## PART (A) : PHYSICS

### Answer Key & Solution

1. (C)

$$\frac{dy}{dx} = 3x^2 - 14x + 8 = 0$$

$$x = \frac{2}{3} \text{ and } 4$$

At $x = 4$, $\frac{d^2y}{dx^2} > 0 \Rightarrow$ Minima

$$y_{\min} = 4^3 - 7(4)^2 + 8(4) + 5$$

$$= -11$$

2. (B)

$$P = t \ln t$$

$$F = \frac{dp}{dt} = t\left(\frac{1}{t}\right) + [\ln t](1) = 0$$

$$t = e^{-1} = \frac{1}{e}$$

3. (B)

$$\frac{\vec{v} \cdot \vec{a}}{|\vec{a}|} = v\cos\theta \text{ parallel to } \vec{a}$$

$$\left[\frac{\vec{v} \cdot \vec{a}}{|\vec{a}|}\right]\hat{a} = \text{Ans.}$$

4. (B)

$$\left|\hat{a} - \hat{b}\right| = \sqrt{2}$$

$$1^2 + 1^2 - 2(1)(1)\cos\theta = 2$$

$$\cos\theta = 0 \Rightarrow \theta = 90^\circ$$

$$\left|\hat{a} - \sqrt{3}\hat{b}\right| = \sqrt{1^2 + \left(\sqrt{3}\right)^2 + 2(1)\left(\sqrt{3}\right)\cos 90}$$

$$= 2$$

5. (B)

6. (C)

$$S_{th} = 0 + \frac{1}{2}\times 10(2t-1)$$

$$S_{(t+1)} = 0 + \frac{1}{2}\times 10(2)[(t+1)-1]$$

$$100 = \frac{1}{2}\times 10(2t-1) + \frac{1}{2}\times 10(2t+1)$$

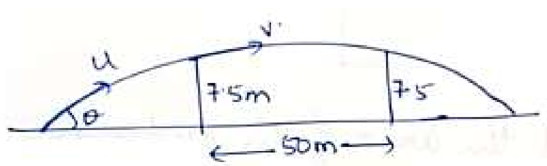
$$t = 5\,\text{sec}$$

$$V = u + at$$

$$= 0 + 10(5) = 20\,\text{m/sec}$$

7. (A)

$$(t_2 - t_1) = 2.5\,\text{sec}$$




$$R = \frac{2u_x u_y}{8} = \frac{2(20)(17.5)}{10} = 70\,\text{m}$$

8. (B)

$$V_r = 10(\hat{j}) \qquad V_c = V\hat{i}$$

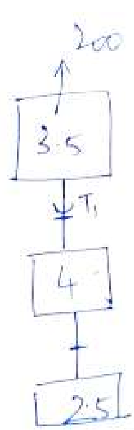
$$\vec{V}_{rc} = \vec{V}_r - \vec{V}_c = -10\hat{j} - V\hat{i}$$

$$\sqrt{100 + V^2} = 20$$

$$V^2 = 400 - 100$$

$$V = 10\sqrt{3}\ \text{m/sec}$$

9. (C)




$$200 - T_1 - 3.5g = 3.5a$$

$$T_1 - 4g - T_2 = 4a$$

$$T_2 - 2.5g = 2.5a$$

$$200 - (35 + 40 + 25) = 10a$$

$$a = 10\,\text{m/s}^2$$

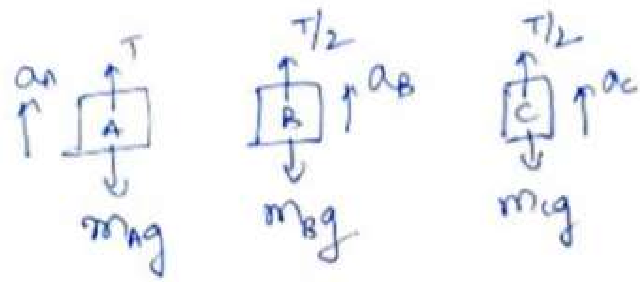
$$T_1 = 130\,\text{N}$$

$$T_2 = 50\,\text{N}$$

10. (A)

11. (A, B, C)

12. (A, B, C, D)




$$a_{P_1} = \frac{a_A + \frac{(a_B + a_C)}{2}}{2} = 26.25\ \text{m/s}^2$$

13. (A, B, C)

14. (A, D)

Let $\ell =$ length of the train

$v =$ Speed

$\ell = 50 = v \times 15$ & $\ell = v \times 5$

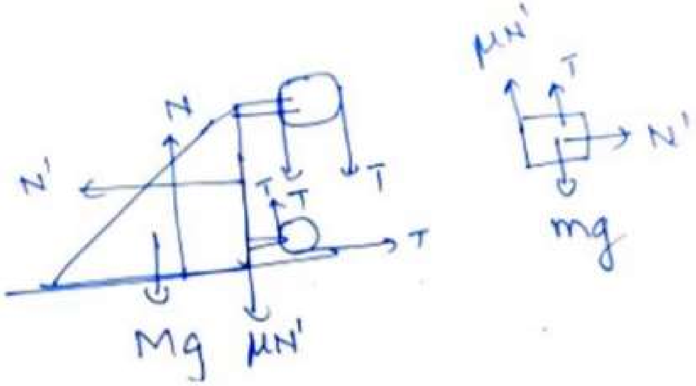
$v = 5$ m/sec & $\ell = 25$ m

15. (A, B, C)

$x = at + bt^2 + c$

$[c] = [x] = [at] = [bt^2]$

16. (2)



$T - N' = Ma \qquad ...(1)$

$N' = ma \qquad ...(2)$

$mg - T - \mu N' = ma \qquad ...(3)$

Solving the three equations

$a = 2\ \text{m/s}^2$

17. (5)

$\vec{R} = 10(\sin 37)i + 10\cos 37\hat{j} + 5\sqrt{2}\cos 45\hat{i} - 5\sqrt{2}45\hat{j} + 20\left(-\cos 53\hat{i} - \sin 53\right)\hat{j}$

$|R| = \sqrt{34\times 5} \quad \therefore n = 5$

18. (9)

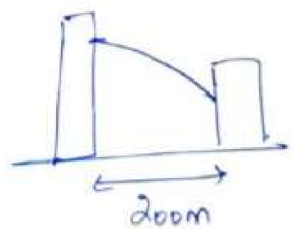
$H = 540 - 50 = 490\,\text{m}$

$R = u\sqrt{\dfrac{2H}{g}}$

$u = R\sqrt{\dfrac{g}{2+1}}$

$= 20\,\text{m/sec}$

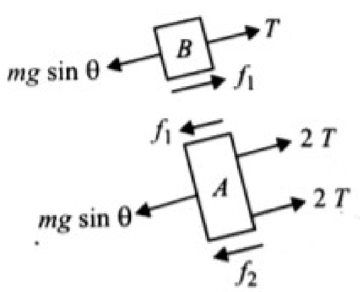
$\Rightarrow \; N = 9$




19. (7)

Since both blocks have same mass and upward force due to tension in strings on $A$ is 4 times of that on $B$, the tendency of $B$ is to slide down and of $A$ is to slide up the incline.

Accordingly, the friction $f_1$ and $f_2$ is shown in the figure.




Here, we have a limiting case, where the system is in equilibrium but the friction is maximum.

Here, $f_1 = \mu mg\cos\theta$ and $f_2 = \mu(2m)g\cos\theta$

From FBD of $A$ and $B$, we have

$4T = mg\sin\theta + f_1 +_2 = mg\sin\theta + 3\mu mg\cos\theta$ and

$T = mg\sin\theta - f_1 = mg\sin\theta - \mu mg\cos\theta$

$$\Rightarrow mg(\sin\theta + 3\mu\cos\theta) = 4mg(\sin - \mu\cos\theta)$$

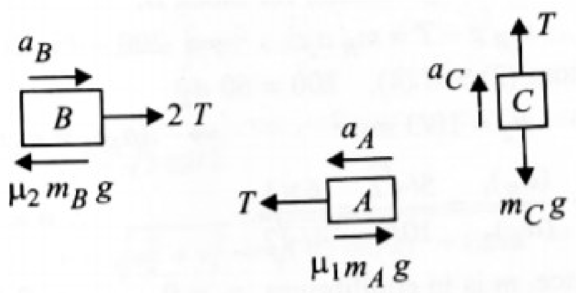
$$\Rightarrow 3\sin\theta = 7\mu\cos\theta \Rightarrow \tan\theta = \frac{7\mu}{3} = \frac{7}{6}$$

$$\Rightarrow \theta = \tan^{-1}\left(\frac{7}{6}\right) \qquad \therefore n = 7$$

20. (3)

Applying $\sum T_i a_i = 0$, we have

$$2Ta_B + Ta_A + Ta_C = 0 \Rightarrow 2a_B + a_A + a_C = 0$$




$$\Rightarrow 2\left(\frac{2T - \mu_2 m_B g}{m_B}\right) + \left(\frac{T - \mu_1 m_A g}{m_A}\right) + \left(\frac{T - m_C g}{m_C}\right) = 0$$

$$\Rightarrow T\left(\frac{4}{m_B} + \frac{1}{m_A} + \frac{4}{m_C}\right) = (2\mu_2 + \mu_1 + 1)g$$

$$\Rightarrow T\left(\frac{4}{9} + \frac{1}{9} + \frac{1}{18}\right) = (2\mu_2 + \mu_2 + 1)g$$

$$\Rightarrow T\left(\frac{4}{9} + \frac{1}{9} + \frac{1}{18}\right) = (2\times 0.5 + 0.5 + 1)\times 10$$

$$\Rightarrow T = \frac{25\times 18}{11} = \frac{1350}{11\times 3}\text{N}$$

$$\therefore n = 3$$