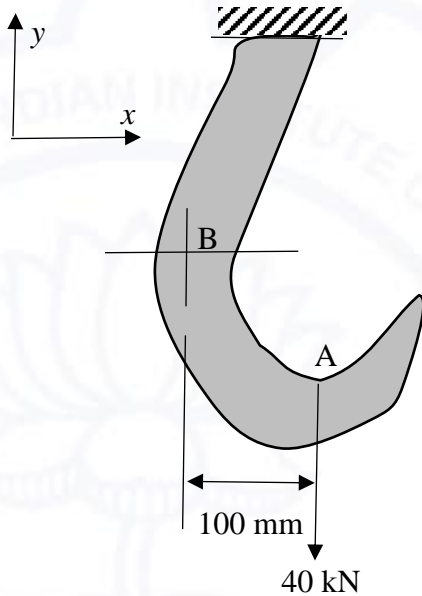


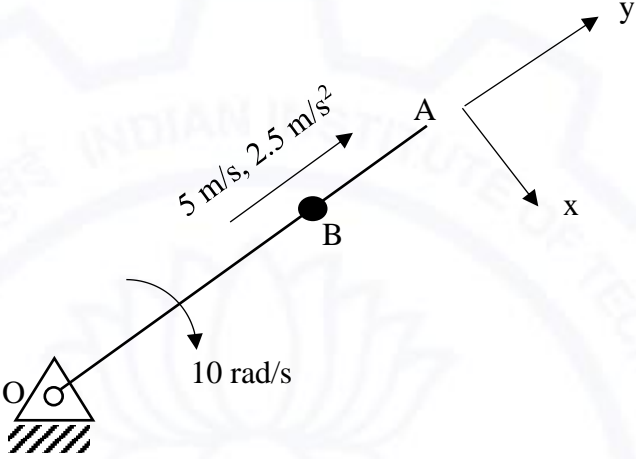


Solid Mechanics (XE-D)

Q.1 – Q.8 Multiple Choice Question (MCQ), carry ONE mark each (for each wrong answer: – 1/3).

<p>Q.1</p>	<p>A force $F = 40 \text{ kN}$ is applied on the hook as shown. The equivalent force-couple system at B is</p> 
<p>(A)</p>	<p>40 kN in +y direction and $M = 0$</p>
<p>(B)</p>	<p>40 kN in –y direction and $M = 0$</p>
<p>(C)</p>	<p>40 kN in +y direction and $M = 4000 \text{ Nm}$ counter clockwise</p>
<p>(D)</p>	<p>40 kN in -y direction and $M = 4000 \text{ Nm}$ clockwise</p>



<p>Q.2</p>	<p>A rigid rod OA rotates clockwise at an angular velocity of 10 rad/s. A bead B (OB = 1 m) translates outward on the rod at a speed of 5 m/s and acceleration 2.5 m/s² (both quantities with respect to the rod). The Coriolis component of acceleration is</p> 
<p>(A)</p>	<p>2.5 m/s² in +x direction</p>
<p>(B)</p>	<p>100 m/s² in +x direction</p>
<p>(C)</p>	<p>100 m/s² in -y direction</p>
<p>(D)</p>	<p>25 m/s² in + y direction</p>

<p>Q.3</p>	<p>A two force member in equilibrium is one in which</p>
<p>(A)</p>	<p>Forces act at two points and forces are collinear</p>
<p>(B)</p>	<p>Forces act at two points and member is always straight</p>
<p>(C)</p>	<p>Forces act at two points but the member is free to carry moment at any point</p>
<p>(D)</p>	<p>Force acts at one point and moment acts at second point</p>

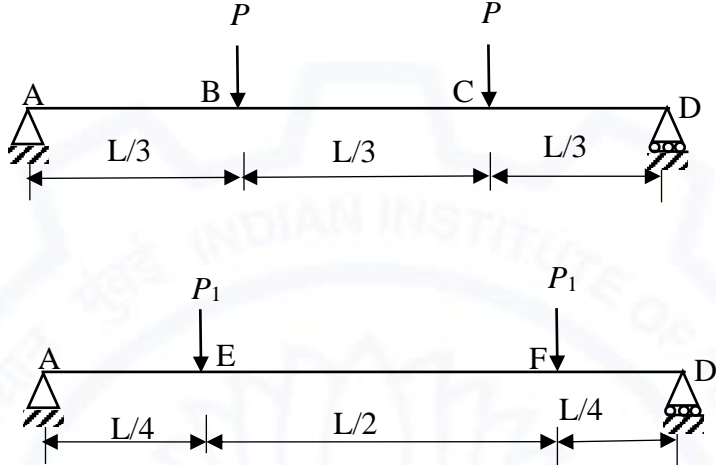


Q.4	If the yield point shear stress obtained from the torsion test of a cylindrical specimen is τ_y, then what is the maximum value of principal strain at yielding? (μ is Poisson's ratio and E is Young's modulus)
(A)	$\frac{\tau_y}{E}$
(B)	$\frac{(1 + \mu)\tau_y}{E}$
(C)	$\frac{\tau_y}{2E}$
(D)	$\frac{(1 - \mu)\tau_y}{E}$

Q.5	If the ratio of Young's modulus to bulk modulus of a material is $3/2$, then the ratio of shear modulus to the Young's modulus of the material is
(A)	1
(B)	$2/5$
(C)	$1/3$
(D)	$3/5$

Q.6	With respect to the plane of maximum shear stress, which of the following statements is INCORRECT?
(A)	The normal stress on this plane is zero.
(B)	The maximum shear stress is equal to the largest of the one half the difference of principal stresses
(C)	The plane of maximum shear stress occurs at 45° to the principal planes.
(D)	The magnitude of the maximum shear stress is equal to the largest of the radius of the Mohr's circles.



<p>Q.7</p>	<p>A simply supported beam of length L is loaded by two symmetrically applied point loads P at $L/3$ from each support. Both the loads are then shifted to new points which are at a distance $L/4$ from each support. The bending moments at the mid-section of the beam in both the cases are same. The magnitude of P_1 in terms of P is</p> 
(A)	$P/4$
(B)	$8P/3$
(C)	$4P/3$
(D)	$P/3$

<p>Q.8</p>	<p>A beam having rectangular cross section is subjected to transverse loading. The ratio of maximum shear stress developed in the beam to the average shear stress is</p>
(A)	1.50
(B)	1.25
(C)	1.33
(D)	1.66



Q.9 Numerical Answer Type (NAT), carry ONE mark each (no negative marks).

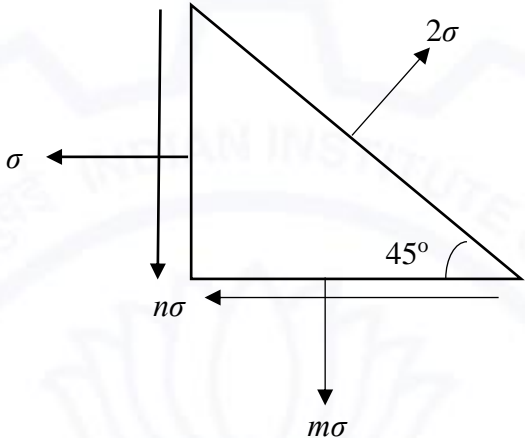
Q.9

During an earthquake, a structure vibrates and the vibration can be assumed to be in simple harmonic motion at 5 Hz. At a measurement point, the RMS value of acceleration is 10 m/s^2 . The approximate amplitude of motion (in mm) at this point (*rounded off to two decimal places*) is _____





Q. 10–Q. 15 Multiple Choice Question (MCQ), carry TWO marks each (for each wrong answer: – 2/3).

<p>Q.10</p>	<p>For the state of plane stress shown, the components of normal and shear stresses are given in terms of stress σ and unknown constants m and n. If the normal and shear components of stress on a 45° plane are 2σ and zero, the values of m and n would be:</p> 
<p>(A)</p>	<p>$m = 1, n = 2$</p>
<p>(B)</p>	<p>$m = 2, n = 1$</p>
<p>(C)</p>	<p>$m = 1, n = 1$</p>
<p>(D)</p>	<p>$m = 2, n = 2$</p>

<p>Q.11</p>	<p>For a state of plane strain, the normal strains are given by $\epsilon_{xx} = 1000 \times 10^{-6}$, $\epsilon_{yy} = 200 \times 10^{-6}$ and the maximum shear strain is $\gamma_{max} = 1000 \times 10^{-6}$. The value of shear strain γ_{xy} for this strain state is</p>
<p>(A)</p>	<p>600×10^{-6}</p>
<p>(B)</p>	<p>183×10^{-6}</p>
<p>(C)</p>	<p>1000×10^{-6}</p>
<p>(D)</p>	<p>800×10^{-6}</p>



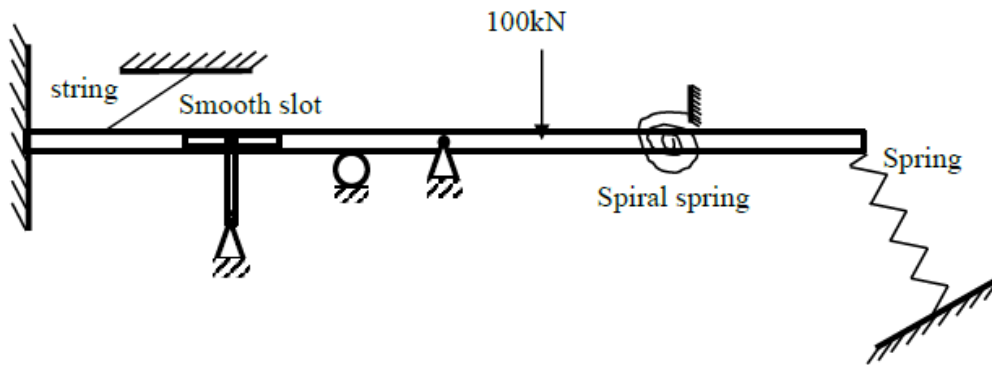
Q.12	A thin cylinder (closed at its ends) of radius r and thickness t ($r \gg t$) is subjected to internal pressure p. The maximum shear stress in the wall of the cylinder is
(A)	$\frac{pr}{t}$
(B)	$\frac{pr}{2t}$
(C)	$\frac{pr}{4t}$
(D)	$\frac{3pr}{2t}$

Q.13	<p>The truss shown is subjected to a force P. All members of the truss have the same length L. The reaction at A and force in member AB are</p>
(A)	$\frac{P\sqrt{3}}{4}$ and $\frac{P}{2}$
(B)	$\frac{P\sqrt{3}}{8}$ and $\frac{P\sqrt{3}}{4}$
(C)	$\frac{P\sqrt{3}}{4}$ and $\frac{P}{4}$
(D)	P and $\frac{P}{4}$

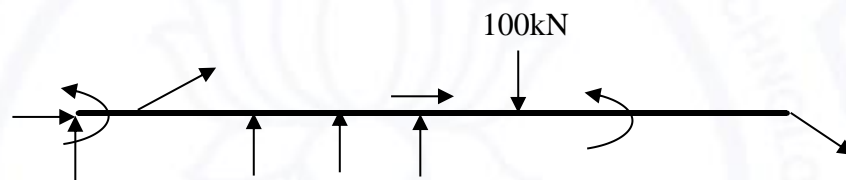


Q.14

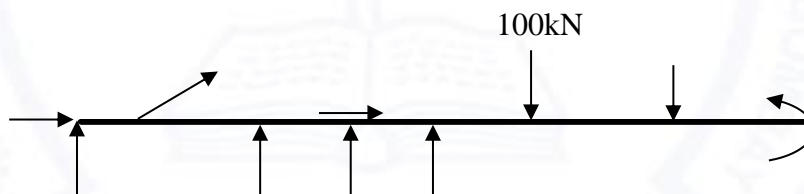
The figure shows a structure with supports. The correct free body diagram when the supports are removed is



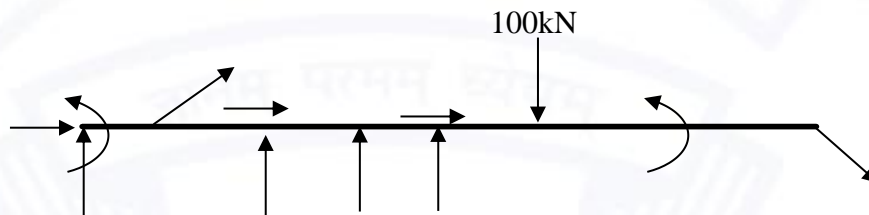
(A)



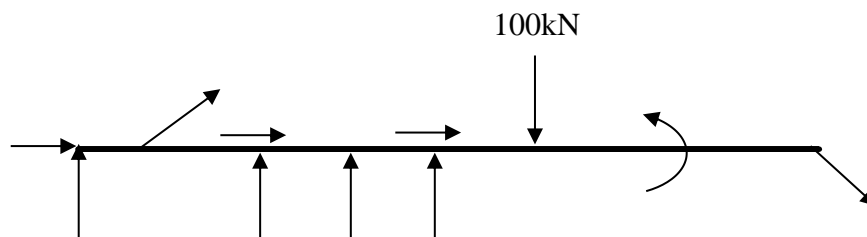
(B)



(C)



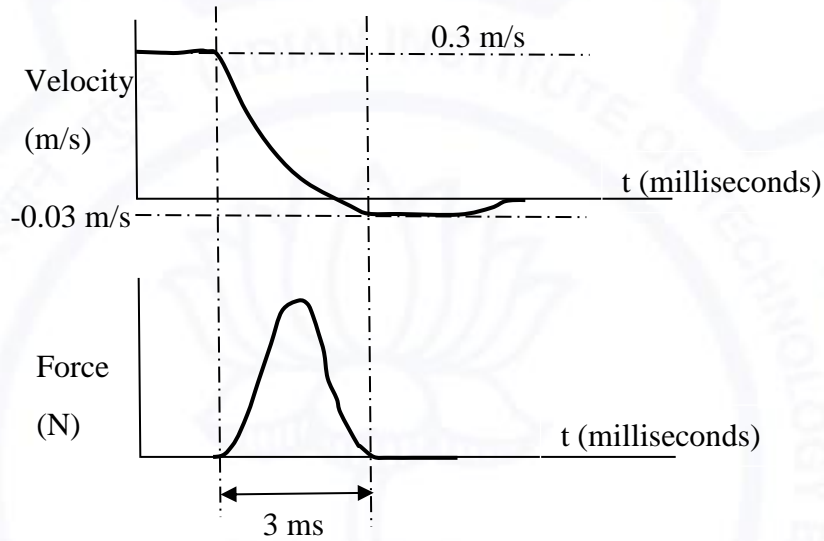
(D)





Q.15

A hammer of mass 1 kg is used to break an almond shell. The velocity time graph of the hammer during the impact duration is shown in the figure. The shape of force time graph is also given, which can be approximated as a triangle. A force of 300 N is required for breaking the shell, while a force of 200 N will not be able to break it, but just introduce a crack. Which one of the following events will happen?



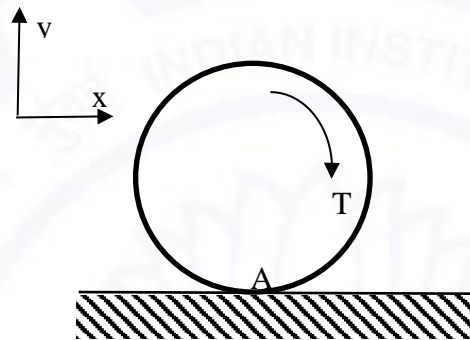
- (A) The almond shell will crack but not break
- (B) The almond shell will not crack.
- (C) The almond shell will break
- (D) Cannot be determined from the given data



Q. 16 – Q. 22 Numerical Answer Type (NAT), carry TWO marks each (no negative marks).

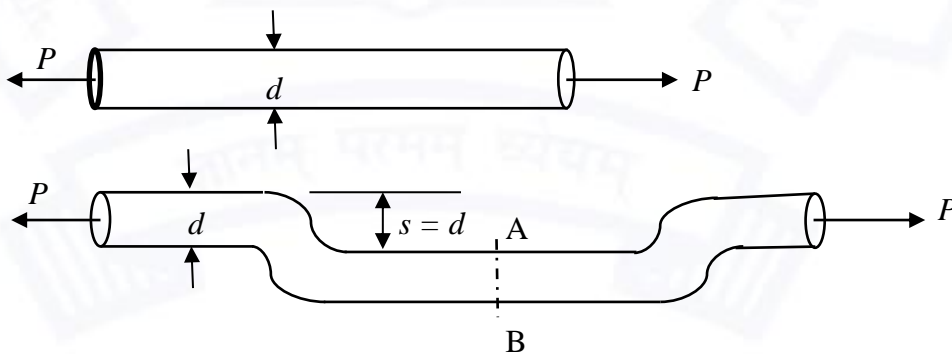
Q.16

A rigid circular disc of radius 0.2 m and mass 10 kg rolls without slip on the ground at A. The coefficient of static friction μ between ground and disc is 0.7. A torque T of 9 Nm acts on the disc as shown. Given acceleration due to gravity $g = 10 \text{ m/s}^2$. The friction force (in N) acting on the disc (in integer) is _____



Q.17

A prismatic solid circular rod of diameter d is bent to introduce an offset $s = d$ as shown. The rod is further subjected to an axial load P . If the maximum longitudinal stress at a section A-B in the rod (with offset) is n times the longitudinal stress in the straight rod, the value of n (in integer) would be _____

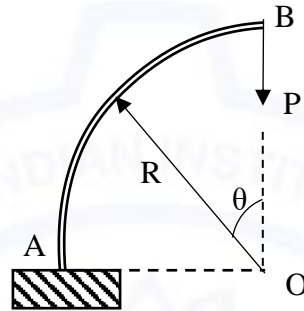




Q.18

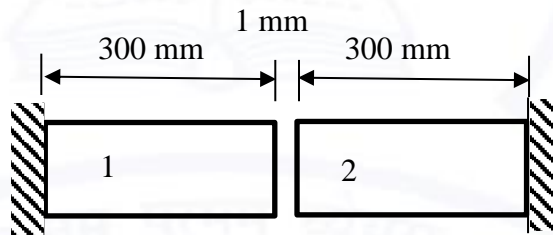
A naturally curved steel beam AB having Young's modulus 208 GPa, area moment of inertia $I = 26.7 \text{ cm}^4$ and radius $R = 2 \text{ m}$ is subjected to a vertical load $P = 1000 \text{ N}$ at B. The end A at $\theta = 90^\circ$ is rigidly fixed. The bending strain energy of the beam

(in Nm, rounded off to two decimal places) is _____



Q.19

At room temperature of 25°C , a gap of 1 mm exists between the ends of the rods 1 and 2 as shown. Given the cross section area A of the rods is 1500 mm^2 , Young's modulus $E = 75 \text{ GPa}$ and the coefficient of thermal expansion $\alpha = 23 \times 10^{-6} / ^\circ\text{C}$. When the temperature has reached 150°C , the magnitude of normal stress in each of the rods (in MPa, rounded off to two decimal places) is _____



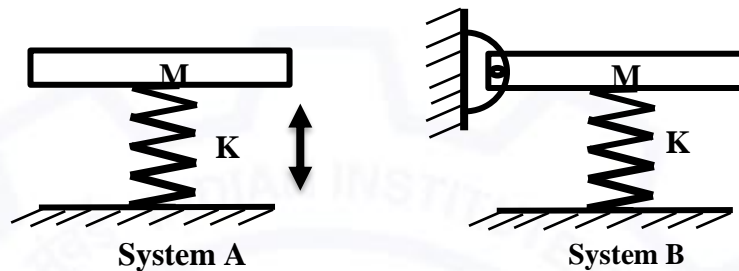
Q.20

A tube of inner radius 4 cm and outer radius 5 cm can carry a maximum torque of T . This tube is now replaced by a solid circular shaft of the same material. The minimum radius of the solid circular shaft (in cm, rounded off to two decimal places) to carry the same amount of torque T is _____



Q.21

In System A, a rectangular block of mass M is centrally supported on a spring of stiffness K as shown. In the System B, the mass is hinged at one of its ends and is supported centrally by the spring. The ratio of natural frequency of System B to that of System A (rounded off to two decimal places) is _____.



Q.22

A coronavirus droplet of mass 1 microgram ejects from the mouth of a patient with a velocity of 0.7 m/s and travels through air. The gravitational force experienced by it can be neglected due to the buoyancy effect. However, the droplet experiences air drag force proportional to its velocity and the drag coefficient is given as $1.0 \mu\text{N}\cdot\text{s}/\text{m}$. The distance travelled by the droplet before its velocity drops to 10% of its initial velocity (in m, rounded off to two decimal places) is _____.

END OF THE QUESTION PAPER