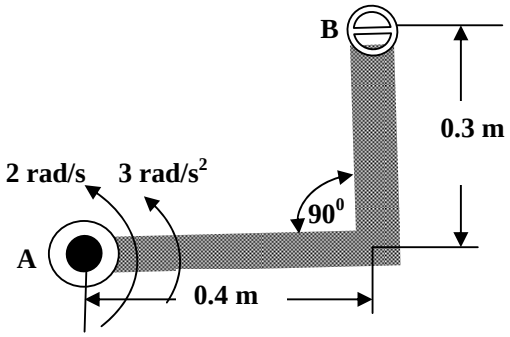
D : SOLID MECHANICS

Q. 1 – Q. 9 carry one mark each.

Q.1 A single degree of freedom vibrating system has mass of 5 kg, stiffness of 500 N/m and damping coefficient of 100 N-s/m. To make the system critically damped

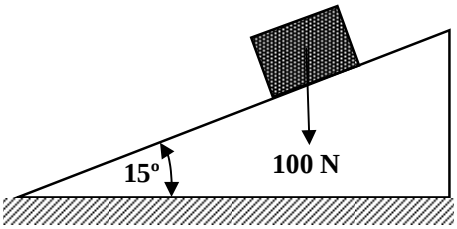
(A) only the mass is to be increased by 1.2 times.
(B) only the stiffness is to be reduced to half.
(C) only the damping coefficient is to be doubled.
(D) no change in any of the system parameters is required.

Q.2 A "L" shaped robotic arm AB is connected to a motor at end A and a magnetic gripper at B as shown in the figure. If the arm is rotating with an angular velocity of 2 rad/s and an angular acceleration of 3 rad/s^2, the magnitude of the acceleration (in m/s^2) of the end B is

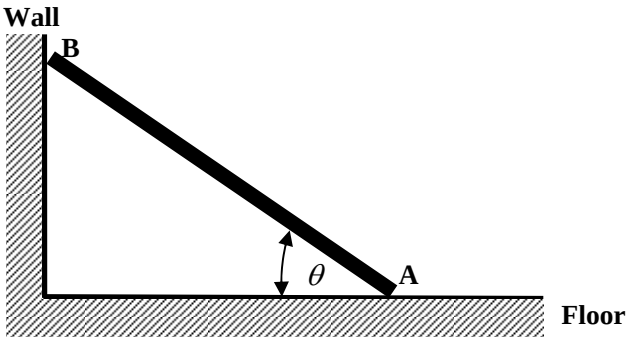


(A) 2.0 (B) 2.5 (C) 5.0 (D) 6.0

Q.3 A block of weight 100 N is in static equilibrium on an inclined plane which makes an angle 15º with the horizontal. The coefficient of friction between the inclined plane and the block is 0.3. The magnitude of friction force (in N) acting on the block is _____

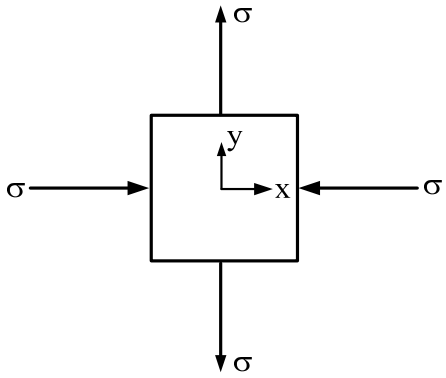


Q.4 The lower end A of the rigid bar AB is moving horizontally on the floor towards right with a constant velocity of 5 m/s and the point B is sliding down the wall. The magnitude of the velocity of point B at the instant $\theta = 30^{\circ}$ is



(A) zero (B) 4.34 m/s (C) 7.25 m/s (D) 8.66 m/s

Q.5 The state of plane stress at a point in a body is shown in the figure. The allowable shear stress of the material of the body is 200 MPa. According to the maximum shear stress theory of failure the maximum permissible value of σ (in MPa) is _____



Q.6 For a slender steel column of circular cross-section the critical buckling load is P_{cr}. If the diameter of the column is doubled (keeping other material and geometrical parameters same), then the critical buckling load of the column is

(A) $P_{cr}/16$ (B) $8\,P_{cr}$ (C) $2\,P_{cr}$ (D) $16\,P_{cr}$

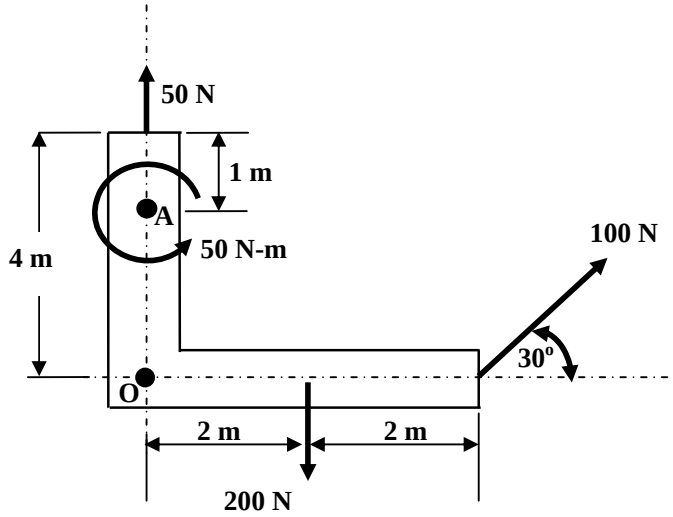
Q.7 A closed thin cylindrical pressure vessel having an internal diameter of 1000 mm and a thickness of 10 mm is subjected to an internal pressure of 4 MPa. The maximum shear stress (in MPa) induced in the cylinder is _____ (neglect the radial stress).

Q.8 A solid circular shaft subjected to pure torsion develops a maximum torsional shear stress of 120 MPa. Keeping the torsional moment same, if the diameter of the shaft is doubled then the maximum shear stress (in MPa) induced in the shaft is _____

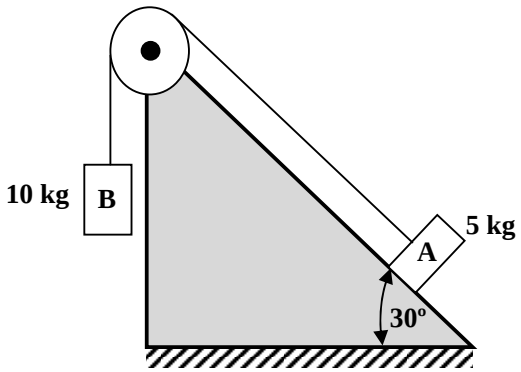
Q.9 On a single straight track, a vehicle of mass 500 kg moving with a velocity of 25 m/s strikes another vehicle of mass 250 kg moving with a velocity 10 m/s in the same direction. After the impact, if both the vehicles stick together, the common velocity (in m/s) with which both the vehicles will move together is _____

Q. 10 – Q. 22 carry two marks each.

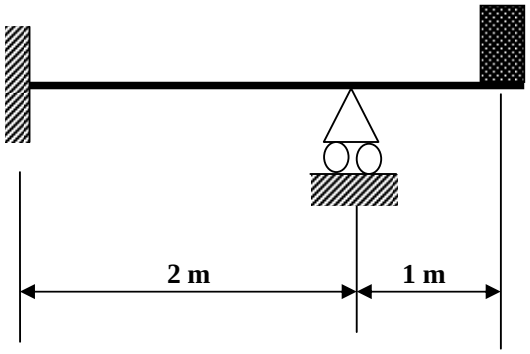
Q.10 A system with three forces and a concentrated moment at A is shown in the figure. The system is replaced by an equivalent force system with a single force and a single couple at point 'O'. The magnitude (in N-m) of the equivalent couple at 'O' is _____



Q.11 A block A on a smooth inclined plane is connected to block B as shown in the figure using an inextensible cord which pass over a mass-less and friction-less pulley. Initially, the block B is constrained to be at rest. If the constraint on block B is released, the magnitude of velocity (in m/s) of the block 'B' after 2 seconds from its release is _____ (assume g =10 m/s^2).

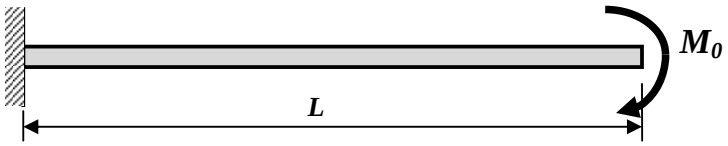


Q.12 The vibrating system shown in the figure carries a mass of 10 kg at the free end, where the static deflection is 1 mm. This system is to be replaced by an equivalent vibrating spring mass system having equivalent mass of 2 kg (assume g =10 m/s^2). The natural frequency (in rad/s) and the stiffness (in kN/m) of the equivalent system respectively are



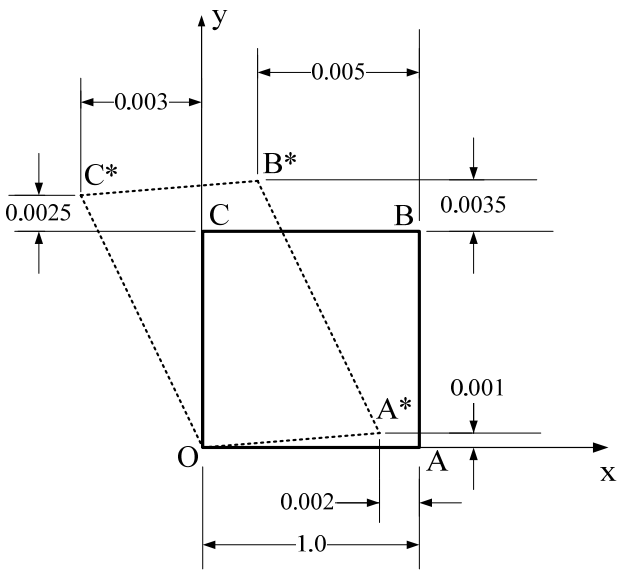
(A) 10 and 20 (B) 20 and 100 (C) 100 and 20 (D) 1000 and 20

Q.13 A beam having flexural rigidity EI and length L is subjected to a concentrated end moment M_0 as shown in the figure. For $EI = 4\times10^3$ N-m^2, $L = 1$ m and $M_0 = 8$ kN-m, the strain energy stored (in kN-m) in the beam and the rotation (in rad) at the free end respectively are



(A) 8.00 and 0.02 (B) 8.00 and 2.00 (C) 8.00 and 0.04 (D) 0.80 and 2.00

Q.14 At a point 'O' on a metal sheet a square OABC of a unit side length is drawn. The square undergoes a small uniform elastic deformation and deforms to OA*B*C* (dashed lines) as shown in the figure. All dimensions are in mm and the figure is not to scale. The normal strains ε_x, ε_y and shear strain γ_{xy} developed in the square respectively are



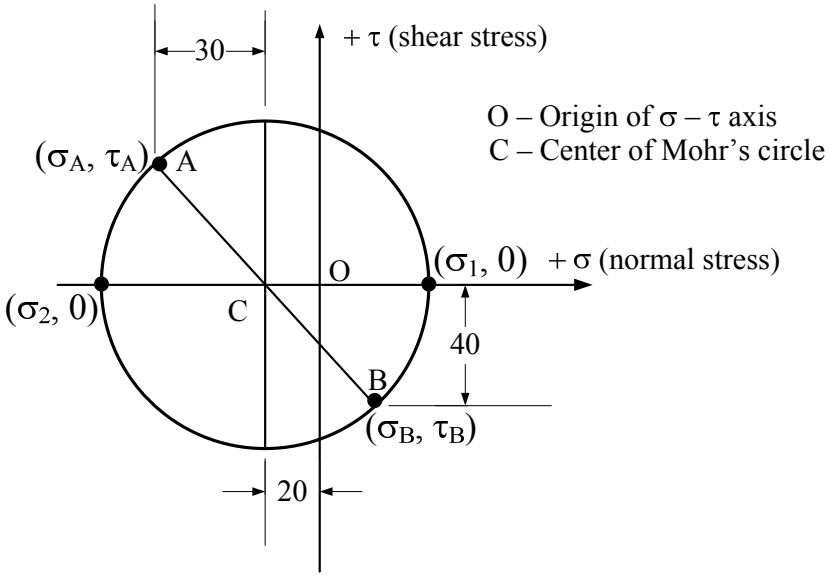
(A) $-0.0020,\quad 0.0025$ and 0.0020

(B) $0.0020, -0.0025$ and -0.0020

(C) $0.0025, -0.0020$ and 0.0020

(D) $-0.0020,\quad 0.0025$ and -0.0020

Q.15 Mohr's circle for the state of plane stress at a point is shown in the figure. Unit of stress is MPa and the circle is drawn not to scale. Which one of the following options (stress values in MPa) is true?



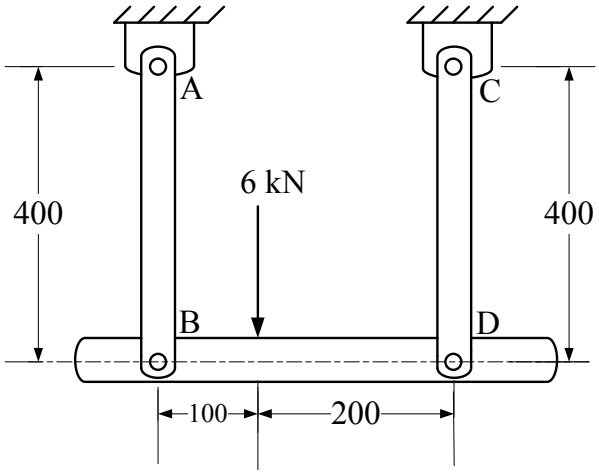
(A) $\sigma_A = -50,\ \sigma_B = 10,\ \sigma_1 = 30,\ \sigma_2 = -70$

(B) $\sigma_A = -50,\ \sigma_B = 20,\ \sigma_1 = 30,\ \sigma_2 = -50$

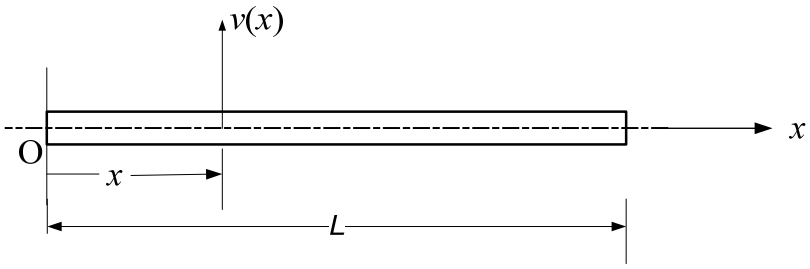
(C) $\sigma_A = -30,\ \sigma_B = 30,\ \sigma_1 = 30,\ \sigma_2 = -10$

(D) $\sigma_A = -20,\ \sigma_B = 10,\ \sigma_1 = 50,\ \sigma_2 = -30$

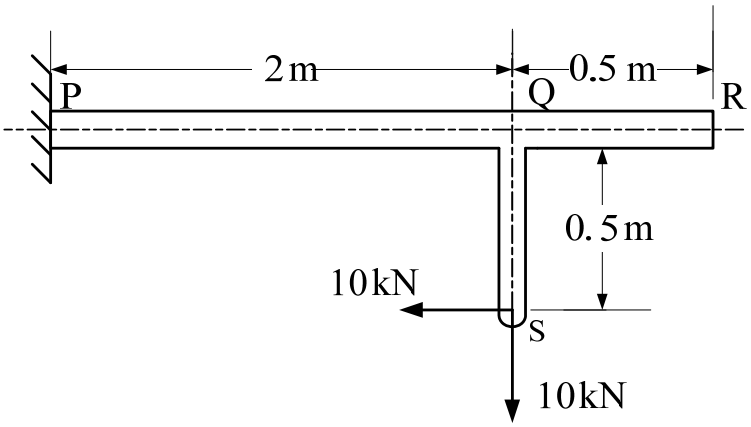
Q.16 As shown in the figure, links AB and CD support the rigid member BD. Links AB and CD are made of aluminum alloy $(E = 100\,\text{GPa})$ and each has a cross-sectional area of $100\,\text{mm}^2$. All the members are pin connected and all the dimensions are in mm. Neglecting the weights of the members, the elongation (in mm) of the link AB is _____



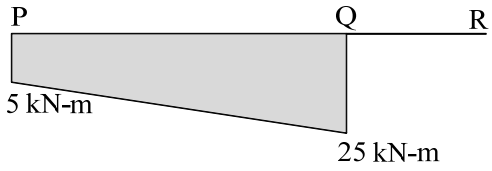
Q.17 Figure shows an elastic beam of constant flexural rigidity EI and length L. The transverse deflection $v(x)$ for the beam is represented by the equation $v(x) = M_0\left(x^3 - x^2 L\right)\big/(4EI\,L)$, where M_0 is the applied couple. If $L = 100\,\text{mm}$ and $M_0 = 100\,\text{N-mm}$, then the magnitude of the shear force (in N) at the middle of the beam (at $x = L/2$) is _____



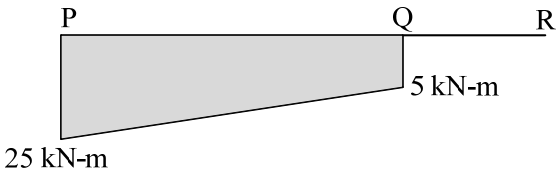
Q.18 Which one of the following represents the correct bending moment diagram of the beam PQR loaded as shown in the figure?



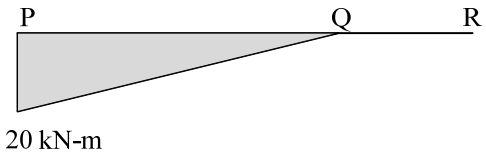
(A)



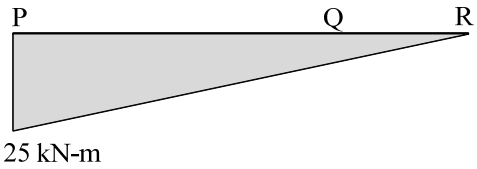
(B)



(C)



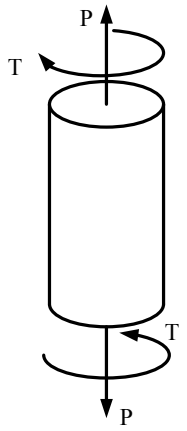
(D)



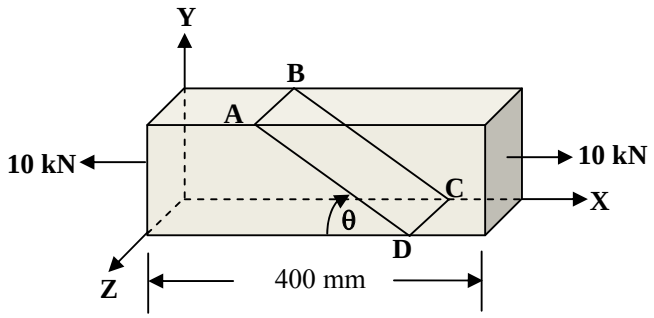
Q.19 A point in a body is subjected to plane state of stress in XY plane. If $\sigma_x = 140\,\text{MPa}$, $\sigma_y = 60\,\text{MPa}$ and the major principal stress is 150 MPa, the magnitude of the in-plane shear stress τ_{xy} (in MPa) is

(A) 75 (B) 30 (C) 40 (D) 70

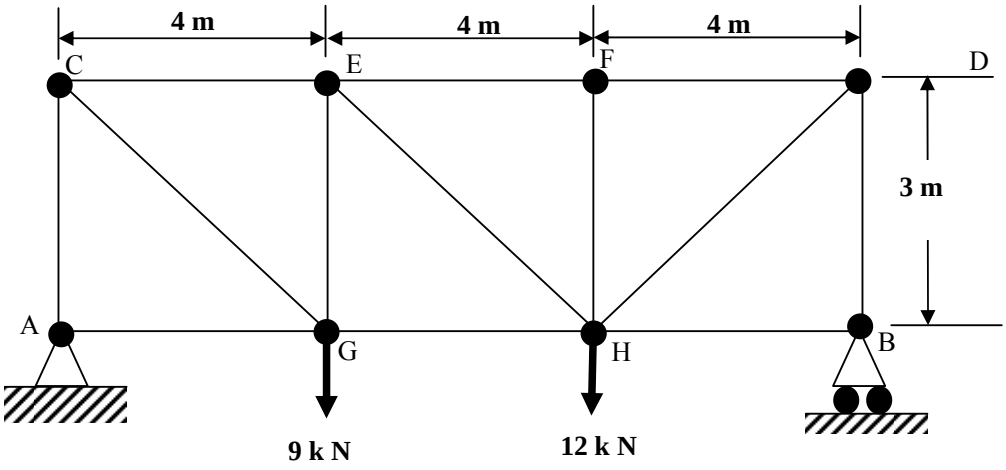
Q.20 A 40 mm diameter rotor shaft of a helicopter transmits a torque T = 0.16 π kN-m and a tensile force P = 24 π kN. The maximum tensile stress (in MPa) induced in the shaft is _____. Use the value of π = 3.1416.



Q.21 A wooden block of length 400 mm, width 50 mm and depth 100 mm is subjected to uniaxial load as shown in the figure. An inclined plane ABCD is shown which makes an angle θ with the XZ plane and the line CD is parallel to the Z-axis. The normal stress on the plane ABCD is σ_{n1} when $\theta = 30^{o}$ and the normal stress on the plane ABCD is σ_{n2} when $\theta = 120^{o}$. The value of $\frac{\sigma_{n2}}{\sigma_{n1}}$ is _____



Q.22 For the truss shown in the figure, which one of the following statements is true?



(A) AG is the only zero force member.
(B) AG and BH are the only two zero force members.
(C) AG, BH and HF are zero force members.
(D) AG, BH, HF and GC are zero force members.

END OF THE QUESTION PAPER