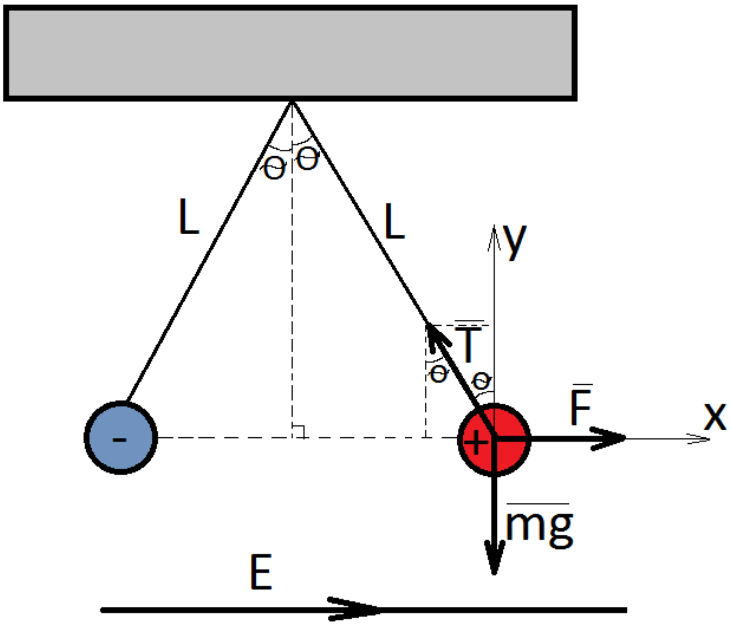
Two 3.0-g spheres are suspended by 8.0-cm-long light strings (see the figure). A uniform electric field is applied in the x-direction. If the spheres have charges of −3. 10-8 C and +3. 10-8 C, determine the electric field intensity that enables the spheres to be in equilibrium at θ = 10°.

Solution:



Condition of equilibrium for a single sphere (Newton's second law):

$$\overrightarrow{mg} + \vec{T} + \vec{F} = \vec{0}$$

mg - the force of gravity; T - tension force; F - the electrostatic force

Newton's second law on the X-axis:

$$x: F - T\sin\theta = 0$$

$$T\sin\theta = F (1)$$

Newton's second law on the Y-axis:

$$y: mg - T\cos\theta = 0$$

$$T\cos\theta = mg (2)$$

$$(1) \div (2): \frac{T\sin\theta}{T\cos\theta} = \tan\theta = \frac{F}{mg}$$

$$F = mg\tan\theta = 0.003\,kg * 9.8\frac{N}{kg} * \tan 10^o = 0.00518\,N (3)$$

Distance between the two charges:

$$r = 2 * L * \sin\theta = 2 * 0.08m * \sin 10^o = 0.027m$$

If E is the electric field intensity, we can write the force by field intensity and Coulomb's law:

$$x: F = F_{field} - F_{electr}$$

$$F_{field} = Eq$$

$$F_{electr} = \frac{kq^2}{r^2} =>$$

$$F = Eq - \frac{kq^2}{r^2}$$

$$E = \frac{F}{q} + \frac{kq}{r^2}$$

$$E = \frac{0.00518N}{3 * 10^{-8}C} + \frac{9 * 10^9 \frac{N * m^2}{C^2} * 3 * 10^{-8}C}{(0.027m)^2} = 172666 + 370370 = 5.43 * 10^5\frac{N}{C}$$

Answer: $E = 5.43 * 10^5 \frac{N}{C}$