MACHINE DESIGN-I
(MECH 3101)

Time Allotted : 3 hrs **Full Marks : 70**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

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

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**

(i) Carbon and Manganese content of steel having grade 65C6 is?
(a) 0.65% and 0.5% to 0.7% (b) 0.65% and 0.6%
(c) 0.60% to 0.70% and 0.5% to 0.7% (d) 0.60% to 0.70% and 0.6%.

(ii) According to Indian standard specifications, a grey cast iron designated by 'FG 900/2' means that
(a) It has Yield Strength of 900 MPa and minimum percentage elongation is 2
(b) It has Yield Strength of 900 MPa and minimum percentage elongation is 0.2
(c) It has Ultimate Strength of 900 MPa and minimum percentage elongation is 2
(d) It has Ultimate Strength of 900 MPa and Min percentage elongation is 0.2.

(iii) For Principal Stress theory, the shape of the region of safety on σ_1, σ_2 co-ordinate system
(a) square (b) hexagon (c) ellipse (d) circle.

(iv) Coulomb, Tresca and Guest's theory of failure is applicable to
(a) Ductile materials (b) elastic materials (c) brittle materials (d) plastic materials.

(v) A self-locking screw has
(a) fine threads
(b) coarse threads
(c) two nuts
(d) coefficient of friction more than tangent of lead angle.

(vi) Stresses on a cantilever beam is varying between maximum value of +150 MPa and a minimum value of -82 MPa. This nature of variation of stresses is specifically called as
(a) repeated stress (b) uneven stress
(c) fluctuating stress (d) reversed stress.

(vii) The approximate relationship between endurance limit of rotating beam specimen (S_e') and ultimate tensile strength (S_{ut}), in case of cast iron and cast steel components, is
(a) $S_e' = 0.4\ S_{ut}$ (b) $S_e' = 0.75\ S_{ut}$ (c) $S_e' = 0.577\ S_{ut}$ (d) $S_e' = 0.5\ S_{ut}$.

(viii) In transverse fillet welded joint, the size of weld is equal to
(a) 0.5 × Throat of the weld (b) 2 × Throat of the weld
(c) $\sqrt{2}$ × Throat of the weld (d) Throat of the weld.

(ix) The condition for maximum power transmission is that the maximum tension in the flat belt should be equal to
(a) 3 T_C (b) T_C (c) $T_C/3$ (d) 2 T_C.
where T_C is tension in belt due to centrifugal force

(x) When the helical torsion spring is subjected to torque, the type of stress induced in the spring wire is,
(a) tensile stress (b) compressive stress
(c) bending stress (d) torsional shear stress.

Group – B

2. (a) Designate the following steel alloys (i) 40Cr1Mo28 (ii) X75W18Cr4V1. [(CO1)(Remember/LOCQ)]
(b) Find out the numbers of R20/4(100, ... , 1000). [(CO1)(Analyse/IOCQ)]
(2 + 2) + 8 = 12

3. (a) A ductile hot-rolled steel bar has a minimum yield strength in tension and compression of 300 MPa. Using the distortion-energy and maximum-shear-stress theories determine the factors of safety for the following plane stress states:
(i) $\sigma_x = 100$ MPa, $\sigma_y = 50$ MPa ,
(ii) $\sigma_x = 100$ MPa, $\sigma_y = 20$ MPa, $\tau_{xy} = -20$ MPa. [(CO2)(Analyze/IOCQ)]
(b) What are the three basic modes of failure of mechanical components? Explain them in brief. [(CO2)(Understand/LOCQ)]
(4 + 4) + 4 = 12

Group - C

4. (a) What is stress concentration factor? What are the causes of stress concentration? [(CO3)(Remember/LOCQ)]
(b) The support bracket shown in Fig.1 is made of mold cast-aluminium alloy (S_{ut} = 262 MPa, S_{yt} = 186 MPa) and subjected to a static pure bending moment of 100 Nm. Would you expect the part to fail when the load is applied? [(CO3)(Analyse/IOCQ)]

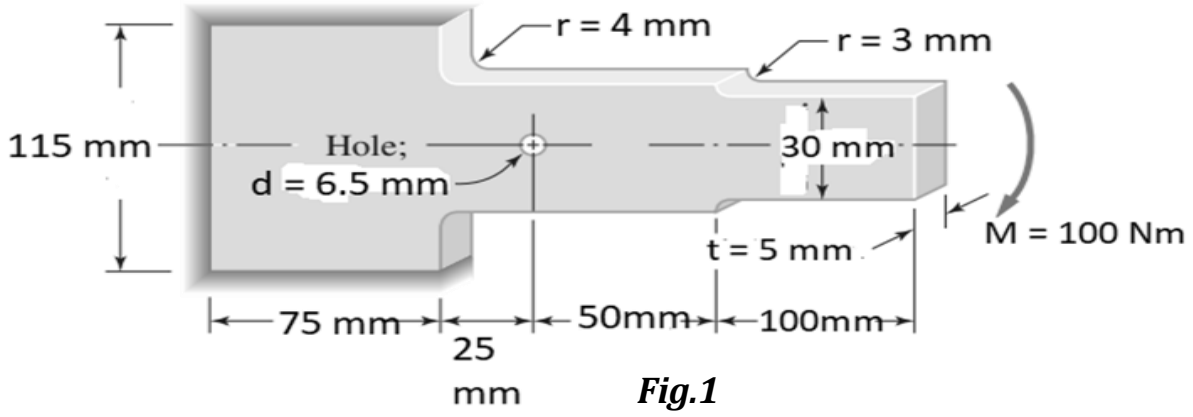

Fig.1

4 + 8 = 12

5. (a) Discuss about various types of cyclic loading with neat schematic representations. [(CO4)(Classify/LOCQ)]

(b) A machine part will be cycled at ±410 MPa for 5×10^3 cycles. Then the loading will be changed to ±290 MPa for 5×10^4 cycles. Finally, the load will be changed to ±245 MPa. How many cycles of operation can be expected at this stress level? For the part, S_{ut} = 580 MPa, f = 0.9, and has a fully corrected endurance strength of S_e = 230 MPa.

[(CO4)(Access/IOCQ)]

4 + 8 = 12

Group – D

6. A cast iron bracket fixed to the steel structure is shown in Fig.2. It supports a load P of 31 kN. There are two bolts at A and two bolts at B. The distances are as follows,
$l_1 = 45mm, l_2 = 200mm$ and $l = 400mm$
Determine cross-sectional area of the shank diameter of the bolts and corresponding size of the bolts, if maximum permissible tensile stress in the bolt is 60 N/mm^2.

[(CO5)(Design/IOCQ)]

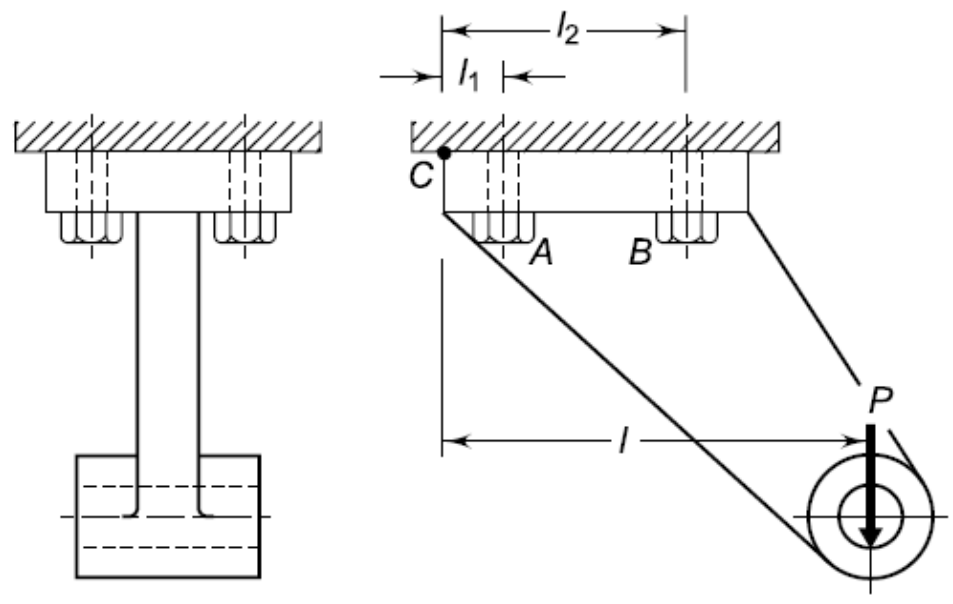

Fig. 2

(9 + 3) = 12

7. (a) A double-threaded power screw is used to raise a load of 5kN. The nominal diameter is 60mm and the pitch is 9mm. The threads are Acme type (2θ = 30°) and the coefficient of friction at the screw threads is 0.15. Neglecting collar friction, calculate:
(i) the torque required to raise the load;
(ii) the torque required to lower the load;
(iii) the efficiency of the screw for lifting load. [(CO5)(Analyse/IOCQ)]

(b) A steel plate subjected to a force of 5kN and fixed to a channel by means of three identical bolts is shown in Fig.3. The bolts are made from plain carbon steel 45C8 (S_{yt} = 380 N/mm^2) and the factor of safety is 3. Specify the size of bolts.

[(CO5)(Analyse/IOCQ)]

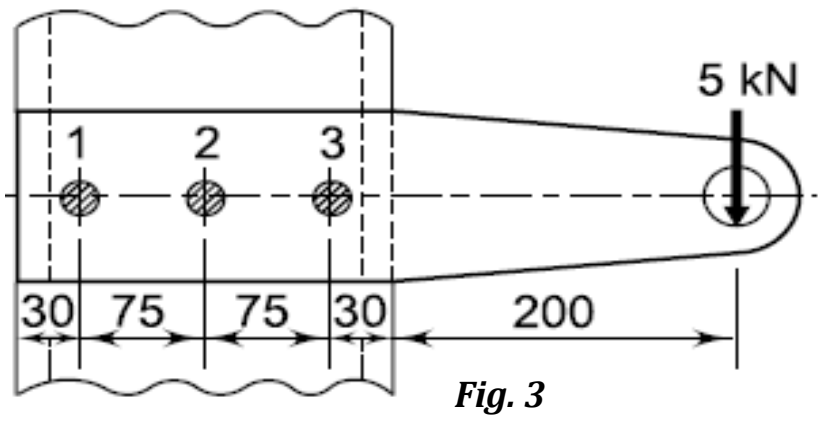

Fig. 3

6 + 6 = 12

Group - E

8. (a) A propeller shaft is required to transmit 50 kW power at 600 rpm. It is a hollow shaft, having an inside diameter 0.8 times of the outside diameter. It is made of steel (S_{yt} = 380 N/mm^2) and the factor of safety is 4. Calculate the inside and outside diameters of the shaft. Assume ($S_{sy} = 0.5S_{yt}$). [(CO6)(Analyse/IOCQ)]

(b) It is required to design a helical compression spring subjected to a maximum force of 8.5 kN. The mean coil diameter should be 150 mm from space consideration. The spring rate is 75 N/mm. The spring is made of oil-hardened and tempered steel wire with ultimate tensile strength of 1250 N/mm^2. (Take spring index (C) = 7.2). The

permissible shear stress for the spring wire is 30% of the ultimate tensile strength and Modulus of Rigidity G = 81 370 N/mm². Calculate: (i) Wire Diameter and (ii) Number of Active Coils. [(CO6)(Design/IOCQ)]

6 + (3 + 3) = 12

9. (a) A hollow transmission shaft, having inside diameter 0.6 times the outside diameter, is made of plain carbon steel 40C8 (S_{yt} = 400 N/mm²) and the factor of safety is 4. A belt pulley, 1000 mm in diameter, is mounted on the shaft, which overhangs the left hand bearing by 250 mm. The belts are vertical and transmit power to the machine shaft below the pulley. The tension on the tight and slack sides of the belt are 3 kN and 1 kN respectively, while the weight of the pulley is 500 N. The angle of wrap of the belt on the pulley is 180°. Calculate the outside and inside diameters of the shaft. [(CO6)(Analyse/IOCQ)]

(b) The layout of a leather belt drive transmitting 25 kW of power is shown in Fig.4. The centre distance between the pulleys is twice the diameter of the bigger pulley. The belt should operate at a velocity of 20 m/s approximately and the stresses in the belt should not exceed 2.25 N/mm². The density of leather is 0.95 g/cc and the coefficient of friction is 0.35. The thickness of the belt is 5 mm. Calculate:
(i) the diameter of pulleys;
(ii) the length and width of the belt; and
(iii) the belt tensions.[(CO6) (Analyse /IOCQ)]

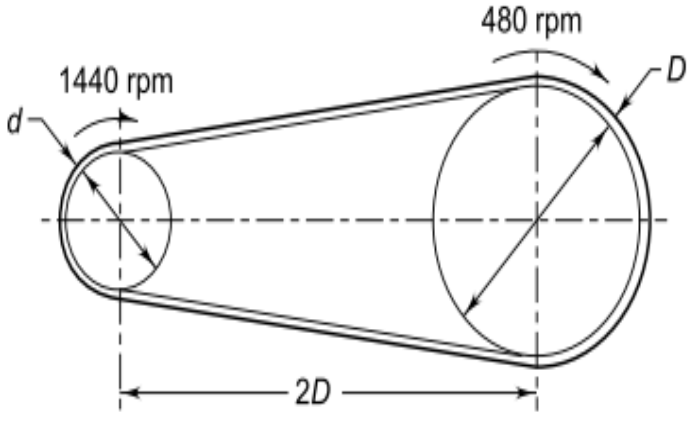

Fig.4

6 + 6 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	16.67	83.33	0

Course Outcome (CO):

On completion of this course students will be able to

1. Choose suitable material of a product to be designed as per the application and strength requirement.
2. Relate relevant 'Mode of Failure' and 'Theory of Failure' when solving a problem regarding design of machine components under different types of loadings and boundary conditions.
3. Identify proper stress intensity factors for objects with dimensional discontinuity subjected to different loadings and boundary conditions.
4. Analyse life of a machine component with or without dimensional discontinuity subjected to various dynamic loadings constrained with different boundary conditions.
5. Evaluate detailed specifications for fasteners like screw, nut-n-bolt, for welding and power screw by analysing the machine component subjected to various loading and boundary conditions.
6. Design a solid and hollow shaft, coil and leaf spring, shaft couplings and various belts for a belt drive for given power rating, loadings and boundary conditions.

*LOCQ: Lower Order Cognitive Question; IOCQ: Intermediate Order Cognitive Question; HOCQ: Higher Order Cognitive Question.