

The length of the point of application of the load from the fulcrum is 600 mm. Determine (i) braking force if the drum rotates in clockwise direction (ii) braking force if the drum rotates in anticlockwise direction (iii) the condition of self-locking for anticlockwise rotation.

- (b) A single block brake with torque capacity of 15 N-m is shown in Figure 4. The coefficient of friction is 0.3 and the maximum pressure on the brake lining is 1 N/mm². The width of the block is equal to its length. Calculate

- the actuating force
- the dimensions of the block
- the resultant hinge pin reaction
- the rate of heat generated, if the brake drum rotates at 50 rpm.

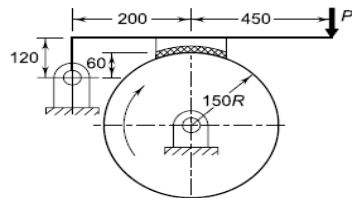


Figure 4 (All dimensions are in mm)

7+5=12

Group - E

- Differentiate between hydrodynamic and hydrostatic lubrication.
 - The specifications of a 360° hydrodynamic bearing is as follows: Radial load = 3.2 kN; Journal speed = 1490 rpm; Journal diameter = 50 mm; Bearing length = 50 mm; Radial Clearance = 0.05 mm and Viscosity of lubricant = 25 cP. Assuming that the total heat generated in the bearing is carried by the total oil flow in the bearing, calculate:
 - Sommerfeld number
 - Coefficient of friction
 - Power lost in friction
 - Minimum oil film thickness
 - Temperature rise
 Raimondi and Boyd chart for $l/d = 1$ is given in Table 1 below. All symbols carry their usual meanings.

Table 1. Raimondi and Boyd chart for Journal Bearing with $l/d = 1$.

ϵ	$\left(\frac{h_o}{c}\right)$	S	ϕ	$\left(\frac{r}{c}\right) \times f$	$\left(\frac{Q}{rcn_s l}\right)$	$\left(\frac{Q_s}{Q}\right)$	$\left(\frac{p}{p_{max}}\right)$
0	1	∞	85°	∞	π	0	-
0.1	0.9	1.33	79.5°	26.4	3.37	0.15	0.54
0.2	0.8	0.63	74.02°	12.8	3.59	0.28	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	0.68	0.415

2 + 10 = 12

- Explain angular contact bearings along with their advantages and disadvantages. What is static load carrying capacity of a bearing?
 - A ball bearing is to be selected based on a reliability of 90%. It is subjected to a radial load of 5 kN and expected to have a life of 8000 hours at 1450 rpm with a reliability of 99%. Calculate the dynamic load carrying capacity of the bearing so that it may be selected from manufacturer's catalogue.

(4 + 2) + 6 = 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)

- Choose the correct alternative for the following: **10 × 1 = 10**
 - The minimum number of teeth on the pinion in order to avoid interference for 20° stub system is
(a) 12 (b) 14 (c) 18 (d) 32.
 - The portion of the gear tooth between the pitch circle and outer circle is called
(a) top land (b) face (c) flank (d) bottom land.
 - In Lewis equation, gear tooth is considered as
(a) simply supported beam (b) cantilever beam
(c) overhung beam (d) fixed beam.
 - A pair of worm gears is designated as (1/30/10/8). The velocity ratio is
(a) 160 (b) 30 (c) 80 (d) 96.
 - Life of a roller bearing is given in million number of cycles by
(a) $(C/P)^3$ (b) $(C/P)^{10/3}$ (c) $(C/P)^{2.5}$ (d) $(C/P)^4$.
Symbols carry usual meaning.
 - In a multi disk clutch, if z_1 and z_2 are the number of disks used on the driving shaft and driven shaft respectively, the total number of pairs of contact surfaces are
(a) $z_1 + z_2$ (b) $z_1 - z_2$ (c) $z_1 + z_2 + 1$ (d) $z_1 + z_2 - 1$.
 - Self-braking (locking) is not possible with the following type of brakes
(a) simple band (b) simple block
(c) differential band (d) internal expanding shoe.
 - The type of clutch used in prime movers with low starting torque is
(a) single plate clutch (b) multi-plate clutch
(c) cone clutch (d) centrifugal clutch.
 - An SKF bearing is designated by the number 6410. It means that the bore dia is
(a) 10 mm (b) 20 mm (c) 30 mm (d) 50 mm.

- (x) When the coefficient of friction is constant, the rate of heat generation of a clutch is
- directly proportional to the product of pressure and velocity
 - inversely proportional to the product of pressure and velocity
 - directly proportional to the ratio of pressure to velocity
 - directly proportional to the ratio of velocity to pressure.

Group - B

2. (a) A train of spur gears is shown in Figure 1. Gear 1 is the driving gear and transmits 5 kW power at 720 rpm. The number of teeth on gears 1, 2, 3 and 4 are 20, 50, 30 and 60 respectively. The module for all gears is 4 mm. The gears have a 20° full-depth involute profile. Calculate the tangential and radial components of the tooth force between
- Gears 1 and 2
 - Gears 3 and 4.

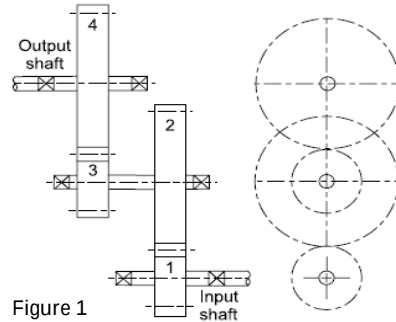


Figure 1

- (b) The following data is given for a pair of spur gears with 20° full-depth involute teeth:
- Number of teeth on pinion = 24
 - Number of teeth on gear = 56
 - Speed of pinion = 1200 rpm
 - Module = 3 mm
 - Service factor = 1.5
 - Face width = 30 mm
 - Both gears are made of steel with an ultimate tensile strength of 600 N/mm².
- Using the velocity factor to account for the dynamic load, calculate:
- Beam strength
 - Velocity factor
 - Rated power that the gears can transmit without bending failure, if the factor of safety is 1.5.
- (Calculate required Lewis Form Factor using the respective analytical relation)

$$(3 + 3) + (2 + 2 + 2) = 12$$

3. A pair of helical gears are to transmit 15 kW. Transverse pressure angle of the teeth is 20° stub and have a helix angle of 45°. The pinion runs at 10000 r.p.m. and has 80 mm pitch diameter. The gear has 320 mm pitch diameter. If the gears are made of cast steel having allowable static strength of 100 MPa; determine a suitable module and face width from static strength considerations and check the gears for wear, given surface endurance strength of the gear and pinion teeth material is 618 MPa and modulus of elasticity of the gear and pinion teeth material is 200 GPa.
- (Calculate required Lewis Form Factor using the respective analytical relation)

$$6 + 2 + 4 = 12$$

Group - C

4. (a) A pair of bevel gears transmitting 7.5 kW at 300 rpm is shown in Figure 2. The pressure angle is 20°. Determine the components of the resultant gear tooth force and draw a free-body diagram of forces acting on the pinion and the gear.

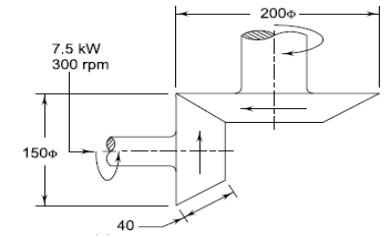


Figure 2 (All dimensions are in mm)

- (b) A pair of straight bevel gears consists of a 30 teeth pinion meshing with a 45 teeth gear. The module and the face width are 6 mm and 50 mm respectively. The pinion as well as the gear is made of steel ($S_{ut} = 600 \text{ N/mm}^2$). After determining required 'Lewis Form Factor' using respective analytical relation, calculate the beam strength of the gear tooth.
- (3 + 2) + 7 = 12
5. A pressure vessel, subjected to a design pressure of 0.75 MPa, consists of a cylindrical shell with 2 m inside diameter and 10 mm thickness. An opening with inner diameter of 300 mm and wall thickness of 10 mm is provided in the shell. The corrosion allowance is 2 mm and the weld joint efficiency is taken as 0.85. The extension of the opening inside the shell is 15 mm. The yield strength of the material used for the shell and opening is 210 N/mm². A reinforcing pad made of a 10 mm thick plate is provided for the opening. Determine the inner and outer diameters of the pad.

$$12$$

Group - D

6. (a) What are the two theories applied to the friction plate of a clutch? Explain each of them in brief.
- (b) A multiple disk clutch is to be used on machine tools. There are 8 driven disks having an outside diameter of 75 mm and an inside diameter of 56 mm. The disks are made of metal and run in oily environment. The coefficient of friction may be assumed to be 0.2 and the permissible pressure 0.7 N/mm². Determine (i) the axial pressure required (ii) the power that can be transmitted at 600 rev/min.

$$5 + 7 = 12$$

7. (a) A differential band brake as shown in Figure 3 has drum diameter of 500 mm. One end of the band is attached to the left of the fulcrum at a distance of 50 mm and the other end is attached to the right of the fulcrum at a distance of 200 mm from the fulcrum. The brake is to sustain a torque of 450 N-m. The coefficient of friction is 0.2 and angle of contact is 3.5 radian.

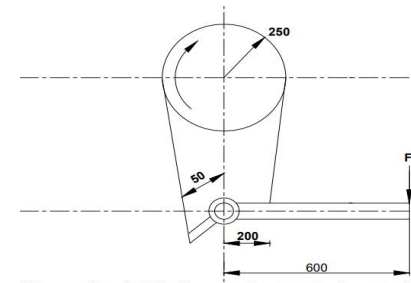


Figure 2 (All dimensions are in mm)