MACHINE DESIGN-II
(MECH 3201)

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

(ii) Involute profile is widely used for gear tooth because
(a) pressure angle remains constant
(b) face and flank form a continuous curve
(c) involute rack has straight sided teeth
(d) all the above factors.

(iii) The helix angle for single helical gears ranges from
(a) 10° to 15° (b) 15° to 20° (c) 20° to 35° (d) 35° to 50°.

(iv) In a thick cylindrical shell, the maximum radial stress at the outer surfaces of the shell is
(a) zero (b) p (c) – p (d) 2p.

(v) The lead angle of worm is given by
(a) $\tan^{-1}\left(\frac{1}{\pi d_1}\right)$ (b) $\tan^{-1}\left(\frac{z_1}{q}\right)$ (c) $\tan^{-1}(\pi m z_1)$ (d) (a) and (b).

(vi) The thickness of thin cylinder is determined on the basis of,
(a) radial stress (b) longitudinal stress
(c) circumferential stress (d) principal shear stress.

(vii) For a band brake, the width of the band for a drum diameter greater than 1 m, should not exceed
(a)150 mm (b) 200 mm (c) 250 mm (d) 300 mm.

(viii) In a multi disk clutch, if z_1 and z_2 are the number of disks used on the driving shaft and driven shaft, the total number of pairs of contact surfaces is
(a) $z_1 + z_2$ (b) $z_1 - z_2$ (c) $z_1 + z_2 + 1$ (d) $z_1 + z_2 - 1$.

(ix) Ball Bearing are made up of
(a) carbon steel (b) carbon chrome steel
(c) stainless steel (d) grey cast iron.

(x) In which of the following bearing, the bearing pressure is acting perpendicular to the axis of the shaft
(a) journal bearing (b) foot step bearing
(c) thrust bearing (d) ball bearing.

Group - B

2. Schematically represent meshing of a pair of teeth of driver and driven gears and show common tangent, common normal, line of action, pitch point, starting point of meshing and end point meshing. Also mention characteristics or properties of the line of action.
[(CO1)(Understand/LOCQ)]
(3 + 6 + 3) = 12

3. It is required to design a pair of spur gears with 20° full-depth involute teeth. The input shaft rotates at 720 rpm and receives 5 kW power through a fl exible coupling. The speed of the output shaft should be 144 rpm. The pinion as well as the gear are made of steel Fe 410 (Sut = 410 N/mm2). The service factor for the application is 1.25. The gears are machined to meet the specifications of Grade 6.
(i) Assume suitable number of teeth for the pinion and the gear.
(ii) For preliminary calculations, assume the pitch line velocity as 5 m/s and the factor of safety as 2. Estimate the module and select the first preference value of the module.
(iii) Using this value of the module, calculate the pitch circle diameters of the pinion and gear and the face width
(iv) Determine static load and the dynamic load by Buckingham's equation. Also, calculate the beam strength and the correct value of factor of safety based on beam strength.
(v) Using a factor of safety of 2 for wear strength, specify the surface hardness for gears. [(CO1(Evaluate/HOCQ)]
(1 + 3 + 3 + 3 + 2) = 12

Group - C

4. (a) What are the advantages of helical gears over spur gears?
[(CO2)(Remember/LOCQ)]

(b) A helical cast steel gear with 30° helix angle has to transmit 35 kW at 1500 rpm. If the gear has 24 teeth, determine the necessary module, pitch diameter and face width for 20° full depth teeth. The static stress for cast steel may be taken as 56 MPa. The width of face may be taken as 3 times the normal pitch. What would be the end thrust on the gear? The tooth factor for 20° full depth involute gear may be taken as $0.154 - 0.912/T_E$ where T_E represents the equivalent number of teeth. [(CO2)(Analyse/IOCQ)]
3 + 9 = 12

5. A pair of straight bevel gears consists of a 24-teeth pinion meshing with a 48 teeth gear. The module at the outside diameter is 6 mm, while the face width is 50 mm. The gears are made of grey cast iron FG 220 (Sut = 220 N/mm2). The pressure angle is 20°. The teeth are generated and assume that velocity factor accounts for the dynamic load. The pinion rotates at 300 rpm and the service factor is 1.5. Calculate-
   (i) the beam strength of the tooth
   (ii) the static load that the gears can transmit with a factor of safety of 2 for bending consideration
   (iii) the rated power that the gears can transmit.

   The tooth form factor may be taken as $\left(0.145 - \frac{0.912}{z'}\right)$ where, z' is the number of teeth on equivalent formative spur gear. [(CO2)(Estimate/IOCQ)]

(6 + 4 + 2) = 12

Group - D

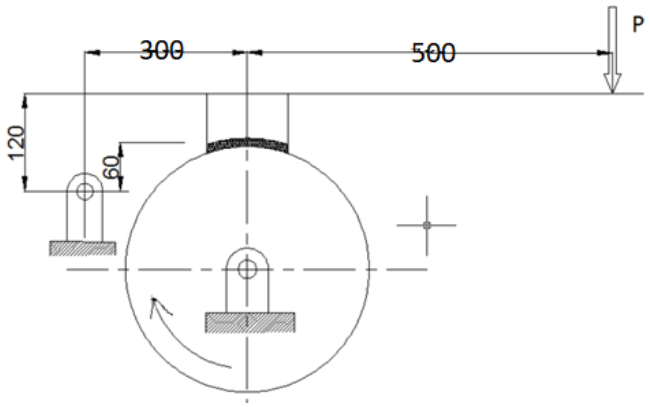
6. (a) A seamless steel pipe of 90 mm internal diameter is subjected to internal pressure of 10 MPa. It is made of steel (S_{yt} = 230 N/mm^2 and μ = 0.27) and the factor of safety is 2.5. Determine the thickness of the pipe. [(CO3)(Assess/IOCQ)]

   (b) Write a short note on Autofrettage process on pressure vessels. [(CO3)(Remember/LOCQ]

7 + 5 = 12

7. (a) A multi-disc clutch has three discs on the driving shaft and two on the driven shaft. The inside diameter of the contact surface is 120 mm. The maximum pressure between the surface is limited to 0.1 N/mm^2. Design the clutch for transmitting 25 kW at 1575 rpm. Assume uniform wear condition and coefficient of friction as 0.3. [(CO4)(Apply/IOCQ)]

   (b) A single block brake with a torque capacity of 20 N-m is shown in Fig. 1. The coefficient of friction is 0.3 and the maximum pressure on the brake lining is 1 N/mm^2. The width of the block is equal to its length and the drum radius is 160 mm. Calculate (i) the actuating force; (ii) the dimensions of the block; (iii) the resultant hinge-pin reaction. [(CO4)(Assess/IOCQ)]



All dimensions are in mm

Fig. 1

6 + (2 + 2 + 2) = 12

Group - E

8. (a) A single-row deep groove ball bearing has a dynamic load capacity of 41500 N and operates on the following work cycle:
   (i) Radial load of 5000 N at 500 rpm for 25% of the time;
   (ii) Radial load of 10000 N at 700 rpm for 50% of the time; and
   (iii) Radial load of 7000 N at 400 rpm for the remaining 25% of the time.
   Calculate the expected life of the bearing in hours. [(CO5)(Analysis/IOCQ)]

   (b) A ball bearing is operating on a work cycle consisting of three parts—a radial load of 3000 N at 1540 rpm for one quarter cycle, a radial load of 5000 N at 740 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 10 000 h. Calculate the dynamic load carrying capacity of the bearing. [(CO5)(Estimate/IOCQ)]

6 + 6 = 12

9. (a) Compare rolling and sliding contact bearing with load characteristics curve. Write down Petroff's equation. [(CO6)(Remember/LOCQ)]

   (b) Design a full hydrodynamic journal bearing with the following specification for machine tool application:
   Journal diameter = 75 mm
   Radial load = 10 kN
   Journal speed = 1450 rpm
   Minimum oil film thickness = 22.5 micron
   Inlet temperature = 40° C.
   Bearing material = babbitt
   Determine the length of the bearing. [(CO5)(Design/HOCQ)]

6 + 6 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	23.9	57.3	18.8

Course Outcome (CO):

On completion of this course students will be able to

1. Choose suitable material of a product to be designed as per the application and strength requirement.
2. Relate relevant 'Mode of Failure' and 'Theory of Failure' when solving a problem regarding design of machine components under different types of loadings and boundary conditions.
3. Identify proper stress intensity factors for objects with dimensional discontinuity subjected to different loadings and boundary conditions.
4. Analyse life of a machine component with or without dimensional discontinuity subjected to various dynamic loadings constrained with different boundary conditions.

5. Evaluate detailed specifications for fasteners like screw, nut-n-bolt, for welding and power screw by analysing the machine component subjected to various loading and boundary conditions.
6. Design a solid and hollow shaft, coil and leaf spring, shaft couplings and various belts for a belt drive for given power rating, loadings and boundary conditions.

*LOCQ: Lower Order Cognitive Question; IOCQ: Intermediate Order Cognitive Question; HOCQ: Higher Order Cognitive Question