Name: **Enrolment No:**	UPES UNIVERSITY WITH A PURPOSE

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
End Semester Examination, July 2020

Course: Strength of Materials		**Semester : IV**
Program: B. TECH. Mechatronics		**Time : 03 hrs.**
Course Code: MECH 2012	**No. of Pages: 06**	**Max. Marks : 100**

NOTE: This question paper has 2 sections; **Section A** and **Section B**.

SECTION A (1 x 25 = 25 marks)

Section A carries 25 marks. This section has multiple-choice objective questions. All the questions of Section A are compulsory and carry equal marks.

1. In a beam of triangular cross section of height ‘h’ and subjected to a shear force, the maximum shear stress is developed
(a) At a distance of h/6 from the top (b) At a distance of h/6 from the neutral axis
(c) At a distance of h/3 from the base (d) At a distance of h/3 from the neutral axis

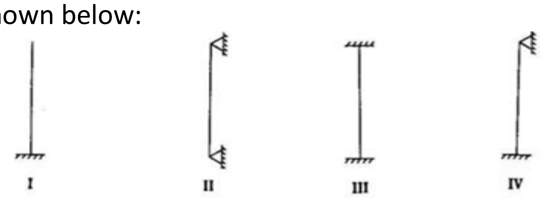
2. A simply supported rectangular beam of span ‘L’ and depth ‘d’ carries a central point load. The ratio of maximum deflection to maximum bending stress is
(a) L^2 / (6Ed) (b) L^2 / (8Ed) (c) L^2 / (48Ed) (d) L^2 / (12Ed)

3. A solid shaft of diameter ‘D’ and length ‘L’ is fixed at both ends. A torque ‘T’ is applied at a distance L/4 from left end. The maximum shear stress developed in the shaft is
(a) 16T / (ΠD^3) (b) 12T / (ΠD^3) (c) 8T / (ΠD^3) (d) 4T / (ΠD^3)

4. A weight of 250 kN is dropped from a height of 20 mm on a steel rod of length 400 mm and cross-sectional area 100 mm^2. The modulus of elasticity is 200 GPa. The stress developed in the rod due to impact is found to be ‘n’ times of the stress produced in the same bar by the same load when applied gradually. The value of ‘n’ is
(a) 3 (b) 4.5 (c) 3.5 (d) 4

5. In case of a hollow shaft, the torsional strain energy per unit volume is given by
(a) $(\tau^2/4G)[(D^2 + d^2)/D^2]$ (b) $(\tau^2/G)[(D^2 + d^2)/D^2]$
(c) $(\tau^2/16G)[(D^2 + d^2)/D^2]$ (d) $(\tau^2/8G)[(D^2 + d^2)/D^2]$

6. Four columns of the same material and having identical geometric properties are supported in different ways as shown below:



It is required to order these four beams in the increasing order of their respective first buckling loads. The correct order is given by
(a) I, II, III, IV (b) III, IV, I, II (c) II, I, IV, III (d) I, II, IV, III

7. According to the maximum shear stress theory of failure, permissible twisting moment in a circular shaft is 'T'. The permissible twisting moment will the same shaft as per the maximum principal stress theory of failure will be

(a) T/2 (b) T (c) $(2)^{1/2}$T (d) 2T

8. The maximum shear stress in a thin cylindrical shell of internal diameter 'd' and wall thickness 't' when subjected to an internal pressure 'p' is equal to

(a) pd / (4t) (b) pd / (8t) (c) pd / (2t) (d) pd / (t)

9. For a plane stress condition with $\sigma_y = 0$, the failure envelope in the plane of σ_x and τ_{xy} produced by maximum shear stress theory will be

(a) Square (b) Rhomboid (c) Irregular Hexagon (d) Ellipse

10. If ε_1 and ε_2 are principal strains and E & ν are elastic constants, the value of principal stress σ_1 is

(a) $[E / (1 - v^2)] (\varepsilon_1 - v\varepsilon_2)$ (b) $[E / (1 - v^2)] (\varepsilon_1 + v\varepsilon_2)$

(c) $[E / (1 + v^2)] (\varepsilon_1 + v\varepsilon_2)$ (d) $[E / (1 + v^2)] (\varepsilon_1 - v\varepsilon_2)$

11. A material has yield strength of 180 MPa and modulus of elasticity as 200 GPa. The modulus of resilience of the material is

(a) 81×10^3 N/m^2 (b) 162×10^3 N/m^2 (c) 40.5×10^3 N/m^2 (d) 324×10^3 N/m^2

12. If E, G, and K denote Young's modulus, Modulus of rigidity and Bulk modulus respectively for an elastic material, then which one of the following can be possibly true

(a) G = 2K (b) G = E (c) K = E (d) G = K = E

13. Ratio of torque transmitted by hollow and solid shafts when both are of same material, length and have same weight, is given by (n is the ratio of outer to inner radius of hollow shaft)

(a) $(n^2-2)/[n\sqrt{(n^2-1)}]$ (b) $n^{2/3}/\sqrt{(n^2-1)}$ (c) $(n^2+1)/[n\sqrt{(n^2-1)}]$ (d) $(n^2-2)n^{2/3}/(n^4-1)^{2/3}$

14. A cantilever of 4.0 m length carries a uniformly distributed load of 30 kN/m over the entire length. The upward point load required at the mid-point of the cantilever to reduce the deflection of free end by half will be

(a) 56 kN (b) 96 kN (c) 72 kN (d) 64 kN

15. Two tapering bars (A and B) of the same material are subjected to a tensile load P. The lengths of both the bars are the same. The larger diameter of each of the bars is D. The smaller diameter of the bar A is D/2 and that of the bar B is D/3. What is the ratio of elongation of the bar A to that of the bar B is

(a) 3 : 2 (b) 2 : 3 (c) 4 : 9 (d) 1 : 3

16. The temperature stress is a function of

1. Coefficient of linear expansion 2. Temperature rise 3. Modulus of elasticity

The correct answer is

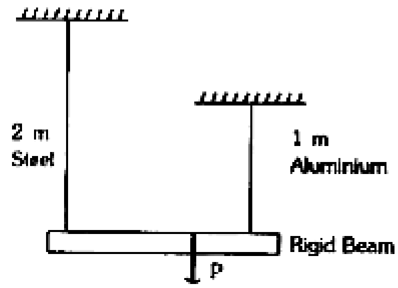
(a) 1 and 2 only (b) 1 and 3 only (c) 2 and 3 only (d) 1, 2 and 3

17. The strain in any direction in case of thin spherical shell of inner diameter 'd' and wall thickness 't' when subjected to internal pressure 'p' is equal to

(a) pd(0.5 – ν) / (2tE) (b) pd(1 – 0.5ν) / (2tE)

(c) pd(1 – ν) / (4tE) (d) 3pd(1 – ν) / (4tE)

18. A rigid beam of negligible weight is supported in a horizontal position by two rods of steel and aluminum, 2 m and 1 m long having values of cross – sectional areas 1 cm^2 and 2 cm^2 and E of 200 GPa and 100 GPa respectively. A load P is applied as shown in the figure below.



If the rigid beam is to remain horizontal then

(a) The forces on both sides should be equal

(b) The force on aluminum rod should be twice the force on steel

(c) The force on the steel rod should be twice the force on aluminum

(d) The force P must be applied at the centre of the beam

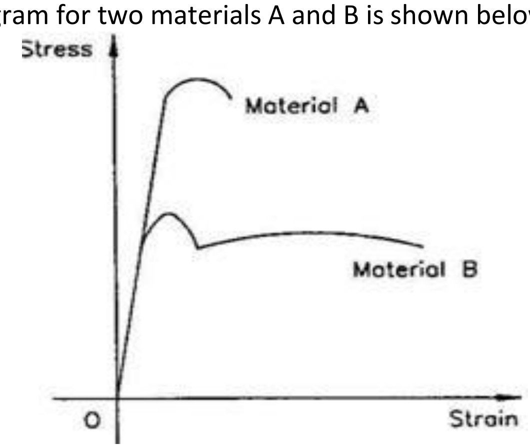
19. Match List-I (Elastic properties of an isotropic elastic material) with List-II (Nature of strain produced) and select the combination of correct answer using the codes.

List-I	List-II
A. Young's modulus	1. Shear strain
B. Modulus of rigidity	2. Normal strain
C. Bulk modulus	3. Transverse strain
D. Poisson's ratio	4. Volumetric strain

Codes:

	A	B	C	D		A	B	C	D
(a)	1	2	3	4	(b)	2	1	3	4
(c)	2	1	4	3	(d)	1	2	4	3

20. The stress-strain diagram for two materials A and B is shown below:



The following statements are made based on this diagram:

(I) Material A is more brittle than material B.

(II) The ultimate strength of material B is more than that of A.

With reference to the above statements, which of the following applies?

(a) Both the statements are false. (b) Both the statements are true.

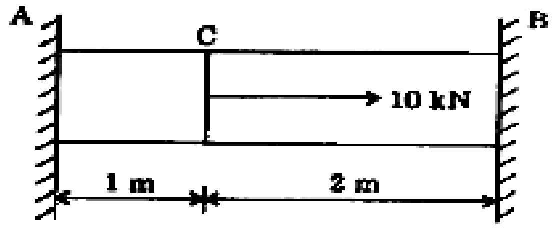
(c) I is true but II is false. (d) I is false but II is true

21. A piece of material experiences no change in volume when subjected to stresses of equal magnitude and same nature in all the three directions. The Poisson's ratio is

(a) 1.0 (b) 0 (c) 0.5 (d) 0.33

22. The reactions at the rigid supports at A and B for the bar loaded as shown in the figure are respectively.

(a) 20/3 kN, 10/3 kN (b) 10/3 kN, 20/3 kN (c) 5 kN, 5 kN (d) 6 kN, 4 kN



23. Two beams, one having square cross-section and another circular cross-section, are subjected to the same amount of bending moment. If the cross-sectional area as well as the material of both the beams are the same then which is true.

(a) Maximum bending stress developed in both the beams is the same.

(b) The circular beam experiences more bending stress than the square one.

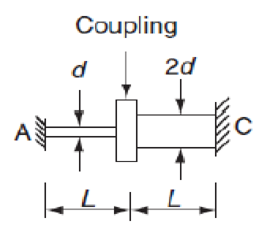
(c) The square beam experiences more bending stress than the circular one.

(d) As the material is same, both beams will experience same deformation.

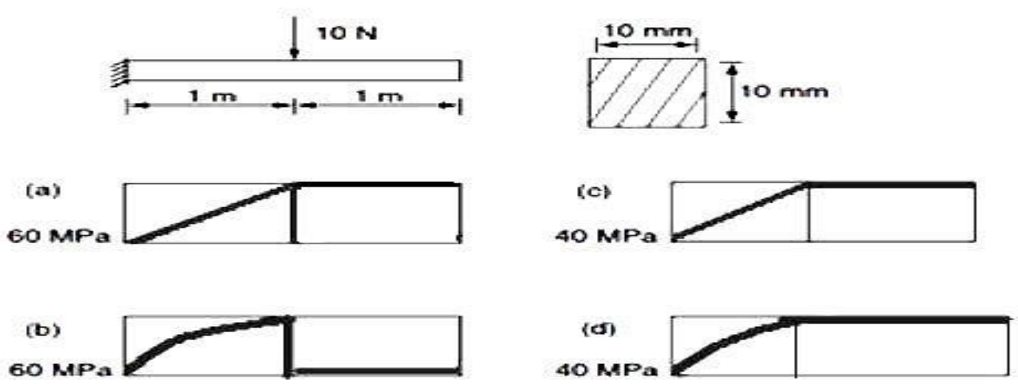
C24. Two shafts AB and BC of equal length and diameters d and $2d$ are made of the same material. They are joined at B through a shaft coupling, while the ends A and C are built-in (cantilevered). A twisting moment T is applied to the coupling. If T_A and T_C represent the twisting moments at the ends A and C, respectively, then:

(a) $T_C = T_A$ (b) $T_C = 8\,T_A$

(c) $T_C = 16\,T_A$ (d) $T_A = 16\,T_C$



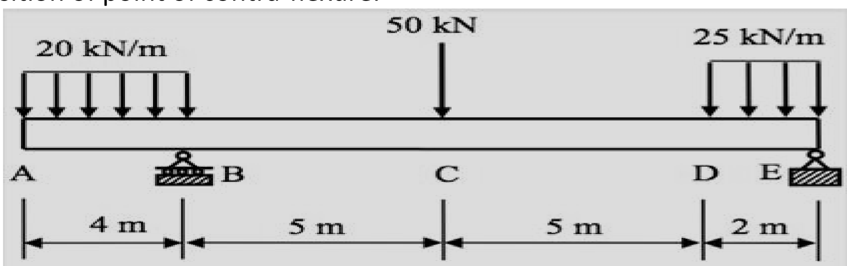
25. A cantilever beam has square cross-section of 10 mm x 10 mm. It carries a transverse load of 10 N. Considering only the bottom fibers of the beam, the correct representation of the longitudinal variation of the bending stress is



SECTION-B (15 x 5 = 75 Marks)

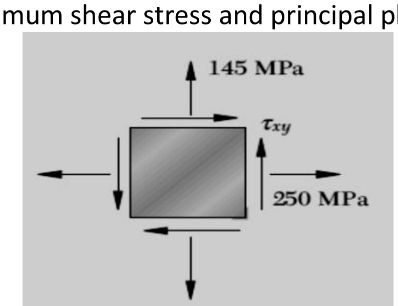
Section B carries 75 marks. All the questions of Section B are compulsory and carry equal marks.

<table>
<tr><th>Q. No.</th><th></th><th>Marks</th><th>CO</th></tr>
<tr><td>1.</td><td>An overhanging beam is used to carry a loading as shown below. Plot SFD and BMD for the beam by indicating the principal values at all the points and position of point of contra-flexure.



This beam has the cross-section of an equilateral triangle. If the allowable stresses for the beam in tension, compression and shear are respectively 150 MPa, 120 MPa and 60 MPa, calculate the least length of the side of safe equilateral triangular cross-section for the given loading.</td><td>09

06</td><td>CO1
CO2</td></tr>
<tr><td>2.</td><td>For the state of plane stress shown below, determine (a) the largest value of τ_{xy} for which the major principal stress is equal to 300 MPa, (b) the minor principal stress, maximum shear stress and principal planes.

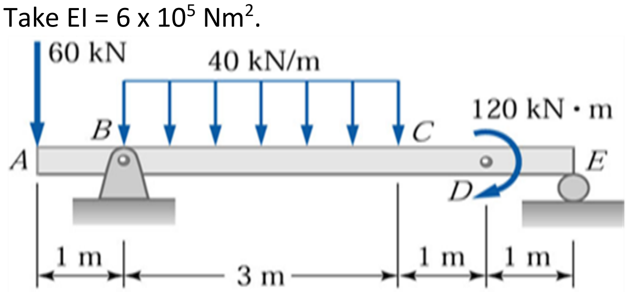


Construct the Mohr's stress circle for this plane stress condition showing the above results and determine graphically the normal and shear stresses on an oblique plane making an angle of 35° clockwise to the plane of σ_x.

If the yield strength and Poisson's ratio of the material in both the above cases is 440 MPa and 0.3 respectively, check whether the failure will occur or not according to (a) Maximum distortion energy per unit volume theory and (b) Maximum strain energy per unit volume theory. If failure does not occur, calculate the Factor of Safety.</td><td>05

05

05</td><td>CO3
CO4</td></tr>
<tr><td>3.</td><td>Determine the slope and deflection at point C of the single overhanging beam hinged at A, roller supported at E and loaded as shown in figure below. Take EI = 6 x 10^5 Nm^2.


</td><td>15</td><td>CO2
CO4</td></tr>
</table>

4.	Enumerate basic assumptions of Euler's buckling theory for long columns. A column of solid circular section, 12 cm diameter, 3.6 m long is hinged at both ends. Rankine's constant is 1/ 600 and σ_c = 54 KN/cm^2. Find the Rankine's buckling load. If another column of the same length, same end conditions and same Rankine's constant but of different material with 12 cm x 12 cm square cross- section, has the same buckling load, find the value of yield strength σ_c of its material.	**05** **10**	 **CO2** **CO3**
5.	A thin spherical shell has an internal diameter of 80 cm and a wall thickness of 12 mm. If yield strength of the material is 350 MPa and a factor of safety of 5 is employed, then determine the maximum value of internal pressure that can be applied safely inside the shell. For this value of pressure, find corresponding change in the volume of the shell. Modulus of elasticity and Poisson's ratio of the shell material is 220 GPa and 0.3 respectively. A solid alloy shaft of 50 mm diameter is coupled in series with a hollow steel shaft of same external diameter. Determine the internal diameter of the hollow steel shaft if the angle of twist per unit length in hollow shaft is 75% of that of the solid alloy shaft. Also, determine the speed at which the compound shaft must be driven to transmit 200 kW, if the limiting shear stresses are 55 MPa and 75 MPa in alloy and steel respectively. Take G_{steel} = 2.2 $G_{alloy.}$	**07** **08**	**CO3** **CO1** **CO2**