



**MAULANA ABUL KALAM AZAD UNIVERSITY OF
TECHNOLOGY, WEST BENGAL**

**Paper Code : ME-603
MACHINE DESIGN**

Time Allotted : 3 Hours

Full Marks : 70

The figures in the margin indicate full marks.

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

GROUP - A

(Multiple Choice Type Questions)

1. Choose the correct alternatives for the following :

10 × 1 = 10

i) A multi disc clutch has 3 discs on driving shaft and 2 discs on driver shaft. Number of pairs of contact surface is

- a) 5 b) 2
c) 3 d) 4.

ii) According to uniform wear theory the mean radius of the friction surface of a disc clutch is

- a) $\frac{2(r_1^3 - r_2^3)}{3(r_1^2 - r_2^2)}$ b) $\frac{(r_1 + r_2)}{2}$
c) $\frac{(r_1 - r_2)}{2}$ d) $\frac{2(r_1^3 + r_2^3)}{3(r_1^2 - r_2^2)}$

iii) Surface endurance limit of gear material is dependent on its

- a) Coefficient of elasticity
b) Brinell hardness test
c) Elastic strength
d) Yield strength.

iv) If Z is the actual number of teeth on a helical gear and ϕ is the helix angle, the number of teeth of on formative spur number is written as

- a) $Z \sec^3 \phi$ b) $Z \sec^2 \phi$
c) $Z / \sec^3 \phi$ d) $Z \operatorname{cosec} \phi$.

v) If E = mean kinetic energy of flywheel, ΔE = maximum fluctuation of energy and C_s = coefficient of fluctuation of speed, then

- a) $\Delta E = E \times C_s$ b) $\Delta E = 2E \times C_s$
c) $\Delta E = E / C_s$ d) $\Delta E = E / 2C_s$.

vi) The form factor of a spur gear tooth depends upon

- a) Circular pitch only
b) No. of teeth and system of teeth
c) Pressure angle only
d) number of teeth and circular pitch.

- vii) In hydrodynamic lubrication, the friction is due to
- Metal to metal contact
 - Fluid shear
 - Load on journal
 - None of these.
- viii) The listed life of a roller bearing in a catalogue is the
- minimum expected life
 - maximum expected life
 - average life
 - none of these.
- ix) If Z = Absolute viscosity of the lubricant, N = speed of the journal, p = bearing pressure then the bearing characteristics number is
- ZN/p
 - Zp/N
 - Z/pN
 - pN/Z
- x) In thrust bearing, the load acts
- along the axis of rotation
 - parallel to the axis of rotation
 - perpendicular to the axis of rotation
 - in any direction.

GROUP - B

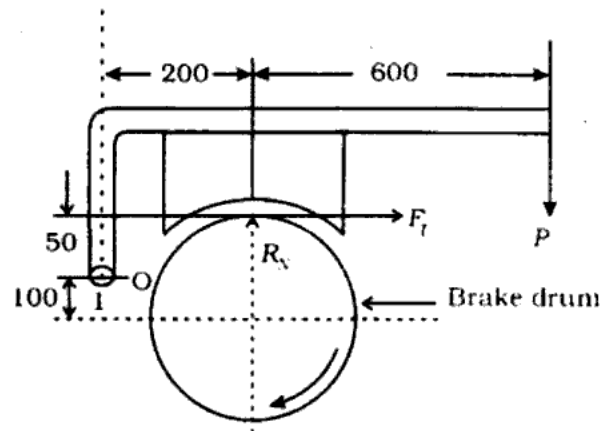
(Short Answer Type Questions)

Answer any three of the following. $3 \times 5 = 15$

- Find the relation between the virtual and actual number of teeth for helical gear.
- A centrifugal clutch is to be designed to transmit 15 kW at 900 rpm. The shoes are four in number. The speed at which the engagement begins is $\frac{3}{4}$ th the running speed. The shoes are lined with Ferrodo for which the coefficient of friction may be taken as 0.25. The distance of the centre of gravity of the shoes may be taken as 120 mm from the axis of rotation. Determine the mass of each shoe, size of the shoes. Assume the inside radius of the pulley rim is 150 mm, the intensity of pressure exerted on shoes is 0.1 N/mm^2 and the arc of contact subtended by each shoe $\theta = 60^\circ$ at the centre of the spider.
- The block brake as shown in figure provides a breaking torque of 360 N-m. The diameter of the brake drum is 300 mm. The coefficient of friction is 0.3.

Find :

- (i) The force (P) to be applied at the end of the lever for the CW and CCW rotation of the brake drum.
 - (ii) The location of the pivot or fulcrum to make the brake self locking for the CW rotation of the brake drum.
- 2 + 2 + 1



5. a) Why cone angle less than 12.5° is not provided in a cone clutch ?
 - b) What are the materials used for lining of friction surfaces of clutch ?
- 3 + 2
6. What is autofrettage ? Describe compounding for pre-stressing the cylinder.
- 5

7. a) How do you express the life of bearing ? What is an average or median life ?
 - b) The journal bearing of a turbine shaft of diameter 300 mm is acted by a radial load of 160 kN. The rpm of shaft is 1800. Determine the following :
 - (i) Length of the bearing if the allowable bearing pressure is 1.6 N/mm^2
 - (ii) Amount of heat to be removed by the lubricant per minute if the bearing temperature is 60°C , the viscosity of oil at 60° is 0.2 kg/m-s , the bearing clearance is 0.25 and end leakage factor $k = 0.002$ for l/d ratio 0.75 to 2.8.
- 1 + 2

GROUP - C

(Long Answer Type Questions)

Answer any three of the following. $3 \times 15 = 45$

8. A machine working intermittently, requires the torque to be applied as follows :
 - a) During the first half revolution, the torque increases uniformly from 1000 Nm to 3000 Nm.

- b) During the next one revolution, the torque remains constant.
- c) During the next half revolution, the torque decreases uniformly from 3000 Nm to 1000 Nm.
- d) During the last one revolution the torque remain constant. The cycle is thus completed in three revolutions. The machine coupled to a motor which exerts a constant torque at 250 rpm determine motor power. If the total fluctuation of speed is not exceed 2% of mean speed. Determine the diameter of flywheel and cross section of the flywheel rim. Assume the entire mass of the flywheel is concentrated at the rim of the wheel.

Width of rim = 3 times the thickness of rim.

The centrifugal stress in the rim = 10 MPa.

Density of the flywheel material = 7200 kg/m³.

9. a) A pair of helical gears consists of 24 teeth pinion meshing with a 72 teeth gear. Normal pressure angle is 20°, and helix angle is 24°. The pinion rotates at 720 rpm. Normal module of gear is 5 mm and the face width is 50 mm. Both pinion and gear are made of steel with $\sigma_{ut} = 600$ MPa. Gears are heat

treated to surface hardness of 360 BHN. What power can be transmitted by the pair. If service factor is 1.4 factor of safety is 2 ? Assume that the velocity factor account for the dynamic load.

Use, $C_v = \frac{5.6}{5.6 + \sqrt{V}}$, $Y = \pi \left(0.154 - \frac{0.912}{z'} \right)$, where

symbols have usual meaning. 10

- b) Explain the functional difference between a flywheel and a governor. 5

10. a) The journal bearing of a turbine shaft of diameter 300 mm is acted upon by a radial load of 160 kN. The rpm of shaft is 1800. Determine the following :

(i) Length of the bearing if the allowable bearing pressure is 1.6 N/mm².

(ii) Amount of heat to be removed by the lubricant per minute if the bearing temperature is 60°C, the viscosity of oil at 60° is 0.02 kg/m-s, the bearing clearance is 0.25 and end leakage factor $k = 0.002$ for l/d ratio 0.75 to 2.8. 4 + 4

- b) A single row deep groove ball bearing is subjected to a radial load of 8 kN and a thrust load of 3 kN. The diameter of the shaft is 75 mm rotating at 1200 rpm. The bearing selected is 6315 for which the basic static capacity $C_0 = 72$ kN and the basic dynamic capacity C is 112 kN. The radial load factor and thrust factor X and Y are given below in the table. You are required to determine the expected rated bearing life.

$\left(\frac{F_a}{C_0}\right)$	$\left(\frac{F_a}{F_r}\right) \leq e$		$\left(\frac{F_a}{F_r}\right) > e$		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

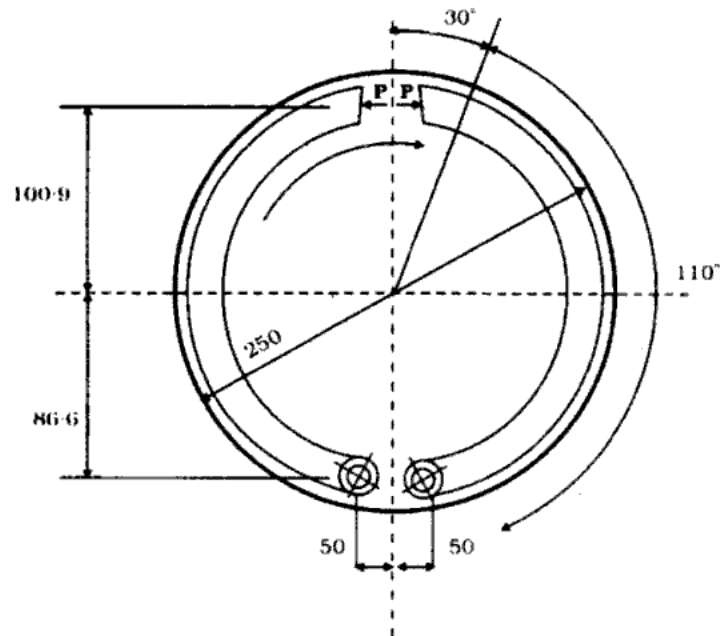
11. A cone clutch is used to connect an electric motor running at 1440 rpm with a machine that is stationary. The machine is equivalent to a rotor of mass 150 kg and radius of gyration as 250 mm. The machine has to be brought to the full speed of 1440 rpm from a stationary

- condition in 40 seconds. The semi-cone angle α is 12.5° . The mean radius of the clutch is twice the face width. The coefficient of friction is 0.2 and the normal intensity of pressure between contacting surfaces should not exceed 0.1 N/mm^2 . Assuming uniform wear, Calculate :
- the inner and the outer diameters
 - the face width of the friction lining
 - the force required to engage the clutch
 - the amount of heat generated during each engagement of clutch.

12. a) A multi-disk clutch consists of five steel plates and four bronze plates. The inner and outer diameters of friction disks are 75 mm and 150 mm respectively. The coefficient of friction is 0.1 and the intensity of pressure of friction lining is limited to 0.3 N/mm^2 . Assuming uniform wear theory, calculate (i) required operating force and (ii) the power transmitting capacity.

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- b) An automobile type internal-expanding double-shoe brake is shown in the figure. The face width of the friction-lining is 40 mm and the maximum intensity of normal pressure is limited to 1 N/mm^2 . The co-efficient of friction is 0.32. Calculate (i) the actuating force P and (ii) the torque absorbing capacity of the brake. 6 + 9



(All linear dimensions are in mm)

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