BENGAL ENGINEERING AND SCIENCE UNIVERSITY, SHIBPUR
B.E. (Mech.) 7TH SEMESTER FINAL EXAMINATION, 2011

TRIBODESIGN OF MACHINE ELEMENTS (ME – 701)

Full Marks: 70 **Time: 3 hrs**

Use separate answer script for each half.
Answer SIX questions, taking THREE from each half.
All questions carry equal marks.

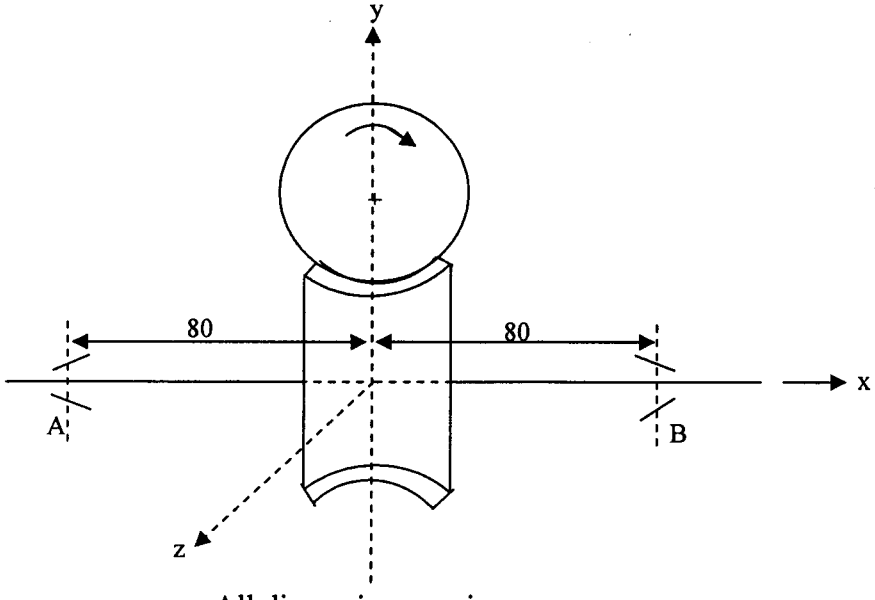
FIRST HALF

A 5 kW power at 1000 r.p.m. is supplied to the worm shaft as shown in the Fig.1. The worm gear drive is designated as 2/40/10/5. The worm has left hand threads and pressure angle is 20^0. The worm wheel is mounted between two tapered roller bearings A and B. Find the speed of worm wheel and its direction of rotation. Draw two figures showing (i) the relative sliding velocity of worm shaft with respect to worm wheel and (ii) resultant tangential force, radial force and axial force acting on the worm wheel.

The gearbox for the worm gears has an effective surface area of 1.20 m^2. A fan is mounted on the worm shaft to circulate air over the surface of the fins. The overall coefficient of heat transfer can be taken as $20 W/m^2/^oC$. The permissible temperature rise of the lubricating oil above the atmospheric temperature is 50^oC.
Calculate the power transmitting capacity based on thermal considerations.

The following data of coefficient of friction for given rubbing speed may be used:

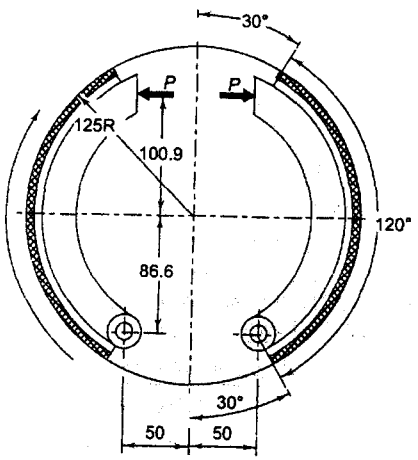
Rubbing Speed (m/s)	0.5	1.0	2.5	2.7	3.0	5.0	10
Coefficient of friction	0.065	0.055	0.048	0.042	0.038	0.032	0.025



All dimensions are in mm
Fig.1

2. In the given problem in Q. No.1 for power transmission of 5 kW, draw a complete free body diagram of the shaft and find the reactions at the two tapered roller bearings at A & B. Following AFBMA and Timken's prescription, find out the Required Radial Ratings of the two tapered roller bearings. Given that the desired life of bearings, application factor, the ratio of basic radial rating to basic thrust rating are 10000hrs, 1.25 and 1.5 respectively.

3. An automotive type internal expanding double-shoe brake is shown in Fig. 2. The face width of the friction lining is 45 mm and the allowable intensity of normal pressure is limited to 1.2 MPa. The coefficient of friction of lining material with the drum is 0.35. State clearly all the assumptions. From the first principle, calculate (i) the actuating force P, (ii) torque absorbing capacity of the brake & (iii) the reactions at both the pivots. Assume that the friction lining starts immediately from the pivot location and ends at a position making an angle of contact of 120^0 with the centre of the drum as shown in the figure.



All dimensions are in mm

Fig. 2

4. (a) State the appropriate mechanical properties needed in selecting worm and worm wheel materials and cite examples.

(b) Stating all the assumptions, derive the Stribeck's Equation for static load capacity of a ball bearing.

(c) From the Hertz Contact Theory, write the expressions of contact area, maximum hertzian contact stress and maximum subsurface shear stress developed for contact of two cylindrical bodies of different radii under a given normal load. State clearly the relevant geometrical parameters and mechanical properties required for the purpose of calculations of contact area and stresses.

(d) What is the meaning of the Greek word 'Tribos'? State the sources of friction and different wear mechanisms. Explain the mechanism of spalling failure of rolling contact bearings.

SECOND HALF

5. (a) Explain Sommerfeld's half boundary condition of lubrication..
   (b) Find out the expression for the film pressure distribution in an infinitely short journal bearing (narrow bearing).
   (c) Deduce the total end flow rate, Q_z using the above expression of film pressure distribution.

6. (a) Deduce the expression for total oil flow from both ends of a pressure-fed journal bearing having a circumferential oil groove operating with an eccentricity ratio of ε_0.
   (b) Establish the expression for bulk temperature rise of oil in the above bearing without the heat transfer through the bearing wall.

7. (a) Deduce the expression for the load capacity of a circular step thrust bearing without a compensator.
   (b) Find out the expressions for the frictional power loss and stiffness of thrust bearing without the compensator.

8. (a) Mention only the various regimes of elasto-hydrodynamic lubrication.
   (b) Discuss the various dimensionless design parameters for a line contact of EHL.
   (c) Derive the expression for the radius, a of the contact zone between two spheres of radii, R_1 and R_2 and are subjected to a contact load, W.
   If two spheres are made of steel having E = 210 GPa and Poisson's ratio, $\sigma = 0.3$, find out the value of a, using the following basic equation of deflection at r = a

$$w = a\left(\frac{1-\sigma^2}{4E}\right)\pi p_{max}$$

with the usual notations.