MACHINE ELEMENTS & SYSTEM DESIGN
(MEC3101)

Time Allotted : 2½ hrs **Full Marks : 60**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 4 (four) from Group B to E, taking one from each group.

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

Group – A

1. Answer any twelve: **12 × 1 = 12**

Choose the correct alternative for the following

(i) Stress concentration factor is defined as the ratio of
(a) maximum stress to the endurance limit (b) nominal stress to the endurance limit
(c) maximum stress to the nominal stress (d) nominal stress to the maximum stress

(ii) Failure of a material is called fatigue when it fails
(a) at the elastic limit (b) below the elastic limit
(c) at the yield point (d) below the yield point

(iii) When a nut is tightened by placing a washer below it, the bolt will be subjected to
(a) tensile stress (b) compressive stress
(c) shear stress (d) none of these

(iv) The design of shafts made of brittle materials is based on
(a) Guest's theory (b) Rankine's theory
(c) St. Venant's theory (d) Von Mises Theory

(v) When a helical compression spring is subjected to an axial compressive load, the stress induced in the wire is
(a) tensile stress (b) compressive stress
(c) shear stress (d) bending stress

(vi) Lewis's equation in spur gears is used to find the.
(a) tensile stress in bending (b) shear stress
(c) compressive stress in bending (d) fatigue stress

(vii) The face angle of a bevel gear is equal to
(a) pitch angle – addendum angle (b) pitch angle + addendum angle
(c) pitch angle – dedendum angle (d) pitch angle + dedendum angle

(viii) A thin film bearing is a bearing
(a) where the surfaces of journal and the bearing are completely separated by a film of lubricant
(b) where the surfaces of journal and the bearing are partially separated by a film of lubricant and there is partial metal to metal contact
(c) where the surfaces of journal and the bearing are separated by a film created by elastic deflection of parts
(d) where there is no lubricant

(ix) In a flat belt drive, the belt can be subjected to a maximum tension (T) and centrifugal tension (T_C). The condition for transmission of maximum power is given by
(a) $T = T_C$ (b) $T = 2T_C$ (c) $T = 3T_C$ (d) $T = \sqrt{3}\ T_C$

(x) In case of V belt drive, the belt makes contact at
(a) the bottom of groove in the pulley (b) the bottom and the sides of groove in the pulley
(c) the sides of groove in the pulley (d) none of the above

Fill in the blanks with the correct word

(xi) Two close coiled helical springs with stiffness k1 and k2 respectively are connected in series. The stiffness of an equivalent spring is given by _____.

(xii) When a shaft is subjected to a bending moment M and a twisting moment T, then the equivalent twisting moment is equal to _____.

(xiii) The notch sensitivity q is expressed in terms of fatigue stress concentration factor K_f and theoretical stress concentration factor K_t , as _____.

(xiv) The product of the diametral pitch and circular pitch is equal to_____.

(xv) In helical gears, the right-hand helices on one gear will mesh _____ helices on the other gear.

Group - B

2. (a) State maximum shear stress theory of failure. *[(CO1)(Remember/LOCQ)]*

(b) A bracket, made of steel FeE 200 (S_{yt} = 200 N/mm²) and subjected to a force of 5 kN acting at an angle of 30° to the vertical, is shown in Fig. 1. The factor of safety is 4. Determine the dimensions of the cross section of the bracket. *[(CO1)(Apply/IOCQ)]*

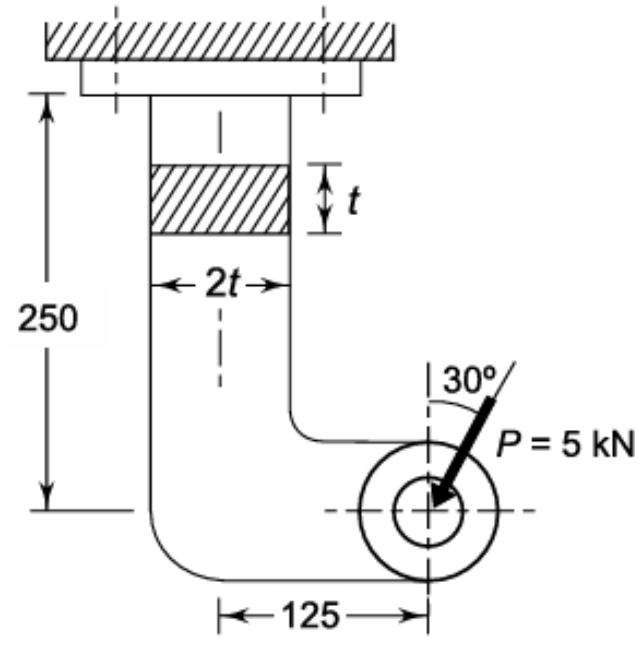

Fig. 1 (All Dimensions are in mm)

4 + 8 = 12

3. (a) What is repeated stress? Draw a stress–time curve for repeated stress. *[(CO2)(Remember/LOCQ)]*

(b) A rectangular plate, 15 mm thick, made of a brittle material is shown in Fig. 2. Calculate the stresses at each of three holes of 3-, 5-, and 10-mm diameter. *[(CO2)(Apply/IOCQ)]*

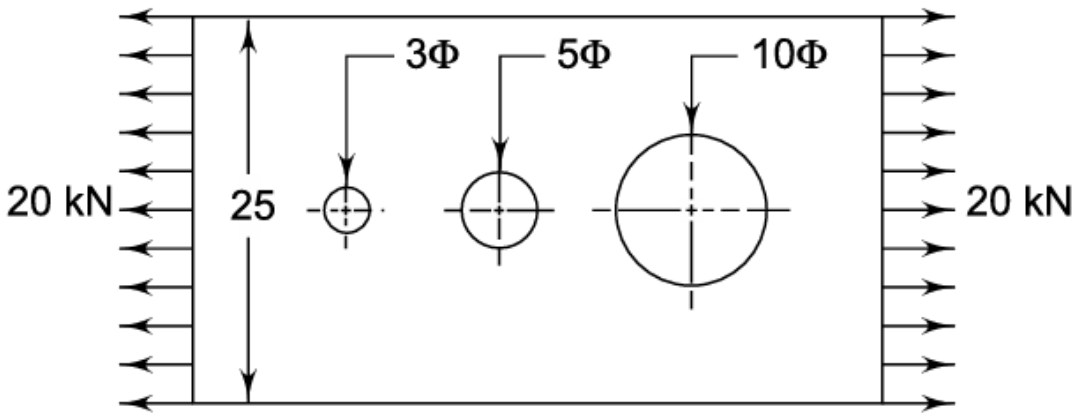

Fig. 2 (All Dimensions are in mm)

4 + 8 = 12

Group - C

4. (a) How will you designate ISO metric coarse threads? *[(CO3)(Remember/LOCQ)]*

(b) A bracket is bolted to a column by 6 bolts of equal size as shown in Fig. 3. It carries a load of 50 kN at a distance of 150 mm from the centre of column. If the maximum stress in the bolts is to be limited to 150 MPa, determine the diameter of bolt.

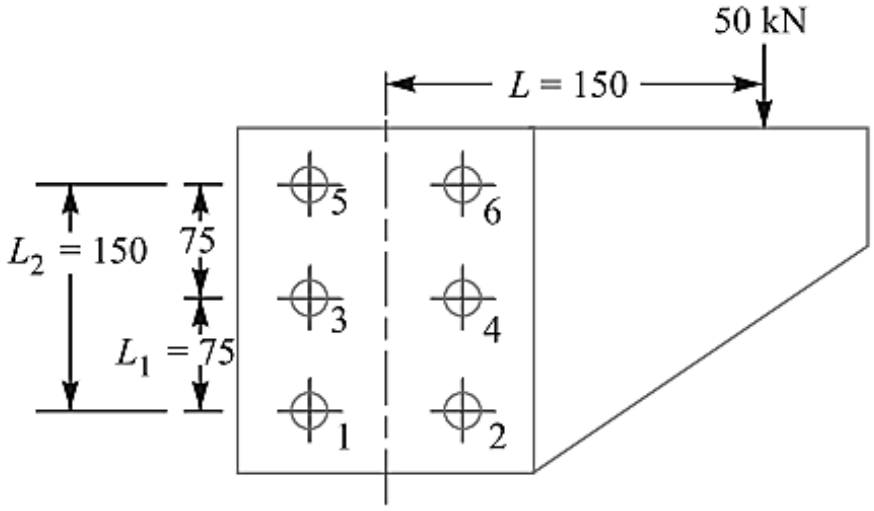

Fig. 3 (All Dimensions are in mm)

[(CO3)(Apply/IOCQ)]

3 + 9 = 12

5. (a) A shaft is supported on bearings A and B, 800 mm between centres as shown in Fig. 4. 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 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 weighs 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.

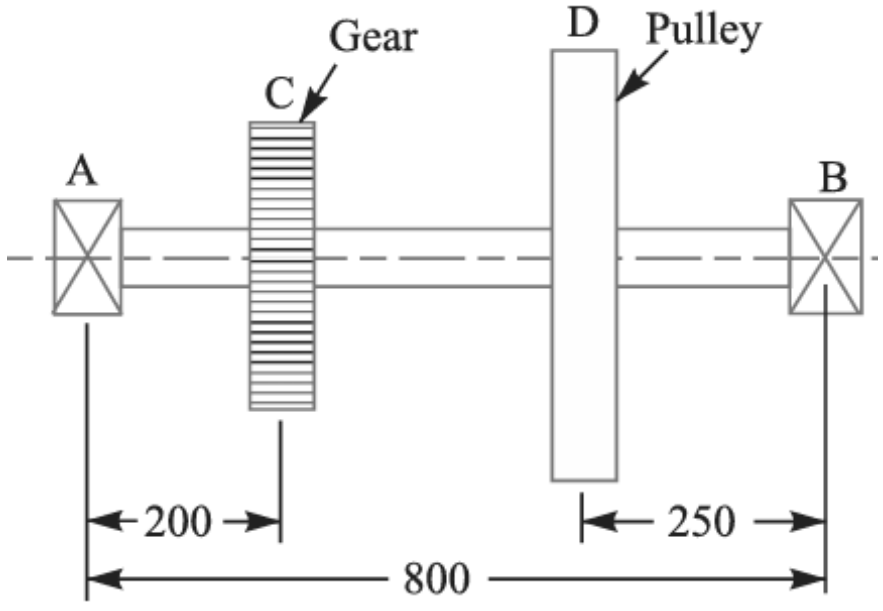

Fig. 4 (All Dimensions are in mm)

(b) What are the advantages of hollow shaft over solid shaft? *[(CO4)(Understand/LOCQ)]*

[(CO4)(Apply/IOCQ)]

9 + 3 = 12

Group - D

6. (a) How many types of bearings are there? Mention various types of rolling contact bearings. *[(CO4)(Remember/LOCQ)]*

(b) Select a single row deep groove ball bearing for a radial load of 5000 N and an axial load of 4000 N, operating at a speed of 1600 r.p.m. for an average life of 5 years at 10 hour per day. Assume uniform and steady load. *[(CO4)(Understand/IOCQ)]*

2 + 10 = 12

7. (a) State the Laws of Gearing. *[(CO5)(Remember/LOCQ)]*

(b) The gears shown in the Fig. 5 have a module of 10 mm and a 20° pressure angle. The pinion rotates at 1200 rev/min clockwise and transmits 120 kW through the idler pair to gear 4 on shaft c. What forces do gears 2 and 3 transmit to the idler shaft? *[(CO5)(Apply/IOCQ)]*

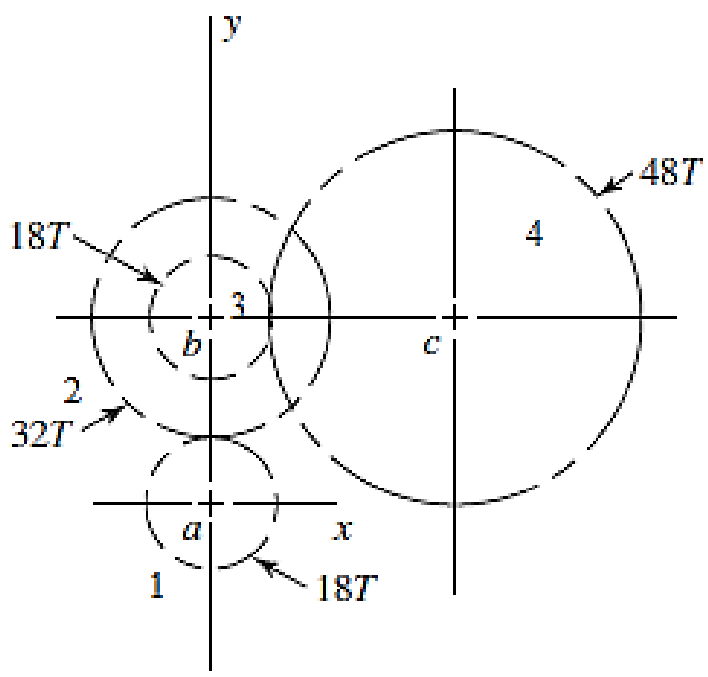

Fig. 5

2 + (5 + 5) = 12

Group - E

8. (a) What do you understand by hand of helix in a helical gear? Give your answer with a schematic representation. *[(CO5)(Understand/LOCQ)]*

(b) 7.5 kW power at 2000 rpm is supplied to the pinion through its shaft. The normal module is 6 mm, while the normal pressure angle is 20°. The helix angle is 23°. Determine the tangential, radial, and axial components of the resultant tooth force between the meshing teeth. *[(CO5)(Apply/IOCQ)]*

2 + 10 =12

9. (a) Write a short note on Damped Longitudinal vibration of a mass 'm' attached with a spring having stiffness 's' and damping coefficient of the environment is 'c'. What is Logarithmic Displacement? *[(CO6)(Understand/IOCQ)]*

(b) What is Magnification Factor (MF)? On which factors does it depend on? *[(CO5)(Remember/LOCQ)]*

(5 + 2) + (3 + 2) = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	26.04	73.96	0