WEST BENGAL UNIVERSITY OF TECHNOLOGY

ME-603

MACHINE DESIGN

Time Allotted: 3 Hours   Full Marks: 70

The questions are of equal value.
The figures in the margin indicate full marks.
Candidates are required to give their answers in their own words as far as practicable.
All symbols are of usual significance.

GROUP A
(Multiple Choice Type Questions)

1. Answer *all* questions. $10 \times 1 = 10$

    (i) The life of a ball bearing is inversely proportional to

    (A) $(\text{Load})^{\frac{1}{3}}$ (B) $(\text{Load})^3$

    (C) $(\text{Load})^{3.3}$ (D) $(\text{Load})^2$

    (ii) For cyclic loading stress concentration is more dangerous in

    (A) Brittle material
    (B) Ductile material
    (C) Brittle as well as ductile materials
    (D) Brittle material with more modulus of elasticity

    (iii) In design a plate clutch, assumption of uniform wear conditions is made because

    (A) it is closure to real-life situation   (B) it leads to safer design
    (C) it leads to cost effective   (D) no other assumption is possible

   (iv) The assumption made in the derivation of Lewis equation is

   (A) tooth as simply supported beam   (B) tooth as cantilever beam
   (C) tooth as fixed beam   (D) tooth as overhanging beam

   (v) Lewis equation for Beam Strength of spur gear teeth, with the symbols of usual meaning, is

   (A) $S_b = [\sigma_0] b \dfrac{m}{Y}$ (B) $S_b = [\sigma_0] \phi b m Y$

   (C) $S_b = [\sigma_0] b m Y$ (D) $S_b = [\sigma_0] \phi m Y$

   (vi) If module increases, size of gear tooth

   (A) decreases   (B) increases   (C) does not have any relation

   (vii) The tensile stress in the flywheel rim due to the centrifugal force acting on the rim is given by

   (A) $\dfrac{\rho.v^2}{4}$ (B) $\dfrac{\rho.v^2}{2}$

   (C) $\dfrac{3\rho.v^2}{4}$ (D) $\rho.v^2$

   Where ρ = Density of the flywheel material, and
   v = Linear velocity of the flywheel.

   (viii) A type of brake commonly used in motor cars is a

   (A) shoe brake   (B) band and block brake
   (C) band brake   (D) internal expanding brake

   (ix) The thickness of high-pressure oil and gas pipes is determined by

   (A) Lame's equation   (B) Clavarino's equation
   (C) Birnie's equation   (D) Barlow's equation

(x) In which type of teeth, variation in centre distance which limits does not affect the velocity ratio of the mating gear

(A) Cycloidal   (B) Involute

(C) Hypoid   (D) All of the above

GROUP B
(Short Answer Type Questions)

Answer any *three* questions.   3×5 = 15

2. 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/mm². Design the clutch for transmitting 25 kW at 1575 r.p.m. Assume uniform wear condition and coefficient of friction is 0.3.   5

3. (a) A ball bearing operating at a load P has 8000 hours of life. Determine the life of the bearing, in hours, when the load is doubled to 2P.   2

(b) In a band brake the ratio of tight side band tension to the tension on the slack side is 3. If the angle of overlap of band on the drum is 180°, determine the coefficient of friction required between drum and band.   2

(c) Why are taper roller bearings used in pairs?   1

4. A pair of worm gears is designed as 1/30/10/8; calculate   2+2+1

(a) The center distance

(b) The speed of rotation

(c) The dimension of the worm and worm wheel.

5. A thin cylindrical pressure vessel of 500 mm diameter is subjected to an internal pressure of 2 N/mm². If the thickness of pressure vessel is 20 mm, find the hoop stress, longitudinal stress and the maximum shear stress.   5

6. Derive an expression for selecting the bearing when reliability other than 90%.   5

7. Two spur gears have a velocity ratio of 1/3. The driven gear has 72 teeth of 8 mm module and rotates at 300 rpm. Calculate the number of teeth and speed of the driver. What will be the pitch line velocity?   5

GROUP C
(Long Answer Type Questions)

Answer any *three* questions.   3×15 = 45

8. A pair of spur gears with 20° full-depth involute teeth is to transmit 14kw at 300 rpm of the pinion. The speed ratio is 3:1. The material of the pinion is plain carbon steel $Fe410$ (S_{ut} = 410 N/mm²), while the gear is made of grey cast iron $FG200$ (S_{ut} = 200 N/mm²). Assuming number of teeth of pinion = 18; face width = 12 times module; velocity factor $C_v = \dfrac{4.5}{4.5+V}$, V being the pitch line velocity in m/s; Lewis form factor $Y = \pi\left(0.154 - \dfrac{0.912}{No.\,of\,teeth}\right)$, the factor of safety of 1.5 and the service factor of 1.5, design the gears based on Lewis equation. Use velocity facto to account for the dynamic load.   15

9. (a) A ball bearing is operating on a work cycle consisting of 3 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 a radial load of 2500 N at 1440 rpm for the remaining cycle. The expected life of the bearing is 10,000h. Calculate the dynamic load carrying capacity of the bearing.   7

(b) The load on the journal bearing is 150 kN due to turbine shaft of 300 mm diameter running at 1800 rpm, determine the following-   8

(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 and viscosity of oil at 60° C is 0.02 kg/m.s and the bearing clearance is 0.25 mm.

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10. A pair of helical gears are to transmit 15 kW. The teeth are 20° stub in diametral plane and have a helix angle of 45°. The pinion runs at 10000 rpm 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, surface endurance limit (σes = 618 MPa). Consider y(Tooth factor) = 0.175 – 0.841/T for 20° stub teeth profile.   15

11.(a) A pair of bevel gears transmitting 7.5 kW at 300 rpm is shown in figure below. 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 gear.   5

150φ

7.5 kW
300rpm

40

200φ
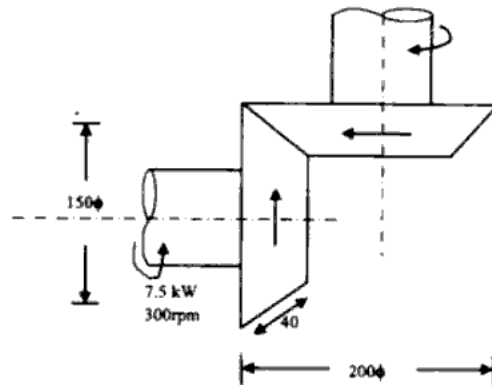
(b) The journal bearing of a 320 mm diameter turbine shaft, rotating at 1800 rpm, is acted upon by a radial of 160 kN. Determine: 10
(i) Length of the bearing if the allowable bearing pressure is 1.6 MPa.
(ii) Amount of heat to removed by the lubricant per minute if the bearing temperature is 60° C. The viscosity of the lubricant at 60° C is 0002 kg/m-s, the bearing clearance is 0.25 and end leakage factor k = 0.002 for 1/d ratio of 0.5 to 2.8.

12.(a) The following data is given for a rimmed flywheel made of grey cast iron FG 200, mean radius of rim = 1.5 m, thickness of rim = 200 mm, width of rim = 300 mm, number of spokes = 6, cross sectional area of each spoke = 10000 mm², speed of rotation =720 rpm.   8+7

Calculate (i) the tensile stress in rim at φ = 30° and φ = 0°

(ii) the axial tensile force in each spoke

The mass density of cast iron FG200 is 7100 kg/m³.

(b) A hydraulic cylinder 400 mm bore operates at a maximum pressure of 6 N/mm². The piston rod is connected to the load and the cylinder to the frame through hinged joints. Design (i) cylinder (ii) piston rod (iii) hinged pin. Allowable tensile stress is 80 MPa.