Answer to Question #72320, Physics / Electric Circuits

Two particles each of mass M is attached to 2ends of a massless rigid nonconducting rod of length L. They have $+q$ and $-q$ charges respectively. This arrangement is held in a region of uniform electric field E such that the rod makes a small angle ($< 5°$) with the field direction. The time period of rod is__? (The rod oscillates about its centre of mass)

Solution.

$$I\varepsilon = FL\sin\theta$$

where the force acting at each mass:

$$F = qE$$

θ is the angle between the rod and electric field direction
Since, θ is small :

$$\sin\theta \approx \theta$$

I is the moment of inertia of the rod :

$$I = \frac{ML^2}{2}$$

ε is angular acceleration

$$\varepsilon = \frac{d\omega}{dt}\ ;\ \omega = \frac{d\theta}{dt} \Rightarrow \varepsilon = \frac{d\omega}{d\theta}\omega$$

where ω is angular velocity.

Then:

$$\frac{ML^2}{2}\cdot\frac{d\omega}{d\theta}\omega = qEL\theta$$

$$\frac{ML^2}{2}\cdot\frac{\omega_0^2}{2} = qEL\int_0^{2\pi}\theta d\theta$$

$$\omega_0 = 2\pi\sqrt{\frac{2qE}{ML}}$$

where ω_0 is angular frequency.

Answer:

The time period of oscillation:

$$T = \frac{2\pi}{\omega_0} = 2\pi\sqrt{\frac{ML}{2qE}}$$