ANSWER KEY

1.	(A)	**13.**	(D)	**25.**	(A)	**37.**	(D)	**49.**	(B)	**61.**	(A)
2.	(A)	**14.**	(B)	**26.**	(22.5)	**38.**	(265.2)	**50.**	(6.6)	**62.**	(B)
3.	(B)	**15.**	(B)	**27.**	(A)	**39.**	(A)	**51.**	(C)	**63.**	(B)
4.	(A)	**16.**	(B)	**28.**	(C)	**40.**	(B)	**52.**	(D)	**64.**	(C)
5.	(C)	**17.**	(B)	**29.**	(C)	**41.**	(C)	**53.**	(0)	**65.**	(C)
6.	(D)	**18.**	(C)	**30.**	(7.826)	**42.**	(672.8)	**54.**	(C)		
7.	(A)	**19.**	(C)	**31.**	(A)	**43.**	(C)	**55.**	(D)		
8.	(C)	**20.**	(A)	**32.**	(D)	**44.**	(D)	**56.**	(B)		
9.	(D)	**21.**	(C)	**33.**	(B)	**45.**	(A)	**57.**	(C)		
10.	(B)	**22.**	(C)	**34.**	(10.62)	**46.**	(C)	**58.**	(A)		
11.	(C)	**23.**	(B)	**35.**	(21)	**47.**	(4.05)	**59.**	(A)		
12.	(B)	**24.**	(B)	**36.**	(200.3)	**48.**	(A)	**60.**	(A)		

SOLUTIONS

1. (A) **2. (A)** **3. (B)**

4. (A) **5. (C)** **6. (D)**

7. (A) **8. (C)** **9. (D)**

10. (B) **11. (C)** **12. (B)**

13. (D) **14. (B)** **15. (B)**

16. (B) **17. (B)** **18. (C)**

19. (C)

Hoop stress $\sigma_h = \dfrac{Pd}{2t}$

$$150 = \frac{4 \times 300}{2t}$$

t = 4 mm

20. (A) $I_y = I_x = \dfrac{1}{2} I_{circle} = \dfrac{1}{2} \times \pi \times \dfrac{D^4}{64} = \dfrac{\pi r^4}{8}$

21. (C) **22. (A)** **23. (B)**

24. (B) **25. (A)**

26. (22.5)

$$\tan 2\theta = \frac{2\tau_{xy}}{(\sigma_x - \sigma_y)} = \frac{2 \times 20}{(60 - 20)} = 1$$

2θ = 45°

θ = 22.5°

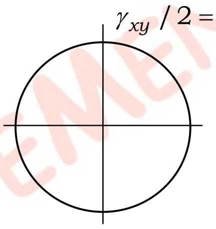
27. (A)

28. (C)

Plane strain condition $\therefore \varepsilon_z = 0$

Normal strain $\varepsilon_x = \varepsilon_y = 0$

∴ It is a condition of pure shear strain.



$\gamma_{xy} = 12\mu$

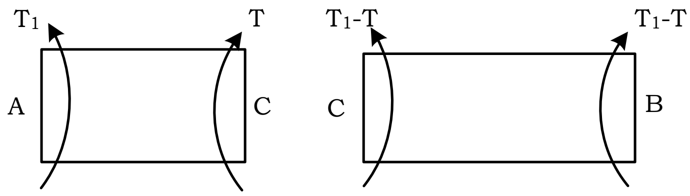
Radius of Mohr's circle $= \sqrt{\left(\dfrac{\varepsilon_x - \varepsilon_y}{2}\right) + \left(\dfrac{\gamma_{xy}}{2}\right)^2} = \dfrac{\gamma_{xy}}{2}$

∴ radius of Mohr's circle $= \gamma_{xy} / 2 = 6\mu$

Diameter of Mohr's circle = 12μ

29. (C)

Let reaction at A is T_1



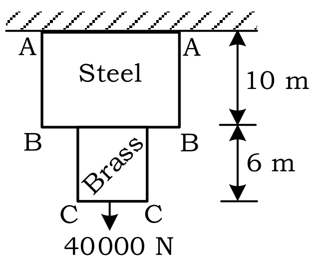
The angle of twist at 'B' is zero.

$$\therefore \frac{T_1 L}{GJ} + \frac{(T_1 - T)2L}{GJ} = 0$$

$3T_1L = 2TL$

$$\therefore T_1 = \frac{2T}{3}$$

30 (7.82)



Maximum stress in steel bar occurs at section A-A, the point of suspension.

The weight of steel bar is

$$W_5 = 10\times 60\times 10^{-4}\times 76000 = 4560 \text{ N}$$

The weight of brass bar is

$$W_b = 6\times 50\times 10^{-4}\times 80000 = 2400 \text{ N}$$

The maximum stress at section

$A = A = (W_s + W_b)/A_s$, where A_3 is the area of the steel.

$$A_s = \frac{(W_s+W_b)+P}{A_s} = \left[\frac{(4560+2400)+40000}{60\times 10^2}\right]$$

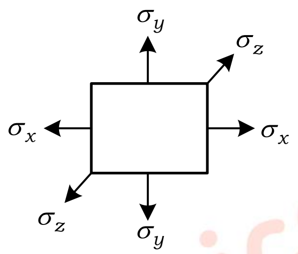
$= 7.83$ MPa

31 (A)

$$\frac{\sigma_x - \mu(\sigma_y+\sigma_z)}{E} = \varepsilon_x \text{ .... (1)}$$

$$\frac{\sigma_y - \mu(\sigma_x+\sigma_z)}{E} = \varepsilon_y = 0 \text{ ....(2)}$$

$$\frac{\sigma_z - \mu(\sigma_x+\sigma_y)}{E} = \varepsilon_z = 0 \text{ ....(3)}$$



Adding eqn. (2) and (3)

$$(\sigma_2+\sigma_y) = 2\mu(\sigma_x)\mu(\sigma_y+\sigma_z)$$

$$(\sigma_z+\sigma_y)[1-\mu] = 2\mu\sigma_x$$

$$(\sigma_z+\sigma_y) = \frac{2\mu\sigma_x}{(1-\mu)} \text{ .... (4)}$$

When only σ_x is acting and lateral contraction is completely restricted

$$\varepsilon_y = \varepsilon_z = 0$$

$$\therefore \mu_{eff} = 0[\because \varepsilon_y = \varepsilon_z = -\mu_{eff}\frac{\sigma_x}{E_{eff}}]$$

Substituting eqn. (4) in eqn. (1)

$$\frac{1}{E}\left[\sigma_x - \frac{2\mu^2}{(1-\mu)}\sigma_x\right] = \varepsilon_x = \frac{\sigma_x}{E_{eff}}$$

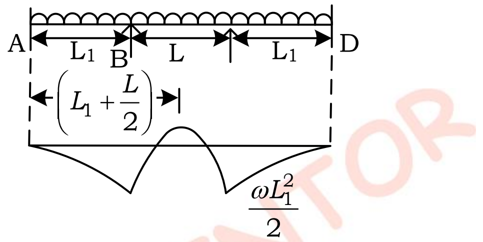
$$\frac{\sigma_x}{E}\left[\frac{(1-\mu)-2\mu^2}{(1-\mu)}\right] = \frac{\sigma_x}{E_{eff}}$$

$$E_{eff} = \frac{(1-\mu)E}{(1+\mu)(1-2\mu)} \text{ and } \mu_{eff} = 0$$

32. (D)

The reaction at the support B and C are given as

$$R_B = R_C = W\left(L_1+\frac{L}{2}\right)+$$



at $L_1+\frac{L}{2}$ maximum positive bending moment occurs and is equal to

$$M_{max1} = \omega\left(L_1+\frac{L}{2}\right)\left(\frac{L}{2}\right) - \frac{\omega}{2}\left(L_1+\frac{L}{2}\right)^2 \text{ .... (1)}$$

and maximum negative moment occurs at C at distance L_1 from

$$D, M_{max2} = \left(\frac{\omega L_1^2}{2}\right) \text{ ....(2)}$$

$\therefore$ Equating (1) and (2)

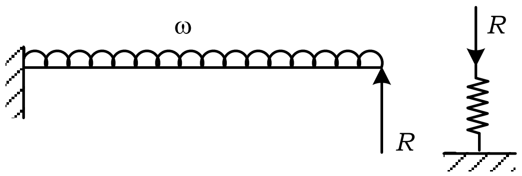
$$\omega\left(L_1+\frac{L}{2}\right)\left(\frac{L}{2}\right) - \frac{\omega}{2}\left(L_1+\frac{L}{2}\right)^2 = \frac{\omega L_1^2}{2}$$

$$\frac{\omega}{2}\left(L_1+\frac{L}{2}\right)\left(\frac{L}{2}-L_1\right) = \frac{\omega L_1^2}{2}$$

$$\left(\frac{L}{2}\right)^2 = 2L_1^2$$

$$\therefore L_1 = \frac{L}{2\sqrt{2}}$$

33. (B)



R is the force exerted by spring = Ky, where y is the deflection of beam.

$$\text{Deflection } (y) = \frac{\omega L^4}{8EI} - \frac{RL^3}{3EI} = \frac{R}{K}$$

$$\frac{\omega L^4}{8EI} = R\left[\frac{L^3}{3EI}+\frac{1}{K}\right]$$

$$R = \frac{\frac{3}{8}\omega L}{1 + \frac{3EI}{KL^3}}$$

34. (10.62)

Correct length occurs at $t = 16°C$ and at load 100 N

Now when it is used at temperature 50°C and load of 50 N then change in length occurs due to

(1) Increase in length and due to increase in temperature = $(l\alpha\delta t)$

= 30×1000×11×410⁻⁶×(50–16)

= 11.22 mm

(2) Decrease in length in length due to decrease in load = $\left(\frac{\Delta PL}{AE}\right)$

$$= (50 - 100) \times \frac{30 \times 1000}{12.5 \times 1 \times 200 \times 1000}$$

= 0.6 mm

Total change in lengthy = 11.22 – 0.6 = 10.62 mm

35. (21)

Maximum load on punch $= \frac{\pi}{4} d^2 \times 800$ N

Punching shear strength of plate

$= (\pi dt) \times 300 \text{ N} = (\pi d) \times 14 \times 300$

Now $\frac{\pi}{4} d^2 \times 800 \geq \pi d \times 14 \times 300$

$d \geq 21$ mm

So the least value of the hole that can be punched is 21 mm.

36. (200.3)

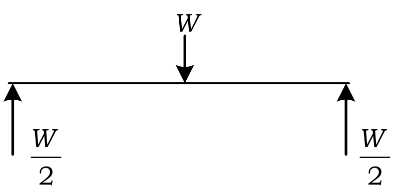
P = 15 kN, *v* = 0.5 m/sec, *L* = 10 m, *A* = 200 mm²

$$\frac{Pv^2}{2g} = \frac{\sigma^2}{2E} \times \text{Volume}$$

$$\frac{15 \times 1000 \times 0.5^2}{2 \times 9.81} = \frac{\sigma^2}{2 \times 210 \times 10^9} \times 10 \times 200 \times 10^{-6}$$

$\sigma = 200.3 \text{ MN/m}^2$

37. (D)



At any cross section

Moment $M = \frac{Wx}{2}$

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

$$\sigma_b = \frac{\frac{W}{2}\left(\frac{d}{2}\right)x}{\left(\frac{bd^3}{12}\right)}$$

$$\therefore \frac{bd^3}{12} = \frac{1}{4}\frac{Wx}{\sigma_b}(d)$$

$$d^2 = \frac{3Wx}{\sigma_b}$$

38. (265.2)

$$\delta L == \frac{WL}{AE}$$

Where, L is the length of rod

$$\frac{4 + 10 \times 10^3 \times L}{\pi \times 10^2 \times 10^{-6} \times E} = 3 \times 10^{-3}$$

$$\frac{L}{E} = 2.355 \times 10^{-11}$$

Stress developed in a rod by a weight *W* falling from a height of *h* is

$$\sigma \frac{W}{A}\left[1 + \sqrt{1 + \frac{2AEh}{WL}}\right]$$

$$= \frac{800 \times 4}{\pi \times (10)^2 \times 10^{-6}}\left[1 + \sqrt{1 + \frac{2 \times \frac{\pi}{4} \times (10)^2 \times 75 \times 10^{-3}}{2.355 \times 10^{-11} \times 800}}\right]$$

= 265.2 MPa

39. (A)

At C the $SF_2 + 3k$ N. So there must be concentrated load at *C* = 3 kN

From C to B the shear force diagram is linear

$$\therefore \frac{(9-3)}{4} = 1.5 \text{ kN/m}$$

Shear force drops from 9 kN to –16 kN.

So, there is concentrated load at B.

= 9–(–16) = 25 kN upwards

As SFD is linear from *B* to *D* the load is

equal to (16–4)/8 = 1.5 kN/m

At *B* ther is a concentrated load = 18 kN

Then SFD constant so R_A = 14 kN

So, the option **(A)** is correct.

40. (B)

$$\tau = \frac{T}{Z}$$

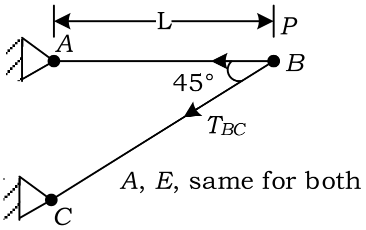
$$\frac{\tau_s}{\tau_h} = \frac{T_s}{Z_s} \times \frac{Z_h}{T_h} = \frac{T_s}{T_h} \times \frac{\frac{\pi}{32} d^4 \left(1 - \left(\frac{1}{2}\right)^4\right)}{\frac{\pi}{32} d^4} = 1$$

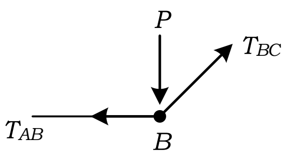
where the subscripts s and h represent solid and hollow shaft respectively.

$$\frac{T_h}{T_s} = \left(\frac{15}{16}\right)$$

41. (C)

FBD of point B is shown below:





In (AB) T_{AB} is load.

In (BC) T_{BC} is load

Equilibrium at point B gives,

$T_{AB} + T_{BC} \cos 45° = 0$, and

$P + T_{BC} \sin 45° = 0$

$P = -T_{BC} \sin 45°$

$$T_{BC} = -\frac{P}{\sin 45°}$$

$T_{AB} = (-P)$

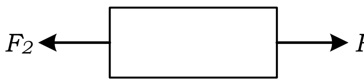
Strain energy in $AB = \frac{1}{2}\frac{T_{AB}^3 L_{AB}}{AE} = \frac{1}{2}\frac{P^2 L}{AE}$

$$\frac{1}{2}\frac{P^2 L}{AE} = \frac{KP^2 L}{AE}$$

⇒ Thus, **K = 0.5**

42. (672.8)

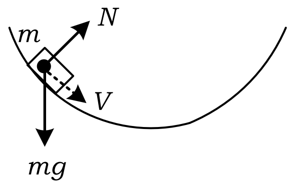
43. (C)



If F_1 = F_2 and both forces are collinear then

$\sum F = 0$ and net moment = 0 (about any point). So the body is in equilibrium.

44. (D)



∵ The block is moving downward so it is not in vertical equilibrium.

The block is moving horizontally also so it is not in the horizontal equilibrium.

Along radial direction there is centripetal acceleration so, net force is there. So the block is not in radial equilibrium.

45. (A)

$s = 2t^3 + 3t$

$$V = \frac{ds}{dt} = 6t^2 + 3$$

$V = 9$ m/s

$\Rightarrow 9 = 6t^2 + 3 \Rightarrow t = 1$ sec

$s = 2\times1^3+3\times1 = 5$ m

46. (C)

m_1	m_2
Initial speed = v_1	Initial speed = 0

Given v_1 = initial speed of m_1

After collision speed of m_1 is zero and let the speed of m_2 becomes v_2

By conversation of linear momentum,

$m_1 v_1 = m_2 v_2$ .... (1)

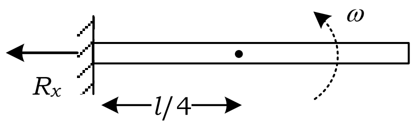
$$e = \frac{\text{velocity of separation}}{\text{velocity of approach}} = \frac{v_2}{v_1} = \frac{m_1}{m_2} \text{ (from (1))}$$

47. $s = ut - \frac{1}{2}gt^2$

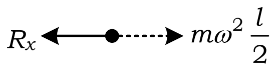
$s = -40m$, $u = 10\, m/s$

$-40 = 10t - \frac{9.8}{2}t^2 \Rightarrow t = 4.05$ sec

48. (A)

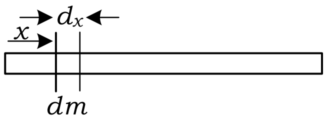


F.B.D. of center of mass gives

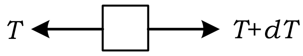


$$R_x = m\omega^2 \frac{l}{2aT}$$

Let us take an element of mass 'dm' at a distance 'x' from pivoted end of length 'dx'



F.B.D. of dm is shown below



This 'dm' mass is revolving around a circle of radius x and angular velocity ω so,

$$T - T(T + dT) = (dm)\omega^2 x$$

$$-dT = \frac{m}{l} dx\omega^2 x$$

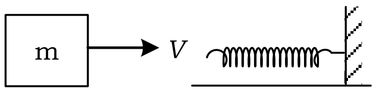
$$-dT = \frac{m}{l}\omega^2 x dx$$

$$\int_{\frac{m\omega^2 l}{2}}^{T} dT = -\frac{m}{l}\omega^2 \int_0^{l/4} x dx$$

$$T - \frac{m\omega^2 l}{2} = -\frac{m}{2l} \times \omega^2 \frac{l^2}{16}$$

$$T = \frac{15m\omega^2 l}{32}$$

49. (B)



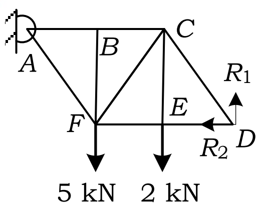
Let 'K' be the spring constant

By conservation of mechanical energy

$$\frac{1}{2}mV^2 = \frac{1}{2}m \times \left(\frac{V}{2}\right)^2 + \frac{1}{2}Kx^2$$

Solving we get $K = \dfrac{3mV^2}{4X^2}$

50. (6.6)



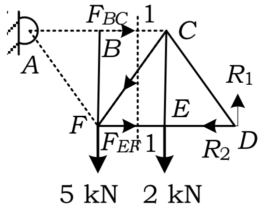
The reaction at roller D is perpendicular to roller support, since angle is 45° so $R_1 = R_2$

Taking moment about point A

$$5 \times 3 + 2 \times 6 = R_1 \times 9 - R_2 \times 4$$

$$R_1 = R_2 = 5.4\,\text{kN}$$

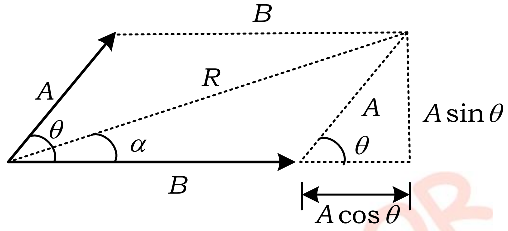
Cutting at section 1-1 and taking moment about F



$$F_{BC} \times 4 = 5.4 \times 6 - 2 \times 3$$

$$F_{BC} = 6.6\,\text{kN}$$

51. (C)



$$\sin\alpha = \frac{A\sin\theta}{R} = \frac{A\sin\theta}{\sqrt{A^2 + B^2 + 2AB\cos\theta}}$$

52. (D)

Using conservation of mechanical energy between points A and B

$$m \times g \times 1 = \frac{1}{2}mV^2$$

$$V^2 = 2g$$

$$V = \sqrt{20}\ \text{m/s}$$

Now by applying basic kinematic equation after point B we get

$$V_f^2 = U^2 + 2as$$

$$V_f = 0$$

$$U = V = \sqrt{20}$$

$$a = \mu g = 0.2 \times 10 = 2\ \text{m/s}^2$$

$$S = \frac{U^2}{2a} = \frac{(\sqrt{20})^2}{2 \times 0.2 \times 10} = 5\text{m}$$

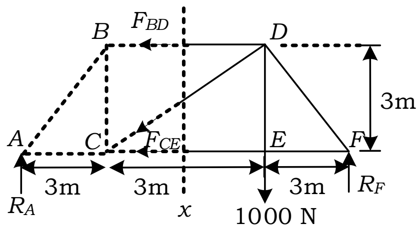
53. (0)

Taking moment about A and F we will get

$$R_A = R_F = 1000\ \text{N}$$

Cut section XX as shown in figure,

Let F_{BD} be the force in member BD, F_{CD} be the force in member CD and F_{CE} be the force in member CE.



$\sum F_y = 0$

$-F_{CD}\sin 45 - 1000 + 1000 = 0$

$F_{CD} = 0$

54. (C)

$I = \dfrac{ml^2}{3}$ (about one end)

$= \dfrac{0.3\times 0.5^2}{3} = 0.025\,\text{kg-m}^2$

Angular momentum $= I\times\omega$ = 0.025 ×2 = 0.05 kg-m²/s

Speed of center of rod = $\omega\times\dfrac{L}{2}$ = 0.5 m/s

Kinetic energy $= \dfrac{1}{2}\times I\times\omega^2 = 0.05\,\text{J}$

55. (D)

Let speed of car moving in opposite direction is V m/s

From relative velocity approach

$\dfrac{12}{V+50} = \dfrac{5}{60}$

12×60 = 5V + 250

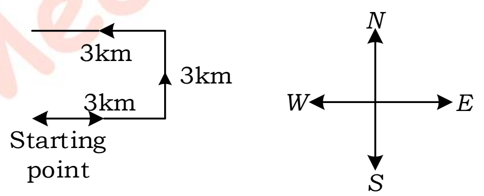
V = 94 km/hr

56. (B)

The use of conjunction because shows that the first part of the sentence must be logical and consequent result of what is stated in the second part. The missing adjective in the sentence must therefore describe a person who consistently shows distrust of human nature and human motives. Cynical is the exact word which describes such a person, and is the answer.

57. (C) **58. (A)** **59. (A)**

60. (A)



From the above direction diagram, it is clear that A is North from his starting point.

61. (A)

As, in 1st figure,

$4^2 + 3^2 = 16 + 9 = 25$

In 2nd figure,

$9^2 + 11^2 = 81 + 121 = 202$

In the same way,

In 3rd figure,

$1^2 + 7^2 = 1 + 49 = 50$

62. (B)

Total number of outcomes $n(s) = 6^2 = 36$

and event of getting a total score of 5

= {(1, 4), (2, 3), (3, 2), (4, 1)} = 4

∴ Favorable outcomes $n(E) = 4$

∴ Required probability $= \dfrac{n(E)}{n(S)} = \dfrac{4}{36} = \dfrac{1}{9}$

63. (B)

Steps covered by first person $= \dfrac{2\times 120}{(2+3)} = 48$

Steps covered by second person $= \dfrac{3\times 120}{(3+5)} = 45$

∴ Total number of steps taken by both the persons = (48 + 45) = 93

64. (C)

The ratio of number of coins is 1 : 2 : 3 for the 50 paise, 25 paise and ₹ 1.50 coins, respectively. In terms of monetary value, the ratio becomes

(1 × 0.50) : (2 × 0.25) : (3 × 1.5) = 0.5 : 0.5 : 4.5

= 1 : 1 : 9

∴ $\left(\dfrac{1}{11}\right)^{th}$ of the total value comes from 25 paise coins (i.e.) $\dfrac{1}{11}\times 6600$ = ₹600 is in the form of 25 paise coins

∴ Total number of 25 paise coins $= \dfrac{600}{0.25} = 2400$

65. (C)

Pension in first year = ₹1000 and thereafter 95% of the amount in the preceding year.

So, the pension received by him forms as infinite

GP with a = 1000 and r = 0.95

[∵ sum of infinite GP, $S_\infty = \dfrac{a}{1-r}$]

So, the old man will get = $\left[\dfrac{1000}{(1-0.95)}\right]$ = ₹ 20,000

if he remains alive forever.