Life of a Particle : Quiz 3

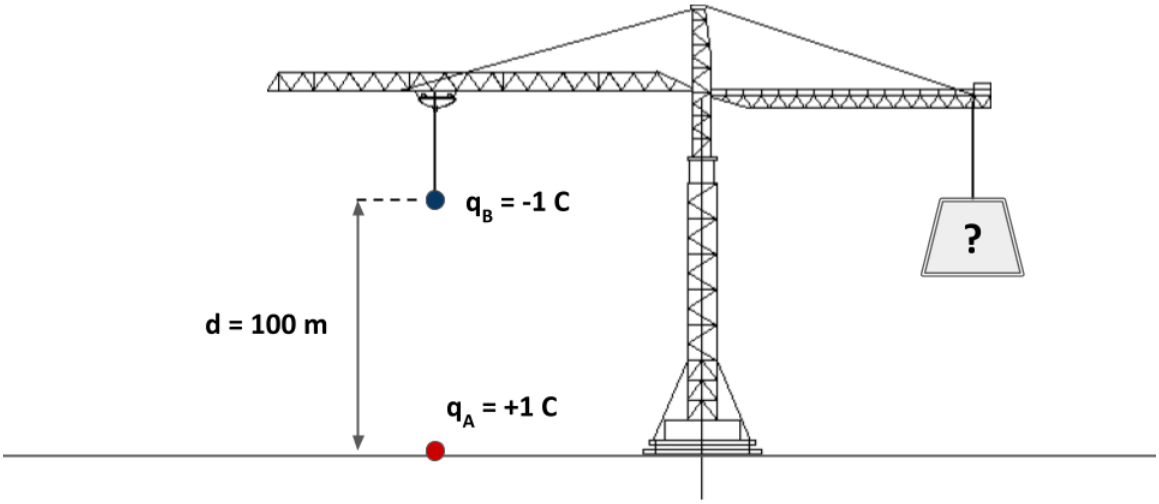
Sam Meehan & Claire David

Due Date : 31 January 2019

Guidelines:
This quiz will last 15 minutes. Write your answers on paper explaining how you get to the results.

1 The unit of charge: the Coulomb

The elementary charge carried by the electron is $q_e = 1.6021766208(98) \times 10^{-19}$ C.
Do you know intuitively what is the charge in one Coulomb?



Let's imagine we can fix a positive charge A of one Coulomb in the ground. Let's have a crane where we hang a negative charge B of one Coulomb above the first at a distance $d = 100$ m. The two charges will attract each other, according to the Coulomb force.

Question A: What is the mass to be suspended on the other side of the crane to balance this system out? Compare this to a day-to-day life object.

Question B: A typical lightning strike is about 40 coulombs of charge, consisting of separate "strokes" (that's why lightning usually looks flickery). Each stroke lasts about 30 microseconds. What is the current?

Reminders on next page (there is also a second question!)

Coulomb's law is given by:

$$\mathbf{F_{12}} = k_e \frac{q_1\, q_2}{|\,\mathbf{r_{21}}|^2}\, \hat{\mathbf{r}}_{\mathbf{21}} \tag{1}$$

with:

k_e: Coulomb's constant, $k_e = 8.9875517873681764 \times 10^9$ N m^2 C^{-2}

q_i: charge of object i

r: distance between the charges

2 The electron volt

An electron volt (eV) is the energy an electron gains when it is accelerated through a potential difference of one volt. This unit of energy is commonly used in subatomic physics. One electron volt corresponds to $1.60218 \cdot 10^{-19}$ Joules.

A Kingsbite Milk Chocolate Bar has 274 Calories (one dietary Calorie is 1000 calories, or 4184 Joules).

The LHC operates at 14 TeV (tera electron volts, or 10^{12} eV).

Question A: How does the energy of the proton-proton collisions at LHC compare with respect to the energy stored in a Kingsbite Milk Chocolate Bar?

Question B: Make the same comparison with energy density.

Guidelines on input data: as volumes you can use these estimations:

LHC: a proton has a volume of roughly 1 fm^3, or about 10^{-39} cm^3

Kingsbite Milk Chocolate Bar is about 10 cm $\times$ 1/2 cm $\times$ 20 cm = 100 cm^3
