B. E. Mechanical Engineering 3rd Year 2nd Sem Exam (OLD), 2018

Machine Design III

Time: Three hours | Full Marks: 100

Missing data, if any, may be assumed.

Answer any **five** questions.

1 a) Explain the mechanism of pressure development in a hydrodynamic bearing.

b) Explain full Sommerfeld boundary conditions for hydrodynamic journal bearing analysis. State its limitation. How can it be overcome?

c) A fixed inclination slider bearing of length 100 mm and width 600 mm operates at a sliding velocity of 1m/s. Find the viscosity of the oil to be used such that the bearing operates with a minimum film thickness of 40μm at maximum load capacity of 20 kN. Also calculate the coefficient of friction. 4+8+8

2 a) Explain the essential features of a typical hydrostatic bearing with neat sketch.

b) For a circular step thrust bearing, write down the appropriate Reynolds equation. Hence deduce the expression for load capacity and total power loss for such a bearing.

c) State the advantages of hydrostatic bearings over hydrodynamic ones. 6+10+4

3 a) What is static load carrying capacity of rolling element bearings? Derive Stribeck's equation for the same.

b) A single-row deep groove ball bearing is used for a 30 seconds work cycle consisting of two parts as given in Table A. For this application, the static and dynamic load capacities are 50 and 68 kN respectively. Calculate the life of the bearing in hours. The load factors are given in Table B.

	Part I	Part II
Duration (s)	10	20
Radial load (kN)	45	15
Axial load (kN)	12.5	6.25
Speed (r.p.m.)	720	1440

Table A

F_a / C_0	$F_a / F_r \le e$		$F_a / F_r > e$		e
	X	Y	X	Y	
0.025	1	0	0.56	2.0	0.22
0.040	1	0	0.56	1.8	0.24
0.070	1	0	0.56	1.6	0.27
0.130	1	0	0.56	1.4	0.31
0.250	1	0	0.56	1.2	0.37
0.500	1	0	0.56	1.0	0.44

Table B

10+10

4. Explain the construction and working principle of a chain drive system, appending neat sketches of the components of the drive system.

   With the help of a sample table, explain the specification of a power transmission chain. Why is the number of pitch selected as an even number and how is the distance between the axes of the two sprockets evaluated?

   What are the factors influencing the determination of design power of a chain drive system? Briefly discuss about the factors. 20

5. A steel disk ($E = 210$ kN/mm^2, $\nu = 0.28$) of uniform thickness having inner and outer radii of 75 mm and 400 mm is rotating at 1440 r.p.m. Determine the induced stresses in the disk.

   Prove that for uniform radial and tangential stress distribution in a disk, rotating at a uniform angular velocity ω, it should be manufactured with a thickness variation $h = C \exp(-\rho\omega^2 r^2 / 2\sigma$, where

   C = a constant
   ρ = density of disk material and
   σ = the allowable uniform strength

   8+12=20

6. State and justify the applicability of Lame, Clavarino and Birnie's equation in connection with the design of thick pressure vessels. A 100 mm diameter thick

cylindrical pipe is subjected to an internal pressure of 25 MPa and it is free to expand axially. The pipe material is steel having yield stress of 230 MPa. Determine the thickness of the pipe.

Explain the industrial design procedure of unfired pressure vessel.

12+8=20

7. Deduce Lame's equation for thick cylindrical pressure vessel.

A high pressure cylinder, made of steel with inner and outer diameters of 60 and 100 mm respectively, is jacketed by an outer steel-tube with an outer diameter of 150 mm. The tubes are assembled by a shrinkage process in such a way that maximum principal stress induced in any tube is limited to 120 N/mm^2. Calculate the shrinkage pressure and the original dimensions of the tubes. Given, E = 207 kN/mm^2.

8+12=20

8. Write short notes (any four):

a) Polygonal effect in a chain drive system
b) Construction and working principle of roller chain drive
c) The fundamental difference between thin and thick walled pressure vessel.
d) Autofrettage
e) Primary design considerations for high speed rotors
f) Principles of form design
g) Squeeze film bearing
h) Petroff's equation
i) Tower's experiment
j) Viscosity Index

4x5=20