SOLUTIONS

Sample Question Paper-1

PHYSICS

Section - A

1. **Option (B) is correct.** 1

2. **Option (B) is correct.**

Explanation:

$\overline{A} = \hat{i} + \hat{j},\ \overline{B} = \hat{i} - \hat{j}$

$\therefore\ |\overline{A}| = \sqrt{(1)^2 + (1)^2} = \sqrt{2},$

$|\overline{B}| = \sqrt{(1)^2 + (-1)^2} = \sqrt{2}$

$\overline{A}.\overline{B} = |\overline{A}||\overline{B}|\cos\theta$

$\Rightarrow \cos\theta = \dfrac{\overline{A}.\overline{B}}{|\overline{A}||\overline{B}|}$

$= \dfrac{(\hat{i}+\hat{j})(\hat{i}-\hat{j})}{\sqrt{2}\times\sqrt{2}}$

$= 0$

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

$\therefore\quad \theta = 90^\circ$ [cos 90° = θ°]

3. **Option (C) is correct.** 1

4. **Option (B) is correct.** 1

Explanation: As the magnetic field due to motion of electron and proton act in a direction perpendicular to the direction of motion, no work is done by the forces. This is why one ignores the magnetic force of one particle on another.

OR

Option (C) is correct.

Explanation: Just because road does not move at all so the work done by the cycle on the road must be zero.

5. **Option (D) is correct.** 1

OR

Option (C) is correct.

6. **Option (D) is correct.** 1

7. **Option (B) is correct.** 1

8. **Option (D) is correct.** 1

Explanation: $\because \alpha_{aluminium} > \alpha_{steel}$

$\therefore$ Aluminium will expand more than that of steel strip. Due to it, this steel strip will bend on concave side

OR

Option (B) is correct. 1

Explanation: Its M.I increases .

$\therefore$ Angular momentum, L=Iω,

ω is angular speed which decreases to conserve L.

9. **Option (C) is correct.** 1

10. **Option (B) is correct.** 1

Explanation:

$y = 3\cos\left(\dfrac{\pi}{4} - 2\omega t\right) = 3\cos\left[-\left(2\omega t - \dfrac{\pi}{4}\right)\right]$

$= 3\cos\left(2\omega t - \dfrac{\pi}{4}\right) \qquad \{\because \cos(-\theta) = \cos\theta\}$

This shows simple harmonic motion with time period, $T = \dfrac{2\pi}{2\omega} = \dfrac{\pi}{\omega}$

11. $[ML^2T^{-2}]$. 1

12. An object is said to be a point object if it is dimensionless. 1

13. Law of conservation of linear momentum. 1

14. Positive work means that force (or its component) is parallel to displacement. 1

OR

Power is defined as the rate at which the body can do the work.

$P = \dfrac{\text{Work done}}{\text{Time Taken}}$ 1

15. Principle of conservation of angular momentum. 1

OR

As $\vec{L} = \vec{r} \times m\vec{v}$ *i.e.*, magnitude of $\vec{L}$ decreases but direction remains constant. 1

16. Moon. 1

$v_e = \sqrt{(2gR)}$. **1**

17. The flat surfaces of the crystal have their relative areas in fixed ratios and the angles between the flat faces also have fixed ratios. **1**

18. Isothermal process is the process in which temperature variation does not exist. Such processes are to be carried in (i) conducting cylinders, (ii) at a slow pace. **1**

19. No, because string is not stretchable. It can neither be compressed nor rarefied. **1**

Commonly Made Error

- Student could not predict the possibility of existence of longitudinal waves on a string.

Answering Tip

- The distinction between longitudinal and transverse waves should be understood clearly.

20. The time period becomes $\sqrt{2}$ times the original value since $T \propto \sqrt{l}$.

as we have $T = 2\pi\sqrt{\frac{l}{g}}$ **1**

21. **Option (B) is correct.** **1**

Explanation: The velocity of *B* relative to *A* is

$$V_B - B_A = 50 - 60$$
$$= -10 \text{ km/h}$$

22. **Option (A) is correct.** **1**

Explanation: The velocity of *A* relative to *B* is

$$V_A - V_B = 60 - 50$$
$$= 10 \text{ km/h}$$

23. **Option (B) is correct.** **1**

Explanation: Since C was in stationary position, his velocity was 0. Hence the velocity of A relative to C was 60 – 0 = 60 km/h and the velocity of B relative to C was 50 – 0 = 50 km/h.

24. **Option (C) is correct.** **1**

25. **Option (B) is correct.** **1**

Explanation: Area under the graph gives the distance. It is 60 × 2 = 120 km.

Section - B

26. Kinetic energy is a scalar quantity ½

S.I. unit of kinetic energy is joule (J) ½

1

27. Pressure at a point is given by the relation

$$P = P_a + h\rho g \quad \mathbf{1}$$

where, P_a is the atmospheric pressure and $h\rho g$ is the column pressure. Here, P is the absolute pressure and $(P - P_a)$ is the gauge pressure normally measured. **1**

28. For an adiabatic change, first law of thermodynamics may be expressed as :

$$dU + PdV = 0$$

or $$dU = -PdV \quad \mathbf{1}$$

The temperature of a gas will increase, if dU is positive. For this, dV has to be negative. Therefore temperature of a gas can be increased without adding heat, if it is compressed adiabatically. **1**

OR

For an adiabatic change, the first law of thermodynamics may be expressed as

$$dU + PdV = 0$$

or $$PdV = -dU \quad \text{...(i)} \ \mathbf{1}$$

During expansion, dV is $+ve$. Therefore the equation (i) will hold, if dU is $-ve$, i.e., temperature decreases. **1**

29. Liquids and gases cannot sustain shearing stress. Therefore, transverse waves in the form of crests and troughs (involving change of shape) are not possible in fluids. Rather, the fluid posses volume elasticity. Therefore, compressions and rarefactions (involving changes in volume) can be propagated through fluids. **2**

30. A simple pendulum which ticks seconds is a second pendulum. Its time period T = 2 s. If l is the length of this pendulum, then

$$T = 2\pi\sqrt{\frac{l}{g}} \quad \mathbf{1}$$

or $$l = \frac{gT^2}{4\pi^2} \quad ½$$

$$= \frac{9.8 \times 2^2}{4 \times (22/7)^2} = 0.99 \text{ m} \quad ½$$

OR

Given : $x = \alpha \sin \omega t + \beta \cos \omega t$

Let $\alpha = r\cos\theta$ and $\beta = r\sin\theta$ **1**

Then $x = r\cos\theta \sin\omega t + r\sin\theta \cos\omega t$

$= r\sin(\omega t + \theta)$ $\therefore$

The amplitude of oscillation is r

$$\alpha^2 = r^2\cos^2\theta \quad ....(i)$$

$$\beta^2 = r^2\sin^2\theta \quad ....(ii)$$

From (i) and (ii)

$$r = \sqrt{\alpha^2 + \beta^2}. \quad 1$$

Section - C

31. **Step I** : Horizontal range

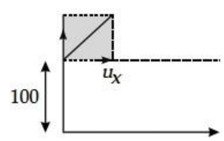
$$R = u\cos\theta \times t$$

where θ is the angle of inclination of gun to cover maximum range and t is the time.

i.e., $R = 150\cos\theta \times t$ ...(i)

Step II :Vertical height, 1

$$H = u\sin\theta t - \frac{1}{2}gt^2$$



i.e., $100 = 150\sin\theta t - \frac{1}{2} \times 10t^2$

$t^2 - (30\sin\theta)t + 20 = 0$

By using $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$ for $ax^2 + bx + c = 0$

we get, $t = \frac{30\sin\theta \pm \sqrt{900\sin^2\theta - 4\times1\times(+20)}}{2}$

$$t = 15\sin\theta \pm \sqrt{225\sin^2\theta - 20} \quad ...(ii)\ 1$$

Step III : Putting the value of t from eqn. (ii) in eq. (i), we get,

$R = 150\cos\theta(15\sin\theta + \sqrt{225\sin^2\theta - 20})$

Choose the value of θ between 43° to 47° to calculate the value of 'R'.

At, θ = 43°, R = 2347 m

θ = 43.5°, R = 2347.7 m

θ = 44°, R = 2348 m

θ = 45°, R = 2346 m

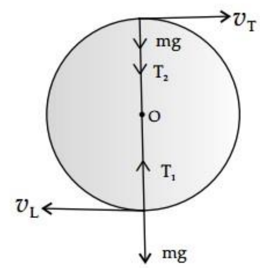
θ = 46°, R = 2341 m

θ = 47°, R = 2334 m

the mean value of $\theta = \frac{43° + 43.5°}{2} = 43.75 = 43.8°$ 1

Thus the required angle should be 43.8 to cover max. range.

32.



Consider an object of mass m completing vertical circle of radius r with velocities v_L at the lowest point and v_T at the highest point.

Minimum velocity at the highest point.

Here, centripetal force = weight of the object + tension in the string

i.e., $\frac{mv_T^2}{r} = mg + T_2$

$= mg + 0$

(if T_2 is taken as zero; since $T_2 \geq 0$)

i.e., $v_T = \sqrt{gr}$ 1

Minimum velocity at the lowest point.

Here, centripetal force = tension in the string – weight of the object

then, $\frac{mv_2^2}{r} = T_1 - mg$

Also by using the law of conservation of energy, total energy of the object at T = kinetic energy of the object at L. 1

$\therefore$ $(P.E. + K.E.)_T = K.E._L$

or, $mg2r + \frac{1}{2}mv_T^2 = \frac{1}{2}mv_L^2$

or, $v_L^2 = v_T^2 + 4gr$

but $v_T = \sqrt{gr}$

$\therefore$ $v_L^2 = 4gr + gr = 5gr$

So, $v_L = \sqrt{5gr}$ 1

33. It states that change in kinetic energy of a body is equal to work done and vice versa. Let a constant force $\vec{F}$ be applied to a body moving with initial velocity $\vec{u}$, so that its velocity becomes $\vec{v}$ along the direction of force when s is its displacement. Using Newton's second law of motion we get magnitude of force $F = ma$ and from equation of motion, we get $v^2 - u^2 = 2as$, where a is the acceleration of the body. 1

Multiplying both sides by $m/2$, we get

$$\frac{1}{2}mv^2 - \frac{1}{2}mu^2 = mas$$

i.e., $\frac{1}{2}mv^2 - \frac{1}{2}mu^2 = Fs = W$

i.e., $K.E._{(f)} - K.E._{(i)} = W$ **1**

where $K.E._{(f)}$ is final kinetic energy and $K.E._{(i)}$ is initial kinetic energy.

Thus work done on a body by a net force is equal to the change in kinetic energy of the body. **1**

OR

Let mass of the block = m

After breaking, $m_1 = \frac{2}{5}$ m and $m_2 = \frac{3}{5}$ m

Linear momentum = $m_1\vec{v_1} + m_2\vec{v_2}$ ½

According to law of conservation of momentum

$$p_f = p_i$$

or $m_1\vec{v_1} + m_2\vec{v_2} = 0$ **1**

Here, $\vec{v_1}$ = velocity of smaller part,

and, $\vec{v_2}$ = velocity of bigger part

or $\frac{2}{5}m(8\hat{i}+6\hat{j}) + \frac{3}{5}m(\vec{v_2}) = 0$ ½

or $\frac{3}{5}m\vec{v_2} = -\frac{1}{5}m(16\hat{i}+12\hat{j})$

$\vec{v_2} = -\left(\frac{16}{3}\hat{i}+4\hat{j}\right)$m/s **1**

34. The minimum energy required to free a satellite from the gravitational attraction is called binding energy. Binding energy is the negative value of total energy of satellite. Let a satellite of mass m be revolving around earth of mass M and radius R. **1**

∴ Total energy of satellite

$= P.E. + K.E.$

$= -\frac{GMm}{R} + \frac{1}{2}mv^2$

$= -\frac{GMm}{R} + \frac{mGM}{2R}$

$= -\frac{GMm}{2R}$ **1**

∴ Binding energy of satellite

= –[total energy of satellite]

$= \frac{GMm}{2R}$ **1**

35. Given : Radius of steel cable,

$r = 1.5$ cm $= 1.5 \times 10^{-2}$ m.

Maximum Stress $= 10^8$ Nm^{-2}.

∴ Area of cross-section of cable

$A = \pi r^2 = \pi(1.5 \times 10^{-2})^2$ **1**

Maximum load the cable can stand

= Maximum force

Maximum stress = $\frac{\text{Maximum force}}{\text{Area of cross-section}}$ **1**

or Maximum force = Maximum stress × Area of cross-section

or $F_{max} = 10^8 \times \pi \times (1.5 \times 10^{-2})^2$

or $F_{max} = 3.142 \times 2.25 \times 10^8 \times 10^{-4}$ N. **1**

or Maximum load the cable can withstand

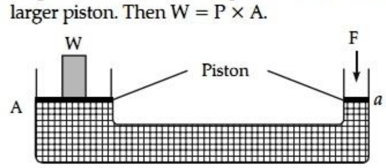
$= 7.07 \times 10^4$ N.

36. Pascal's Law : It states that if gravity effect is neglected, the pressure at every point of liquid in equilibrium of rest is same. Pascal's law also states that the increase in pressure at one point of the enclosed liquid in equilibrium of rest is transmitted equally to all other points of liquid provided the gravity effect is neglected. **1**

Applications : This principle is used to manufacture hydraulic lift. It consists of two cylinders–one of larger area of cross-section A and the other smaller piston of cross-sectional area a. Force is applied to smaller piston to produce a pressure,

$$P = \frac{F}{a}$$ ½

As per Pascal's law same pressure is transmitted to larger piston. Then W = P × A.



½

Clearly large area A is producing more lifting force W.

Hydraulic brakes are also based upon Pascal's law. **1**

OR

When a razor blade is made to float on water, three forces act on the blade :

(i) Weight of the blade acting vertically downwards. **1**

(ii) Reaction on blade exerted by the liquid surface acting vertically upwards. **1**

(iii) Force of the surface tension on circumference of the blade acting tangentially to the liquid surface. **1**

In this case, as no portion of razor blade is immersed in water, hence Archimedes principle is not applicable.

Commonly Made Error

- A few students are not aware about the concept of surface tension.

Answering Tip

- Students should learn about surface tension.

37. **(i)** When the spring is pulled sideways, the kink moves at 90° to the length of the spring. Waves are transverse. **1**

(ii) Waves in this case are longitudinal, because molecules of the liquid will move along the direction of motion of the piston. **1**

(iii) The water surface is cut laterally and pushed backwards by the propeller of motor boat. Therefore, the waves are a mixture of longitudinal and transverse waves. **1**

Section - D

38. **(i) Maximum height :** It is the maximum vertical height attained by the object above the point of projection during its flight denoted by h.

$$y = u\sin\theta,\ a_y = -g,\ y_0 = 0$$

$$y = h,\ t = T/2 = u\sin\theta/g$$

Using relation,

$$y = y_0 + u_y t + \frac{1}{2}a_y t^2,$$

we have, $h = 0 + u\sin\theta \times \dfrac{u\sin\theta}{g} + \dfrac{1}{2}(-g)\left(\dfrac{u\sin\theta}{g}\right)^2$

or $$h = \frac{u^2}{g}\sin^2\theta - \frac{1}{2}u^2\frac{\sin^2\theta}{g}$$

$$h = \frac{u^2\sin^2\theta}{2g}$$ **1**

(ii) Time of flight : The total time for which the projectile is in flight, taking vertical downward motion of object from O to C.

Let time taken to complete the trajectory = T

As the projectile is reaching the same level of projection, vertical displacement, $y = 0$

We have, $s = ut + \frac{1}{2}at^2$

$$0 = u\sin\theta.\ T - \frac{1}{2}gT^2$$

$$T = \frac{2u\sin\theta}{g}$$ **2**

(iii) Horizontal range : It is the horizontal distance travelled by projectile during its flight i.e., horizontal distance covered by object while going from O to C.

Distance = velocity × time

$$= u\cos\theta \times T$$

$$= \frac{u\cos\theta \times 2u\sin\theta}{g}$$

$$= \frac{u^2(2\sin\theta\cos\theta)}{2g}$$

$$= \frac{u^2\sin 2\theta}{g}$$ **2**

OR

Step 1 : Using

$$H = \frac{u^2\sin^2\theta}{2g}$$

when $H = 25$ m, $u = 40$ m/s

and $g = 9.8$ m/s^2

$$25 = \frac{40^2\sin^2\theta}{2\times 9.8}$$ **1**

or, $$\sin^2\theta = \frac{490}{40^2}$$ **1**

or, $$\sin\theta = \frac{\sqrt{490}}{40} = 0.5534$$

∴ $\theta = 33.6°$ **1**

Step 2 : $$R = \frac{u^2\sin 2\theta}{g}$$ **1**

$$R = \frac{40^2\sin 2(33.6)}{9.8}\ \text{m}$$

$$= \frac{40^2\sin 67.2}{9.8}\ \text{m}$$

$$= \frac{40^2\times 0.9219}{9.8}\ \text{m}$$

$= 150.514$ m **1**

39. In order to express torque as the rate of change of some quantity, we rewrite expression for torque of rotating a particle in XY plane as

$$\tau = xF_y - yF_x \qquad ...(i) \ ½$$

If $p_x = mv_x$ and $p_y = mv_y$ are the x and y components of linear momentum of the body, then

According to Newton's 2nd law of motion

$$F_x = \frac{dp_x}{dt} = \frac{d}{dt}(mv_x)$$

$$= \frac{mdv_x}{dt} \qquad ½$$

$$F_y = \frac{dp_y}{dt} = \frac{d}{dt}(mv_y)$$

$$= \frac{mdv_y}{dt} \qquad 1$$

Substituting in (i), we get

$$\tau = x\frac{mdv_y}{dt} - y\frac{mdv_x}{dt}$$

or $$\tau = m\left[x\frac{dv_y}{dt} - y\frac{dv_x}{dt}\right] \qquad ...(ii) \ 1$$

Now, Differentiating $(xv_y - yv_x)$,

$$\frac{d}{dt}(xv_y - yv_x) = x\frac{dv_y}{dt} + v_y\frac{dx}{dt} - y\frac{dv_x}{dt} - v_x\frac{dv_y}{dt}$$

$$= x\frac{dv_y}{dt} + v_y v_x - y\frac{dv_x}{dt} - v_x v_y$$

$$\left[\because \frac{dx}{dt} = v_x, \frac{dy}{dt} = v_y\right]$$

$$= x\frac{dv_y}{dt} - y\frac{dv_x}{dt} \qquad ...(iii)$$

Substituting (iii) in (ii)

we get, $$\tau = m\frac{d}{dt}(xv_y - yv_x) \qquad 1$$

$$\tau = \frac{d}{dt}(xmv_y - ymv_x)$$

As $mv_y = p_y$

and $mv_x = p_x$

$$\tau = \frac{d}{dt}(xp_y - yp_x) \qquad ...(iv)$$

$$xp_y - yp_x = L$$

$$\therefore \quad \tau = \frac{dL}{dt} \qquad 1$$

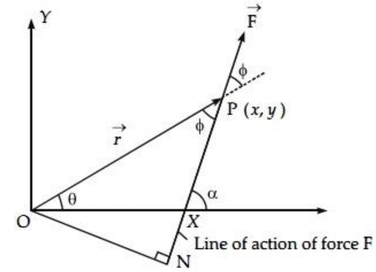
OR

Suppose the line of action of force F makes an angle α with x-axis

$$F_x = F\cos\alpha \qquad ...(i)$$

$$F_y = F\sin\alpha \qquad ...(ii) \ 1$$

If x, y are the co-ordinates of the point P where $\vec{OP} = \vec{r}$ and $\angle XOP = \theta$.



Then $x = r\cos\theta$

$$y = r\sin\theta \qquad ...(iii) \ ½$$

Substituting those values in $\tau = (xF_y - yF_x)$,

$$\tau = (r\cos\theta)F\sin\alpha - (r\sin\theta)(F\cos\alpha)$$

$$= rF[\sin\alpha\cos\theta - \cos\alpha\sin\theta] \qquad ½$$

$$\tau = rF\sin(\alpha - \theta) \qquad ...(iv) \ ½$$

Let ϕ be the angle which the line of action of force $\vec{F}$ make, with the position vector

$$\vec{OP} = \vec{r}$$

As clear from figure,

$$\theta + \phi = \alpha$$

or $$\phi = \alpha - \theta \qquad ...(v) \ 1$$

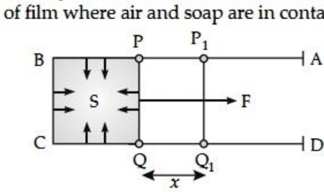
Putting in (iv)

$$\tau = rF\sin\phi \qquad ...(vi) \ 1$$

Equation (vi) is the expression for torque in polar co-ordinates. ½

40. Surface energy is defined as the amount of the work done against the force of surface tension, in forming the liquid surface of a given area at a constant temperature. 1

To obtain an expression for surface energy, take a rectangular frame ABCD having a wire PQ which can slide along the sides AB and CD. Dip the frame in soap solution and form a soap film BCQP on the rectangular frame. There will be two free surfaces of film where air and soap are in contact. ½



Let S = Surface tension of the soap solution.

l = Length of the wire PQ.

Since there are two free surfaces of the film and surface tension acts on both of them, hence total inward force on the wire PQ is

$$F = S \times 2l \qquad \mathbf{1}$$

To increase the area of the soap film we have to pull the sliding wire PQ outwards with a force F. Let the film be stretched by displacing wire PQ through a small distance x to the position P_1Q_1.

The increase in area of film PQQ_1P_1 in both sides

$$= a$$

$$= 2(l \times x) \qquad \mathbf{1}$$

∴ Work done in stretching film is

$$W = \text{Force applied} \times \text{Distance moved}$$

$$= (S \times 2l) \times x$$

$$= S \times (2lx)$$

$$= S \times a \qquad \tfrac{1}{2}$$

where, $2lx = a$ = increase in area of the film in both sides

If temperature of the film remains constant in this process, this work done is stored in the film as its surface energy. **1**

■■■