# Physics Numericals

Topics: Mechanics/ Math Method/ Electrostatics/ Heat

Course: B.Sc/ Physics

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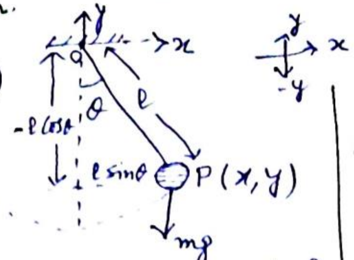
Ref

Eqn. of motion of S.P in Matrix form.

① Simple Pendulum with bob having Position $P(x,y)$




$$(x,y) = (l\sin\theta, -l\cos\theta)$$
$$= l(\sin\theta, -\cos\theta)$$

Velocity components

$$(\dot{x},\dot{y}) = \dot{\theta} l(\cos\theta, \sin\theta)$$ & Corresponding Accln.

$$(\ddot{x},\ddot{y}) = \ddot{\theta} l(\cos\theta, +\sin\theta) + l\dot{\theta}^2(-\sin\theta, \cos\theta)$$

External force acting on Pendulum is along $-y$ axis only, i.e $F = (0, -mg)$.

x comp: $\ddot{\theta}\cos\theta - \dot{\theta}^2\sin\theta = 0$.

y comp: $\ddot{\theta}\sin\theta + \dot{\theta}^2\cos\theta = -\frac{g}{l}$

} Newton's 2nd Law $\vec{F} = m\vec{a}$

In Matrix form

$$\begin{bmatrix} \ddot{\theta} \\ \dot{\theta}^2 \end{bmatrix} \begin{bmatrix} \cos\theta & -\sin\theta \\ \sin\theta & \cos\theta \end{bmatrix} = \begin{bmatrix} 0 \\ -g/l \end{bmatrix}$$

⇓ Rotation Matrix $(\theta)$

③ If the energy of two Black bodies is $E_1 = 3.82E_2$, find relation between $T_1$ & $T_2$.

By Stefan-Boltzmann law for black body is

$$E \propto T^4$$
$$= \sigma T^4;\ \sigma = \text{S.B Const}$$

$$\therefore \frac{E_2}{E_1} = \left(\frac{T_2}{T_1}\right)^4 \quad E_1 = 3.82E_2$$

$$\therefore \frac{T_2}{T_1} = \left(\frac{1}{3.82}\right)^{1/4} = \frac{1}{0.714}$$

$$= 1.4 \Rightarrow \boxed{T_2 = 1.4T_1}$$

② Find the $\Delta v_e$ of the given form.

② $$v_e = \sqrt{\frac{10}{7} g[(h_i - h_e) - (h_{iB} - h_{eB})]} \equiv [h_i - h_e - h_{iB} + h_{eB}]^{1/2}$$ as $g$ is Const.

Now from error propagation formula for $x = au^b$ is given as $\boxed{\frac{\delta x}{x} = b\frac{\delta u}{u}}$ where $\delta x$ is error in calculation of $x$, $\delta u$ " " " " " $u$.

Thus $$\frac{\delta v_e}{v_e} = \frac{1}{2}\left[\frac{\delta h_i}{h_i} + \frac{\delta h_e}{h_e} + \frac{\delta h_{iB}}{h_{iB}} + \frac{\delta h_{eB}}{h_{eB}}\right],$$ we can write $\delta = \Delta$

$$\therefore \boxed{\Delta v_e = \frac{v_e}{2}\left[\frac{\Delta h_i}{h_i} + \frac{\Delta h_e}{h_e} + \frac{\Delta h_{iB}}{h_{iB}} + \frac{\Delta h_{eB}}{h_{eB}}\right]}$$

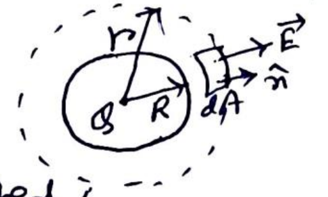
$(0.261)^{0.25} = 0.714$

# Electric Field due to solid spherical charge of radius R. (UG I)

**Total charge = q & charge density, $\rho = \frac{q}{V}$ & Plot E vs. r**

Case (i) $r > R$

We construct a Gaussian spherical surface of radius r such that $r > R$, so inside the Gaussian surface whole charged sphere is present whose total charge is q.




Gaussian surface of radius r

$d\vec{A} = |d\vec{A}|\,\hat{n}$

$\vec{E} \parallel \hat{n}$

By Gauss's law $\oiint_S \vec{E}\cdot d\vec{A} = \frac{q_{enclosed}}{\epsilon_0} = \frac{q}{\epsilon_0}$ Now $\vec{E}\cdot d\vec{A} = E\,dA\cos 0^\circ = E\,dA$

Also $|\vec{E}|$ is same everywhere on the Gaussian surface, so it is constant $\therefore E \oiint_S dA = \frac{q}{\epsilon_0} \Rightarrow E \times 4\pi r^2 = \frac{q}{\epsilon_0}$

$\therefore E = \frac{1}{4\pi\epsilon_0}\frac{q}{r^2}$ — (1) $\therefore$ $\boxed{E_{r>R} \propto \frac{1}{r^2}}$

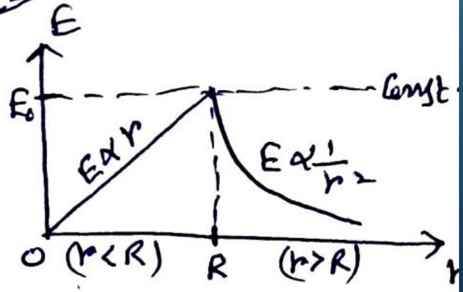
Gaussian surf.


Case (ii) $\underline{r < R}$, volume of Gaussian sphere, $v = \frac{4}{3}\pi r^3$ $\therefore$ charge enclosed is $q' = q_{enclosed} = \rho v = \frac{4\pi\rho r^3}{3}$.

By Gauss's law $\oiint \vec{E}\cdot d\vec{A} = \frac{q_{encl.}}{\epsilon_0} = \frac{4\pi\rho r^3}{3\epsilon_0}$

or $E \times 4\pi r^2 = \frac{4\pi\rho r^3}{3\epsilon_0}$

or, $E = \frac{\rho r}{3\epsilon_0}$ — (2) $\therefore$ $\boxed{E_{r<R} \propto r}$ Now $\rho = \frac{q}{\frac{4}{3}\pi R^3}$




At the surface of the sphere, $r = R$ then from (2) $E_{r=R} = \frac{\rho R}{3\epsilon_0} = \text{Const.} = E_0$

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**Thanksss**