HINTS AND SOLUTIONS

PART-A : PHYSICS

1. (A)

$\frac{2\beta\ell}{ma}$ is unitless

$\therefore$ units of $\frac{ma}{\beta}$ = unit of ℓ = meter

and unit of α = unit of $\frac{ma}{\beta}$ = meter

2. (C)

$\tan 30° = \frac{v_{2y}}{v_x}$ and $\tan 60° = \frac{v_{1y}}{v_x}$

$\therefore$ $v_{1y} = 3v_{2y}$

Now, $v_{1y}^2 - v_{2y}^2 = 2gh$

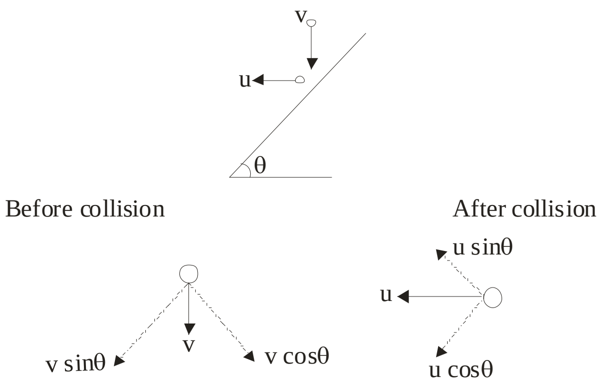
$\Rightarrow v_{2y} = \sqrt{\frac{gh}{4}}$ or $v_x = \sqrt{\frac{3gh}{4}}$

or $v = \frac{v_x}{\cos 60°} = \sqrt{3gh}$

3. (B)

Initially block moves downward and its momentum increases (with –ve sign)
Due to water resistance damping of motion happened.

4. (A)



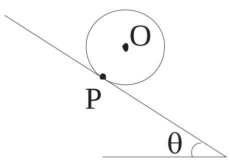
Now, velocity before and after collision along the incline plane remains same, so

$v\sin\theta = u\cos\theta$ …..(i)

and $e = \frac{u\sin\theta}{v\cos\theta}$

$e = \tan^2\theta$

5. (D)



$\tau = I_0\alpha$

$fR = \frac{1}{2}mR^2\alpha$

$$f = \frac{1}{2}ma \qquad (\because a = \alpha R)$$

6. (A)

$$T = Y\frac{\Delta\ell}{\ell}A$$

$$T = Y\frac{\Delta\ell}{\ell}.\frac{\mu}{\rho}$$

$$\frac{T}{\mu} = \frac{Y\Delta\ell}{\rho\ell} = \frac{9\times10^{10}\times5\times10^{-4}}{9\times10^{3}} = 5000$$

$$v = \sqrt{\frac{T}{\mu}} = \sqrt{50}\times10 \text{ m/s}$$

$$\lambda_{max} = 2\ell$$

$$\text{and } f_{min} = \frac{v}{\lambda_{max}} = \frac{\sqrt{50}\times10}{2}$$

$$\simeq 35\,\text{Hz}$$

7. (D)

$$f' = f\frac{(u+v_{\omega})}{(u+v_{\omega}-v_s\cos60°)} = \frac{510(330+20)}{330+20-20\cos60°} = 525 \text{ Hz}$$

8. (C)

By equation of continuity

$$\frac{v_y}{v_x} = \frac{3\text{cm}^2}{1.5\text{cm}^2} = 2$$

By Bernoulli's equation

$$p_x + \frac{1}{2}\rho v_x^2 = p_y + \frac{1}{2}\rho v_y^2$$

$$p_x - p_y = \frac{3}{2}\rho v_x^2$$

v_x = 0.63 m/s

Q = A_x v_x = (3 cm^2) (0.63 m/s) = 189 cm^3/s

9. (C)

$$I_0\omega_0 = I_t\omega_t$$

$$\frac{2}{5}Mr_0^2\omega_0 = \frac{2}{5}Mr_0^2(1+2\alpha\Delta T)\omega_t$$

$$\boxed{\omega_t = \frac{\omega_0}{1+0.004}}$$

10. (A)

$$\omega = \sqrt{\frac{k}{m}} \text{ and } \omega' = \sqrt{\frac{k}{2m}}$$

Now, by conservation of momentum

mu = 2mv

$$\Rightarrow v = \frac{u}{2}$$

$$\Rightarrow \omega' A = \frac{\omega a}{2}$$

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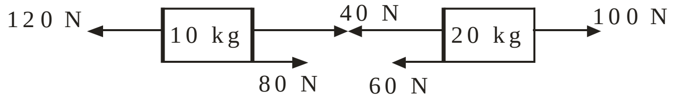
$$\Rightarrow \sqrt{\frac{k}{2m}}A = \sqrt{\frac{k}{m}}.\frac{a}{2}$$

$$\Rightarrow A = \frac{a}{\sqrt{2}}$$

11. (B)



12. (D)

$\Delta Q = \Delta U + \Delta W = \Delta U + nR\Delta T$

$$\Delta Q = \Delta U\left(1+\frac{2}{f}\right)$$

$\Delta U = 75$ J

13. (A)

$$\frac{v_1}{v_2} = \frac{r_1^2}{r_2^2}$$

and $\frac{p_1}{p_2} = \frac{m_1 v_1}{m_2 v_2} = \frac{r_1^5}{r_2^5}$

14. (D)

$$E = \frac{1}{4\pi \in_0}\frac{q}{x^2}$$

$$E = \frac{1}{4\pi \in_0}\frac{\int_0^x \rho_0 r^3 4\pi r^2 dr}{x^2}$$

$$E \propto x^4$$

15. (D)

$$F = p_2\frac{dE_1}{dr} = p_2\frac{d}{dr}\left[\frac{1}{4\pi \in_0}\frac{2p_1}{r^3}\right]$$

$$F \propto \frac{1}{r^4}$$

16. (B)

$$K_i + U_i = K_f + U_f$$

$$\Rightarrow \frac{1}{2}mk^2\left(\frac{2GM}{R}\right) - \frac{GMm}{R} = 0 - \frac{GMm}{h}$$

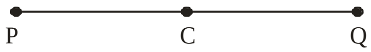
$$\Rightarrow h = \frac{R}{1-k^2}$$

17. (A)

$$I\sin\phi = \frac{V}{Z}.\frac{X_L}{Z}$$

$$= \frac{220\times 220}{220^2 + 220^2} = \frac{1}{2} = 0.5A$$

18. (D)



$$\text{emf}_{PC} = \frac{B\omega\ell^2}{8}$$

$$\text{emf}_{CQ} = -\frac{B\omega\ell^2}{8}$$

$$\text{emf}_{PQ} = 0$$

19. (C)

K.E. is maximum when angle between $\vec{M}$ and $\vec{B}$ is 0°.

Now, $K_i + U_i = K_f + U_f$

$$0 - MB\cos 120° = K_{max} - MB\cos 0°$$

$$K_{max} = \frac{3}{2}MB$$

20. (D)

$$\frac{R_1}{R_2} = \frac{\ell_1}{A_1} \times \frac{A_2}{\ell_2} = \frac{\ell_1^2}{V} \times \frac{V}{\ell_2^2}$$

$$\Rightarrow \frac{R_1}{R_2} = \frac{\ell_1^2}{\ell_2^2}$$

$R_2 = 9 \times 20 = 180\ \Omega$

21. (B)

$$\sin\theta = \frac{2\lambda}{a} = \frac{2 \times 6 \times 10^{-7}}{24 \times 10^{-5} \times 10^{-2}}$$

$\theta = 30°$

22. (A)

$F_{photon} = F_{gravity}$

$$\frac{p}{c} = Mg$$

$$p = 3 \times 10^8 \times 10^{-2} \times 10$$

$$p = 3 \times 10^7\ W$$

23. (B)

$\lambda = D\sin\phi$

$$\Rightarrow \frac{12.27}{\sqrt{v}}\text{Å} = D\sin\phi$$

$$\Rightarrow \frac{12.27 \times 10^{-10}}{\sqrt{10 \times 10^3}} = 0.55 \times 10^{-10}\sin\phi$$

$\phi = \sin^{-1}(0.223)$

24. (C)

$$B = \frac{E}{c} = \frac{6.3}{3 \times 10^8}$$

$= 2.1 \times 10^{-8}$ T

For direction of $\vec{B}$

$$\hat{E} \times \hat{B} = \hat{i}$$

$$\therefore \hat{B} = \hat{k}$$

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25. (C)

$$v = 2f_0(\ell_2 - \ell_1) \Rightarrow v = 340\,m/s$$

$$\left(\frac{\Delta v}{v}\right)_{max} = \frac{\Delta f_0}{f_0} + \frac{\Delta \ell_2 + \Delta \ell_1}{\ell_2 - \ell_1}$$

$$= \frac{1}{100} + \frac{0.1 + 0.1}{74.0 - 24.0}$$

□ 1.4%

26. (A)

At t = 0; resistance offered by C_1 and C_2 is 0 and after long time, resistance offered by C_1 and C_2 is ∞

27. (B)

$A = A_0 e^{-\lambda t}$

$$\ell nA = \ell nA_0 + \ell ne^{-\lambda t}$$

$$\ell nA = \ell nA_0 - \lambda t$$

28. (B)

$$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2} \Rightarrow f = +20$$

$$\text{and} \frac{1}{v} - \frac{1}{-10} = \frac{1}{20} \Rightarrow v = -20 \text{ cm}$$

$$m = \frac{v}{u} = \frac{-20cm}{-10cm} = 2$$

29. (C)

$$\beta = \frac{\alpha}{1-\alpha} = 24$$

$$i_C = \frac{0.5V}{800\Omega} = 0.625 \times 10^{-3} A$$

$$i_B = \frac{i_C}{\beta} = \frac{0.625 \times 10^{-3}}{24} = 26\mu A$$

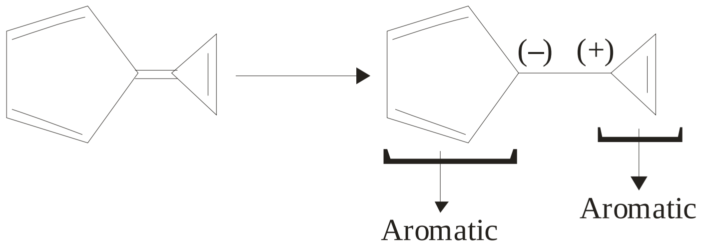
30. (D)

B.E.=[26 × 1.00783u + 30 ×1.00867u – 55.9349u] c^2

= (0.52878 u) c^2

= 492 MeV

58. (B)



59. (B)

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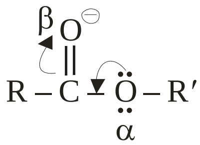

Hence, O denoted by β is more basic due to negative charge.