B.E. (Mech.) Part-IV 8th Semester Final Examination, 2012

Design of Mechanical Systems (ME – 801)

Time: 3 Hours | Full Marks: 70

Use separate answer script for each half.

FIRST HALF
(ANSWER ANY TWO QUESTIONS)

1. A 2 x 3 gear box drive is required to be designed for transmitting 10 KW with speeds ranging from 100 r.p.m. with preferred common ration $\phi = 1.40$.

(a) Draw at least four ray diagrams and select the optimum one.

(b) Find out the shaft diameters, number of teeth of each spur gears and module of gears. Given that the materials of shaft and gear are recommended as C-30 steel (allowable shear stress = 50MPa) and alloyed steel (allowable yield stress = 250 MPa).
Module is to be calculated on the basis of beam strength, expressing only the requirement of checking effective dynamic load & wear strength.

Given that
Lewis Form Factor for 20° fdi, $Y = \pi (0.154 - 0.912/Z)$
Grade-5 spur gears: Tooth Action Error, $e = 5.00 + 0.40\varphi$ microns, where $\varphi = m + 0.25\sqrt{d}$, Service Factor = 1.5.

(c) Draw a neat sketch for the layout of the gear box showing the minimum dimensions related to volume of the gear box.

2. A given mechanical stepless drive consists of a roller and a friction disc with the following particulars:

Roller radius r =100mm, length of the roller & friction disc b = 50mm, radius of the friction disc making contact with the roller R = 160 mm, coefficient of friction between the roller and the friction disc $\mu = 0.35$, the compressive force of the spring required to ensure contact between the roller and the friction disc Q=800N, speed of the driving roller = 600 r.p.m. If the torque transmitted in friction disc is 30 N-m, draw a complete diagram showing all the relevant elements and derive the expressions in finding the followings:

(a) The radius of the friction disc at the no-slip point i.e. R′
(b) The speed of the friction disc and power loss in kW,

(c) Hertzian contact area and maximum hertzian contact stress, if equivalent modulus of elasticity is 112 GPa.

3. (a) Satisfying the following boundary conditions , find the polynomial equation of displacement of a knife-edge follower as a function cam rotational angle for an advanced cam curve.

Given boundary conditions:
When cam angle $\theta = 0$; displacement, velocity & acceleration of the follower are all zero. When Cam angle $\theta = \beta$; maximum rise of the follower = h and its velocity & acceleration are zero.

(b) The aforesaid cam-follower system has the following data:

Rise of follower, $h = 40$ mm, corresponding Cam rotational angle $\beta = 180°$, prime circle radius $r_o = 30$ mm, offset of the follower, $e = 10$ mm, Cam factor, $f = 3.80$, Cam shaft speed $N = 1000$ rpm, follower weight $w = 20$ N, spring stiffness $k = 25$ N/mm, initial spring compression $y_i = 5$ mm

Determine displacement, velocity, acceleration & jerk of the knife-edge follower and pressure angle & torque transmission of the cam shaft at cam rotational angle of 90°.

Second Half

Attempt **any three** questions

1. (a) Discuss the design criteria of the connecting rod of an engine.

   (b) What is whipping stress?

   (c) Consider the connecting rod made of steel with the cross-section as shown in Figure 1. The length of the connecting rod is 300 mm, flange and web thickness t = 5 mm. Piston stroke is 180 mm and the engine speed is 200 rpm.

   (i) Determine the maximum axial load that the connecting rod can withstand.

   (ii) Estimate the whipping stress induced in the connecting rod.

   (iii) Estimate the maximum tensile stress induced in the connecting rod.

   Density of the material of the connecting rod may be taken as 7800 Kg/m^3. Crushing strength of the material is 400 MPa.

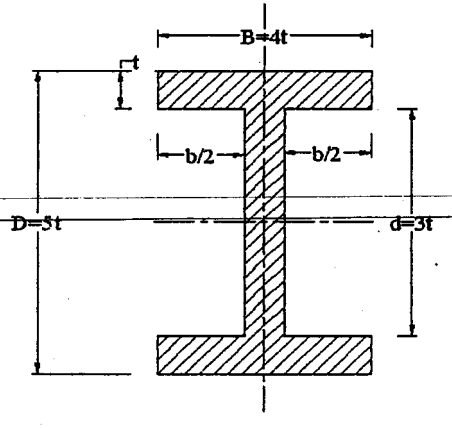

Figure 1

2. Consider the following data provided for a four-stroke single-cylinder engine: cylinder bore diameter = 100 mm, stroke length = 150 mm, engine speed = 300 rpm., maximum combustion pressure = 2.5 M/mm^2, indicated mean effective pressure = 0.35 MPa, weight of flywheel and pulley = 1 kN, total belt pull at full load = 600 N. (horizontal), pulley diameter = 600 mm. When the crank has turned through 35^0 from the inner dead centre, the pressure on the piston is 1 N/mm^2 and the torque on the crank is the maximum. The ratio of the connecting rod length to the crank radius is 5.

Suggest the basic sizes of the following parts

(i) Crank pin

(ii) Crank Web

(iii) Diameter of the crank shaft and journals

Assume the bearing layout and any other date required for the design.

3. (a) Discuss the linear mathematical model of viscoelastic materials under dynamic load.
   (b) Define and explain complex elastic modulus.
   (c) Define loss factor.
   (d) What is the loss factor for Kelvin-Voigt model of materials? Is the model applicable for rubber like materials? If not, why?

4. (a) What is apparent elastic modulus of a bonded rubber spring? Discuss the factors that determine the apparent elastic modulus.

   (c) Discuss how bonded metal-rubber isolation mounts should be designed to optimally utilize the material (rubber) strength in shear and compression.

   (b) Suggest the suitable spring stiffness of the isolators for suspending a fan of total mass 60 kg at six points. The minimum speed of the fan is 1000 rpm. What is the maximum isolation efficiency that can be achieved without violating the allowable static sag of 5 mm? Assume zero damping.