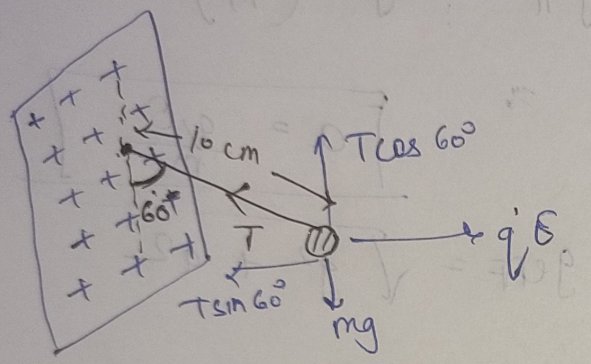
One end of a 10 cm long silk thread is fixed to a large vertical surface of a charged non-conducting plate and the other end is fastened to a small ball of mass 10 g and charge 4×10^{-6} C. In equilibrium the thread makes an angle of 60° with the vertical (a) find charge density (σ) of non conducting plate.

(b) Find the tension in the string in equilibrium.

(c) Suppose ball is slightly pushed aside and released. find the Time period of small oscillations.



(a) Since given that the ball is in equilibrium

So, $T\cos 60 = mg$ — (1) $\quad T\sin 60 = qE$ — (2)

Divide 2 by 1

$\tan 60° = \frac{qE}{mg}$

[$E = \frac{\sigma}{2\varepsilon_0}$, Electric field due to non conducting plate]

$\sqrt{3} = \frac{q\sigma}{mg(2\varepsilon_0)}$

$\sigma = \frac{\sqrt{3}(2\varepsilon_0 mg)}{q}$

$\sigma = \frac{\sqrt{3} \times 2 \times 8.85 \times 10^{-12} \times 10^{-2} \times 10}{4 \times 10^{-6}}$

$\boxed{\sigma = 7.415 \times 10^{-7} \text{ c/m}^2}$

$\boxed{\sigma \approx 7.5 \times 10^{-7} \text{ c/m}^2}$

(b) Using equation (2)

~~$T\sin 60 = qE$~~

$T\cos 60 = mg$

$T\left(\frac{1}{2}\right) = 10^{-2} \times 10$

$\boxed{T = 0.2\ N}$

(c) $T = 2\pi\sqrt{\frac{l}{g_{eff}}}$

$T = 2\pi\sqrt{\frac{10}{100 \times 20}}$

$T = 2\pi(0.07)$

$T = 2 \times 3.14 \times 0.07$

$\boxed{T = 0.43 \text{ seconds}}$

$g_{eff} = \sqrt{g^2 + \left(\frac{qE}{m}\right)^2}$

$\boxed{a = \frac{qE}{m}}$

$g_{eff} = \sqrt{g^2 + a^2}$

Also, $qE = T\sin 60$

$qE = 0.2\left(\frac{\sqrt{3}}{2}\right)$

$a = \frac{qE}{m} = \frac{0.1000 \times \sqrt{3}}{10 \times 10}$

$\boxed{a = 10\sqrt{3}}$

$g_{eff} = \sqrt{(10)^2 + (10\sqrt{3})^2}$

$\boxed{g_{eff} = 20\ m/s^2}$