Answer on Question #72670 Physics / Electromagnetism

A spherical balloon has a radius of $R = 73$ cm, and its surface has been charged uniformly. You measure the electric field to be $E = -E_s$ at the balloon's surface, where $E_s = 25$ kN/C.

(a) Calculate the field strength $r_1 = 45$ cm from the balloon's center.

(b) Calculate the field strength r_2=192 cm from the balloon's center.

(c) Calculate the net charge on the balloon.

Solution:

Let us consider a Gauss's law for spherical symmetry case

$$\oint_S EdA = \frac{Q}{\varepsilon_0}$$

where E is a electric field strength, S is a closed surface, Q is a total charge enclosed within surface, ε_0 is the electric constant.

(a) Let us consider a surface S as a sphere with radius $r_1 < R$. Then total charge enclosed within sphere is zero. Thus $E = 0$.

(b) When $r > R$

$$\oint_S EdA = E \times 4\pi r^2$$

So

$$E = \frac{Q}{4\pi\varepsilon_0 r^2}$$

and

$$E_s = -\frac{Q}{4\pi\varepsilon_0 R^2}$$

$$E_2 = \frac{Q}{4\pi\varepsilon_0 r_2^2}$$

Thus

$$E_2 = -E_s\frac{R^2}{r_2^2} = -25\left(\frac{73}{192}\right)^2 = -3.61\frac{\text{kN}}{\text{C}}$$

(c) The net charge of balloon

$$Q = 4\pi\varepsilon_0 r_2^2 E_2 = 4\pi \times 8.85 \times 10^{-12} \times 1.92^2 \times (-3.61 \times 10^3) = -1.48\ \mu\text{C}$$

Answers: 0, $-3.61\frac{\text{kN}}{\text{C}}$, -1.48 μC.