CS/B.TECH/ME/PE/EVEN/SEM-6/ME-603/2018-19

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 any *ten* of the following :   10 × 1 = 10

  i)   An antifriction bearing with number 22210 will have a bore diameter

      a)   20 mm

      b)   40 mm

      c)   50 mm

      d)   60 mm.

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i) The torque transmitting capacity of a cone clutch of outer radius R, inner radius r and semi-cone angle α, by uniform pressure theory (where P = axial load and μ = coefficient of friction) is

a) $\dfrac{\mu P(R+r)}{2\sin\alpha}$

b) $\dfrac{\mu P(R+r)}{3\sin\alpha}$

c) $\dfrac{2\mu P(R^3-r^3)}{3\sin\alpha(R^2-r^2)}$

d) $\dfrac{3\mu P(R^3-r^3)}{4\sin\alpha(R^2-r^2)}$

iii) The resistance to fatigue of materials is measured by

a) Young's modulus

b) Elastic limit

c) Ultimate tensile strength

d) Endurance limit.

iv) The maximum reduction ratio is obtained at one stage in

a) Helical gear

b) Worm gear

c) Bevel gear

d) Spur gear.

v) Zero axial thrust is experienced in

a) Helical gears

b) Bevel gears

c) Herringbone gears

d) Worm gears.

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vi) In order to find the maximum bending moment on the arms of a flywheel, it is assumed as a

a) simply supported beam carrying a uniformly distributed load over the arm

b) fixed at both ends (*i.e.* at the hub and at the free end of the rim) and carrying a uniformly distributed load over the arm

c) cantilever beam fixed at the hub and carrying a concentrated load at the free end of the rim

d) none of these.

vii) A type of brake commonly used in motor car is a

a) shoe brake

b) band and block brake

c) band brake

d) internal expanding brake.

viii) Stribeck curve helps to find

a) Boundary lubrication regime

b) Mixed lubrication regime

c) Hydrodynamic lubrication regime

d) All of these.

ix) Lewis equation in spur gears is applied

    a)   only to the pinion

    b)   only to the gear

    c)   to the stronger of the pinion or gear

    d)   to the weaker of the pinion or gear.

x)   Coefficient of steadiness in flywheel is

    a)   the reciprocal of coefficient of fluctuation of speed

    b)   difference between maximum and minimum speeds

    c)   ratio of maximum speed to mean speed

    d)   none of these.

xi) A multi-disc clutch has three discs on driving shaft (n_1) and two discs on the driver shaft (n_2). Number of pairs of contact surfaces is

    a)   2   b)   3

    c)   4   d)   5

xii) A pressure vessel is said to be thin if the ratio of wall thickness of the shell to its internal diameter is

    a)   equal to 1/15   b)   less than 1/15

    c)   more than 1/15   d)   none of these.

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GROUP - B

(Short Answer Type Questions)

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

2. A pair of spur gears with a centre distance of 669 mm is used for a speed reduction of 4.5. Module of the gear is 6 mm. Calculate the number of teeth of the gear and pinion.

3. A ball bearing has a dynamic load capacity of 26 kN. The desired life for 90% of the bearings is 8000 hrs and the speed is 300 rpm. Calculate the equivalent load that the bearing can carry.

4. The inner diameter of a thick cylindrical tank for liquefied gas is 250 mm. The gas pressure is limited to 15 MPa. The tank is made of plain carbon steel 10C4 (S_{yt} = 340 N/mm^2 and μ = 0·27) and the factor of safety is 5. Calculate the cylinder wall thickness.

5. Explain the functional difference between a flywheel and a governor. Define the terms 'coefficient fo fluctuation of speed' and 'coefficient of fluctuation of energy'. $3 + 2$

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6. The following are the details of a helical gear set

Normal module m_n = 6mm, normal pressure angle
$\alpha_n = 20°$, angle of helix $\psi = 25°$, power transmitted by
the gear set P = 7.5 kW at speed of 970 rpm of pinion,
number of teeth of pinion and gear are 19 and 40
respectively. Determine the components of the resultant
tooth force on gear tooth due to power transmission.

7. A multi-disk clutch consists of five steel plates and four
bronze plates. The inner and outer diameters of the
friction disk are 5 mm and 150 mm respectively. The
coefficient of friction is 0.1 and the intensity of pressure
on friction lining limited to 0.3 N/mm², assuming
uniform theory,

Calculate :

The required force to engage the clutch and power
transmitting capacity at 750 rpm.

GROUP – C

(Long Answer Type Questions)

Answer any *three* of the following.   3 × 15 = 45

8. a)   A rimmed flywheel made of grey cast iron FG 200 (density = 7100 kg/m^3) is required to keep down fluctuation of speed from 200 to 220 rpm. The cyclic fluctuation of energy is 30000 N-m. The outside diameter of the flywheel should not exceed 2m. It can be assumed that there are six spokes and the rim contributes 90% of the required moment of inertia. The cross-section of the rim is rectangular and the ratio of width to thickness is 2. Determine the dimensions of the rim. Calculate the stresses in the rim and spokes using Timoshenko's expressions.

   b)   The piston rod of a hydraulic cylinder exerts an operating force of 10 kN. The friction due to piston packing and stuffing box is equivalent to 10% of the operating force. The pressure in the cylinder is 10 MPa. The cylinder is made of cast iron and the factor of safety is 5. Determine the diameter and the thickness of the cylinder.   8 + 7

9. The following are the details of a bevel gear set :
Number of teeth of pinion and gear are 20 and 40
respectively, module is 5 mm, face width is 30 mm,
pressure angle is 20°, material for both the gears is
steel (σ_{ut} = 900 N/mm²), teeth surface hardness is
450BHN. The rated power is 4kW at 500 rpm of pinion,
the starting torque of the motor being 1·5 times the
rated torque. Take expected error e = 0·025 mm and
deformation factor C = 11400 N/mm² in Buckingham's
equation and estimate the factor of safety in bending
and in wear.

10. a) Two spur gears with 20 and 41 teeth of 20° PD
involute profile and module 6 mm have been
selected to transmit 10 kW from an IC engine
running at 1200 rpm. The drive has a service
factor of 1·5. Both the pinion and the gear are
made of steel (σ_{ut} = 600 MPa). Face width is 10

times the module. Check :

i) where the drive is safe by using velocity
factor for dynamic load,

ii) if the BHN of the pinion teeth surface is
380, calculate the factor of safety against
pitting.

b) In a worm gear drive, the worm has triple-start threads and the pitch circle diameter is 60 mm. There are 30 teeth on the worm with module 6mm and pressure angle of 20°. The input power to the drive is 2kW at the motor speed of 740 rpm. Find,

  i) efficiency of the drive, and

  ii) loss of power due to friction in watts. Assume coefficient of friction as 0·032.

  10 + 5

11. A punching machine makes 25 working strokes per minute and is capable of punching 25 mm diameter holes in 18mm thick steel plates having an ultimate shear stress of 300 MPa. The punching operation takes place during 1/10 of a revolution of crank shaft. Estimate the power needed for the driving motor assuming a mechanical efficiency of 95 %. Determine the suitable dimensions for the rim cross-section of the flywheel, which is to revolve at 9 times the speed of the crank shaft. The permissible coefficient of fluctuations of speed is 0·1. The width of the flywheel is to be taken as 2 times the thickness.

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12. a) 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 maximum normal intensity of pressure between contacting surfaces should not exceed 0·1 N/mm^2. Assuming uniform wear criterion, calculate :

    i) The inner and the outer diameters,

    ii) The face width of the friction lining,

    iii) The force required to engage the clutch, and

    iv) The amount of heat generated during each engagement of clutch

  b) The load on the journal bearing is 150 kN due to turbine shaft of 300 mm diameter running at 1800 r.p.m. Determine length of the bearing if the

allowable bearing pressure is 1·6 N/mm².
Amount of heat to be removed by the lubricant per minute if the bearing temperature is 60°C and viscosity of the oil at 60°C is 0·02 kg/m-s and the bearing clearance is 0·25 mm. Take, factor to correct for end leakage, k = 0·002.

8 + 7

$$\mu = \frac{33}{10^8}\left(\frac{ZN}{p}\right)\left(\frac{d}{c}\right) + k$$

13. a) A ball bearing 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 10,000 h. Determine the dynamic load carrying capacity of the bearing.

b) A differential band brake is shown in the given figure. The width and the thickness of the steel band are 100 mm and 3 mm respectively and the maximum tensile stress in the band is

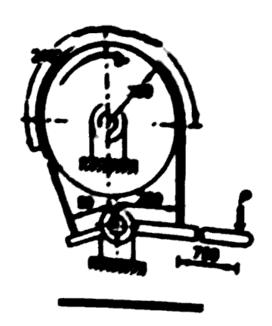50 N/mm². The coefficient of friction between the friction lining and the brake drum is 0.25.

Calculate :

i)   Tension in the band,

ii)   The actuating force,

iii) The torque capacity of the brake.

Find out whether the brake is self-locking.