(vii) Sommerfeld number is
(a) similar to bearing characteristic number
(b) similar to Reynold's number
(c) dimensionless parameter that contains all the bearing design parameters
(d) used to find out dynamic load carrying capacity of the hydrodynamic bearing.

(viii) Autofrettage is the method of
(a) joining thick cylinders
(b) relieving thick cylinders
(c) pre-stressing thick cylinders
(d) increasing the life of thick cylinders.

(ix) A multi-disc clutch has three discs on the driving shaft (n1) and two discs on the driven shaft (n2). Number of pairs of contact surfaces is
(a) 2 (b) 3 (c) 4 (d) 5.

(x) For high pressure oil and gas cylinders, the thickness of the cylinder is determined by
(a) Lame's equation (b) Clavarino's equation
(c) Barlow's equation (d) Birnie's equation.

Group – B

2. (a) The pitch circle diameters of the pinion and gear are 100mm and 300mm respectively. The pinion is made of plain carbon steel 40C8 (S_{yt} = 380 MPa and S_{ut} = 600 MPa) while the gear is made of grey cast iron FG 300 (S_{yt} = 200 MPa and S_{ut} = 300 MPa). The pinion receives 5kW of power at 500 rpm through its shaft. The service factor and factor of safety can be taken as 1.5 each. The face width of the gear can be taken as 10 times of the module. Assume that the velocity factor accounts for the dynamic load. Calculate (i) Module and (ii) Number of teeth on pinion and gear. Here adapt the following equation to calculate Lewis Form Factor of the gear and pinion assuming 20° full depth involute profile.

$$Y = \pi \left(0.145 - \frac{0.192}{Number\ of\ Teeth}\right)$$

(b) Compare 14.5° full depth involute profile and 20° full depth involute profile.

(6 + 3) + 3 = 12

3. (a) A pair of parallel helical gears consist of a 20 teeth pinion meshing with a 100 teeth gear. Pinion rotates at 720 rpm. The normal pressure

Group – E

8. (a) A ball bearing is operating on a work cycle consisting of three parts- a radial load of 3000 N at 1440 rpm for one quarter cycle, a radial load of 5000 N at 720 rpm for one half cycle and radial load of 2500 N at 1440 rpm for the remaining cycle. The expected life of the bearing is 10000Hr. Calculate the dynamic load carrying capacity of the bearing.

(b) State advantages and disadvantages of deep groove ball bearing.

9 + 3 = 12

9. A full journal bearing operating under a steady load has the following specifications:
Journal Diameter - 60mm; Radial load on bearing - 2.8kN; Journal speed- 1020 rpm; Radial clearance - 0.05mm; Density of oil - 860 kg/m3 and Specific heat of oil - 1.76 kJ/kg-°C. Using Raimondi-Boyd chart given below determine:
(i) Sommerfeld Number
(ii) Power loss in friction
(iii) Temperature rise if heat is entirely carried by oil
(iv) Minimum film thickness and its location.

Raimondi and Boyd chart for Journal Bearing with L/D = 1

Attitude Angle (ε)	h_0/c	S	ϕ	$\left(\frac{r}{c}\right)f$	$\left(\frac{Q}{rcn_s l}\right)$	$\left(\frac{Q_s}{Q}\right)$	$\left(\frac{p}{p_{max}}\right)$
0	1.0	∞	85°	∞	π	0	-
0.1	0.9	1.33	79.5°	26.4	3.37	0.150	0.540
0.2	0.8	0.630	74.02°	12.8	3.59	0.280	0.529
0.4	0.6	0.264	63.10°	5.79	3.99	0.497	0.484
0.6	0.4	0.121	50.58°	3.22	4.33	0.680	0.415

(4 + 4 + 2 + 2) = 12

DESIGN OF MECHANICAL SYSTEMS - II
(MECH 3251)

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

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

Candidates are required to give answer in their own words as far as practicable.

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**

(i) When the axes of two shafts are non-parallel and non-intersecting, use
(a) helical gears (b) crossed helical gears
(c) straight bevel gears (d) spiral bevel gears.

(ii) The minimum number of teeth on standard gear with pressure angle (α) is given by,
(a) $\frac{2}{\sin^2 \alpha}$ (b) $2 \sin^2 \alpha$ (c) $\frac{\sin^2 \alpha}{2}$ (d) $2 \sin \alpha$

(iii) If z is the actual number of teeth on a helical gear and ψ is the helix angle for the teeth, then the formative number of teeth is given by,
(a) $z \cos^3 \psi$ (b) $\frac{z}{\cos^3 \psi}$ (c) $z \cos^2 \psi$ (d) $\frac{z}{\cos^2 \psi}$

(iv) The pitch circle diameter and number of teeth in a spur gear are d' and z respectively. The module m is defined as
(a) $\frac{\pi d'}{z}$ (b) $\frac{z}{d'}$ (c) $\frac{d'}{z}$ (d) $d'z$

(v) The lead angle of worm is given by,
(a) $\tan^{-1}\left(\frac{1}{\pi d_1}\right)$ (b) $\tan^{-1}\left(\frac{q}{z_1}\right)$
(c) $\tan^{-1}(\pi m_1)$ (d) none of these.

(vi) A bearing number XX10 indicates that the bearing is having
(a) bore diameter of 10 mm (b) bore diameter of 100 mm
(c) bore diameter of 50 mm (d) outer diameter of 100 mm.

angle is 20° while the helix angle is 25°. The face width is 40 mm and normal module is 4mm.The pinion as well as the gear is made of plain carbon steel 40C8 (S_{ut} = 600 N/mm^2) and heat treated to a surface hardness of 300 BHN. The service factor and factor of safety are 1.5 and 2 respectively. Assuming velocity factor accounts for the dynamic load calculate power transmitting capacity of the gear. Relation for the calculation of Lewis form factor mentioned in question number [2(a)] may be referred.

(b) What is the difference between 'Transverse Circular Pitch' and 'Normal Circular Pitch' in a helical gear? Represent your answer schematically.

10 + 2 = 12

Group – C

4. (a) A pair of straight bevel gears consists of 30 teeth pinion meshing with a 45 teeth gear. The module and face width are 6mm and 50mm respectively. The pinion as well as the gear is made of steel (S_{ut} = 660 N/mm^2). Calculate the beam strength of the tooth.

(b) What kind of contact occurs between worm and worm wheel? How does it differ from other types of gear?

9 + 3 = 12

5. (a) A hydraulic cylinder with closed ends is subjected to an internal pressure of 20 MPa. The inner and outer diameters of the cylinder are 200 mm and 240 mm respectively. The cylinder material is cast iron with ultimate tensile strength of 260 MPa. Determine the factor of safety used in the design. If the cylinder pressure is further increased by 50%, what will be the factor of safety?

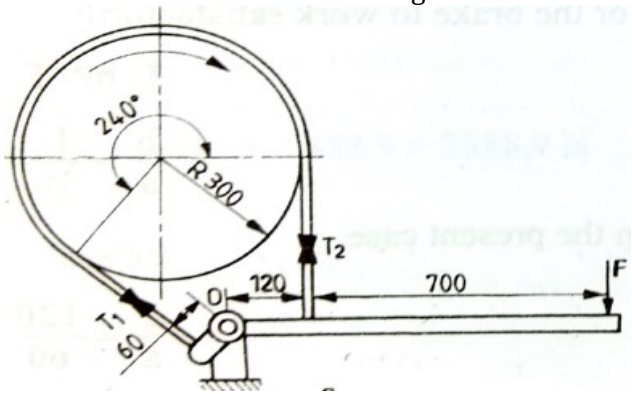
(b) For a gauge pressure 'p', derive the expression for stresses developed in a thick cylinder of inner diameter Di and Outer diameter Do and show the stress variations with proper sketch. Also derive the expression for cylinder thickness considering suitable material and design criterion.

(3 + 2) + (4 + 3) = 12

Group – D

6. (a) A differential band brake is shown in Figure 1. The width and thickness of the steel band are 90 mm and 3 mm respectively, and the permissible tensile stress in the band is limited to 60 MPa. The

coefficient of friction between the band and drum is 0.25. Determine at maximum braking condition:
(i) the tensions in the band
(ii) the actuating force, and
(iii) the torque capacity of the brake.
Also, check whether the brake is self-locking?



(All Dimensions are in mm)

Figure 1

(b) A cone clutch with asbestos friction lining transmits 25 KW at 600 rpm. The coefficient of friction is 0.25, and the maximum intensity of pressure is 0.25 N/mm2. The semi-cone angle is 12.5°. The outer diameter of friction lining is 250 mm. Considering uniform wear theory, determine
(i) the inner diameter of friction lining,
(ii) the face width of friction lining and
(iii) the force required to engage the clutch.

(2 + 1 + 1 + 2) + (2 + 2 + 2) = 12

7. (a) Derive with proper sketch the torque transmitting capacity of single plate friction clutch assuming
(i) uniform pressure theory
(ii) uniform wear theory.

(b) An engine developing 45 KW at 1000 rpm is fitted with a cone clutch built inside the flywheel. The cone has a face angle of 12.5° and a maximum mean diameter of 500 mm. The coefficient of friction is 0.2. The normal pressure on the clutch is not to exceed 0.1 N/mm^2. Determine (i) the face width required and (ii) the axial spring force necessary to engage the clutch.

(4 + 3) + (2 + 3) = 12