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) Series factor for R40 preferred number series is [(CO1)(IOCQ)]
(a) 1.58 (b) 1.26 (c) 1.12 (d) 1.06.

(ii) For distortion energy theory, the shape of the region of safety on σ_1, σ_2 co-ordinate system is [(CO2) (LOCQ)]
(a) Square (b) Hexagon (c) Ellipse (d) Circle.

(iii) When a ferrous material is subjected to fatigue loading, the ratio of endurance limit to the ultimate tensile stress is nearly equal to [(CO4) (IOCQ)]
(a) 0.25 (b) 0.35 (c) 0.5 (d) 0.7.

(iv) A static load is mounted at the centre of a shaft rotating at uniform angular velocity. This shaft will be designed for [(CO4) (IOCQ)]
(a) the maximum compressive stress (static)
(b) the maximum tensile stress (static)
(c) the maximum bending moment (static)
(d) fatigue loading.

(v) The size of a fillet weld is given by [(CO4) (LOCQ)]
(a) throat of fillet (b) smaller side of triangle
(c) hypotenuse of triangle (d) bigger side of triangle.

(vi) The efficiency of a power screw is a function of [(CO5) (LOCQ)]
1. Screw geometry 2. Coefficient of friction 3. Load on the screw
Which of these statements are correct?
(a) 1, 2 and 3 (b) 2 and 3 (c) 1 and 3 (d) 1 and 2.

(vii) A spring with 25 active coils cannot be accommodated within a given space, hence 5 coils of the spring are cut. What is the stiffness of the new spring? [(CO6) (IOCQ)]
(a) same as that of original spring (b) 1.25 times that of original spring.

(c) 0.8 times that of original spring (d) 0.5 times that of original spring.

(viii) The design stress for a shaft is taken as _____ times the tensile stress at the elastic limit or _____ time the ultimate stress which ever us small. [(CO6) (LOCQ)]
(a) 0.25 and 0.15 (b) 0.3 and 0.18
(c) 0.4 and 0.25 (d) 0.5 and 0.3.

(ix) Stresses which vary from a minimum value to a maximum value of the same nature (i.e. tensile or compressive) is called [(CO3) (IOCQ)]
(a) repeated stress (b) yield stress
(c) fluctuating stress (d) reversed stress

(x) A cast iron designated by FG300 is, [(CO1) (LOCQ)]
(a) grey cast iron with carbon content of 3%
(b) grey cast iron with ultimate tensile strength of 300 N/mm^2
(c) grey cast iron with compressive strength of 300 N/mm^2
(d) grey cast iron with tensile yield strength of 300 N/mm^2 .

Group – B

2. (a) Designate the following steel alloys (i) 40Ni8Cr8V2 (ii) X15Cr25Ni12. [(CO1) (LOCQ)]
(b) It is required to standardise load-carrying capacities of dumpers in a manufacturing unit. The maximum and minimum capacities of such dumpers are 40 and 630kN respectively. The company is interested in developing seven models in this range. Specify their load carrying capacities. [(CO1)(IOCQ)]

(2 + 2) + 8 = 12

3. (a) A ductile hot-rolled steel bar has a minimum yield strength in tension and compression of 350 MPa. Using the distortion-energy and maximum-shear-stress theories determine the factors of safety for the following plane stress states: (i) σ_x = 100 MPa, σ_y = 100 MPa (ii) σ_x = −50 MPa, σ_y = −75 MPa, τ_{xy} = −50 MPa [(CO2) (Analyze)/IOCQ)]
(b) What do you understand by factor of safety? Describe in brief the factors upon which factor of safety depends. [(CO2)(Understand/(LOCQ)]

(4 + 4) + 4 = 12

Group – C

4. (a) Knowing that the hole has a diameter of 9 mm as shown in Figure 1, determine (i) the radius r_f of the fillets for which the same maximum stress occurs at the hole A and at the fillets, (ii) the corresponding maximum allowable load P if the allowable stress is 100 MPa. [(CO3) (Analyze/IOCQ)]

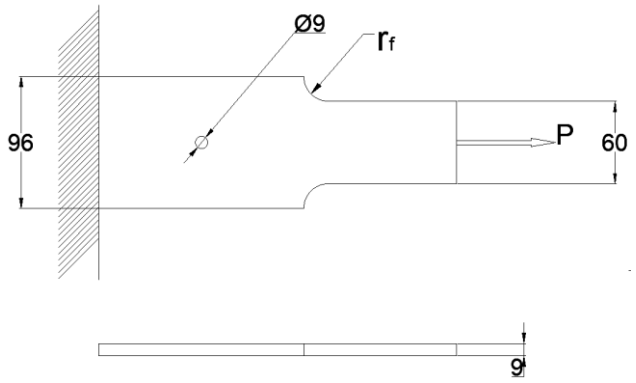

Fig.1

All Dimensions are in mm

(b) What are the methods of reducing stress concentration?
[(CO3) (Understand/LOCQ)]

(4 + 4) + 4 = 12

5. (a) An alloy steel strut for an experimental aircraft application is fabricated from a supply of material that has an ultimate strength of 930 MPa, yield strength of 827 MPa, elongation of 20 percent in 0.0508 m, and fatigue properties under test conditions that match the actual operating conditions, as shown in the table of experimental results in Table 1. The cross-sectional area of the strut is 6.45 x 10^{-5} m^2 and buckling has been found not to be a problem due to the selected cross-sectional shape. In service, the strut is to be subjected to the following spectrum of completely reversed axial loads during each duty cycle:
P_a = 48928 N for 1000 cycles
P_b = 36918 N for 4000 cycles
P_c = 28912 N for 500,000 cycles
This duty cycle is to be repeated three times during the life of the strut. Assuming fatigue to be the governing failure mode, would this strut be expected to survive all three duty cycles, or would it fail prematurely?
[(CO4) (Evaluate/HOCQ)]

Table 1: Fatigue Test Data for Strut Material

Stress Amplitude (MPa)	Cycles to Failure, N
758	6600
723	9500
689	13500
655	19200
620	27500
586	39000
551	55000
517	87000
503	116000
489	170000
482	220000
475	315000
472	400000
468	∞

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

8 + 4 = 12

Group – D

6. (a) For supporting the travelling crane in a workshop, the brackets are fixed on steel columns as shown in Figure 2. The maximum load that comes on the bracket is 12kN acting vertically at a distance of 400 mm from the face of the column. The vertical face of the bracket is secured to a column by four bolts, in two rows (two in each row) at a distance of 50 mm from the lower edge of the bracket; determine the size of the bolts if the permissible value of the tensile stress for the bolt material is 84 MPa. Also find the cross-section of the arm of the bracket which is rectangular.[(CO5) (Analyze/IOCQ)]

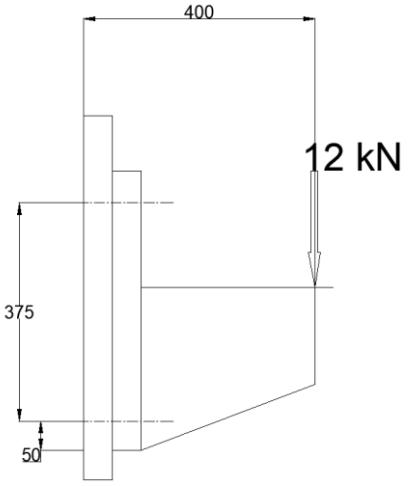

Fig.2

All Dimensions are in mm

(b) Designate the following threads (i) Sq 30X6 (ii) Tr 40X14(P7)LH [(CO5) (Understand/LOCQ)]

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

7. (a) A sluice valve, used in a water-pipeline, consists of a gate raised by the spindle, which is rotated by the hand wheel. The spindle has single-start square threads. The nominal diameter is 36 mm and the pitch is 6 mm. The inner and outer diameters of the friction collar are 30 mm and 50 mm respectively. The coefficients of friction at the threads and the collar are 0.15 and 0.20 respectively.

The weight of the gate is 7.5 kN and the frictional resistance to open the valve due to water pressure is 2.5 kN. Using the uniform wear theory for collar friction, calculate:

(i) The torque required to raise the gate

(ii) The overall efficiency of the mechanism. [(CO5) (Analyze/IOCQ)]

(b) What do you understand by the single start and double start threads? Briefly explain the meaning of bolt M24 x 2. [(CO5) (Understand/LOCQ)]

8 + (2 + 2) = 12

Group – E

8. (a) A shaft is supported by two bearings placed 1m apart. A 600mm diameter pulley is mounted at a distance of 300mm to the right of left hand bearing and this drives a pulley directly below it with the help of belt having maximum tension of 2.25kN. Another pulley 400 mm diameter is placed 200mm 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. [(CO6) (Analyze/IOCQ)]

   (b) What is the Wahl factor? Why is it used? [(CO6) (Remember/LOCQ)]

8 + 4 = 12

9. (a) It is required to design a helical compression spring subjected to a force of 500 N. The deflection of the spring corresponding to this force is approximately 20 mm. The spring index should be 6. The spring is made of cold-drawn steel wire with ultimate tensile strength of 1000 N/mm^2. The permissible shear stress for the spring wire can be taken as 50% of the ultimate tensile strength (G = 81370 N/mm^2). Design the spring and calculate:
(i) wire diameter; (ii) mean coil diameter; (iii) number of active coils; (iv) total number of coils; (v) free length of the spring; and (vi) pitch of the coils. [(CO6) (Design/HOCQ)]

   (b) A 15kW power motor rotating at 700 rpm is attached with a pump using a rigid flange coupling. Shaft of the pump is made of plain carbon steel of grade 30C8 having Yield Stress S_{yt} = 400 N/mm^2. Keys used for attachment of flange hubs with the shafts and bolts used for fastening two flanges togetherare made of plain carbon steel of grade 40C8 whose Yield Stress 'S_{yt}' is 380 N/mm^2. Flanges are made ofcast iron of grade FG200 having Yield Stress S_{yt} = 200 N/mm^2. Design the complete flange consideringbolts are fitted in reamed and ground holes of the flange. In the above designing process consider factor of safety 3 for Shaft and Keys and 6 for Flanges. [(CO6) (Design/HOCQ)]

6 + 6 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	31.13%	50.00%	18.86%

Course Outcome (CO):

After the completion of the course students will be able to

CO1	**Choose** suitable material of a product to be designed as per the application and strength requirement.
CO2	**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.

CO3	**Identify** proper stress intensity factors for objects with dimensional discontinuity subjected to different loadings and boundary conditions.
CO4	**Analyze** life of a machine component with or without dimensional discontinuity subjected to various dynamic loadings constrained with different boundary conditions.
CO5	**Evaluate** detailed specifications for fasteners like screw, nut-n-bolt, for welding and power screw by analyzing the machine component subjected to various loading and boundary conditions.
CO6	**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

Department & Section	Submission link:
ME-A	https://classroom.google.com/u/1/w/NDA1NTU3NjA5MDE2/tc/NDY0NDU5NDMwNjM5
ME-B	https://classroom.google.com/c/NDA2MDQ1NzI4NzA3/a/NDY0MjkxMzc4NDMy/details