Strength of Materials
(ME-202/204, Dec-07)

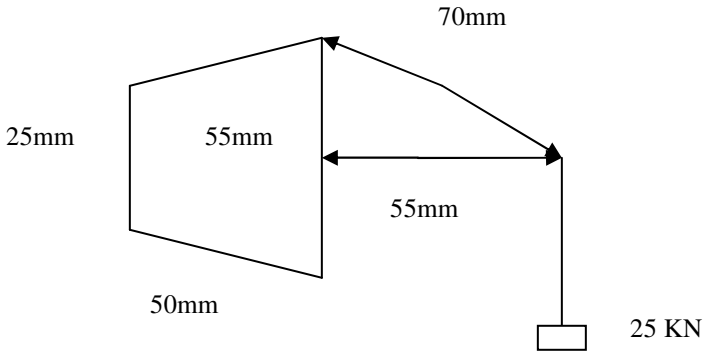
Note: Section A is compulsory. Attempt any four questions from Section B and any two from Section C.

Section-A

1. a) Define Castigliano's theorem.
   b) What is dilation energy and its significance?
   c) Differentiate between the opened coiled and closed coiled helical spring.
   d) What is the relationship between the radial and circumferential stresses?
   e) What is shear centre and its importance?
   f) I-section beams are generally preferred for lateral loading. Why?
   g) Define resilience.
   h) What is "Unit-moment" procedure?
   i) What is maximum principal stress and maximum principal shear stress theory?
   j) What is Maxwell's theorem of reciprocal deflection?

Section-B

2. (a) Find the slope and deflection using 'area moment' method at the tip of the cantilever beam of length 4 m carries a uniformly distributed load 20 KN/m and a point load of 20 KN at the free end.
   (b) What load 'P' must be applied upward at mid span to reduce the deflection by half? Given that EI = 200 MNm^2.
3. At a point the surface of an alloy steel (E = 210 GPa and v = 0.30) machine part subjected to a biaxial state of stress, the measured strains were ε_x = + 1394 μm/m, ε_y = - 660 μm/m, and γ_{xy} = 2054 μrad. Determine;
   (a) The stress components σ_x , σ_y and τ_{xy} at the point.
   (b) The principal stresses and the maximum shear stress at the point. Locate the planes on which these stresses act and show the stresses on a complete sketch.
4. A flat spiral spring is 12 mm wide, 0.3 mm thick and 2.5 m long. Assuming the maximum stress of 900 MN/m^2 to occur at the greatest bending moment, calculate the torque, the work stored and the number of turns to wind up the spring.
5. A crane hook is constructed from trapezoidal cross-sectional material. At the critical section AB the dimensions are as shown in fig below. The hook supports a vertical load of 25 KN with a line of action 40 mm from AB on the inside face. Calculate the values of the stresses at points A and B taking into account both bending and direct load effects across the section.



6. A close coiled helical spring carries an axial load W. Show that the deflection is related to W by $\delta = \frac{8WD^3n}{Gd^4}$

Section-C

7. (a) Derive an expression for the strain energy stored in a material when subjected to three principal stresses.
   (b) A bending moment of 4 KN is found to cause elastic failure of a solid circular shaft. An exactly similar shaft is now subjected to a torque T. Determine the value of T which causes failure of the shaft according to the following theories:
   (i) Maximum principal stress
   (ii) Maximum principal strain
   (iii) Maximum shear strain energy (ν = 0.3)
8. Show that the tensile hoop stress set up in a thin rotating ring or cylinder is given by $\sigma_H = \rho\omega^2 r^2$
   Hence determine the maximum angular velocity at which the disc can be rotated if the hoop stress is limited to 20 MN/$m^{2.}$ The ring has a mean diameter of 260 mm.
9. Define what is meant by strain energy? Derive an equation for the strain energy of uniform bar subjected to tensile load of P newtons. Hence calculate the strain energy in a 50 mm diameter bar, 4 m long, when carrying an axial tensile pull of 150KN. E = 208 GN/m^2.