power in pumping water. The impeller is fitted between A and B on the shaft.

Using an allowable shear stress as 56 MPa, determine the diameter of the shaft required. Assume that the pinion is a spur gear with pressure angle 20^0 and no shocks on the shaft. [14 marks]

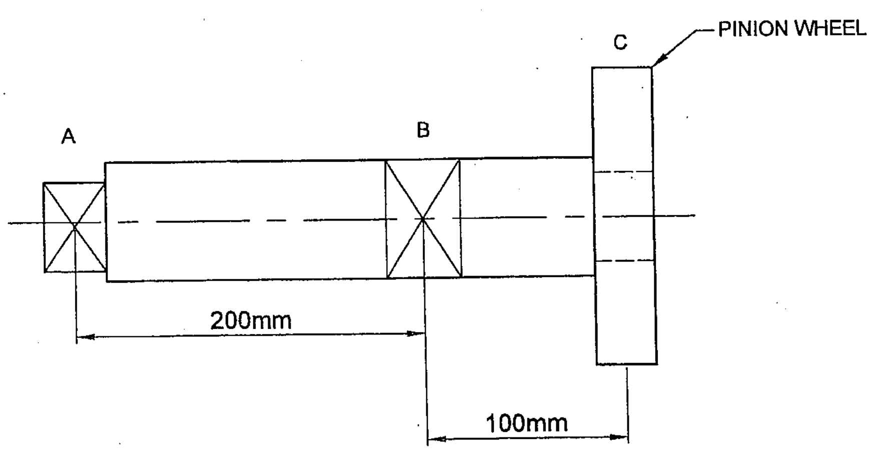

Figure Q6

Question 7

A pair of spur gears made of steel is to be designed to transmit 30 kW for a speed of 1,000 rpm of the pinion with a speed of ratio of 1:6. Design the pair of gears. The design should be economical and not fail against strength and dynamic loading. The gears operate 8 – 10 hours/day continuously. Pressure angle = 20^0. *For additional information use the data sheets available for gears.*

[20 marks]

Question 8

i) The frame of a hacksaw is shown in Figure Q8 (a). The blade is tightened to have a tension 400 N. The frame is made of plain carbon steel with tensile yield strength of 243 MPa. The cross section of the frame is rectangular with a ratio of depth to width as 3.

Where is the location on the frame, which develops the highest stress? Give reasons for your answer.

Determine the dimension *(t)* of the cross section. Assume a safety factor of 2.5.

[10 marks]

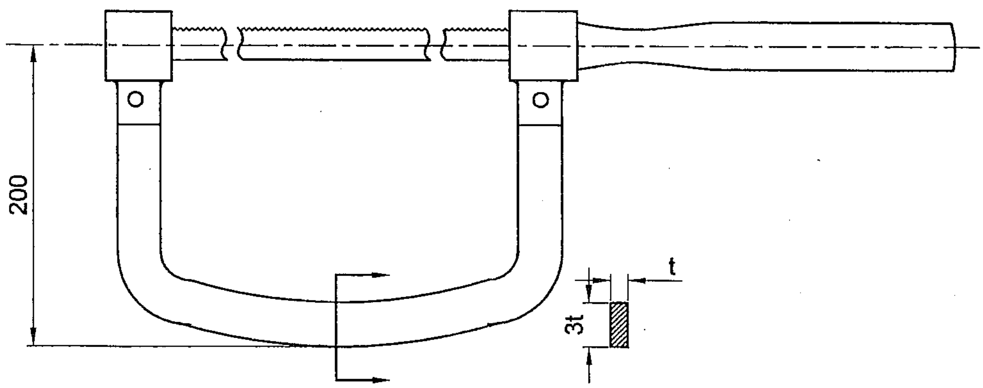

Figure Q8(a) NOT TO SCALE

ii) A horizontal shaft of rectangular cross section with 150 mm x 100 mm is welded to a vertical support by means of a fillet weld right round as shown in Figure Q8 (b). At the free end of the shaft a vertical load of 25 kN is applied.

Where is the heavily stressed point of the weld? Give reasons to your answer.

Determine the size of the weld, if the permissible shear stress in the weld is limited to 75 MPa.

Assume that the breadth and depth of the section are large compared to the throat dimension of the weld. If I_{xx} is the second moment of area of the weld section about x-x, *t* throat thickness, *b* width and *d* depth of the weld, $I_{xx} = t\left[\frac{bd^2}{2} + \frac{d^3}{6}\right]$

[10 marks]

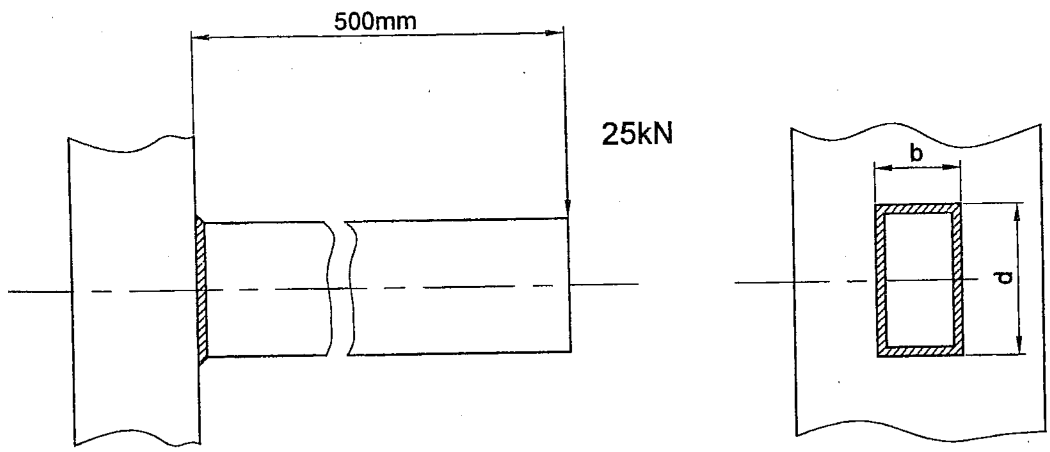

Figure Q8(b) NOT TO SCALE

Table 2a Tolerances for shafts of sizes up to 100 mm (from d to h)

Diameter Steps in mm		d					e					f				g			h						
		8–11	8	9	10	11	6–9	6	7	8	9	6–8	6	7	8	6–7	6	7	5–10	5	6	7	8	9	10
Over	to	es	ei				es	ei				es	ei			es	ei		es	ei					
0	3	–20	–34	–45	–60	–80	–14	–20	–24	–28	–39	–6	–12	–16	–20	–2	–8	–12	0	–4	–6	–10	–14	–25	–40
3	6	–30	–48	–60	–78	–105	–20	–28	–32	–38	–50	–10	–18	–22	–28	–4	–12	–16	0	–5	–8	–12	–18	–30	–48
6	10	–40	–62	–76	–98	–130	–25	–34	–40	–47	–61	–13	–22	–28	–35	–5	–14	–20	0	–6	–9	–15	–22	–36	–58
10	18	–50	–77	–93	–120	–160	–32	–43	–50	–59	–75	–16	–27	–34	–43	–6	–17	–24	0	–8	–11	–18	–27	–43	–70
18	30	–65	–98	–117	–149	–195	–40	–53	–61	–73	–92	–20	–33	–41	–53	–7	–20	–28	0	–9	–13	–21	–33	–52	–84
30	50	–80	–119	–142	–180	–240	–50	–66	–75	–89	–112	–25	–41	–50	–64	–9	–25	–34	0	–11	–16	–25	–39	–62	–100
50	80	–100	–146	–174	–220	–290	–60	–79	–90	–106	–134	–30	–49	–60	–76	–10	–29	–40	0	–13	–19	–30	–46	–74	–120
80	100	–120	–174	–207	–260	–340	–72	–94	–107	–126	–159	–36	–58	–71	–90	–12	–34	–47	0	–15	–22	–35	–54	–87	–140

Table 2b Tolerances for shafts of sizes up to 100 mm (from j to s)

Diameter steps in mm		j						k			m			n			p			r			s			
		5		6		7		5	6	5–6	6	7	6–7	6	7	6–7	6	7	6–7	5	6	5–6	5	6	7	5–7
over	to	es	ei	es	ei	es	ei	es		ei	es		ei	es		ei	es		ei	es		ei	es			ei
0	3	+2	–2	+4	–2	+6	–4	+4	+6	0	+8	–	+2	+10	+14	+4	+12	+16	+6	+14	+16	+10	+18	+20	+24	+14
3	6	+3	–2	+6	–2	+8	–4	+6	+9	+1	+12	+16	+4	+16	+20	+8	+20	+24	+12	+20	+23	+15	+24	+27	+31	+19
6	10	+4	–2	+7	–2	+10	–5	+7	+10	+1	+15	+21	+6	+19	+25	+10	+24	+30	+15	+25	+28	+19	+29	+32	+38	+23
10	18	+5	–3	+8	–3	+12	–6	+9	+12	+1	+18	+25	+7	+23	+30	+12	+29	+36	+18	+31	+34	+23	+36	+39	+46	+28
18	30	+5	–4	+9	–4	+13	–8	+11	+15	+2	+21	+29	+8	+28	+36	+15	+35	+43	+22	+37	+41	+28	+44	+48	+56	+35
30	50	+6	–5	+11	–5	+15	–10	+13	+18	+2	+25	+34	+9	+33	+42	+17	+42	+51	+26	+45	+50	+34	+54	+59	+68	+43
50	80	+6	–7	+12	–7	+18	–12	+15	+21	+2	+30	+41	+11	+39	+50	+20	+51	+62	+32	+55	+61	+42	+69	+75	+86	+56
80	100	+6	–9	+13	–9	+20	–15	+18	+25	+3	+35	+48	+13	+45	+58	+23	+59	+72	+37	+66	+73	+54	+86	+93	+106	+71

Table 2a Tolerances for shafts of sizes up to 100 mm (from d to h)

Diameter Steps in mm		d					e					f				g			h						
		8–11	8	9	10	11	6–9	6	7	8	9	6–8	6	7	8	6–7	6	7	5–10	5	6	7	8	9	10
Over	to	es	ei				es	ei				es	ei			es	ei		es	ei					
0	3	–20	–34	–45	–60	–80	–14	–20	–24	–28	–39	–6	–12	–16	–20	–2	–8	–12	0	–4	–6	–10	–14	–25	–40
3	6	–30	–48	–60	–78	–105	–20	–28	–32	–38	–50	–10	–18	–22	–28	–4	–12	–16	0	–5	–8	–12	–18	–30	–48
6	10	–40	–62	–76	–98	–130	–25	–34	–40	–47	–61	–13	–22	–28	–35	–5	–14	–20	0	–6	–9	–15	–22	–36	–58
10	18	–50	–77	–93	–120	–160	–32	–43	–50	–59	–75	–16	–27	–34	–43	–6	–17	–24	0	–8	–11	–18	–27	–43	–70
18	30	–65	–98	–117	–149	–195	–40	–53	–61	–73	–92	–20	–33	–41	–53	–7	–20	–28	0	–9	–13	–21	–33	–52	–84
30	50	–80	–119	–142	–180	–240	–50	–66	–75	–89	–112	–25	–41	–50	–64	–9	–25	–34	0	–11	–16	–25	–39	–62	–100
50	80	–100	–146	–174	–220	–290	–60	–79	–90	–106	–134	–30	–49	–60	–76	–10	–29	–40	0	–13	–19	–30	–46	–74	–120
80	100	–120	–174	–207	–260	–340	–72	–94	–107	–126	–159	–36	–58	–71	–90	–12	–34	–47	0	–15	–22	–35	–54	–87	–140

Table 2b Tolerances for shafts of sizes up to 100 mm (from j to s)

Diameter steps in mm		j						k			m			n			p			r			s			
		5		6		7		5	6	5–6	6	7	6–7	6	7	6–7	6	7	6–7	5	6	5–6	5	6	7	5–7
over	to	es	ei	es	ei	es	ei	es		ei	es		ei	es		ei	es		ei	es		ei	es			ei
0	3	+2	–2	+4	–2	+6	–4	+4	+6	0	+8	–	+2	+10	+14	+4	+12	+16	+6	+14	+16	+10	+18	+20	+24	+14
3	6	+3	–2	+6	–2	+8	–4	+6	+9	+1	+12	+16	+4	+16	+20	+8	+20	+24	+12	+20	+23	+15	+24	+27	+31	+19
6	10	+4	–2	+7	–2	+10	–5	+7	+10	+1	+15	+21	+6	+19	+25	+10	+24	+30	+15	+25	+28	+19	+29	+32	+38	+23
10	18	+5	–3	+8	–3	+12	–6	+9	+12	+1	+18	+25	+7	+23	+30	+12	+29	+36	+18	+31	+34	+23	+36	+39	+46	+28
18	30	+5	–4	+9	–4	+13	–8	+11	+15	+2	+21	+29	+8	+28	+36	+15	+35	+43	+22	+37	+41	+28	+44	+48	+56	+35
30	50	+6	–5	+11	–5	+15	–10	+13	+18	+2	+25	+34	+9	+33	+42	+17	+42	+51	+26	+45	+50	+34	+54	+59	+68	+43
50	80	+6	–7	+12	–7	+18	–12	+15	+21	+2	+30	+41	+11	+39	+50	+20	+51	+62	+32	+55	+61	+42	+69	+75	+86	+56
80	100	+6	–9	+13	–9	+20	–15	+18	+25	+3	+35	+48	+13	+45	+58	+23	+59	+72	+37	+66	+73	+54	+86	+93	+106	+71

Table 2.1 Tolerances for holes of sizes up to 100 mm (H5 to H11)

Diameter steps in mm		H							
		5	6	7	8	9	10	11	5–11
over	to	es							ei
0	3	+4	+6	+10	+14	+25	+40	+60	0
3	6	+5	+8	+12	+18	+30	+48	+75	0
6	10	+6	+9	+15	+22	+36	+58	+90	0
10	18	+8	+11	+18	+27	+43	+70	+110	0
18	30	+9	+13	+21	+33	+52	+84	+130	0
30	50	+11	+16	+25	+39	+62	+100	+160	0
50	80	+13	+19	+30	+46	+74	+120	+190	0
80	100	+15	+22	+35	+54	+87	+140	+220	0