Note: All questions are compulsory. Internal choices, if any, are indicated. Answers of Q.1 (MCQs) should be written in full instead of only a, b, c or d. Use of Mahadevan design data book is permitted in examination hall.

Q.1 i. Which of the following reduces the stress concentration? **1**
(a) Use of multiple notches
(b) Drilling additional holes
(c) Removal of undesired material
(d) All of these

ii. If the mean stress value for a sinusoidal stress function is zero, then this type of stress falls in which category? **1**
(a) Reversed stresses   (b) Fluctuating stresses
(c) Repeated stresses   (d) Alternating stresses

iii. Which of the following loading is considered for the design of axles? **1**
(a) Bending moment only
(b) Twisting moment only
(c) Combined bending moment and torsion
(d) Combined action of bending moment, twisting moment and axial thrust

iv. Two shafts will have equal strength, if- **1**
(a) Twisting moment of both the shafts is same
(b) Angle of twist of both the shafts is same
(c) Material of both the shafts is same
(d) Diameter of both the shafts is same

v. Lewis's equation in spur gears is used to find the- **1**
(a) Tensile stress in bending   (b) Shear stress
(c) Compressive stress in bending   (d) Fatigue stress

vi. The energy absorb by brake is always- **1**
(a) Potential   (b) Kinetic
(c) Strain energy   (d) None of these

---

ii A multiple disc clutch, steel on bronze, is to transmit 4.5 kW at 750 r.p.m. The inner radius of the contact is 40 mm and outer radius of the contact is 70 mm. The clutch operates in oil with an expected coefficient of 0.1. The average allowable pressure is 0.35 N/mm². Find: (a) The total number of steel and bronze discs; (b) The actual axial force required; (c) The actual average pressure; and (d) The actual maximum pressure. **7**

OR iii The block brake, as shown in Figure 2, provides a braking torque of 360 N-m. The diameter of the brake drum is 300 mm. The coefficient of friction is 0.3. Find (a) The force (P) to be applied at the end of the lever for the clockwise and counter clockwise rotation of the brake drum; and (b) The location of the pivot or fulcrum to make the brake self-locking for the clockwise rotation of the brake drum. **7**
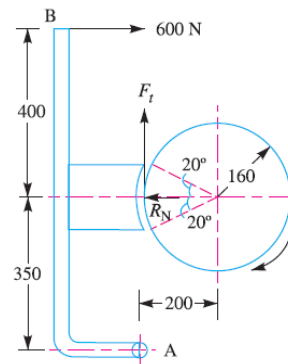

Figure 2 (All dimensions in mm)

Q.6 i What are journal bearings? Give a classification of these bearings. **3**

ii A full journal bearing of 50 mm diameter and 100 mm long has a bearing pressure of 1.4 N/mm². The speed of the journal is 900 r.p.m. and the ratio of journal diameter to the diametral clearance is 1000. The bearing is lubricated with oil whose absolute viscosity at the operating temperature of 75°C may be taken as 0.011 kg/m-s. The room temperature is 35°C. Find (a) The amount of artificial cooling required. (b) The mass of the lubricating oil required, if the difference between the outlet and inlet temperature of the oil is 10°C. Take specific heat of the oil as 1850 J/kg/°C & Heat dissipation coefficient (C) = 280 W/m²/°C. **7**

OR iii A 80 mm long journal bearing supports a load of 2800 N on a 50 mm diameter shaft. The bearing has a radial clearance of 0.05 mm and the viscosity of the oil is 0.021 kg / m-s at the operating temperature. If the bearing is capable of dissipating 80 J/s, determine the maximum safe speed. **7**

******

vii. In case of a multiple disc clutch, if n_1 are the number of discs on the driving shaft and n_2 are the number of the discs on the driven shaft, then the number of pairs of contact surfaces will be- **1**
    (a) $n_1 + n_2$ (b) $n_1 + n_2 + 1$
    (c) $n_1 + n_2 - 1$ (d) None of these

viii. When the length of the journal is equal to the diameter of the journal, then the bearing is said to be a- **1**
    (a) Short bearing   (b) Long bearing
    (c) Medium bearing   (d) Square bearing

ix. In thrust bearings, the load acts- **1**
    (a) Along the axis of rotation
    (b) Parallel to the axis of rotation
    (c) Perpendicular to the axis of rotation
    (d) In any direction

Q.2 i. What is stress concentration factor? What are the methods of reducing stress concentrations? **3**

ii. A component machined from a plate made of steel 45C8 (Ultimate strength = 630 MPa) is shown in Figure 1. It is subjected to a completely reversed axial force of 50 kN. The expected reliability is 90% and the factor of safety is 2. The Size factor is 0.85. Determine the plate thickness 't' for infinite life, if the notch sensitivity factor is 0.8. **7**
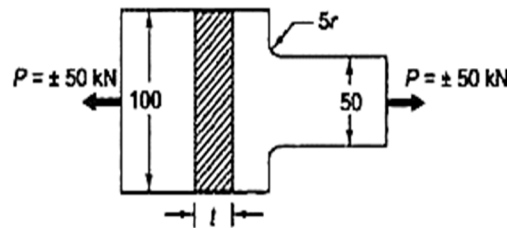

Figure 1

OR iii. A circular bar of 500 mm length is supported freely at its two ends. It is acted upon by a central concentrated cyclic load having a minimum value of 20 kN and a maximum value of 50 kN. Determine the diameter of bar by taking a factor of safety of 1.5. The material properties of bar are given by: ultimate strength of 650 MPa, yield strength of 500 MPa and endurance strength of 350 MPa. **7**

Q.3 i. Find the diameter of a solid steel shaft to transmit 20 kW at 200 r.p.m. The ultimate shear stress for the steel may be taken as 360 MPa and a factor of safety as 8. If a hollow shaft is to be used in place of the solid shaft, find **3**

the inside and outside diameter when the ratio of inside to outside diameters is 0.5.

ii. A shaft is supported by two bearings placed 1 m apart. A 600 mm diameter pulley is mounted at a distance of 300 mm to the right of left hand bearing and this drives a pulley directly below it with the help of belt having maximum tension of 2.25 kN. Another pulley 400 mm diameter is placed 200 mm to the left of right hand bearing and is driven with the help of electric motor and belt, which is placed horizontally to the right. The angle of contact for both the pulleys is 180° and $\mu = 0.24$. Determine the suitable diameter for a solid shaft, allowing working stress of 63 MPa in tension and 42 MPa in shear for the material of shaft. Assume that the torque on one pulley is equal to that on the other pulley. **7**

OR iii. A shaft is supported on bearings A and B, 800 mm between centres. A 20° straight tooth spur gear having 600 mm pitch diameter, is located 200 mm to the right of the left hand bearing A, and a 700 mm diameter pulley is mounted 250 mm towards the left of the bearing B. the gear is driven by a pinion with a downward tangential force while the pulley drives a horizontal belt having 180° angle of wrap. The pulley also serves as a flywheel and weights 2000 N. the maximum belt tension is 3000 N and the tension ratio is 3: 1. Determine the maximum bending moment and the necessary shaft diameter if the allowable shear stress of the material is 40 MPa. **7**

Q.4 i. What are the merits and demerits of gear drives? **3**

ii. A gear drive is required to transmit a maximum power of 22.5 kW. The velocity ratio is 1:2 and r.p.m. of the pinion is 200. The approximate centre distance between the shafts may be taken as 600 mm. The teeth has 20° stub involute profiles. The static stress for the gear material (which is cast iron) may be taken as 60 MPa and face width as 10 times the module. Find the module, face width and number of teeth on each gear. **7**

OR iii. A helical cast steel gear with 30° helix angle has to transmit 35 kW at 1500 r.p.m. 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? **7**

Q.5 i Describe, with the help of a neat sketch, a centrifugal clutch. **3**

Marking Scheme
ME3CO39 Machine Design

Q.1　i)　Which of the following reduces the stress concentration?　**1**
(d) Each of the mentioned

ii)　If the mean stress value for a sinusoidal stress function is zero, then this type of stress falls in which category?　**1**
(a) Reversal Stress

iii)　Which of the following loading is considered for the design of axles?　**1**
(a) Bending moment only

iv)　Two shafts will have equal strength, if　**1**
(a) twisting moment of both the shafts is same

v)　Lewis equation in spur gears is used to find the　**1**
(c) compressive stress in bending

vi)　1 Mark allotted (bonus)　**1**

vii)　The energy absorb by brake is always kinetic.　**1**
(b) None of these

viii)　In case of a multiple disc clutch, if n_1 are the number of discs on the driving shaft and n_2 are the number of the discs on the driven shaft, then the number of pairs of contact surfaces will be　**1**
(c) $n_1 + n_2 - 1$

ix)　When the length of the journal is equal to the diameter of the journal, then the bearing is said to be a　**1**
(d) square bearing

x)　In thrust bearings, the load acts　**1**
(a) along the axis of rotation

Q.2　i.　1 Mark for definition　**3**
2 Marks for Methods

ii.　3 Marks for endurance limit = 90.54 MPa　**7**
2 Marks for Stress amplitude = 36.72 MPa
2 Marks for Thickness t = 27.61 mm

OR　iii.　1 Mark for M_{max} = 6250000 N-mm　**7**
1 Mark for M_{min} = 2550000 N-mm
1 Mark for M_m = 4375000 N-mm
1 Mark for M_v = 1875000 N-mm
D = 60 mm

Q.3　i.　1 Mark for diameter of solid shaft = 50 mm　**3**
2 Marks for dia of hollow shaft = 50/25 mm

ii.　3 Marks for Mc = 756 N-m　**7**
3 Marks for Md = 819 N-m
1 Mark for d = 51.7 = 55 mm

OR　iii.　3 Marks for Mc = 606 N-m　**7**
3 Marks for Md = 887 N-m
1 Mark for d = 52.4 = 55 mm

Q.4　i.　3 Marks for Merits and Demerits　**3**
ii.　2 Marks for Diameters D_P = 400 mm; D_G = 800 mm　**7**

2 Marks for Module; m = 8 mm
2 Marks for face width ; b = 80 mm
1 Mark for No of Teeth; T_P = 50 ,T_G = 100

OR　iii.　2 Marks for Module; m = 6 mm　**7**
2 Marks for face width ; b = 50 mm
2 Marks for Diameters D_G = 144 mm
1 Mark for Axial load = 1790 N

Q.5　i　3 Mark for explanation　**3**

ii　2 Marks for explanation　**7**
2 Marks for total no of steel and bronze disc = 3 & 2
2 Marks for axial force = 2604 N
1 Mark for average pressure p = 0.25 MPa
2 Marks for Maximum pressure = 0.345 MPa

OR　iii　Force (P) for the clockwise and counter clockwise rotation of the brake drum　**7**
2 Mark for Tangential Force F_T = 2400 N
1 Mark for Tangential Force R_N= 8000 N
2 Marks for P = 1850 N
Location of the pivot or fulcrum to make the brake self-locking
3 Mark for location X = 667 mm

Q.6　i　Definition: 1 Mark　**3**
Classification: 2 Marks

ii　(a) Amount of Artificial cooling: 4 Marks　**7**
Coeff. of friction = 0.00433
W = 7000 N
Velocity = 2.36 m/s
Q_g = 71 J/s, Q_g = 28 J/s
Amount of artificial cooling = 43.5 J/s
(b) Mass of lubricating oil : 3 Marks
m = 0.233 kg/min

iii　1 Mark for pressure p = 0.7 N/mm2　**7**
2 Marks for Coeff. of friction = 495 N/108+0.002
2 Marks for heat generated Qg = 3628N2/108+0.01466N
2 Marks for N = 1295 rpm

****