BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI
FIRST SEMESTER 2023 – 2024
Comprehensive Exam
Mechanics of Solids

Course No: CE F211 **Date: 13. 12. 2023**
Time: 9 AM to 12 Noon
Instructions: **Max. Marks: 90**

(a) Part A will be Closed Book and Part B will be Open Book
(b) Assume necessary data suitably
(c) Solve Part B after submission of Part A
(d) Text book and Hand-written class notes are only allowed for Part B

Part A (Closed book)

Q1. A material is subjected to two mutually perpendicular linear strains together with a shear strain. One of the linear strains is 0.00025 tensile. Determine the magnitudes of the other linear strain and the shear strain if the principal strains are 0.0001 compressive and 0.0003 tensile. Use Mohr's circle method. **[2+2+2]**

Q2. Assume that the force exerted on the head of the nail being plucked out by the hammer is vertical, and neglect the hammer's weight (**Fig. Q2**).
(a) Draw the free-body diagram of the hammer.
(b) If F =10 N, what are the magnitudes of the forces exerted on the nail by the hammer and the reaction forces exerted on the floor by the hammer? **[2+4+2]**

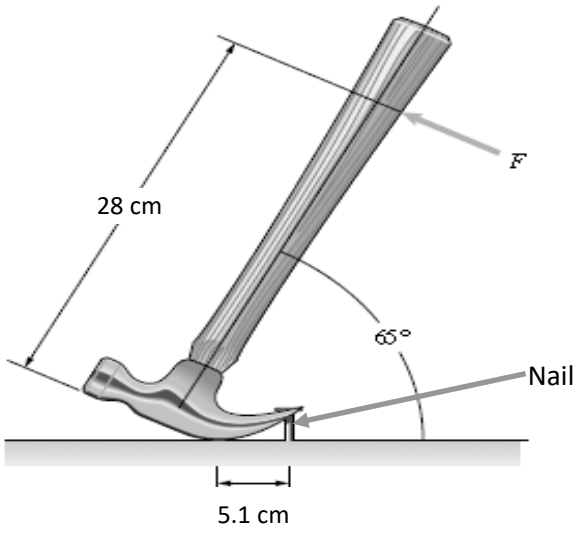


Fig. Q2

Q3. A circular bar is subjected to an axial pull of 100 kN. If the maximum intensity of shear stress on any oblique plane is not to exceed 60 MN/m^2, determine the diameter of the bar [**4]**

BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI
FIRST SEMESTER 2023 – 2024
Comprehensive Exam
Mechanics of Solids

Course No: CE F211 **Date: 13. 12. 2023**
Time: 9 AM to 12 Noon

Part B (Open Book)

Q1) A beam of I-section, 3m in length is simply supported at its ends and carries a uniforml distributed load of 15kN/m, as shown in Fig. Q1.

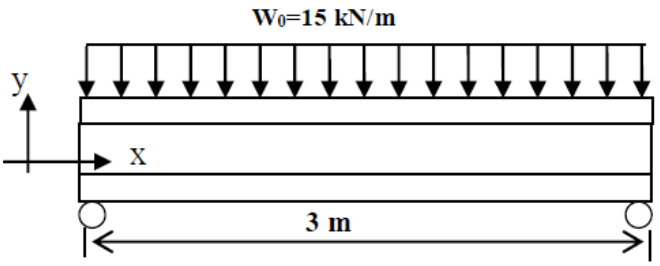
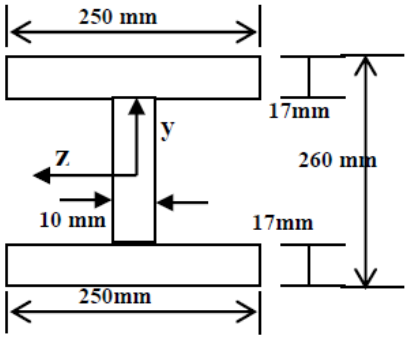


Fig. Q1.



Determine the maximum normal stress due to bending; where does it act? **[1+1]**
Determine the stress components (i.e. σ_x , σ_y and τ_{xy}) at
(i) A point on the neutral axis, at the left end of beam. **[2+2+2]**
(ii) A point on the web where it meets the flange, again at the left end of beam. **[2+2+2]**
For **(i)**, Determine the principal stress components and their orientation. **[4+2]**

Q.2 a) With neat illustrations, write boundary conditions, which correspond to, built in end, simply supported end and free end for the analysis of the beam. **[4]**
b) A beam *ABC* is simply supported at *A* and B and it overhangs from B to *C*, and is loaded as shown in **Fig.Q2(b)**. (Take EI = 2×10^5 MPa and I = 1.5×10^9 mm^4.) Calculate
i. slopes at *A* and B;
ii. deflection at free end;
iii. maximum deflection in the span AB. **[3+3+4+2+4]**

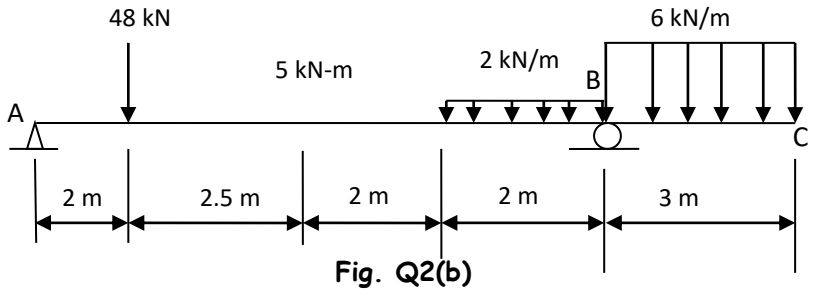


Fig. Q2(b)

Q3. A rectangular plate in biaxial stress (FigQ3) is subjected to normal stress σ_x= 65 MPa (Tension) and σ_y = - 20 MPa (Compression). The plate has dimensions 200×300× 15 mm and is made of aluminum with E = 75 GPa and v = 0.33. Determine

(a) The maximum in-plane Shear strain (γ_{max}) in the plate.

(b) The change (Δ t) in the thickness of the plate.

(c) The change (Δ V) in the volume of the plate.

[6+5+5]

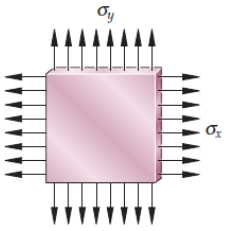


Fig. Q3

Q.4 (a) Write the basic assumptions for deformation of twisted circular shaft. **[2]**

Q4) b) The electric motor exerts a torque of 300N.m on the steel shaft ABCD when it is rotating at constant speed. Design specifications require that the diameter of the shaft be uniform from A to D and that the angle of twist between A and D not exceed 1.5^0. Knowing that $\tau_{max} \leq 60$ MPa and G=77 GPa, determine the diameter of the shaft that may be used. **[14]**

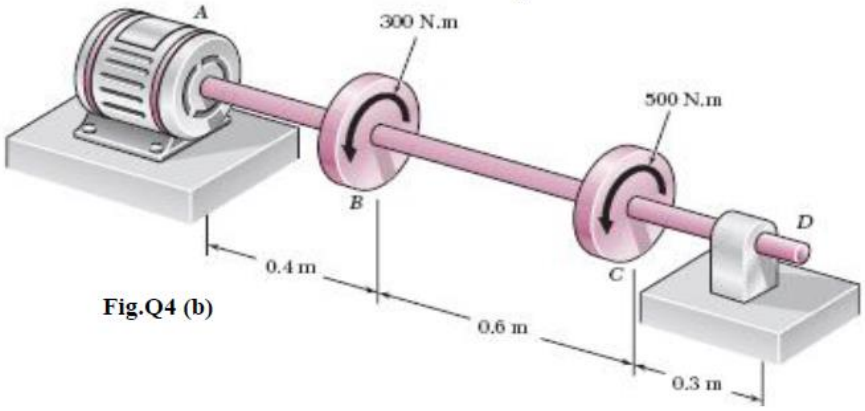


Fig.Q4 (b)