ACE
Engineering Academy

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ESE- 2018 (Prelims) - Offline Test Series Test - 11

MECHANICAL ENGINEERING

SUBJECT: ENGINEERING MECHANICS AND STRENGTH OF MATERIALS + ENGINEERING MATERIALS – SOLUTIONS

01. Ans: (d)

Sol: For a given tapered circular bar,

Change in length due to axial pull 'P' is given by,

$$\delta\ell = \frac{4PL}{\pi EDd}$$

Thus, for a given load 'P', $\delta\ell \propto \frac{L}{D.d}$

02. Ans: (a)

Sol: Gibbs phase rule

F+P =C+1

At equilibrium point, the degree of freedom (F) = 0

And in tertiary phase diagram,

no. of components (C) = 3

$0+P = 3+1$

$\Rightarrow P = 4$

03. Ans: (c)

Sol: The direction of velocity changes from point to point on the circle. Hence, options (a), (b) and (d) are incorrect as they are vector quantities.

04. Ans: (c)

Sol: If an element is subjected to hydrostatic pressure, then

$$\sigma_x = \sigma_y = \sigma_z = \sigma$$

Also, $\varepsilon_x = \varepsilon_y = \varepsilon_z = \frac{\sigma}{E} - \mu\frac{\sigma}{E} - \mu\frac{\sigma}{E}$

$$= \frac{\sigma}{E}(1-2\mu)$$

$$= 0 \quad (\because \ \mu = 0.5)$$

Thus, change in volume,

$$\frac{\Delta V}{V} = \varepsilon_x + \varepsilon_y + \varepsilon_z$$

$$\therefore \ \Delta V = 0$$

05. Ans: (d)

Sol: load (p) = 5kg = 5×9.81 N

$$D = \left(\frac{45+55}{2}\right)\mu m = 50\ \mu m$$

Vickers Hardness Number

$$= \frac{1.854\,P}{D^2} = \frac{1.854\times5\times9.81}{\left(50\times10^{-6}\right)^2}$$

$$= 3.637\times10^{10}$$

06. Ans: (a)

Sol: Let total distance = L

Time taken to cover first half distance

$$= \frac{\frac{L}{2}}{3}\sec = \frac{L}{6}\sec$$

Let the particle moves with a speed of 4.5 m/s for 't' second and with a speed of 7.5 m/s for next t seconds

Then

$$4.5\,t + 7.5\,t = \frac{L}{2}$$

$$t = \frac{L}{24}\sec$$

$$\text{Average speed} = \frac{\text{Total distance}}{\text{Total time}}$$

$$= \frac{L}{\frac{L}{6}+\frac{2L}{24}} = 4\,m/s$$

07. Ans: (d)

Sol: Given data:

$\varepsilon_x = 25\times10^{-6}$, $\varepsilon_y = -5\times10^{-6}$,

$\varepsilon_{xy} = 40\times10^{-6}$

Radius of Mohr circle is given by,

$$R = \frac{\gamma_{max}}{2} = \sqrt{\left(\frac{\varepsilon_x-\varepsilon_y}{2}\right)^2+\left(\frac{\gamma_{xy}}{2}\right)^2}$$

$$= \sqrt{\left(\frac{25\times10^{-6}-\left(-5\times10^{-6}\right)}{2}\right)^2+\left(\frac{40\times10^{-6}}{2}\right)^2}$$

$$= \sqrt{\left(15\times10^{-6}\right)^2+\left(20\times10^{-6}\right)^2}$$

$\therefore$ R = 25 × 10^{-6}

$\therefore$ D = 2R = 50 × 10^{-6}

08. Ans: (d)

Sol: Nickel alloys exhibit good carburization resistance because nickel unlike iron is not a strong carbide former.

09. Ans: (a)

Sol: ⟶ x-direction

The particle P will leave the bowl at B with same speed v ($\because$ There is no friction so the mechanical energy is conserved). Along horizontal (x) direction the velocity of particle P increases (due to component of normal force along horizontal direction) upto the bottom most point of bowl.

After the bottom most point the velocity (along x-direction) will decrease but it will always be greater than v.

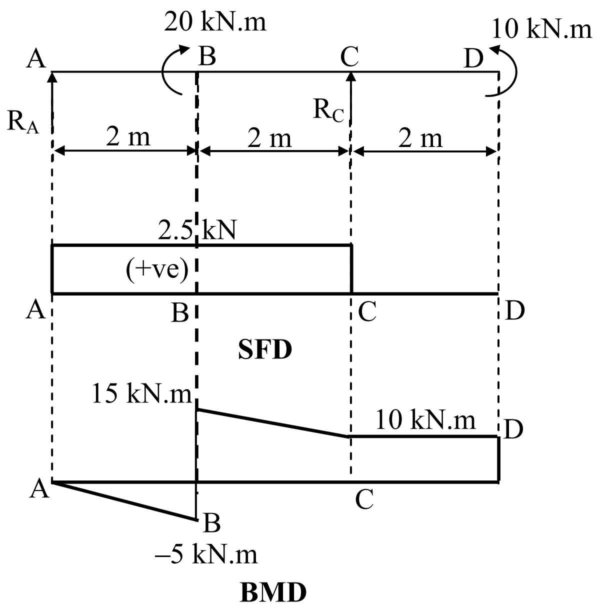
Time taken by bead = $t_Q = \dfrac{\text{Length AB}}{v}$

Time taken by particle = $t_P = \dfrac{\text{Length AB}}{v'}$

Therefore, the time taken by particle P is less than the time taken by bead.

10. Ans: (b)

Sol: Free body diagram of the given beam,



Take moment about point 'C',

$R_A \times 4 + 20 = 10$

$\therefore\ R_A = -2.5$ kN (downward)

Now, $R_A + R_C = 0$

$\therefore\ R_C = 2.5$ kN (upward)

Bending Moment:

$(BM)_D = 10$ kN.m

$(BM)_C = 10$ kN.m

$(BM)_{Bright} = 10 + R_C \times 2 = 15$ kN.m

$(BM)_{Bleft} = 15 - 20 = -5$ kN.m

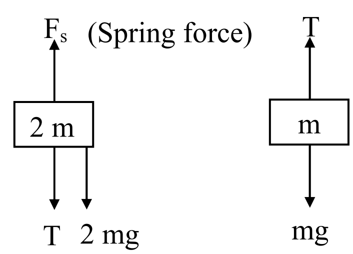
Thus, maximum bending moment in the beam is 15 kN.m

11. Ans: (a)

Sol: Wet corrosion is explained by mechanism of electrochemical reaction. All the other statements are correct.

12. Ans: (a)

Sol: F.B.D. of the two masses at equilibrium condition is shown below



Acceleration of block of mass 'm' kg = g downwards [$\because$ It will fall freely]

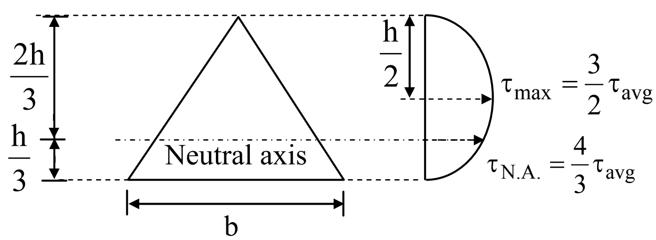
Now, the block of mass '2m' was under equilibrium but when string is cut, a net upward force (T=mg) will act so

acceleration of block of mass 2m = $\dfrac{mg}{2m}$

$= \dfrac{g}{2}$ upwards

13. Ans: (b)

Sol: Shear stress distribution for a triangular cross section can be drawn as shown in the figure below.



The ratio of maximum shear stress to the shear stress at neutral axis,

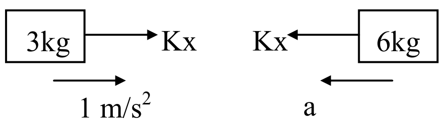
$$\frac{\tau_{max}}{\tau_{N.A}} = \frac{\frac{3}{2}\tau_{avg}}{\frac{4}{3}\tau_{avg}} = \frac{9}{8}$$

14. Ans: (b)

Sol: The crystal structure of martensite is body centered tetragonal form of iron in which some carbon is dissolved. Martensite forms during quenching, when the face centered cubic lattice of austenite is distored into the body centered tetragonal structure without the loss of its contained carbon atoms into cementite and ferrite.

15. Ans: (d)

Sol: The only force acting on the blocks are spring forces. Let at this instant spring force is Kx then F.B.D. of two blocks are as shown in figure.



For 3 kg block, Kx =ma = 3 × 1 = 3

For 6 kg block, acceleration,

$$a = \frac{Kx}{6} = \frac{3}{6} = \frac{1}{2} m/s^2 \text{ to left}$$

16. Ans: (d)

Sol: Plane strain follows that an element has zero normal strain, ε_z and zero shear strains, γ_{xz} and γ_{yz} in the xz and yz planes, respectively.

Thus, $\tau_{xz} = \tau_{yz} = 0$

Also, $\varepsilon_z = \frac{\sigma_z}{E} - \mu\left(\frac{\sigma_x + \sigma_y}{E}\right) = 0$

$\therefore \quad \sigma_z = \mu(\sigma_x + \sigma_y)$

17. Ans: (a)

Sol: Melting is a process which proceeds by changing from highly ordered state to a disordered state.

18. Ans: (a)

Sol: If the block and slab move together then combined acceleration,

$$a = \frac{100}{10+40} = 2m/s^2$$

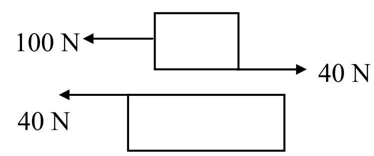
But only force acting on 40kg slab is friction, and maximum possible acceleration of slab is ,

$$a_{max} = \frac{f_{max}}{40} = \frac{0.6 \times 10 \times 10}{40} = 1.5m/s^2$$

$\Rightarrow a_{max} < 2$

So, the block will slip over slab.

Now, kinetic friction will act between block and slab and F.B.D is shown below

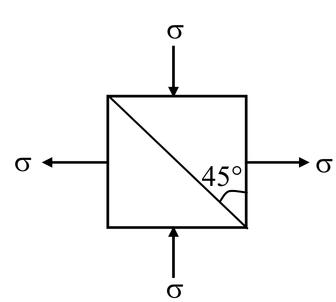


$f_k = 0.4 \times 10 \times 10 = 40$ N

$\therefore$ Acceleration of slab = $\frac{40}{40} = 1m/s^2$

19. Ans: (b)

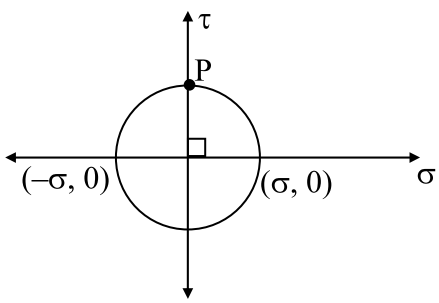
Sol: Given element is shown in the figure below.



Principal stresses for a given state of stress are,

$\sigma_1 = \sigma$ and $\sigma_2 = -\sigma$

Mohr's circle can be drawn as shown in the figure below. The plane which is at 45° to the x-axis can be represented by a point P in Mohr circle.

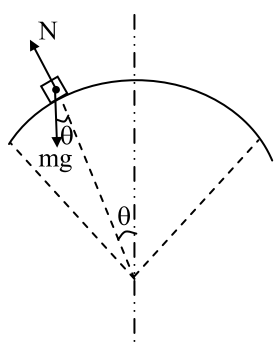


At point P, shear stress is maximum and normal stress is zero.

20. Ans: (b)

21. Ans: (a)

Sol:



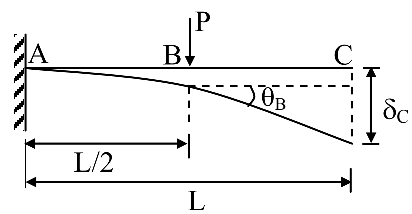
$$mg\cos\theta - N = \frac{mv^2}{R}$$

$$N = mg\cos\theta - \frac{mv^2}{R}$$

As motor cycle is ascending θ decreases so cosθ increases ⇒ N increases

22. Ans: (b)

Sol: Due to load P, beam deflects by an amount δ_c at free end,



$$\delta_c = \delta_B + \theta_B . \frac{L}{2}$$

$$= \frac{P(L/2)^3}{3EI} + \frac{P(L/2)^2}{2EI} \times \frac{L}{2}$$

$$= \frac{PL^3}{24EI} + \frac{PL^3}{16EI}$$

$$= \frac{5PL^3}{48EI} = \frac{5 \times 1000 \times (1)^3}{48EI} = \frac{625}{6EI}$$

23. Ans: (c)

Sol: Above eutectoid temperature line at 0.7%C steel proecutectoid -α ferrite and austenite is present and hence no cementite phase in 0.7% C steel above eutectoid temperature (723°C)

24. Ans: (c)

Sol: Angular momentum = Iω + MVR

$$= \frac{MR^2}{2}\omega + M\omega R^2$$

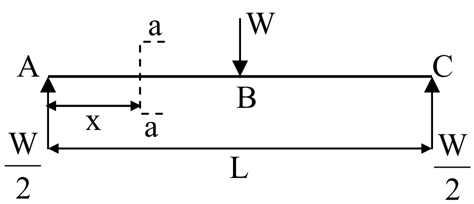
$$= \frac{3}{2}MR^2\omega$$

25. Ans: (a)

Sol: Given data:

L = 3 m, W = 2 N

The beam is drawn in the figure below.



Bending moment at a section a-a is given by,

$$M(x) = \frac{Wx}{2}$$

Total strain energy stored in the beam is given by,

$$U = 2 \times \text{strain energy stored in the part AB}$$

$$= 2 \times \int_o^{L/2} \frac{M(x)^2\,dx}{2EI}$$

$$= \frac{1}{EI}\int_o^{L/2}\left(\frac{Wx}{2}\right)^2 dx$$

$$= \frac{W^2}{4EI}\left[\frac{x^3}{3}\right]_o^{\frac{L}{2}}$$

$$= \frac{W^2}{12EI}(L/2)^3$$

$$= \frac{W^2L^3}{96EI}$$

$$= \frac{(2)^2\times(3)^3}{96EI} = \frac{9}{8EI}$$

Alternate approach:

$$U = \frac{1}{2}\times W \times \delta_{max}$$

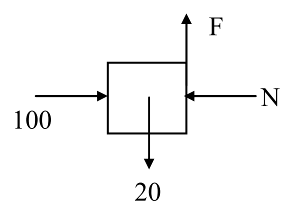
$$= \frac{1}{2}\times W \times \frac{WL^3}{48EI} = \frac{W^2L^3}{96EI}$$

26. Ans: (d)

Sol: Nitriding process is applicable for only low carbon steel.

27. Ans: (d)

Sol: F.B.D. of 2 kg block is shown below



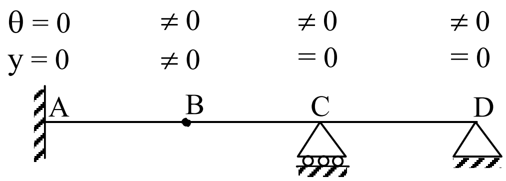
The limiting value of friction force is

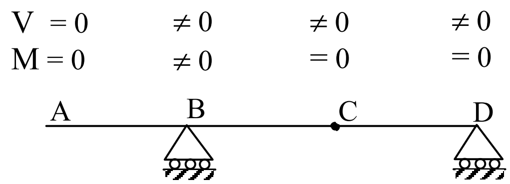
$$f_L = 0.6 \times 100 = 60 \text{ N}$$

But force applied is 20 N only, So friction is static in nature and its value is equal to, f = 20 N.

28. Ans: (c)

Sol:





To convert the simple (real) beam into the conjugate beam, some points to be taken care regarding the support conditions as given below.

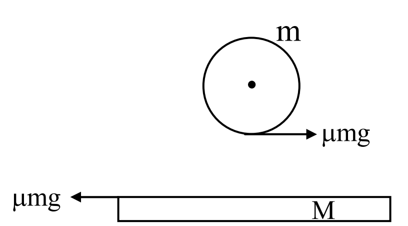
No.	Simple (real) beam	Conjugate beams
01.	Shear force and bending moment exist at the fixed end.	Shear force and bending moment at fixed end will provide some values of slope and deflection in conjugate beam which is not feasible. Thus a fixed end is transformed into free end to obtain shear force as well as bending moment as zero.
02.	Bending moment at the supports of simply supported beam is zero.	Deflection at the supports is zero. So, end conditions remain same.
03.	An intermediate support has same slope on both sides. Also intermediate support has no deflection.	To have same shear force (slope) on both sides and zero bending moment (deflection), it is transformed into an intermediate hinge.

29. Ans: (b)

Sol: The process by which Ta, Nb & Ti combine with carbon to form respective carbides and prevent, corrosion is known as neutralization. The 'pH' of the neutralized solution depends on the acid strength of the reactions.

30. Ans: (b)

Sol: Since the relative motion exists between the plank and the cylinder, therefore, the friction force acting between them is $f = \mu mg$.



Acceleration of plank is $a = \dfrac{\mu mg}{M}$

31. Ans: (b)

Sol: Given data:

E = 200 GPa, d = 1.25 mm, R = 500 mm

Maximum bending stress is given by,

$$\sigma_{max} = \frac{E\left(\frac{d}{2}\right)}{\rho}$$

(where, ρ = Radius of curvature = $R + \frac{d_o}{2}$)

Here, $R >> \frac{d_o}{2} \Rightarrow R + \frac{d_o}{2} \approx R$

Thus, $\sigma_{max} = \frac{Ed}{2R} = \frac{200 \times 10^3 \times 1.25}{2 \times 500}$

= 250 MPa

32. Ans: (d)

Sol: $X \to 1$ $(-1, 2, \infty)$

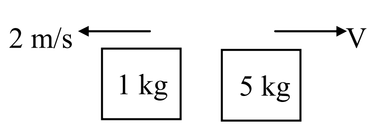
$Y \to 2$ $\left(\frac{-1}{1}, \frac{1}{2}, \frac{1}{\alpha}\right) = (\bar{2}10)$

$Z \to \infty$

33. Ans: (a)

Sol: Initial situation (Before collision)

Final situation (After collision)



By using conservation of linear momentum

$1 \times U = -1 \times 2 + 5 \times V$ .... (i)

$e = 1 = \frac{V+2}{U}$ .... (ii)

From (i) and (ii)

V = 1 m/s

U = 3 m/s

Total momentum of system

= 1 × 3 = 3 kg m/s

Momentum of 5 kg mass after collision

= 5 × 1 = 5 kg m/s

Momentum of 1 kg mass after collision

= 1 × 2 = 2 kg m/s (Towards left)

Kinetic energy of system

$$= \frac{1}{2} \times 1 \times 2^2 + \frac{1}{2} \times 5 \times 1^2 = 4.5 \text{ J}$$

34. Ans: (d)

Sol: Given data:

d = 40 mm, T = 0.16π kN.m

P = 24π kN

Shear stress due to T is,

$$\tau_{xy} = \frac{16T}{\pi d^3} = \frac{16 \times 0.16\pi \times 10^6}{\pi \times (40)^3} = 40 \text{ MPa}$$

Tensile stress due to P is,

$$\sigma_x = \frac{P}{A} = \frac{24\pi \times 10^3}{\frac{\pi}{4}(40)^2} = 60 \text{ MPa}$$

Maximum tensile stress is given by,

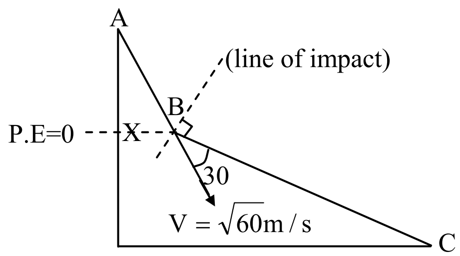
$$\sigma_1 = \frac{\sigma_x + \sigma_y}{2} \pm \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2}$$

$$= \frac{60}{2} + \sqrt{\left(\frac{60-0}{2}\right)^2 + (40)^2} = 80 \text{ MPa}$$

35. Ans: (b)

36. Ans: (b)

Sol:



By using conservation of mechanical energy between point A and point B [Take reference for gravitational potential energy as shown]

$$M \times g \times 3 = \frac{1}{2} \times M \times V^2 \Rightarrow V = \sqrt{60}\ \text{m/s}$$

Component of velocity along

$$BC = \sqrt{60}\cos 30 = \frac{\sqrt{60} \times \sqrt{3}}{2} = \sqrt{45}\text{m/s}$$

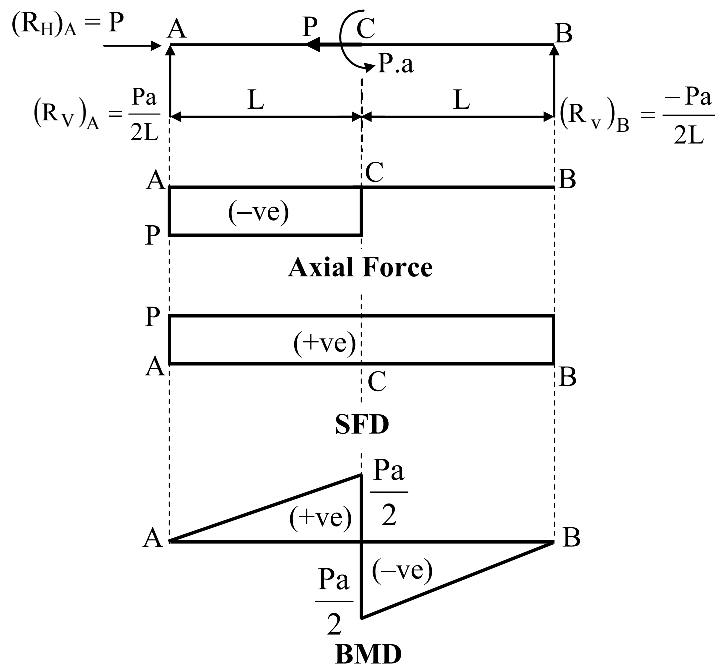
Component of velocity perpendicular to BC = 0

($\because$ During completely inelastic collision the relative velocity of separation along line of impact is zero)

Net velocity = $\sqrt{45}$ m/s

37. Ans: (c)

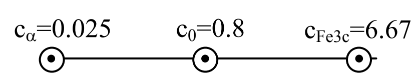
Sol: Free body diagram along with the axial force, bending moment and shear force diagram of a given beam are shown in the figure below.



Thus, from the above diagram it is concluded that, axial force and bending moment are discontinuous at mid-span (i.e., point C).

38. Ans: (b)

Sol:



$$m_{Fe_3c} = \frac{c_0 - c_\alpha}{c_{Fe_3c} - c_\alpha} = \frac{0.8 - 0.025}{6.67 - 0.025} \times 100$$

$$= \frac{0.775}{6.645} \times 100 = 0.1166 \times 100 = 11.66$$

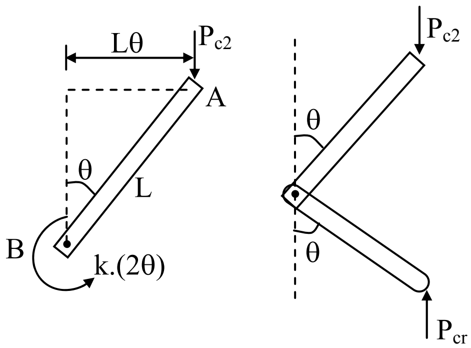
39. Ans: (b)

Sol: Given data:

L = 1 m, k = 1 kN.m/rad.

Due to application of load P_{cr}, column is rotated by θ at point B.

Free body diagram of bar AB:



Taking moment about point A,

$\Sigma M_A = 0$

$\therefore -P_{cr} \times L\theta + K \times 2\theta = 0$

$\therefore P_{cr} = \frac{2K}{L} = \frac{2\times10^3}{1} = 2 \text{ kN}$

40. Ans: (b)

Sol:

Structure	No. of Atoms	Co-ordination no.	Atomic packing factor
Simple cubic	1	6	52 %
Body centered	2	8	68 %
Face centered	4	12	74 %
Hexagonal closed pack	6	12	74 %
Diamond	8	4	34 %

41. Ans: (b)

Sol: Given data: W = mg = 5 N,

h = 400 mm, δ = 100 mm

From energy conservation,

Decrease in potential energy = Strain energy stored in the spring.

$\therefore mg(h + \delta) = \frac{1}{2}k\delta^2$

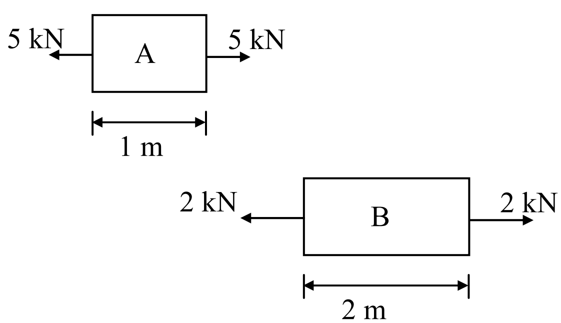
$\therefore 5\times(400 + 100) = \frac{1}{2}\times k\times(100)^2$

$\therefore k = 0.5$ N/mm

42. Ans: (b)

43. Ans: (d)

Sol: Free body diagram of given sections:



Tensile stress, in section A is given by,

$\sigma_A = \frac{P}{A} = \frac{5000}{400} = 12.5$ MPa (Tensile)

44. Ans: (c)

Sol: The iron material transforms from BCC to FCC with increase in temperature to above 910°C. Then the volume of iron material decreases.

45. Ans: (d)

Sol:

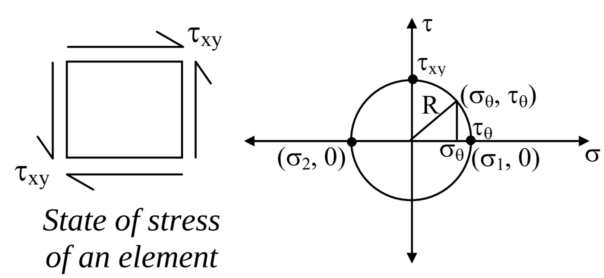
- When centre of Mohr circle coincides with the origin of axis of graph, at any plane value of resultant stress is distance between centre of Mohr circle and at that plane (point) in a Mohr circle i.e. radius of the Mohr circle. $\sigma_R = \sqrt{\sigma_\theta^2 + \tau_\theta^2} = R$ (radius of Mohr's circle)

  Thus, statement (1) is correct.

- For an element subjected to hydrostatic pressure, principal stresses are equal in nature and magnitude both. Then radius of Mohr circle, i.e. $R = \frac{\sigma_1 - \sigma_2}{2} = 0$, which represents a point with identical normal stress on any plane.

  Thus, statement (2) is also correct.

- In case of pure shear stress, Mohr circle can be represented as shown in the figure below.



State of stress of an element

For this case,

$\sigma_1 = \tau_{xy}$ = Radius of Mohr circle.

Thus, statement (3) is incorrect.

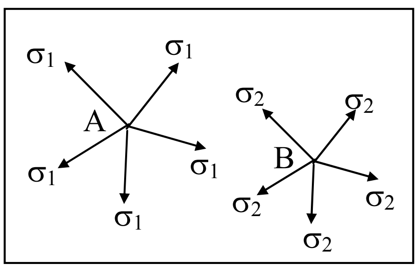
46. Ans: (c)

Sol: Mechanical grinding is an example of top-down approach for the preparation of nanomaterials. All the other options are the example of bottom-up approach

47. Ans: (a)

Sol:

- In an isotropic material, properties are same in all direction at one particular point only.



Isotropic

Thus statement (1) is correct.

- The cross section of a uniform strength of the beam varies in a section in such a way that maximum bending stress remains constant through out the beam.

  Thus statement (2) is incorrect.

- It is not always true that the shear stress at the neutral axis is always maximum. For example in triangular and diamond cross section of beam shear stress in not maximum at the neutral axis.

  Thus statement (3) is incorrect.

48. Ans: (a)

Sol: Self-assembly is a bottom-down manufacturing technique all the other options are correct. In self-assembly weak interactions play very important role, self-assembly molecules adopt a organized structure which is thermodynamically more stable than the single, unassembled components.

49. Ans: (b)

Sol: Given data:

$t_1 = 2t_2$

$d_1 = 3d_2$

Longitudinal stress for a thin cylinder is given by,

$$\sigma_\ell = \frac{Pd}{4t} \Rightarrow \sigma_\ell \; \alpha \; \frac{d}{t}$$

$$\Rightarrow \frac{(\sigma_\ell)}{(\sigma_\ell)_2} = \left(\frac{d_1}{d_2}\right) \times \left(\frac{t_2}{t_1}\right) = \frac{3}{2}$$

50. Ans: (b)

Sol: The correct order is copper, lead, aluminium, zinc, magnesium. Magnesium is the most active towards corrosion and copper is the least active towards corrosion among the given elements.

51. Ans: (b)

Sol: Modulus of resilience (u_r) is given by the area under the stress-strain diagram upto proportional limit only.

$$u_r = \frac{1}{2} \times (0.001 - 0) \times 210$$

$$= 0.105 \frac{N.mm}{mm^3} = 105 \text{ kJ/m}^3$$

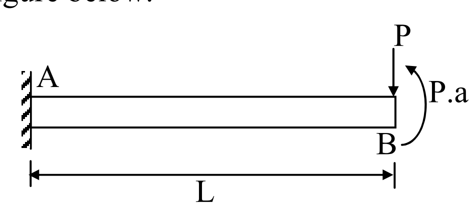
52. Ans: (a)

Sol: **Sulphur** (0.08-0.15%) is added in small amounts, sulphur improves machinability without resulting in hot shortness.

- **Spheroidization annealing:** The process of Spheroidisation annealing consists in heating the steel just above the lower critical temperature (730°–770°C), and prolonged holding at this temperature followed by slow cooling to 600°C within the furnace.
- The subsequent cooling may be conducted in still air; the process is applied to high carbon steels to improve machinability.

53. Ans: (a)

Sol: The given loading condition can be represented to B point as shown in the figure below.



Net deflection of point B is given by,

$$\sigma_B = \frac{PL^3}{3EI} - \frac{(P.a)L^2}{2EI} = 0$$

$$\therefore \frac{L}{3} = \frac{a}{2} \Rightarrow \frac{a}{L} = \frac{2}{3}$$

54. Ans: (c)

Sol: Powder metallurgical components possess porosity due to evolution of solvent vapors during sintering. For filling of pores a liquid oil or grease is filled in the final component.

55. Ans: (d)

Sol: It is difficult to produce large size parts; porosity is always present in the part.

56. Ans: (d)

Sol: Given data: $\theta_{BA} = 0.3$ radian,

$D_{AB} = 100$ mm, $D_{BC} = 50$ mm

Angle of twist is given by,

$$\theta = \frac{TL}{GJ}$$

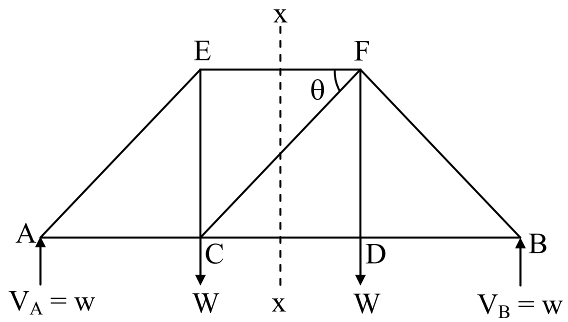
$$\therefore \theta \propto \frac{1}{J}$$

$$\therefore \frac{\theta_{CB}}{\theta_{BA}} = \frac{J_{BA}}{J_{CB}}$$

$$\therefore \frac{\theta_{CB}}{0.3} = \frac{\frac{\pi}{32}(100)^4}{\frac{\pi}{32}(50)^4} = 4.8 \text{ radian}$$

57. Ans: (d)

Sol:



Cut a section x-x and consider RHS

$\Sigma F_y = 0$

$F_{CF} \sin\theta - w + w = 0$

$F_{CF} = 0$

58. Ans: (c)

Sol:

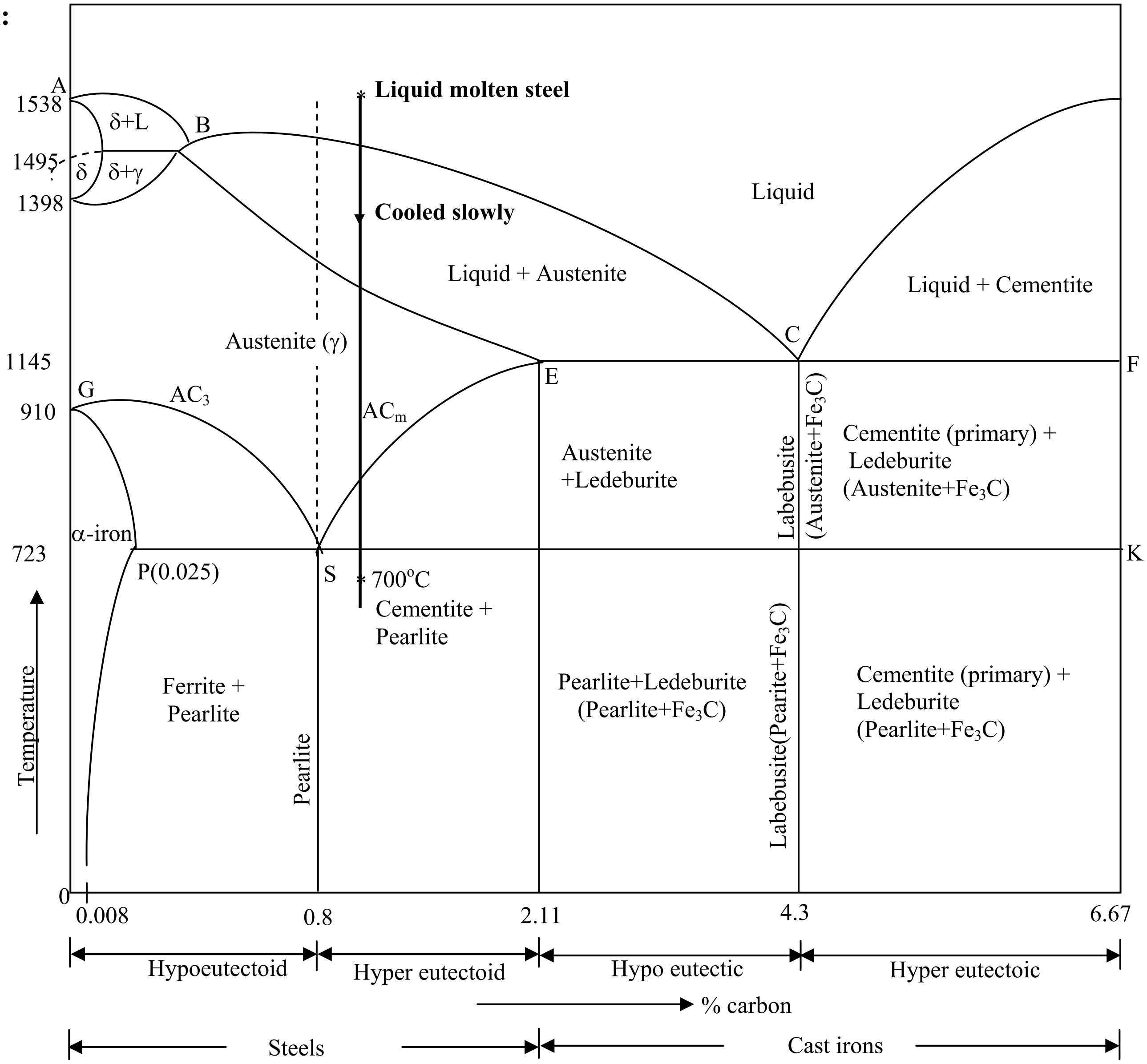
- For a cantilever beam subjected to only bending moment will have zero shear force at fixed support (P-2).
- Simply supported beam subjected to only couple moment (M) will have equal magnitude of reaction force (M/L) but of opposite direction (R-4).
- Uniformly distributed load is represented by inclined lines in shear force diagram (S-3).
- Uniformly varying load is represented by parabolic curve in shear force diagram (Q-1).

59. Ans: (a)

Sol: Mottled Cast Iron contains microstructures of both white Cast Iron and grey Cast Iron. This type of cast iron is obtained when the casting solidified as white cast iron on the surface and grey cast iron at the interior. Therefore, fracture of chilled cast iron shows white and grey structures. Chilled iron is also called as mottled cast iron.

60. Ans: (d)

Sol:



Iron – Iron carbide equilibrium diagram

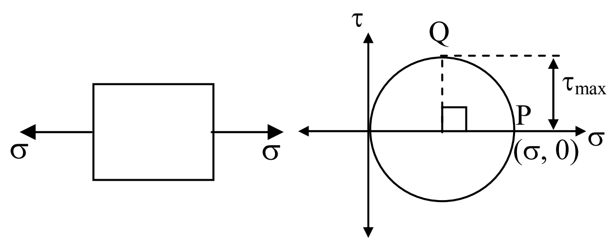
61. Ans: (b)

Sol:

- There is no any external force acting on the ball and earth system. Therefore the total momentum of the ball and the earth is conserved.
- In an inelastic collision final K.E. is less than initial K.E because some of the kinetic energy get converted to strain energy, heat etc.

62. Ans: (d)

Sol: Mild steel is strong in tension but it is weak in shear. When a mild steel bar is subjected to tensile test, the state of stress on an element and Mohr circle can be represented as shown in the figure below.



Thus, is fails at 45° (in Mohr circle, at 2θ = 90°) to the axis of the rod where maximum shear stress occurs. Therefore statement (I) is false and statement (II) is true.

63. Ans: (c)

Sol: Statement (I) is correct, statement (II) is wrong because at low temperature, the transformation occurs sooner (It is controlled by the rate of nucleation) and grain growth is reduced.

64. Ans: (b)

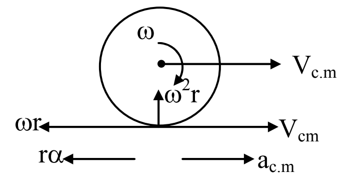
Sol: Intensity of distributed is defined as,

$$w = \frac{dV}{dx} \qquad \text{(where V = shear force)}$$

Thus, both the statements are correct, but statement (II) is not the explanation of statement (I).

65. Ans: (c)

Sol:



- During rolling motion (without slip), there is radial acceleration towards the centre. Hence, the contact point moves vertically upward.
- In pure rolling ICR is located at point of contact. Hence, the point of contact has zero velocity.

66. Ans: (a)

Sol: The equation, $\frac{T}{J} = \frac{\tau}{r} = \frac{G\theta}{L}$ is derived for circular section following the assumption that plane section remain plane after twisting.

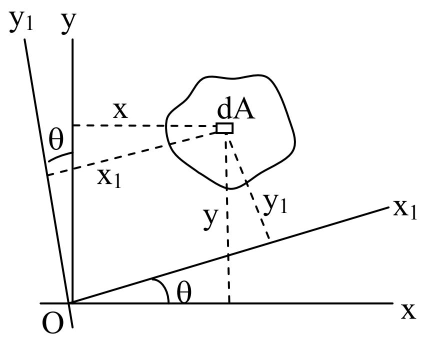
Thus, both the statements are correct, and statement (II) is correct explanation of statement (I).

67. Ans: (d)

Sol: Circular bar is more stronger as there is no probability of distribution in circular bar and maximum shear stress is uniform at outer fiber and less than that in rectangular bar.

68. Ans: (d)

Sol: For a plane area as shown in the figure below,



$I_x = \int y^2\, dA$, $I_y = \int x^2\, dA$

Products of moment inertia,

$I_{xy} = \int xy\, dA$

If the axes x and y are rotated by θ in counter clockwise direction.

$x_1 = x\cos\theta + y\sin\theta$

$y_1 = y\cos\theta - x\sin\theta$

Thus,

$$I_{x_1y_1} = \int x_1y_1\, dA$$

$$= \int (x\cos\theta + y\sin\theta)(y\cos\theta - x\sin\theta)\, dA$$

$$= (I_x - I_y)\sin\theta\cos\theta + I_{xy}\cos 2\theta$$

Thus, $I_{xy} \neq I_{x_1y_1}$

Thus, statement (I) is false.

Sum of the moment of inertia about pair of axes remains constant.

i.e. $I_{x1} + I_{y1}$

$$= \int (x\cos\theta + y\sin\theta)^2 dA + \int (-x\sin\theta + y\cos\theta)^2 dA$$

$$= \int x^2(\cos^2\theta + \sin^2\theta)dA + \int y^2(\sin^2\theta + \cos^2\theta)dA$$

$$+ \int (2xy\sin\theta\cos\theta - 2xy\sin\theta\cos\theta)dA$$

$\therefore\ I_{x1} + I_{y1} = I_x + I_y$

Thus, statement (II) is true.

69. Ans: (b)

Sol: High carbon steels are heat treated by hardening process because of more percent of carbon in it.

Low carbon steels are heat treated by case hardening process by enriching carbon (or) nitrogen atoms on the surface.

70. Ans: (b)

Sol:

- The area under load-deformation curve up to failure indicates toughness of the material.
- For a ductile material, area under the load deformation curve is more compare to brittle material. Hence ductile materials are generally tough material.

Thus, both the statements are true but statement (II) is not an explanation of statement (I).

71. Ans: (a)

Sol: At high temperature coarse grain material are having high strength because of low slip deformation.

72. Ans: (c)

Sol: Given that:

$A_{circular} = A_{square}$

$\therefore \frac{\pi}{4}D^2 = a^2$

$\therefore \frac{D}{a} = \frac{2}{\sqrt{\pi}}$

Now, section modulus ratio,

$$\frac{Z_{circular}}{Z_{square}} = \frac{\frac{\pi}{32}D^3}{\frac{a^3}{6}} = \frac{6\pi}{32}\left(\frac{D}{a}\right)^3$$

$$= \frac{6\pi}{32}\left(\frac{2}{\sqrt{\pi}}\right)^3 = \frac{3}{2\sqrt{\pi}}$$

$\therefore Z_{circular} < Z_{square}$ --------- (I)

Thus, statement (2) is false.

From bending formula,

$\frac{M}{I} = \frac{\sigma_b}{y}$

$\therefore M = \sigma_b.Z$

$\therefore M_{circular} < M_{square}$ ($\because$ Equation (I))

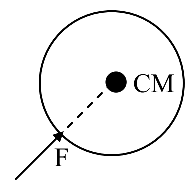
Thus, moment of resistance for a square section is more than that of circular section. Hence, statement (1) is true.

73. Ans: (b)

Sol: Poly crystal materials are stronger than single crystal material because they require more stresses to initiate slip and yielding. In poly crystalline materials, there are many preferred planes and direction for different grains due to their random orientation.

74. Ans: (d)

Sol:



- Force may be acting through centre of mass as shown in the figure. For this, torque about centre of mass will be zero. The force F will produce acceleration of centre of mass.
- The linear momentum of an isolated system always remains constant as there is no external force.

75. Ans: (a)

Sol: The machine beds are made up of gray cast iron because of high damping capacity; they can transfer vibrations from machine tool to the earth in a short period of time.