Bx/BBSUS/ME- 601/10

B.E. (ME) Part-Ill 6th Semester Examination, 2010

Design of Machine Elements-II
(ME-601)

Time : 3 hours | Full Marks : 70

Use separate answerscript for each half.
Answer SIX questions, taking THREE from each half.
The questions are of equal value.

FIRST HALF

1. a) Deduce an expression based on uniform wear theory* for the axial force and torque transmiting capacity of a frictional clutch having a single pair of contact surfaces in terms of the maximum intensity of pressure and geometrical parameters of the disc clutch.

   b) A multiple disc clutch has 5 steel and 4 bronze plates. The clutch is required to transmit 6kW at 800 rpm. The ratio of inner to outer diameters is 0.75. The coefficient of friction is 0.3. The permissible normal pressure is 0.35 MPa. Find the inside and outside diameters and also the axial force required.

2. a) What are the desirable properties of clutch frictional lining materials?

   b) Mention the main factors to be considered for selecting a type of clutch. Explain any one of them.

   c) An industrial cone clutch is to be designed to transmit 45 kW at 800 rpm. The design data available is :-
   semi cone angle, a = 12°, allowable normal pressure, p = 0.6 MPa, coefficient of friction for the frictional material (asbestose), u = 0.30.
   Given that the mean diameter of clutch is 6 times the face width, b. Assuming the uniform wear condition, find -
   (i) the diameter at smaller and bigger ends, (ii) face width,
   (iii) axial force required for the engagement of clutch.

3. a) Two co-axial machine rotors having moments of inertia, Ij and I_2 and running at uniform speeds, **C0[** and **©3** respectively are engaged by a frictional clutch. If the clutch torque remains constant, show that the total energy lost in the clutch during slipping is given by

$$\frac{1}{2}\,\frac{I1I2}{Ii+b}\,(coi - co_2)^2.$$

b) Write short notes :-

(i) uniform wear theory,

(ii) advantages of disc clutches.

4. a) Explain the concept of the formatic number of teeth on bevel gear.

b) A pair of straight bevel gears is mounted on shafts which are intersecting at right angles. The number of teeth on the bevel pinion is 24. The teeth are 14.5° full depth involute type. The pinion shaft is connected to an electric motor developing 13.5kW at 600 rpm. The drive has a speed ratio of 4:3. The service factor can be taken as 0.8. The pinion and gear are made of cast steel for which the allowable static working stress, CT_w is 150 MPa and are heat treated to a surface hardness of 360BHN. Both bevel pinion and gear teeth are finished to meet the specification of grade 6.

In the initial stages of gear design, assume that the pitch line velocity, V_m is approximately 8.0 m/sec. Determine the module at the larger diameter, face width and pitch circle diameter of gears. Check the design against the dynamic and wear loads.

Assuming the following data :-

Deformation factor (X) for grade 6 accurate teeth = 125 kN/m.

Young's modulus for cast steel = 210 GPa

Velocity factor, $(C_v) = \frac{.}{6 + V_m}$, V_n is in m/sec.

Surface endurance limit, $a_{en} = 2.8 \times BHN - 70$ MPa

Load-stress factor, K_w = Ocn² sina.cosffi \ 1 + E^"J MPa

Lewis form factor, Y = TT (O. 124 -), Z = no. of teeth.

5. a) With a neat sketch, define (i) pitch cone, (ii) pitch cone centre, (iii) pitch cone distance, (iv) back cone of a bevel gear.

b) What is bevel factor? Derive the expression for the pitch cone distance in terms of pitch circle diameters of bevel pinion and gear.

c) Draw a neat sketch of the force diagram related to the bevel gear-for a given sense of rotation of a bevel pinion. Express the radial and axial force components in terms of tangential force component.

SECOND HALF

6.. A compressor running at 300 r.p.m. is driven by a 15kW, 1200 rpm motor through a pair of 20° full depth external spur gears. The pinion is made of C-30 forged steel hardened and tempered, and the driven gear is to be of cast steel. Determine the module, face width and centre distance for a compact design. Check the design against dynamic load and wear load. Following information may be used :

Lewis form factor (Y) = TC ^0.154 - - i ^ - ^ ; C_v = 4 y ; V is in m/s

Kts)pinion " 675 MPa : ('uts)$_{gea}$r " 420 MPa - C' " 08

Average hardness of the gear pair = 315 BHN.

Gears are of class 2 type with tooth action error = 0.028 mm. E_p = Eg = 210 GPa.

If any other data is necessary, assume and mention clearly.

In case the design fails against any check, do not repeat calculations, but suggest possible remedies.

7. a) What is the philosophy behind development of a helical gear tooth?

b) Why a formative number of teeth is used in design of a helical gear? Derive its expression in terms of actual number of teeth and helix angle.

c) A helical gear with 30° helix angle transmits 35 kW at 1500 rpm and has 24 teeth. The gear has full depth involute teeth with 20° normal pressure angle. Determine necessary module, pitch circle diameter and face width based on strength analysis only. The allowable static stress may be taken as 56 MPa. Compute the force components acting on the gear. If any other data is required, assume and mention clearly.

8. a) Why an involute is primarily chosen as the profile of a spur gear tooth? What are its advantages?

b) The layout of a double reduction helical gearbox is shown in Fig.-A. Pinion A is the driving gear and 10 kW at 720 rpm is supplied to it through its shaft No. I. The number of teeth on different helical gears are as follows :
T_A = 30, T_B - 50, T_c = 20, T_D = 60. Normal pressure angles for all gears is 20°. For the pair A and B, the helix angle is 30° and that for the pair C and D is 25°. Normal module of all the gears is 4mm. The bearings Bj and B_2 are mounted on saft 2 in such a way that Bj can take only radial load, while B_2 takes both radial as well as thrust loads. Determine the magnitude and direction of bearing reactions on shaft No. 2.

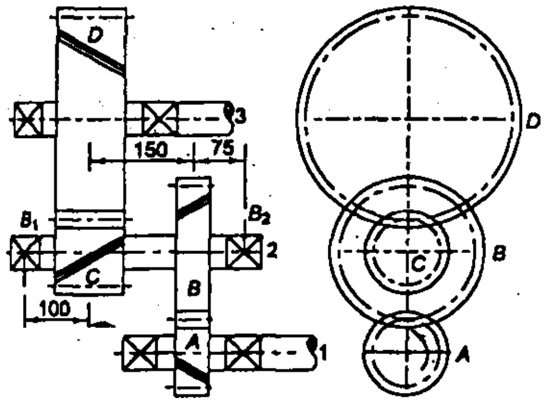

Fig.-A

a) A two-bar turss is to be designed to carry a load 2 W as shown in Fig.-B. Both bars have a tubular section with mean diameter d and wall thickness t. The material of the bars has Young's modulus E and yield stress $a_{Y}p$. The design problem involves determination of values'd* and *t* so that the weight of the truss is a minimum and neither yielding nor buckling occurs in any of the bars. Formulate the optimization problem by identifying the objective and constraint functions and convert it into the standard form. (No solution is necessary).

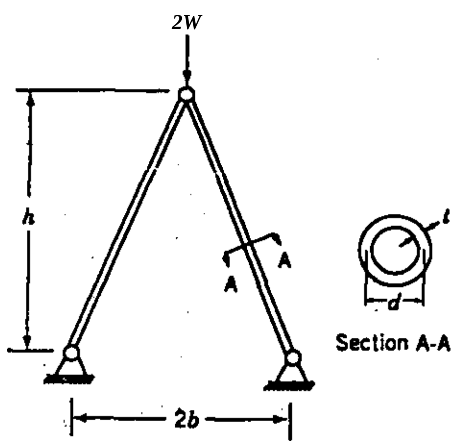

Fig.-B

b) An open rectangular box is to be manufactured from a given amount of short metal of area S. Using Lagrange Multiplier's method, find the dimensions of the box to maximize its volume.

a) Write the K-T necessary conditions in minimizing a multivariate function f(x) subject to a constraint set gj(x) < 0; i = 1 to p. State the restrictions.

b) Using K-T conditions, find the values of **0** for which the point x * = 1, x_2* = 2 will be optimal to the problem :

Maximize f(xj, x_2) = 2$x_($ + px_2

subject to g|(xi, x_2) =• x? + x_2^2 - 5 <, 0

g_2(xi,x_2) = X ! - x $_2$ - 2 ^ 0

Verify your result through a tentative plot of the cost and constraint functions.