JEE Main July 2021

Question Paper With Text Solution

22 July. | Shift-2

PHYSICS

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JEE MAIN JULY 2021 | 22TH JULY SHIFT-2

SECTION – A

1. Statement I : The ferromagnetic property depends on temperature. At high temperature, ferromagnet becomes paramagnet.

Statement II : At high temperature, the domain wall are of a ferromagnetic substance increases.

In the light of the above statements, choose the most appropriate answer from the options given below :

(1) Statement I is true but Statement II is false

(2) Both Statement I and Statement II are true

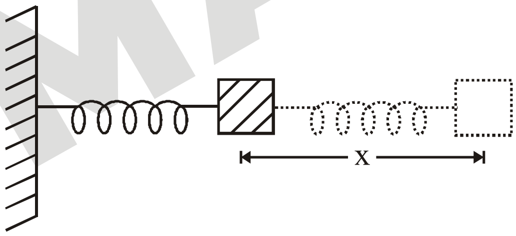
(3) Both Statement I and Statement II are false

(4) Statement I is false but Statement II is true

Ans. Official Answer NTA (1)

Sol. At high temp. damain structure breaks so ferromagnetic material behawes like paramagnetic material.

2. The motion of a mass on a spring, with spring constant K is as shown in figure.



The equation of motion is given by x(t) = Asinωt + Bcosωt with $\omega = \sqrt{\frac{K}{m}}$ Suppose that at time t = 0, the position of mass is x(0) and velocity υ(0), then its displacement can also be represented as x(t) = C cos(ωt – ϕ), where C and ϕ are :

(1) $C = \sqrt{\frac{2\upsilon(0)^2}{\omega^2} + x(0)^2}, \phi = \tan^{-1}\left(\frac{x(0)\omega}{2\upsilon(0)}\right)$

(2) $C = \sqrt{\frac{\upsilon(0)^2}{\omega^2} + x(0)^2}, \phi = \tan^{-1}\left(\frac{\upsilon(0)}{x(0)\omega}\right)$

(3) $C = \sqrt{\frac{\upsilon(0)^2}{\omega^2} + x(0)^2}, \phi = \tan^{-1}\left(\frac{x(0)\omega}{\upsilon(0)}\right)$

(4) $C=\sqrt{\frac{2\upsilon(0)^2}{\omega^2}+x(0)^2},\phi=\tan^{-1}\left(\frac{\upsilon(0)}{x(0)\omega}\right)$

Ans. Official Answer NTA (2)

Sol. $x = A\sin\omega t + B\cos\omega t$

$$x = \sqrt{A^2+B^2}\left[\frac{A}{\sqrt{A^2+B^2}}\sin\omega t+\frac{B}{\sqrt{A^2+B^2}}\cos\omega t\right]$$

$$x=\sqrt{A^2+B^2}\left[\sin\phi\sin\omega t+\cos\phi\cos\omega t\right]$$

$$\frac{A}{\sqrt{A^2+B^2}}=\sin\phi \Rightarrow A=\sqrt{A^2+B^2}\sin\phi$$

& $B=\sqrt{A^2+B^2}\cos\phi$

$$\Rightarrow x=\sqrt{A^2+B^2}\cos(\omega t-\phi)\Rightarrow x(0)=\sqrt{A^2+B^2}\cos\phi$$

$$\therefore C=\sqrt{A^2+B^2}$$

and $V=\frac{dx}{dt}=-\omega\sqrt{A^2+B^2}\sin(\omega t-\phi)$

$$V(0)=-\omega\sqrt{A^2+B^2}\sin\phi$$

$$\therefore \frac{V(0)}{x(0)}=\omega\tan\phi \Rightarrow \phi=\tan^{-1}\left[\frac{V(0)}{\omega x(0)}\right] \text{ and } \frac{V(0)^2}{\omega^2}=(A^2+B^2)\sin^2\phi$$

$$x(0)^2=(A^2+B^2)\cos^2\phi$$

$$\therefore\sqrt{\frac{V(0)^2}{\omega^2}+x(0)^2}=\sqrt{A^2+B^2}=C$$

3. A bullet of '4g' mass is fired from a gun of mass 4kg. If the bullet moves with the muzzle speed of $50ms^{-1}$, the impulse imparted to the gun and velocity of recoil of gun are :

(1) 0.2 kg ms^{-1}, 0.1 ms^{-1}
(2) 0.2 kg ms^{-1}, 0.05 ms^{-1}
(3) 0.4 kg ms^{-1}, 0.1 ms^{-1}
(4) 0.4 kg ms^{-1}, 0.05 ms^{-1}

Ans. Official Answer NTA (2)

Sol. Impulse imparted = change in momentum of bullet

$$=\frac{4}{1000}\times 50=\frac{1}{5}=0.2kg$$

and velocity of recoil of gun = $\frac{\text{Im pulse imparted}}{\text{mass of gun}}$

$= \frac{0.2}{4} = 0.05 m/s$

4. An electron of mass m_e and a proton of mass m_p are accelerated through the same potential difference. The ratio of the de–Broglie wavelength associated with the electron to that with the proton is :

(1) $\frac{m_p}{m_e}$ (2) 1 (3) $\frac{m_e}{m_p}$ (4) $\sqrt{\frac{m_p}{m_e}}$

Ans. Official Answer NTA (4)

Sol. De-Broglie wave length $(\lambda) = \frac{h}{p}$

$P = \sqrt{2mk} = \sqrt{2m(qv)}$

$\therefore \frac{\lambda_e}{\lambda_p} = \sqrt{\frac{m_p}{m_e}}$

5. Consider a situation in which reverse biased current of a particular P–N junctin increases when it is exposed to a light of wavelength ≤ 621 nm. During this process, enhancement in carrier concentration takes place due to generation of hole–electron pairs. The value of band gap is nearly.

(1) 2 eV (2) 1 eV (3) 4 eV (4) 0.5 eV

Ans. Official Answer NTA (1)

Sol. Band Gap $= \frac{hc}{\lambda} = \frac{1240}{621} \approx 2eV$

6. What should be the height of transmitting antenna and the population covered if the television telecast is to cover radius of 150 km ? The average population density around the tower is $2000/km^2$ and the value of $R_e = 6.5 \times 10^6$ m.

(1) Height = 1731 m

Population Covered = 1413×10^5

(2) Height = 1241 m

Population Covered = 7×10^5

(3) Height 1800 m

Population Covered = 1413×10^8

(4) Height = 1600 m

Population Covered = 2×10^5

Ans. Official Answer NTA (1)

Sol. (R) Radius of Earth = 6.5×10^6m , Let height of antenna is h.

$\therefore$ Radius Covered = 150 km = $150 \times 10^3 = \sqrt{2gh}$

$\Rightarrow 150 \times 150 \times 10^6 = 2 \times 6.5 \times 10^6 \times h$

$\Rightarrow h = \dfrac{150 \times 150}{2 \times 6.5} \approx 1731 m$

Population covered = $2\pi Rh \times \text{density}$

$= 2\pi \times 6.5 \times 10^6 \times 1731 \times 2000 \times 10^{-6}$

$\approx 1413 \times 10^5$

7. T_0 is the time period of a simple pendulum at a place. If the length of the pendulum is reduced to $\dfrac{1}{16}$ times of its initial value, the modified time period is :

(1) $4\ T_0$ (2) T_0 (3) $8\pi\ T_0$ (4) $\dfrac{1}{4} T_0$

Ans. Official Answer NTA (4)

Sol. $T_o = 2\pi\sqrt{l/g}$

$T' = 2\pi\sqrt{l/16g} = \dfrac{T_o}{4}$

8. What will be the average value of energy for a monotomic gas in thermal equilibrium at temperature T ?

(1) $\dfrac{1}{2}k_B T$ (2) $k_B T$ (3) $\dfrac{2}{3}k_B T$ (4) $\dfrac{3}{2}k_B T$

Ans. Official Answer NTA (4)

Sol. $E = \dfrac{f}{2}k_b T = \dfrac{3}{2}k_b T$

9. What will be the projection of vector $\vec{A} = \hat{i} + \hat{j} + \hat{k}$ on vector $\vec{B} = \hat{i} + \hat{j}$?

(1) $(\hat{i} + \hat{j})$ (2) $\sqrt{2}(\hat{i} + \hat{j})$ (3) $2(\hat{i} + \hat{j} + \hat{k})$ (4) $2(\hat{i} + \hat{j} + \hat{k})$

Ans. Official Answer NTA (1)

Sol. Angle b/w $\overline{A}$ & $\overline{B} \Rightarrow$ $\cos\theta = \dfrac{\overline{A} \cdot \overline{B}}{AB} = \dfrac{1+1+0}{\sqrt{3}\sqrt{2}} = \sqrt{\dfrac{2}{3}}$

Projection of $\overline{A}$ on $\overline{B}$ = $(A\cos\theta)\hat{B} = \sqrt{3}\left(\sqrt{\dfrac{2}{3}}\right)\left(\dfrac{\hat{i}+\hat{j}}{\sqrt{2}}\right) = \hat{i} + \hat{j}$

10. A porter lifts a heavy suitcase of mass 80 kg and at the destination lowers it down by a distance of 80 cm with a constant velocity. Calculate the workdone by the porter in lowering the suitcase.
(take $g = 9.8\ ms^{-2}$)

(1) 784.0 J (2) –627.2 J (3) –62720.0 J (4) +627.2 J

Ans. Official Answer NTA (2)

Sol. $w_{porter} + w_g = \Delta k = 0 \quad (\because V \rightarrow \text{constant})$

$$\Rightarrow w_{porter} = -w_g = -mgh = -(80)(9.8)\left(\frac{80}{100}\right)$$

$$\Rightarrow w_{porter} = -627.2J$$

11. Intensity of sunlight is observed as $0.092\ Wm^{-2}$ at a point in free space. What will be the peak value of magnetic field at that point ? ($\varepsilon_0 = 0.85 \times 10^{-12}\ C^2\ N^{-1}m^{-2}$)

(1) 8.31 T (2) 2.77×10^{-8} T (3) 1.96×10^{-8} T (4) 5.88 T

Ans. Official Answer NTA (2)

Sol. $\frac{1}{2} \in_o E_o^2 C = I$

$$\Rightarrow E_o = \sqrt{\frac{2I}{\in_o C}}$$

$$\therefore B_o = \frac{E_o}{C}$$

$$\Rightarrow B_o = \frac{1}{C}\sqrt{\frac{2I}{\in_o C}} = \frac{1}{3\times10^8}\sqrt{\frac{2\times0.092}{8.85\times10^{-12}\times3\times10^8}}$$

$= 2.77 \times 10^{-8}$ T

12. Match List – I with List – II :

List – I	List – II
(a) $\omega L > \frac{1}{\omega C}$	(i) Current is in phase with emf
(b) $\omega L = \frac{1}{\omega C}$	(ii) Current lags behind the applied emf
(c) $\omega L < \frac{1}{\omega C}$	(iii) Maximum current occurs
(d) Resonant frequency	(iv) Current leads the emf

Choose the correct answer from the options given below :

(1) (a)–(iii); (b)–(i); (c)–(iv); (d)–(ii)   (2) (a)–(ii); (b)–(i); (c)–(iii); (d)–(iv)

(3) (a)–(ii); (b)–(i); (c)–(iv); (d)–(iii)   (4) (a)–(iv); (b)–(iii); (c)–(ii); (d)–(i)

Ans. Official Answer NTA (3)

Sol. (a) $\omega L > \frac{1}{\omega C}$ $\Rightarrow$ Current lags behind the applied EmF

(b) $\omega L = \frac{1}{\omega C} \Rightarrow$ Current is in phase with emF

(c) $\omega L < \frac{1}{\omega C} \Rightarrow$ current leads the emF.

(d) Resonant frequency $\Rightarrow$ maximum current occurs.

13. Choos the correct option :

(1) True dip is always equal to apparent dip.

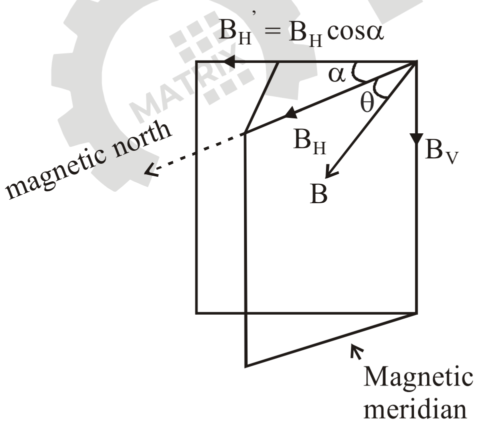
(2) True dip is not mathematically related to apparent dip.

(3) True dip is always greater than the apparent dip.

(4) True dip is less than tthe apparent dip.

Ans. Official Answer NTA (4)

Sol.



$\tan\theta' = \frac{\tan\theta}{\cos\alpha}$ where $\theta' \rightarrow$ apparent dip and $\theta \rightarrow$ true dip.

As $\cos\alpha < 1$ so $\tan\theta' > \tan\theta$ so $\theta' > \theta$

14. A body is projected vertically upwards from the surface of earth with a velocity sufficient enough to carry it to infinity. The time taken by it to reach height h is ____________s.

(1) $\frac{1}{3}\sqrt{\frac{2R_e}{g}}\left[\left(1+\frac{h}{R_e}\right)^{\frac{3}{2}}-1\right]$

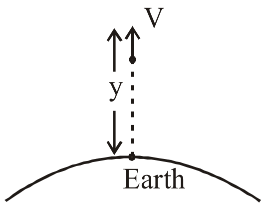
(2) $\frac{1}{3}\sqrt{\frac{R_e}{2g}}\left[\left(1+\frac{h}{R_e}\right)^{\frac{3}{2}}-1\right]$

(3) $\sqrt{\frac{2R_e}{g}}\left[\left(1+\frac{h}{R_e}\right)^{\frac{3}{2}}-1\right]$

(4) $\sqrt{\frac{R_e}{2g}}\left[\left(1+\frac{h}{R_e}\right)^{\frac{3}{2}}-1\right]$

Ans. Official Answer NTA (1)

Sol.



From M.E. constravation from y to infinite.

$$\frac{1}{2}mv^2-\frac{GMm}{R_e+y}=0$$

$$\Rightarrow v=\sqrt{\frac{2GM}{R_e+y}}$$

$$\Rightarrow \frac{dy}{dt}=\sqrt{\frac{2GM}{R_e+y}}$$

$$\Rightarrow \int_0^h\left(\sqrt{R_e+y}\right)dy=\sqrt{2GM}\int_0^t dt$$

$$\Rightarrow \left[\frac{2(R_e+y)}{3}\right]_0^h=\sqrt{2GM}t \Rightarrow \sqrt{2GM}t$$

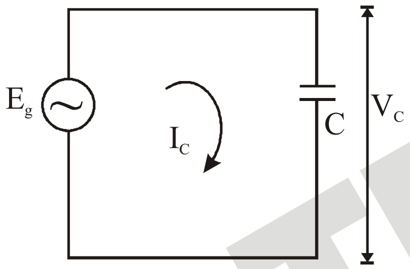
$$=\frac{2}{3}\left[\left(R_e+b\right)^{3/2}-R_e^{\ 3/2}\right]$$

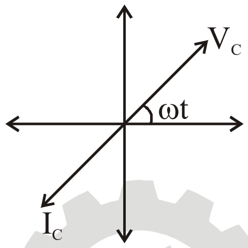
$$\Rightarrow t=\frac{\frac{2}{3}\left[\left(R_e+y\right)^{3/2}-R_e^{\ 3/2}\right]}{\sqrt{2GM}}$$

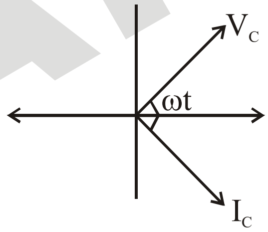
$$t = \frac{2}{3}\sqrt{\frac{R_e^3}{2GM}}\left[\left(1+\frac{h}{R_e}\right)^{3/2} - 1\right]$$

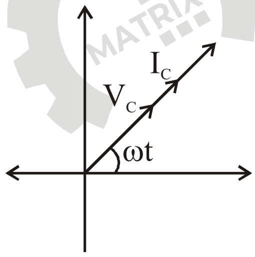
$$t = \frac{1}{3}\sqrt{\frac{2R_e^3}{g}}\left[\left(1+\frac{h}{R_e}\right)^{3/2} - 1\right]$$

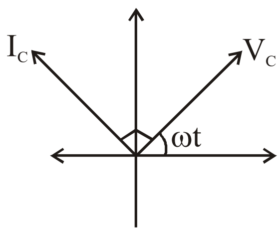
15. In a circuit consisting of a capacitance and a generator with alternating emf $E_g = E_{g0}$ sinωt, V_C and I_C are the voltage and current. Correct phasor diagram for such circuit is :



(1)


(2)


(3)


(4)


Ans. Official Answer NTA (4)

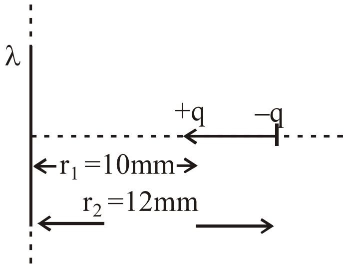
Sol. In pure capacitive circuit, current leads valtage by $\pi/2$ phase.

16. An electric dipole is placed on x–axis in proximity to a line charge of linear charge density 3.0×10^{-6} C/m. Line charge is placed on z–axis and positive and negative charge of dipole is at a distance of 10 mm and 12 mm from the origin respectively. If total force of 4 N is exerted on the dipole, find out the amount of positive or negative charge of the dipole.

(1) 8.8 μC (2) 0.485 mC (3) 815.1 nC (4) 4.44 μC

Ans. Official Answer NTA (4)

Sol.



$$F_{net} = \frac{2k\lambda q}{r_1} + \frac{2k\lambda}{r_2}(-q)$$

$$\Rightarrow 4N = 2k\lambda q\left[\frac{1}{r_1} - \frac{1}{r_2}\right]$$

$$\Rightarrow 4 = 2 \times 9 \times 10^9 \times 3 \times 10^{-6} \times q\left[\frac{1}{10} - \frac{1}{12}\right] \times 10^3$$

$$\Rightarrow 4 = 54 \times 10^3 \times q\left[\frac{2}{10 \times 12}\right] \times 10^3$$

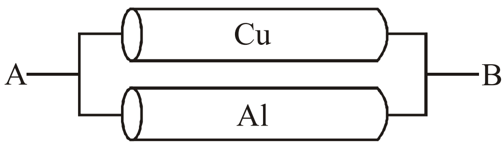
$$\Rightarrow q = \frac{4 \times 10 \times 12}{54 \times 10^3 \times 2 \times 10^3} = 0.444 \times 10^{-5}$$

$$\Rightarrow q = 4.44 \times 10^{-6} C = 4.44 \mu C$$

17. A Copper (Cu) rod of length 25 cm and cross–sectional are 3 mm^2 is joined with a similar Aluminium (Al) rod as shown in figure. Find the resistance of the combination between the ends A and B.

(Take Resistivity of Copper = 1.7×10^{-8} Ωm

Resistivity of Copper = 1.6×10^{-8} Ωm)



(1) 0.858 mΩ (2) 1.420 mΩ (3) 0.0858 mΩ (4) 2.170 mΩ

Ans. Official Answer NTA (1)

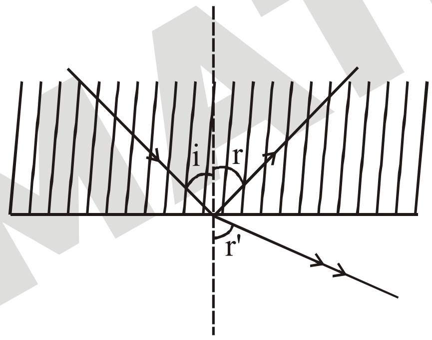
Sol. $$Req = \frac{R_1R_2}{R_1+R_2} = \frac{\rho_1\left(\frac{l}{A}\right)\rho_2\left(\frac{l}{A}\right)}{\rho_1\left(\frac{l}{A}\right)+\rho_2\left(\frac{l}{A}\right)} = \frac{l}{A}\left[\frac{\rho_1\rho_2}{\rho_1+\rho_2}\right]$$

$$Req = \frac{0.25}{3\times10^{-6}}\left[\frac{1.7\times10^{-8}\times2.6\times10^{-8}}{1.7\times10^{-8}+2.6\times10^{-8}}\right]$$

$= 0.0858\times10^{-2}$

$= 0.858 m\Omega$

18. A ray of light passes from a denser medium to a rarer medium at an of incidence i. The reflected and refracted rays make an angle of 90º with each other. the angle of reflection and refraction are respectively r and r'. The critical angle is given by :



(1) $\sin^{-1}(\cot r)$ (2) $\sin^{-1}(\tan r')$ (3) $\tan^{-1}(\sin i)$ (4) $\sin^{-1}(\tan r)$

Ans. Official Answer NTA (4)

Sol. i = r and r + r' = 90

$\Rightarrow r' = 90 - r$

and $\mu \sin i = (1)\sin r'$

$$\Rightarrow \frac{1}{\mu} = \frac{\sin i}{\sin r'}$$

$$\Rightarrow \frac{1}{\mu} = \frac{\sin r}{\cos r} = \tan r$$

$\therefore$ Critical angle $(\theta_c) = \sin^{-1}\left[\frac{1}{\mu}\right]$

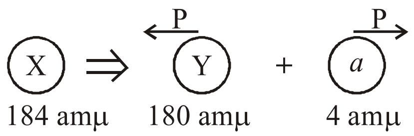
$\Rightarrow (\theta_c) = \sin^{-1}(\tan r)$

19. A nucleus with mass number 184 initially at rest emits an α–particle. If the Q value of the reaction is 5.5 MeV, calculate the kinetic energy of the α–particle.

(1) 5.0 MeV (2) 5.5 MeV (3) 5.38 MeV (4) 0.12 MeV

Ans. Official Answer NTA (3)

Sol.



$$k_\alpha = \left(\frac{A-4}{A}\right)Q = \left(\frac{180}{184}\right)\times 5.5\text{MeV}$$

$$\Rightarrow k_\alpha = 5.38\text{MeV}$$

20. Consider a situation in which a ring, a solid cylinder and a solid sphere roll down on the same inclined plane without slipping. Assume that they start roling from rest and having identical diameter.

The correct statement for this situation is :

(1) The ring has the greatest and the cylinder has the least velocity of the centre of mass at the bottom of the inclined plane.

(2) The sphere has the greatest and the ring has the least velocity of the centre of mass at the bottom of the inclined plane.

(3) The cylinder has the greatest and the sphere has the least velocity of the centre of mass at the bottom of the inclined plane.

(4) All of them will have same velocity.

Ans. Official Answer NTA(2)

Sol. From work energy theorm:-

$mgh = \frac{1}{2}I_C\omega^2 + \frac{1}{2}mV_C^2$ and for pure Rolling $V_C = \omega R$

$$\Rightarrow 2mgh = I_C\frac{V_C^2}{R^2} + mV_C^2$$

$$\Rightarrow V_C\sqrt{\frac{2gh}{1+\frac{I_C}{mR^2}}}$$

we can see as $I_C \uparrow \Rightarrow V_C \downarrow$

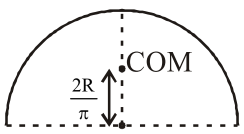
SECTION - B

1. The position of the centre of mass of a uniform semi–circular wire of radius 'R' placed in x–y plane with its centre at the origin and the line joining its ends as x–axis is given by $\left(0, \frac{xR}{\pi}\right)$.

Then, the value of |x| is ___________.

Ans. Official Answer NTA (2)

Sol.



$\therefore\ x = 2$

2. In 5 minutes, a body cools from 75ºC to 65ºC at room temperature of 25ºC. The temperature of body at the end of next 5 minutes is __________ºC.

Ans. Official Answer NTA(57)

Sol. $\frac{\Delta T}{t} = -k\left[\frac{T_1 + T_2}{2} - T_s\right]$

$\frac{75-65}{5} = -k\left[\frac{75+65}{2} - 25\right]$ ......(1)

$\frac{65-T}{5} = -k\left[\frac{T+65}{2} - 25\right]$ ......(2)

from (1) & (3) $\Rightarrow \frac{65-T}{75-65} = \frac{T+15}{90}$

$\Rightarrow T = 57°C$

3. The total charge enclosed in a incremental volume of 2×10^{-9} m^3 located at the origin is ___________nC, if electric flux density of its field is found as

$D = e^{-x} \sin y\ \hat{i} - e^{-x} \cos y\ \hat{j} + 2z\ \hat{k}$ C\m^2.

Ans. Official Answer NTA (4)

Sol. $\overline{D} = \left(\frac{Charge}{Area}\right) \times \hat{r} = \left(\frac{Q}{4\pi r^2}\right)\hat{r} = \epsilon_o \left(\frac{Q}{4\pi 60 r^2}\hat{r}\right) = \epsilon_o \overline{E}$

$\Rightarrow \overline{E} = \frac{\overline{D}}{\epsilon_o} = \frac{e^{-x}\sin y\hat{i} - e^{-x}\cos y\hat{j} + 2z\hat{k}}{\epsilon_o}$

and from Gauss Law : -

$\vec{\Delta}\bullet\vec{E} = \frac{\rho}{\epsilon_o}$

$\Rightarrow \left(\frac{\partial}{\partial x}\hat{i} + \frac{\partial}{\partial y}\hat{j} + \frac{\partial}{\partial z}\hat{k}\right)\bullet\left(\frac{e^{-x}\sin y\hat{i} - e^{-x}\cos y\hat{j} + 2z\hat{k}}{\epsilon_o}\right) = \frac{\rho}{\epsilon_o}$

$\rho = \frac{\partial}{\partial x}(e^{-x}\sin y) + \frac{\partial}{\partial y}(-e^{-x}\cos y) + \frac{\partial(2z)}{\partial z}$

$\Rightarrow \rho = -e^{-x}\sin y + e^{-x}\sin y + 2 = 2$

At origin $\Rightarrow\ \Rightarrow \rho = -e^{-0}\sin 0 + e^{-0}\sin 0 + 2 = 2$

$\therefore \rho = 2\frac{C}{m^3}$

$\therefore$ Charge $= \rho \times$ Volume $= 2 \times 2 \times 10^{-9} = 4nC$

4. Three particles P, Q and R are moving along the vectors $\vec{A} = \hat{i} + \hat{j}, \vec{B} = \hat{j} + \hat{k}$ and $\vec{C} = -\hat{i} + \hat{j}$ respectively. They strike on a point and start to move in different directions. Now particle P is moving normal to the plane which contains vector $\vec{A}$ and $\vec{B}$. Similarly particle Q is moving normal to the plane which contains vector $\vec{A}$ and $\vec{C}$. The angle between the direction of motion of P and Q is $\cos^{-1}\left(\frac{1}{\sqrt{x}}\right)$. Then the value of x is ________.

Ans. Official Answer NTA(3)

Sol. $\overline{P} = K_1\left(\overline{A}\times\overline{B}\right) = K_1\begin{vmatrix}\hat{i} & \hat{j} & \hat{k}\\ 1 & 1 & 0\\ 0 & 1 & 1\end{vmatrix} = K_1\left(\hat{i} - \hat{j} + \hat{k}\right)$

and $\overline{Q} = K_2\left(\overline{A}\times\overline{C}\right) = K_2\begin{vmatrix}\hat{i} & \hat{j} & \hat{k}\\ 1 & 1 & 0\\ -1 & 1 & 0\end{vmatrix} = K_2\left(2\hat{k}\right)$

$\therefore \hat{P} = \hat{i} - \hat{j} + \hat{k}$ and $\hat{Q} = 2\hat{k}$

Now angle betweeen the direction of motion of P and Q will be : -

$$\cos\theta = \frac{\hat{P}\cdot\hat{Q}}{|\hat{P}||\hat{Q}|} = \frac{2}{\sqrt{3}\times 2} = \frac{1}{\sqrt{3}}$$

$$\therefore \theta = \cos^{-1}\left(\frac{1}{\sqrt{3}}\right)$$

So x = 3

5. In an electric circuit, a cell of certain emf provides a potential difference of 1.25 V across a load resistance of 5Ω. However, it provides a potential difference of 1 V across a load resistance of 2Ω. The emf of the cell is given by $\frac{x}{10}$ V. Then the value of x is _________.

Ans. Official Answer NTA (15)

Sol.

$i_1 = \frac{1.25}{5} = 0.25A$

$V_{AB} = \varepsilon - i_1 r$

$\Rightarrow 1.25 = \varepsilon - 0.25r$ ....(1)

$i_2 = \frac{1}{2} = 0.5A$

$V_{CD} = \varepsilon - i_2 r$

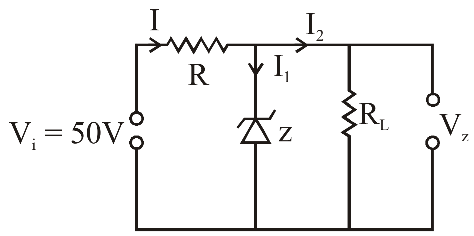
$\Rightarrow 1 = \varepsilon - 0.5r$ ....(2)

From (1) & (2) : -

$\varepsilon = 1.5\,\text{Volt} = \frac{x}{10}\,\text{Volt}$

$\therefore x = 15$

6. In a given circuit diagram, a 5V zener diode along with a series resistance is connected across a 50 V power supply. The minimum value of the resisstance required, if the maximum zener current is 90 mA will be ___________Ω.



Ans. Official Answer NTA (500)

Sol. Voltage across $R_L = 5V$

$\therefore\ i_1 = \frac{5}{R_L}$

and voltage across R = 50 –5 = 45

By ohm's Law : -

$45 = iR = (i_1 + i_2)R$

$\Rightarrow R = \frac{45}{i_1 + i_2} = \frac{45}{90mA + \frac{5}{R_L}}$

Current in zener is maximum when $R_L \to \infty\,(i_1 = i, i_2 \to 0)$

$\therefore R = \frac{45}{90mA} = 500\Omega$

7. Three students S_1, S_2 and S_3 perform an experiment for determining the acceleration due to gravity (g) using a simple pendulum. They use different lengths of pendulum and record time for different number of oscillations. The observations are as shown in the table.

Student No.	Length of Pendulum (cm)	No. of oscillations (n)	Total time for m oscillations	Time period (s)
1	64.0	8	128.0	16.0
2	64.0	4	64.0	16.0
3	20.0	4	36.0	9.0

(Least count of length = 0.1 cm

least count for time = 0.1s)

If E_1,E_2 and E_3 are the percentage errors in 'g' for students 1,2 and 3 respectively, then the minimum percentage error is obtained by student no. __________.

Ans. Official Answer NTA (1)

Sol. % Error in g $= \left(\frac{\Delta l}{l} + \frac{2\Delta T}{T}\right) \times 100\%$

and $\Delta T = \dfrac{\text{least count of time}(\Delta T_o)}{\text{number of Oscillation}(n)}$

$\therefore$ % Error in g $= \left(\dfrac{\Delta l}{l} + \dfrac{2\Delta T_o}{nT}\right) \times 100\%$

We can see error is minimum for highest values of l, n, T.

So minimum % error in g is for stadent no-1.

8. The area of cross–section of a railway track is 0.01 m^2. The temperature variation is 10ºC. Coefficient of linear expansion of material of track is 10^{-5}/ºC. The energy stored per meter in the track is ________ J/m. (Young's modulus of material of track is 10^{11} Nm^{-2})

Ans. Official Answer NTA (5)

Sol. Elastic energy = $\dfrac{1}{2} \times$ stress × strain ×valume

$\Rightarrow U = \dfrac{1}{2} \times \text{stress} \times \text{Strain} \times Al$

$\Rightarrow \dfrac{U}{l} = \dfrac{A}{2}(\gamma \times \text{strain}) \times \text{Strain} = \dfrac{A\gamma}{2}(\text{strain})^2$

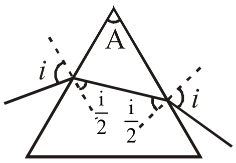
$= \dfrac{A\gamma}{2}\left(\dfrac{\Delta l}{l}\right)^2 = \dfrac{A\gamma}{2}(\alpha\Delta T)^2 = \dfrac{1}{2}A\gamma\alpha^2\Delta T^2$

$= \dfrac{1}{2} \times (0.01) \times 10^{11} \times \left(10^{-5}\right)^2 (10)^2$

$= 5 \text{ joule / meter}$

9. A ray of light passing through a prism ($\mu = \sqrt{3}$) suffers minimum deviation. It si found that the angle of incidence is double the angle of refraction within the prism. Then, the angle of prism is _______ (in degrees).

Ans. Official Answer NTA (60)

Sol. 

(1) $\sin i = \sqrt{3} \sin \dfrac{i}{2}$

$\Rightarrow 2\sin\frac{i}{2}\cos\frac{i}{2} = \sqrt{3}\sin\frac{i}{2}$

$\Rightarrow \cos\frac{i}{2} = \frac{\sqrt{3}}{2}$

$\Rightarrow \frac{i}{2} = 30°$ so i = 60°

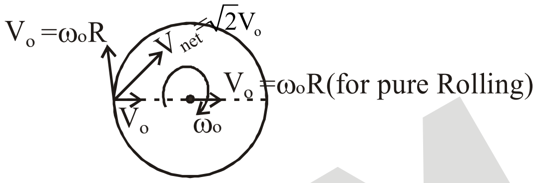
For minimum deviation $r_1 = r_2 = \frac{A}{2} = \frac{i}{2}$

A = i = 60°

10. The centre of a wheel rolling on a plane surface moves with a speed υ_0. A particle on the rim of the wheel at the same level as the centre will be moving at a speed $\sqrt{x}\upsilon_0$. Then the value of x is _______.

Ans. Official Answer NTA (2)

Sol.



$V_{net} = \sqrt{2}V_o$

So x = 2