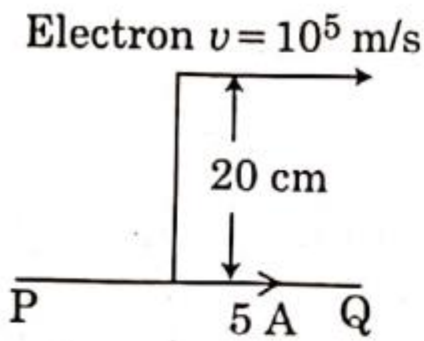
NEET 2021 Question paper & Solutions PDF by Embibe
PHYSICS (Code -M5)

1. An infinitely long straight conductor carries a current of $5A$ as shown. An electron is moving with a speed of 10^5m/s parallel to the conductor. The perpendicular distance between the electron and the conductor is 20cm at an instant. Calculate the magnitude of the force experienced by the electron at that instant.



(1) 4×10^{-20}N

(2) $8\pi \times 10^{-20}$N

(3) $4\pi \times 10^{-20}$N

(4) 8×10^{-20}N

Correct Answer: (4)

Q.1. Solution:

M.F due to long current carrying wire at 20 cm,

$$B = \frac{\mu_0 I}{2\pi d}$$

$$B = \frac{2 \times 10^{-7} \times 5}{20 \times 10^{-2}}$$

$$B = 0.5 \times 10^{-5} \text{ T}$$

Now,

Force experienced by electron $= qVB$

$$F_m = eVB$$

$F_m = 1.6 \times 10^{-19} \times 10^5 \times 0.5 \times 10^{-5}$

$= 8 \times 10^{-20}$ N

2. A body is executing simple harmonic motion with frequency 'n', the frequency of its potential energy is:

(1) n

(2) $2n$

(3) 3n

(4) 4n

Correct Answer: (2)

Q.2. Solution:

Given,
frequency of SIHM $= n$
as we know,

∵ In one time period PE become maximum & minimum two time

So,
It means frequency of PE is $2n$.

3. A radioactive nucleus ${}_{Z}^{A}X$ undergoes spontaneous decay in the sequence ${}_{Z}^{A}X \rightarrow {}_{Z-1}B \rightarrow {}_{Z-3}C \rightarrow {}_{Z-2}D$ where Z is the atomic number of element X. The possible decay particles in the sequence are:

(1) α, β^-, β^+

(2) α, β^+, β^-

(3) β^+, α, β^-

(4) β^-, α, β^+

Correct Answer: (3)

Q.3. Solution:

As we know due to α-decay atomic number decreases by 2 and mass number decreases by 4. Due to β^-decay mass number remains unchange and atomic number increases by 1.

Due to β^+ decay mass number remains unchange but atomic number decreares by 1.

So, option (3) is correct option.

4. The escape velocity from the Earth's surface is v. The escape velocity from the surface of another planet having a radius, four times that of Earth and same mass density is :

(1) v

(2) $2v$

(3) $3v$

(4) $4v$

Correct Answer: (4)

Q.4. Solution:

As we know escape velocity is given by,

$$v_e=\sqrt{2gR}=\sqrt{\frac{2GM}{\frac{4}{3}\pi R^3}\frac{4}{3}\pi R^2}=\sqrt{\frac{2GM}{V}\frac{4}{3}\pi R^2}$$

$$V_e\propto\sqrt{R^2}\propto R$$

Escape velocity from Earth's surface $=v$

Escape velocity from surface of another planet =?

$R_{planet}=4R_{earth}$

$S_{planet}=S_{earth}$

So we can write ,

$$\frac{(v_e)_{\text{earth}}}{(v_e)\text{ planet}}=\frac{R_{earth}}{R_{planet}}=\frac{R}{4R}=\frac{1}{4}$$

It means,

$(v_e\ \ )_{\text{earth}}=(v_e)_{\text{Planet}}$

$(v_e)_{\text{Planet}}=4v$

5. The half-life of a radioactive nuclide is 100 hours. The fraction of original activity that will remain after 150 hours would be :

(1) 1/2

(2) $\frac{1}{2\sqrt{2}}$

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

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

Correct Answer: (2)

Q.5. Solution:

Given,

$T_{\frac{1}{2}} = 100$ hours

$t = 150$ hours

$\because$ no. of nuclide remain after n half life, $N = \frac{N_0}{2^n}$

$\because$ 100 hours = 1 half life

150 hours $= \frac{1}{100} \times 150$

$= \frac{3}{2}$ half life

So, Fraction Remain after $\frac{3}{2}$ half life

$\frac{N}{N_0} = \left(\frac{1}{2}\right)^{3/2} = \frac{1}{2\sqrt{2}}$

6. A convex lens 'A' of focal length 20cm and a concave lens ' B ' of focal length 5cm are kept along the same axis with a distance 'd' between them. If a parallel beam of light falling on 'A' leaves 'B' as a parallel beam, then the distance 'd' in cm will be :

(1) 25

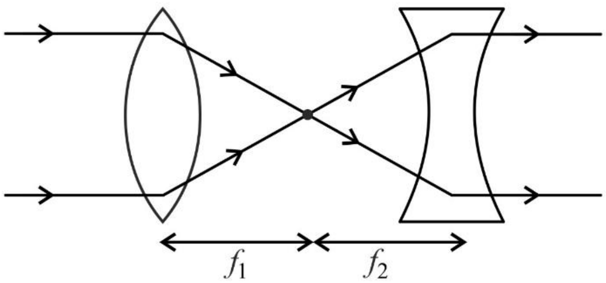
(2) 15

(3) 50

(4) 30

Correct Answer: (1)

Q.6. Solution:



Total distance $= f_1 + f_2$

$= 25\ cm$

7. A capacitor of capacitance 'C', is connected across an ac source of voltage V, given by $\mathrm{V} = \mathrm{V}_0 \sin\ \omega \mathrm{t}$ The displacement current between the plates of the capacitor, would then be given by:

(1) $\mathrm{I_d} = \mathrm{V_0} \omega \mathrm{C} \cos \omega \mathrm{t}$

(2) $\mathrm{I_d} = \frac{\mathrm{V_0}}{\omega \mathrm{C}} \cos\ \omega \mathrm{t}$

(3) $I_d = \frac{V_0}{\omega C} \sin\ \omega t$

(4) $\mathrm{I_d} = \mathrm{V_0} \omega \mathrm{C} \sin \omega \mathrm{t}$

Correct Answer: (1)

Q.7. Solution:

$\because\ \ q = CV$

And $V = V_0 \sin \omega t$

$I_d = ?$

As we know,

$\because\ \ I_d = \varepsilon_0 \frac{d\phi}{dt}$

$= \varepsilon_0 \frac{dEA}{dt}\ \ \left(\because\ \ E = \frac{V}{d}\right)$

$= \frac{\varepsilon_0 A\ dV}{d\ dt}$

$= \left(\frac{\varepsilon_0 A}{d}\right)\frac{d}{dt} V_0 \sin \omega t$

$I_d = C V_0 \omega \cos \omega t$

8. A small block slides down on a smooth inclined plane, starting from rest at time $\mathrm{t} = 0$ Let $\mathrm{S_n}$ be the distance travelled by the block in the interval $\mathrm{t} = \mathrm{n} - 1$ to $\mathrm{t} = \mathrm{n}$ Then, the ratio $\frac{\mathrm{S_n}}{\mathrm{S_{n+1}}}$ is:

(1) $\frac{2n-1}{2n}$

(2) $\frac{2n-1}{2n+1}$

(3) $\frac{2n+1}{2n-1}$

(4) $\frac{2n}{2n-1}$

Correct Answer: (2)

Q.8. Solution:

$\because S_{n^{th}} = u + \left(\frac{2n-1}{2}\right) a$

but $u = 0$

$\therefore s_n = \left(\frac{2n-1}{2}\right) a \ldots (1)$

$s_{n+1} = \left[\frac{2(n+1)-1}{2}\right] a \ldots(2)$

Now,
eq (1) divide by (2)

$$\frac{s_n}{s_{n+1}} = \frac{2n-1}{2n+1}$$

9. A particle is released from height S from the surface of the Earth. At a certain height its kinetic energy is three times its potential energy. The height from the surface of earth and the speed of the particle at that instant are respectively:

(1) $\frac{\mathrm{S}}{4}, \frac{3\mathrm{gS}}{2}$

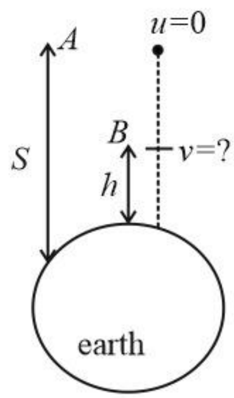
(2) $\frac{\mathrm{S}}{4}, \frac{\sqrt{3\mathrm{gS}}}{2}$

(3) $\frac{S}{2}, \frac{\sqrt{3gS}}{2}$

(4) $\frac{S}{4}, \sqrt{\frac{3gS}{2}}$

Correct Answer: (4)

Q.9. Solution:



$\because$ At every $pt.$

$KE + PE$ =constant
so,$(K\varepsilon)_A + (P\varepsilon)_A = (k\varepsilon)_B + (P\varepsilon)_B$

$0 + mgS = 3(P\varepsilon)_B + (P\varepsilon)_B$

$mgS = 4mgh$

$h = S/4$

Now,

$\because$At $pt. B -$

$K\varepsilon = 3P\varepsilon$

$$\frac{1}{2}mv^2 = 3\frac{mgs}{4}$$

$$v = \sqrt{\frac{3}{2}gS}$$

10. In a potentiometer circuit a cell of EMF 1.5 V gives balance point at 36cm length of wire. If another cell of EMF 2.5V replaces the first cell, then at what length of the wire, the balance point occurs?

(1) 60cm

(2) 21.6cm

(3) 64cm

(4) 62cm

Correct Answer: (1)

Q.10. Solution:

Given,

$E_1 = 1.5 \text{ V}$

$l_1 = 36 \text{ cm}$

$E_2 = 2.5\text{v}$

$l_2 = ?$

AS we know,

$$\frac{E_1}{E_2} = \frac{l_1}{l_2}$$

$$\frac{1 \cdot 5}{2 \cdot 5} = \frac{36}{l_2}$$

$$\frac{3}{5} = \frac{36}{l_2}$$

$l_2 = 60 \text{ cm}$

11. For a plane electromagnetic wave propagating in x −direction, which one of the following combination gives the correct possible directions for electric field (E) and magnetic field (B) respectively?

(1) $\hat{j} + \hat{k}, \hat{j} + \hat{k}$

(2) $-\hat{j} + \hat{k}, -\hat{j} - \hat{k}$

(3) $\hat{j} + \hat{k}, -\hat{j} - \hat{k}$

(4) $-\hat{j} + \hat{k}, -\hat{j} + \hat{k}$

Correct Answer: (2)

Q.11. Solution:

Direction $= \vec{E} \times \vec{B}$

(i) $(\hat{j} + \hat{k}) \times (\hat{j} + \hat{k}) = 0$

(ii) $(-\hat{j} + \hat{k}) \times (-\hat{j} - \hat{k})$

$= 0 + \hat{\imath} - (-\hat{\imath}) + 0$

$= 2\hat{\imath}$

(iii) $(\hat{j} + \hat{k}) \times (-\hat{j} - \hat{k}) = 0$

(iv) $(-\hat{j} + \hat{k}) \times (-\hat{j} + \hat{k})$

$= 0$

12. Polar molecules are the molecules:

(1) having zero dipole moment.

(2) acquire a dipole moment only in the presence of electric field due to displacement of charges.

(3) acquire a dipole moment only when magnetic field is absent.

(4) having a permanent electric dipole moment.

Correct Answer: (4)

Q.12. Solution:

A polar molecule is a molecule in which one end of the molecule is slightly positive, while the other end is slightly negative. Therefore, these molecules have permanent electric dipole moment.

13. The velocity of a small ball of mass M and density d, when dropped in a container filled with glycerine becomes constant after some time. If the density of glycerine is $\frac{d}{2}$, then the viscous force acting on the ball will be :

(1) $\frac{\mathrm{Mg}}{2}$

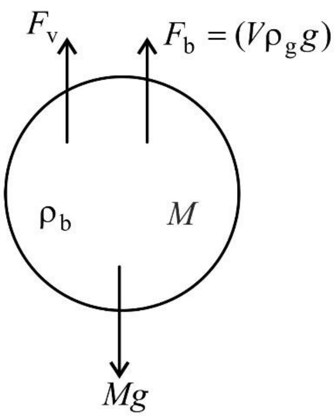
(2) Mg

(3) $\frac{3}{2}\mathrm{Mg}$

(4) 2Mg

Correct Answer: (1)

Q.13. Solution:



$$F_r + F_b = Mg$$

$$F_r = Mg - F_b$$

$$= V\rho_b g - V\rho_g g$$

$$= Vg\left[d - \frac{d}{2}\right]$$

$$= \frac{Vgd}{2}$$

$$= \frac{(Vd)g}{2} = \frac{Mg}{2}$$

14. Match Column - I and Column - II and choose the correct match from the given choices.

Column - I	Column - II
(A) Root mean square speed of gas molecules	(P) $\frac{1}{3}\mathrm{nm}\bar{v}^2$
(B) Pressure exerted by ideal gas	(Q) $\sqrt{\frac{3RT}{M}}$
(C) Average kinetic energy of a molecule	(R) $\frac{5}{2}RT$
(D) Total internal energy of 1 mole of a diatomic gas	(S) $\frac{3}{2}k_BT$

(1) (A) − (R), (B) − (P), (C) − (S), (D) − (Q)

(2) (A) − (Q), (B) − (R), (C) − (S), (D) − (P)

(3) (A) − (Q), (B) − (P), (C) − (S), (D) − (R)

(4) (A) − (R), (B) − (Q), (C) − (P), (D) − (S)

Correct Answer: (3)

Q.14. Solution:

Standard formula for each physical quantity needs to be used.
$(A \rightarrow Q), (B \rightarrow P), (C \rightarrow S)$ & $(D \rightarrow R)$

15. Water falls from a height of 60m at the rate of $15 \mathrm{kg/s}$ to operate a turbine. The losses due to frictional force are 10 \% of the input energy. How much power is generated by the turbine? ($\mathrm{g} = 10 \mathrm{m/s^2}$)

(1) 10.2kW

(2) 8.1kW

(3) 12.3kW

(4) 7.0kW

Correct Answer: (3)

Q.15. Solution:

Change in potential energy of water per second $= 15 \times g \times 60$

$= 9000\ J/s$

Energy remaining per second after loss $= 90\%$ of $9000\ J/s$

$= \left(\frac{90}{100}\right) \times 9000$

$= 8100\ J/s = 8.1\ kW$

16. A lens of large focal length and large aperture is best suited as an objective of an astronomical telescope since :

(1) a large aperture contributes to the quality and visibility of the images.

(2) a large area of the objective ensures better light gathering power.

(3) a large aperture provides a better resolution.

(4) all of the above.

Correct Answer: (4)

Q.16. Solution:

The larger the objective, the more light telescope collects and increases the brightness of image and large focal length enhances the magnifying power of the telescope.

17. The electron concentration in an : n-type semiconductor is the same as hole concentration in a p-type semiconductor. An external field (electric) is applied across each of them. Compare the currents in them.

(1) current in n $-$type = current in p $-$type.

(2) current in n −type > current in p −type.

(3) current in n −type > current in p −type.

(4) No current will flow in p-type, current will only flow in n-type.

Correct Answer: (3)

Q.17. Solution:

Electrons effective mass is smaller than holes therefore mobility of electrons is higher than holes and for equal electric field, drift velocity of the electron will be greater compared to holes.

As concentration is also same for both the cases, hence magnitude of current due to electron will be greater compared to that of holes as $I = neAv$.

18. A nucleus with mass number 240 breaks into two fragments each of mass number 120, the binding energy per nucleon of unfragmented nuclei is 7.6MeV while that of fragments is 8.5MeV. The total gain in the Binding Energy in the process is :

(1) 0.9MeV

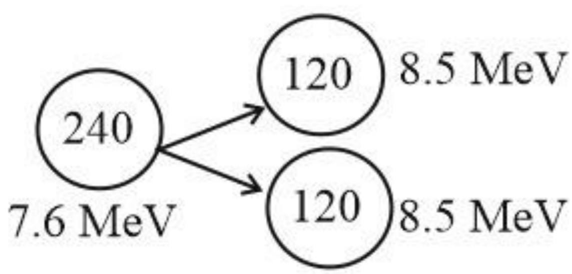
(2) 9.4MeV

(3) 804MeV

(4) 216MeV

Correct Answer: (4)

Q.18. Solution:

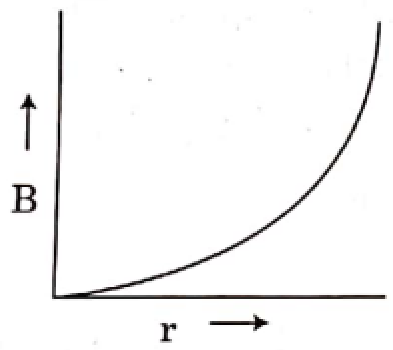


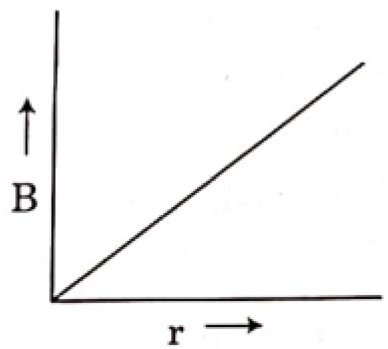
BE gain $= (120 \times 8.5) + (120 \times 8.5) - (240 \times 7.6)$

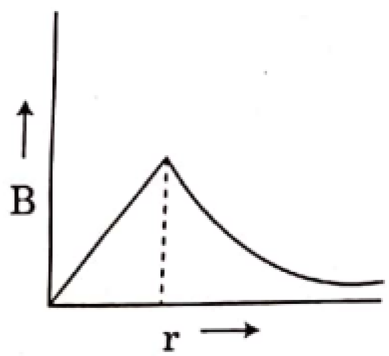
$= 2040 - 1824$

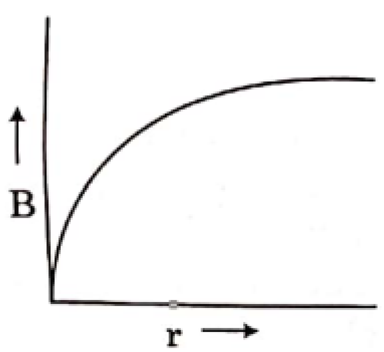
$= 216\ MeV$

19. A thick current carrying cable of radius 'R' carries current 'I' uniformly distributed across its cross-section. The variation of magneticfield B(r) due to the cable with the distance 'r' from the axis of the cable is represented by:

(1) 

(2) 

(3) 

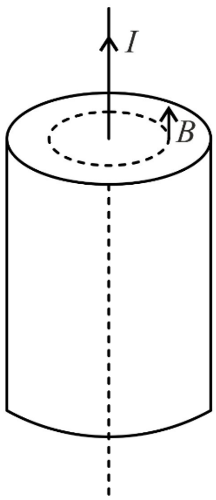
(4) 

Correct Answer: (3)

Solution:

For inside part

$J = \frac{I}{\pi R^2}$



$\int \vec{B} \cdot d\vec{l} = \mu_0 i$ ...(i)

$B\ 2\pi r = \mu_0 \left(\frac{I}{\pi R^2}\right) \times \pi r^2$

$B\ 2\pi r = \mu_0 I \frac{r^2}{R^2}$

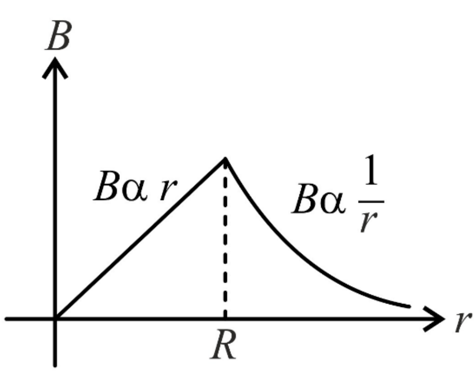
$B = Cr$ where $C =$ constant

For outside part

$\int \vec{B} \cdot d\vec{l} = \mu_0 I$

$B(2\pi r) = \mu_0 I$

$\therefore\ B = \frac{C'}{r}$, where $C' =$ constant



20. Two charged spherical conductors of radius R_1 and R_2 are connected by a wire. Then the ratio of surface charge densities of the spheres (σ_1/σ_2) is :

(1) $\frac{R_1}{R_2}$

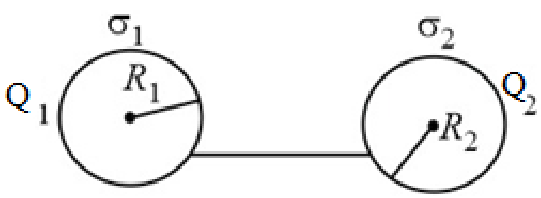
(2) $\frac{R_2}{R_1}$

(3) $\sqrt{\left(\frac{R_1}{R_2}\right)}$

(4) $\sqrt{\left(\frac{R_1}{R_2}\right)}$

Correct Answer: (2)

Solution:



$V_1 = V_2$

$\frac{kQ_1}{R_1} = \frac{kQ_2}{R_2}$

$\frac{\sigma_1 4\pi (R_1)^2}{R_1} = \frac{\sigma_2\, 4\pi (R_2)^2}{R_2}$

$\frac{\sigma_1}{\sigma_2} = \frac{R_2}{R_1}$

21. If E and G respectively denote energy and gravitational constant, then $\frac{E}{G}$ has the dimensions of:

(1) $[M^2][L^{-1}][T^0]$

(2) $[M][L^{-1}][T^{-1}]$

(3) $[M][L^0][T^0]$

(4) $[M^2][L^{-2}][T^{-1}]$

Correct Answer: (1)

Solution:

Dimensional Formulas,

Energy, $[E] = M^1\, L^2\, T^{-2}$

Gravitational constant

$[G] = \left[\frac{Fr^2}{M^2}\right] = \frac{M^1\, L^1 T^{-2} \times L^2}{M^2}$

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

Now,

$\left[\frac{E}{G}\right] = \frac{M\, L^2\, T^{-2}}{M^{-1}\, L^3\, T^{-2}} = M^2\, L^{-1}\, T^o$

Correct option (1)

22. A spring is stretched by 5cm by a force 10N. The time period of the oscillations when a mass of 2kg is suspended by it is:

(1) 0.0628 s

(2) 6.28 s

(3) 3.14 s

(4) 0.628 s

Correct Answer: (2)

Solution:

Spring force, $F = kx$

Spring constant, $k = \frac{F}{x} = \frac{10}{0.05} = 200\ N/m$

Time period, $T = 2\pi\sqrt{\frac{m}{k}}$

$T = 2\pi\sqrt{\frac{2}{200}} = 0.2\,\pi = 6.285$ s

23. Column - I gives certain physical terms associated with flow of current through a metallic conductor. Column - II gives some mathematical relations involving electrical quantities. Match Column - I and Column - II with appropriate relations.

Column - I	Column - II
(A) Drift Velocity	(P) $\frac{\mathrm{m}}{\mathrm{ne}^2\rho}$
(B) Electrical Resistivity	(Q) $\mathrm{ne}v_\mathrm{d}$

(C) Relaxation Period	(R) $\frac{eE}{m}\tau$
(D) Current Density	(S) $\frac{E}{J}$

(1) (A) − (R), (B) − (S), (C) − (P), (D) − (Q)

(2) (A) − (R), (B) − (S), (C) − (Q), (D) − (P)

(3) (A) − (R), (B) − (P), (C) − (S), (D) − (Q)

(4) (A) − (R), (B) − (Q), (C) − (S), (D) − (P)

Correct Answer: (1)

Solution:

Drift velocity, $V = \left(\frac{eE}{m}\right)\tau$

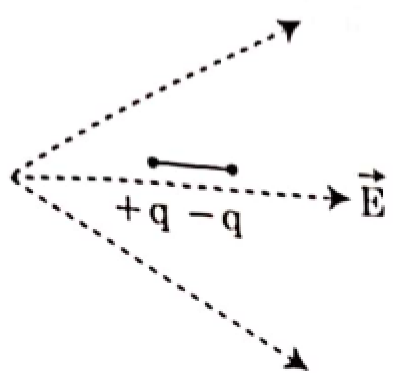
Electrical resistivity, $\rho = \frac{E}{J}$

Relaxation period, $\tau = \frac{m}{ne^2\rho}$

Current Density, $J = neV_d$

$$A - R, B - S, C - P, D - Q$$

24. A dipole is placed in an electric field as shown. In which direction will it move?



(1) towards the left as its potential energy will increase.

(2) towards the right as its potential energy will decrease.

(3) toward, the left as its potential energy will decrease.

(4) towards the right as its potential energy will increase.

Correct Answer: (2)

Solution:

$F_1 = qE_1$, $F_2 = qE_2$

$E_1 > E_2 \Rightarrow F_1 > F_2$

Hence, net force is towards right and its potential energy will decrease.

25. Consider the following statements (A) and (B) and identify the correct answer.

(A) A zener diode is connected in reverse bias, when used as a voltage regulator.

(B) The potential barrier of $\mathrm{p}-\mathrm{n}$ junction lies between 0.1V to 0.3V

(1) (A) and (B) both are correct.

(2) (A) and (B) both are incorrect.

(3) (A) is correct and (B) is incorrect.

(4) (A) is incorrect but (B) is correct.

Correct Answer: (3)

Solution:

$(A)$is correct while (B) is incorrect because Si diode has barrier potential of 0.7V.

26. A screw gauge gives the following readings when used to measure the diameter of a wire

Main scale reading : 0mm

Circular scale reading : 52 divisions

Given that 1mm on main scale corresponds to 100 divisions on the circular scale. The diameter of the wire from the above data is:

(1) 0.52cm

(2) 0.026cm

(3) 0.26cm

(4) 0.052cm

Correct Answer: (3)

Solution:

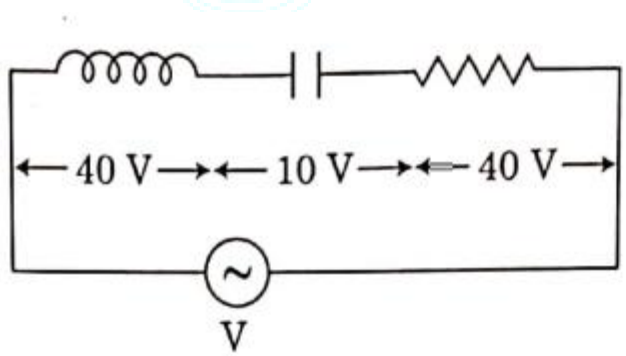
$L \cdot C. = \frac{1}{100}\ mm$

$= 0.01\ mm$

Now,

Diameter of wire $= 52 \times 0.01 = 0.52$ mm $= 0.052$ cm

27. An inductor of inductance L, a capacitor of capacitance C and a resistor of resistance ' R ' are connected in series to an ac source of potential difference ' V ' volts as shown in figure. Potential difference across L,C and R is 40V, 10V and 40V, respectively. The amplitude of current flowing through LCR series circuit is $10\sqrt{2}$A. The impedance of the circuit is :



(1) $4\sqrt{2}\Omega$

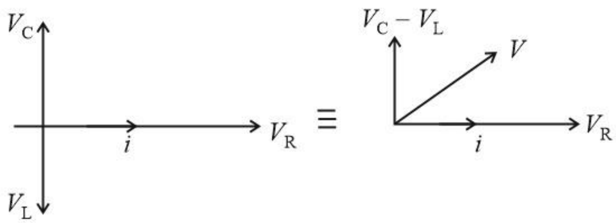
(2) $5/\sqrt{2}\Omega$

(3) 4Ω

(4) 5Ω

Correct Answer: (4)

Solution:



$V = \sqrt{V_R^2 + (V_c - V_L)^2}$

$= \sqrt{40^2 + (10 - 40)^2} = 50$ volt

$i_{\text{rms}} = \frac{v_{rms}}{z}$

$\Rightarrow$ Impedance, $\quad z = \frac{V_{rms}}{i_{rms}}$

$\Rightarrow \quad z = \frac{V_{rms} \times \sqrt{2}}{10}$

$\Rightarrow = \frac{\sqrt{2} \times 50}{10\sqrt{2}}$

$\Rightarrow z = 50\ \Omega$

28. A parallel plate capacitor has a uniform electric field ' $\vec{E}$' in the space between the plates. If the distance between the plates is 'd' and the area of each plate is ' A', the energy stored in the capacitor is : $\varepsilon_0 =$ permittivity of free space)

(1) $\frac{1}{2}\varepsilon_0 \mathrm{E}^2$

(2) $\varepsilon_0 \mathrm{EAd}$

(3) $\frac{1}{2}\varepsilon_0 E^2 Ad$

(4) $\frac{\mathrm{E}^2 \mathrm{Ad}}{\varepsilon_0}$

Correct Answer: (3)

Solution:

Electric energy density $u = \frac{1}{2}\varepsilon_0 E^2$

Volume of the space between plates of Capacitor is Ad.

∴ Energy Stored = Energy density ×Volume

$$= \frac{1}{2}\varepsilon_0 E^2 Ad$$

29. An electromagnetic wave of wavelength ' λ ' is incident on a photosensitive surface of negligible work function. If ' m ' mass is of photoelectron emitted from the surface has de-Broglie wavelength λ_{d}, then :

(1) $\lambda = \left(\frac{2\mathrm{m}}{\mathrm{hc}}\right)\lambda_{\mathrm{d}}^2$

(2) $\lambda_{\mathrm{d}} = \left(\frac{2\mathrm{mc}}{\mathrm{h}}\right)\lambda^2$

(3) $\lambda = \left(\frac{2\mathrm{mc}}{\mathrm{h}}\right)\lambda_{\mathrm{d}}^2$

(4) $\lambda = \left(\frac{2\mathrm{h}}{\mathrm{mc}}\right)\lambda_{\mathrm{d}}2$

Correct Answer: (3)

Solution:

From Einstein's equation,

$$E_{\text{incident}} = \phi \pm KE_{\max}$$

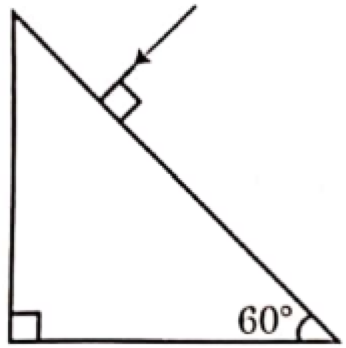
$$h\vartheta = 0 + \frac{1}{2}mv^2$$

$$\frac{hc}{\lambda} = \frac{p^2}{2m} \Rightarrow p = \sqrt{\frac{2mhc}{\lambda}},$$

$$\lambda_d = \frac{h}{p} = \frac{h}{\sqrt{\frac{2mhc}{\lambda}}} = \sqrt{\frac{\lambda h}{2mc}}$$

$$\Rightarrow \lambda = \left(\frac{2mc}{h}\right)\lambda_d^2$$

30. Find the value of the angle of emergence from the prism. Refractive index of the glass is $\sqrt{3}$.



(1) 60°

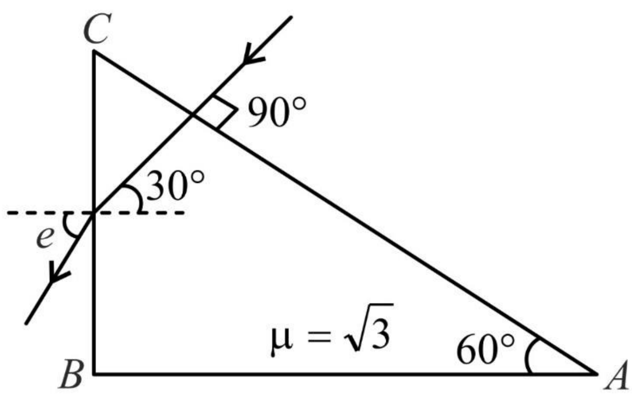
(2) 30°

(3) 45°

(4) 90°

Correct Answer: (1)

Solution:



No refraction at face AC.

Apply Snell's law at face BC, we get

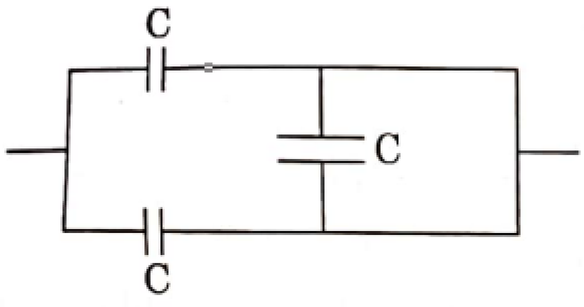
$\mu_1 \sin i = \mu_2 \sin r$

$\sqrt{3} \sin 30° = 1 \times \sin e$

$\frac{\sqrt{3}}{2} = \sin e$

$\Rightarrow e = 60°$

31. The equivalent capacitance of the combination shown in the figure is :



(1) $3C$

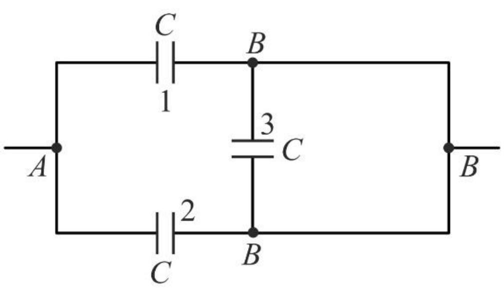
(2) 2C

(3) C/2

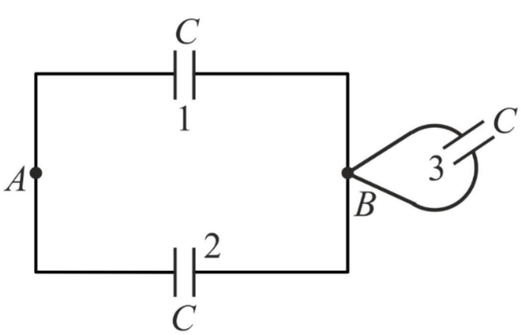
(4) 3C/2

Correct Answer: (2)

Solution:



Redrawing the circuit between A & B



Capacitor 3 can be eliminated and Capacitor1 & 2 are in parallel.

$C_{AB} = C_1 + C_2$

$= C + C$

$= 2C$

32. If force [F], acceleration [A] and time [T] are chosen as the fundamental physical quantities. Find the dimensions of energy.

(1) [F][A][T]

(2) [F][A][T^2]

(3) [F][A][T^{-1}]

(4) [F][A^{-1}][T]

Correct Answer: (2)

Solution:

$[Energy] = [F]^a\ [A]^b\ [T]^c$

$[ML^2T^{-2}] = [MLT^{-2}]^a\ [LT^{-2}]^b\ [T]^c$

$[ML^2T^{-2}] = [M^a L^{a+b} T^{-2a-2b+c}]$

On comparing powers of $[M]$

$a = 1$

On comparing powers of $[L]$

$a + b = 2$

$\Rightarrow\ 1 + b = 2$

$\Rightarrow\ b = 1$

On comparing powers of $[T]$

$-2a - 2b + c = -2$

$\Rightarrow\ -2 - 2 + c = -2$

$\Rightarrow\ c = 2$

$[Energy] = [F]\ [A]\ [T^2]$

33. A cup of coffee cools from 90°C to 80°C in t minutes, when the room temperature is 20°C. The time taken by a similar cup of coffee to cool from 80°C to 60°C at a room temperature same at 20°C is :

(1) $\frac{13}{10}$t

(2) $\frac{13}{5}$t

(3) $\frac{10}{13}$t

(4) $\frac{5}{13}$t

Correct Answer: (2)

Solution:

From Newton's Law of cooling,

$$\frac{\Delta T}{\Delta t} = k(T - T_s)$$

$$\Rightarrow \frac{T_2 - T_1}{t} - k\left(\frac{T_1 + T_2}{2} - T_s\right) T_s$$

where, T_1 =Initial temperature of body

T_2 = Final temperature of body

T_s = Surrounding temperature

t =time taken

For case1,

$$\frac{90 - 80}{t} = k\left(\frac{90 + 80}{2} - 20\right)$$

$$\Rightarrow \frac{10}{t} = 65k$$

$$\Rightarrow k = \frac{10}{65t} \dots (1)$$

For case 2,

$$\frac{80 - 60}{t'} = k\left(\frac{80 + 60}{2} - 20\right)$$

$$\Rightarrow \frac{20}{t'} = 50k$$

Putting the value k from eq. (i),

$$\Rightarrow \frac{20}{t'} = 50 \times \frac{10}{65t}$$

$$\Rightarrow t' = \frac{20 \times 65}{500} t$$

$$\Rightarrow t' = \frac{13}{5} t$$

34. The effective resistance of a parallel connection that consists of four wires of equal length, equal area of cross-section and same material is 0.25 Ω. What will be the effective resistance if they are connected in series?

(1) 0.25Ω

(2) 0.5Ω

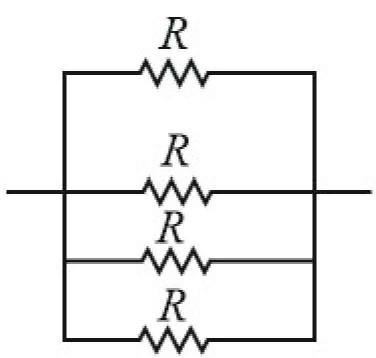
(3) 1Ω

(4) 4Ω

Correct Answer: (4)

Solution:

Let the resistance of each curve be R



Effective resistance in parallel combination,

$R_P = \frac{R}{4}$

$\Rightarrow \quad R = 4R_P$

$\Rightarrow \quad R = 4 \times 0.25 = 10\ \Omega$

Effective resistance is series combination,

$R_S = 4R$

$\Rightarrow \ R_s = 4 \times 1 = 4\Omega$

35. The number of photons per second on an average emitted by the source of monochromatic light of wavelength 600 nm, when it delivers the power of 3.3×10^{-3} watt will be : (h $= 6.6 \times 10^{-34}$ Js)

(1) 10^{18}

(2) 10^{17}

(3) 10^{16}

(4) 10^{15}

Correct Answer: (3)

Solution:

Energy of each photon, $E = \frac{hc}{\lambda}$

$\Rightarrow \ E = \frac{6.6\times10^{-34}\times3\times10^{8}}{600\times10^{-9}}$

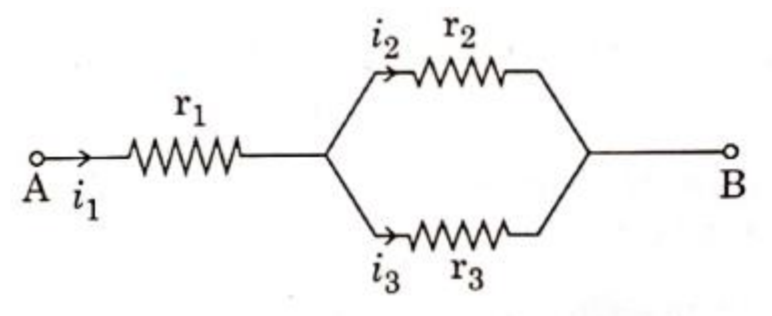
$\Rightarrow \ E = 3.3 \times 10^{-19}\ J$

Number of photons emitted per second, $N = \frac{P}{E}$

$\Rightarrow \ N = \frac{3.3\times10^{-3}}{3.3\times10^{-19}}$

$\Rightarrow \ N = 10^{16}$

36. Three resistors having resistances r_1, r_2 and r_3 are connected as shown in the given circuit. The ratio $\frac{i_3}{i_1}$ of currents in terms of resistances used in the circuit is :



(1) $\frac{r_1}{r_2+r_3}$

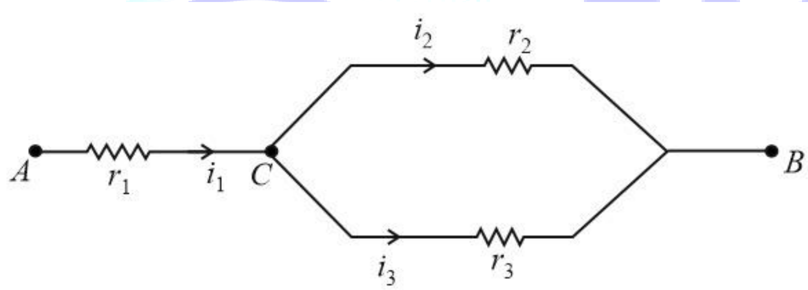
(2) $\frac{r_2}{r_2+r_3}$

(3) $\frac{r_1}{r_1+r_2}$

(4) $\frac{r_1}{r_1+r_2}$

Correct Answer: (2)

Solution:

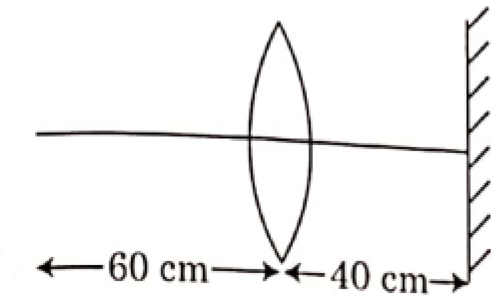


Potential difference between B and C,

$$V_{BC} = i_3 r_3 = i_1 \times \frac{r_2 r_3}{r_2 + r_3}$$

$$\Rightarrow \ i_3 = i_1 \times \frac{r_2}{r_2 + r_3}$$

37. A point object is placed at a distance of 60 cm from a convex lens of focal length 30 cm. If a plane mirror were put perpendicular to the principal axis of the lens and at a distance of 40 cm from it, the final image would be formed at a distance of :



(1) 20cm from the lens, it would be a real image.

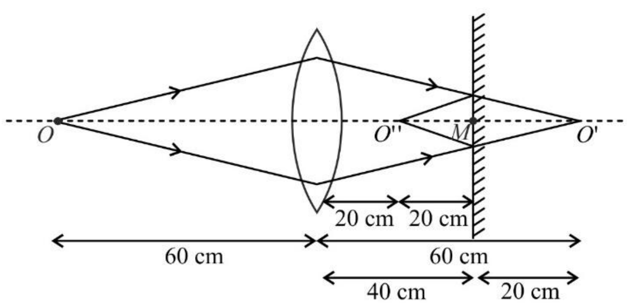
(2) 30cm from the lens, it would be a real image.

(3) 30cm from the plane mirror, it would be a virtual image.

(4) 20cm from the plane mirror, it would be a virtual image.

Correct Answer: (4)

Solution:



Using lens formula,

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$$

$$\Rightarrow \frac{1}{v_1} - \frac{1}{(-60)} = \frac{1}{(+30)}$$

$$\Rightarrow \frac{1}{v_1} = \frac{1}{30} - \frac{1}{60}$$

$$\Rightarrow \frac{1}{v_1} = \frac{1}{60}$$

$$\Rightarrow v_1 = +60 \text{ cm}$$

Distance of image forwed by lens from Mirror,

$d = v_1 - 40 = 60 - 40 = 20 \text{ cm}$

The final image will be formed at a distance of 20 cm from Mirror.

Distance of image from lens in 20 cm.

Again, light will refract from lens

Using lens formula,

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$$

$$\Rightarrow \frac{1}{v_1} - \frac{1}{(-20)} = \frac{1}{(+30)}$$

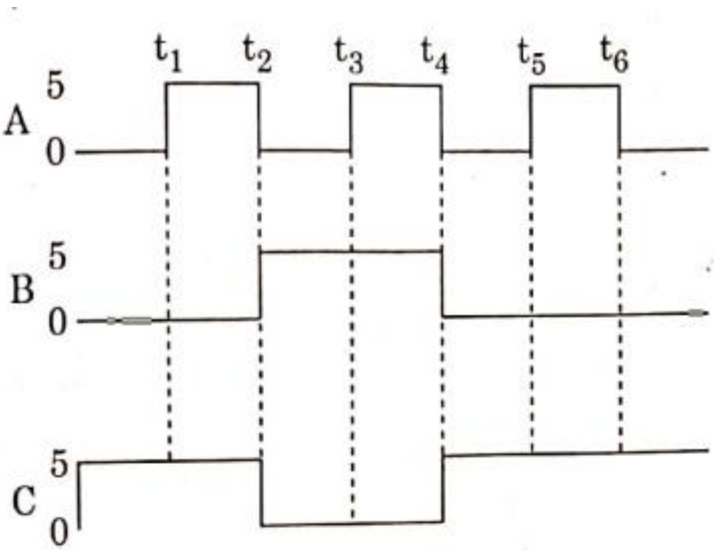
$$\Rightarrow \frac{1}{v_1} = \frac{1}{30} - \frac{1}{20}$$

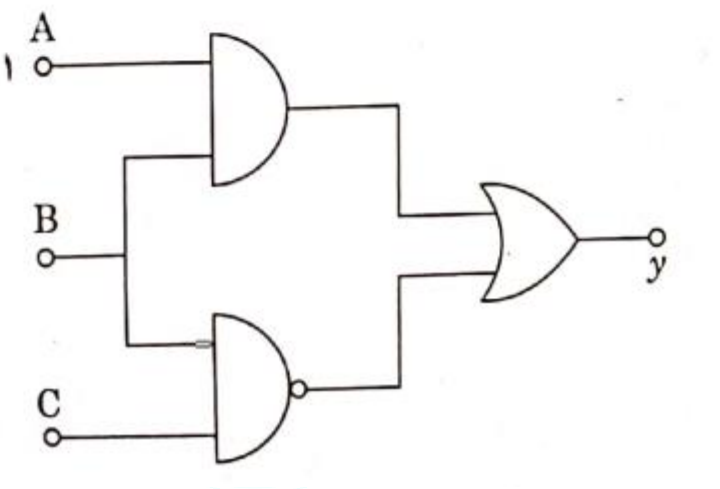
$$\Rightarrow \frac{1}{v_1} = \frac{-10}{600}$$

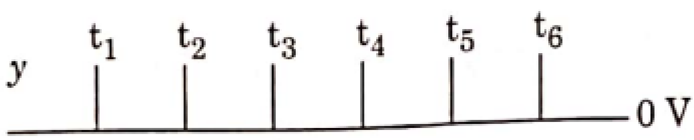
$$\Rightarrow v_1 = -60 \text{ cm}$$

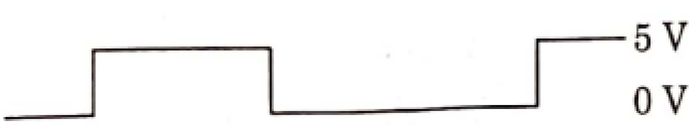
Hence, the image will be virtual and formed at a distance of 60 from lens or 20 from mirror.

38. For the given circuit, the input digital signals are applied at the terminals A, B and C. What would be the output at the terminal y ?





(1) 

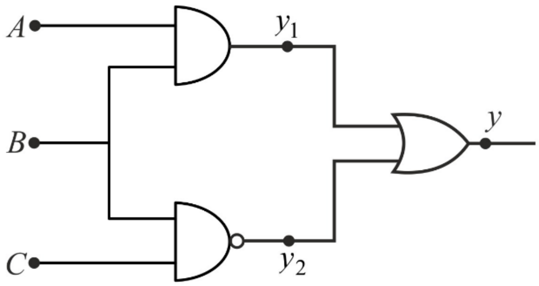
(2) 

(3) 

(4) 

Correct Answer: (3)

Solution:



Truth table of AND gate for output y_1

A	B	y_1
0	0	0
0	1	0
1	0	0
1	1	1

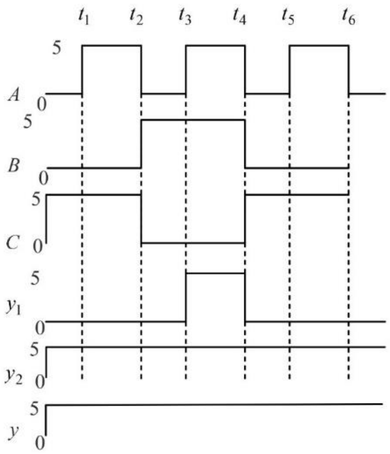
Truth table of NAND gate for output y_2

B	C	y_2
0	0	1
0	1	1
1	0	1
1	1	0

Truth table of OR gate for output y

y_1	y_2	y
0	0	0
0	1	1
1	0	1

1	1	1



39. A step down transformer connected to an ac mains supply of 220V is made to operate at 11 V, 44 W lamp. Ignoring power losses in the transformer, what is the current in the primary circuit?

(1) 0.2A

(2) 0.4A

(3) 2A

(4) 4A

Correct Answer: (1)

Solution:

Power loss is zero. Hence, output Power is equal to input Power.

So, Input Power, $P_1 = 44$ W

$\Rightarrow V_1 i_1 = P_1$

$\Rightarrow i_1 = \frac{P_1}{V_1} = \frac{44}{220} = 0.2$ A

40. A uniform conducting wire of length 12a and resistance ' R ' is wound up as a current carrying coil in the shape of,

(i) an equilateral triangle of side 'a'.

(ii) a square of side 'a'.

The magnetic dipole moments of the coil in each case respectively are :

(1) $\sqrt{3} Ia^2$ and $3Ia^2$

(2) $3Ia^2$ and Ia^2

(3) $3Ia^2$ and $4Ia^2$

(4) $4Ia^2$ and $3Ia^2$

Correct Answer: (1)

Solution:

Area of equilateral triangle of side a,

$$A = \frac{1}{2} \times a \times \frac{\sqrt{3}a}{2} = \frac{\sqrt{3}}{4} a^2$$

Magnetic moment of each triangle,

$$m = IA = \frac{\sqrt{3}}{4} a^2 I$$

$12a$ length of wire will form 4 loops of triangle of side a.

Magnetic moment of triangle,

$$M_1 = Nm = 4 \times \frac{\sqrt{3}}{4} a^2 I = \sqrt{3} I a^2$$

Similarly, magnetic moment of square

$$M_2 = 3 \times (Ia^2)$$

$$= 3Ia^2$$

41. In the product

$$\vec{F} = q(\vec{v} \times \vec{B})$$

$$= q\vec{v} \times \left(B\hat{i} + B\hat{j} + B_0\hat{k} \right)$$

For q = 1 and $\vec{v} = 2\hat{i} + 4\hat{j} + 6\hat{k}$ and $\vec{F} = 4\hat{i} - 20\hat{j} + 12\hat{k}$

What will be the complete expression for $\vec{B}$?

(1) $-8\hat{i} - 8\hat{j} - 6\hat{k}$

(2) $-6\hat{i} - 6\hat{j} - 8\hat{k}$

(3) $8\hat{i} + 8\hat{j} - 6\hat{k}$

(4) $6\hat{i} + 6\hat{j} - 8\hat{k}$

Correct Answer: (2)

Solution:

$$4i - 20j + 12k = (2i + 4j + 6k) \times \left(B\hat{\imath} + B\hat{\jmath} + B_o\hat{k}\right)$$

$$4i - 20j + 12k = \begin{vmatrix} +i & -j & +k \\ 2 & 4 & 6 \\ B & B & B_0 \end{vmatrix}$$

$$= (4B_0 - 6B)i - (2B_0 - 6B)j + (2B - 4B)k$$

$$4B_0 - 6B = 4$$

$$2B_0 - 6B = 20$$

$$2B - 4B = 12 \Rightarrow B = 6$$

SO $2B_0 - 6(-6) = 20$

$$2B_0 = 20 - 36 \Rightarrow B_0 = -8$$

$$\therefore \vec{B} = -6\hat{\imath} - 6\hat{\jmath} - 8\hat{k}$$

42. A particle moving in a circle of radius R with a uniform speed takes a time 'I' to complete one revolution. If this particle were projected with the same speed at an angle ' θ ' to the horizontal, the maximum height attained by it equals 4R. The angle of projection, θ, is then given by :

(1) $\theta = \cos^{-1}\left(\frac{gT^2}{\pi^2 R}\right)^{1/2}$

(2) $\theta=\cos^{-1}\left(\frac{\pi^2 R}{gT^2}\right)^{1/2}$

(3) $\theta=\sin^{-1}\left(\frac{\pi^2 R}{gT^2}\right)^{1/2}$

(4) $\theta=\sin^{-1}\left(\frac{2gT^2}{\pi^2 R}\right)^{1/2}$

Correct Answer: (4)

Solution:

$$T=\frac{2\pi}{\omega}=\frac{2\pi r}{v}\Rightarrow v=\frac{2\pi r}{T}$$

$$H=\frac{v^2\sin^2\ \theta}{2g}\Rightarrow 4R=\frac{4\pi^2R^2\sin^2\ \theta}{2gT^2}$$

$$\Rightarrow \sin^2\theta=\frac{2gT^2}{\pi^2R}$$

$$\Rightarrow \sin\theta=\left(\frac{2gT^2}{\pi^2R}\right)^{1/2}$$

$$\Rightarrow \theta=\sin^{-1}\left(\frac{2gT^2}{\pi^2R}\right)^2$$

43. A series LCR circuit containing 5.0 H inductor, 80 μF capacitor and 40 Ω resistor is connected to 230 V variable frequency ac source. The angular frequencies of the source at which power transferred to the circuit is half the power at the resonant angular frequency are likely to be:

(1) 25rad/s and 75rad/s

(2) 50rad/s and 25rad/s

(3) 46rad/s and 54rad/s

(4) 42rad/s and 58rad/s

Correct Answer: (3)

Solution:

$L=5H, C=80\mu F, R=40\omega; \varepsilon_{rms}=230\ V$

Half power frequencies,

$\omega_1 = -\frac{RC+\sqrt{R^2C^2+4LC}}{2LC}$ and $\omega_2 = \frac{RC+\sqrt{R^2C^2+4LC}}{2LC}$

$\omega_1 = \frac{(-40\times80\times10^{-6})+\sqrt{(40\times80\times10^{-6})^2+(4\times5\times80\times10^{-6})}}{2\times5\times80\times10^{-6}}$

Here, $(40 \times 80 \times 10^{-6})^2$ is negligible.

We get,

$\omega_1 = 46\ rad/s$

And $\omega_2 = 54\ rad/s$

44. From a circular ring of mass 'M' and radius 'R'an arc corresponding to a 90° sector is removed. The moment of inertia of the remaining part of the ring about an axis passing through the centre of the ring and perpendicular to the plane of the ring is 'K' times $'MR^{2\prime}$. Then the value of 'K' is :

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

(2) $\frac{7}{8}$

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

(4) $\frac{1}{8}$

Correct Answer: (1)

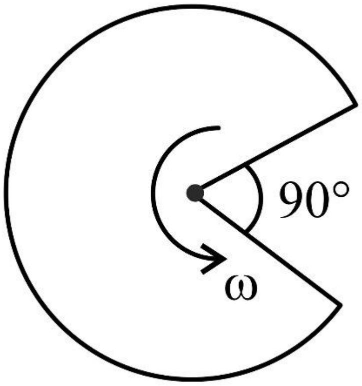
Solution:

mass per unit length of the ring is

$\lambda = \frac{M}{2\pi R}$

$\therefore$ Mass of remaining ring is $M' = \lambda \times \frac{3}{4}(2\pi R)$

$\therefore\ M' = \frac{3}{4}M.$

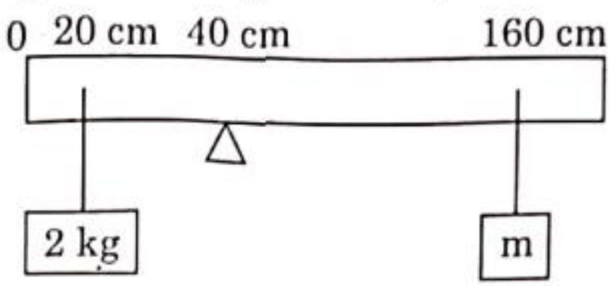


Moment of inertia of remaining part is

$I' = M'R^2 = \frac{3}{4}MR^2 = KMR^2$

$\therefore \quad K = \frac{3}{4}$

45. A uniform rod of length 200cm and mass 500g is balanced on a wedge placed at 40cm mark. A mass of 2kg is suspended from the rod at 20cm and another unknown mass ' m ' is suspended from the rod at 160cm mark as shown in the figure. Find the value of 'm' such that the rod is in equilibrium. $(g = 10 m/s^2)$



(1) $\frac{1}{2}$ kg

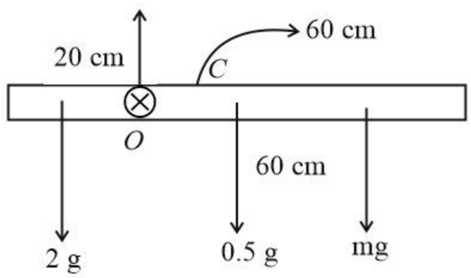
(2) $\frac{1}{3}$ kg

(3) $\frac{1}{6}$ kg

(4) $\frac{1}{12}$ kg

Correct Answer: (4)

Solution:



Torque balance about $'O'$

$2g \times 20 = 0.5\ g \times 60 + mg \times 120$

$\Rightarrow \quad 2 = 1.5 + 6m$

$\Rightarrow \quad m = \frac{0.5}{6} = \frac{1}{12}\ kg$

46. Twenty-seven drops of same size are charged at 220V each. They combine to form a bigger drop. Calculate the potential of the bigger drop.

(1) 660V

(2) 1320V

(3) 1520V

(4) 1980V

Correct Answer: (4)

Solution:

$V_{big} = n^{2/3}\ V_{small}$

$= (27)^{2/3} \times 220$

$= 1980\ V$

47. A car starts from rest and accelerates at $5 \mathrm{m/s^2}$ At $\mathrm{t} = 4\mathrm{s}$, a ball is dropped out of a window by a person sitting in the car. What is the velocity and acceleration of the ball at $t = 6s$?

(Take $\mathrm{g} = 10 \mathrm{m/s^2}$)

(1) $20 \mathrm{m/s}, 5 \mathrm{m/s^2}$

(2) $20 \mathrm{m/s}, 0$

(3) $20\sqrt{2} \mathrm{m/s} \cdot 0$

(4) $20\sqrt{2} \mathrm{m/s}, 10 \mathrm{m/s^2}$

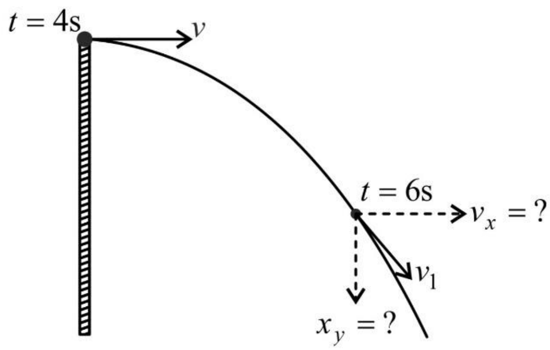
Correct Answer: (4)

Solution:

Car velocity at $t = 4\ s$ is $v = u + at$

$v = 0 + 5 \times 4 = 20\ ms^{-1}$

For an observe on ground, the ball follows parabolic path same as horizontal projectile.



Velocity at $6s$ is $v_1 = \sqrt{v_x^2 + v_y^2}$

$v_1 = \sqrt{v^2 + g^2(\Delta t)^2}$

$= \sqrt{20^2 + 10^2 \times 2^2}$

$= 20\sqrt{2}\ ms^{-1}$

And as the body is under free fall, its acceleration at $t = 6s$ is $10\ ms^{-2}$

$\left(20\sqrt{2}\ ms^{-1}, 10\ ms^{-2}\right)$

48. A particle of mass ' m ' is projected with a velocity $v = \mathrm{kV_e}(\mathrm{k} < 1)$ from the surface of the earth. ($\mathrm{V_e}$ =escape velocity) The maximum height above the surface reached by the particle is:

(1) $R\left(\frac{k}{1-k}\right)^2$

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

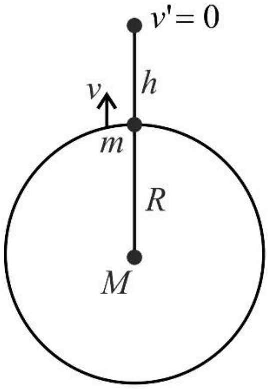
(3) $\frac{\mathrm{R^2k}}{1+\mathrm{k}}$

(4) $\frac{\mathrm{Rk^2}}{1-\mathrm{k^2}}$

Correct Answer: (4)

Solution:

$v = kV_e (k < 1)$



$$\frac{1}{2}mv^2 - \frac{GMm}{R} = 0 - \frac{GMm}{R+h}$$

$$\frac{1}{2}mk^2 \times \frac{2GM}{R} - \frac{GMm}{R} = -\frac{GMm}{R+h}$$

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

$$V_e = \sqrt{\frac{2GM}{R}}$$

$$\frac{k^2}{R} = \frac{h}{R(R+h)} \Rightarrow 1 + \frac{R}{h} = \frac{1}{k^2}$$

$$\Rightarrow \frac{R}{h} = \frac{1}{k^2} - 1$$

$$\Rightarrow h = \frac{RK^2}{1-k^2}$$

49. A ball of mass 0.15kg is dropped from a height 10m strikes the ground and rebounds to the same height. The magnitude of impulse imparted to the ball is $(\text{g} = 10\text{m/s}^2)$ nearly:

(1) 0kgm/s

(2) 4.2kgm/s

(3) 2.1kgm/s

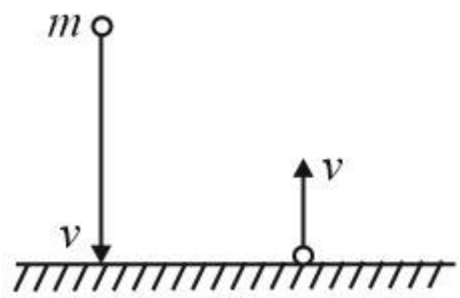
(4) 1.4kgm/s

Correct Answer: (2)

Solution:

$m = 0.15$ kg; $h = 10$ m.

$v = \sqrt{2gh} = \sqrt{2 \times 9.8 \times 10} = 14\ m/s$



Impulse

$= -mv - mv = -2mv$

$= 2 \times 0.15 \times 14$

$= -4.2\ kg\ m/s$

(To raise back to same height ,rebound velocity is same as the hitting velocity)

50. Two conducting circular loops of radii R_1 and R_2 are placed in the same plane with their centres coinciding. If $R_1 >> R_2$, the mutual inductance M between them will be directly proportional to:

(1) $\frac{R_1}{R_2}$

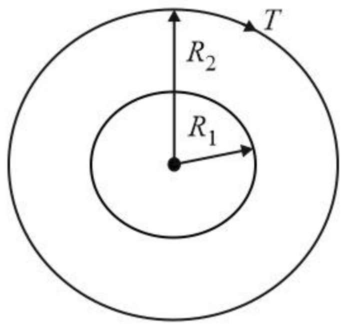
(2) $\frac{R_2}{R_1}$

(3) $\frac{R_1^2}{R_2}$

(4) $\frac{R_2^2}{R_1}$

Correct Answer: (4)

Solution:



magnetic field at center of the smaller coil is

$$B = \frac{\mu_0 i}{2\pi R_1}$$

Flux linking with the smaller coil is $\phi = \frac{\mu_0 i}{2\pi R_1}\pi R_2^2$

$\therefore$ Mutual inductance,

$$M = \frac{\phi}{i} = \frac{\mu_0 R_2^2}{2R_1}$$

$\therefore\ M \propto \frac{R_2^2}{R_1}$