NATIONAL ELIGIBILITY CUM ENTRANCE TEST

Phase-1 (Code:A-P-W)

Answers & Solutions

Physics

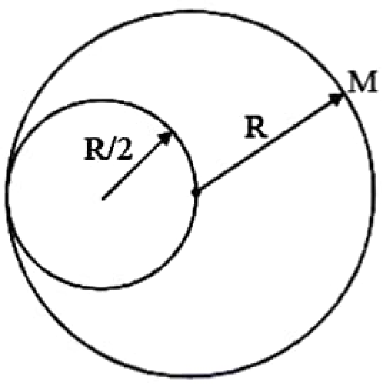
1. From a disc of radius R and mass M, a circular hole of diameter R, whose rim passes through the centre is cut. What is the moment of inertia of the remaining part of the disc about a perpendicular axis, passing through the centre?

(1) $15\ MR^2/32$
(2) $13\ MR^2/32$
(3) $11\ MR^2/32$
(4) $9\ MR^2/32$

Solution: (2)

$$I = \frac{MR^2}{2} - \frac{3\sigma}{2}\pi\left(\frac{R}{2}\right)^2\left(\frac{R}{2}\right)^2$$

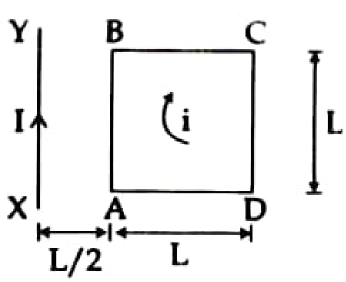
Where $\sigma = \frac{M}{\pi R^2}$



$$I = \frac{MR^2}{2} - \frac{3}{32}MR^2$$

$$I = \frac{13}{32}MR^2$$

2. A square loop ABCD carrying a current i, is placed near and coplanar with a long straight conductor XY carrying a current I, the net force on the loop will be:

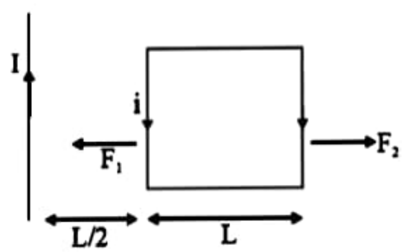


(1) $\frac{2\mu_0 Ii}{3\pi}$
(2) $\frac{\mu_0 Ii}{2\pi}$
(3) $\frac{2\mu_0 IiL}{3\pi}$
(4) $\frac{\mu_0 IiL}{2\pi}$

Solution: (1)

$$F_1 = \frac{\mu_0 IiL}{2\pi \frac{L}{2}} = \frac{\mu_0 Ii}{\pi}$$

$$2 = \frac{\mu_0 IiL}{2\pi \frac{3L}{2}} = \frac{\mu_0 Ii}{3\pi}$$



$$\therefore F_{net} = F_1 - F_2$$

$$F_{net} = \frac{2}{3}\frac{\mu_0 Ii}{\pi}$$

3. The magnetic susceptibility is negative for:

(1) diamagnetic material only
(2) paramagnetic material only
(3) ferromagnetic material only
(4) paramagnetic and ferromagnetic materials

Solution: (1)

Magnetic susceptibility χ_m

is negative for diamagnetic substance only

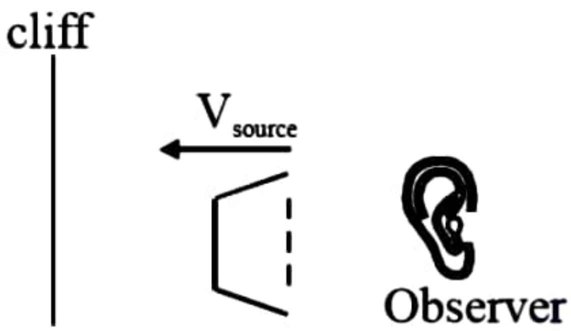
4. A siren emitting a sound of frequency 800 Hz moves away from an observer towards a cliff at a speed of $15\ ms^{-1}$. Then, the frequency of sound that the observer hears in the echo reflected from the cliff is : (Take velocity of sound in air = $330\ ms^{-1}$)

(1) 765 Hz
(2) 800 Hz
(3) 838 Hz
(4) 885 Hz

Solution: (3)

$f_0 = 800\text{Hz}$

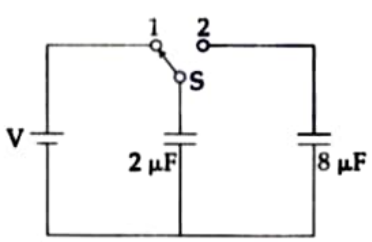
$V_{source} = 15$ m/s



$$f_a = \frac{330}{(330-15)}800 = \frac{330}{315} \times 800$$

$f_a = 838$ Hz

5.



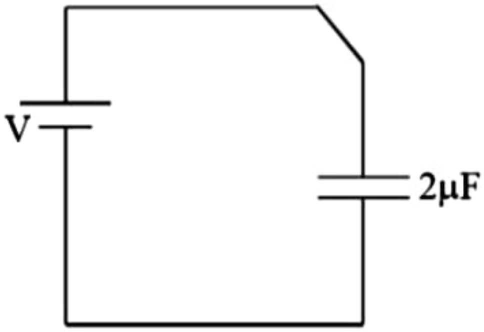
A capacitor of $2\mu F$ is charged as shown in the diagram. When the switch S is turned to position 2, the percentage of its stored energy dissipated is:

(1) 0%
(2) 20%
(3) 75%
(4) 80%

Solution: (4)

$Q = 2V$

$$U_i = \frac{1}{2} \times \frac{(2V)^2}{2} = V^2$$



$$\therefore V_y = \frac{1}{2}\frac{64V^2}{25 \times 8}$$

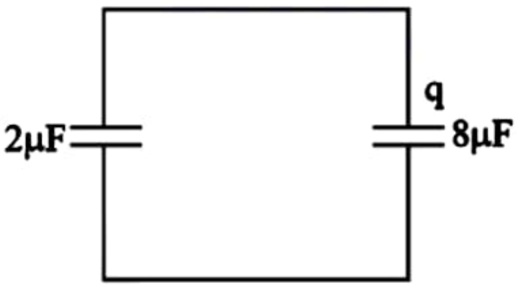
$$\frac{2V - q}{2} = \frac{q}{8} + \frac{1}{2}\frac{4V^2}{25 \times 2}$$

$$\therefore 8V - 4q = q$$

$$U_f = \frac{5V^2}{25} = \frac{V^2}{5}$$

$$\therefore q = \frac{8V}{5}$$

Energy dissipated $= \frac{4V^2}{5}$



∴ % energy

Dissipated $= \frac{4V^2}{5V^2} \times 100$

$= 80\%$

6. In a diffraction pattern due to a single slit of width 'a', the first minimum is observed at an angle 30° when light of wavelength 5000 Å is incident on the slit. The first secondary maximum is observed at an angle of:

(1) $\sin^{-1}\left(\frac{1}{4}\right)$
(2) $\sin^{-1}\left(\frac{2}{3}\right)$
(3) $\sin^{-1}\left(\frac{1}{2}\right)$
(4) $\sin^{-1}\left(\frac{3}{4}\right)$

Solution: (4)

$a \sin 30 = \lambda$

$a \sin \theta = \frac{3\lambda}{2}$

$\frac{\sin \theta}{\sin 30} = \frac{3}{2}$

$\sin \theta = \frac{3}{2} \times \frac{1}{2}$

$\sin \theta = \frac{3}{4}$

$\theta = \sin\left(\frac{3}{4}\right)$

7. At what height from the surface of earth the gravitation potential and the value of g are $-5.4 \times 10^7 \, \mathrm{J\,kg^{-2}}$ and $6.0 \, \mathrm{ms^{-2}}$ respectively? Take the radius of earth as 6400 km:

(1) 2600 km
(2) 1600 km
(3) 1400 km
(4) 2000 km

Solution: (1)

$V = \frac{GM}{R + h} = -5.4 \times 10^7$

$g = \frac{GM}{(R + h)^2} = 6$

$\therefore \frac{5.4}{6} \times 10^7 = R + h$

$\therefore a \times 10^6 = 6.4 \times 10^6 + h$

$\therefore h = 2600$ km

8. Out of the following options which one can be used to produce a propagating electromagnetic wave?
(1) A charge moving at constant velocity
(2) A stationary charge
(3) A chargeless particle
(4) An accelerating charge

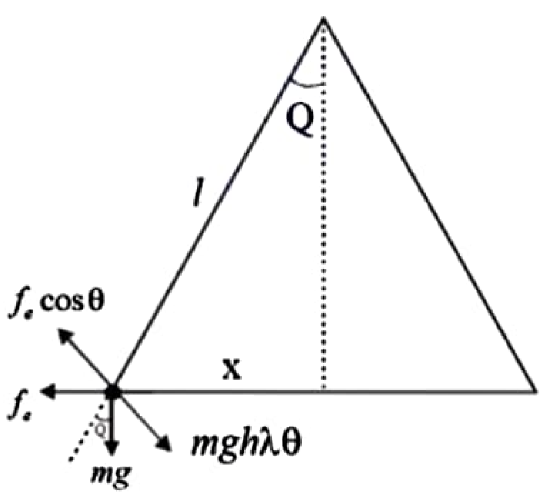
Solution: (4)

An accelerating charge can produce electromagnetic wave.

9. Two identical charged spheres suspended from a common point by two massless strings of lengths l, are initially at a distance $d(d << l)$ apart because of their mutual repulsion. The charges begin to leak from both the spheres at a constant rate. As a result, the spheres approach each other with a velocity υ. Then υ varies as a function of the distance x between the spheres, as

(1) $\upsilon \propto x^{\frac{1}{2}}$
(2) $\upsilon \propto x$
(3) $\upsilon \propto x^{-\frac{1}{2}}$
(4) $\upsilon \propto x^{-1}$

Solution: (3)



$\theta = \frac{x}{2l}$

$f_e \cos\theta = mgh\lambda\theta$

$f_e = mg.\left(\frac{x}{2}\right)$

$$\frac{kq^2}{x^2} = \frac{mgx}{2e}$$

$$kq^2 = \frac{mg}{2l}x^3$$

$$q \propto x^{\frac{3}{2}}$$

$$\frac{dq}{dt} \propto \frac{3}{2}\, x^{\frac{1}{2}}.\frac{dx}{dt}$$

$$\Rightarrow x^{\frac{1}{2}}.v = \text{constant}$$

$$v \propto x^{-\frac{1}{2}}$$

10. A uniform rope of length L and mass m_1, hangs vertically from a rigid support. A block of mass m_2 is attached to the free end of the rope. A transverse pulse of wavelength λ_1 is produced at the lower end of the rope. The wavelength of the pulse when it reaches the top of the rope is λ_2. The ratio λ_2/λ_1 is:

(1) $\sqrt{\frac{m_1}{m_2}}$

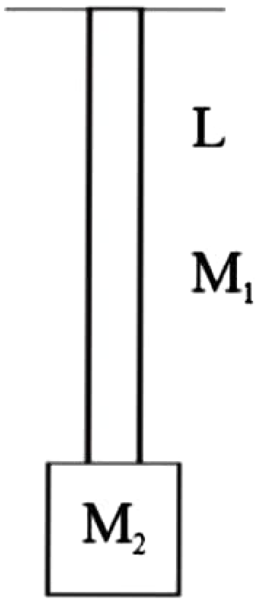
(2) $\sqrt{\frac{m_1+m_2}{m_2}}$

(3) $\sqrt{\frac{m_1}{m_2}}$

(4) $\sqrt{\frac{m_1+m_2}{m_1}}$

Solution: (2)

At bottom



$$v_1 = \sqrt{\frac{M_2 g L}{M_1}}$$

$$\therefore \lambda_1 = \sqrt{\frac{M_2}{M_1} g L}\frac{1}{f}$$

At top.

$$\therefore \frac{\lambda_2}{\lambda_1} = \sqrt{\frac{M_1 + M_2}{M_2}}$$

$$v_1 = \sqrt{\frac{(M_1 + M_2) g L}{M_1}}$$

$$\therefore \lambda_2 = \sqrt{\frac{(M_1 + M_2) g L}{M_1}}\frac{1}{f}$$

11. A refrigerator works between 4°C and 30°C. It is required to remove 600 calories of heat every second in order to keep the temperature of the refrigerated space constant. The power required is:
(Take 1 cal = 4.2 Joules)

(1) 2.365 W
(2) 23.65 W
(3) 236.5 W

(2) $10^{-2}\,A$
(3) $10^{-1}\,A$
(4) $10^{-3}\,A$

Solution: (2)

$V_A - V_3 = 4 - (-6) = 10$

$\therefore i = \frac{10}{1000} = 10^{-2}\ A$

14. The charge flowing through a resistance R varies with time t as $Q = at - bt^2$ where a and b are positive constants. The total heat produced in R is :

(1) $\frac{a^3R}{6b}$
(2) $\frac{a^3R}{3b}$
(3) $\frac{a^3R}{2b}$
(4) $\frac{a^3R}{b}$

Solution: (1)

$Q = at - bt^2$

$\therefore t \in \left[0, \frac{a}{b}\right]$

$i = \frac{dq}{dt} = a - 2bt$

Note: i is +ve $t \in \left(0, \frac{a}{2b}\right)$

And i is – ve $t \in \left(\frac{a}{2b}, \frac{a}{b}\right)$

Positive current means current one direction and negative current means current in opposite direction.

$\therefore dH = i^2 R dt$

$= (a - 2bt)^2 R\, dt$

$$H = \int_0^{\frac{a}{b}} (a - 2bt)^2\, R\, dt$$

$$= \frac{(a - 2bt)^3 R}{3(-2b)}\bigg|_0^{\frac{a}{b}}$$

$$= \frac{1}{-b}\left[\left(a - 2b\frac{a}{b}\right)^3 - (a)^3\right] R$$

$$= -\frac{1}{6b}[(-a)^3 - a^3]R$$

$$H = \frac{a^3R}{3b}$$

15. A black body is at a temperature of 5760 K. The energy of radiation emitted by the body at wavelength 250 nm is U_1, at wavelength 500 nm is U_2 and that at 1000 nm is U_3. Wien's constant, $b = 2.88 \times 10^6$ nmK. Which of the following is correct?

(1) $U_1 = 0$
(2) $U_3 = 0$
(3) $U_1 > U_2$
(4) $U_2 > U_1$

Solution: (3)

$$\lambda_{min} T = b$$

$$\lambda \propto \frac{1}{T}$$

$$u \propto (T)^4 \propto \frac{1}{(\lambda)^4}$$

So

$$u_1 > u_2$$

16. Coefficient of linear expansion of brass and steel rods are α_1 and α_2. Lengths of brass and steel rods are l_1 and l_2 respectively. If $(l_2 - l_1)$ is maintained same at all temperatures, which one of the following relations holds good?

(1) $\alpha_1^2 l_2 = \alpha_2^2 l_1$
(2) $\alpha_1 l_2^2 = \alpha_2 l_1^2$
(3) $\alpha_1^2 l_2 = \alpha_2^2 l_1$
(4) $\alpha_1 l_1 = \alpha_2 l_2$

Solution: (4)

Difference in length are same so increase in length are equal

$$\Delta l_1 = \Delta l_2$$

$$l_1 \alpha_2 \Delta T = l_2 \alpha_2 \Delta T$$

$\Rightarrow l_1\alpha_1 = l_2\alpha_2$

17. A npn transistor is connected in common emitter configuration in a given amplifier. A load resistance of 800 Ω is connected in the collector circuit and the voltage drop across it is 0.8 V. If the current amplification factor is 0.96 and the input resistance of the circuit is 192 Ω, the voltage gain and the power gain of the amplifier will respectively be:

(1) 4, 3.84
(2) 3.69, 3.84
(3) 4, 4
(4) 4, 3.69

Solution: (1)

Voltage gain $= \beta.\left(\frac{R_C}{R_B}\right)$

$$V = 0.96\left(\frac{80}{192}\right)$$

$$V = \frac{96 \times 8}{192} = 4$$

And power gain of the amplifier is

$\beta_{ac}.A_V$

$= 0.96 \times 4$

$= 3.84$

18. The intensity at the maximum in a Young's double slit experiment is I_0. Distance between two slits is $d = 5\lambda$, where λ is the wavelength of light used in the experiment. What will be the intensity in front of one of the slits on the screen placed at a distance $D = 10\,d$?

(1) I_0
(2) $\frac{I_0}{4}$
(3) $\frac{3}{4}I_0$
(4) $\frac{I_0}{2}$

Solution: (4)

In YDSE $I_{max} = I_0$

Path difference at a point in front of one of shifts is

$$\Delta x = d\left(\frac{y}{D}\right) = d\left(\frac{\frac{d}{2}}{D}\right) = \frac{d^2}{2D}$$

$$\Delta x = \frac{d^2}{2(10d)} = \frac{d}{20} = \frac{5\lambda}{20} = \frac{\lambda}{4}$$

Path difference is

$$\phi = \frac{2\pi}{\lambda} = (\Delta x) = \frac{2\pi}{\lambda}\left(\frac{\lambda}{4}\right)$$

$$\phi = \frac{\pi}{2}$$

So intensity at that pt is

$$I = I_{max} \cos^2\left(\frac{\theta}{2}\right)$$

$$I = I_0 \cos^2\left(\frac{\pi}{4}\right) = \frac{I_0}{2}$$

19. A uniform circular disc of radius 50 cm at rest is free to tum about an axis which is perpendicular to its plane and passes through its centre. It is subjected to a torque which produces a constant angular acceleration of 2.0 rad s^{-2}. Its net acceleration in ms^{-2} at the end of 2.0 s is approximately:

(1) 8.0
(2) 7.0
(3) 6.0
(4) 3.0

Solution: (1)

At the end of 2 sec, $w = w_0 + \alpha t$

$w = 0 + 2(2) = 4$ rad/sec

Particle acceleration towards the center is $= a_c = rw^2$

$a_r = \frac{1}{2}(4)^2 = 8$ m/s

20. An electron of mass m and a photon have same energy E. the ratio of de-Broglie wavelengths associated with them is:
SS

(1) $\frac{1}{c}\left(\frac{E}{2m}\right)^{\frac{1}{2}}$
(2) $\left(\frac{E}{2m}\right)^{\frac{1}{2}}$
(3) $c(2mE)^{\frac{1}{2}}$
(4) $\frac{1}{c}\left(\frac{2m}{E}\right)^{\frac{1}{2}}$

(c being velocity of light)

Solution: (1)

De-Broglie wavelength is given by

$\lambda_e = \frac{h}{p} = \frac{h}{\sqrt{2m.E}}$ for electron

De-Broglie wavelength of photon is given by

$$\lambda_p = \frac{h}{p} = \frac{h}{\frac{E}{c}} = \frac{hc}{E}$$

$$\frac{\lambda_e}{\lambda_p} = \frac{1}{\sqrt{2mE}} . \frac{E}{c} = \frac{1}{c}\sqrt{\frac{E}{2m}}$$

21. A disk and a sphere of same radius but different masses roll off on two inclined planes of the same altitude and length. Which one of the two objects gets to the bottom of the plane first?

(1) Disk
(2) Sphere
(3) Both reach at the same time
(4) Depends on their masses

Solution: (2)

Acceleration of the object on rough inclined plane is $a = \frac{g\sin\theta}{1+\frac{I}{mR^2}}$

For sphere $a_1 = \frac{5g\sin\theta}{7}$

For disc $a_2 = \frac{2g\sin\theta}{3}$

$a_1 > a_2$, so sphere will reach bottom first.

22. The angle of incidence for a ray of light at a refracting surface of a prism is 45°. The angle of prism is 60°. If the ray suffers minimum deviation through the prism, the angle of minimum deviation and refractive index of the material of the prism respectively, are:

(1) $45°; \frac{1}{\sqrt{2}}$
(2) $30°; \sqrt{2}$
(3) $45°; \sqrt{2}$
(4) $30°; \frac{1}{\sqrt{2}}$

Solution: (2)

At minimum deviation $\delta_{min} = 2i - A$

$\delta_{min} = 2(45) - 60$

$\delta_{min} = 30^o$

Refractive index of material is

$$\mu = \frac{\sin\left(\frac{\delta_{min} + A}{2}\right)}{\sin\left(\frac{A}{2}\right)} = \frac{\sin\left(\frac{30+60}{2}\right)}{\sin(30^o)}$$

$$\mu = \frac{\sin 45^o}{\sin 30^o} = \frac{\frac{1}{\sqrt{2}}}{\frac{1}{2}} = \sqrt{2}$$

23. When an α-particle of mass 'm' moving with velocity 'v' bombards on a heavy nucleus of charge 'Ze', its distance of closest approach from the nucleus depends on m as:

(1) $\frac{1}{m}$
(2) $\frac{1}{\sqrt{m}}$
(3) $\frac{1}{m^2}$
(4) m

Solution: (1)

At the distance of lowest approach, total K.E. of α-particle changes to P.E. so

$$\frac{1}{2}mv^2 = \frac{KQ.q}{r} = \frac{K(ze)(2e)}{r}$$

$$r = \frac{4K\,ze^2}{mv^2} \Rightarrow r \propto \frac{1}{m}$$

$r \propto \frac{1}{m}$

24. A particle of mass 10 g moves along a circle of radius 6.4 cm with a constant tangential acceleration. What is the magnitude of this acceleration if the kinetic energy of the particle becomes equal to 8×10^{-4} J by the end of the second revolution after the beginning of the motion?

(1) $0.1\ m/s^2$
(2) $0.15\ m/s^2$
(3) $0.18\ m/s^2$
(4) $\frac{0.2m}{s^2}$

Solution: (1)

Tangential acceleration $a_t = r\alpha = \text{constant} = K$

$\alpha = \frac{K}{r}$

At the end of second revoluation angular velocity is w then

$w^2 - w_0^2 = 2 \propto \theta$

$w^2 - 0^2 = 2\left(\frac{K}{r}\right)(4\pi)$

$w^2 = \frac{8\pi K}{r}$

K.E. of the particle is $= K.E. = \frac{1}{2}mv^2$

$K.E. = \frac{1}{2}mr^2w^2$

$K.E. = \frac{1}{2}m(r^2)\left(\frac{8\pi K}{r}\right)$

$8 \times 10^{-4} = \frac{1}{2} \times 10 \times 10^{-3} \times 6.4 \times 10^{-2} \times 3.14 \times K$

$K = \frac{2}{6.4 \times 3.14} = 0.1 \frac{m}{ssec^2}$

25. The molecules of a given mass of a gas have r.m.s velocity of 200 ms^{-1} at $27^\circ C$ and $1.0 \times 10^5\ Nm^{-2}$ pressure. When the temperature and pressure of the gas are respectively, $127^\circ C$ and $0.05 \times 10^5\ Nm^{-2}$, the r.m.s. velocity of its molecules in ms^{-1} is:

(1) $100\sqrt{2}$
(2) $\frac{400}{\sqrt{3}}$
(3) $\frac{100\sqrt{2}}{3}$
(4) $\frac{100}{3}$

Solution: (2)

Rms speed of molecules is $V_{ms} = \sqrt{\frac{3RT}{M}}$

So it depends only on temperature

$V_{rms} \propto \sqrt{T}$

$$\frac{V_1}{V_2} = \sqrt{\frac{T_1}{T_2}} \Rightarrow \frac{200}{V_2} = \sqrt{\frac{300}{400}}$$

$$\frac{200}{V_2} = \frac{\sqrt{3}}{2} \Rightarrow V_2 = \frac{400}{\sqrt{3}} \text{ m/sec}$$

26. A long straight wire of radius a carries a steady current I. the current is uniformly distributed over its cross-section. The ratio of the magnetic fields B and B′, at radial distances $\frac{a}{2}$ and 2a respectively, from the axis of the wire is:

(1) $\frac{1}{4}$
(2) $\frac{1}{2}$
(3) 1
(4) 4

Solution: (3)

$\frac{\text{Inside the wire}}{\text{By ampere's law}}$

$$\int \vec{B}.\vec{dl} = \mu_0(i_{enclosed})$$

$$\int B.dl\cos 0 = \mu_0\left(\frac{I}{\pi a^2}.\pi\left(\frac{a}{2}\right)^2\right)$$

$$B\int dl = \mu_0\frac{I}{4}$$

$$B\left(2\pi\left(\frac{a}{2}\right)\right) = \frac{\mu_0 I}{4}$$

$B = \frac{\mu_0 I}{4\pi a}$

Outside the wire,

$B' = \frac{\mu_0 I}{2\pi r} = \frac{\mu_0 I}{2\pi(2a)} = \frac{\mu_0 I}{4\pi a}$

So, $\frac{B}{B'} = 1.$

27. A particle moves so that its position vector is given by $\vec{r} = \cos\omega t\,\hat{x} + \sin\omega t\,\hat{y}$. Where ω is a constant. Which of the following is true?

(1) Velocity and acceleration both are perpendicular to $\vec{r}$.
(2) Velocity and acceleration both are parallel to $\vec{r}$.
(3) Velocity is perpendicular to $\vec{r}$ and acceleration is directed towards the origin.
(4) Velocity is perpendicular to $\vec{r}$ and acceleration is directed away from the origin.

Solution: (3)

Position vector is $\vec{r} = \cos\omega + \hat{x} + \sin\omega + \hat{y}$

Velocity of particle is $\vec{v} = \frac{d\vec{r}}{dt}$

$\vec{v} = \sin\omega t.\omega\,\hat{x} + \cos\omega t.\omega\hat{y}$

$\vec{v} = \omega(-\sin\omega t\hat{x} + \cos\omega t\hat{y})$

Acceleration of the particle is

$\vec{a} = \frac{d\vec{v}}{dt}$

$\vec{a} = -\omega^2(\cos\omega t\,\hat{x} + \sin\omega t\hat{y})$

$\vec{a} = -\omega^2\vec{r}$,

So direction of $\vec{r}$ and $\vec{a}$ are opposite.

$\vec{v}.\vec{a} = 0 \Rightarrow \vec{v} \perp \vec{a}$

$\vec{v}.\vec{r} = 0 \Rightarrow \vec{v} \perp \vec{r}$

So, ans is (Velocity is perpendicular to $\vec{r}$ and acceleration is directed towards the origin.)

28. What is the minimum velocity with which a body of mass m must enter a vertical loop of radius R so that it can complete the loop?

(1) $\sqrt{gR}$
(2) $\sqrt{2gR}$
(3) $\sqrt{3gR}$
(4) $\sqrt{5gR}$

Solution: (4)

Minimum velocity required is $v = \sqrt{5gR}$

29. When a metallic surface is illuminated with radiation of wavelength λ, the stopping potential is V. If the same surface is illuminated with radiation of wavelength 2λ, the stopping potential is $\frac{V}{4}$. The threshold wavelength for the metallic surface is:

(1) 4λ
(2) 5λ
(3) $\frac{5}{2}\lambda$
(4) 3λ

Solution: (4)

In photo electric effects

$eV_0 = 48 - W$

$eV_0 = \frac{hc}{\lambda} - W$

$eV = \frac{hc}{\lambda} - W \quad ...(i)$

$e\frac{V}{4} = \frac{hc}{2\lambda} - W \quad ....(ii)$

From (i) and (ii)

$\frac{hc}{\lambda} - W = 4\left(\frac{hc}{2\lambda} - W\right)$

$\frac{hc}{\lambda} - W = \frac{2hc}{\lambda} - 4W$

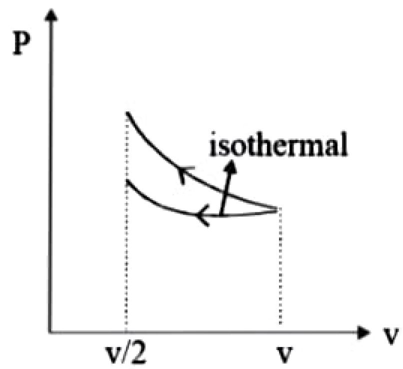
$3W = \frac{hc}{\lambda} \Rightarrow W = \frac{hc}{3\lambda}$

$\frac{hc}{\lambda_{max}} = \frac{hc}{3\lambda} \Rightarrow \lambda_{max}$ = threshold wavelength 3λ

30. A gas is compressed isothermally to half its initial volume. The same gas is compressed separately through an adiabatic process until its volume is again reduced to half. Then:

(1) Compressing the gas isothermally will require more work to be done.
(2) Compressing the gas through adiabatic process will require more work to be done.
(3) Compressing the gas isothermally or adiabatically will require the same amount of work.
(4) Which of the case (whether compression through isothermal or through adiabatic process) requires more work will depend upon the atomicity of the gas.

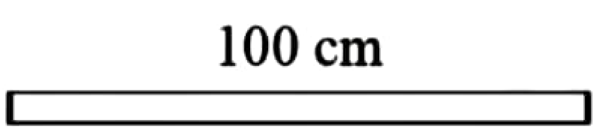
Solution: (2)



Isothermal curve lie below the adiabatic curve, So in adiabatic process more work to be done.

31. A potentiometer wire is 100 cm long and a constant potential difference is maintained across it. Two cells are connected in series first to support one another and then in opposite direction. The balance points are obtained at 50 cm and 10 cm from the positive end of the wire in the two cases. The ratio of emf's is :
(1) 5 : 1
(2) 5 : 4
(3) 3 : 4
(4) 3 : 2

Solution: (4)



$$\frac{E_1 + E_2 = \lambda 50}{E_1 - E_2 = \lambda 10}$$

$$E_1 + E_2 = 5E_1 - 5E_2$$

$$6E_2 = 4E_1$$

$$\frac{3}{2} = \frac{E_1}{E_2}$$

32. A astronomical telescope has objective and eyepiece of focal lengths 40 cm and 4 cm respectively. To view an object 200 cm away from the objective, the lenses must be separated by a distance:

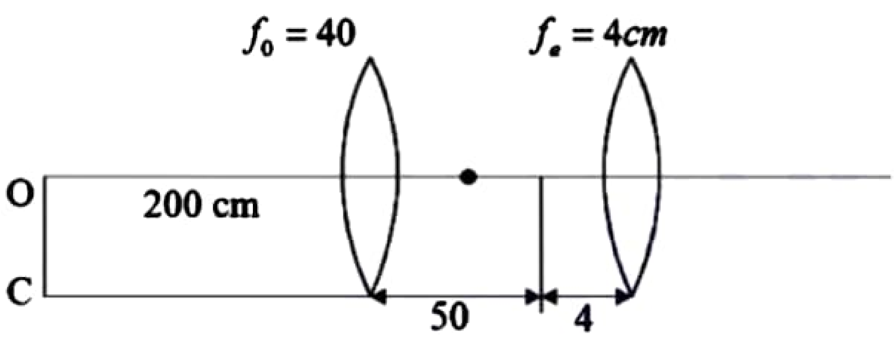
(1) 37.3 cm
(2) 46.0 cm
(3) 50.0 cm
(4) 54.0 cm

Solution: (4)

$$\frac{1}{V}-\frac{1}{-200}=\frac{1}{40}$$

$$\frac{1}{V}=\frac{5}{5}\frac{1}{40}-\frac{1}{200}$$

$$=\frac{5}{200}-\frac{1}{200}$$



$$\frac{1}{V}=\frac{4}{200}=\frac{1}{50}$$

$V = 50$

$\therefore d = 50 + 4 = 54$ cm

33. Two non-mixing liquids of densities ρ and $n\rho(n > 1)$ are put in a container. The height of each liquid is h. A solid cylinder of length L and density d is put in this container. The cylinder floats with its axis vertical and length $pL(p < 1)$ in the denser liquid. The density d is equal to:

(1) $\{1 + (n + 1)p\}\rho$
(2) $\{2 + (n + 1)p\}\rho$
(3) $\{2 + (n - 1)p\}\rho$
(4) $\{1 + (n - 1)p\}\rho$

Solution: (4)

(1) A → b and c; B→ b and c; C→ b and d; D→ a and d
(2) A → a and c; B→ a and d; d→ a and b; D→ c and d
(3) A → a and d; B→ b and c; C→ b and d; D→ b and c
(4) A → c and d; B→ b and d; C→ b and c; D→ a and d

Solution: (1)

$$m = \frac{-V}{u} = \frac{f}{f \times u}$$

m = −2 then “V” and “u” same given

$$-2 = \frac{f}{f \times u} - 2f + 2u = f$$

$$= 3f = -2u$$

$$\frac{+3f}{2} = 4$$

For mirror so 4 negative

∴ V has to be negative

45. A car is negotiating a curved road of radius R. The road is banked at an angle θ. The coefficient of friction between the tyres of the car and the road is μ_s. The maximum safe velocity on this road is:

(1) $\sqrt{gR^2 \frac{\mu_s + \tan\theta}{1 - \mu_s \tan\theta}}$

(2) $\sqrt{gR \frac{\mu_s + \tan\theta}{1 - \mu_s \tan\theta}}$

(3) $\sqrt{\frac{g}{R} \frac{\mu_s + \tan\theta}{1 - \mu_s \tan\theta}}$

(4) $\sqrt{\frac{g}{R^2} \frac{\mu_s + \tan\theta}{1 - \mu_s \tan\theta}}$

Solution: (2)

(1) 34 km
(2) 544 km
(3) 136 km
(4) 68 km

Solution: (3)

$$\frac{1}{4}mgh = mL$$

$$h = \frac{4L}{g} = \frac{4 \times 3.4 \times 10^5}{10} = 13.6 \times 10^4$$

$$= 136 \times 10^3 \text{ km}$$

$$= 136 \text{ km}$$

36. The ratio of escape velocity at earth (υ_e) to the escape velocity at a planet (υ_p) whose radius and mean density are twice as that of earth is:

(1) 1 : 2
(2) $1 : 2\sqrt{2}$
(3) 1 : 4
(4) $1 : \sqrt{2}$

Solution: (2)

$$\frac{V_e}{V_P} = \frac{\sqrt{2\frac{GM_e}{R_e}}}{\sqrt{2\frac{GM_P}{R_P}}} = \sqrt{\frac{M_R}{M_P}\frac{R_P}{R_e}} = \sqrt{\frac{P_e\frac{4}{3}\pi R_e^3 R_P}{P_P\frac{4}{3}\pi R_P^3 R_e}}$$

$$\frac{V_e}{V_P} = \sqrt{\frac{P_e R_e^2}{P_P R_P^2}} = \sqrt{\frac{1}{2\,2^2}} = \frac{1}{2\sqrt{2}}$$

37. If the magnitude of sum of two vectors is equal to the magnitude of difference of the two vectors, the angle between these vectors is:

(1) 0^o
(2) 90^o
(3) 45^o
(4) 180^o

Solution: (2)

$|\vec{A}+\vec{B}| = |\vec{A}-\vec{B}|$

$A^2 + B^2 + 2AB\cos\theta = A^2 + B^2 = 2AB\cos\theta$

$4AB\cos\theta = 0$

$\cos\theta = 0$

$\theta = 90°$

38. Given the value of Rydberg constant is $10^7\ m^{-1}$, the wave number of the last line of the Balmer series in hydrogen spectrum will be:

(1) $0.025 \times 10^4\ m^{-1}$
(2) $0.5 \times 10^7\ m^{-1}$
(3) $0.25 \times 10^7\ m^{-1}$
(4) $2.5 \times 10^7\ m^{-1}$

Solution: (3)

$\frac{1}{\lambda} = R = \left(\frac{1}{h_1^2} - \frac{1}{h_2^2}\right)$

Wavelength $= \frac{1}{\lambda} = R\left[\frac{1}{2^2}\right] = \frac{R}{4} = \frac{10^7}{4} = 0.25 \times 10^7\ m^{-1}$

39. A body of mass 1 kg begins to move under the action of a time dependent force $\vec{F} = (2t\,\hat{\imath} + 3t^2\,\hat{\jmath})N$, where $\hat{\imath}$ and $\hat{\jmath}$ are unit vectors along x and y axis. What power will be developed by the force at the time t?

(1) $(2t^2 + 3t^3)W$
(2) $(2t^2 + 4t^4)W$
(3) $(2t^3 + 3t^4)W$
(4) $(2t^3 + 3t^5)W$

Solution: (4)

$\vec{a} = 2t\hat{\imath} + 3t^2\hat{\jmath}$

$\vec{V} = 2t^2\hat{\imath} + \frac{3}{3}t^3\hat{\jmath}$

$\vec{F} = 2t\hat{\imath} + 3t^2\hat{\jmath}$

$P = \vec{F}.\vec{V} = 2t^3 + 3t^5$

40. An inductor 20 mH, a capacitor 50 μF and a resistor 40 Ω are connected in series across a source of emf $V = 10 \sin 340\,t$. The power loss in A.C. circuit is :

(1) 0.51 W
(2) 0.67 W
(3) 0.76 W
(4) 0.89 W

Solution: (1)

$wL = 340 \times 20 \times 10^{-3} = 68 \times 10^{-1} = 6.8$

$\frac{1}{wC} = \frac{1}{340 \times 50 \times 10^{-6}} = \frac{10^4}{34 \times 5} = \frac{2}{34} \times 10^3$

$= 0.0588 \times 10^3 = 58.82$

$2 = \sqrt{\left(wL - \frac{1}{wc}\right)^2 + R^2}$

$2 = \sqrt{2704 + 1600} \approx 65.6$

$i = \frac{V}{2}, \frac{10}{65 \times \sqrt{2}} = \frac{10}{65.6\sqrt{2}}$

Power $= \frac{100 \times 40}{(65.6)^2 \times 2} = \frac{2000}{(65.6)^2}$

$= 0.51\ w$

41. If the velocity of a particle is $\upsilon = At + Bt^2$, where A and B are constants, then the distance travelled by it between 1s and 2s is:

(1) $\frac{3}{2}A + 4B$
(2) $3A + 7B$
(3) $\frac{3}{2}A + \frac{7}{3}B$
(4) $\frac{A}{2} + \frac{B}{3}$

Solution: (3)

$V = At + Bt^2$

$X = \frac{At^2}{2} + \frac{Bt^3}{3}$

$t = 1$

$X_1 = \frac{A}{2} + \frac{B}{3}$

$t = 2$

$X_2 = 2A + \frac{8B}{3}$

$X_2 - X_1 = \frac{3A}{2} + \frac{7B}{3}$

42. A long solenoid has 1000 turns. When a current of 4A flows through it the magnetic flux linked with each turn of the solenoid is 4×10^{-3} Wb. The self-inductance of the solenoid is:

(1) 4 H
(2) 3 H
(3) 2 H
(4) 1 H

Solution: (4)

$\phi = Li$

$1000 \times 4 \times 10^{-3} = L4$

$1 = L$

43. A small signal voltage $V(t) = V_0 \sin \omega t$ is applied across an ideal capacitor C:

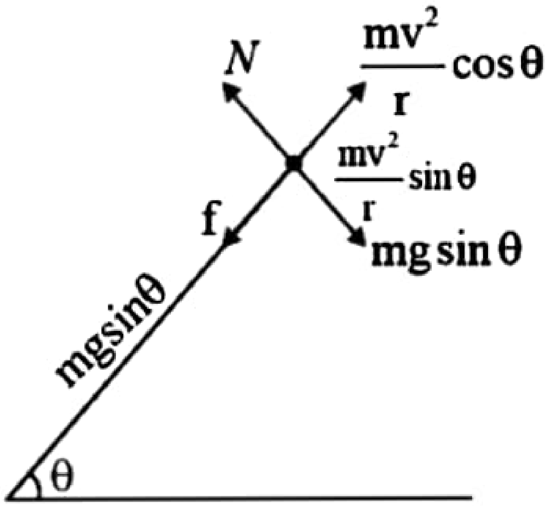
(1) Current I(t), legs voltage V(t) by 90°
(2) Over a full cycle the capacitor C does not consume any energy from the voltage source
(3) Current I(t) is in phase with voltage V(t).
(4) Current I(t) leads voltage V(t) by 180°

Solution: (2)

In capacitor current leads the voltage. Average power dissipated in capacitor is zero

44. Match the corresponding entries of column 1 with column 2. [Where m is the magnification produced by the mirror]

	Column 1		Column 2
(A)	$m = -2$	(a)	Convex mirror
(B)	$m = -\frac{1}{2}$	(b)	Concave mirror
(C)	$m = +2$	(c)	Real image
(D)	$m = +\frac{1}{2}$	(d)	Virtual image



$$N = mg\cos\theta + \frac{mv^2}{r}\sin\theta$$

$$f_{max} = \mu mg\cos\theta + \frac{\mu mv^2}{r}\sin\theta$$

$$mg\sin\theta + \mu mg\cos\theta + \frac{\mu mv^2}{r}\sin\theta = \frac{mv^2}{r}\cos\theta$$

$$g\sin\theta + g\cos\theta = \frac{V^2}{r}(\cos\theta - \mu\sin\theta)$$

$$gr\left[\frac{\tan\theta + \mu}{1 + \mu\tan\theta}\right] = V^2$$