WBJEE 2017 (Physics)

1. The velocity of a particle executing a simple harmonic motion is 13 ms^{-1}, when its distance from the equilibrium position (Q) is 3 m and its velocity is 12 ms^{-1}, when it is 5 m away from Q. The frequency of the simple harmonic motion is

a. $\frac{5\pi}{8}$

b. $\frac{5}{8\pi}$

c. $\frac{8\pi}{5}$

d. $\frac{8}{5\pi}$

2. A uniform string of length L and mass M is fixed at both ends while it is subject to a tension T. It can vibrate at frequencies (υ) given by the formula (where n = 1, 2, 3, ...)

a. $\upsilon = \frac{n}{2}\sqrt{\frac{T}{ML}}$

b. $\upsilon = \frac{n}{2L}\sqrt{\frac{T}{M}}$

c. $\upsilon = \frac{1}{2n}\sqrt{\frac{T}{ML}}$

d. $\upsilon = \frac{n}{2}\sqrt{\frac{TL}{M}}$

3. A uniform capillary tube of length l and inner radius r with its upper end sealed is submerged vertically into water. The outside pressure is p_0 and surface tension of water is γ. When a length x of the capillary is submerged into water, it is found that water levels inside and outside the capillary coincide. The value of x is

a. $\frac{l}{\left(1+\frac{p_0 r}{4\gamma}\right)}$

b. $l\left(1-\frac{p_0 r}{4\gamma}\right)$

c. $l\left(1-\frac{p_0 r}{2\gamma}\right)$

d. $\frac{l}{\left(1+\frac{p_0 r}{2\gamma}\right)}$

4. A liquid of bulk modulus k is compressed by applying an external pressure such that its density increases by 0.01%. The pressure applied on the liquid is

a. $\frac{k}{10000}$

b. $\frac{k}{1000}$

c. 1000 k

d. 0.01k

5. Temperature of an ideal gas, initially at 27ºC, is raised by 6°C. The rms velocity of the gas molecules will,

a. increase by nearly 2%

b. decrease by nearly 2%

c. increase by nearly 1%

d. decrease by nearly 1%

6. 2 moles of an ideal monoatomic gas is carried from a state (P_0, V_0) to a state ($2P_0$, $2V_0$) along a straight line path in a P-V diagram. The amount of heat absorbed by the gas in the process is given by

a. $3P_0V_0$

b. $\frac{9}{2}P_0V_0$

c. $6P_0V_0$

d. $\frac{3}{2}P_0V_0$

7. A solid rectangular sheet has two different coefficients of linear expansion α_1 and α_2 along its length and breadth respectively. The coefficient of surface expansion is (for $\alpha_1 t << 1$, $\alpha_2 t << 1$)

a. $\frac{\alpha_1 + \alpha_2}{2}$

b. $2(\alpha_1 + \alpha_2)$

c. $\frac{4\alpha_1\alpha_2}{\alpha_1 + \alpha_2}$

d. $\alpha_1 + \alpha_2$

8. A positive charge Q is situated at the centre of a cube. The electric flux through any face of the cube is (in SI units)

a. $\frac{Q}{6\varepsilon_0}$

b. $4\pi Q$

c. $\frac{Q}{4\pi\varepsilon_0}$

d. $\frac{Q}{6\pi\varepsilon_0}$

9. Three capacitors of capacitance 1.0, 2.0 and 5.0 μF are connected in series to a 10V source. The potential difference across the 2.0 μF capacitor is

a. $\frac{100}{17}$ V

b. $\frac{20}{17}$ V

c. $\frac{50}{17}$ V

d. 10 V

10. A charge of 0.8 coulomb is divided into two charges Q_1 and Q_2. These are kept at a separation of 30 cm. The force on Q1 is maximum when
    a. $Q_1 = Q_2 = 0.4C$
    b. $Q_1 \approx 0.8C$, Q_2 negligible
    c. Q_1 negligible, $Q_2 \approx 0.8C$
    d. $Q_1 = 0.2$ C, $Q_2 = 0.6$ C

11. The magnetic field due to a current in a straight wire segment of length L at a point on its perpendicular bisector at a distance r (r >> L)
    a. decreases as $\frac{1}{r}$
    b. decreases as $\frac{1}{r^2}$
    c. decreases as $\frac{1}{r^3}$
    d. approaches a finite limit as $r \to \infty$

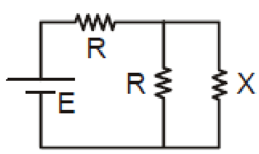
12. The magnets of two suspended coil galvanometers are of the same strength so that they produce identical uniform magnetic fields in the region of the coils. The coil of the first one is in the shape of a square of side a and that of the second one is circular of radius $a/\sqrt{\pi}$. When the same current is passed through the coils, the ratio of the torque experienced by the first coil to that experienced by the second one is
    a. $1 : \frac{1}{\sqrt{\pi}}$
    b. 1 : 1
    c. $\pi : 1$
    d. $1 : \pi$

13. A proton is moving with a uniform velocity of 10^6 ms^{-1} along the Y-axis, under the joint action of a magnetic field along Z-axis and an electric field of magnitude 2×10^4 Vm^{-1} along the negative X-axis. If the electric field is switched off, the proton starts moving in a circle. The radius of the circle is nearly (given : $\frac{e}{m}$ ratio for proton = 10^8 Ckg^{-1})
    a. 0.5 m
    b. 0.2 m
    c. 0.1m
    d. 0.05 m

14. When the frequency of the AC voltage applied to a series LCR circuit is gradually increased from a low value, the impedance of the circuit
    a. monotonically increases
    b. first increases and then decreases
    c. first decreases and then increases
    d. monotonically decreases

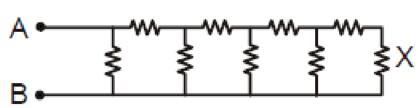
15. Six wires, each of resistance r, are connected so as to form a tetrahedron. The equivalent resistance of the combination when current enters through one corner and leaves through some other corner is
    a. r
    b. 2r
    c. $\frac{r}{3}$
    d. $\frac{r}{2}$

16. A Consider the circuit shown in the figure. The value of the resistance X for which the thermal power generated in it is practically independent of small variation of its resistance is



    a. X = R
    b. $X = \frac{R}{3}$
    c. $X = \frac{R}{2}$
    d. X = 2R

17. Consider the circuit shown in the figure where all the resistances are of magnitude 1kΩ. If the current in the extreme right resistance X is 1 mA, the potential difference between A and B is

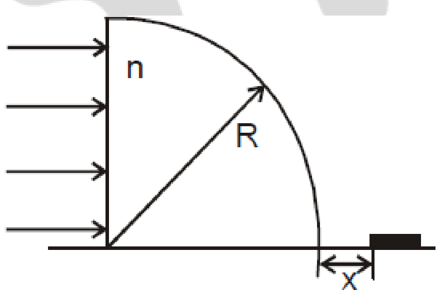


    a. 34 V
    b. 21 V
    c. 38 V
    d. 55 V

18. The ratio of the diameter of the sun to the distance between the earth and the sun is approximately 0.009. The approximate diameter of the image of the sun formed by a concave spherical mirror of radius of curvature 0.4 m is
   a. 4.5×10^{-6} m
   b. 4.0×10^{-6} m
   c. 3.6×10^{-3} m
   d. 1.8×10^{-3} m

19. Two monochromatic coherent light beams A and B have intensities L and $\frac{L}{4}$ respectively. If these beams are superposed, the maximum and minimum intensities will be
   a. $\frac{9L}{4}, \frac{L}{4}$
   b. $\frac{5L}{4}$, 0
   c. $\frac{5L}{2}$, 0
   d. 2L, $\frac{L}{2}$

20. A point object is held above a thin equiconvex lens at its focus. The focal length is 0.1 m and the lens rests on a horizontal thin plane mirror. The final image will be formed at
   a. infinite distance above the lens
   b. 0.1 m above the center of the lens
   c. infinite distance below the lens
   d. 0.1 m below the center of the lens

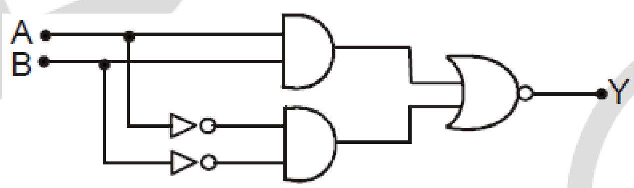
21. 

A parallel beam of light is incident on a glass prism in the shape of a quarter cylinder of radius R = 0.05 m and refractive index n = 1.5 placed on a horizontal table as shown in the figure. Beyond the cylinder, a patch of light is found whose nearest distance x from the cylinder is
   a. $(3\sqrt{3}-4)\times 10^{-2}$m
   b. $(2\sqrt{3}-2)\times 10^{-2}$m
   c. $(3\sqrt{5}-5)\times 10^{-2}$m
   d. $(3\sqrt{2}-3)\times 10^{-2}$m

22. The de Broglie wavelength of an electron is 0.4 × 10–10 m when its kinetic energy is 1.0 keV. Its wavelength will be 1.0×10^{-10} m, when its kinetic energy is
    a. 0.2 keV
    b. 0.8 keV
    c. 0.63 keV
    d. 0.16 keV

23. When light of frequency υ_1 is incident on a metal with work function W (where h $\upsilon_1 >$ W), the photocurrent falls to zero at a stopping potential of V_1. If the frequency of light is increased to υ_2, the stopping potential changes to V_2. Therefore, the charge of an electron is given by
    a. $\dfrac{W(\upsilon_2+\upsilon_1)}{\upsilon_1 V_2+\upsilon_2 V_1}$
    b. $\dfrac{W(\upsilon_2+\upsilon_1)}{\upsilon_1 V_1+\upsilon_2 V_2}$
    c. $\dfrac{W(\upsilon_2-\upsilon_1)}{\upsilon_1 V_2-\upsilon_2 V_1}$
    d. $\dfrac{W(\upsilon_2-\upsilon_1)}{\upsilon_2 V_2-\upsilon_1 V_1}$

24. Radon-222 has a half-life of 3.8 days. If one starts with 0.064 kg of Radon-222, the quantity of Radon-222 left after 19 days will be
    a. 0.002 kg
    b. 0.062 kg
    c. 0.032 kg
    d. 0.024 kg

25. 

In the given circuit, the binary inputs at A and B are both 1 in first case and both 0 in the next case. The respective outputs at Y in these two cases will be:

a. 1, 1

b. 0, 0

c. 0, 1

d. 1, 0

26. When a semiconducting device is connected in series with a battery and a resistance, a current is found to flow in the circuit. If, however, the polarity of the battery is reversed, practically no current flows in the circuit. The device may be
   a. a p-type semiconductor
   b. a n-type semiconductor
   c. an intrinsic semiconductor
   d. a p-n junction

27. The dimension of the universal constant of gravitation G is
   a. $[ML^2T^{-1}]$
   b. $[M^{-1}L^3T^{-2}]$
   c. $[M^{-1}L^2T^{-2}]$
   d. $[ML^3T^{-2}]$

28. Two particles A and B (both initially at rest) start moving towards each other under a mutual force of attraction. At the instant when the speed of A is v and the speed of B is 2v, the speed of the centre of mass is
   a. Zero
   b. v
   c. $\frac{3v}{2}$
   d. $-\frac{3v}{2}$

29. Three vectors $\vec{A} = a\vec{i} + \vec{j} + \vec{k}$; $\vec{B} = \vec{i} + b\vec{j} + \vec{k}$ and $\vec{C} = \vec{i} + \vec{j} + c\vec{k}$ are mutually perpendicular ($\vec{i}$, $\vec{j}$ and $\vec{k}$ are unit vectors along X,Yand Z axis respectively). The respective values of a, b and c are
   a. 0,0,0
   b. $-\frac{1}{2},-\frac{1}{2},-\frac{1}{2}$
   c. 1, −1, 1
   d. $\frac{1}{2},\frac{1}{2},\frac{1}{2}$

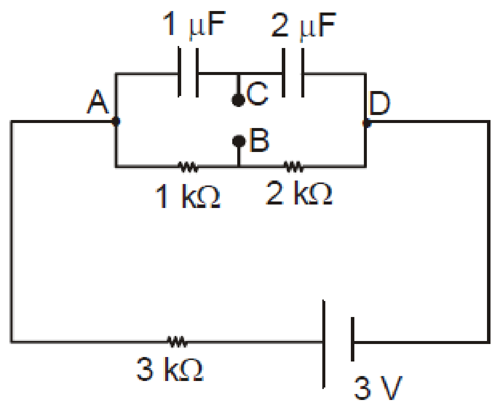
30. A block of mass 1 kg starts from rest at x = 0 and moves along the x-axis under the action of a force F=kt, where t is time and k =1 Ns^{-1}. The distance the block will travel in 6 seconds is
   a. 36 m
   b. 72 m
   c. 108 m
   d. 18 m

31. A particle with charge Q coulomb, tied at the end of an inextensible string of length R meter, revolves in a vertical plane. At the centre of the circular trajectory there is a fixed charge of magnitude Q coulomb. The mass of the moving charge M is such that $Mg = \frac{Q^2}{4\pi\varepsilon_0 R^2}$. If at the highest position of the particle, the tension of the string just vanishes, the horizontal velocity at the lowest point has to be
   a. 0
   b. $2\sqrt{gR}$
   c. $\sqrt{2gR}$
   d. $\sqrt{5gR}$

32. A bullet of mass 4.2×10^{-2} kg, moving at a speed of 300 ms^{-1}, gets stuck into a block with a mass 9 times that of the bullet. If the block is free to move without any kind of friction, the heat generated in the process will be
   a. 45 cal
   b. 405 cal
   c. 450 cal
   d. 1701 cal

33. A particle with charge e and mass m, moving along the X-axis with a uniform speed u, enters a region where a uniform electric field E is acting along the Y-axis. The particle starts to move in a parabola. Its focal length (neglecting any effect of gravity) is
   a. $\frac{2mu^2}{eE}$
   b. $\frac{eE}{2mu^2}$
   c. $\frac{mu}{2eE}$
   d. $\frac{mu^2}{2eE}$

34. A unit negative charge with mass M resides at midpoint of the straight line of length 2a adjoining two fixed charges of magnitude + Q each. If it is given a very small displacement $x(x << a)$ in a direction perpendicular to the straight line, it will
   a. come back to its original position and stay there
   b. execute oscillations with frequency $\frac{1}{2\pi}\sqrt{\frac{Q}{4\pi\varepsilon_0 Ma^3}}$
   c. fly to infinity
   d. execute oscillations with frequency $\frac{1}{2\pi}\sqrt{\frac{Q}{4\pi\varepsilon_0 Ma^2}}$

35. 

Consider the circuit given here. The potential difference V_{BC} between the points B and C is

a. 1V
b. 0.5 V
c. 0
d. –1V

36. If the pressure, temperature and density of an ideal gas are denoted by P, T and ρ, respectively, the velocity of sound in the gas is

a. Proportional to $\sqrt{P}$, when T is constant.
b. Proportional to $\sqrt{T}$
c. Proportional to $\sqrt{P}$, when r is constant.
d. Proportional to T.

37. Two long parallel wires separated by 0.1 m carry currents of 1 A and 2 A respectively in opposite directions. A third current-carrying wire parallel to both of them is placed in the same plane such that it feels no net magnetic force. It is placed at a distance of

a. 0.5 m from the 1st wire, towards the 2nd wire.
b. 0.2 m from the 1st wire, towards the 2nd wire.
c. 0.1 m from the 1st wire, towards the 2nd wire.
d. 0.2 m from the 1st wire, away from the 2nd wire.

38. If χ stands for the magnetic susceptibility of a substance, μ for its magnetic permeability and μ_0 for the permeability of free space, then

a. for a paramagnetic substance : $\chi > 0, \mu > 0$
b. for a paramagnetic substance : $\chi > 0, \mu > \mu_0$
c. for a diamagnetic substance : $\chi < 0, \mu < 0$
d. for a ferromagnetic substance : $\chi > 1, \mu < \mu_0$

39. Let v_n and E_n be the respective speed and energy of an electron in the nth orbit of radius r_n, in a hydrogen atom, as predicted by Bohr's model. Then

a. plot of $E_n r_n / E_1 r_1$ as a function of n is a straight line of slope 0.

b. plot of $r_n v_n / r_1 v_1$ as a function of n is a straight line of slope 1.

c. plot of $\ln\left(\frac{r_n}{r_1}\right)$ as a function of ln(n) is a straight line of slope 2.

d. plot of $\ln\left(\frac{r_n E_1}{E_n r_1}\right)$ as a function of ln(n) is a straight line of slope 4.

40. A small steel ball bounces on a steel plate held horizontally. On each bounce the speed of the ball arriving at the plate is reduced by a factor e (coefficient of restitution) in the rebound, so that

$V_{upward} = eV_{downward}$

If the ball is initially dropped from a height of 0.4 m above the plate and if 10 seconds later the bouncing ceases, the value of e is

a. $\sqrt{\frac{2}{7}}$

b. $\frac{3}{4}$

c. $\frac{13}{18}$

d. $\frac{17}{18}$

WBJEE 2017 (Physics)

ANSWER KEYS

1. (b)	2. (a)	3. (d)	4. (a)	5. (c)	6. (c)	7. (d)	8. (a)	9. (c)	10. (a)
11. (b)	12. (b)	13. (a)	14. (c)	15. (d)	16. (c)	17. (a)	18. (d)	19. (a)	20. (b)
21. (c)	22. (d)	23. (c)	24. (a)	25. (b)	26. (d)	27. (b)	28. (a)	29. (b)	30. (a)
31. (b)	32. (b)	33. (d)	34. (G)	35. (b)	36. (b,c)	37. (c)	38. (b,d)	39. (a,b,c,d)	40. (d)

Solution

1. (b)
Velocity of particle at any x from mean-position executing SHM is:-

$$v = \omega\sqrt{A^2 - x^2}$$

$$\frac{v^2}{\omega^2} + x^2 = A^2$$

Given:-

(i) At x = 3 m ; v = 13 ms^{-1}

$$\frac{[13]^2}{\omega^2} + [3]^2 = A^2 \quad .....(1)$$

(ii) At x = 5 m ; v = 12 ms^{-1}

$$\frac{[12]^2}{\omega^2} + [5]^2 = A^2 \quad .....(2)$$

From (1) & (2):-

$$\frac{169}{\omega^2} + 9 = \frac{144}{\omega^2} + 25$$

$$\frac{169}{\omega^2} - \frac{144}{\omega^2} = 25 - 9$$

$$\frac{1}{\omega^2}[25] = 16$$

$$\omega^2 = \frac{25}{16}$$

$$\omega = \frac{5}{4}\ \frac{\text{Rad}}{\text{Sec}}$$

Frequency [f] :-

$$\omega = 2\pi f$$

$$f = \frac{\omega}{2\pi}$$

$$f = \frac{5}{8\pi}$$

2. (a)
If the string is vibrating in n segment and wavelength of wave is λ.

$$L = \frac{n\lambda}{2}$$

Velocity of transverse wave in string is:-

$$v = \sqrt{\frac{T}{\mu}}$$

T = Tension in the string

μ = mass per unit length = $\frac{M}{L}$

$$v=\sqrt{\frac{T}{\left[\frac{M}{L}\right]}}=\sqrt{\frac{TL}{M}}$$

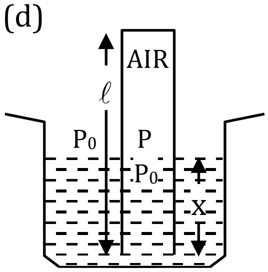
Velocity of a wave:-

$v=\upsilon\lambda$

$$\upsilon=\frac{v}{\lambda}$$

$$\upsilon=\frac{n}{2L}\sqrt{\frac{TL}{M}} \quad ; \qquad \upsilon=\frac{n}{2}\sqrt{\frac{T}{ML}}$$

3. (d)



Assumption:-

The temperature of Air in the capillary remains constant

[PV = nRT]

So for air inside capillary

$P_iV_i = P_fV_f$

$P_0A\ell = PA[\ell - x]$

$$P=\frac{P_0\ell}{\ell-x} \qquad .....(i)$$

[Angle of contact $\theta = 0°$]

At interface:- $P-P_0=\frac{2\gamma}{r}$ .....(ii)

Put value of P from (i) in equation (ii):-

$$\frac{P_0\ell}{\ell-x}-P_0=\frac{2\gamma}{r}$$

$$\frac{P_0x}{\ell-x}=\frac{2\gamma}{r}$$

$$\frac{P_0r}{2\gamma}=\frac{\ell-x}{x}$$

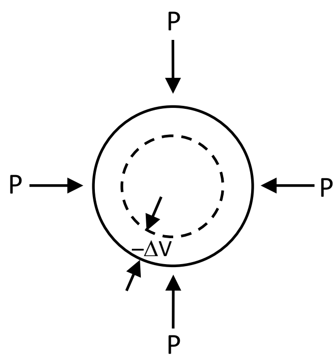
$$\frac{P_0r}{2\gamma}=\frac{\ell}{x}-1$$

$$\frac{P_0r}{2\gamma}+1=\frac{\ell}{x}$$

$$x=\frac{\ell}{1+\frac{P_0r}{2\gamma}}$$

4. (a)

Bulk – modulus $[K]=\frac{-P}{\frac{\Delta V}{V}}$ .....(i)



Mass of liquid element is constant

$$m = \rho V$$

$$\frac{\Delta m}{m}=\frac{\Delta\rho}{\rho}+\frac{\Delta V}{V}$$

$$0=\frac{\Delta\rho}{\rho}+\frac{\Delta V}{V}$$

$$-\frac{\Delta V}{V}=\frac{\Delta\rho}{\rho}$$

From (i) :-

$$P=-K\frac{\Delta V}{V}$$

$$P=+K\frac{\Delta\rho}{\rho}$$

$$\frac{\Delta\rho}{\rho}=\frac{0.01}{100}=\frac{1}{10000}$$

$$P=\frac{K}{10000}$$

5. (c)

The rms velocity of an ideal gas:-

$$v_{rms} = \sqrt{\frac{3RT}{M}}$$

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

For % change in rms velocity:-

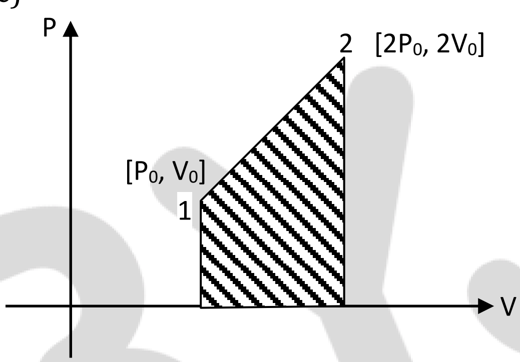
$$\frac{\Delta v}{v} = \frac{1}{2}\frac{\Delta T}{T}$$

$$\frac{\Delta V}{V} = \frac{1}{2}\left[\frac{6}{300}\right]$$

$$\left[\frac{\Delta v}{v}\right] = \frac{1}{100}$$

$$\%\frac{\Delta v}{v} = 1\%$$

6. (c)



Given:-

n = 2 moles

[Ideal monoatomic gas] $C_v = \frac{3R}{2}$,

Work done by the gas = Area enclosed by curve on volume axis

$$W = \frac{1}{2}[P_0 + 2P_0] \cdot v_0$$

$$= \frac{3P_0V_0}{2}$$

$$\Delta U = nC_v\Delta T$$

$$= n\left[\frac{3R}{2}\right][T_2 - T_1]$$

$$= n\left[\frac{3R}{2}\right]\left[\frac{2P_0 2V_0}{nR} - \frac{P_0V_0}{nR}\right]$$

$$= \frac{9P_0V_0}{nR}$$

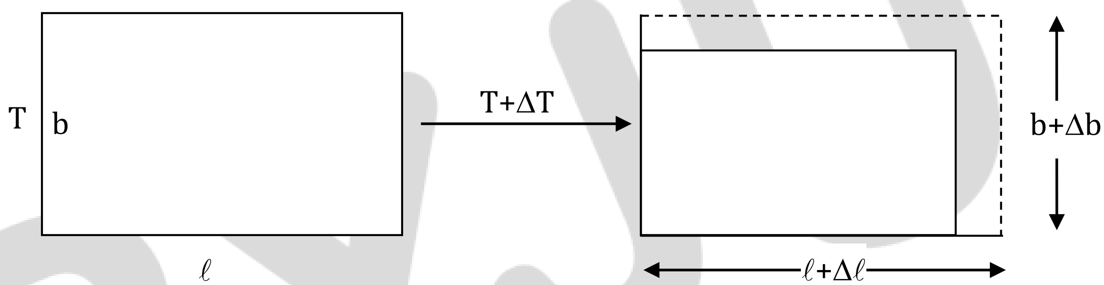
For a process:-

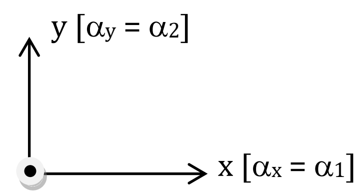
$$\Delta Q = W + \Delta U$$

$$\Delta Q = \frac{3P_0V_0}{2} + \frac{9P_0V_0}{2}$$

$$= 6P_0V_0$$

7. (d)





$$A = \ell b$$

$$\frac{\Delta A}{A} = \frac{\Delta \ell}{\ell} + \frac{\Delta b}{b}$$

$$\Delta \ell = \ell \alpha_1 \Delta T$$

$$\Delta b = b\alpha_2 \Delta T$$

$$\frac{\Delta A}{A} = \alpha_1 \Delta T + \alpha_2 \Delta T \quad .....(i)$$

If β is Arial co-efficient of solid then,

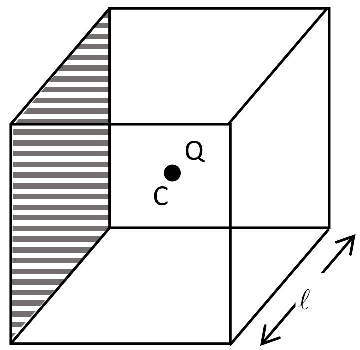
$$\Delta A = \beta A \Delta T$$

$$\beta \Delta T = \alpha_1 \Delta T + \alpha_2 \Delta T \quad .....(ii)$$

From (i) and (ii)

$$\beta = \alpha_1 + \alpha_2$$

8. (a)



From Gauss law electric flux through any closed surface is given by:-

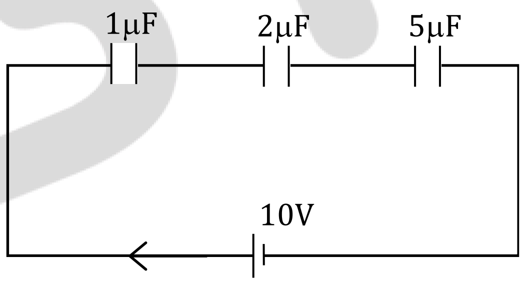
$$\phi = \frac{qin}{\varepsilon_0}$$

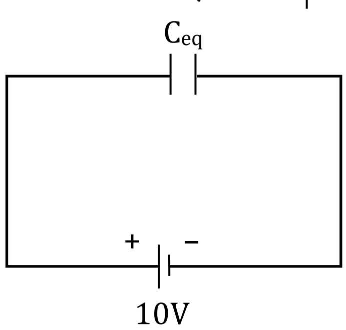
$$\phi = \frac{Q}{\varepsilon_0}$$

As charge is at the body centre of the cube hence, flux passing through each face is same according to symmetricity.

$$\phi_{face} = \frac{Q}{6\varepsilon_0}$$

9. (c)





$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$$

$$\frac{1}{C_{eq}} = \frac{1}{1} + \frac{1}{2} + \frac{1}{5}$$

$$\frac{1}{C_{eq}} = 1 + \frac{1}{2} + \frac{1}{5}$$

$$C_{eq} = \frac{10}{17}\mu F$$

\# Charge – flown by battery:-

$Q = C_{eq}V$

$= \left[\frac{10}{17}\right][10]$

$= \frac{100}{17}\mu C$

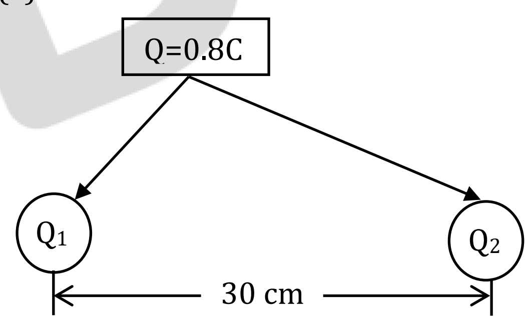
As all capacitors are connected in series charge is same across all capacitors.

For 2 μF $q_2 = Q = C_2V_2$

$$V_2 = \frac{Q}{C_2} = \frac{\left[\frac{100}{17}\right]\mu C}{2\mu F}$$

$$V_2 = \frac{50}{17}\text{volt}$$

10. (a)



$Q = Q_1 + Q_2$

$Q_2 = Q - Q_1$

Force on charge Q_1

$F = \frac{KQ_1Q_2}{r^2}$

$F = \frac{KQ_1[Q - Q_1]}{r^2}$

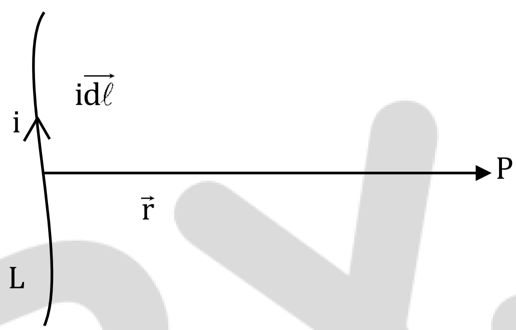
For F_{max}

$\frac{dF}{dQ_1} = 0$

$Q - 2Q_1 = 0$

$Q_1 = \frac{Q}{2}$ = 0.4 C

11. (b)



By Biot – Savart law:-

$$\vec{dB} = \frac{\mu_0 i}{4\pi r^3}\left[\vec{d\ell} \times \vec{r}\right]$$

$$\vec{dB} \propto \frac{1}{r^2}$$

12. (b)

Torque [τ] = iAB

As i and B are same

so $\tau \propto A$

$\frac{\tau_1}{\tau_2} = \frac{A_1}{A_2}$

$\frac{\tau_1}{\tau_2} = \frac{a^2}{\pi\left[\frac{a}{\sqrt{\pi}}\right]^2}$

= 1 Ans.

13. (a)

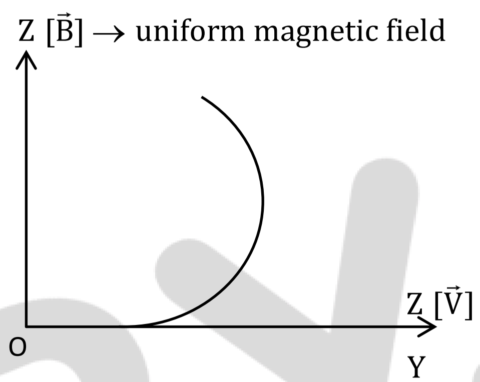
We know from EM waves:-

$|\vec{E}| = |\vec{B}| V$

$B = \frac{F}{V} = \frac{2\times10^4}{10^6}$

$B = 2\times10^{-2}$ T

Now when E is switched off



$\vec{F}_{net} = \overrightarrow{qE} + 9[\vec{V}\times\vec{B}]$ $\because (\overrightarrow{qE} = 0)$

$\vec{F}_{net} = q[\vec{V}\times\vec{B}]$

For circular motion

$\frac{mv^2}{R} = qVB$

$R = \frac{mv}{qB}$ Given $\left[\frac{m}{a}\right] = 10^{-8} Ckg^{-1}$

$= \frac{10^{-8}\times10^6}{2\times10^{-2}}$

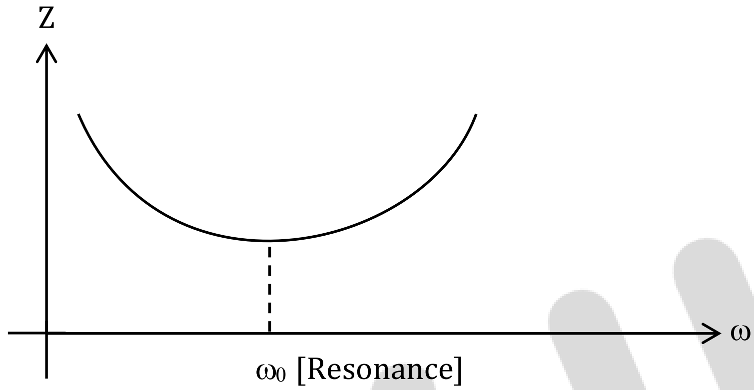
= 0.5 m

14. (c)

The impedance of the circuit [series LCR] is given by:-

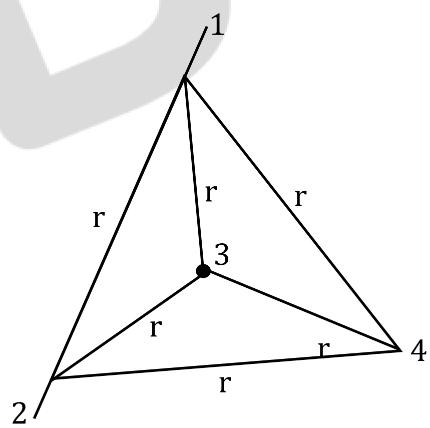
$$Z^2 = [X_L - X_C]^2 + R^2$$

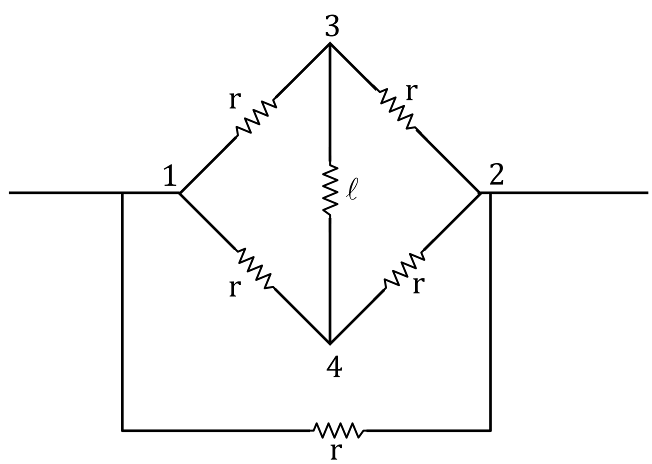
$$Z^2 = [\omega_L - \frac{1}{\omega c}]^2 + R^2$$



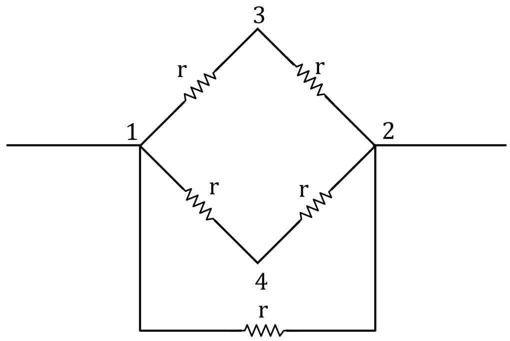
As we gradually increase frequency, z first decreases and then increases.

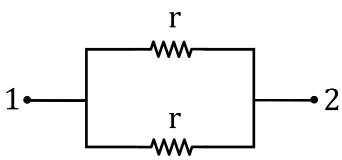
15. (d)





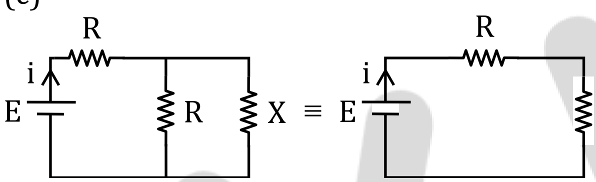
3 & 4 are equipotential point then,





$$Req = \frac{r}{2}$$

16. (c)



$$\frac{RX}{R+X} = R_1$$

$$i = \frac{E}{R + \frac{RX}{R+X}}$$

Voltage-drop across [R1] :-

$$V_{R_1} = iR_1$$

$$= \left[\frac{E}{R + \frac{RX}{R+X}}\right]\left[\frac{RX}{R+X}\right]$$

$$V_{R_1} = \frac{EX}{R+2X}$$

$$P_X = \frac{V_{R_1}^2}{X}$$

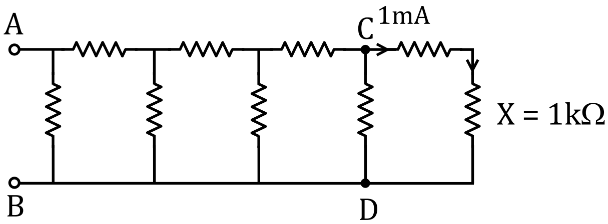
$$P_X = \frac{E^2X}{[R+2X]^2}$$

$$\frac{dP_X}{dx} = \frac{E^2[R-2X]}{[R+2X]^3}$$

[dPX] will be zero for all dx if

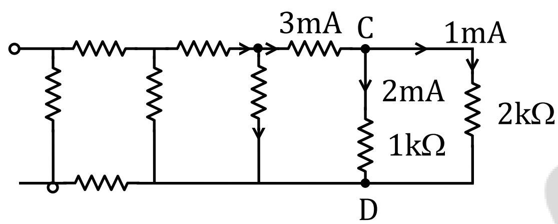
$$X = \frac{R}{2}$$

17. (a)

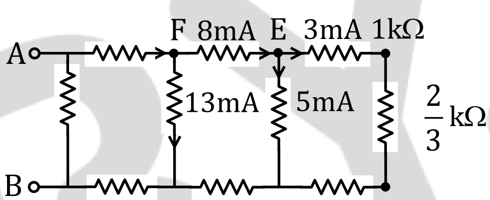


Across C & D same potential current will divide according to :-

$$i \propto \frac{1}{R}$$

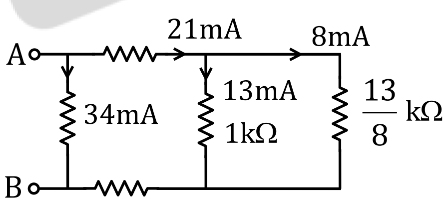


At C apply KCL



Apply KCL at E.

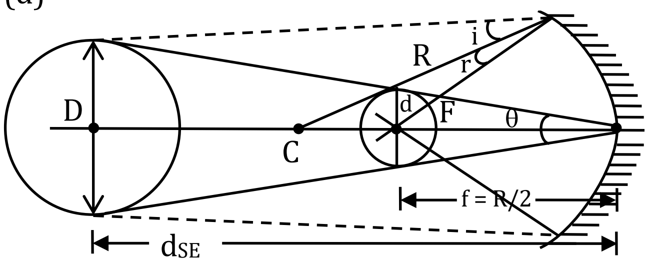
Apply KCl at F.



$V_{AB} = iR = 34 \times 10^{-3} A \times 1 \times 10^{3}\ \Omega$

$= 34\ V$

18. (d)



For concave-mirror if object is placed at infinity: image will be formed at focus [f]

$$\theta = \frac{D}{d_{SE}} = \frac{d}{f}$$

d = θ.f

d = 0.009 × 0.2 m

d = 1.8×10^{-3} m

19. (a)

$$I = \sqrt{I_1}^2 + \sqrt{I_2}^2 + 2\sqrt{I_1}\sqrt{I_2}\cos\phi$$

For maximum intensity:-

cosϕ = 1

$$I_{max} = \left[\sqrt{I_1} + \sqrt{I_2}\right]^2$$

For minimum intensity:-

$$I_{min} = \left[\sqrt{I_1} - \sqrt{I_2}\right]^2$$

$$I_{max} = \left[\sqrt{L} + \sqrt{\frac{L}{4}}\right]^2$$

$$= \frac{9L}{4}$$

$$I_{min} = \left[\sqrt{L} - \sqrt{\frac{L}{4}}\right]^2$$

$$= \frac{L}{4}$$

20. (b)

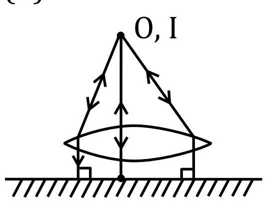
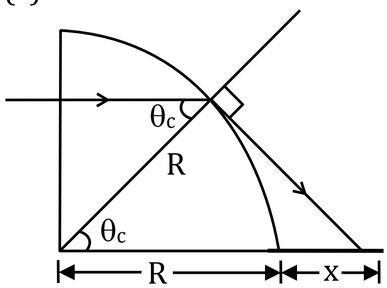


Image will be formed on object itself.

21. (c)



$$\sin\theta_c = \frac{1}{n} = \frac{2}{3}$$

$$\cos\theta_c = \frac{R}{R+x}$$

$$\sqrt{1-\frac{4}{9}} = \frac{R}{R+x}$$

$$\frac{\sqrt{5}}{3} = \frac{R}{R+x}$$

$$x = \left[3\sqrt{5}-5\right]\times 10^{-2}\text{ m}$$

22. (d)

Wavelength:-

$$\lambda = \frac{h}{p}$$

$$\lambda = \frac{h}{\sqrt{2mk}}$$

$$\lambda \propto \frac{1}{\sqrt{k}}$$

$$\sqrt{\frac{k_2}{k_1}} = \left[\frac{\lambda_1}{\lambda_2}\right]$$

$$\frac{k_2}{k_1} = \left[\frac{\lambda_1}{\lambda_2}\right]^2$$

$$k_2 = \left[\frac{0.4\times 10^{-10}\text{m}}{1.0\times 10^{-10}\text{m}}\right]^2 1\text{keV}$$

$k_2 = 0.16$ keV

23. (c)

We know for a photon:-

$KE_{max} = h\upsilon - h\upsilon_0$

$KE_{max} = h\upsilon - \phi_0$ .....(i)

$KEmax = qV_0$ .....(ii)

q = charge on electron

V_0 = stopping potential

ϕ_0 = work-function of a metal

From (i) & (ii)

$qV_0 = h\upsilon - \phi_0$

When light of intensity υ_1 falls :-

$eV_1 = h\upsilon_1 - w$

$h\upsilon_1 = w + eV_1$ .....(iii)

When light of intensity υ_2 falls

$eV_2 = h\upsilon_2 - w$

$h\upsilon_2 = eV_2 + w$ .....(iv)

(iii) ÷ (iv) :-

$$\frac{\upsilon_1}{\upsilon_2} = \frac{w + eV_1}{w + eV_2}$$

$w\upsilon_1 + e\upsilon_1V_2 = w\upsilon_2 + e\upsilon_2V_1$

$e\upsilon_1V_2 - e\upsilon_2V_1 = w[\upsilon_2 - \upsilon_1]$

$$e = \frac{w[\upsilon_2 - \upsilon_1]}{\upsilon_1V_2 - \upsilon_2V_1}$$

24. (a)

The equation of Radioactive-Decay :-

$N=N_0e^{-\lambda t}$

The radioactive constant:-

$$\lambda = \frac{\ell n2}{t_{1/2}}$$

$$= \frac{\ell n2}{3.8}$$

Quantity N at t = 19 day:-

$$N = 0.064e^{-\frac{\ell n2}{3.8}\times 19}$$

$N = 0.064\ e^{-5\ell n2}$

$N = 0.064\ e^{-\ell n32}$

N = 0.002 kg

25. (b)

$$Y=\overline{AB+\overline{AB}}$$

For A = 1 ; B = 1

$Y = 0$

& For A = 0 ; B = 0

$Y = 0$

26. (d)

p–n junction Diode :-

- It is a one way device. It offers a low resistance when forward biased hence current easily flow.
- It offers high resistance when reverse biased and current almost becomes zero.

27. (b)

From Newton's law of gravitation:-

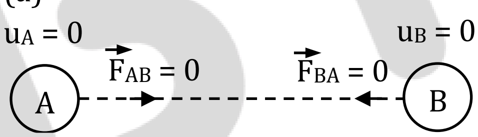
$$F=\frac{Gm_1m_2}{r^2}$$

$$[G]=\left[\frac{Fr^2}{m_1m_2}\right]$$

$$=\left[\frac{M^1L^1T^{-2}\cdot L^2}{M^2}\right]$$

$$= [M^{-1}L^3T^{-2}]$$

28. (a)



(initial condition at t = 0)

$$\vec{V}_{com}\Big|_{t=0}=0$$

$$\vec{F}_{ext}=m\vec{a}_{com}\Big|_{system}=m\frac{d\vec{V}_{com}\big|_{sys}}{dt}$$

Considering A & B as a system

$$\vec{F}_{ext}\Big|_{sys}=0$$

$$\vec{V}_{com}\Big|_{sys}=0$$

Hence, at all instants centre of mass the system will be at rest.

29. (b)

There are three unknowns hence we require 3 equations accordingly. [use application of scalar product]

$\vec{A}\cdot\vec{B}=0$ [θ = 90°]

a + b + 1 = 0 .....(i)

$\vec{B}\cdot\vec{C}=0$

1 + b + c = 0 .....(ii)

$\vec{C}\cdot\vec{A}=0$

a + 1 + c = 0 .....(iii)

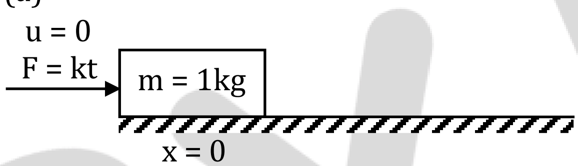
Adding (i), (ii) & (iii) :-

2[a + b + c] + 3 = 0

$a=\frac{-3-2[b+c]}{2}$; $b=\frac{-3-2[a+c]}{2}$; $c=\frac{-3-2[a+b]}{2}$

$a=-\frac{1}{2}$ $b=-\frac{1}{2}$ $c=-\frac{1}{2}$

30. (a)



F = kt = ma

k = $1NS^{-1}$; m = 1

$t=\frac{ma}{k}=\frac{dv}{dt}$

$\int_{u=0}^{v} dv=\int_{t=0}^{t} t\,dt$

$v=\frac{t^2}{2}$

$\frac{dx}{dt}=\frac{t^2}{2}$

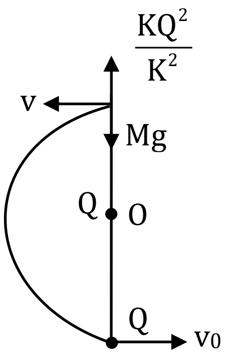
$\int_{x=0}^{x} dx=\int_{t=0}^{t}\frac{t^2}{2}dt$

$x=\frac{t^3}{6}$

At t = 6 second:-

x = 36 m

31. (b)



As $Mg = \frac{Q^2}{4\pi\varepsilon_0 R^2}$

At highest point tension in the string vanishes

T = 0

As T = 0

v = 0

Applying work-kinetic-energy theorem:-

$WD|_{\text{All-forces}} = \Delta K.E$

$Mg[2R] = \frac{1}{2}mv_0^2 \; v_0 = 2\sqrt{gR}$

32. (b)

Mass of Bullet = m

Velocity of Bullet = $300\frac{m}{s}$

When Bullet will get stuck inside Block, both will move with same velocity i.e. V

Applying conservation of linear – momentum:-

mv = [m + 9m] V

$V = \frac{v}{10}$

As there is no friction hence

Heat generated = change in K.E

$= \frac{1}{2}mv^2 - \frac{1}{2}10mV^2$

$= \frac{1}{2}mv^2 - \frac{1}{2}10m\left[\frac{v}{10}\right]^2$

$= \frac{9}{20}mv^2$

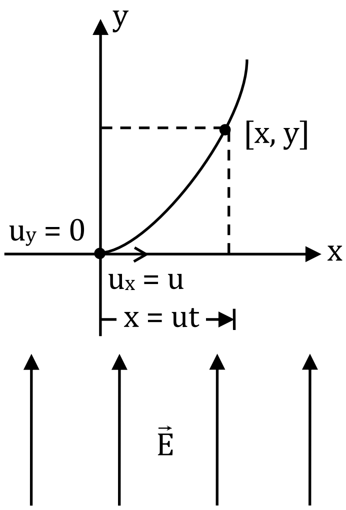
= 1701 J

Total heat generated in calories:-

$= \frac{1701}{4.2}$

= 405 cal

33. (d)



$$\vec{a}_y = \frac{\vec{F}_E}{m} = \left[\frac{q\vec{E}}{m}\right]$$

No effect of gravity is considered

For particle trajectory

$$S_y = u_y t + \frac{1}{2} a_y t^2$$

$$y = \frac{1}{2}\left[\frac{qE}{m}\right] t^2$$

$$y = \frac{1}{2}\left[\frac{qE}{m}\right]\left[\frac{x}{u}\right]^2$$

$$y = \frac{Ee}{2mu^2} x^2$$

Now this parabola relates with

$$x^2 = 4ay$$

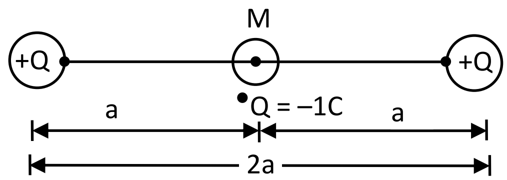
$$x^2 = \left[\frac{2mu^2}{Ee}\right] y$$

$$4a = \frac{2mu^2}{Ee}$$

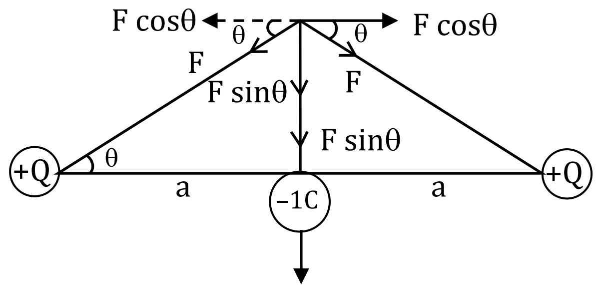
Hence

$$a = \frac{mu^2}{2Ee}$$

34. (G) Bonus



Its given small displacement



Mean-position [Equilibrium-position]
Restoring force towards mean position

$$F_{net} = -2F\sin\theta$$

$$F_{net} = -2\frac{KQ\times 1}{\left[y^2+a^2\right]}\times\frac{y}{\sqrt{y^2+a^2}}$$

$$F_{net} = -\frac{2KQy}{\left[y^2+a^2\right]^{3/2}}$$

y <<< a small-displacement

$$F_{net} = -\frac{2KQy}{a^3}$$

$$\text{Frequency}[f] = \frac{1}{2\pi}\sqrt{\frac{K}{M}}$$

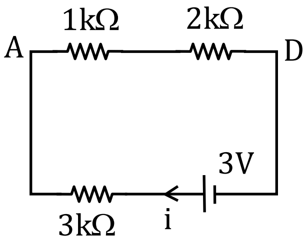
$$= \frac{1}{2\pi}\sqrt{\frac{2KQ}{Ma^3}}$$

$$= \frac{1}{2\pi}\sqrt{\frac{Q}{2\pi\varepsilon_0 Ma^3}}$$

None of the option is correct.

35. (b)

At starting of the circuit [t = 0] capacitor can be replaced by a simple wire. Hence



$$i = \frac{V}{Req}$$

[Req = 6kΩ]

$$i = \frac{3}{6 \times 10^3}$$

$I = 0.5 \times 10^{-3}$ A

$V_{AD} = iR = 0.5 \times 10^{-3} \times 3 \times 10^3$

$= 1.5$ V

$$Q = \left[\frac{2}{3}\right] \times 1.5 = 1\mu C$$

Applying KVL from B to C

$$V_B - 0.5 \times 10^{-3} \times 2 \times 10^3 + \frac{1}{2} = V_C$$

$V_B - V_C = 0.5$ V

36. (b,c)

Velocity of sound:-

$$V = \sqrt{\frac{\gamma RT}{M}} \qquad \text{.....(i)}$$

$$PV = nRT$$

$$PV = \frac{m}{M}RT$$

$$P = \left[\frac{m}{V}\right]\frac{RT}{M}$$

$$P = \frac{\rho RT}{M}$$

$$\frac{RT}{M} = \frac{P}{\rho}$$

Putting value in (i):-

$$V = \sqrt{\frac{\gamma P}{\rho}} \qquad \text{.....(ii)}$$

Now from (i) & (ii)

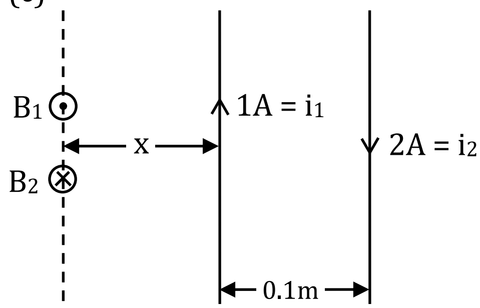
$$V \propto \sqrt{T}$$

When ρ = constant

$$V \propto \sqrt{P}$$

Option (b) & (c) are correct.

37. (c)



$B_1 = B_2$

$$\frac{\mu_0[1]}{2\pi x} = \frac{\mu_0[2]}{2\pi[0.1+x]}$$

x = 0.1 m

38. (b,d)

$\chi = \mu_r - 1$

$$\mu_r = \frac{\mu}{\mu_0}$$

For paramagnetic substance:- $\chi > 0$, $\mu_r > 1$; $\mu > \mu_0$

For diamagnetic substance:- $\chi < 0$, $\mu_r < 1$; $\mu < \mu_0$

For ferromagnetic substance:- $\chi >> 1$, $\mu >> \mu_0$

If $0 < \mu < \mu_0$ then substance will not be paramagnetic. Hence option (a) is incorrect.

39. (a,b,c,d)

$V_n \propto \frac{1}{n}$ $\quad E_n \propto \frac{1}{n^2}$ $\quad r_n \propto n^2$

$\because E_n r_n \propto n^\circ$ $\quad \because E_n r_n \propto E_1 r_1$ $\quad \frac{E_n r_n}{E_1 r_1} = \text{constant}$ [slope = 0]

$\because r_n V_n \propto n$ $\quad \because \frac{r_n V_n}{r_1 V_1} = n$ $\quad$ [Slope = 1]

$\because r_n \propto n^2$ $\quad \because \frac{r_n}{r_1} = n^2$

$$\ell n\left[\frac{r_n}{r_1}\right] = 2\ell n n \text{ [slope = 2]}$$

$\because \frac{r_n}{E_n} \propto n^4$ $\quad \because \frac{r_n E_1}{E_n r_1} = n^4$

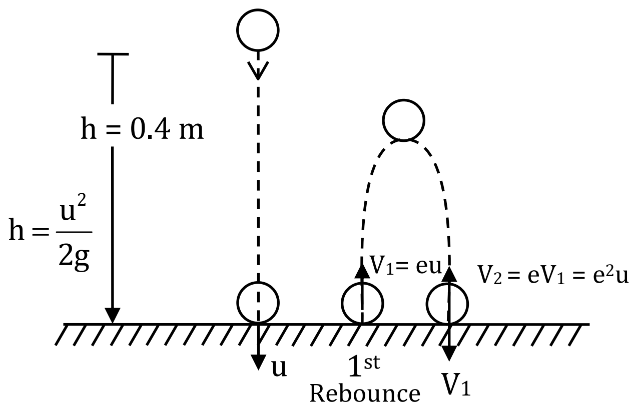
$$\ell n\left[\frac{r_n E_1}{r_1 E_n}\right] = 4\ell n n \text{ [Slope = 4]}$$

Option a, b, c & d are correct.

40. (d)

Total time of bouncing = 10 sec

$$t = \sqrt{\frac{2h}{8}} + 2\sqrt{\frac{2h_1}{g}} + 2\sqrt{\frac{2h_2}{8}} + ...$$



Maximum height achieved in 1st rebounce :-

$$h_1 = \frac{V_1^2}{2g} = \frac{e^2u^2}{2g} = he^2$$

Time taken in 1st rebounce :-

$$t_1 = 2\sqrt{\frac{2h_1}{g}} = 2\sqrt{\frac{he^2}{g}}$$

Time taken in 2nd rebounce :-

$$t_2 = 2\sqrt{\frac{2he^4}{g}}$$

$$t = 2\sqrt{\frac{2h}{g}} + 2\sqrt{\frac{2he^2}{g}} + 2\sqrt{\frac{2he^4}{g}} + ... = 10$$

$$= \sqrt{\frac{2h}{g}}\left[1 + 2e + 2e^2 + ...\right] = 10$$

$$= \sqrt{\frac{2h}{g}}\left[\frac{1+e}{1-e}\right] = 10$$

$$e = \frac{17}{18}$$