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AEROSPACE STRUCTURES

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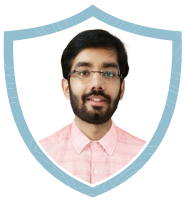

K SUNIL
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ACHARYA INSTITUTE, B'LORE
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IIST TRIVANDRUM
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ADITYA ANIL KUMAR
IIST TRIVANDRUM
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GATE-2023 AE

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Vagicharla Dinesh
Lovely Professional Univ - Punjab

Anantha Krishan A.G
Amrita Univ - Coimbatore

HAL DT ENGINEER 2022

Fathima J
MIT - Chennai

Mohan Kumar H
MVJCE - Bangalore

HAL DT ENGINEER 2021

Arathy Anilkumar Nair
Amrita Univ - Coimbatore

Sadsivuni Tarun
Sastra Univ - Tanjore

DRDO & ADA Scientist B

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Ajitha Nishma V
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Dheeraj Sappa
IIEST - Shibpur

F Jahangir
MIT - Chennai

Goutham
KCG College - Chennai

M Kumar
MVJ College - Bangalore

Mohit Kudal
RTU - Kota

Niladhari Pahari
IIEST - Shibpur

Nitesh Singh
Sandip Univ - Nashik

Ramanathan A
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Shruti S Rajpara
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DGCA Air Safety & Worthiness Officer

Job Position for Recruitment (2023)

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BMS College - Bangalore

Anil Kumar Nakkala
Malla Reddy College - Hyderabad

Ayush Boral
KIIT - Bhubaneswar

Dhiraj Rajendra Kapte
Priyadarshini College - Nagpur

Govardhan K
RVCE - Bangalore

R Selvaraj
Sri Ramakrishna College - Coimbatore

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Sathyabama University - Chennai

Shrenith Suhas
IIEST - Shibpur

Ankur Vats
School Of Aeronautics - Neemrana

7. Aerospace Structures

GATE AE - 2007

One Mark Questions.

1. For a plane strain problem in the x – y plane, in general, the non-zero stress terms of

(A) $\sigma_{zz}, \sigma_{xz}, \sigma_{yz}, \sigma_{xy}$ (C) $\sigma_{xx}, \sigma_{xy}, \sigma_{yy}, \sigma_{xz}$

(B) $\sigma_{zz}, \sigma_{xz}, \sigma_{yz}, \sigma_{xy}$ (D) $\sigma_{xx}, \sigma_{yy}, \sigma_{xy}, \sigma_{zz}$

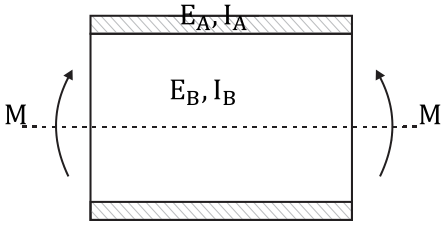
2. For an elastic anisotropic solid, the number of independent elastic constants in its constitutive equations is

(A) 2 (C) 21

(B) 9 (D) 36

Two Marks Questions.

3. Shown in the figure below is a model of an Euler-Bernoulli beam made up of two materials subjected to pure bending moment M. The Young's modulus of material A and B are E_A and E_B, respectively. The sectional moment of area, about the neutral axis, of the cross-sectional areas made of materials A and B, are I_A and I_B, respectively. The radius of curvature ρ of the flexural deflection of this composite beam to the bending moment M is then



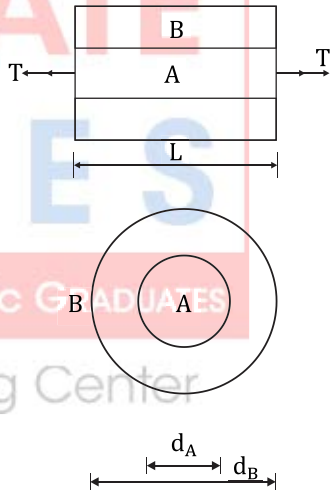
(A) $\rho = \dfrac{E_A I_A + E_B I_B}{M}$

(B) $\rho = \dfrac{E_A I_B + E_B I_A}{M}$

(C) $\rho = \dfrac{M}{E_A I_A + E_B I_B}$

(D) $\rho = \dfrac{(E_A + E_B)(I_A + I_B)}{M}$

4. A circular shaft is made-up of two materials A and B. The inner core is made-up of material A with diameter d_A, torsion constant J_A, and shear modulus G_A. The outer sleeve is made-up of material B with diameter d_B, torsion constant J_B, and shear modulus G_B. The composite shaft is of length L and is subjected to pure torsion moment T. The torsional stiffness, T/ϕ, where ϕ is the angle of twist, of this composite shaft is then



(A) $\dfrac{\left(\frac{G_A J_A}{L}\frac{G_B J_B}{L}\right)}{\left(\frac{G_A J_A}{L} + \frac{G_B J_B}{L}\right)}$

(B) $\dfrac{G_A J_A}{L} + \dfrac{G_B J_B}{L}$

(C) $\dfrac{(G_A + G_B)(J_A + J_B)}{L}$

(D) $\dfrac{G_A J_B}{L} + \dfrac{G_B J_A}{L}$

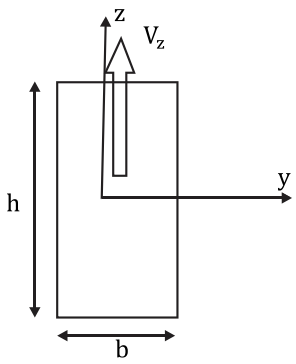
5. The boundary conditions for an Euler-Bernoulli column are given in column X and the critical buckling loads are given in column Y. Match the boundary condition of the column to its corresponding buckling load. P_{cr} is the critical buckling load, E is the Young's modulus of the column material, I its sectional moment of area, and L is the length of the column.

X. Boundary Condition	**Y. Critical buckling load**
X1. Pinned-pinned column	Y1. $P_{cr} = \frac{4\pi^2 EI}{L^2}$
X2. Fixed-free(cantilevered) column	Y2. $P_{cr} = \frac{2.046\pi^2 EI}{L^2}$
X3. Fixed-fixed column	Y3. $P_{cr} = \frac{\pi^2 EI}{4L^2}$
X4. Fixed pinned column	Y4. $P_{cr} = \pi^2 EI/L^2$

(A) X1-Y4, X2-Y3, X3-Y1, X4-Y2
(B) X1-Y4, X2-Y2, X3-Y3, X4-Y1
(C) X1-Y4, X2-Y1, X3-Y2, X4-Y3
(D) X1-Y4, X2-Y3, X3-Y2, X4-Y1

6. The von Mises yield criterion or the maximum distortion energy criterion for a plane stress problem with σ_1, and σ_2 as the principal stresses in the plane, and α_y as the yield stress, requires
(A) $\sigma_1^2 - \sigma_1\sigma_2 + \sigma_2^2 \le \sigma_y^2$
(B) $|\sigma_1 - \sigma_2| \le \sigma_y$
(C) $|\sigma_1| \le \sigma_y$
(D) $|\sigma_2| \le \sigma_y$

7. An Euler-Bernoulli beam having a rectangular cross-section, as shown in the figure, is subjected to a non-uniform bending moment along its length. $V_z = \frac{dM_y}{dx}$. The shear stress distribution τ_{xz} across its cross section is given by



(A) $\tau_{xz} = \frac{V_z}{2I_y}\frac{z}{(h/2)}$
(B) $\tau_{xz} = \frac{V_z\left(\frac{h}{2}\right)^2}{2I_y}\left(1 - \frac{z^2}{(h/2)^2}\right)$
(C) $\tau_{xz} = \frac{V_z}{2I_y}\left(\frac{z}{(h/2)}\right)^2$
(D) $\tau_{xz} = \frac{V_z(h/2)^2}{2I_y}$

8. The torsion constant J of a thin-walled closed tube of thickness t and mean radius r is given by
(A) $J = 2\pi rt^3$ (C) $J = 2\pi r^2 t^2$
(B) $J = 2\pi r^3 t$ (D) $J = 2\pi r^4$

Statement for Linked Answer Questions 9 and 10:

The equation of motion of a vibrating rod is given by $\frac{\partial^2 u}{\partial x^2} = \frac{1}{c^2}\frac{\partial^2 u}{\partial t^2}$. Here u is the displacement along the rod and is a function of both position x and time t. To find the response of the vibrating rod, we need to solve this equation using boundary conditions and initial conditions.

9. The boundary conditions needed for a rod fixed at the root (x = 0) and free at the tip (x = l) are
(A) $u(x = 0) = 0, \frac{\partial u}{\partial x}(x = l) = 0$
(B) $u(x = l) = 0, \frac{\partial u}{\partial x}(x = l) = 0$
(C) $u(x = 0) = 0, u(x = l) = 0$
(D) $\frac{\partial u}{\partial x}(x = 0) = 0, \frac{\partial u}{\partial x}(x = l) = 0$

10. The natural frequencies ω of the fixed free rod can then be obtained using

(A) $\cos\left(\frac{\omega l}{c}\right) = 0$ (C) $\cos\left(\frac{\omega c}{l}\right) = 0$

(B) $\sin\left(\frac{\omega l}{c}\right) = 0$ (D) $\cos\left(\frac{\omega}{c}\right) = 0$

GATE AE - 2008

One Mark Questions.

11. In the absence of body moments, the symmetry of the stress tensor is derived from

(A) force equilibrium conditions

(B) moment equilibrium conditions

(C) linear relations between stresses and strains

(D) compatibility conditions

12. In a 3-D orthotropic material, the number of elastic constants in linear stress-strain relationship is

(A) 3 (C) 9

(B) 5 (D) 21

13. The compatibility conditions in theory of elasticity ensure that

(A) there is compatibility between various direct and shear stresses

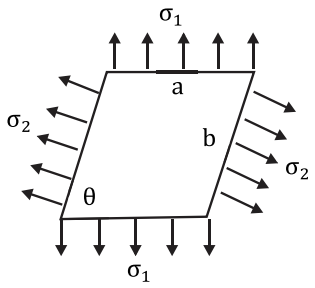
(B) relationships between stresses and strains are consistent with constitutive relations

(C) displacements are single-valued and continuous

(D) stresses satisfy bi-harmonic equation

Two Marks Questions.

14. A parallelogram shaped plate of dimensions 'a' and 'b' as shown in the figure, is subjected to a uniform loading of normal stresses σ_1 and σ_2. The plate is in equilibrium for



(A) Any value of σ_1 and σ_2

(B) $\sigma_2 = \sigma_1 \cos\theta$

(C) $\sigma_1 = \sigma_2 \cos\theta$

(D) $\sigma_2 = \sigma_1$

15. A column of solid circular cross-section and length L can have various end conditions. Choose the correct set that matches the end conditions (listed in Group I) with the corresponding effective length for buckling (listed in Group II).

Group I (end conditions)

(P) one end built-in and other end free

(Q) both ends pinned

(R) both ends built-in

(S) one end built-in and other end pinned

Group II (effective length)

(1) 1.0 L

(2) 0.7 L

(3) 2.0 L

(4) 0.5 L

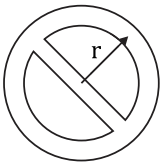
(A) P – 3, Q – l, R – 4, S – 2

(B) P – 4, Q – l, R – 2, S – 3

(C) P – 2, Q – l, R – 3, S – 4

(D) P – 3, Q – l, R – 2, S – 4

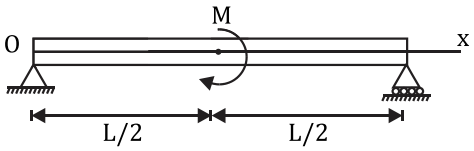
16. A thin-walled tube of circular cross-section with mean radius r has a central web which divides it into two symmetric cells as shown. A torque M is acting on the section. The shear flow q in the central web is

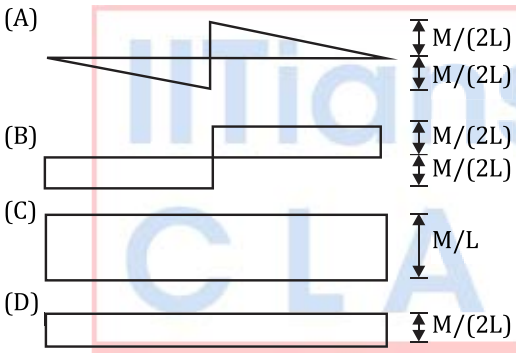


(A) $q = \frac{M}{2\pi r^2}$ (C) $q = \frac{M}{4\pi r^2}$

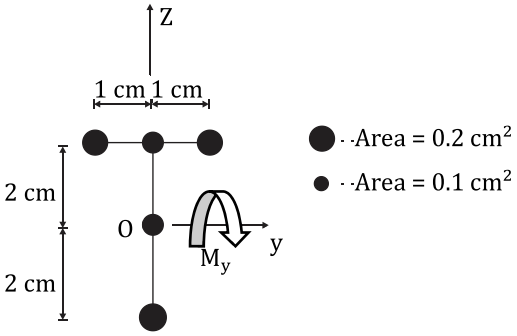
(B) $q = 0$ (D) $q = \frac{M}{\pi r^2}$

17. A concentrated bending moment M is acting at mid-span of a beam as shown. The shear force diagram for the beam is:





18. An idealized thin-walled cross-section of a beam and the respective areas of the booms are as shown. A bending moment M_y is acting on the cross-section. The ratio of the magnitude of normal stress in the top booms to that of the bottom boom is



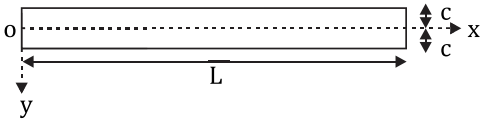
(A) 5/11 (C) 1

(B) 2/5 (D) 5/2

19. A beam occupies a region $0 \le x \le L$; $-c \le y \le c$; $-0.5 \le z \le 0.5$ as shown below. The beam can be considered to be in plane stress condition in x-y plane. Airy's stress function for the beam is given as:

$$\phi(x,y) = -\frac{Pxy^3}{4c^3} + \frac{3Pxy}{4c}$$

Where P is a constant



The above stress function pertains to a

(A) simply supported beam carrying a point load P at mid span

(B) simply supported beam carrying a uniform distributed load of intensity P per unit length

(C) cantilever beam clamped at end $x = L$ and carrying a shear load P at $x = 0$

(D) cantilever beam clamped at end $x = 0$ and carrying a shear load P at $x = L$

Common Data for Questions 20, 21 and 22:

A two-dimensional state of stress in an isotropic material is given by

$$[\sigma] = c\begin{bmatrix} -8 & 5 \\ 5 & 16 \end{bmatrix} \text{ MPa}$$

where c is linearly proportional to the applied loading. The failure stress is σ_f =350 MPa (which is 0.2 % offset yield stress).

20. The principal stresses are

(A) $\sigma_1 = 17c$ MPa, $\sigma_2 = -9c$ MPa

(B) $\sigma_1 = 9c$ MPa, $\sigma_2 = 17c$ MPa

(C) $\sigma_1 = -17c$ MPa, $\sigma_2 = -9c$ MPa

(D) $\sigma_1 = -17c$ MPa, $\sigma_2 = 9c$ MPa

21. The maximum shear stress is

(A) $\tau_{max} = 7c$ MPa (C) $\tau_{max} = 13c$ MPa

(B) $\tau_{max} = 10c$ MPa (D) $\tau_{max} = 15c$ MPa

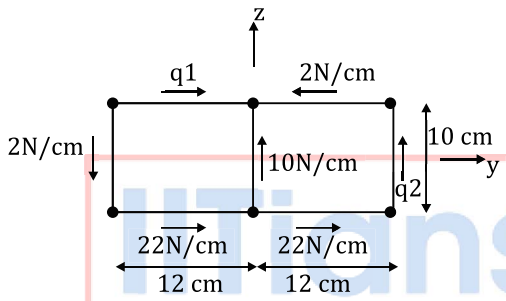
22. The maximum value of c for safe loading of the structure, based on von-Mises failure criterion is

(A) 10.2 (C) 25.4

(B) 15.3 (D) 31.8

Statement for Linked Answer Qns 23 and 24:

An idealized thin walled two cell symmetric box beam is as shown. The shear flows in the walls are due to the applied shear forces V_y =480 N, V_z =300 N, and a torque M, all acting at the shear center.



23. The shear flows q_1 and q_2 are

(A) $q_1 = -2$ N/cm, $q_2 = +22$ N/cm (C) $q_1 = +2$ N/cm, $q_2 = -22$ N/cm

(B) $q_1 = +2$ N/cm, $q_2 = +22$ N/cm (D) $q_1 = -2$ N/cm, $q_2 = -22$ N/cm

24. The torque M is

(A) 3360 N.cm (C) 6960 N.cm

(B) 5760 N.cm (D) 8160 N.cm

GATE AE - 2009

One Mark Questions.

25. For a plane strain problem, the stresses satisfy the condition

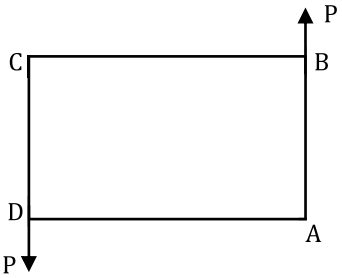
(A) $\tau_{xz} = \tau_{yz} = \sigma_z = 0$

(B) $\tau_{xz} = \tau_{yz} = 0, \sigma_z = v(\sigma_x + \sigma_y)$

(C) $\tau_{xz} = \tau_{yz} = 0, \sigma_z = v\tau_{xy}$

(D) $\tau_{xz} = \tau_{yz} = 0, \sigma_z = v(\sigma_x + \sigma_y) + (1 - v)\tau_{xy}$

26. In a thin-walled rectangular tube subjected to equal and opposite forces P as shown in the figure, the shear stress along leg AB is



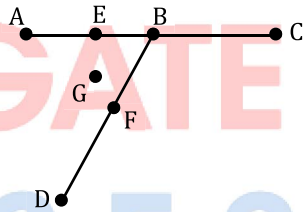
(A) zero

(B) constant non-zero

(C) varies linearly

(D) varies parabolically

27. For the thin walled beam cross section as shown in the figure, the shear centre lies at



(A) Mid point of AB, i.e. at point E

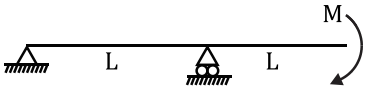
(B) Mid point of BD, i.e. at point F

(C) Junction point B

(D) at a point G lying within the area ABC

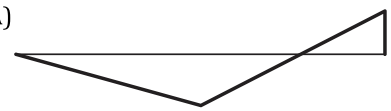
Two Marks Questions.

28. Consider a simply supported beam of length 2L with an overhang of length L, loaded by an end moment M, as shown below.



The bending moment distribution for this beam is

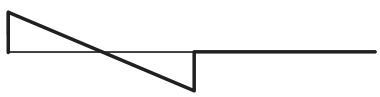
(A)



(B)

(C)

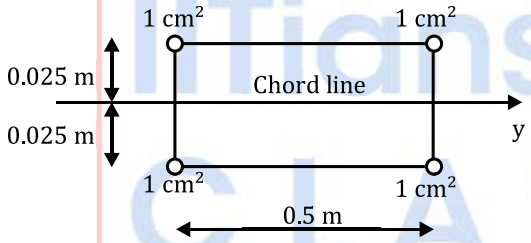
(D)



29. The buckling load for a simply supported column of rectangular cross section of dimensions 1 cm × 1.5 cm and length 0.5 m made of steel ($E = 210 \times 10^9$ N/m^2) is approximately

(A) 10 kN (C) 23 kN
(B) 4 kN (D) 46 kN

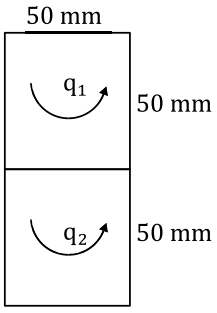
30. A wing root cross section is idealized using lumped areas (booms) as shown below.



The wing root bending moment in steady level flight is $M_y = 10$ N − m. If the airplane flies at a load factor n =3.5, the maximum bending stress at the root is

(A) 1×10^6N/m^2 (C) 7×10^6N/m^2
(B) 3.5×10^6N/m^2 (D) 0.286×10^6N/m^2

31. A 2-celled tube with wall thickness 0.5 mm is subjected to a torque of 10 N-m. The resulting shear flows in the two cells are q_1 and q_2 as shown below.



The torque balance equation (Bredt-Batho formula) for this section leads to

(A) $q_1 - q_2 = 2000$ N/m
(B) $q_1 + 2q_2 = 2000$ N/m
(C) $q_1 + q_2 = 2000$ N/m
(D) $2q_1 + q_2 = 2000$ N/m

GATE AE - 2010

One Mark Questions.

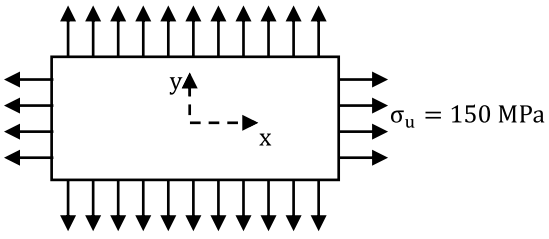
32. In a general case of a homogeneous material under thermo-mechanical loading the number of distinct components of the state of stress is

(A) 3 (C) 5
(B) 4 (D) 6

33. A vertical slender rod is suspended by a hinge at the top and hangs freely. It is heated until it attains a uniform temperature, T. Neglecting the effect of gravity, the rod has

(A) Stress but no strain
(B) Strain but no stress
(C) Both stress and strain
(D) Neither stress nor strain

34. A thin rectangular plate made of isotropic material which satisfies the octahedral (i.e., Von Mises/Distortion energy) failure criterion has yield strength of 200 MPa under uniaxial tension. As shown in the figure, if it is loaded with uniform tension of 150 MPa along the x-direction, the maximum uniform tensile stress that can be applied along the y-direction before the plate starts yielding is about



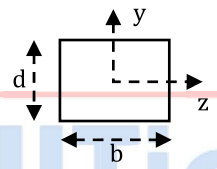
(A) 227 MPa (C) 87 MPa
(B) 77 MPa (D) 114 MPa

35. A column of length l and flexural rigidity EI, has one end fixed and the other end hinged. The critical buckling load for the column is

(A) $\frac{\pi^2 EI}{(0.5l)^2}$ (C) $\frac{\pi^2 EI}{l^2}$

(B) $\frac{\pi^2 EI}{(0.7l)^2}$ (D) $\frac{\pi^2 EI}{(2l)^2}$

36. A horizontal cantilevered steel beam of rectangular cross-section having width b and depth d is vibrating in the vertical plane. The natural frequency of bending vibration is highest when



(A) b =10 , d =10

(B) b =20 , d = 5

(C) b =5, d = 20

(D) b =25, d = 4

Two Marks Questions.

37. Following stress state is proposed for a 2-D problem with no body forces:

$\sigma_{xx} = 3x^2y + 4y^2, \sigma_{yy} = y^3 + 14xy,$

$\tau_{xy} = -3xy^2 - 7x^2$. It satisfies

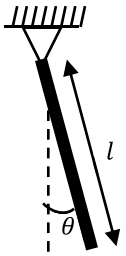
(A) Equilibrium equations but not compatibility equations

(B) Compatibility equation but not equilibrium equations

(C) Neither equilibrium equations nor compatibility equations

(D) Both equilibrium equations and compatibility equations

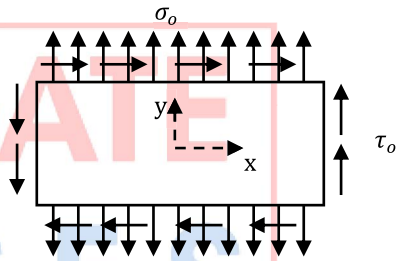
38. A uniform cross-section rigid rod of mass m and length l, is hinged at its upper end and suspended like a pendulum. Its natural frequency for small oscillations is



(A) $\sqrt{g/2l}$ (C) $\sqrt{2g/l}$

(B) $\sqrt{g/l}$ (D) $\sqrt{3g/2l}$

39. A thin rectangular plate shown in the figure is loaded with uniform shear, τ_D, along all edges and uniform uniaxial tension in the y-direction. The appropriate Airy's stress function to solve for stresses is given by



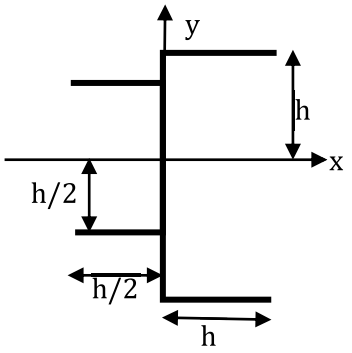
(A) $-\tau_0 xy - \sigma_0 \frac{x^2}{2} + \sigma_0 (x^4 - y^4)$

(B) $\tau_0 xy - \sigma_0 \frac{x^2}{2}$

(C) $-\tau_0 xy + \sigma_0 \frac{x^2}{2}$

(D) $\tau_0 xy + \sigma_0 \frac{x^2}{2} + \sigma_0 (x^4 - y^4)$

40. The given thin wall section of uniform thickness, t, is symmetric about x-axis. Moment of inertia is given to be $I_{xx} = \frac{35}{12} th^3$. Shear centre for this section is located at

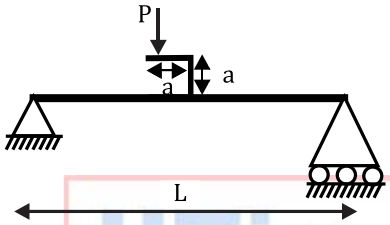


(A) $x = -\frac{3}{8}h$ (C) $x = -\frac{35}{36}h$

(B) $x = -\frac{9}{28}h$ (D) $x = -\frac{17}{35}h$

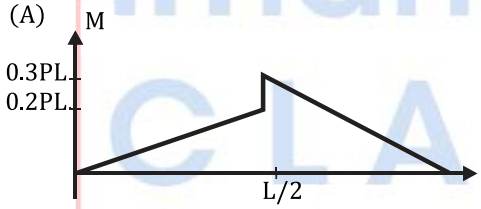
Common data for Questions 41 and 42:

Consider a simply supported beam of length L, carrying a bracket welded at its center. The bracket carries a vertical load, P, as shown in the figure. Dimensions of bracket are a = 0.1L. The beam has a square cross section of dimension h × h.

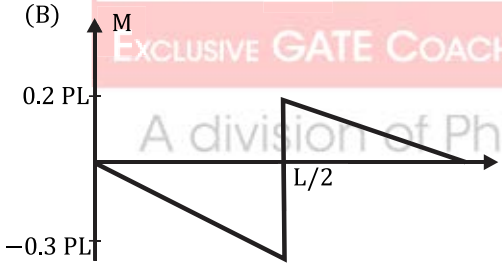


41. Bending moment diagram is given by

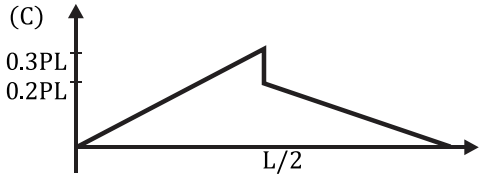
(A)



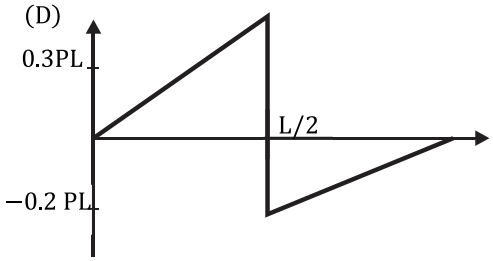
(B)



(C)



(D)



42. Maximum value of shear stress is

(A) 0.67 P/h^2 (C) 1.5 P/h^2

(B) 1.33 P/h^2 (D) 0.9 P/h^2

GATE AE - 2011

One Mark Questions.

43. In three-dimensional linear elastic solids, the number of non-trivial stress-strain relations, strain-displacement equations and equations of equilibrium are, respectively,

(A) 3, 3 and 3 (C) 6, 6 and 3

(B) 6, 3 and 3 (D) 6, 3 and 6

44. An Euler-Bernoulli beam in bending is assumed to satisfy

(A) both plane stress as well as plane strain conditions

(B) plane strain condition but not plane stress condition

(C) plane stress condition but not plane strain condition

(D) neither plane strain condition nor plane stress condition

45. A statically indeterminate frame structure has

(A) same number of joint degrees of freedom as the number of equilibrium equations

(B) number of joint degrees of freedom greater than the number of equilibrium equations

(C) number of joint degrees of freedom less than the number of equilibrium equations

(D) unknown number of joint degrees of freedom, which cannot be solved using laws of mechanics

46. Consider a simply supported two-dimensional beam

If the beam is converted into a fixed-fixed beam as

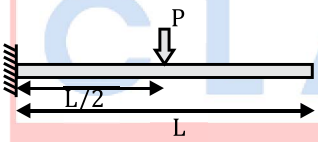
then the degree of static indeterminacy will

(A) increase by 3 (C) decrease by 1

(B) increase by 2 (D) decrease by 3

Two Marks Questions.

47. Consider a cantilever beam having length L=1 m, square cross-section (width = depth = 0.01 m) and Young's modulus 50 GPa. The beam is subjected to a transverse load P = 1 N at the mid-span (L/2) at the center of the cross-section. Under the small deformation theory, the transverse deflection of the beam (in mm) at its free-end is_____.



48. Consider a beam in bending with a solid circular cross-section of 1 mm^2, which is subjected to a transverse shear force of 1 N. The shear stress at the center of the cross-section (in N/mm^2) is _____.

49. A simply supported slender column of square cross section (width=depth=d) has to be designed such that it buckles at the same instant as it yields. Length of the column is given to be 1.57 m and it is made of a material whose Young's modulus is 200 GPa and yield stress is 240 MPa. The width, d, of the column (in cm) should be_____.

50. A body undergoes deformation under plane strain conditions when subjected to the following stresses (in MPa): $\sigma_{xx} = 450, \sigma_{yy} = 450, \tau_{xy} = 75, \tau_{xz} = 0, \tau_{yz} = 0$. What are the remaining components of stresses (in MPa) and strains? Assume the material to be isotropic and linear-elastic with Young's modulus E = 200 Gpa and Poisson's ratio v= 1/3

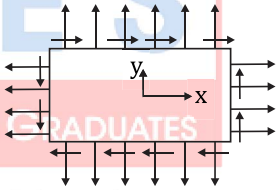
(A) $\sigma_{zz} = 0, \varepsilon_{xx} = 0.00225, \varepsilon_{yy} = 0.00225,$
$\gamma_{xy} = 0.002, \gamma_{xz} = 0, \gamma_{yz} = 0$

(B) $\sigma_{zz} = 300, \varepsilon_{xx} = 0.001, \varepsilon_{yy} = 0.001,$
$\gamma_{xy} = 0.001, \gamma_{xz} = 0, \gamma_{yz} = 0$

(C) $\sigma_{zz} = 300, \varepsilon_{xx} = 0.00225, \varepsilon_{yy} = 0.00225,$
$\gamma_{xy} = 0.001, \gamma_{xz} = 0, \gamma_{yz} = 0$

(D) $\sigma_{zz} = 0, \varepsilon_{xx} = 0.001, \varepsilon_{yy} = 0.001,$
$\gamma_{xy} = 0.002, \gamma_{xz} = 0, \gamma_{yz} = 0$

51. Which of the following Airy's stress functions could satisfy the given boundary conditions, assuming constant values of $\sigma_{xx} = P, \sigma_{yy} = Q$ and $\tau_{xy} = R$, along the boundary?



(A) $\phi = P\frac{x^2}{2} + Q\frac{y^2}{2} - Rxy$

(B) $\phi = P\frac{y^2}{2} + Q\frac{x^2}{2} + Rxy$

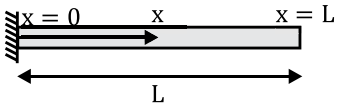
(C) $\phi = P\frac{y^2}{2} + Q\frac{x^2}{2} - Rxy$

(D) $\phi = P\frac{x^2}{2} + Q\frac{y^2}{2} + Rxy$

Common Data for Questions 52 and 53:

The partial differential equation (PDE) governing free vibrations of a uniform Euler-Bernoulli beam is given by $EI\frac{\partial^4 w}{\partial x^4} + m\frac{\partial^2 w}{\partial t^2} = 0$, where EI is the flexural stiffness, m is the mass per unit length w(x, t) is the bending

displacement, x is the coordinate along the beam length, t is time and L is the beam length



52. To solve the PDE, the number of boundary conditions (BC) and initial conditions (IC) needed are

(A) 4 BC, 3 IC (C) 2 BC, 4 IC
(B) 2 BC, 2 IC (D) 4 BC, 2 IC

53. For the cantilever beam shown in the figure, which of the following CANNOT be a possible boundary condition?

(A) $w(0,t) = 0$ (C) $\frac{\partial^2 w}{\partial x^2}(0,t) = 0$
(B) $\frac{\partial^2 w}{\partial x^2}(L,t) = 0$ (D) $\frac{\partial^3 w}{\partial x^3}(L,t) = 0$

Statement for Linked Answer Qns 54 and 55:

A thin-walled (thickness << radius), hollow shaft of length 1m and mean radius, R = 5 cm has to be designed such that it can transmit a torque, T = 7 kN-m. A survey of different commercially available materials was made and following data was obtained from the suppliers (E: Young's modulus, τ_y: yield stress in shear, ρ: density):

Material	E(GPa)	τ_y (MPa)	$\rho(kg/m^3)$
x	200	550	7700
y	70	225	2700
z	110	375	4875

54. Which of the above materials would you choose such that weight of the shaft is minimum?

(A) X only (C) Z only
(B) Y only (D) X or Y

55. If you assume a factor of safety of 2, what should be the approximate thickness of such a shaft?

(A) 0.5 mm (C) 2 mm
(B) 1 mm (D) 4 mm

GATE AE - 2012

One Mark Questions.

56. The governing equation for the static transverse deflection of a beam under an uniformly distributed load, according to Euler-Bernoulli (engineering) beam theory, is a

(A) 2nd order linear homogenous partial differential equation.
(B) 4th order linear non-homogenous ordinary differential equation.
(C) 2nd order linear non-homogenous ordinary differential equation.
(D) 4th order nonlinear homogenous ordinary differential equation.

57. The Poisson's ratio, ν of most aircraft grade metallic alloys has values in the range:

(A) $-1 \le \nu \le 0$ (C) $0.2 \le \nu \le 0.4$
(B) $0 \le \nu \le 0.2$ (D) $0.4 \le \nu \le 0.5$

58. In a semi-monocoque construction of an aircraft wing, the skin and spar webs are the primary carriers of

(A) shear stresses due to an aerodynamic moment component alone.
(B) normal (bending) stresses due to aerodynamic forces.
(C) shear stresses due to aerodynamic forces alone.
(D) shear stresses due to aerodynamic forces and a moment component.

Two Marks Questions.

59. The Airy stress function, $\phi = \alpha x^2 + \beta xy + \gamma y^2$ for a thin square panel of size $l \times l$ automatically satisfies compatibility. If the panel is subjected to uniform tensile stress, σ_0 on all four edges, the

traction boundary conditions are satisfied by

(A) $\alpha = \sigma_0/2\,;\beta = 0;\gamma = \sigma_0/2$

(B) $\alpha = \sigma_0;\beta = 0;\gamma = \sigma_0$

(C) $\alpha = 0;\beta = \sigma_0/4;\gamma = 0$

(D) $\alpha = 0;\beta = \sigma_0/2;\gamma = 0$

60. Buckling of the fuselage skin can be delayed by

(A) increasing internal pressure.

(B) placing stiffeners farther apart.

(C) reducing skin thickness.

(D) placing stiffeners farther and decreasing internal pressure.

Statement for Linked Answer Qns 61 and 62:

A thin-walled spherical vessel (1 m inner diameter and 10 mm wall thickness) is made of a material with $|\sigma_Y| = 500$ MPa in both tension and compression.

61. The internal pressure p_Y at yield, based on the von Mises yield criterion, if the vessel is floating in space, is approximately

(A) 500MPa (C) 100MPa

(B) 250MPa (D) 20MPa

62. If the vessel is evacuated (internal pressure = 0) and subjected to external pressure, yielding according to the von Mises yield criterion (assuming elastic stability until yield)

(A) occurs at about half the pressure p_Y

(B) occurs at about double the pressure p_Y

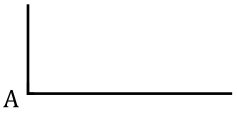
(C) occurs at about the same pressure p_Y

(D) never occurs.

GATE AE - 2013

One Mark Questions.

63. The cross-section of a long thin-walled member is as shown in the figure. When subjected to pure twist, point A



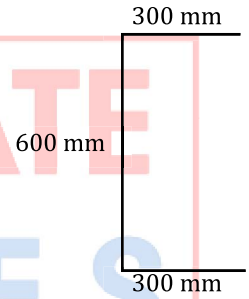
(A) does not move horizontally or axially, but moves vertically

(B) does not move axially, but moves both vertically and horizontally

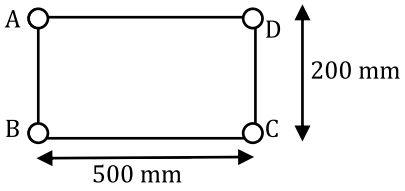
(C) does not move horizontally, vertically or axially

(D) does not move vertically or axially, but moves horizontally

64. The channel section of uniform thickness 2mm shown in the figure is subjected to a torque of 10 Nm. If it is made of a material with shear modulus of 25 GPa, the twist per unit length in radians/m is _____



65. The stiffened cross-section of a long slender uniform structural member is idealized as shown in the figure below. The lumped areas at A, B, C and D have equal cross-sectional area of 3 cm^2. The webs AB, BC, CD and DA are each 5 mm thick. The structural member is subjected to a twisting moment of 10 kNm. The magnitudes of the shear flow in the webs, q_{AB}, q_{BC}, q_{CD}, and q_{DA} in kN/m are, respectively

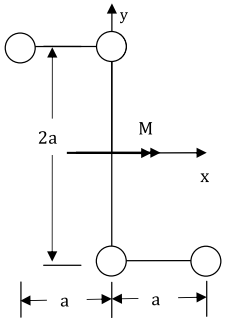


(A) 20, 20, 20, 20 (C) 40, 40, 0, 0

(B) 0, 0, 50, 50 (D) 50, 50, 50, 50

Two Marks Questions.

66. The idealized cross-section of a beam is comprised of four identical booms connected by shear webs. The beam is subjected to a bending moment M as shown in the figure. The inclination of the neutral axis to the x-axis in degrees is



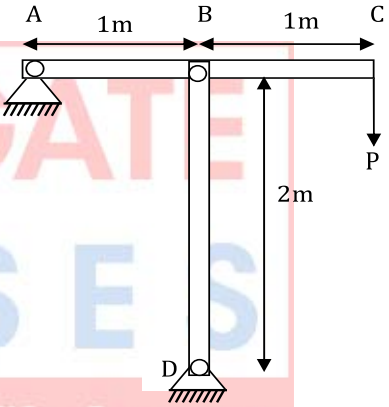
(A) 45 CW (C) 26.6 CW
(B) 45 CCW (D) 63.4 CCW

67. A composite circular shaft is comprised of a steel core surrounded by an aluminum annulus, perfectly bonded to each other as shown in the figure. If it subjected to a pure torque, which one of the following statements is TRUE?

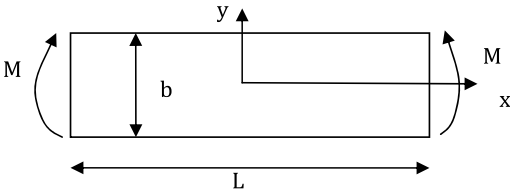
(A) Only shear stress is continuous across the steel–aluminum interface
(B) Only shear strain is continuous across the steel–aluminum interface
(C) Both shear stress and shear strain are continuous across the steel–aluminum interface
(D) Both shear stress and shear strain are discontinuous across the steel–aluminum interface

68. A horizontal rectangular plate ABCD is hinged at points A, B and C. AC and BD are diagonals of the plate. Downward force P is applied at D. The upward reactions R_A, R_B, and R_C at points A, B and C, respectively, are
(A) indeterminate
(B) P, -P, P
(C) 0, P, 0
(D) P/3, P/3, P/3

69. In the steel structure (Young's modulus = 200 GPa) shown in the figure, all members have a circular cross-section of radius 10 mm. Column BD is pinned at B and D. The support at A is hinged. The minimum value of load P at which the column BD may buckle in Newtons is approximately _____



70. The thin rectangular plate has dimensions L × b × t. It develops a stress field corresponding to an applied bending moment M as shown in the figure. A valid Airy's stress function is

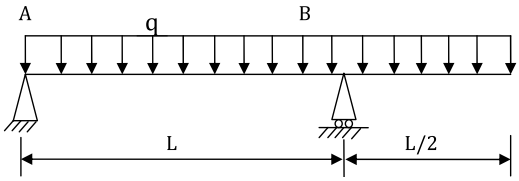


(A) $\frac{2M}{tb^3}x^3$ (C) $\frac{2M}{tb^3}(x^3+y^3)$
(B) $\frac{2M}{tb^3}y^3$ (D) $\frac{2M}{tb^3}y^4$

71. A cantilever beam of negligible mass is 0.6 m long. It has a rectangular cross-section of width

8 mm and thickness 6 mm and carries a tip mass of 1.4 kg. If the natural frequency of this system is 10 rad/s, Young's modulus of the material of the beam in GPa is _____

72. A simply supported beam with overhang is loaded by uniformly distributed load of intensity q as shown in the figure. The bending moment at the mid-point of AB is



(A) $\frac{qL^2}{16}$ sagging (C) $\frac{3qL^2}{16}$ hooging

(B) $\frac{qL^2}{16}$ hogging (D) $\frac{3qL^2}{16}$ sagging

GATE AE - 2014

One Mark Questions.

73. It is desired to measure the Young's modulus and the Poisson's ratio of a given homogeneous, isotropic material. A bar of length 20cm and square cross-section (10mm × 10mm) of this material is subjected to a tensile load of 40kN. Under this load, length increases to 20.1cm while the cross-section reduces to 9.98mm × 9.98mm. Young's modulus and Poisson's ratio of the material are:

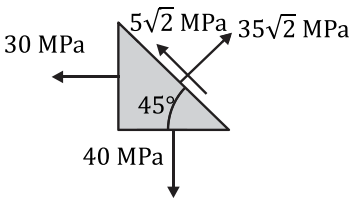
(A) 80 GPa & 0.4 respectively
(B) 40 GPa & −0.4 respectively
(C) 80 GPa & −0.2 respectively
(D) 40 GPa & 0.2 respectively

74. In general, for any given solid subjected to arbitrary loading, which of the following statements is always true:

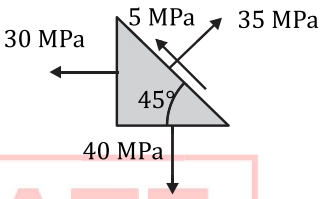
(A) Volume does not vary with loading
(B) Mass does not vary with loading
(C) Density does not vary with loading
(D) Volume, mass and density vary with loading

75. Which one of the following objects with inclined face at 45°, subjected to the given stresses, are in static equilibrium:

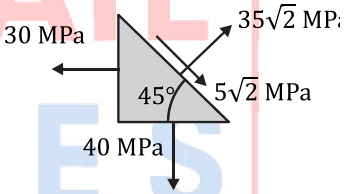
(A)



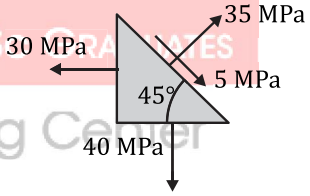
(B)



(C)

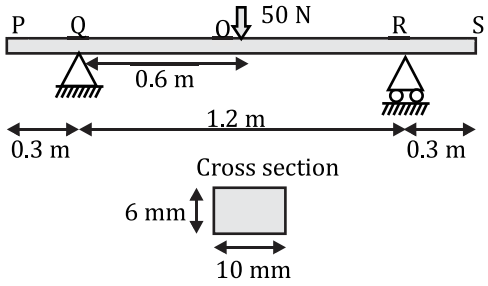


(D)

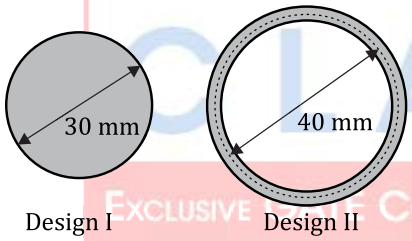


Two Marks Questions.

76. A 1.8m long steel beam of rectangular cross section (10mm × 6mm) is simply supported with a length of 1.2m between the supports and an overhang of 0.3m on either side. Young's modulus for the material of the beam is 200GPa. For a 50N load applied at the center of the beam, magnitude of the slope of the beam at tip S is ____.

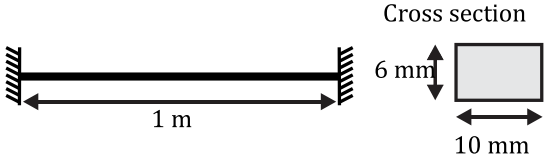


77. There are 2 designs proposed for a shaft of length l, with a torque carrying capacity of T. Design I is a solid circular cross-section shaft of diameter 30mm. Design II is a thin-walled circular shaft of average diameter 40mm. Thickness of the wall in Design II has to be determined such that maximum shear stress is the same in both the designs for the given torque T(so that same material can be used for manufacturing both the shafts). Ratio of mass of shaft using Design I to the mass of shaft using Design II is



(A) 2.68 (C) 1.79
(B) 5.36 (D) 3.58

78. A structural member of rectangular cross-section 10mm × 6mm and length 1m is made of steel (Young's modulus is 200GPa and coefficient of thermal expansion is 12×10^{-6}/ °C). It is rigidly fixed at both the ends and then subjected to a gradual increase in temperature. Ignoring the three dimensional effects, the structural member will buckle if the temperature is increased by ΔT °C which is

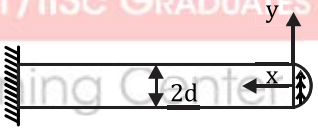


(A) 19.74 (C) 78.96
(B) 9.87 (D) 39.48

79. A gas cylinder (closed thin-walled cylindrical pressure vessel) of diameter 30cm and wall thickness 1mm is subjected to a design maximum internal pressure of 5bar (0.5MPa). The material used for manufacturing this cylinder has a failure stress of 260MPa. Assuming von Mises failure criterion, the factor of safety (with respect to maximum allowable stress) for this cylinder is

(A) 2.8 (C) 6.9
(B) 2.0 (D) 4.0

80. A cantilevered beam is subjected to a parabolic distribution of shear traction at the right edge while the top and bottom surfaces are traction free. To solve this problem, following Airy's stress function is proposed: $\phi = C_1xy + C_2xy^3 + C_3x^2y^2 + C_4x^3y$. This is an admissible Airy's function that would satisfy the bi-harmonic equation as well as the boundary conditions if and only if



$\tau_{xy} = -\lambda\left[1 - \left(\frac{y}{d}\right)^2\right]$

(A) $C_1 = 0, C_2 = \lambda, C_3 = 0, C_4 = \frac{\lambda}{3d^2}$

(B) $C_1 = \lambda, C_2 = \frac{\lambda}{3d^2}, C_3 = 0, C_4 = 0$

(C) $C_1 = 0, C_2 = 0, C_3 = \lambda, C_4 = -\frac{\lambda}{3d^2}$

(D) $C_1 = \lambda, C_2 = -\frac{\lambda}{3d^2}, C_3 = 0, C_4 = 0$

GATE AE - 2015

One Mark Questions.

81. A cantilever with thin-walled channel cross section is subjected to a lateral force at its shear center.

The cantilever undergoes

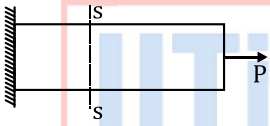
(A) bending without twisting

(B) bending and twisting
(C) neither bending nor twisting
(D) twisting without bending

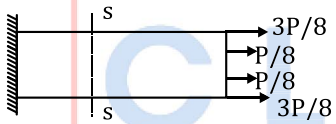
82. The two non-zero principal stresses at a point in a thin plate are $\sigma_1 = 25$ MPa and $\sigma_2 = -25$ MPa. The maximum shear stress (in MPa) at this point is ____.

83. A slender structure is subjected to four different loading cases (I, II, III and IV) as shown below (Figures not to scale). Which pair of cases results in identical stress distribution at section S-S located far away from both ends?

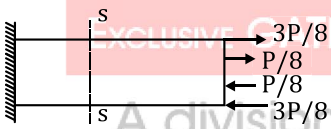
I.



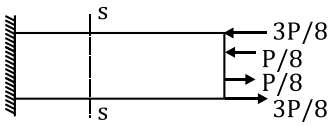
II.



III.



IV.



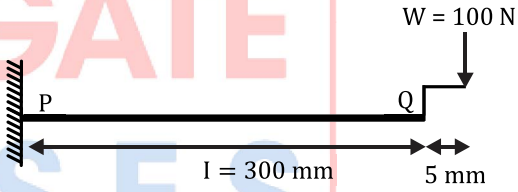
(A) I and II (C) III and IV
(B) II and III (D) IV and I

Two Marks Questions.

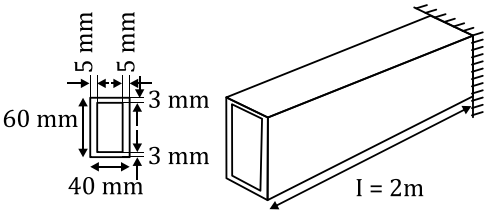
84. The 2-D stress state at a point P in the x-y coordinate system is $\begin{bmatrix} 60 & 50 \\ 50 & -40 \end{bmatrix}$ MPa. The magnitude of the tangential stress (in MPa) on a surface normal to the x-axis at P is ____.

85. A cube made of a linear elastic isotropic material is subjected to a uniform hydrostatic pressure of
100 k/mm^2. Under this load, the volume of the cube shrinks by 0.05%. The Young's modulus of the material, E = 300 GPa. The Poisson's ratio of the material is ____.

86. A massless cantilever beam PQ has a solid square cross section (10 mm × 10 mm). This beam is subjected to a load W through a rigid massless link at the point Q, as shown below (figure not to
scale). If the Young's modulus of the material E = 200 GPa, the deflection (in mm) at point Q is ____.



87. The thin rectangular tube shown below is made of a material with shear modulus, G = 80 GPa. The shear flow is calculated based on the mid-thickness dimensions. If the free end is allowed to twist no more than 0.0727 rad, then the maximum torque (in Nm) which the tube can be subjected to at its free end is _____.



88. A 200 mm long simply-supported column has a 5 mm × 10 mm rectangular cross section. The Young's modulus of the material, E = 200 GPa.

Assuming a factor of safety of 2.5 corresponding to the buckling load, the maximum load (in N) the column can support in compression is _____.

GATE AE - 2016

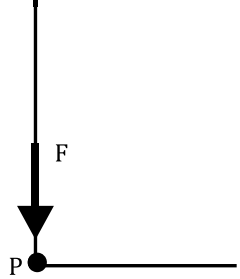
One Mark Questions.

89. The total number of material constants that are necessary and sufficient to describe the three dimensional Hooke's law for an isotropic material is ___.

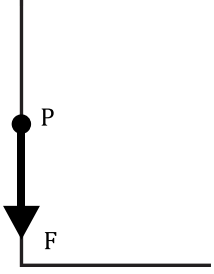
90. Determine the correctness or otherwise of the following statements, [a] and [r]:
[a]: In a plane stress problem, the shear strains along the thickness direction of a body are zero but the normal strain along the thickness is not zero.
[r]: In a plane stress problem, Poisson effect induces the normal strain along the thickness direction of the body.
(A) Both [a] and [r] are true and [r] is the correct reason for [a].
(B) Both [a] and [r] are true but [r] is not the correct reason for [a].
(C) Both [a] and [r] are false.
(D) [a] is true but [r] is false.

91. Consider four thin-walled beams of different open cross-sections, as shown in the cases (i-iv). A shear force of magnitude '**F**' acts vertically downward at the location '**P**' in all the beams. In which of the following case, does the shear force induce bending and twisting?

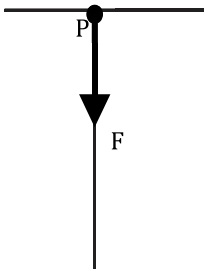
Case (i)



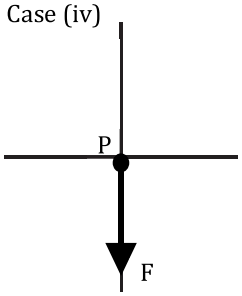
Case (ii)



Case (iii)



Case (iv)



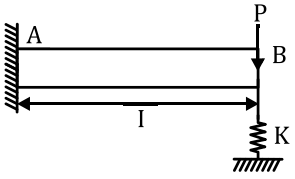
(A) (i)
(B) (ii)
(C) (iii)
(D) (iv)

92. A structural member supports loads, which produce at a particular point, a state of pure shear stress of 50 N/mm^2. At what angles are the principal planes oriented with respect to the plane of pure shear?
(A) π/6 and 2π/3
(B) π/4 and 3π/4
(C) π/4 and π/2
(D) π/2 and π

Two Marks Questions.

93. A bar made of linear elastic isotropic material is fixed at one end and subjected to an axial force of 1 kN at the other end. The cross-sectional area of the bar is 100 mm^2, length is 100 mm and the Young's Modulus is 1×10^5N/mm^2. The strain energy stored in the bar is ___ Nmm.

94. A cantilever beam-spring system is shown in the figure. The beam is made with a material of Young's modulus 1×10^5N/mm^2 and geometry such that its moment of inertia is 100 mm^4 and length l = 100 mm. It is supported by a spring of stiffness K = 30 N/mm and subjected to a load of P = 100 N at the point 'B'. The deflection at the point 'B' due to the load P is ___mm.



95. Determine the correctness or otherwise of the following statements, [a] and [r],

[a]: Ribs, used in airplane wings, increase the column buckling strength of the longitudinal stiffeners.

[r]: Ribs distribute concentrated loads into the structure and redistribute stresses around discontinuities.

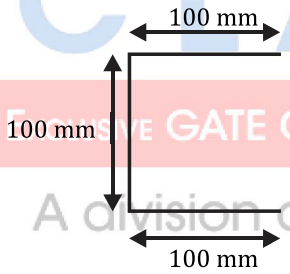
(A) Both [a] and [r] are true and [r] is the correct reason for [a]

(B) Both [a] and [r] are true but [r] is not the correct reason for [a]

(C) Both [a] and [r] are false

(D) [a] is true but [r] is false

96. A channel section shown in the figure has uniform thickness. It is subjected to an anticlockwise torque of 62.5×10^3Nmm. The maximum possible thickness of the channel section, such that the shear stress induced in it does not exceed 100 N/mm^2, is ___ mm.



97. The two dimensional state of stress in a body is described by the Airy's stress function:

$$\phi = 5\frac{x^4}{12} + \frac{x^3y}{6} + 3\frac{x^2y^2}{2} + 7\frac{xy^3}{6} + E\frac{y^4}{12}.$$

The Airy's stress function will satisfy the equilibrium and the compatibility requirements if and only if the value of the coefficient E is ___.

GATE AE - 2017

One Mark Questions.

98. Which of the following statement(s) is / are true about the shear centre of a cross-section:

P: It is that point in the cross-section through which shear loads produce no twisting.

Q: This point is also the centre of twist of sections subjected to pure torsion.

R: The normal stress at this point is always zero.

(A) P, Q and R (C) P and Q only

(B) P only (D) P and R only

99. Which of the following statements about the neutral axis of a beam with unsymmetrical cross section is true:

(A) The product of second moment of area about the neutral axis is always zero.

(B) The normal stress along the neutral axis is always zero.

(C) The shear stress along the neutral axis is always zero.

(D) The product of second moment of area about the neutral axis and the normal stress about the neutral axis are always zero.

100. Assuming that the aircraft is flying straight, the top spar cap / flange of a wing is most likely to fail

(A) Yielding (C) Crushing

(B) Buckling (D) Creep

101. A 2-DOF undamped spring-mass system with two masses and two springs has natural frequencies ω_1 =0.79 rad/s and ω_2 = 1.538 rad/s. The mode shapes for the system are given by $\phi_1 = [0.732\ 1]^T$ and $\phi_2 = [-2.73\ 1]^T$. If the first mass is displaced by 1 cm. the minimum displacement in cms to be given to the second mass to make the system vibrate in first mode alone is =_____ (in three decimal place).

102. An aircraft landing gear can be idealized as a single degree of freedom spring-mass-damper system. The desirable damping characteristics of such a system is:

(A) Under damped
(B) Over damped
(C) Critically damped
(D) Undamped

103. A single degree of freedom spring-mass system of natural frequency 5 Hz is modified in the following maimers:

Case 1: Viscous damping with damping ratio $\varsigma = 0.2$ is introduced in parallel to the spring.

Case 2: The original undamped spring-mass system is moved to a surface with coefficient of friction. $\mu = 0.01$.

The ratio of the damped natural frequency for the cases 1 and 2 is given by_____(in three decimal places).

104. Which of the following statements about the compatibility equations are true:

P. Strain compatibility equations must be satisfied in the solution of three-dimensional problems in elasticity.

Q. Six strains are defined in terms of three displacement functions and can have arbitrary values.

R. Compatibility equations are an expression of the continuity of displacements.

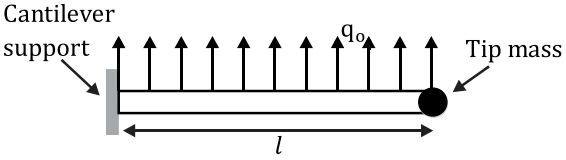
(A) P and Q (C) P and R
(B) Q and R (D) P, Q and R

Two Marks Questions.

105. A batch of aluminium alloy yields in uniaxial tension at the stress of 330 MN/m^2. If this material is subjected to the following state of stress: $\sigma_x = 140\ MN/m^2$, $\sigma_y = -70\ MN/m^2$, $\sigma_z = 0, \tau_{xy} = x\ MN/m^2$, $\tau_{yx} = 0$ and $\tau_{zx} = 0$.

The value of x that would result in yielding according to the Von Mises failure criterion is_____(in three decimal places).

106. An aircraft wing is idealized as a cantilever beam of constant width and length l with a tip mass of weight W (Newtons) and has a uniformly distributed loading of q_o (Newtons/m) as shown in the figure. Flexural rigidity = EI and $q_o\, l = 10W$

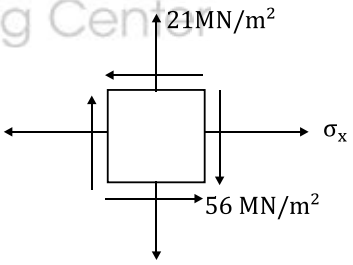


The upward deflection of the tip of the aircraft wing under the given loading can be expressed as

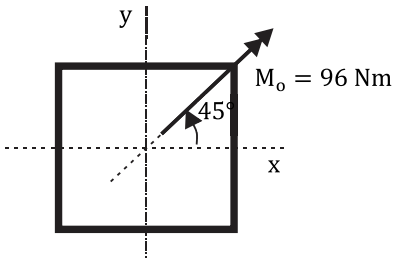
$$\delta = k\frac{Wl^3}{EI}$$

The value of k is _____ (in three decimal places).

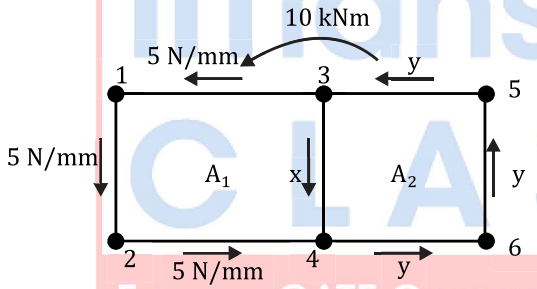
107. For the state of plane stress shown in the figure, the minimum principal stress is -7 MN/m^2. The normal stress σ_x in MN/m^2 is equal to____(round to nearest integer).



108. The maximum normal stress in MN/m^2 for the thin walled beam of square cross section of outer dimension 120 mm × 120 mm and wall thickness 1 mm under the action of moment $M_o = 96$ Nm as shown in the figure is _____ (in three decimal places).



109. The idealized cross section of a thin-walled wing box structure shown in the figure is subjected to an anticlockwise torque of 10 kNm. The corresponding shear-flow distribution under this loading condition is shown in the figure. The area of each cell is $A_1 = 300 \times 10^3 mm^2$ and $A_2 = 250 \times 10^3 mm^2$. The ratio of the unknowns $\frac{x}{y}$ is given by___(in three decimal places).



GATE AE - 2018

One Mark Questions.

110. Determine the correctness or otherwise of the following statements, [a] and [r]:

[a] A closed-section box beam configuration is used in aircraft wings.

[r] Closed-section box beam configuration is capable of resisting torsional loads.

(A) Both [a] and [r] are true and [r] is the correct reason for [a].

(B) Both [a] and [r] are true but [r] is not the correct reason for [a].

(C) Both [a] and [r] are false.

(D) [a] is true but [r] is false.

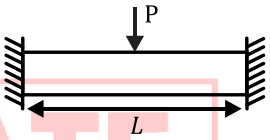
Two Marks Questions.

111. A solid circular shaft of diameter d is under pure torsion of magnitude T. The maximum tensile stress experienced at any point on the shaft is

(A) $\frac{32T}{\pi d^3}$ (C) $\frac{32T}{\pi d^4}$

(B) $\frac{16T}{\pi d^4}$ (D) $\frac{16T}{\pi d^3}$

112. A clamped-clamped beam, subjected to a point load P at the midspan, is shown in the figure below. The magnitude of the moment reaction at the two fixed ends of the beam is



(A) PL/2 (C) PL/8

(B) PL/4 (D) PL/16

113. Which of the following statement(s) is/are true about the state of a body in plane strain condition?

P. All the points in the body undergo displacements in one plane only, for example the x-y plane, leading to $\varepsilon_{zz} = \gamma_{xz} = \gamma_{yz} = 0$.

Q. All the components of stress perpendicular to the plane of deformation, for example the x-y plane, of the body are equal to zero, i.e. $\sigma_{zz} = \tau_{xz} = \tau_{yz} = 0$.

R. Except the normal component, all the other components of stress perpendicular to the plane of deformation of the body, for example the x-y plane, are equal to zero, i.e. $\sigma_{zz} \neq 0, \tau_{xz} = \tau_{yz} = 0$.

(A) P only (C) P and Q

(B) Q only (D) P and R

114. A thin-walled tube with external radius of 100 mm and wall thickness of 2 mm, is fixed at one end. It is subjected to a compressive force of 1 N acting at a point on the circumference parallel to its length. The maximum normal stress (in kPa) experienced by the structure is _____ (accurate to two decimal places).

115. A cantilever beam having a rectangular cross-section of width 60 mm and depth 100 mm, is made of aluminum alloy. The material mechanical properties are: Young's modulus, E = 73 GPa and ultimate stress, σ_u = 480 MPa. Assuming a factor of safety of 4, the maximum bending moment (in kN-m) that can be applied on the beam is ____ (accurate to one decimal place).

116. The components of stress in a body under plane stress condition, in the absence of body forces, is given by:
$\sigma_{xx} = Ax^2$; $\sigma_{yy} = 12x^2 - 6y^2$ and $\sigma_{xy} = 12xy$.
The coefficient, A, such that the body is under equilibrium is ____ (accurate to one decimal place).

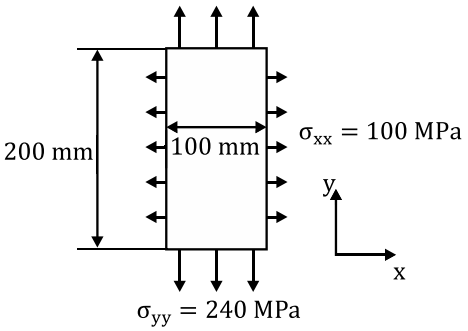
GATE AE - 2019

One Mark Questions.

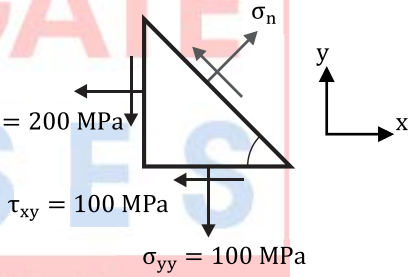
117. For a beam subjected to a transverse shear load through its shear- center,
(A) the twist per unit length is zero.
(B) the shear stress is uniform throughout the cross-section.
(C) the bending stresses in the cross section are zero.
(D) the shear strain is zero at the shear center.

118. The number of independent elastic constants for a homogeneous isotropic linear elastic material is _____.

119. A thin plate with Young's modulus 210 GPa and Poisson's ratio 0.3 is loaded as shown in the figure. The change in length along the y-direction is _____ mm(round off to 1 decimal place)

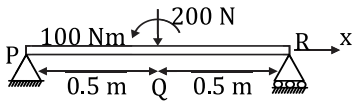


120. For the state of stress shown in the figure, the normal stress, σ_n , on a plane inclined at 45 degrees to the x-axis is _____ MPa (round off to the nearest integer).

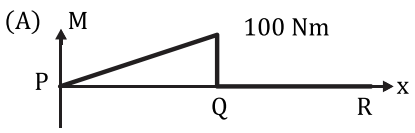


Two Marks Questions.

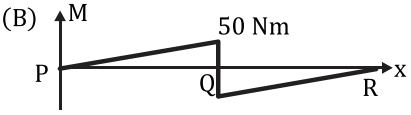
121. For a 1 m long simply supported beam with a concentrated vertical load of 200 N and a concentrated bending moment of 100 Nm at the center as shown in the figure, the correct bending moment diagram is:

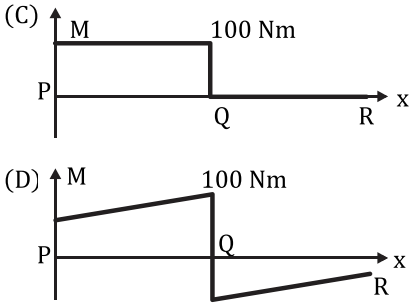


(A)

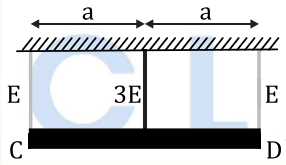


(B)

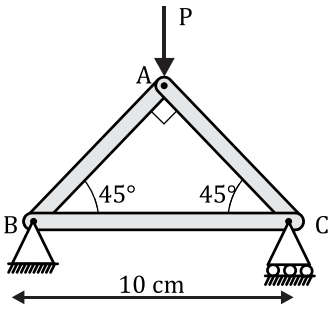




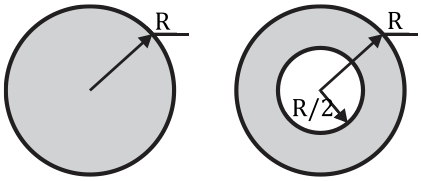
122. As shown in the figure, a rigid slab CD of weight W (distributed uniformly along its length) is hung from a ceiling using three cables of identical length and cross-sectional area. The central cable is made of steel (Young's modulus = 3E) and the other two cables are made of aluminium (Young's modulus = E). The percentage of the total weight taken by the central cable is_____ % (round off to the nearest integer).



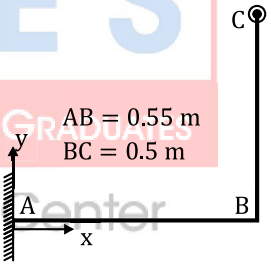
123. All the bars in the given truss are elastic with Young's modulus 200 GPa, and have identical cross-sections with moment of inertia 0.1 cm^4. The lowest value of the load P at which the truss fails due to buckling is _____ kN (round off to the nearest integer).



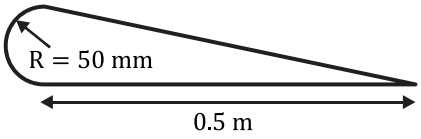
124. A solid circular shaft is designed to transmit a torque T with a factor of safety of 2. It is proposed to replace the solid shaft by a hollow shaft of the same material and identical outer radius. If the inner radius is half the outer radius, the factor of safety for the hollow shaft is _____ (round off to 1 decimal place).



125. In the structure shown in the figure, bars AB and BC are made of identical material and have circular cross-sections of 10 mm radii. The yield stress of the material under uniaxial tension is 280 MPa. Using the von Mises yield criterion, the maximum load along the z-direction (perpendicular to the plane of paper) that can be applied at C, such that AB does not yield is _____ N (round off to the nearest integer).



126. A thin-walled tube, with the cross-section shown in the figure, is subjected to a torque of $T = 1\ kN - m$ The walls have uniform thickness t= 1 mm and shear modulus G = 26 GPa. Assume that the curved portion is semi-circular. The shear stress in the wall is _____ MPa (round off to 1 decimal place).



GATE AE - 2020

One Mark Questions.

127. Which one of the following conditions needs to be satisfied for $\phi = Ax^4 + By^4 + Cxy^3$ to be considered as an Airy's stress function

(A) $A - B = 0$ (C) $A - C = 0$
(B) $A + B = 0$ (D) $A + C = 0$

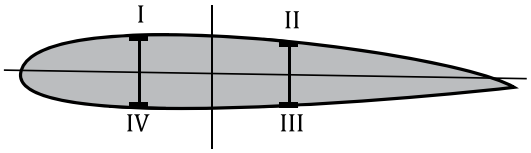
128. Consider the plane strain field given by $\varepsilon_{xx} = Ay^2 + x, \varepsilon_{yy} = Ax^2y, \gamma_{xy} = Bxy + y$. The relation between A and B needed for this strain field to satisfy the compatibility condition is

(A) $B = A$ (C) $B = 3A$
(B) $B = 2A$ (D) $B = 4A$

129. Three long and slender aluminum bars of identical length are subjected to an axial tensile force. These bars have circular, triangular and rectangular cross sections, with same cross sectional area. If they yield at $F_{circle}, F_{triangle}$ and $F_{rectangle}$, respectively, which one of the following is true?

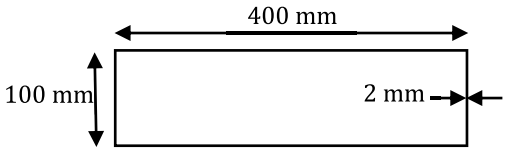
(A) $F_{circle} > F_{triangle} > F_{rectangle}$
(B) $F_{circle} < F_{triangle} < F_{rectangle}$
(C) $F_{triangle} > F_{circle} > F_{rectangle}$
(D) $F_{circle} = F_{triangle} = F_{rectangle}$

130. The positive high angle-of-attack condition is obtained in a steady pull-out maneuver at the largest permissible angle-of-attack of the wing. Under this condition, at which of the following regions of the wing does the maximum tension occur?



(A) I (C) III
(B) II (D) IV

131. A thin walled beam of constant thickness shown in the figure is subjected to a torque of 3.2 kNm. If the shear modulus is 25 GPa, the angle of twist per unit length is _____ rad/m (round off to three decimal places).

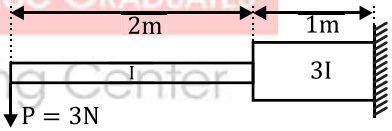


Two Marks Questions.

132. The value of Poisson's ratio at which the shear modulus of an isotropic material is equal to the bulk modulus is

(A) 1/2 (C) 1/6
(B) 1/4 (D) 1/8

133. A load P is applied to the free end of a stepped cantilever beam as shown in the figure. The Young's modulus of the material is E, and the moments of inertia of the two sections of length 2 m and 1 m are I and 3I, respectively. Ignoring transverse shear and stress concentration effects, the deflection at the point where the load is applied at the free end of the cantilever is



(A) 23/243EI (C) 43/3EI
(B) 1/3EI (D) 23/3EI

134. The three-dimensional strain-stress relation for an isotropic material, written in a general matrix form, is

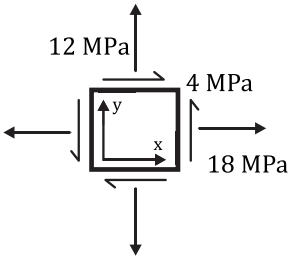
$$\begin{Bmatrix} \varepsilon_{xx} \\ \varepsilon_{yy} \\ \varepsilon_{zz} \\ \gamma_{yz} \\ \gamma_{xz} \\ \gamma_{xy} \end{Bmatrix} = \begin{bmatrix} A & C & C & 0 & 0 & 0 \\ C & A & C & 0 & 0 & 0 \\ C & C & A & 0 & 0 & 0 \\ 0 & 0 & 0 & B & 0 & 0 \\ 0 & 0 & 0 & 0 & B & 0 \\ 0 & 0 & 0 & 0 & 0 & B \end{bmatrix} \begin{Bmatrix} \sigma_{xx} \\ \sigma_{yy} \\ \sigma_{zz} \\ \tau_{yz} \\ \tau_{xz} \\ \tau_{xy} \end{Bmatrix}$$

A, B and C are compliances which depend on the elastic properties of the material. Which one of the following is correct?

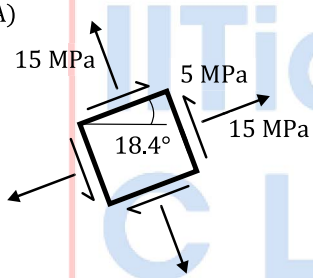
(A) $C = \frac{A}{2} - B$ (C) $C = A + \frac{B}{2}$

(B) $C = \frac{A}{2} + B$ (D) $C = A - \frac{B}{2}$

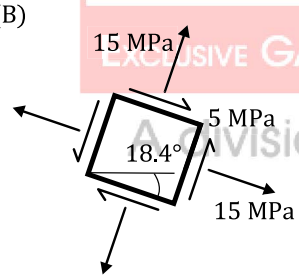
135. For the state of stress shown in the figure, which one of the following represents the correct free body diagram showing the maximum shear stress and the associated normal stresses?



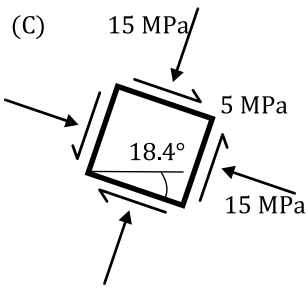
(A)



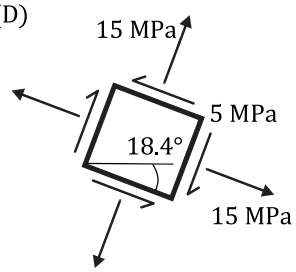
(B)



(C)

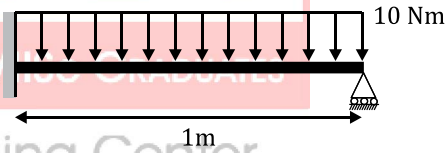


(D)



136. A solid circular shaft, made of ductile material with yield stress σ_y = = 280 MPa, is subjected to a torque of 10 kNm. Using the Tresca failure theory, the smallest radius of the shaft to avoid failure is _____ cm (round off to two decimal places).

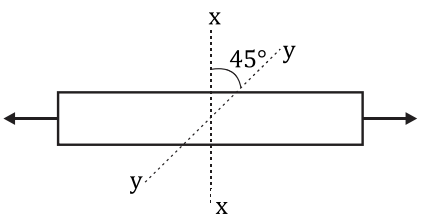
137. As shown in the figure, a beam of length 1 m is rigidly supported at one end and simply supported at the other. Under the action of a uniformly distributed load of 10 N/m, the magnitude of the normal reaction force at the simply supported end is _____ N (round off to two decimal places).



GATE AE - 2021

One Mark Questions.

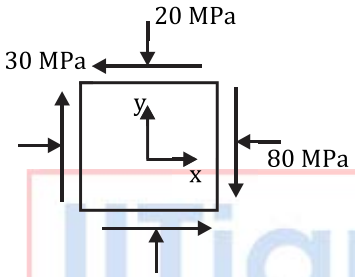
138. Uniaxial tension test (see the figure) is conducted on two different samples prepared with homogeneous, isotropic materials. One of the materials is brittle, whereas the other is ductile.



Assuming that there is no stress concentration at loading points, the failure would initiate:

(A) along x-x in both materials
(B) along x-x in brittle material and along y-y in ductile material
(C) along y-y in brittle material and along x-x in ductile material
(D) along y-y in both materials

139. For the state of stress as shown in the figure, what is the orientation of the plane with maximum shear stress with respect to the x-axis?



(A) 45° (C) 22.5°
(B) −45° (D) −22.5°

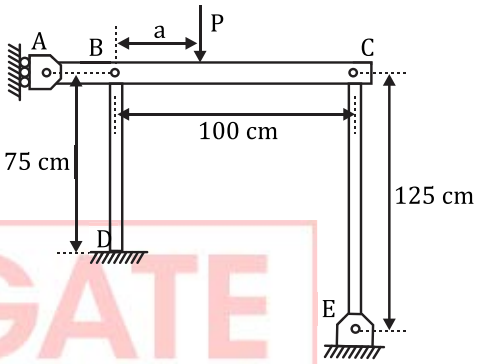
140. A thin-walled cylindrical tank with closed ends, made of homogeneous and isotropic material, is pressurized internally. If the hoop (circumferential) strain developed in the material is thrice the value of the axial strain then the Poisson's ratio of the material is _____ (correct up to one decimal place).

Two Marks Questions.

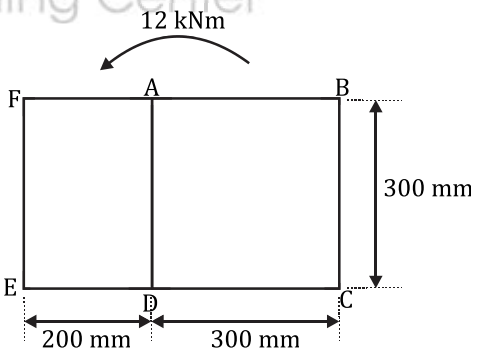
141. The deflection y of a certain beam of length l and uniform weight per unit length w, is given as $y = \frac{w}{48EI}(2x^4 - 3lx^3 + l^3x)$, where x is the distance from the point of support and EI is a constant. The non-dimensional location x/l, where the deflection of the beam is maximum, is ____ (round off to two decimal places).

142. A rigid horizontal bar ABC, with roller support at A, is pinned to the columns BD and CE at points B and C, respectively as shown in figure. The other end of the column BD is fixed at D, whereas the column CE is pinned at E. A vertical load P is applied on the bar at a distance 'a' from point B.

The two columns are made of steel with elastic modulus 200 GPa and have a cross section of 1.5 cm × 1.5 cm. The value of 'a' for which both columns buckle simultaneously, is _____ cm (round off to one decimal place).

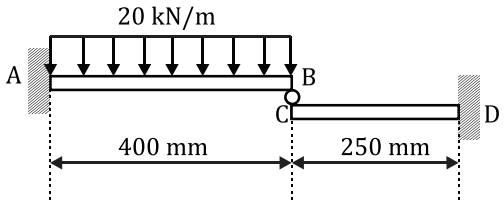


143. A two-cell wing box is shown in the figure. The cell walls are 1.5 mm thick and the shear modulus G = 27 GPa. If the structure is subjected to a torque of 12 kNm, then the wall AD will experience a shear stress of magnitude _____ MPa (round off to one decimal place).

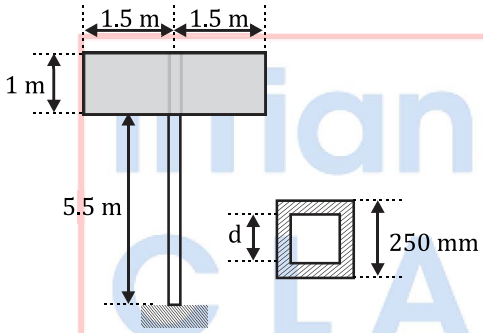


144. Two cantilever beams AB and DC are in contact with each other at their free ends through a roller as shown in the figure. Both beams have a square cross section of 50 mm x 50 mm, and the elastic modulus E = 70 GPa. If beam AB is subjected to a uniformly distributed load of 20 kN/m, then the compressive force experienced

by the roller is _____ kN (round off to one decimal place).



145. A 3 m × 1 m signboard is supported by a vertical hollow pole that is fixed to the ground. The pole has a square cross section with outer dimension 250 mm. The yield strength of the pole material is 240 MPa. To sustain a wind pressure of 7.5 kPa, the dimension d of the pole is _____ mm (round off to nearest integer).

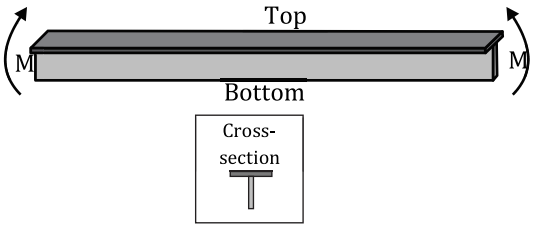


(Neglect the effect of transverse shear and load due to wind pressure acting on the pole)

GATE AE - 2022

One Mark Questions.

146. A beam with a symmetrical T-shaped cross-section, as shown in the figure, is subjected to pure bending. The maximum magnitude of the normal stress is realised:



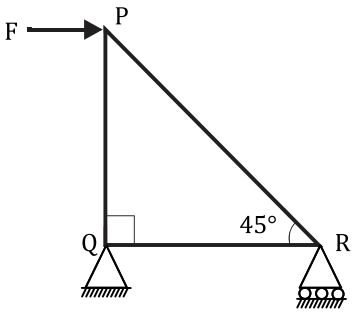
(A) only at the top fibres of the cross-section

(B) only at the bottom fibres of the cross-section

(C) both at the top and bottom fibres of the cross-section

(D) only at the centroidal fibres of the cross-section

147. A three-member truss is simply supported at Q and R, and loaded at P by a horizontal force F as shown. The force in QR is



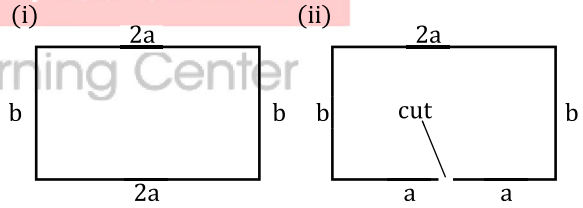
(A) 0

(B) F(tensile)

(C) $F/\sqrt{2}$ (Compressive)

(D) $\sqrt{2}F$(tensile)

148. The closed thin-walled rectangular channel shown in figure (i) is opened by introducing a sharp cut at the center of the bottom edge, as shown in figure (ii). Which one of the following statements is correct?



(A) Centroids of (i) and (ii) coincide while shear centers do not

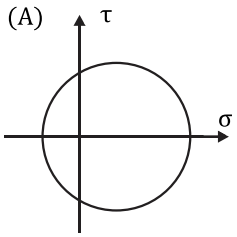
(B) Shear centers of (i) and (ii) coincide while centroids do not

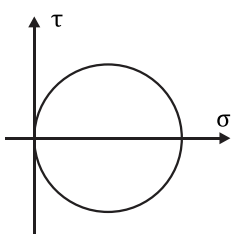
(C) Both centroids and shear centers of (i) and (ii) coincide

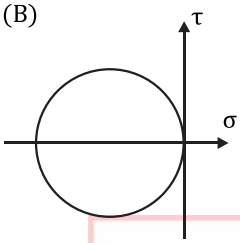
(D) Neither centroids nor shear centers of (i) and (ii) coincide

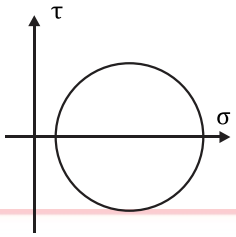
149. Let σ and τ represent the normal stress and shear stress on a plane, respectively.

The Mohr circle(s) that may possibly represent the state of stress at points in a beam of rectangular cross-section under pure bending is/are:

(A) 

(C) 

(B) 

(D) 

150. An isotropic linear elastic material point under plane strain condition in the x-y plane always obeys:

(A) out-of-plane normal strain, $\epsilon_{zz} = 0$

(B) out-of-plane normal stress, $\sigma_{zz} = 0$

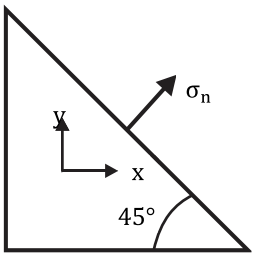
(C) out-of-plane shear stress, $\tau_{xz} = 0$

(D) out-of-plane shear strain, $\gamma_{xz} = 0$

151. The two-dimensional plane-stress state at a point is:

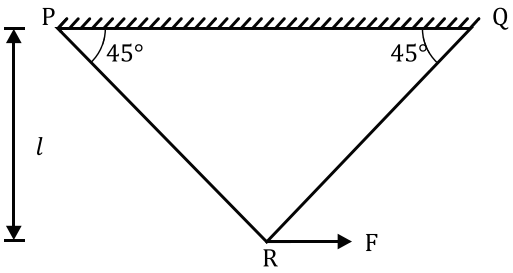
$\sigma_{xx} = 110$ MPa; $\sigma_{yy} = 30$ MPa; $\tau_{xy} = 40$ MPa.

The normal stress, σ_n , on a plane inclined 45° as shown in the figure is ___ MPa (round off to the nearest integer).



Two Marks Questions.

152. A horizontal load F is applied at point R on a two-member truss, as shown in the figure. Both the members are prismatic with cross-sectional area, A_0, and made of the same material with Young's modulus E. The horizontal displacement of point R is:



(A) 0

(B) $\frac{Fl}{EA_0}$

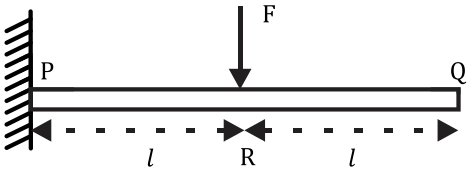
(C) $\sqrt{2}\frac{Fl}{EA_0}$

(D) $2\frac{Fl}{EA_0}$

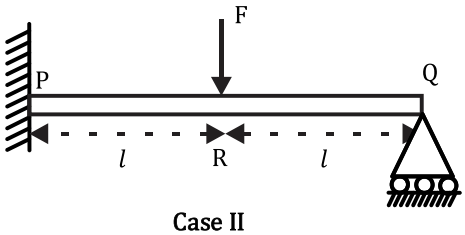
153. Given: The tip deflection and tip slope for a tip loaded cantilever of length L are: $NL^3/3EI$ and $NL^2/2EI$, respectively, where N is the tip force and EI is the flexural rigidity.

A cantilever PQ of rectangular cross-section is subjected to transverse load, F, at its mid-point. Two cases are considered as shown in the figure. In Case I, the end Q is free and in Case II, Q is simply supported.

The ratio of the magnitude of the maximum bending stress at P in Case I to that in Case II is ____ (rounded off to one decimal place).



Case I



Case II

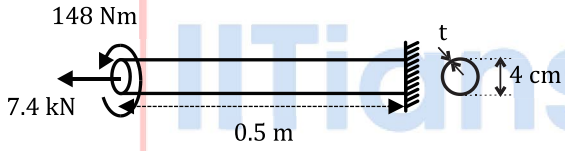
154. A simply supported Aluminium column of length 1 m and rectangular cross-section w × t

with $t \leq w$, is subjected to axial compressive loading.

Young's modulus is 70 GPa. Yield stress under uniaxial compression is 120 MPa.

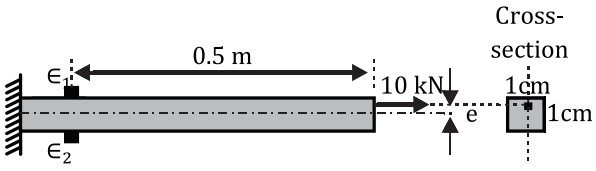
The value of t at which the failure load for yielding and buckling coincide is _____mm.

155. A 0.5 m long thin-walled circular shaft of radius 2 cm is to be designed for an axial load of 7.4 kN and a torque of 148 Nm applied at its tip, as shown in the figure. The allowable stress under uniaxial tension is 100 MPa. Using maximum principal stress criterion, the minimum thickness, *t*, of the shaft so that it does not fail is ____ mm (rounded off to the nearest integer).



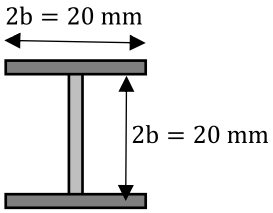
156. A 10 kN axial load is applied eccentrically on a rod of square cross-section (1 cm × 1 cm) as shown in the figure. The strains measured by the two strain gages attached to the top and bottom surfaces at a distance of 0.5 m from the tip are $\epsilon_1 = 0.0016$ and $\epsilon_2 = 0.0004$, respectively.

The eccentricity in loading, *e* is _____mm.



157. For a thin-walled I section, the width of the two flanges as well as the web height are the same, i.e., 2b = 20 mm. Thickness is 0.6 mm.

The second moment of area about a horizontal axis passing through the centroid is _____ mm^4.



GATE AE - 2023

One Mark Questions.

158. Which of the following statement(s) is/are true about the state of stress in a plane?

(A) Maximum or major principal stress is algebraically the largest direct stress at a point.

(B) The magnitude of minor principal stress cannot be greater than the magnitude of major principal stress.

(C) The planes of maximum shear stress are inclined at 90 degrees to the principal axes.

(D) The normal stresses along the planes of maximum shear stress are equal.

159. Which of the following statement(s) is/are true about the ribs of an airplane wing with semi-monocoque construction?

(A) For a rectangular planform wing, the dimensions of the ribs DO NOT depend on their spanwise position in the wing.

(B) Ribs increase the column buckling stress of longitudinal stiffeners connected to them.

(C) Ribs increase plate buckling stress of the skin panels.

(D) Ribs help in maintaining aerodynamic shape of the wing.

Two Marks Questions.

160. Which of the following statement(s) about the elastic flexural buckling load of columns is/are correct?

(A) The buckling load increases with increase in flexural rigidity of the column.

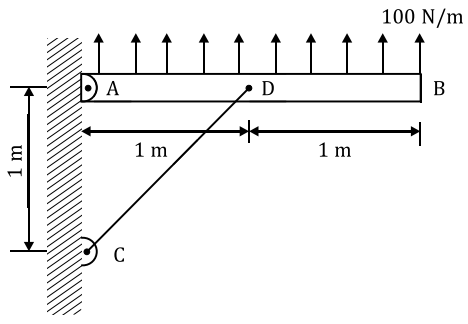
(B) The buckling load increases with increase in the length of the column.

(C) The boundary conditions of the column affect the buckling load.

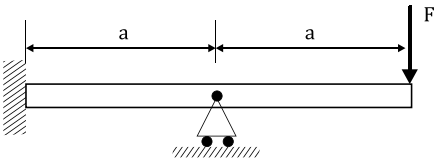
(D) The buckling load is NOT directly dependent on the density of the material used for the column.

161. The thickness of a uniform hollow circular shaft is equal to the difference between the outer radius and the inner radius. The ratio of the inner diameter to outer diameter of the shaft is 0.5. For the shaft reacting to an applied torque, the ratio of the maximum shear stress τ to the maximum shear stress $\tau_{thin\text{-}wall}$ obtained using the thin-wall approximation is _____. (Round off to one decimal place)

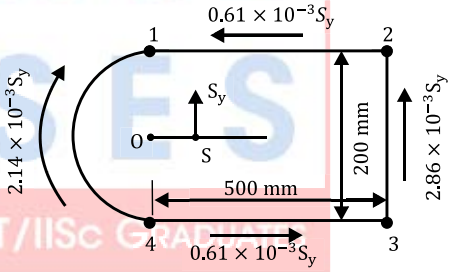
162. A rigid bar AB is subjected to a uniformly distributed load of 100 N/m as shown in the figure. The bar is supported by rod CD, with A, C, and D as pin joints. The rod CD has axial stiffness of 40 N/mm. The vertical deflection at point D is _____ mm. (round off to nearest integer)



163. A cantilever beam of length 2a is loaded at the tip with force F as shown in the figure. The beam is supported in the middle by a roller with a pin. The magnitude of moment reaction at the built-in end of the beam is αFa, where α is _____ . (round off to one decimal place)



164. The shear flow distribution in a single cell, thin-walled beam under the action of an arbitrary shear load S_y applied at the shear centre S is shown in the figure. The cell has horizontal symmetry with booms marked by 1 to 4 that carry direct stresses. The shear modulus G is the same for all the walls, and the area of the cell is 135000 mm^2. With respect to the point O marked in the figure, the distance to the shear centre S is _____ mm. (round off to the nearest integer)



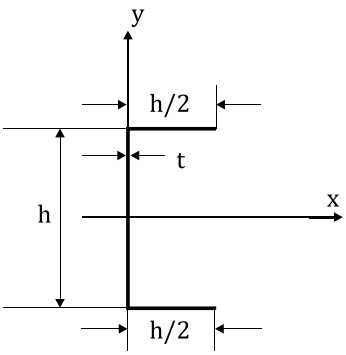
165. Consider a thin-walled cylindrical pressure vessel made of an alloy with yield strength of 300 MPa. The vessel has end caps to contain the pressure. The ratio of radius of the vessel to its wall thickness is 100. As per the von Mises yield criterion, the internal pressure that would cause the failure of the vessel is ____ MPa. (round off to two decimal places)

GATE AE - 2024

Two Marks Questions.

166. The cross section of a thin-walled beam with uniform wall thickness t, shown in the figure, is subjected to a bending moment M_x = 10 Nm. If h=1m and t=0.001 m, the magnitude of

maximum normal stress in the cross section is _____N/m^2 (answer in integer).



167. Consider the plane strain field given by

$\varepsilon_{xx} = 10xy^2, \varepsilon_{yy} = -5x^2y$ and

$\gamma_{xy} = A\,xy\,(2x - y)$

where, A is a constant and γxy is the engineering shear strain. The value of the constant A for the strain field to be compatible is _____ (rounded off to 1 decimal place).

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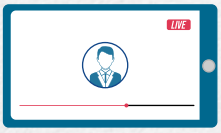

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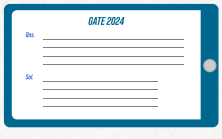

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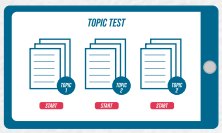

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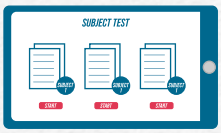

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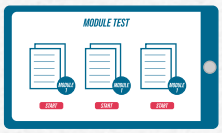

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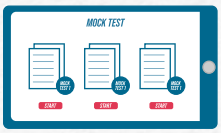

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Answer Keys Aerospace Structures

1	D	2	C	3	A	4	B	5	A
6	A	7	B	8	B	9	A	10	A
11	B	12	C	13	C	14	D	15	A
16	B	17	C	18	A	19	C	20	A
21	C	22	B	23	A	24	B	25	B
26	B	27	C	28	B	29	A	30	B
31	C	32	D	33	B	34	A	35	B
36	D	37	A	38	D	39	C	40	B
41	C	42	D	43	C	44	A	45	B
46	A	47	2.45 to 2.55	48	1.30 to 1.35	49	5.95 to 6.05	50	B
51	C	52	D	53	C	54	B	55	D
56	B	57	C	58	D	59	A	60	A
61	D	62	C	63	Marks to All	64	0.12 to 0.13	65	D
66	A	67	B	68	B	69	1900 to 2000	70	B
71	70 to 70	72	A	73	A	74	B	75	B
76	0.12 to 0.13	77	A	78	B	79	D	80	D
81	A	82	24.99 to 25.01	83	A	84	49.99 to 50.01	85	0.24 to 0.26
86	5.45 to 5.60	87	990 to 1020	88	2046 to 2075	89	2.0 to 2.0	90	A
91	B	92	B	93	5.0 to 5.0	94	1.5 to 1.7	95	B
96	2.4 to 2.6	97	-11.0 to -11.0	98	C	99	B	100	B
101	1.360 to 1.370	102	C	103	0.970 to 0.990	104	C	105	157.000 to 158.000
106	0.910 to 0.920	107	104 to 106	108	6.900 to 7.400	109	0.640 to 0.650	110	A
111	D	112	C	113	D	114	-2.50 to -2.20	115	12.0 to 12.0
116	-6.0 to -6.0	117	A	118	2 to 2	119	0.2 to 0.2	120	247 to 255
121	A	122	60 to 60	123	550 to 570	124	1.8 to 1.9	125	310 to 320
126	17.0 to 17.5	127	B	128	D	129	D	130	C
131	0.009 to 0.011	132	D	133	C	134	D	135	B
136	3.55 to 3.58	137	3.74 to 3.76	138	B	139	D	140	0.2 to 0.2
141	0.41 to 0.43	142	14.0 to 16.0	143	2.1 to 2.5	144	2.2 to 2.6	145	232 to 238
146	B	147	B	148	A	149	B, C	150	A, C, D
151	109 to 111	152	C	153	2.6 to 2.7	154	43 to 48	155	1 to 1

156	0.95 to 1.05	157	2700 to 2960	158	A, D	159	B, C, D	160	A, C, D
161	1.1 to 1.3	162	10 to 10	163	0.5 to 0.5	164	196 to 198	165	3.40 to 3.50
166	14900 to 15100	167	4.9 to 5.1						

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