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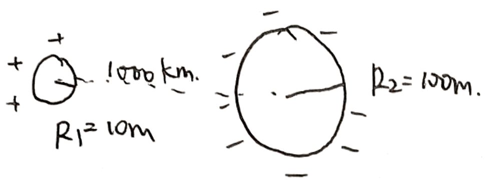
Question 1.



(1) According to Coloumb law

$$F = k\frac{q_1q_2}{d^2}$$

Since $d >> R_1, d >> R_2$, $R_1 \& R_2$ can be ignored

$$C_1 = 4\pi\varepsilon_0 R_1 = \frac{10}{9\times10^9} f = 1.11\times10^{-9} f$$

$$C_2 = 4\pi\varepsilon_0 R_2 = \frac{100}{9\times10^9} f = 1.11\times10^{-8} f$$

$$Q = CV \Rightarrow Q_1 = C_1V_1 = (1.11\times10^{-9}\times10^4)C = 1.11\times10^{-5}C$$

$$Q_2 = -C_2V_2 = -(1.11\times10^{-8}\times10^4)C = -1.11\times10^{-4}C$$

$$\Rightarrow F = \frac{kQ_1Q_2}{r^2} = -\frac{9\times10^9\times(1.11\times10^{-5})\times(1.11\times10^{-4})}{(10^3\times10^3)^2} N = -1.11\times10^{-11} N$$ attractive force.

(b) After touch:

$V_1 = V_2$ $\quad \frac{Q_1'}{C_1} = \frac{Q_2'}{C_2}$ $\quad Q_1'+Q_2' = Q_1+Q_2 \Rightarrow Q_1' = -9.08\times10^{-6}C$ $\quad Q_2' = -9.08\times10^{-5}C$

$$\Rightarrow F = \frac{kQ_1'Q_2'}{r^2} = \frac{9\times10^9\times(-9.08\times10^{-6})\times(-9.08\times10^{-5})}{(10^3\times10^3)^2} = 7.42\times10^{-12}N$$ repulsive force.

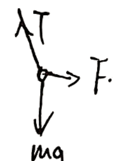
(c). When they touched each other, the V equal.

As electrostatic force depends on the charge.

Therefore, force acting between the sphere changes.

Question 2

(a) Assume the sphere is uniformly charged. Assume the unit area charge of the ball is. $(\sigma_{free}-\sigma_{bound})$



Since it's in equilibrium state

$$\frac{F}{mg} = \tan 10^\circ \Rightarrow F = mg\cdot\tan 10^\circ = E\cdot q = q\cdot\frac{\sigma_{free}-\sigma_{bound}}{\varepsilon_0} = \frac{(\sigma_{free}-\sigma_{bound})^2\cdot S}{\varepsilon_0}$$

$$E = \frac{U}{d} = \frac{100}{0.1} = 1000\,V/m. \qquad E_0 = \frac{\sigma_{free}}{\varepsilon_0} \Rightarrow \sigma_{free} = E\cdot\varepsilon_0$$

$$\frac{(E\cdot\varepsilon_0-\sigma_{bound})^2\, 4\pi R^2}{\varepsilon_0} = mg\tan 10^\circ$$

$$\Rightarrow \begin{cases} \sigma_{bound} = E\cdot\varepsilon_0 - \sqrt{\frac{mg\tan 10^\circ}{4\pi R^2}\cdot\varepsilon_0} \\ \sigma_{free} = E\cdot\varepsilon_0 \end{cases}$$

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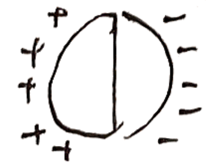
(2) Assume it is a sphere with half positive charge, half negative charge. And the area charge of the ball is σ bound.



for the right ~~and~~ half. $E = \int_0^{\frac{\pi}{2}} \frac{\sigma \sin\theta \cos\theta \, d\theta}{2\varepsilon} = \frac{\sigma}{4\varepsilon} \Rightarrow E_{all} = \frac{\sigma}{2\varepsilon}$

Question 3.

(a). we can view the gravitational field as electric field.

$\frac{1}{4\pi\varepsilon_g} \Rightarrow \frac{1}{4\pi\varepsilon_0} \Rightarrow \frac{1}{4\pi\varepsilon_g} = G \Rightarrow \varepsilon_g = \frac{1}{4\pi G}$

Considering Gauss's Law $E = \frac{\sigma}{2\varepsilon_0} \Rightarrow g = \frac{\sigma_M}{2\varepsilon_g}$

$\Rightarrow F_G = g \cdot \lambda \cdot s$ $\quad F_G/s = g \cdot \sigma_M = \frac{\sigma_M^2}{2\varepsilon_g} = 2\pi G \sigma_M^2 = 2 \times \pi \times 6.67 \times 10^{-11} \times \left(\frac{1.5}{1000}\right)^2 = 9.43 \times 10^{-16} N$

(B) Consider ds.

$\Rightarrow F_E = \frac{\sigma^2}{2\varepsilon_0} \cdot ds.$ $\quad$ since. $E \cdot d = V \Rightarrow \sigma = \frac{V \cdot \varepsilon_0}{d}.$

$E_k = \int_d^{\infty} \int (F_G - F_E)\, dx = \int_d^{\infty} \left(2\pi G \lambda^2 - \frac{V^2 \varepsilon_0}{2d^2}\right) ds \, dx = \text{infinity}.$