THE OPEN UNIVERSITY OF SRI LANKA
FACULTY OF ENGINEERING TECHNOLOGY
DIPLOMA IN TECHNOLOGY – LEVEL 04

FINAL EXAMINATION 2007/2008

MEX4231 / MED2202 – ELEMENTARY MACHINE DESIGN – PAPER I

DATE : 27th April 2008
TIME : 1430 hours to 1630 hours
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 has* ***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 already answered.*

6. *Some questions require design data. They are provided to you separately as charts, catalogues, data sheets and tables. Do not write anything on these data books At the end of the examination return them to the supervisor.*

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

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

PART A

Question 1

(a) What do you understand by the following terms? Use relevant examples to explain your answer.

- Design by Evolution
- Design by innovation

[6 marks]

(b) The designer develops and converts his idea into finished plans for a product/machine. In order to perform this task, his knowledge and experience in the following areas are useful.

- Theory (knowledge)
- Industry (experience)
- Human factors

What does each area cover and why do you think that each area is important in performing a complete design exercise?

[9 marks]

(c) Draw a flow chart that explains the step by step design process and identify each step. Illustrate the steps in which the application of the digital computer is useful in the design process.

[5 marks]

Question 2

(a) The properties of materials used in engineering design may be classified as:

- Mechanical properties
- Physical and chemical properties
- Technological properties

Explain why the designer should take the properties under each category into account in producing a feasible design. Use a few machine elements with your design experience to explain the answer.

[9 marks]

(b) Plastics replace many metal parts in a wide range of industrial applications. What are the advantages and disadvantages of plastics in the industry?

[6 marks]

(c) What are the main alloying elements in alloy steel? Consider three such elements and explain how each alloy influences on the properties of steel.

[5 marks]

Question 3

(a) What are the methods used to express the **value** of surface roughness?

[4 marks]

(b) Explain with suitable examples why surface roughness needs to be considered in design of machine elements.

[3 marks]

(c) The four symbols given below represent the surface roughness values. What are the approximate roughness values represented by each symbol.

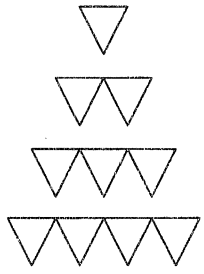
[3 marks]

(i)

(ii)

(iii)

(iv)



(d) Calculate the fundamental deviation and tolerance and hence obtain the limits of the size for the hole and shaft in the fit, 60 H7f7, a close running fit.

Standard Tolerance, $i=(0.45\times\sqrt[3]{D}+0.001D)\ \ \mu m$, where D is the geometrical mean of the diameter step. In this case it is 50-65 mm.

Use the information given in the attached sheets in addition to above.

Present the limits of the sizes for the hole and the shaft in a diagramme.

[10 marks]

PART B

Question 4

Figure Q4 shows rivet layout of an eccentrically loaded lap joint. The bracket plate is to be 25 mm thick and all rivets are of the same size. The load on the bracket is 30 kN. The rivet spacing 100 mm spacing and eccentricity of the load is 400 mm. Assume that the shear strength of the rivet is 60 N/mm^2. Determine the diameter of the rivets.

{20marks

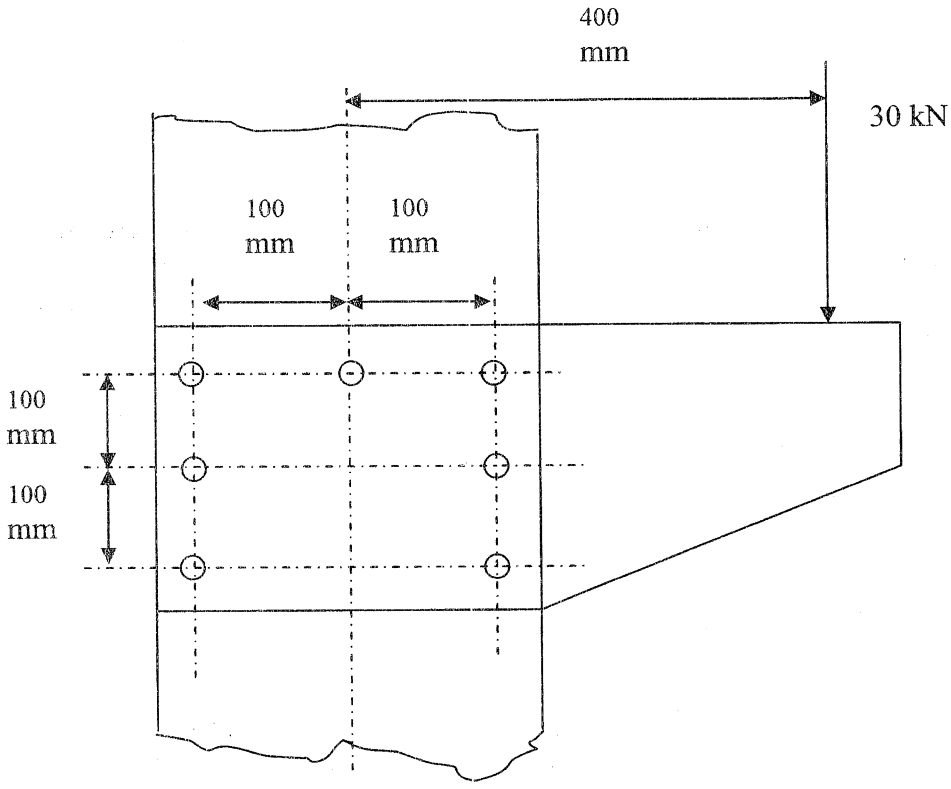


Figure Q4

Question 5

A cylinder of a steam power plant has an effective diameter of 350 mm and the maximum steam pressure acting on the cylinder cover is 1.25 N/mm^2. Calculate the number and the size of studs required to fix the cylinder cover. Also specify the pitch of the stud layout to satisfy safe conditions.

Use the information given below.

Permissible stress in the stud – 70 N/mm^2

Recommended stud to be used – **M18 X 1.5,** it has an area of 216 mm^2 which is subjected to a stress.

Stud hole size = Stud diameter (d_s) + 1 mm

Pitch circle diameter of the studs =

Effective Diameter of the cylinder + 3 times the stud hole size

For a leak proof joint the pitch of the stud layout should be less than $30\sqrt{stud\ hole\ diameter}$ (mm).

[20 marks]

Question 6

Answer the following questions with particular reference to Rolling Element Bearings.

(a) Distinguish between Load Ratings and Rated Life (L_{10}) and state their relationship.

[3 marks]

(b) Illustrate **L**ife - **R**eliability relationship. What is the statistical expression that relates **E**xpected **L**ife (life with other than 90% reliability) to L_{10}?

[3 marks]

(c) Under what condition/s do you prefer to use taper roller bearings over cylindrical roller bearings?

[2 marks]

(d) What are the parameters that influence the type of lubrication? What is the lubricant used under normal working condition?

[2 marks]

(e) Select a bearing to support one end of a 40 mm diameter shaft, which is subjected to radial and axial loads 3.0 kN and 4.5 kN respectively. The speed of the shaft is 400 rpm and the required bearing life (L_{10}) is 10,000 hours. Use SKF bearing catalogue.

[10 marks]

Question 7

A gear train mounted on three shafts is shown in Figure Q7. The gear wheel 1, when viewed from left end rotates at 2,000 rpm clockwise and transmits 80 kW power. The wheels have following parameters.

Gear Wheel	Module	No. of teeth	Type
1	6	20	20^0 full depth spur
2	-	40	-
3	5	30	20^0 full depth spur
4	-	45	-

Shaft AB is mounted on two bearings at A and B with AB 450 mm apart. Spur gears 2 and 4 are keyed on to the shaft AB at 50 mm and 300 mm distances respectively from the bearing at A. Calculate the magnitudes of tangential and radial forces and the directions and magnitudes of resultant forces on each bearing

[13 marks]

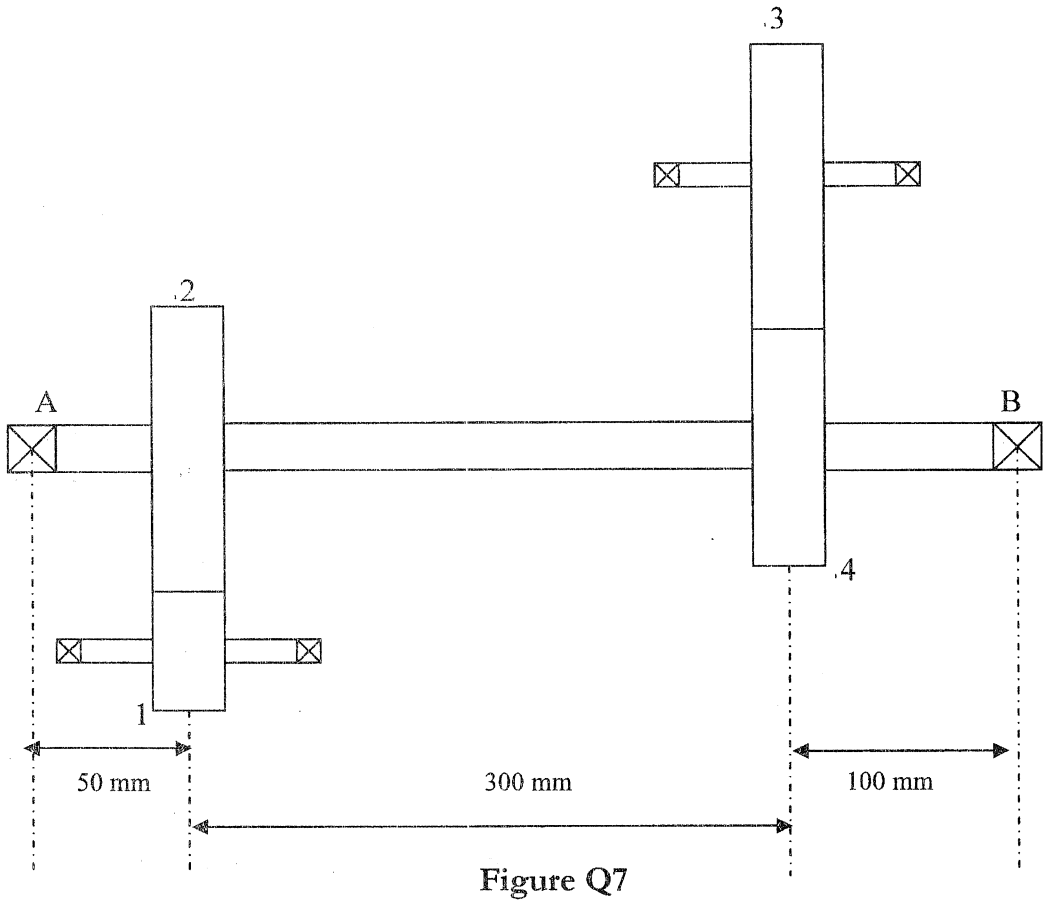


Figure Q7

If the wheels 1 and 2 are helical gears instead of spur gears, and all other given parameters are same, what would be the new forces at A & B? Explain the changes required to shaft mountings with helical gears. Assume the helical angle of the helical gears is 25^0.

[7 marks]

Question 8

A shaft, 1.5 m long, is supported on a bearing at its each end. It carries two flat belt pulleys as shown in the Figure Q8. The pulley at A weighs 200 N and has a diameter 200 mm and the pulley at B weighs 300 N and has a diameter 300 mm. Angle of wrap at pulley A and B is 210^0 and 170^0 respectively. If the shaft is receiving 20 kW at pulley A and delivering the same power to the pulley B, determine the diameter of the shaft assuming a coefficient of friction 0.3 between the pulley and belt material and shaft speed to be at 450 rpm. Safe shear stress for shaft is 50 N/mm^2. If necessary, assume the density of belt material as 1 kg/m^3.

[20 marks]

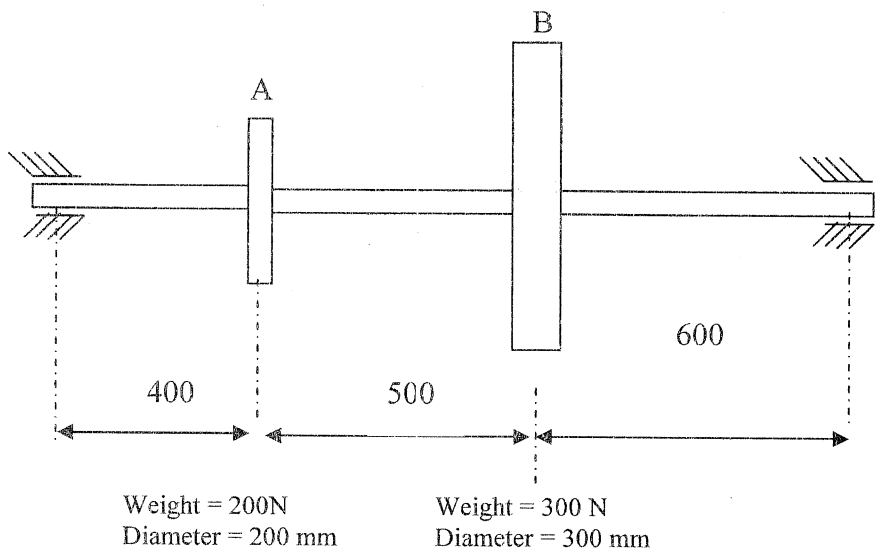


Figure Q8

Question 9

A pair of gears is to be designed to transmit 30 kW for a pinion speed of 1,000 rpm and a speed ratio of 1:5. Design the gear pair from the stand point of strength, dynamic load and wear. Use the information given below in addition to those in the tables.

(i) If the pinion speed is less than 3,600 rpm or pitch line velocity is less than 25 m/s use spur gears, otherwise use helical gears.

(ii) The centre distance should be kept as small as possible to conserve the space.

(iii) The best possible combination of materials with their physical properties are as follows:

Wheel	Material	Tensile Strength (N/mm^2)	Material Condition (as finished)	Typical hardness combination (HB)
Pinion	40 Cr 4 (Steel)	784.5	Forged, hardened and tempered	245
Gear	55C (Steel)	784.5	Forged	285

Pressure angle is 20^0 and recommended number of teeth for smallest gear is 18.

Lewis Factor for 20^0 involute full depth tooth is:

$$y = 0.154 - \frac{0.912}{z}$$, where z is the number of teeth

Service Factor = 0.80

For operating velocities:

up to 10 m/s , $C_v = \frac{3}{3 + v_m}$

up to 20 m/s, $C_v = \frac{6.1}{6.1 + v_m}$

over 20 m/s, $C_v = \frac{5.56}{5.56 + \sqrt{v_m}}$

Where C_v is the velocity factor and v_m is the pitch line velocity in m/s.

Dynamic Load and Allowable Wear Load equations in usual notations are as follows:

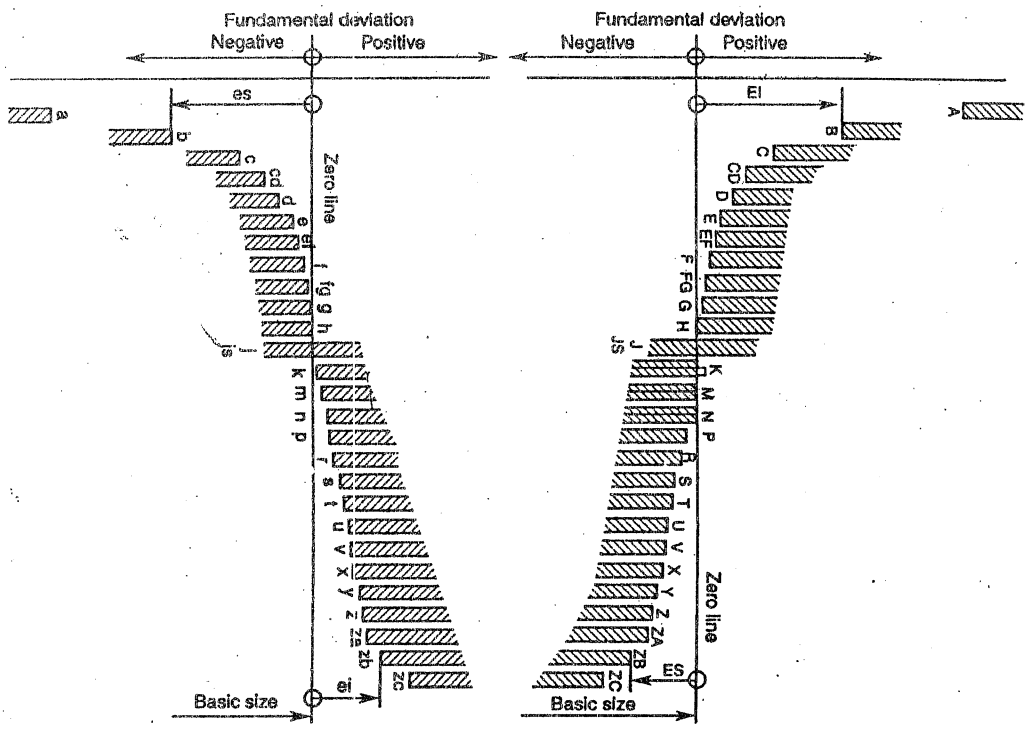
$$F_d = F_t + \frac{10 v_m \{bC + F_t\}}{10 v_m + 0.474\sqrt{bC + F_t}}$$; [v_m] = m/s, [b] = mm, [C] = N/mm, [F_t] = N

$$F_w = \frac{\sigma_{es} b \, Sin\phi}{1.4} + \left(\frac{2 d_g d_p}{d_p + d_g}\right)\left(\frac{1}{E_d} + \frac{1}{E_g}\right)$$

$\sigma_{es} = 2.76\ HB - 68.96$ N/mm^2

$E_g \approx E_p = 2.05 \times 10^5$ N/mm^2

[20marks]



Tolerance letter symbols.

Magnitude of tolerance of grades IT5 to IT16

Grade	IT5	IT6	IT7	IT8	IT9	IT10	IT11	IT12	IT13	IT14	IT15	IT16
Value	7*i*	10*i*	16*i*	26*i*	40*i*	64*i*	100*i*	160*i*	250*i*	400*i*	640*i*	1000*i*

Formulae for fundamental shaft deviation

Upper deviation (es)		*Lower deviation* (ei)	
Shaft designation	es in µm (for D in mm)	Shaft designation	ei in µm (for D in mm)
a	$-(265 + 1.3D)$ for $D \leq 120$	j5 to j8	—
	$-3.5D$ for $D > 120$	k4 to k7	$+0.6D^{0.33}$
b	$-(140 + 0.85D)$ for $D \leq 160$		
	$-1.8D$ for $D > 160$	m	+ (IT7–IT6)
c	$-52D^{0.2}$ for $D \leq 40$		
	$-(95 + 0.8D)$ for $D > 40$	n	$+5D^{0.34}$
d	$-16D^{0.44}$	p	+ IT7 + (0–5)
e	$-11D^{0.41}$	r	geometric mean of values of ei for p and s
f	$-5.5D^{0.41}$		
g	$-2.5D^{0.34}$	s	IT8 + 1 to 4 for $D \leq 50$
h	0		IT7 + 0.4D for $D > 50$
		t	IT7 + 0.63D
		u	IT7 + D
		v	IT7 + 1.25D
		x	IT7 + 1.6D
		y	IT7 + 2D
		z	IT7 + 2.5D
		za	IT8 + 3.15D
		zb	IT9 + 4D
		zc	IT10 + 5D