MACHINE DESIGN - I
(MECH 3101)

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

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and
<u>any 4 (four)</u> from Group B to E, taking <u>one</u> 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) Series factor for R20 series is,
(a) $\sqrt[10]{20}$ (b) $\sqrt{20}$ (c) $\sqrt[20]{10}$ (d) $\sqrt[20]{20}$

(ii) Distortion energy theory of failure is applicable to
(a) components made of plain carbon steel   (b) components made of composites
(c) components made of cast iron   (d) components made of non-metals.

(iii) The bending stress induced in a beam is
(a) maximum at the farthest fiber from neutral axis and zero at the neutral axis
(b) uniform throughout the cross-section
(c) zero at the farthest fiber from neutral axis and maximum at the neutral axis
(d) zero at the neutral axis as well as at the farthest fiber.

(iv) The stress which vary from a minimum value to a maximum value of the same nature (i.e. tensile or compressive) is called
(a) repeated stress   (b) yield stress
(c) fluctuating stress   (d) alternating stress.

(v) In cyclic loading, stress concentration is more serious in
(a) brittle materials   (b) ductile materials
(c) brittle as well as ductile materials   (d) elastic materials.

(vi) A bolt of M 24 × 2 means that
(a) the pitch of the thread is 24 mm and depth is 2 mm
(b) the cross-sectional area of the threads is 24 mm²
(c) the nominal diameter of bolt is 24 mm and the pitch is 2 mm
(d) the effective diameter of the bolt is 24 mm and there are two threads per cm.

(vii) The surface finish factor for a mirror polished material is
(a) 0.45   (b) 0.65   (c) 0.85   (d) 1.

(viii) The transverse fillet welded joints are designed for
(a) tensile strength   (b) compressive strength
(c) bending strength   (d) shear strength.

(ix) When a belt drive is transmitting maximum power,
(a) effective tension is equal to the centrifugal tension
(b) effective tension is half of the centrifugal tension
(c) driving tension in slack side is equal to the centrifugal tension
(d) driving tension in tight side is twice the centrifugal tension.

(x) 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.

Fill in the blanks with the correct word

(xi) According to distortion energy theory of failure, the allowable stress in terms of tensile yield strength (S_{yt}) is equal to _____.

(xii) For maximum shear stress theory, the shape of the region of safety on σ_1 and σ_2 co-ordinate system is a _____.

(xiii) In transverse fillet welded joint, the size of weld is equal to _____ × Throat of the weld.

(xiv) A screw is said to be self-locking screw, if its efficiency is less than _____ %.

(xv) _____ spring is used in a mechanical wrist watch.

Group - B

2. (a) Mention Material type, name and chemical compositions of FG200, 55C4 and 40C8. *[(CO1)(Remember/LOCQ)]*

(b) Find out the numbers of the R5 basic series from 1 to 10. Find out the numbers of R20/4(100, ..., 1000) derived series.
[(CO1)(Understand/IOCQ)]

4 + 8 = 12

3. A bracket, made of steel FeE 200 (S_{yt} = 200 N/mm²) and subjected to a force of 7 kN acting at an angle of 40° to the vertical, is shown in Fig.1. The factor of safety is 4. Determine the dimensions of the cross-section of the bracket.

Fig. 1 *[(CO1)(Analysis/HOCQ)]*
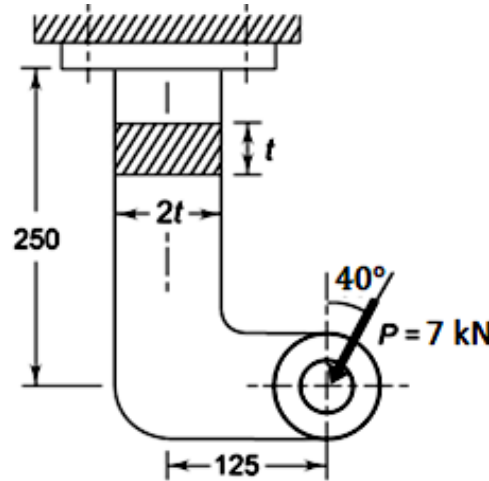
12

Group - C

4. (a) Find the maximum stress induced in the following cases shown in Fig.2 taking stress concentration into account: (i) A rectangular plate 60 mm × 10 mm with a hole 12 diameter as shown in Fig.2(a) and subjected to a tensile load of 12 kN. (ii) A stepped shaft as shown in Fig.2(b) and carrying a tensile load of 12 kN.
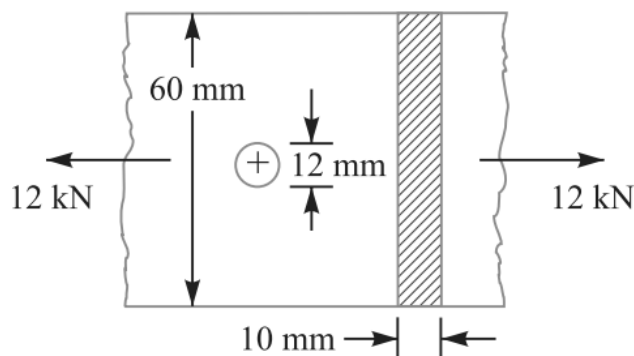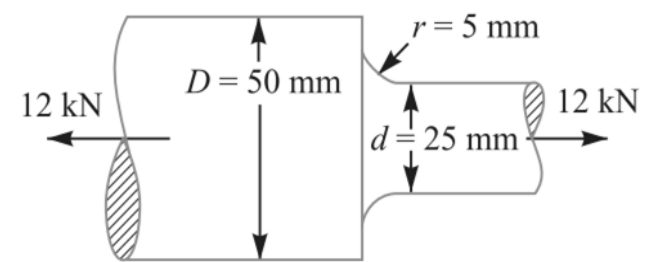

Fig. 2(a)

Fig. 2(b)

[(CO3)(Analyse/IOCQ)]

(b) What is meant by endurance strength of a material? How do the size and surface condition of a component and type of load affect such strength? *[(CO4)(Remember/LOCQ)]*

(4 + 4) + 4 = 12

5. (a) A cantilever beam made of cold drawn steel 40C8 (S_{ut} = 600 N/mm² and S_{yt} = 380N/mm²) is shown in Fig.3. The force P, acting at the free end varies from -40N to +140 N. The expected reliability is 90 % and the factor of safety is 2. The notch sensitivity factor at the fillet is 0.9. Determine the diameter 'd' of the beam at the fillet cross-section. *[(CO4)(Analyse/IOCQ)]*
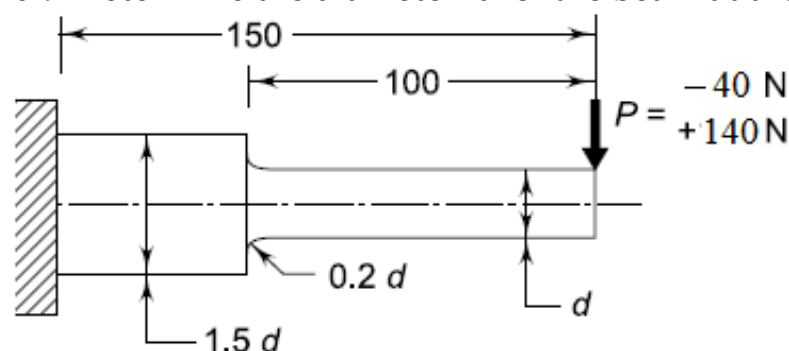
(All dimensions are in mm)
Fig. 3

(b) Draw the 'Soderberg' diagram for different types of fluctuating loads. *[(CO4)(Understand/LOCQ)]*

10 + 2 = 12

Group - D

6. (a) A steel plate subjected to a force of 10kN and fixed to a channel by means of three identical bolts is shown in Fig.4. The bolts are made from plain carbon steel 45C8 (S_{yt}= 380 N/mm²) and the factor of safety is 2. Specify the size of bolts.
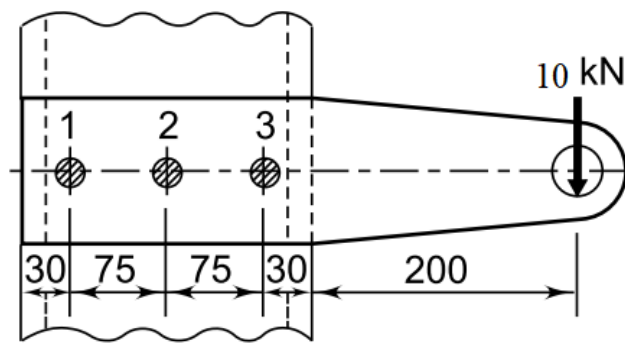
Fig. 4

(b) What do you understand by the single start and double start threads? [(CO5)(Understand/LOCQ)]

9 + 3 = 12

7. A rigid bracket subjected to a vertical force of 20 kN is shown in Fig.5. It is fastened to a vertical stanchion by means of four identical bolts. Determine the size of the bolts by maximum shear stress theory. The maximum permissible shear stress in any bolt is limited to 50 N/mm². [(CO5)(Analyse/IOCQ)]
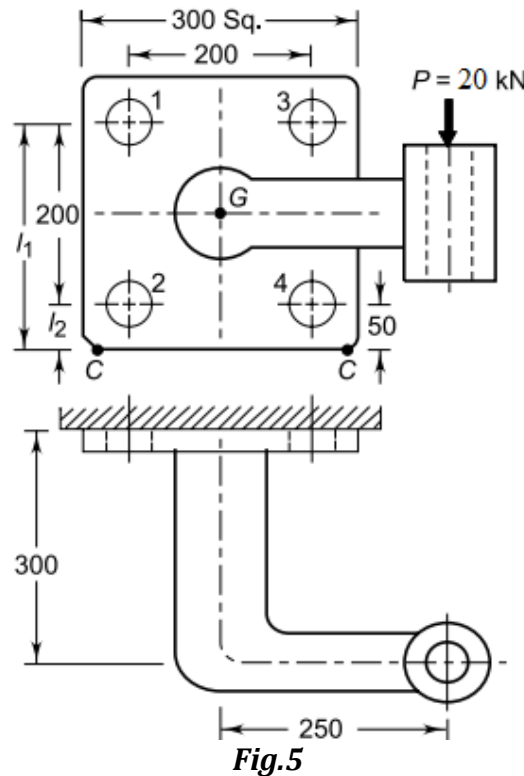

Fig.5

12

Group - E

8. (a) An intermediate shaft of a gearbox, supporting two spur gears A and B and mounted between two bearings C_1 and C_2, is shown in Fig.6. The pitch circle diameters of gears A and B are 500 and 250 mm, respectively. The shaft is made of alloy steel 20MnCr5. (S_{ut} = 620 N/mm² and S_{yt}= 480 N/mm²). The factors k_b and k_t of the ASME code are 2 and 1.5, respectively. The gears are keyed to the shaft. Determine the shaft diameter using the ASME code. [(CO6)(Analyse/IOCQ)]
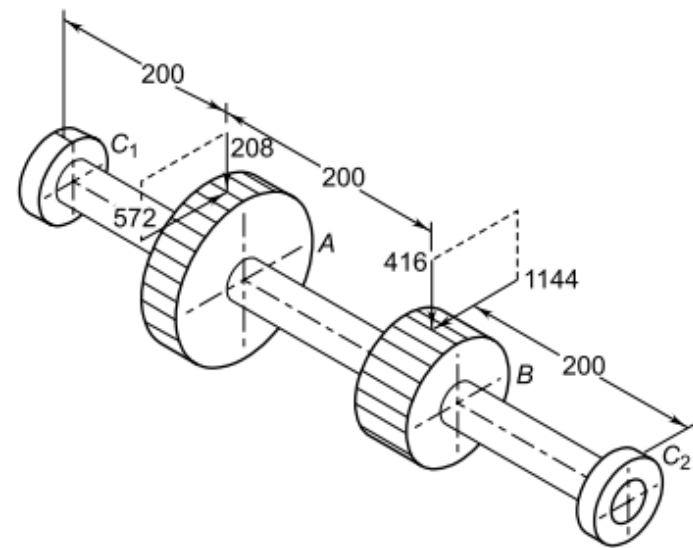
All Dimensions are in mm
Fig.6

(b) What are the advantages and disadvantages of bushed-pin flexible coupling? [(CO6)(Remember/LOCQ)]

9 + 3 = 12

9. A helical compression spring is required to deflect through approximately 25 mm when the external force acting on it varies from 500 to 1000 N. The spring index is 8. The spring has square and ground ends. There should be a gap of 2 mm between adjacent coils when the spring is subjected to the maximum force of 1000 N. The spring is made of cold-drawn steel wire with ultimate tensile strength of 1000 N/mm² and permissible shear stress in the spring wire should be 50% of the ultimate tensile strength (G = 81370 N/mm²). Design the spring and calculate: (i) wire diameter; (ii) mean coil diameter; (iii) number of active coils; (iv) total number of coils; (v) solid length; (vi) free length; (vii) required spring rate; and (viii) actual spring rate. [(CO6)(Design/HOCQ)]

12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	16.67	48.96	34.37

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.