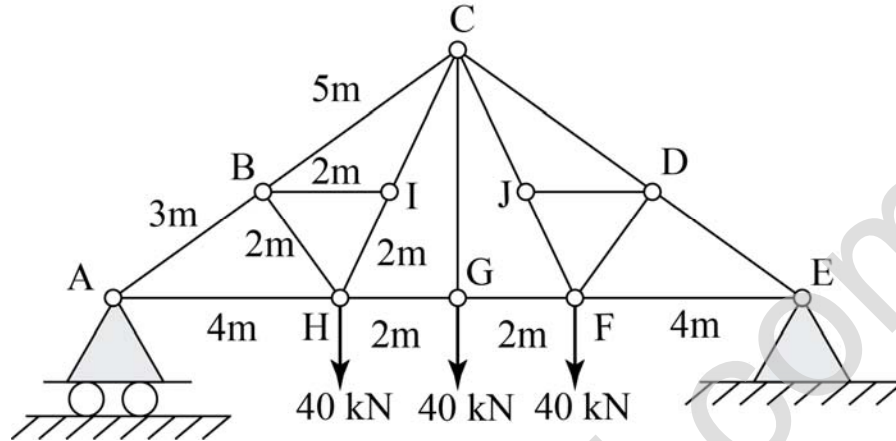


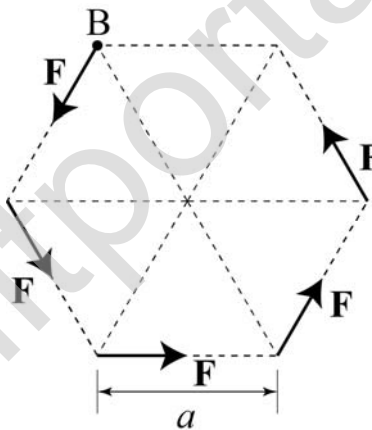
D : SOLID MECHANICS

Q. 1 – Q. 9 carry one mark each.

Q.1 Find the force (in kN) in the member **BH** of the truss shown.



Q.2 Consider the forces of magnitude **F** acting on the sides of the regular hexagon having side length **a**. At point **B**, the equivalent force and couple are, respectively,



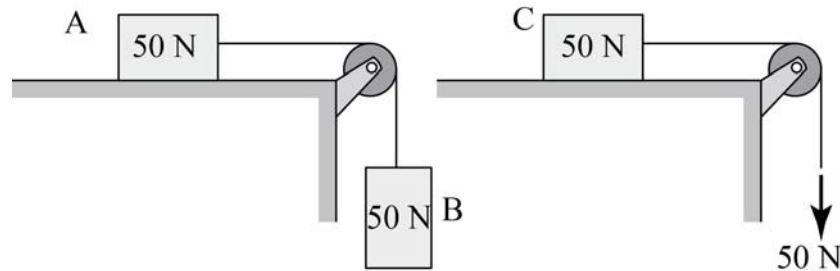
- (A) $F(\leftarrow)$ and $3\sqrt{3}Fa$ (clockwise)
 (B) $F(\rightarrow)$ and $\sqrt{3}Fa$ (clockwise)
 (C) $F(\leftarrow)$ and $\sqrt{3}Fa$ (counter clockwise)
 (D) $F(\rightarrow)$ and $3\sqrt{3}Fa$ (counter clockwise)

Q.3 Bar-1 has a diameter **d**, length **L**, and elastic modulus **E** and subjected to tensile load **P**, resulting in an elongation of Δ_1 . Bar-2 has diameter, **2d**, length **2L**, an elastic modulus **2E** and subjected to tensile load **2P**, resulting in an elongation of Δ_2 . Find the ratio Δ_1/Δ_2 .

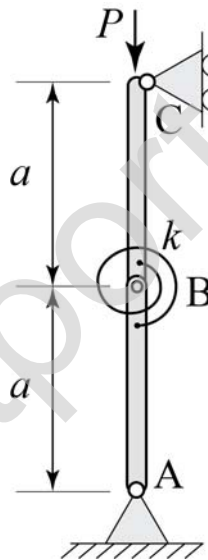
Q.4 In a plane stress problem, the principal stresses at a point are **30MPa** and **-15MPa**. At the same point, on an element whose sides make an angle of **45°** with respect to the principal axes, the normal stresses (in **MPa**) are

- (A) 15/2 and 15/2 (B) 30/2 and 30/2 (C) 15/2 and -15/2 (D) 30/2 and -30/2

- Q.5 Two systems shown below start from rest. For the system shown on the left, two **50N** blocks are connected by a cord. For the system shown on the right, the **50N** block is pulled by a **50N** downward force. Neglect friction. Which of the following is true?



- (A) Blocks **A** and **C** have the same acceleration.
 (B) Block **C** will have a larger acceleration than block **A**.
 (C) Block **A** will have a larger acceleration than block **C**.
 (D) Block **A** will not move.
- Q.6 Two massless rigid bars, each of length $a = 0.5\text{m}$, are connected by a rotational spring having stiffness $k = 1000\text{ N.m/rad}$. Find the buckling load P (in kN).



- Q.7 A simply supported beam having a rectangular cross-section of depth d is subjected to a vertical concentrated load P at the mid-span. The maximum shear stress in a section occurs at
- (A) $d/2$ from the top of the cross-section
 (B) $d/3$ from the top of the cross-section
 (C) $2d/3$ from the top of the cross-section
 (D) Top of the cross-section
- Q.8 A steel block of size $100 \times 50 \times 25\text{ mm}^3$ is subjected to a uniform pressure on all faces. The dimension of the **100mm** edge reduces by **25 μm** (note $1\text{ }\mu\text{m} = 10^{-6}\text{ m}$). Find the applied pressure (in **GPa**). Use $E = 240\text{ GPa}$ and $\nu = 0.3$.

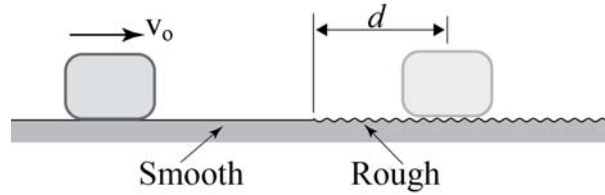
Q.9 Which one of the following statements is true?

- (A) In a tensile test on a rod made of ductile material, failure occurs along a plane making 45° with respect to the axis of the rod
- (B) In a tensile test on a rod made of brittle material, failure occurs along a plane making 45° with respect to the axis of the rod
- (C) In a torsion test on a rod made of ductile material, failure occurs along a plane making 45° with respect to the axis of the rod
- (D) In a torsion test on a rod made of brittle material, failure occurs along a plane making 0° with respect to the axis of the rod

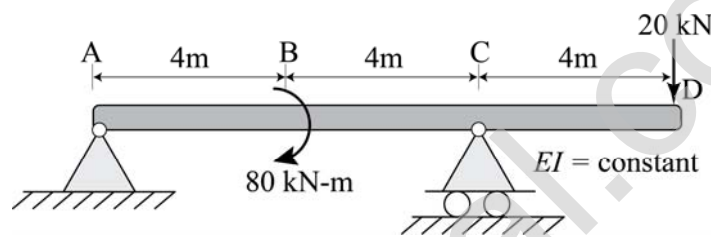
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Q. 10 – Q. 22 carry two marks each.

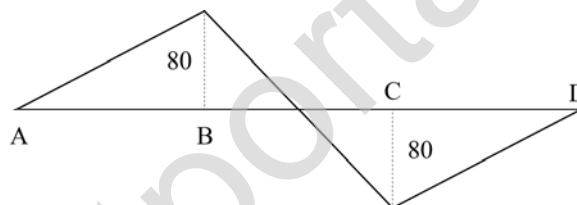
- Q.10 A block is travelling with a constant speed v_0 on a smooth surface when the surface suddenly becomes rough with a coefficient of friction μ , which causes the block to stop after a distance d . When the block travels twice as fast, i.e. at a speed $2v_0$, it travels a distance D on the rough surface before stopping. Find the ratio D/d .



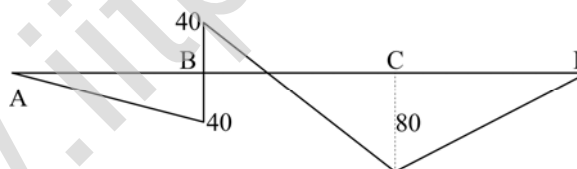
- Q.11 The beam shown below is loaded with a concentrated clockwise moment of 80kN-m at point B. The bending moment diagram (in kN-m) is



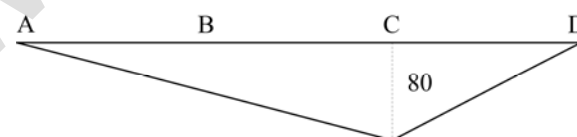
(A)



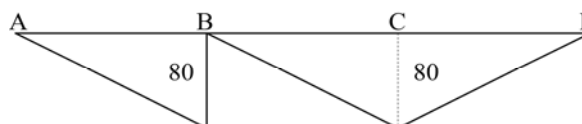
(B)



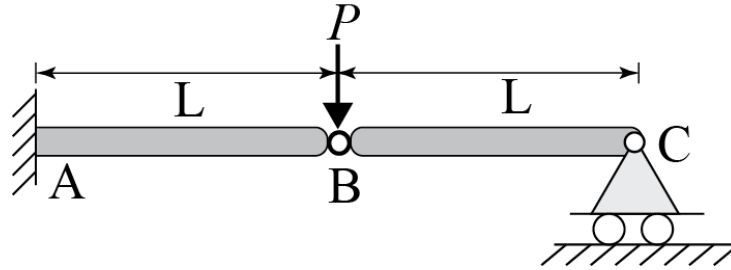
(C)



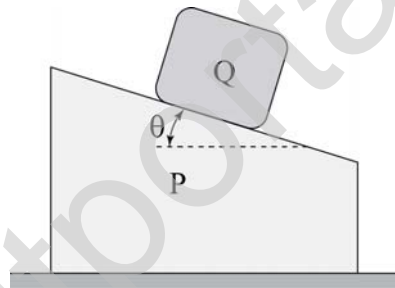
(D)



- Q.12 The beam shown has an internal hinge at **B**. A vertical load $P = 25\text{kN}$ is applied at **B**. Use $L = 2\text{m}$. Magnitude of the reactions (i.e. forces and moments) at **A** and **C** are



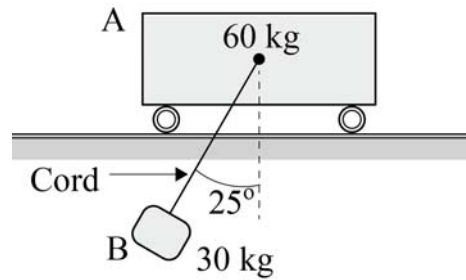
- (A) Vertical reaction force at **C** is 12.5kN , vertical reaction force at **A** is 12.5kN , moment reaction at **A** is 0kN-m .
- (B) Vertical reaction force at **C** is 0kN , vertical reaction force at **A** is 25kN , moment reaction at **A** is 50kN-m .
- (C) Vertical reaction force at **C** is 25kN , vertical reaction force at **A** is 0kN , moment reaction at **A** is 50kN-m .
- (D) Vertical reaction force at **C** is 0kN , vertical reaction force at **A** is 25kN , moment reaction at **A** is 25kN-m .
- Q.13 Blocks **P** and **Q** are released from rest in the positions shown. Neglect friction between all surfaces, i.e., both blocks can translate freely. Then the direction of the acceleration of block **Q** (i.e. a_Q) is



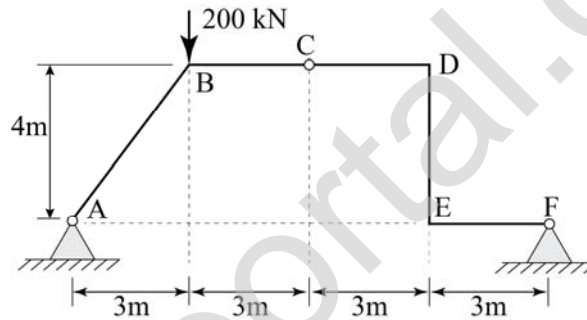
- (A) (B)
- (C) (D)

- Q.14 The acceleration, a , of a particle as a function of its position, x , is given by the relation $a = 0.1 + \sin \frac{x}{b}$, where a and x are expressed in m/s^2 and **meters**, respectively. Consider $b = 1\text{m}$. When $x = 0$, velocity is $v = 1\text{m/s}$. Find v (in m/s) when $x = \pi$ meters.

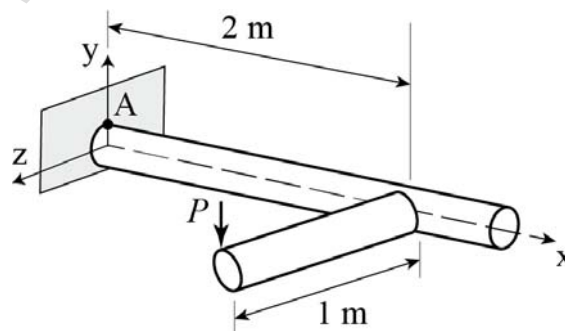
- Q.15 The **30kg** block **B** shown below is suspended by a **2m** cord attached to the **60kg** cart **A**. Friction is negligible. If the system is released from rest in the position shown, find the ratio of the velocity magnitudes $|v_A|/|v_B|$ when the cord is vertical.



- Q.16 The plane frame shown has an internal hinge at **C**. Find the magnitude of axial force (in kN) in member **BC**.



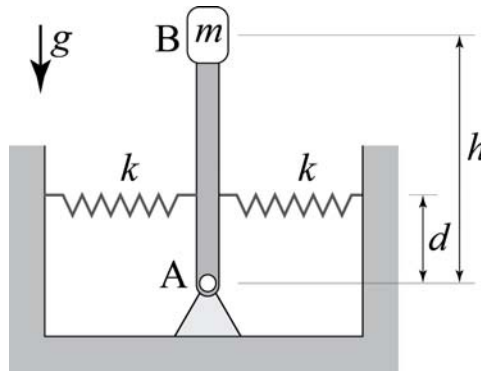
- Q.17 Two **50mm** diameter solid steel rods are rigidly connected together at right angles and loaded as shown. Use $P = 1000\pi$ kN. At point **A**, located at the top of the cross-section at the fixed end, the magnitude of bending stress (σ) and shear stress (τ) are



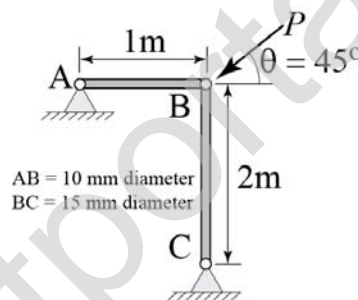
- (A) $\sigma = 256$ MPa, $\tau = 512$ MPa
 (B) $\sigma = 512$ MPa, $\tau = 256$ MPa
 (C) $\sigma = 512$ MPa, $\tau = 128$ MPa
 (D) $\sigma = 128$ MPa, $\tau = 512$ MPa

- Q.18 At a temperature of 40°C , a rod tightly fits between two rigid walls such that the compressive stress in the rod is **60MPa**. Given $E = 200\text{GPa}$ and $\alpha = 20 \times 10^{-6}/^\circ\text{C}$, find the temperature at which the rod will just lose contact with the walls.

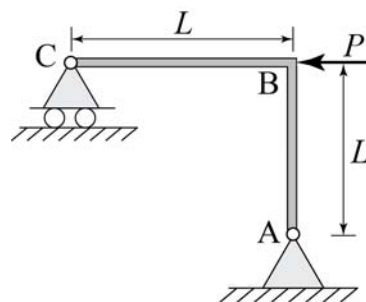
- Q.19 A massless rigid rod **AB** of length h is pinned at end **A** and carries mass m at end **B**. The rod is also supported by two linear springs of stiffness k at a height d from the end **A**. Use $m = 4\text{kg}$, $h = 0.5\text{m}$, $d = 0.2\text{m}$, $k = 600\text{N/m}$ and $g = 10\text{ m/s}^2$. For small oscillations about the position shown, find the frequency of free vibration (in **rad/s**).



- Q.20 Find the maximum force P (in **kN**) that can be applied to the planar structure **ABC** so as to prevent buckling in any of the members. Consider buckling only in the plane of the structure. Joint **B** is a pin connection. Use $E = 200\text{GPa}$ for both members. The diameter of member **AB** is **10 mm** and the diameter of member **BC** is **15 mm**.



- Q.21 The plane frame shown is analyzed by neglecting axial and shear deformations. The horizontal displacement of **joint B** is



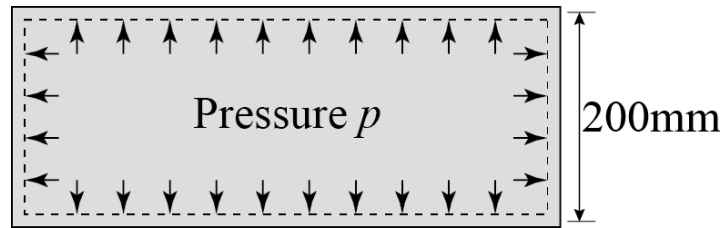
(A) $\frac{2PL^3}{3EI}$

(B) $\frac{PL^3}{EI}$

(C) $\frac{3PL^3}{2EI}$

(D) $\frac{PL^3}{2EI}$

- Q.22 A thin walled cylindrical pressure vessel having mean radius **100mm** and wall thickness **5mm**, is subjected to internal pressure p . If the factor of safety is **2** and the yield stress in shear is **100MPa**, find the maximum value of p (in **MPa**).



END OF THE QUESTION PAPER