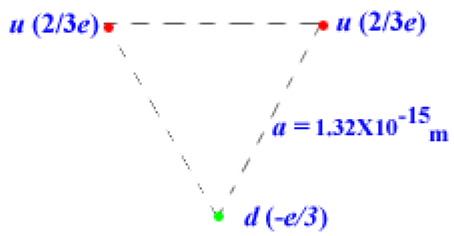
335.

Problem 30.1 (RHK)

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 three quarks are equidistant from each other. We can take the distance this distance to be* 1.32×10^{-15} m. *We will calculate* (a) *the potential energy of the interaction between the two "up" quarks and* (b) *the total potential energy of the system.*



Solution:

(a)

Distance between the two "up" quarks, *a*, is

1.32×10^{-15} m.

Charge of each "up" quark, *q*, is $+2e/3$.

Therefore, the potential energy of the two “up” quarks will be

$$U\left(u,u\right)=\frac{1}{4\pi\varepsilon_0}\times\frac{\left(2e/3\right)^2}{a}=\frac{8.99\times10^{9}\times4\times\left(1.6\times10^{-19}\right)^2}{9\times1.32\times10^{-15}}\ \text{J}$$

$$=7.749\times10^{-14}\ \text{J}$$

$$=484\ \text{keV.}$$

(b)

The total electric potential energy of the 2 “up” and 1 “d” quark system will be

$$U\left(u,u,d\right)=\frac{1}{4\pi\varepsilon_0}\left(\frac{4}{9}e^2-\frac{2}{9}e^2-\frac{2}{9}e^2\right)=0.$$