2.2: Analysis Tools - Point Charges

Point Charges

The three charges below are located as shown. Each grid square has width a. Find the net electric force on the positive charge.

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To find the electric force on the positive charge, you must first find the electric field at its location in space. Thus, this is really just more practice in calculating the electric field!

The electric field at the location of the positive charge will be the vector sum of the electric field from the -2q charge ($\mathbf{E}_{-2Q}$) and the electric field from the -2q charge ($\mathbf{E}_{-2q}$). Let's calculate these two fields separately and then add them together.

From the -2q charge:

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and from the +2q charge:

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Adding these two contributions together yields

pic

So the force on the positive charge is:

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The force on the positive charge is to the left, and slightly downward, attracted to the two negative charges.

Force and Motion

In many applications, oppositely charged parallel plates are used to "steer" beams of charged particles. In this example, a proton is injected at 2.0 x 10^6 m/s into the space between the plates. The plates are 2.0 cm long. What charge density is needed on the plates to give proton a y-velocity of 2.0 x 10^5 m/s as it exits the plates?

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Since this problem involves the motion of a particle between two distinct events, let's complete a motion table.

Event 1: The proton enters the device. Event 2: The proton exits the device.

$t_1 = 0$ s $t_2 =$

$r_{1x} = 0$ m $r_{2x} = 0.02$ m

$r_{1y} = 0$ m $r_{2y} =$

$v_{1x} = 2 \times 10^6$ m/s $v_{2x} =$

$v_{1y} = 0$ m/s $v_{2y} = 2 \times 10^5$ m/s

Between the plates, the proton will experience an electrical force, and hence acceleration, in the y-direction. Remember from mechanics that this y-acceleration will not affect thte kinematics of the proton in the x-direction. Thus, in the x-direction the acceleration of the proton is zero.

Applying the kinematic equations in the x-direction yields:

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Applying the same kinematics equations in the y-direction yields:

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Now, using Newton's Second Law and the relation for electric field from parellel conducting plates, find the necessary charge density.

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The bottom plate should be made positive and the top plate negative, both with this charge density. (Note that the force of gravity acting on the proton is completely insignificant compared to the electrical force. This is generally true and we will typically ignore the force of gravity acting on individual particles such as protons and electrons.)

Paul D'Alessandris (Monroe Community College)
