PART-1 (PHYSICS)

JEE Advanced 2017

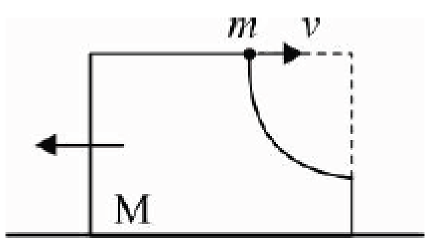
Ans 1. Net external force acting on the system along the x-axis is zero.

∴ Along the *x*-axis

Momentum is conserved

$\Rightarrow$ $mv = MV$

From conservation of energy



Loss in GPE of particle of mass *m* = Gain in kinetic energy of both the masses

$$\Rightarrow \quad mgh = \frac{1}{2}mv^2 + \frac{1}{2}MV^2 \qquad \Rightarrow mgh = \frac{1}{2}mv^2 + \frac{1}{2}M\left(\frac{mv}{M}\right)^2$$

$$\Rightarrow \quad 2gh = \left(1+\frac{m}{M}\right)v^2 \qquad \Rightarrow \sqrt{\frac{2gh}{1+\frac{m}{M}}}$$

Hence option (A) is correct.

$$V = \frac{m}{M}v = \frac{m\sqrt{2gh}}{\sqrt{M\left(m+M\right)}} \text{ along} - \text{ve x} - \text{axis}$$

Hence option (B) is incorrect.

$$\Delta x_{m/G} = R - x = \frac{MR}{M+m}$$

Final position of $m = -x = \frac{mR}{m+M}$

Hence option (C) is incorrect.

Since, along the x-axis the location of center of mass does not change.

$$m\Delta x_{m/G} + m\Delta x_{m/G} = 0 \quad \Rightarrow \qquad m(R-x) = Mx = 0f$$

$$x = \frac{mR}{m+M}$$

$$\Delta x_{m/G} = \frac{-mR}{m+M}$$

Hence option (D) is correct.

Hence, the correct options are A and D.

Ans 2. At $\omega \sim 0, X_L \sim 0$ and $X_C \to \infty$

Therefore, current will be nearly zero.

At $\omega >> 10^6, X_L >> 1$ and $X_C \to 0$

Hence, the circuit does not behave like a capacitor.

At resonance frequency (ω_0) i.e. when $X_C = X_L$ current will be in phase with voltage and frequency is independent of *R*.

Resonant frequency $\omega_0 = \frac{1}{\sqrt{LC}} = 10^6 rad/s$

Hence, the correct options are A and C.

Ans 3.

Velocity is independent of frequency and wavelength as velocity of the wave depends upon the tension in the rope and mass per unit length of the rope.

Therefore, option (B) is correct.

Since tension at the midpoint is same, therefore speeds at that point will also be same.

Therefore, option (A) is correct.

But the direction of motion of pulses is opposite; velocities will be equal and opposite. By this point, option (A) is incorrect.

Since the velocities at position is dependent only on tension at every point (μ = constant) therefore time taken for the wave the reach *A* from *O* and *O* from *A* will be same.

$$T_{OA} = T_{AO}$$

Therefore, option (D) is correct

$$V = \lambda v$$

Since v depends on the source

$$\Rightarrow \lambda \propto v \Rightarrow \lambda \propto \sqrt{T}$$

Tension decreases as we move from *O* to *A*, therefore λ becomes shorter.

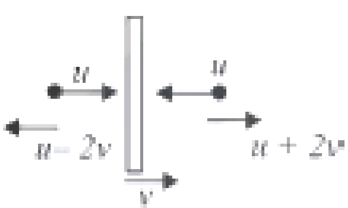
Therefore, option (C) is incorrect.

Hence, the correct options are (B) and (D).

Ans 4. Molecules hitting the forward and rear surfaces will bounce back with speeds given above.

Let mass of one molecule be m_0. Then,

$$\Delta P_0(\text{forward}) = 2m_0(u+v)$$
$$\Delta P_0(\text{Rear}) = 2m_0(u-v)$$



Let R_1 and R_2 be the rates of collision with front and rear surfaces respectively.

So,

$$R_1 a(u+v)$$
$$R_2 a(u-v)$$

Force, $\Delta P.R.$

So,

$$F_1 = R_1 2m_0 (u+v)_2\ F_2 = R_2.2m_0 (u-v)$$
$$F_1 - F_2\,\alpha\, 2m_0 (u+v)^2 - 2m_0 (u-v)^2$$
$$\Rightarrow F_1 - F\alpha\, 2m_0 [4uv]$$
$$\Rightarrow F_1 - F\alpha\, uv$$

Clearly, the net force due to gas is proportion to *v*, i.e. it is variable hence acceleration of plate is variable.

Finally the plate will start moving with terminal velocity.

Therefore, option (C) is correct.

Resistive force = $\Delta P.A \propto V$

Therefore, option (D) is correct.

Hence, the correct options are A, C and D.

Ans 5 Net power radiated $\sigma a\left(T^4 - T_0^4\right)$

For small temperature difference, $\Delta T = T_0$

$$P(Net) = \sigma A\left[(T_0 + \Delta T)^4 - T_0^4\right] = \sigma A T_0^4\left[\left(1 + \frac{\Delta T}{T_0}\right)^4 - 1\right] = \sigma A T_0^4\left[\frac{4\Delta T}{T_0}\right]$$

$$\therefore\ P(Net) = 4\sigma A T_0^3 (T - T_0)$$

(A) By the above result P(Net) decreases with A

(B) For rise in temperature peak shifts to shorter wave lengths.

(C) *P* (Radiated) = $\sigma AT^4 = \sigma A(T_0+10)^4 > 460$ watt

Therefore, (C) is incorrect

If *P* (Net) is taken, then (C) will be correct

(D) Energy radiated by a body is dependent only on its own temperature, not the temperature of surroundings.

Hence (D) is incorrect.

If P(Net) is taken, then from the calculation shown

above, (D) will also be correct.

So, considering P(Net).

Hence, the correct options are A, C and D.

Ans 6. Angular deviation: $\delta = i_1 + i_2 - A$

For min deviation: $i_1 = i_2$ so, $i_1 = A$ ...(i)

$r_1 = r_2 = A$

i.e. $r_1 = \dfrac{A}{2}$ $\quad ...(ii)$

$\therefore \quad r_1 = \dfrac{i_1}{2}$ (A is correct)

By Snell's law, $\sin i_1 = \mu \sin r_1$

$$\text{i.e.} \sin A = \mu \sin\left(\frac{A}{2}\right)$$

$$\Rightarrow 2\cos\left(\frac{A}{2}\right) = \mu$$

$$A = 2\cos^{-1}\left(\frac{\mu}{2}\right)$$

Therefore, option (B) is incorrect.

Option (C) is correct.

For tangential emergence $i_2 \to 90^o$.

So, $\mu \sin r_2 = 1$

$$\cos r_2 = \sqrt{1-\frac{1}{\mu^2}}$$

Also, $r_1 = A - r_2$

$$\sin r_1 = \sin A \cos r_2 - \cos A \sin r_2$$
$$= (\sin A)\frac{\sqrt{\mu^2-1}}{\mu} - (\cos A)\frac{1}{\mu}$$

By Snell's law on 1st surface,

$$\sin i_1 = \mu \sin r_1$$

$$\Rightarrow \sin i_1 = \sin A\left(\mu^2-1\right)^{1/2} - \cos A \Rightarrow i_1 = \sin^{-1}\left(\sin A\sqrt{4\cos^2\frac{A}{2}-1} - \cos A\right)$$

i.e. (D) is correct

Hence, the correct options are A, C and D.

Ans 7. The angle that area vector makes with B at time *t* is $\theta = wt$.

$$|\phi_1| = BA\cos\omega t \Rightarrow |\varepsilon_1| = BA\omega\sin(\omega t)$$
$$|\phi_2| = 2BA\cos\omega t \Rightarrow |\varepsilon_2| = 2BA\omega\sin(\omega t)$$

Due to orientation of loops, the two EMFs will work against each other.

$$So, |\varepsilon(Net)| = BA\omega\sin(\omega t)$$

So, option (A) is correct.

We can see that ε_{net} is maximum when $\theta = \frac{\pi}{2}$

So, option (B) is correct. Obviously, option (C) is incorrect.

Option (D) is incorrect as the EMF is proportional to difference in areas.

Hence, the correct options are A and B.

Ans 8. $V \propto \frac{1}{n^2}$

So, $\frac{V_1}{V_f} = \left(\frac{n_f}{n_f}\right)^2 = 6.25 \quad \therefore \quad \frac{n_f}{n_f} = 25 = \frac{5}{2}$

Minimum integral value of n_f is 5.

Ans 9. We know that for the given case,

$\mu \sin\theta =$ Constant

So, $1.6\sin\left(30^o\right) = \left(n - m\Delta n\right)\sin 90^o$

i.e. $0.8 = n - m\Delta n$

By solving we get *m* = 8

Ans 10. $A = A_0 e^{-\lambda t}$

Here, $\lambda = \frac{In2}{8}\left(days\right)^{-1}$

$t = 12hrs = \frac{1}{2}day$

So, $A = A_0 / \exp\left[\frac{In2}{8}.\frac{1}{2}\right] \cong \frac{A_0}{2\left(1+\frac{1}{16}\right)}$

$A = \frac{A_0}{2}\left(\frac{16}{17}\right)$

Let V be the volume of the blood, then

$$115 = A.\left(\frac{25}{V}\right)$$

$$\Rightarrow 115 = \frac{A_0}{2}\left(\frac{16}{17}\right).\left(\frac{2.5}{V}\right)$$

By solving we get $V = 5L$

Ans 11.

Frequency that is received by car = $= \left[\frac{330+2}{330}\right]492 = \frac{332}{330}\times 492 = 492Hz$

Frequency that is received by source $= \frac{330}{330-2}\times 495 = 498Hz$

Original frequency f_1 = 492Hz

Final frequency f_2 = 498Hz

Beat frequency $= \left|f_1 - f_2\right| = 6Hz$

Ans 12. Let *R* and *r* be the radius of the bigger and smaller drop respectively.

$$\frac{4}{3}\pi R^3 = \frac{4}{3}\pi r^3 \times K$$

$$R^3 = r^3 \times K \qquad \ldots(i)$$

$$U_i = S\left(4\pi R^2\right)$$

$$U_f = KS\left(4\pi r^2\right)$$

$$\Rightarrow KS\left(4\pi r^2\right) - S\times 4\pi R^2 = 10^{-3} \qquad (\text{Given})$$

$$\Rightarrow 4\pi S\left[Kr^2 - R^2\right] = 10^{-3}$$

$$\Rightarrow K^{\frac{1}{3}}R^2 - R^2 = 10^{-2}$$

$\Rightarrow 10^{a/3} - 1 = 100$

$\Rightarrow 10^{a/3} = 101$

$\Rightarrow a \approx 6$

Ans 13. Acceleration of the particle should be zero for constant velocity

Hence net force should be zero.

$qVB = qE \quad \Rightarrow \quad V = \frac{E}{B}(\text{For } a = 0)$

Electric field and magnetic field should be perpendicular.

Option (D) : $\overline{V} = \frac{E_0}{B_0}\hat{y}, \overline{E} = -E_0\hat{x}, \overline{B} = B_0\hat{z}(\text{for electron})$

$$\overline{F}_B = q(\overline{V} \times \overline{B}) = -e\left(\frac{E_0}{B_0}\hat{y} \times B_0\hat{z}\right) = -E_0\hat{x}$$

$$F_E = E_0\hat{x}$$

Hence, the correct option is (D).

Ans 14. $\overline{V} = 0, \overline{E} = -E_0\hat{y}, \overline{B} = B_0\hat{y}$ (Proton)

F_B = 0 only force along -y axis is acting due to electric field alone.

Hence, the correct option is (B).

Ans15. For proton

$$\overline{V} = 2\frac{E_0}{B_0}x; \overline{E} = E_0\hat{z}; \overline{B} = B_0\hat{z}$$

Let F_B and F_E be the force along – *y* axis and + *z* axis respectively.

So, condition for helical path is satisfied

Hence, the correct option is (D).

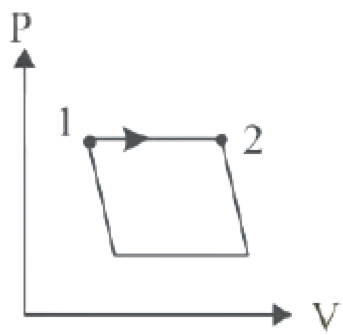
Ans 16. (Please note that $W_{1\to 2}$ is work done on the gas).

Process 1 to 2 represents isobaric process

$$W_{1\to 2} = P(V_1 - V_2) = PV_1 - PV_2$$

$\Delta U = \Delta Q - P\Delta V$ is correct.

No other combination is possible.

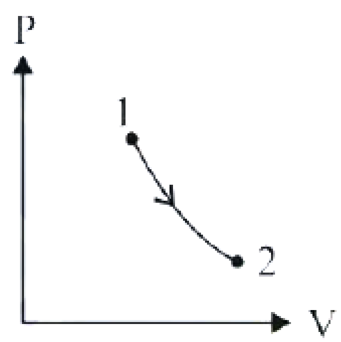


Hence, the correct option is C.

Ans 17. To determine the speed of the sound in ideal gas Laplace correction is done, which states that the process assumed was not isothermal but is Adiabatic.

$$W_{adiabatic1\to 2} = \frac{1}{\gamma - 1}(P_2V_2 - P_1V_1)$$

Corresponding graph is



Hence, the correct option is (A).

Ans 18. Let's consider all the options one by one:

(A) is incorrect since $W = 0$ in isochoric process.

(B) Correct as $W_{\text{choric}} = 0$

Therefore, option B is correct.

(C) Since $W_{1\to2} = -PV_2 + PV_1$ which does not satisfy for adiabatic process. So, it is incorrect combination.

(D) Incorrect combination of process and graph.

Hence, the correct option is (B).