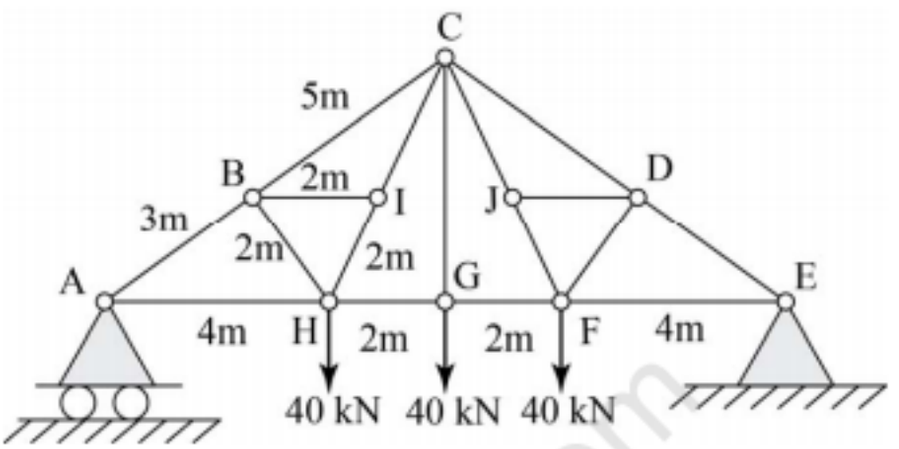
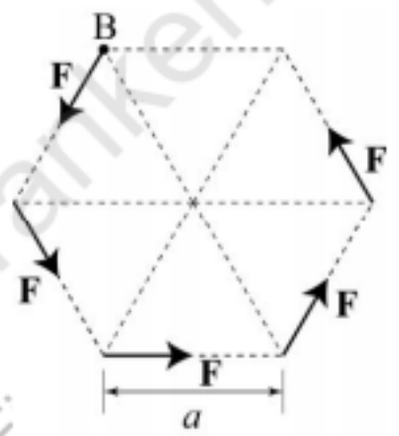
D : SOLID MECHANICS

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,



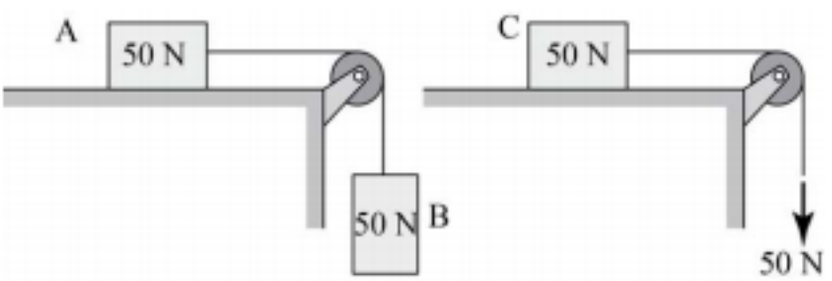
(A) **F**(←) and $3\sqrt{3}Fa$ (clockwise)
(B) **F**(→) and $\sqrt{3}Fa$ (clockwise)
(C) **F**(←) and $\sqrt{3}Fa$ (counter clockwise)
(D) **F**(→) and $3\sqrt{3}Fa$ (counter clockwise)

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

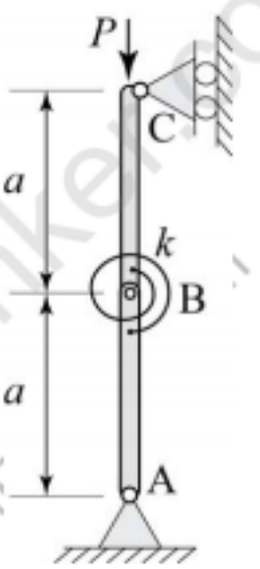
(A) 15/2 and 15/2 (B) 30/2 and 30/2 (C) 15/2 and -15/2 (D) 30/2 and -30/2

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 = **0.5m**, are connected by a rotational spring having stiffness k = **1000 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

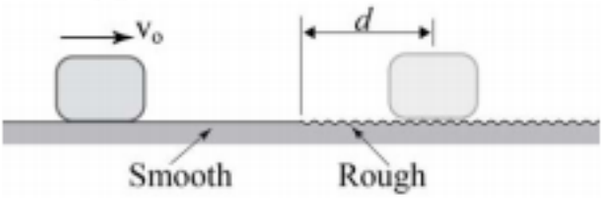
Q.8 A steel block of size **100×50×25 mm^3** is subjected to a uniform pressure on all faces. The dimension of the **100mm** edge reduces by **25μm** (note **1 μm = 10^{-6}m**). Find the applied pressure (in **GPa**). Use **E = 240 GPa** and **ν = 0.3**.

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

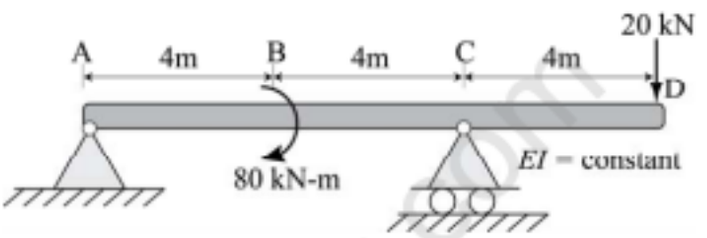
(A) In a tensile test on a rod made of ductile material, failure occurs along a plane making **45°** with respect to the axis of the rod
(B) In a tensile test on a rod made of brittle material, failure occurs along a plane making **45°** with respect to the axis of the rod
(C) In a torsion test on a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

Q. 10 – Q. 22 carry two marks each.

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

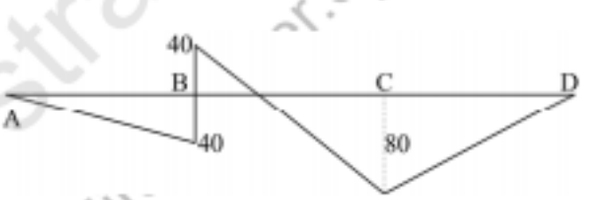


Q.11 The beam shown below is loaded with a concentrated clockwise moment of **80kN-m** at point **B**. The bending moment diagram (in **kN-m**) is



(A)

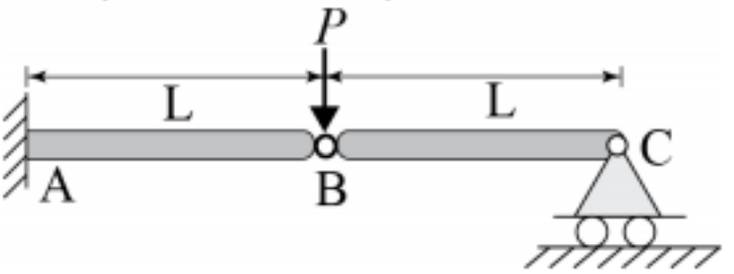
(B)



(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



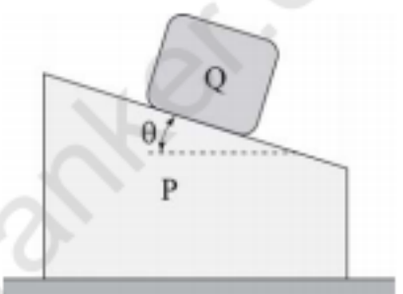
(A) Vertical reaction force at **C** is **12.5kN**, vertical reaction force at **A** is **12.5kN**, moment reaction at A is **0kN-m**.

(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**.

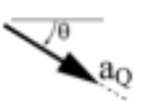
(D) Vertical reaction force at **C** is **0kN**, vertical reaction force at **A** is **25kN**, moment reaction at **A** is **25kN-m**.

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. $\mathbf{a}_Q$) is

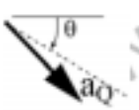


(A)

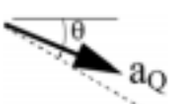
(B)



(C)

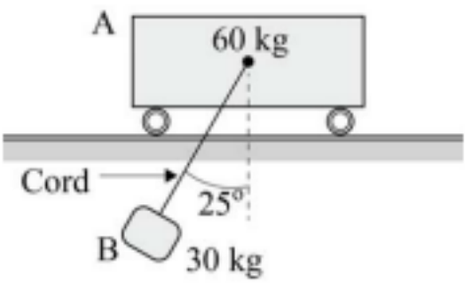


(D)

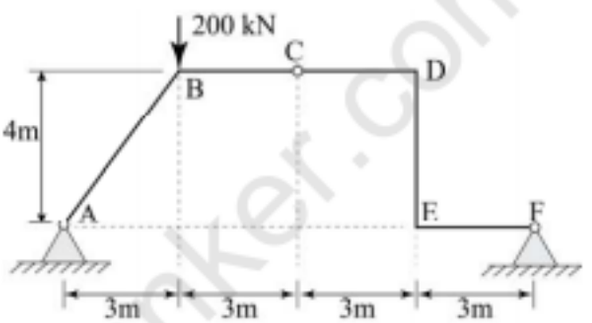


Q.14 The acceleration, a, of a particle as a function of its position, x, is given by the relation $a = 0.1 + \sin\frac{x}{b}$, where a and x are expressed in m/s^2 and **meters**, respectively. Consider $b = 1\text{m}$. When $x = 0$, velocity is $v = 1\text{m/s}$. Find v (in **m/s**) when $x = \pi$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

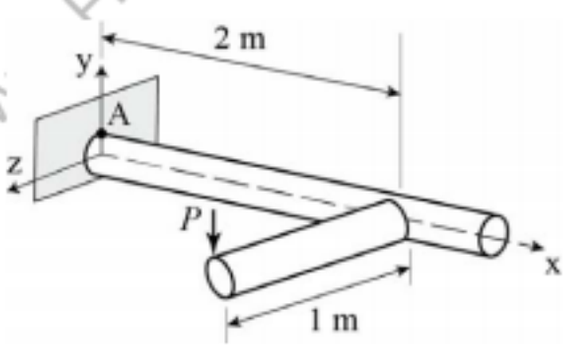
Q.15 The **30kg** block **B** shown below is suspended by a **2m** cord attached to the **60kg** cart **A**. Friction is negligible. If the system is released from rest in the position shown, find the ratio of the velocity magnitudes
$|v_A|/|v_B|$ when the cord is vertical.



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



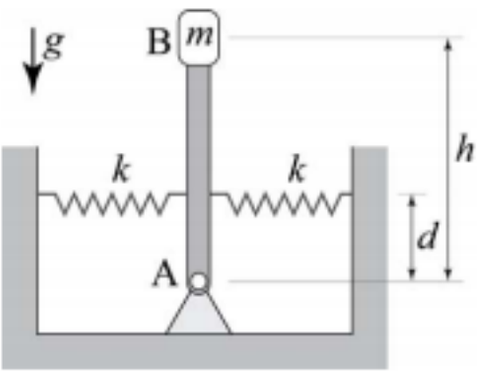
Q.17 Two **50mm** diameter solid steel rods are rigidly connected together at right angles and loaded as shown. Use $P = 1000\pi$ **kN**. At point **A**, located at the top of the cross-section at the fixed end, the magnitude of bending stress (σ) and shear stress (τ) are



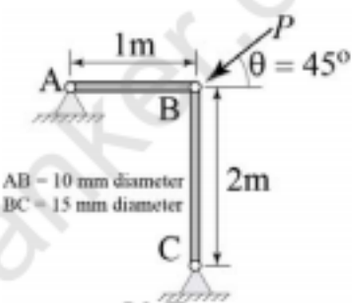
(A) $\sigma = 256$ MPa, $\tau = 512$ MPa
(B) $\sigma = 512$ MPa, $\tau = 256$ MPa
(C) $\sigma = 512$ MPa, $\tau = 128$ MPa
(D) $\sigma = 128$ MPa, $\tau = 512$ MPa

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 = 200GPa** and $\alpha = 20\times10^{-6}$/°C, find the temperature at which the rod will just lose contact with the walls.

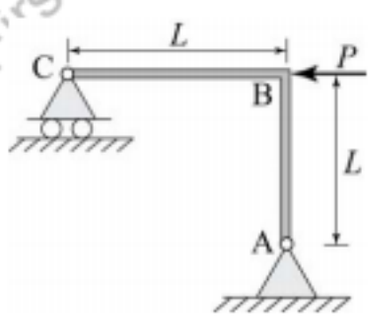
Q.19 A massless rigid rod **AB** of length h is pinned at end **A** and carries mass m at end **B**. The rod is also supported by two linear springs of stiffness k at a height d from the end **A**. Use $m = 4\text{kg}$, $h = 0.5\text{m}$, $d = 0.2\text{m}$, $k = 600\text{N/m}$ and $g = 10\ \text{m/s}^2$. 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 = 200GPa** for both members. The diameter of member **AB** is **10 mm** and the diameter of member **BC** is **15 mm**.

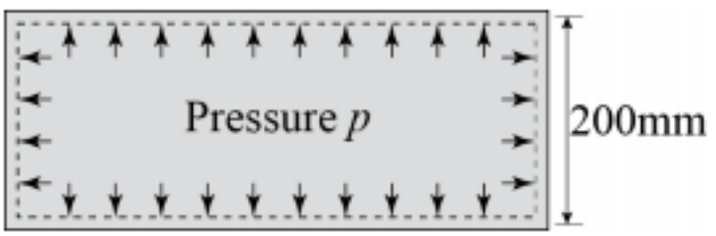


Q.21 The plane frame shown is analyzed by neglecting axial and shear deformations. The horizontal displacement of **joint B** is



(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