Department of Mechanical Engineering
Motilal Nehru National Institute of Technology Allahabad
End Semester Examination
ME-1502/ME-501: Machine Design I
Session: 2016-17

M.M.90

Time: 3 Hr

Note: Printed data sheets are allowed. Attempt all the questions. In case any assumption is taken, mention clearly that in a box.

For Invigilators: Printed datasheet provided by course coordinator is allowed. It contains only tabular data and Figures. Any hand written matter and formula should be treated as unfair practice.

Q.1. The section of shaft shown in Fig.1 is to be designed to approximate relative sizes of d = 0.75D and r = D/20 with diameter d conforming to that of standard metric rolling-bearing bore sizes. The shaft is to be made of SAE 2340 steel, heat-treated to obtain minimum strengths at the shoulder area of 1276-MPa ultimate tensile strength and 1130-MPa yield strength with a Brinell hardness not less than 368. At the shoulder the shaft is subjected to a completely reversed bending moment of 75 N · m, accompanied by a steady torsion of 40 N · m. Use a design factor of 2.5 and determine the size the shaft for a finite life of 3 (10^5) cycles. (15

OR

Design a bushed-pin type flexible coupling for connecting a motor shaft to a pump shaft for the following service conditions: Power to be transmitted = 40 kW ; speed of the motor shaft = 900 r.p.m. ; diameter of the motor shaft = 50 mm ; diameter of the pump shaft = 40 mm. The bearing pressure in the rubber bush and allowable stress in the pins are to be limited to 0.5 N/mm² and 25 N/mm² respectively.

Q.2. (a) The cantilever bracket shown in Fig.2 is bolted to a column with three M12 x 1.75 ISO 8.8 bolts. The bracket is made from AISI 1020 hot rolled steel. Assume the bolt threads do not extend into the joint. Find the factors of safety for the following failure modes: shear of bolts, bearing of bolts, bearing of bracket, and bending of bracket. (10

(b) A square-thread power screw has a major diameter of 32 mm and pitch of 4 mm with double threads. The given data include co-efficient of frictions $f = f_c = 0.08$, mean diameter of the collar d_c = 44 mm, external force F = 7 kN per screw. Find (a) Find efficiency and raising the load (b) the von Mises stress at the root of the thread and (c) maximum shear stress at the root of the thread. (10

Q.3. Fig.3 shows a connection using cap screw. The joint is subjected to a fluctuating force whose maximum value is 22 kN per screw. The required data are: class 5.8 cap screw, M16; hardened-steel washer, t_w = 3.5 mm thick; steel cover plate, t_1 = 15 mm, E_s = 206 MPa; and cast-iron base, t_2 = 15 mm, E_d = 110 GPa. (a) Find k_b, k_m and C using the assumptions given in the caption of the Fig.3 and (b) find factors of safety guarding against separation and fatigue. (15

Q.4. (a) Show the stress distribution across the sides (leg and the side perpendicular to the leg) and throat of a fillet weld. For the case of transverse fillet weld what is the effect of considering entire external force on the minimum throat area? (8

(b) A specially rolled A36 structural steel section for the attachment has a cross section as shown in the Fig.4 and has yield and ultimate tensile strengths of 248 and 400 MPa respectively. It is statically loaded through the attachment centroid by a load of F = 110 kN. Unsymmetrical weld tracks are to compensate for eccentricity such as that there is no moment to be resisted by the welds. Specify the weld track lengths l_1 and l_2 for an 8-mm fillet weld using an E70XX electrode. Check the condition applicable for the base metal also. (1

Q.5 (a) Explain the methods of developing beneficial residual stresses in a helical spring? Why load reversal is not advisable in a helical spring? (5

(b) A music wire helical compression spring is to be designed with life 10^6 number of cycles to resist a dynamic load that varies from 20 to 80 N at 5 Hz while the end deflection varies from 12 to 36 mm. Because of assembly considerations, the solid height cannot exceed 25 mm and the free length cannot be more than 100 mm. (1

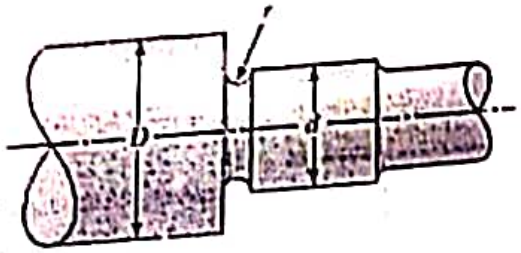

Fig.1

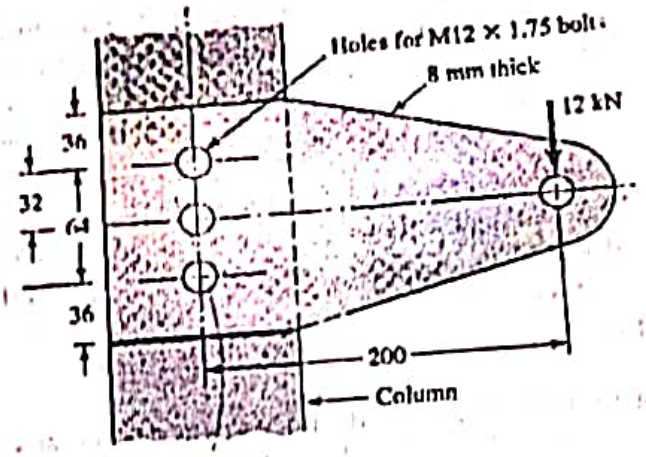

Fig.2

Pressure-cone frustum member model for a cap screw. For this model the significant sizes are

$$l = \begin{cases} h + t_2/2 & t_2 < d \\ h + d/2 & t_2 \geq d \end{cases}$$

$D_1 = d_w + l \tan \alpha =$
$1.5d + 0.577l$
$D_2 = d_w = 1.5d$
where l = effective grip. The solutions are for $\alpha = 30°$ and $d_w = 1.5d$.

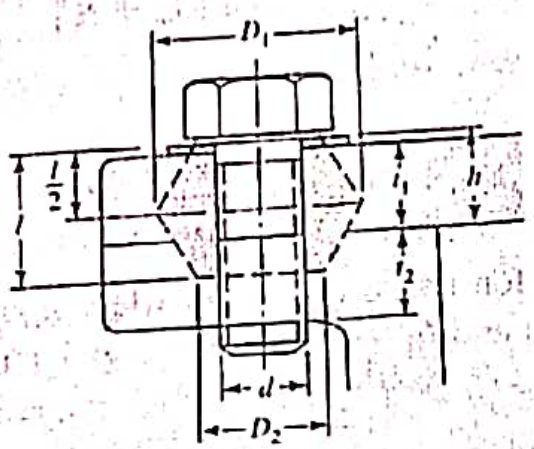

Fig.3

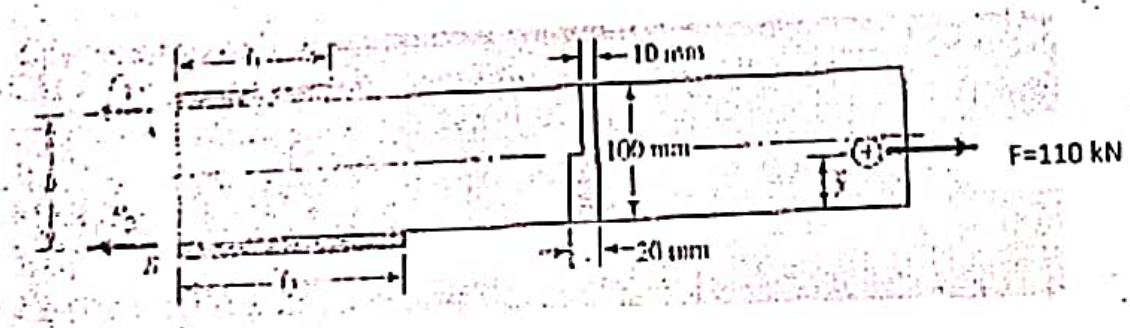

Fig. 4