$F = QE$ ... **1**

$a_y = \frac{F}{M} = \frac{QE}{M}$ ... **1**

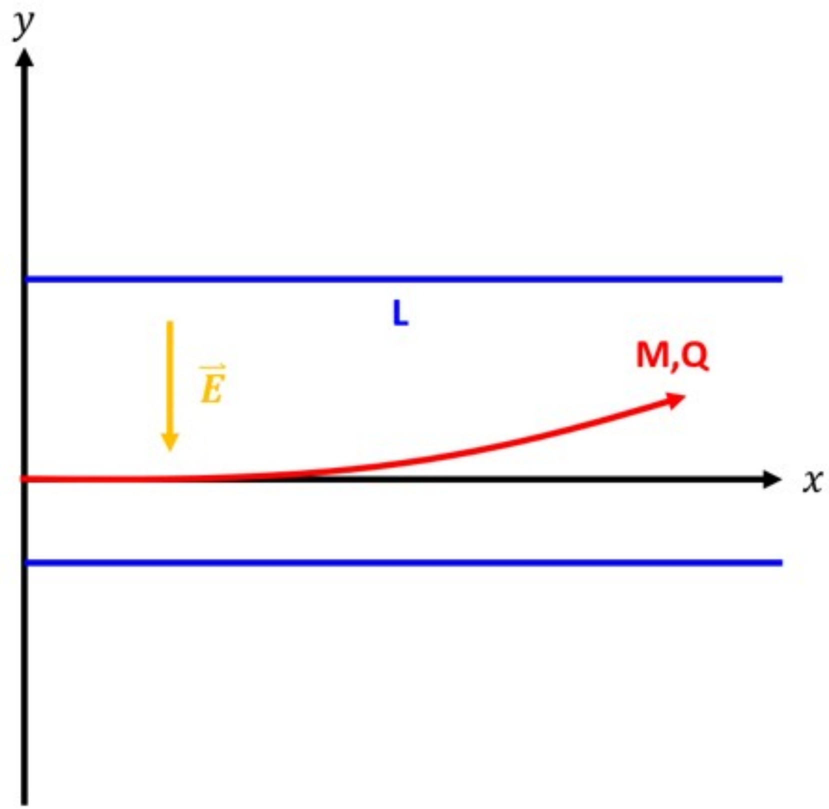
$L = v_x t\ , t = \frac{L}{v_x}$ ... **1**

$v_y = a_y t = \frac{QE}{M}\frac{L}{v_x}$... **2**

$v_y = \frac{(10^{-12})\times(4\times10^{6})}{(10^{-10})}\frac{(10^{-2})}{(20)} = 20\ m/s$ ... **2**

$\frac{v_x}{v_y} = \frac{20}{20} = 1$... **1**

$tan\theta = 1\ , \theta = \frac{\pi}{4}$ ... **2**



Q.2 There is a sphere of radius $R = 10\ (m)$ with spherically symmetric charge distribution. The volume charge density is non-uniform, which follows the function of radius r is $\rho = r^2\ (\frac{C}{m^3})$. The vacuum permittivity is ε_0. **(a)** What are the enclosed charges in the concentric spherical Gaussian surfaces of radius $r = 5\ (m)$ and $15\ (m)$? (6 points) **(b)** What are the electric fields on above two Gaussian surfaces? (4 points)

(a) $$Q_{enc}(r) = \int_0^{2\pi}\int_0^{\pi}\int_0^{r} \rho\, dr\, r d\theta\, r\sin\theta\, d\phi \quad ①$$

$$= \int_0^{2\pi} d\phi \cdot \int_0^{\pi} \sin\theta\, d\theta \cdot \int_0^{r} \rho r^2 dr$$

$$= 4\pi \int_0^{r} r^2 \cdot r^2 dr = \frac{4}{5}\pi r^5 \quad ①$$

$$r = 5\ m < R = 10\ m \Rightarrow \frac{4}{5}\pi 5^5 = 2500\pi\ C \quad ②$$

$$r = 15\ m > R = 10\ m \Rightarrow \frac{4}{5}\pi 10^5 = 80000\pi\ C \quad ②$$

(b) $$\iiint_V (\nabla \cdot \vec{E})\, dV = \frac{1}{\varepsilon_0}\iiint_V \rho_{enc}\, dV = \frac{Q_{enc}}{\varepsilon_0}$$

$$\xRightarrow[\text{divergence theorem}]{} \oiint_S \vec{E} \cdot d\vec{A}$$

$$\oiint_S \vec{E} \cdot d\vec{A} = \frac{Q_{enc}}{\varepsilon_0} \quad ①$$

$$r = 5\ m \Rightarrow \vec{E} = \frac{2500\pi}{4\pi\varepsilon_0 5^2} = \frac{25}{\varepsilon_0}\hat{r}\ N/C \quad (1.5)$$

$$r = 15\ m \Rightarrow \vec{E} = \frac{80000\pi}{4\pi\varepsilon_0 15^2} = \frac{800}{9\varepsilon_0}\hat{r}\ N/C \quad (1.5)$$