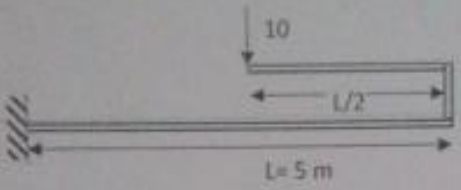
7. Draw the bending moment diagram for the cantilever beam shown in the Figure. (2 marks)



8. A rectangular block of material with modulus of rigidity $G = 620$ MPa is bonded to two rigid horizontal plates. The lower plate is fixed, while the upper plate is subjected to a horizontal force P. Knowing that the upper plate moves through 1.00 mm under the action of the force, what is the force P on the plate? (2 marks)

9. What is bulk modulus? If a material is incompressible then what is the value of its bulk modulus? (1 Mark)
10. What is plane stress? How many non-zero strain components are there in a plane stress condition, and what are they? (1 Mark)
11. What is a constitutive equation of a material? Write down generalized Hook's law for the isotropic material. (1 Mark)
12. What is the value of maximum shear stress if the principle stresses in a 2D condition is 10 MPa and -10 MPa. (1 Mark)
13. Can the principle stress direction and direction of maximum shear coincide? if not, why? (1 Mark)

AML 150

Mechanics of solids and fluids

MAJOR

(24 Nov. '12)

Answer all questions. Time: Two hours. Maximum marks = 90 (part I – 75 marks, part II – 15 marks).

PART I

1. An inclined gate has water on one side (see figure P1). A wooden float is tied to the gate as shown. Find the height of the water h at which the gate opens. The weight of the gate is W and the densities of water and wood are respectively ρ and ρ_w. (15)

2. A scalar function ϕ is given by $\phi = 6xyzt$. How can you construct a velocity field using this? What are the properties of this velocity field? In this velocity field the pressure at (1,1,1) is 5 Pascals at $t = 1$second. Determine the pressure at (2,2,2). (15)

3. A piston pushes water up a variable cross section pipe as shown in figure P3. The acceleration of the piston at this instant of time is a. Determine the force on the piston. Neglect the effects of viscosity. (15)

4. A thin plate moves with an unknown speed V at the centre of a long channel of width $2h$ as shown in figure P4. The plate is free to move along the channel but contrained in the perpendicular directions. The fluids on either side of the plate are different, with properties μ_1, μ_2, ρ_1 and ρ_2 respectively. The lower fluid is being driven with a pressure gradient dp/dx, which in turn drives the plate through viscous shear force which drives the fluid at the top half of the channel. Determine the velocity profiles in both halves of the channel as well as the speed V. (20)

5. Determine the force on the nozzle (figure P5). (10)

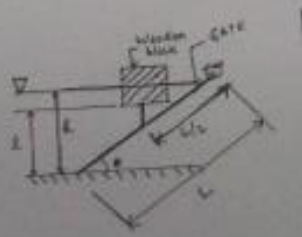


Figure P1

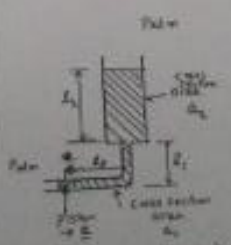


Figure P3

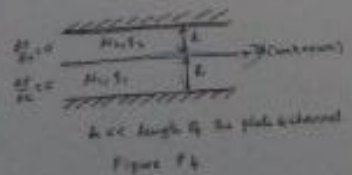


Figure P4

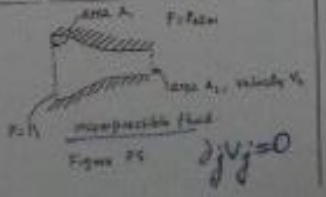


Figure P5

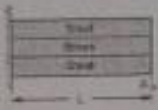
AML 150

Major

Part II

Answer for any 15 marks

1. The following figure shows a composite beam (at room temperature) made of steel and brass. Considering $\alpha_{brass} > \alpha_{steel}$, where α is the coefficient of thermal expansion, what type of stress is observed in the steel portion of the beam when the temperature is increased? (1 mark)



2. The ratio of the maximum deflections of a beam simply supported at its ends with an isolated central load and that of with a uniformly distributed load over its entire length, is
(a) 1 (b) 15/24 (c) 24/15 (d) 2/3 (1 mark)

3. For a given material, Young's modulus is 200 GPa GN/m^2 and modulus of rigidity is 80 GN/m^2. The value of Poisson's ratio is
(a) 0.15 (b) 0.25 (c) 0.2 (d) 0.3 (1 mark)

4. An element in plane stress is subjected to stresses $\sigma_x = 80$ MPa, $\sigma_y = 60$ MPa and $\tau_{xy} = 40$ MPa. What are the orientation of the principal planes (principal angles)? (1 mark)

5. Isotropic materials are those which possess (1 mark)
(a) Identical properties at all points.
(b) Identical properties in tensile and compressive loading.
(c) Identical properties in all directions.
(d) Identical properties when rotated through an angle θ where $0^\circ \le \theta \le 360^\circ$

6. A variable cross section concrete bridge pier with top and bottom widths of 600 mm and 1800 mm, respectively, carries a uniformly distributed load of 25 kN/m^2 at its top as shown in Figure. The unit weight of concrete is 25 kN/m^3. What is the normal stress developed across the section at a distance 1.0 m from the top, i.e. at mid height of the pier. (2 marks)