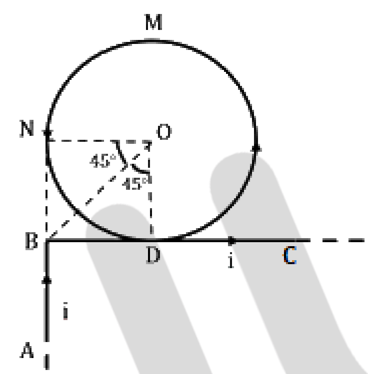
JEE Main 2020 Paper

Date of Exam: **8th January (Shift II)**
Time: **2:30 pm – 5:30 pm**
Subject: **Physics**

1. A very long wire ABDMNDC is shown in figure carrying current i. AB and BC parts are straight, long and at right angle. At D wire forms a circular turn DMND of radius R. AB, BC are tangential to circular turn at N and D. Magnetic field at the centre of circle is



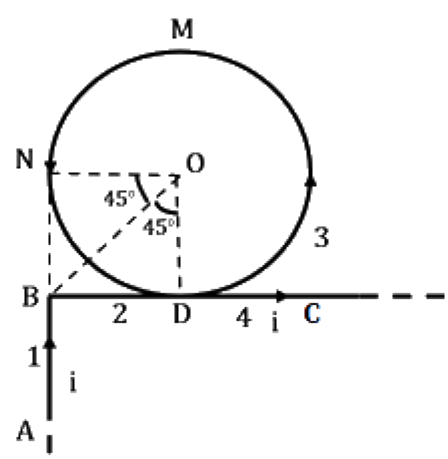
a. $\frac{\mu_0 i}{2\pi R}\left[\pi - \frac{1}{\sqrt{2}}\right]$

b. $\frac{\mu_0 i}{2\pi R}[\pi + 1]$

c. $\frac{\mu_0 i}{2R}$

d. $\frac{\mu_0 i}{2\pi R}\left[\pi + \frac{1}{\sqrt{2}}\right]$

Solution: (d)



To get magnetic field at O, we need to find magnetic field due to each current carrying part 1, 2, 3 and 4 individually.

Let's take total magnetic field as B_T, then

$\vec{B}_T = \vec{B}_1 + \vec{B}_2 + \vec{B}_3 + \vec{B}_4$

Since 2 and 4 are parts of same wire, hence

$$\vec{B}_T = \frac{\mu_o i}{4\pi R}(\sin 90° - \sin 45°)(-\hat{k}) + \frac{\mu_o i}{2R}\,\hat{k} + \frac{\mu_o i}{4\pi R}(\sin 90° + \sin 45°)\hat{k}$$

$$= \frac{-\mu_o i}{4\pi R}\left[1 - \frac{1}{\sqrt{2}}\right] + \frac{\mu_o i}{2R} + \frac{\mu_o i}{4\pi R}\left[1 + \frac{1}{\sqrt{2}}\right]\,\hat{k}$$

$$\vec{B}_T = \frac{\mu_o i}{4\pi R}\left[\sqrt{2} + 2\pi\right]\hat{k}$$

$$\vec{B}_T = \frac{\mu_o i}{2\pi R}\left[\frac{1}{\sqrt{2}} + \pi\right]\,\hat{k}$$

$\hat{k}$ denotes that direction of magnetic field is in the plane coming out of the plane of current.

2. A particle moves such that its position vector $\vec{r}(\mathrm{t}) = \cos\omega t\,\hat{\imath} + \sin\omega t\,\hat{\jmath}$, where ω is a constant and t is time. Then which of the following statements is true for the velocity $\vec{v}(t)$ and acceleration $\vec{a}(t)$ of the particle?
   a. $\vec{v}$ and $\vec{a}$ both are perpendicular to $\vec{r}$
   b. $\vec{v}$ and $\vec{r}$ both are parallel to $\vec{r}$
   c. $\vec{v}$ is perpendicular to $\vec{r}$ and $\vec{a}$ is directed away from the origin
   d. $\vec{v}$ is perpendicular to $\vec{r}$ and $\vec{a}$ is directed towards the origin

Solution :(d)

$$\vec{r} = \cos\omega t\,\hat{\imath} + \sin\omega t\,\hat{\jmath}$$
$$\vec{v} = \frac{d\vec{r}}{dt} = \omega[-\sin\omega t\,\hat{\imath} + \cos\omega t\,\hat{\jmath}]$$
$$\vec{a} = \frac{d\vec{v}}{dt} = -\omega^2[\cos\omega t\,\hat{\imath} + \sin\omega t\,\hat{\jmath}]$$
$$\vec{a} = -\omega^2\vec{r}$$

Since there is negative sign in acceleration, this means that acceleration is in opposite direction of $\vec{r}$

For velocity direction we can take dot product of $\vec{v}$ and $\vec{r}$.

$$\vec{v}.\vec{r} = \omega(-\sin\omega t\,\hat{\imath} + \cos\omega t\,\hat{\jmath}).(\cos\omega t\,\hat{\imath} + \sin\omega t\,\hat{\jmath})$$
$$= \omega[-\sin\omega t\cos\omega t + \cos\omega t\sin\omega t] = 0$$

This implies that $\vec{v}$ is perpendicular to $\vec{r}$.

3. Consider two charged metallic spheres S_1 and S_2 of radii r_1 and r_2, respectively. The electric fields $E_1(\text{on } S_1)$ and $E_2(\text{on } S_2)$ on their surfaces are such that $\frac{E_1}{E_2} = \frac{r_1}{r_2}$. Then the ratio $V_1(\text{on } S_1)/V_2(\text{on } S_2)$ of the electrostatic potentials on each sphere is

   a. $\frac{r_1}{r_2}$
   b. $\left(\frac{r_1}{r_2}\right)^2$
   c. $\frac{r_2}{r_1}$
   d. $\left(\frac{r_1}{r_2}\right)^3$

   Solution: (b)

$$\frac{E_1}{E_2} = \frac{r_1}{r_2}$$

$$\frac{V_1}{V_2} = \frac{E_1 r_1}{E_2 r_2} = \frac{r_1}{r_2} \times \frac{r_1}{r_2} = \left(\frac{r_1}{r_2}\right)^2$$

4. A transverse wave travels on a taut steel wire with a velocity of V when tension in it is $2.06 \times 10^4\ N$. When the tension is changed to T, the velocity changed to $\frac{V}{2}$. The value of T is close to

   a. $30.5 \times 10^4\ N$
   b. $2.50 \times 10^4\ N$
   c. $10.2 \times 10^2\ N$
   d. $5.15 \times 10^3 N$

   Solution :(d)

$$V \propto \sqrt{T}$$

$$\frac{V_1}{V_2} = \sqrt{\frac{T_1}{T_2}}$$

$$\Rightarrow \frac{2V}{V} = \sqrt{\frac{2.06 \times 10^4}{T}}$$

$$\Rightarrow T = \frac{2.06 \times 10^4}{4}\ N = 5.15 \times 10^3\ N$$

5. A particle of mass m is dropped from a height h above the ground. At the same time another particle of the same mass is thrown vertically upwards from the ground with a speed of $\sqrt{2gh}$. If they collide head-on completely inelastically, the time taken for the combined mass to reach the ground, in units of $\sqrt{\frac{h}{g}}$ is

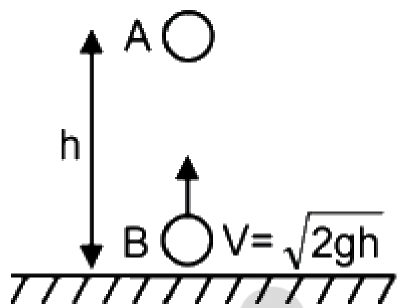
a. $\sqrt{\frac{3}{2}}$

b. $\sqrt{\frac{1}{2}}$

c. $\frac{1}{2}$

d. $\sqrt{\frac{3}{4}}$

Solution: (a)



Time taken for the collision $t_1 = \frac{h}{\sqrt{2gh}}$

After t_1

$$V_A = 0 - gt_1 = -\frac{\sqrt{gh}}{2}$$

And $V_B = \sqrt{2gh} - gt_1 = \sqrt{gh}\left[\sqrt{2} - \frac{1}{\sqrt{2}}\right]$

At the time of collision

$$\vec{P_i} = \vec{P_f}$$

$\Rightarrow m\vec{V_A} + m\vec{V_B} = 2m\vec{V_f}$

$$\Rightarrow -\sqrt{\frac{gh}{2}} + \sqrt{gh}\left[\sqrt{2} - \frac{1}{\sqrt{2}}\right] = 2\vec{V_f}$$

$$V_f = 0$$

And height from the ground $= h - \frac{1}{2}g\,t_1^2 = h - \frac{h}{4} = \frac{3h}{4}$

So, time taken to reach ground after collision $= \sqrt{2 \times \frac{(\frac{3h}{4})}{g}} = \sqrt{\frac{3h}{2g}}$

6. A Carnot engine having an efficiency of $\frac{1}{10}$ is being used as a refrigerator. If the work done on the refrigerator is 10 J, the amount of heat absorbed from the reservoir at lower temperature is

a. 99 J
b. 90 J
c. 1 J
d. 100 J

Solution :(b)

For Carnot engine using as refrigerator

Work done on engine is given by

$W = Q_1 - Q_2 \ldots (1)$

where Q_1 is heat rejected to the reservoir at higher temperature and Q_2 is the heat absorbed from the reservoir at lower temperature.

It is given $\eta = 1/10$

$$\eta = 1 - \frac{Q_2}{Q_1}$$

$$\Longrightarrow \frac{Q_2}{Q_1} = \frac{9}{10} \ldots\ldots (2)$$

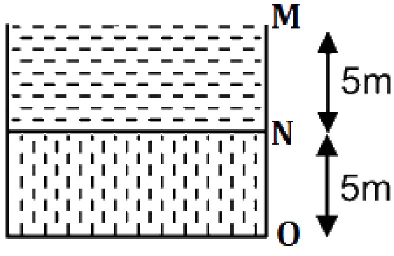
We are given, $W = 10$ J

Therefore, from equations (1) and (2),

$$Q_2 = \frac{10}{\frac{10}{9} - 1}$$

$$\Rightarrow Q_2 = 90 \text{ J}$$

7. Two liquids of density ρ_1 and ρ_2 ($\rho_2 = 2\rho_1$) are filled up behind a square wall of side 10 m as shown in figure. Each liquid has a height of 5 m. The ratio of forces due to these liquids exerted on the upper part MN to that at the lower part NO is (Assume that the liquids are not mixing)



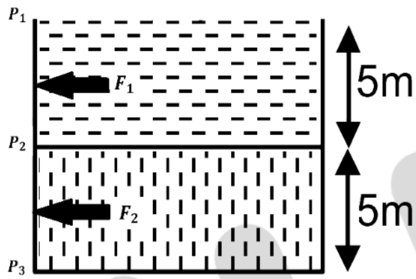
a. $\frac{2}{3}$

b. $\frac{1}{2}$

c. $\frac{1}{4}$

d. $\frac{1}{3}$

Solution:(c)



The net force exerted on the wall by one type of liquid will be average value of pressure due to that liquid multiplied by the area of the wall.

Here, since the pressure due a liquid of uniform density varies linearly with depth, its average will be just the mean value of pressure at the top and pressure at the bottom.

So,

$$P_1 = 0$$

$$P_2 = \rho g \times 5$$

$$P_3 = 5\rho g + 2\rho g \times 5$$

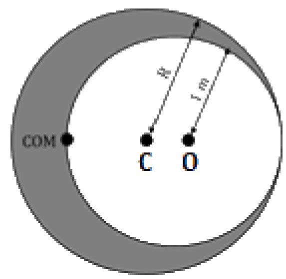
$$F_1 = \left(\frac{P_1 + P_2}{2}\right) A$$

$$F_2 = \left(\frac{P_2 + P_3}{2}\right) A$$

So,

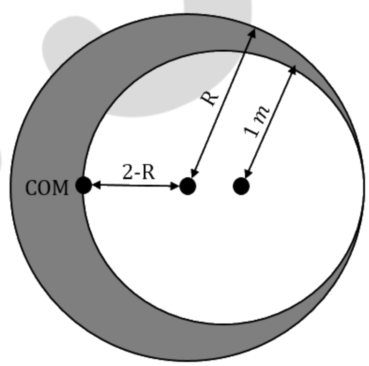
$$\frac{F_1}{F_2} = \frac{1}{4}$$

8. As shown in figure, when a spherical cavity (centered at O) of radius 1 m is cut out of a uniform sphere of radius R (centered at C), the center of mass of remaining (shaded) part of sphere is shown by COM, i.e. on the surface of the cavity. R can be determined by the equation



a. $(R^2 + R + 1)(2 - R) = 1$
b. $(R^2 - R - 1)(2 - R) = 1$
c. $(R^2 - R + 1)(2 - R) = 1$
d. $(R^2 + R - 1)(2 - R) = 1$

Solution (a)



Let M be the mass of the sphere and M' be the mass of the cavity.

Mass of the remaining part of the sphere = $M - M'$

Mass moments of the cavity and the remaining part of sphere about the original COM should add up to zero.

$$(M - M')(2 - R) - M'(R - 1) = 0$$

(Mass of the cavity to be taken negative)

$$\Rightarrow \frac{4}{3}\pi(R^3 - 1^3)\rho g\,(2 - R) = \frac{4}{3}\pi(1)^3\rho g(R - 1)$$

$$\Rightarrow (R^3 - 1^3)(2 - R) = (1^3)(R - 1)$$

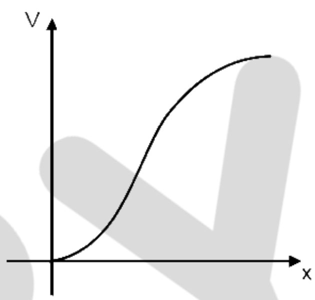
$$\Rightarrow (R^2 + R + 1)(R - 1)(2 - R) = (R - 1)$$

(using identity)

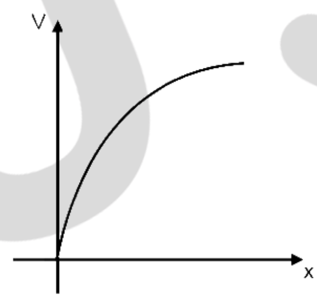
$$\Rightarrow (R^2 + R + 1)(2 - R) = 1$$

9. A particle of mass m and charge q is released from rest in uniform electric field. If there is no other force on the particle, the dependence of its speed V on the distance x travelled by it is correctly given by (graphs are schematic and not drawn to scale)

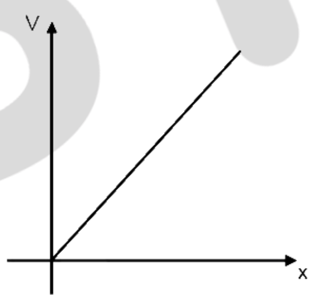
a.



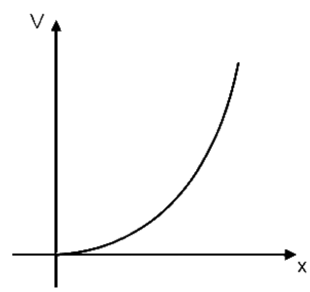
b.



c.



d.



Solution. (b)

Applying work energy theorem,

$$qEx = \frac{1}{2}mv^2$$

$$v^2 \propto x$$

Hence, solution will be option (b)

10. A galvanometer having a coil resistance 100 Ω gives a full scale deflection when a current of 1 mA is passed through it. What is the value of the resistance which can convert this galvanometer into voltmeter giving full scale deflection for a potential difference of 10 V? In full scale deflection, current in galvanometer of resistance is 1 mA. Resistance required in series to convert it into voltmeter of range 10 V.

a. 7.9 $k\Omega$
b. 9.9 $k\Omega$
c. 8.9 $k\Omega$
d. 10 $k\Omega$

Solution: (b)

$$V_0 = i_g R_g = 0.1\, v$$

$$v = 10\, V$$

$$R = R_g \left(\frac{v}{v_g} - 1\right)$$

$$= 100 \times 99 = 9.9\ k\Omega$$

11. Consider a mixture of n moles of helium gas and $2n$ moles of oxygen gas (molecules taken to be rigid) as an ideal gas. Its $\left(\frac{Cp}{Cv}\right)$ value will be

a. $\frac{67}{45}$
b. $\frac{40}{27}$
c. $\frac{19}{13}$
d. $\frac{23}{15}$

Solution: (c)

Using formula

$$C_{v_{mix}} = \frac{n_1 C_{v_1} + n_2 C_{v_2}}{n_1 + n_2}$$

$$C_{v_{mix}} = \frac{n \times \frac{3R}{2} + 2n \times \frac{5R}{2}}{3n} = \frac{13R}{6} \quad (\because He \text{ is monoatomic and } O_2 \text{ is diatomic})$$

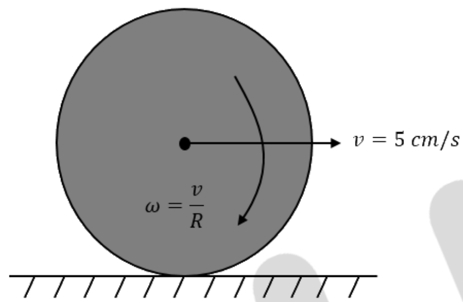
$$C_{p_{mix}} = C_{v_{mix}} + R = \frac{19R}{6}$$

$$\therefore \gamma_{mix} = \frac{C_{p_{mix}}}{C_{v_{mix}}} = \frac{19}{13}$$

12. A uniform sphere of mass 500 gm rolls without slipping on a plane horizontal surface with its centre moving at a speed of 5 cm/sec. Its kinetic energy is

a. $8.75 \times 10^{-4}\ J$
b. $6.25 \times 10^{-4}\ J$
c. $8.75 \times 10^{-3}\ J$
d. $1.13 \times 10^{-3}\ J$

Solution :(a)



Total K.E. = Translational K.E + Rotational K.E.

$$= \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$$

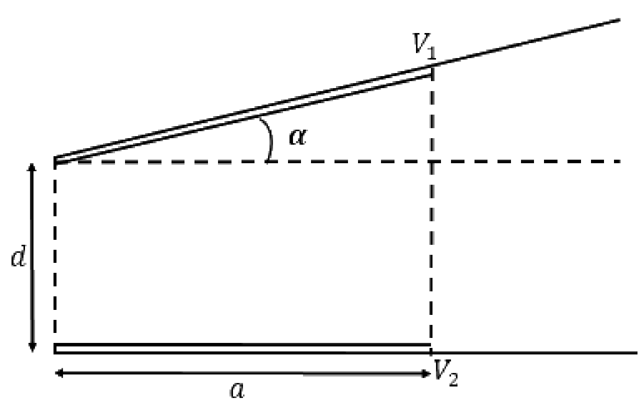
$$= \frac{1}{2}mv^2\left(1 + \frac{k^2}{R^2}\right)$$

k is radius of gyration.

$$= \frac{1}{2} \times \frac{1}{2} \times \left(\frac{5}{100}\right)^2 \left(1 + \frac{2}{5}\right)$$

$$= 8.75 \times 10^{-4}\ J$$

13. A capacitor is made of two square plates each of side 'a' making a very small angle α between them, as shown in figure. The capacitance will be close to



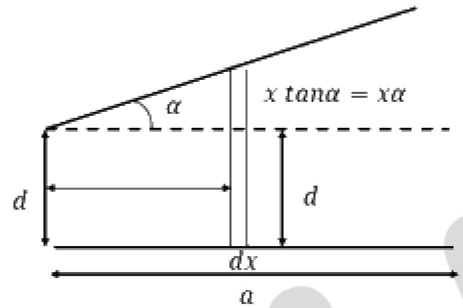
a. $\frac{\varepsilon_0 a^2}{d}\left(1-\frac{\alpha a}{2d}\right)$

b. $\frac{\varepsilon_0 a^2}{d}\left(1-\frac{3\alpha a}{2d}\right)$

c. $\frac{\varepsilon_0 a^2}{d}\left(1+\frac{\alpha a}{d}\right)$

d. $\frac{\varepsilon_0 a^2}{d}\left(1-\frac{\alpha a}{4d}\right)$

Solution :(a)



Let dC be the capacitance of the element of thickness dx

$$dc = \frac{\varepsilon_0 a dx}{d + \alpha x}$$

These are effectively in parallel combination

So,

$$C = \int dc$$

$$C = \int_0^a \frac{\varepsilon_0 a dx}{d + \alpha x}$$

$$\Rightarrow C = \frac{\varepsilon_0 a}{\alpha}[\ln(d+\alpha x)]_0^a$$

$$C = \frac{\varepsilon_0 a}{\alpha}\left[\ln\left(1+\frac{\alpha a}{d}\right)\right]$$

$$C \approx \frac{\varepsilon_0 a^2}{d}\left(1-\frac{\alpha a}{2d}\right)$$

14. In a double-slit experiment, at a certain point on the screen the path difference between the two interfering waves is $\frac{1}{8}th$ of a wavelength. The ratio of the intensity of light at that point to that at the centre of a bright fringe is

a. 0.568

b. 0.853

c. 0.672

d. 0.760

Solution: (b)

In YDSE, the intensity at a point on the screen varies with the phase difference between the interfering light waves as:

$$I = I_0\, cos^2\left(\frac{\Delta\emptyset}{2}\right)$$

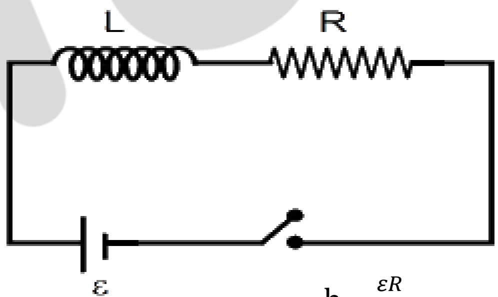
Here, $\Delta\emptyset$ = phase difference between the interfering waves

I_0 = maximum intensity on the screen

$$\frac{I}{I_0} = cos^2\left[\frac{\frac{2\pi}{\lambda} \times \Delta x}{2}\right] = \cos^2\left(\frac{\pi}{8}\right)$$

$$\frac{I}{I_0} = 0.853$$

15. As shown in figure, a battery of emf ε is connected to an inductor L and resistance R in series. The switch is closed at $t = 0$. The total charge that flows from thebattery, between $t = 0$ and $t = t_c$ (t_c is the time constant of the circuit) is



a. $\frac{\varepsilon L}{eR^2}$
b. $\frac{\varepsilon R}{eL^2}$
c. $\frac{\varepsilon L}{R^2}(1 - \frac{1}{e})$
d. $\frac{\varepsilon L}{R^2}$

Solution :(a)

This is standard $L - R$ growth of current circuit.

$$i(t) = \frac{\varepsilon}{R} e^{-\frac{t}{T_c}}$$

Substituting in the integral

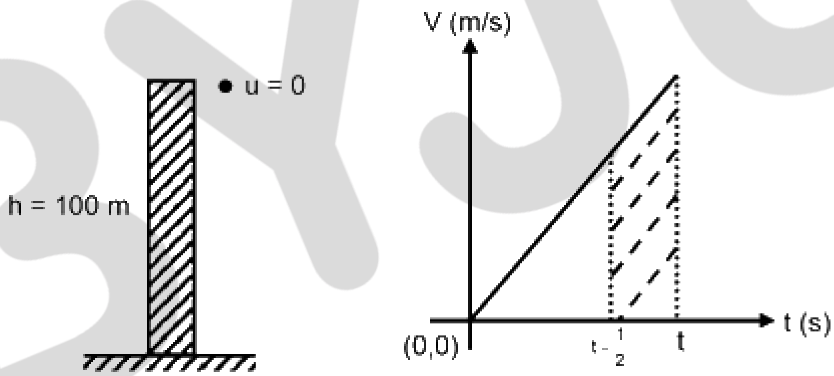
$$q = \int_0^{T_c} (i)dt$$

$$= \frac{\varepsilon}{R}\left[t - \frac{e^{\frac{-t}{T_c}}}{\frac{-1}{T_c}}\right]_0^{T_c}$$

$$= \frac{\varepsilon L}{eR^2}$$

16. A ball is dropped from the top of a 100 m high tower on a planet. In the last $\frac{1}{2}$ s before hitting the ground, it covers a distance of 19 m. Acceleration due to gravity (in ms^{-2}) near the surface on that planet is

Solution: $g = 8\ m/s^2$



Since the radius of planet is much larger than100 m, it's a uniformly accelerated motion.

So, Trapezium's area

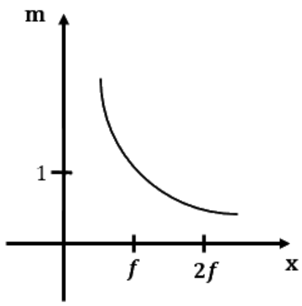
$$s = \frac{g(\left[t-\frac{1}{2}+t\right]}{2} \times \frac{1}{2} = 19 \qquad \text{(i)}$$

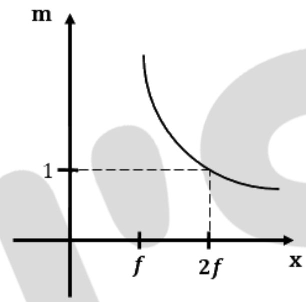
$$\frac{1}{2}gt^2 = 100 \qquad \text{(ii)}$$

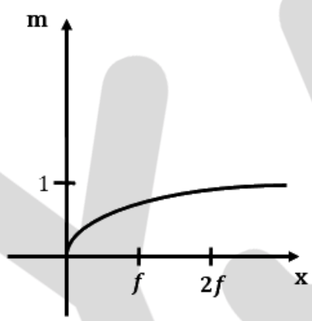
Solving equations (i) and (ii), we get

$$g = 8\ m/s^2$$

17. An object is gradually moving away from the focal point of a concave mirror along the axis of the mirror. The graphical representation of the magnitude of linear magnification (m) versus distance of the object from the mirror (x) is correctly given by
(Graphs are drawn schematically and are not to scale)

a.


b.


c.


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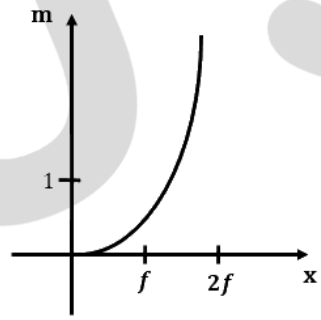


Solution: (b)
Magnitude of linear magnification, m= $\left|-\frac{v}{x}\right|$
From mirror formula,

$$\frac{1}{v}+\frac{1}{x}=\frac{1}{f}$$

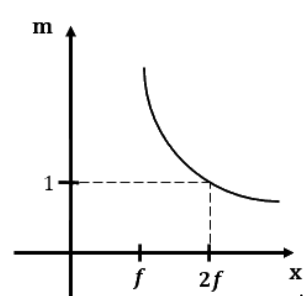
Multiplying the whole equation by u, we get

$$\frac{v}{x}=\frac{f}{x-f}$$

Using the above equation in magnification formula,

$$m=\left|-\frac{v}{x}\right|=\left|\frac{f}{f-x}\right|$$

For $x=2f$, $m=1$



Thus option (b) is correct

18. A simple pendulum is being used to determine the value of gravitational acceleration g at a certain place. The length of the pendulum is 25.0 cm and a stop watch with 1 sec resolution measures the time taken for 40 oscillations to be 50 sec. The accuracy in g

a. 5.40%
b. 3.40%
c. 4.40%
d. 2.4%

Solution :(c)

$$T = 2\pi\sqrt{\frac{L}{g}}$$

$$g = L.\left(\frac{2\pi}{T}\right)^2$$

$$\frac{\Delta g}{g} = 2\frac{\Delta T}{T} + \frac{\Delta L}{L}$$

$$2\left(\frac{1}{50}\right) + \frac{0.1}{25} = 4.40\%$$

19. An electron (mass m) with initial velocity $\vec{v} = v_o\hat{\imath} + v_o\hat{\jmath}$ is in an electric field $\vec{E} = -E_0\hat{k}$. If λ_0 is initial de-Broglie wavelength of electron, its de-Broglie wavelength at time t is given by

a. $\frac{\lambda_0}{\sqrt{1+\frac{e^2E_0^2t^2}{m^2v_0^2}}}$
b. $\frac{\lambda_0\sqrt{2}}{\sqrt{1+\frac{e^2E^2t^2}{m^2v_0^2}}}$
c. $\frac{\lambda_0}{\sqrt{1+\frac{e^2E^2t^2}{2m^2v_0^2}}}$
d. $\frac{\lambda_0}{\sqrt{2+\frac{e^2E^2t^2}{m^2v_0^2}}}$

Solution :(a)

Momentum of an electron, $p = mv = \frac{h}{\lambda}$

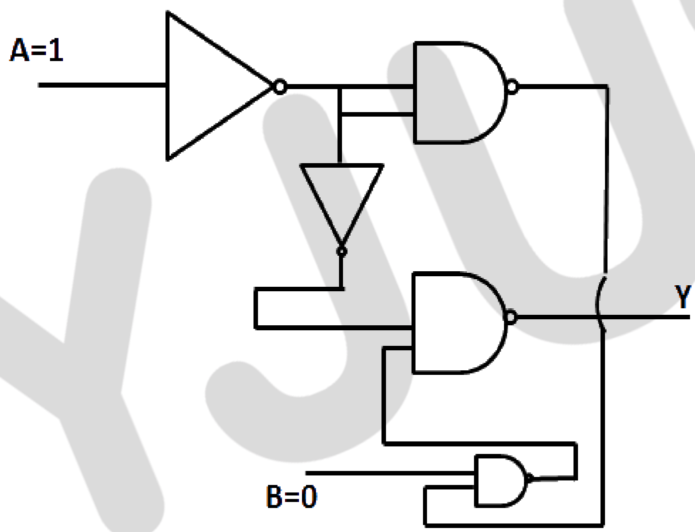
Initially $m\left(\sqrt{2}v_0\right) = \frac{h}{\lambda_0}$

Velocity as a function of time=$v_0\hat{\imath} + v_0\hat{\jmath} + \frac{eE_0}{m}t\hat{k}$

So, wavelength $\lambda = \frac{h}{m\sqrt{2v_0^2 + \frac{e^2E_0^2}{m^2}t^2}}$

$$\Rightarrow \lambda = \frac{\lambda_0}{\sqrt{1 + \frac{e^2E_0^2}{m^2v_0^2}t^2}}$$

20. In the given circuit, value of Y is



a. 1
b. 0
c. Will not execute
d. Toggles between 0 and 1

Solution: (b)

$$Y = \overline{\overline{AB}.A}$$

$$= \overline{\overline{AB}} + \bar{A}$$

$$= AB + \bar{A}$$

$$Y = 0 + 0 = 0$$

21. The first member of Balmer series of hydrogen atom has a wavelength of 6561 Å. The wavelength of the second member of the Balmer series (in nm) is

Solution: (486 nm)

$$\frac{1}{\lambda} = RZ^2\left(\frac{1}{{n_1}^2} - \frac{1}{{n_2}^2}\right)$$

$$\frac{1}{\lambda_1} = R(1)^2\left(\frac{1}{2^2} - \frac{1}{3^2}\right) = \frac{5R}{36}$$

$$\frac{1}{\lambda_2} = R(1)^2\left(\frac{1}{2^2} - \frac{1}{4^2}\right) = \frac{3R}{36}$$

$$\frac{\lambda_2}{\lambda_1} = \frac{20}{27}$$

$$\lambda_2 = \frac{20}{27} \times 6561\ \text{Å} = 486\ \text{nm}$$

22. A plane electromagnetic wave of frequency 25 GHz is propagating in vacuum along the z-direction. At a particular point in space and time, the magnetic field is given by $\vec{B} = 5 \times 10^{-8}\hat{j}\ T$. The corresponding electric field is given by $\vec{E}$ is (speed of light $c = 3 \times 10^8\ m/s$)

a. $1.66 \times 10^{-16}\hat{\imath}$ V/m
b. $-1.66 \times 10^{-16}\hat{\imath}$ V/m
c. $15\hat{\imath}$ V/m
d. $-15\hat{\imath}$ V/m

Solution: (c)

$$\frac{|E|}{|B|} = c$$

$$|E| = |B| \times c$$

Given,
$\vec{B} = 5 \times 10^{-8}\hat{j}\ T$ and $C = 3 \times 10^8\ \frac{m}{s}$

Therefore, $|E| = 15\ \frac{volt}{m}$

Direction of $\vec{E}$ will be perpendicular to $\vec{B}$ and $\vec{E} \times \vec{B}$ gives direction of propagation of wave which is in z-direction ($\hat{k}$). Therefore, $\vec{E}$ will be along positive x-direction ($\hat{\imath}$).
Hence, $\vec{E} = 15\hat{\imath}$ V/m

23. Three containers C_1, C_2 and C_3 have water at different temperatures. The table below shows the final temperature T when different amounts of water (given in liters) are taken from each container and mixed (assume no loss of heat during the process)

C_1	C_2	C_3	$T(^0C)$
$1\ l$	$2\ l$	--	60
--	$1\ l$	$2\ l$	30
$2\ l$	--	$1\ l$	60
$1\ l$	$1\ l$	$1\ l$	θ

The value of θ (in °C to the nearest integer) is

Solution: (50)

Since, all the containers have same material, specific heat capacity is the same for all.

$$V_1\theta_1 + V_2\theta_2 = (V_1+V_2)\theta_f$$

From second row of table,

$$1\theta_1 + 2\theta_2 = (1+2)60$$

$\theta_1 + 2\theta_2 = 180$…………… (1)

From third row of table,

$$0 \times \theta_1 + 1 \times \theta_2 + 2 \times \theta_3 = (1+2)30$$

$\theta_2 + 2\theta_3 = 90$…………… (2)

From fourth row of table,

$$2\theta_1 + \theta_3 = (1+2)60$$

$2\theta_1 + \theta_3 = 180$…………… (3)

From fifth row of table,

$$\theta_1 + \theta_2 + \theta_3 = (1+1+1)\theta$$

$\theta_1 + \theta_2 + \theta_3 = 3\theta$………… (4)

From equation. (1)+ (2) + (3)

$$3\theta_1 + 3\theta_2 + 3\theta_3 = 450$$

Thus, $\theta_1 + \theta_2 + \theta_3 = 150$

From (4) equation $150 = 3\theta$

So, $\theta = 50^0C$

24. An asteroid is moving directly towards the centre of the earth. When at a distance of 10R (R is the radius of the earth) from the earth's centre, it has a speed of 12 km/s. Neglecting the effect of earth's atmosphere, what will be the speed of the asteroid when it hits the surface of the earth (escape velocity from the earth is 12 km/s)? Give your answer to the nearest integer in km/s

Solution: (16)

Taking, asteroid and earth as an isolated system conserving total energy.

$$KE_i + PE_i = KE_f + PE_f$$

$$\frac{1}{2}mu_0^2 + \left(-\frac{GMm}{10R}\right) = \frac{1}{2}mv^2 + \left(-\frac{GMm}{R}\right)$$

$$v^2 = u_0^2 + \frac{2GM}{R}\left[1 - \frac{1}{10}\right]$$

$$v = \sqrt{u_0^2 + \frac{9}{5}\frac{GM}{R}}$$

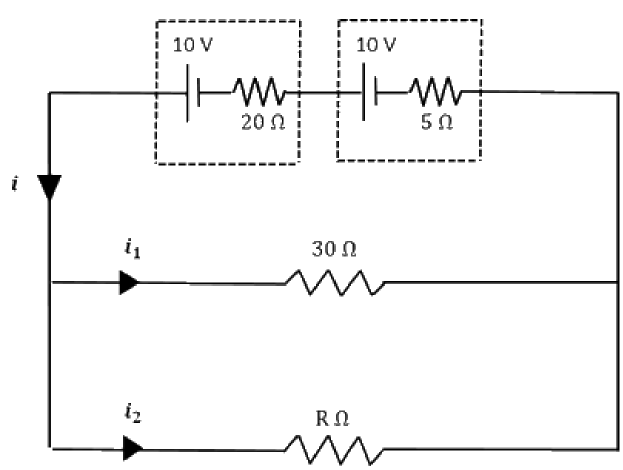
Since, escape velocity from surface of earth is $11.2\,\frac{km}{sec^2} = \sqrt{\frac{2GM}{R}}$

$$= \sqrt{12^2 + \frac{9}{5}\frac{(11.2)^2}{2}}$$

$$= \sqrt{256.9} \approx 16\ km/s$$

25. The series combination of two batteries both of the same emf 10 V, but different internal resistance of 20 Ω and 5 Ω , is connected to the parallel combination of two resistors 30 Ω and R Ω. The voltage difference across the battery of internal resistance 20 Ω is zero, the value of R (in Ω) is

Solution: (30)



If V_1 and V_2 are terminal voltage across the two batteries.

$$V_1 = 0$$

$$V_1 = \varepsilon_1 - i.r_1$$

$$0 = 10 - i \times 20$$

$$i = 0.5\ A$$

$$V_2 = 10 - 0.5 \times 5$$

$$V_2 = 7.5\ V$$

$$0.5 = \frac{7.5}{30} + \frac{7.5}{x}$$

$$\frac{7.5}{x} = 0.25$$

$$x = 30\ \Omega$$