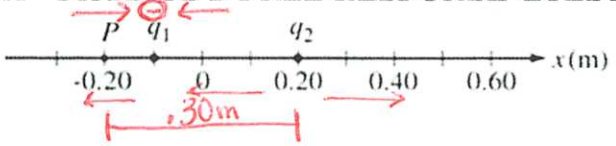
Electrostatics Exam Review

Directions – Complete the following problems to help prepare you for the upcoming test.

2006 AP® PHYSICS B FREE-RESPONSE QUESTIONS



3. (15 points)

Two point charges, q_1 and q_2, are placed 0.30 m apart on the x-axis, as shown in the figure above. Charge q_1 has a value of -3.0×10^{-9} C. The net electric field at point P is zero.

(a) What is the sign of charge q_2?

✓ Positive ____ Negative

Justify your answer.

The electric field by q_1 points to the ~~left~~ right because it enters a negative charge. If the net E is zero the field must be opposite direction and opposite sign

(b) Calculate the magnitude of charge q_2.

$\Sigma E = 0$ N/C

$E_1 = E_2$

$\frac{Kq_1}{r_1^2} = \frac{Kq_2}{r_2^2}$

$q_2 = \frac{q_1 r_2^2}{r_1^2} = \frac{(3.0 \times 10^{-9}\ C)(.40m)^2}{(.10m)^2} = 4.8 \times 10^{-8}\ C$

(c) Calculate the magnitude of the electric force on q_2 and indicate its direction.

$F = \frac{Kqq}{r^2} = \frac{9.0 \times 10^9 \frac{Nm^2}{C^2}(3.0 \times 10^{-9} C)(4.8 \times 10^{-8} C)}{(.30m)^2} = 1.4 \times 10^{-5}$ N left

(because they attract)

(d) Determine the x-coordinate of the point on the line between the two charges at which the electric potential is zero.

x = distance from q_1 to pt

$r_1 = x$

$r_2 = .30m - x$

$\Sigma V = 0V$

$V_1 + V_2 = 0V$

$-V_1 = +V_2$

$-\frac{Kq_1}{r_1} = \frac{Kq_2}{r_2}$

$-\left(\frac{-3.0 \times 10^{-9} C}{x}\right) = \frac{4.8 \times 10^{-8} C}{.30m - x}$

$x(4.8 \times 10^{-8}) = (9.0 \times 10^{-10}) - (3.0 \times 10^{-9})x$

$(5.1 \times 10^{-8})x = 9.0 \times 10^{-10}$

$x = .018$ m from q_1

q_1 @ $-.10$ m so coordinate $-.082$ m

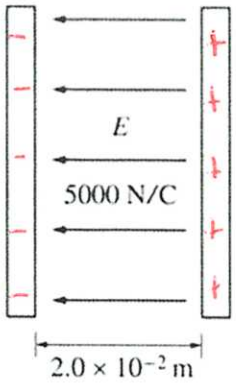
(e) How much work must be done by an external force to bring an electron from infinity to the point at which the electric potential is zero? Explain your reasoning.

$W = q\Delta V$

$V_i = 0V$ @ infinity

$V_f = 0V$ @ new location

since $\Delta V = 0V$, then $W = 0J$



Note: Figure not drawn to scale.

5. (10 points)

Two parallel conducting plates, each of area $0.30\ m^2$, are separated by a distance of 2.0×10^{-2} m of air. One plate has charge $+Q$; the other has charge $-Q$. An electric field of 5000 N/C is directed to the left in the space between the plates, as shown in the diagram above.

(a) Indicate on the diagram which plate is positive (+) and which is negative (-).

(b) Determine the potential difference between the plates.

$V = Ed = (5000\ N/C)(2.0 \times 10^{-2}\ m) = 100\ V$

(c) Determine the capacitance of this arrangement of plates.

$C = \frac{K\varepsilon_0 A}{d} = \frac{8.85 \times 10^{-12}\ \frac{C^2}{Nm^2}\,(.30\ m^2)}{2.0 \times 10^{-2}\ m} = 1.3 \times 10^{-10}\ F$

An electron is initially located at a point midway between the plates.

(d) Determine the magnitude of the electrostatic force on the electron at this location and state its direction.

$F = Eq = (5000\ N/C)(1.60 \times 10^{-19}\ C)$

$= 8.0 \times 10^{-16}\ N$ right

(e) If the electron is released from rest at this location midway between the plates, determine its speed just before striking one of the plates. Assume that gravitational effects are negligible.

$x = 1.0 \times 10^{-2}\ m$

$v_0 = 0\ m/s$

$v_f = ?$

① $a = \frac{F_{net}}{m}$

② $v^2 = v_0^2 + 2ax$

$v_f = \sqrt{2\left(\frac{F_{net}}{m}\right)x}$

$= \sqrt{2\left\{\frac{8.0 \times 10^{-16}\ N}{9.11 \times 10^{-31}\ kg}\right\}(1.0 \times 10^{-2}\ m)}$

$= 4.2 \times 10^6\ m/s$

OR $W = Vq = \Delta K = \frac{1}{2}mv^2$

$v = \sqrt{2Vq/m}$