15-Phys-202

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Quiz 3 Name _____

Useful formulae and constants:

Potential of a point charge

$$V = \frac{1}{4\pi\varepsilon_0}\frac{q}{r}$$

Potential energy of a pair of point charges

$$U = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r}$$

$$\varepsilon_0 = 8.85 \times 10^{-12}\ \mathrm{C}^2/\mathrm{N}\cdot\mathrm{m}^2$$

1. In the quark model of fundamental particles, a proton is composed of three quarks: two "up" quarks, each having charge $+2e/3$, and one "down" quark, having charge $-e/3$. Suppose that the thee quarks are equidistant from one another. Take the distance to be 1.32×10^{-15} m and calculate the total potential energy of the three-quark system.

   Solution

   The total consists of all pair-wise terms:

$$U = \frac{1}{4\pi\varepsilon_0}\left[\frac{(2e/3)\,(2e/3)}{r} + \frac{(2e/3)\,(-e/3)}{r} + \frac{(2e/3)\,(-e/3)}{r}\right] = 0$$

2. A nonuniform linear charge distribution given by $\lambda = bx$, where b is a constant, is located along an x axis from $x = 0$ to $x = 20$ m. If $b = 20$ nC/m^2, what is the electric potential (relative to potential of zero at infinity) at the origin?

   Solution

   Here $r = x$

$$dV = \frac{1}{4\pi\varepsilon_0}\frac{dq}{x}$$

   and

$$\begin{aligned} V &= \frac{1}{4\pi\varepsilon_0}\int_0^{0.20}\frac{\lambda dx}{x} = \frac{1}{4\pi\varepsilon_0}\int_0^{0.20}\frac{bxdx}{x} = \frac{b\,(0.20)}{4\pi\varepsilon_0} \\ &= \frac{(20\times 10^{-9})\,(0.20)}{4\pi\,(8.85\times 10^{-12})} = \frac{1}{8.85\pi}\times 10^3 = 36\ \mathrm{V} \end{aligned}$$