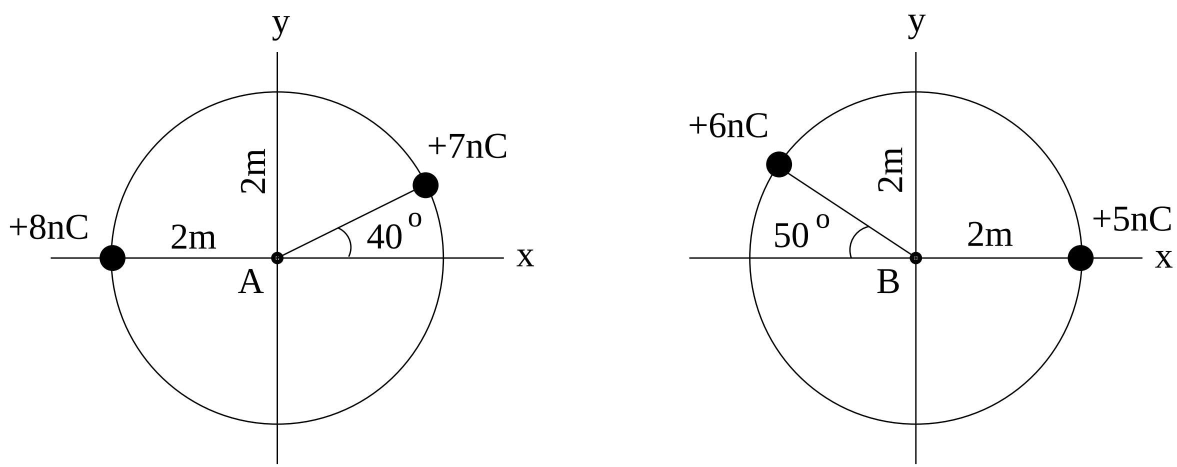
Unit Exam I: Problem #1 (Fall '18)

Consider two point charges positioned on a circle as shown left and right.
(a) Find the horizontal component E_x of the electric field at points A and B.
(b) Find the vertical component E_y of the electric field at points A and B.
(c) Find the electric potential V at points A and B.



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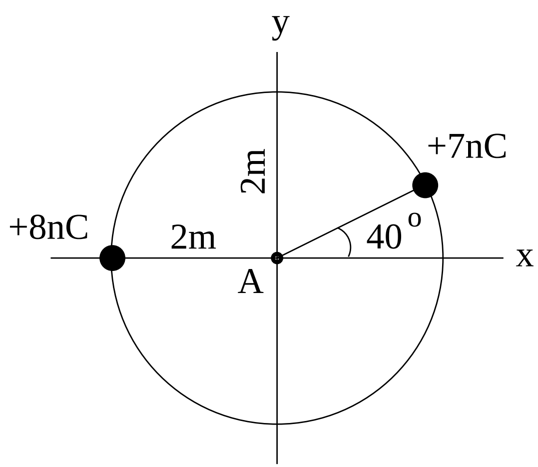
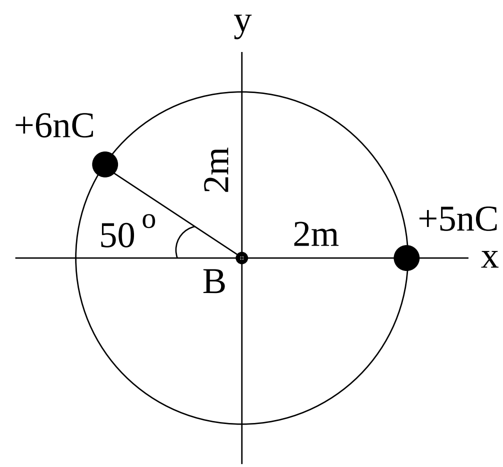




Solution:

(a) $E_x = k\frac{8\text{nC}}{(2\text{m})^2} - k\frac{7\text{nC}}{(2\text{m})^2}\cos 40^\circ = 5.9\text{N/C}$

$E_x = k\frac{6\text{nC}}{(2\text{m})^2}\cos 50^\circ - k\frac{5\text{nC}}{(2\text{m})^2} = -2.57\text{N/C}$

(b) $E_y = -k\frac{7\text{nC}}{(2\text{m})^2}\sin 40^\circ = -10.1\text{N/C}$

$E_y = -k\frac{6\text{nC}}{(2\text{m})^2}\sin 50^\circ = -10.4\text{N/C}$

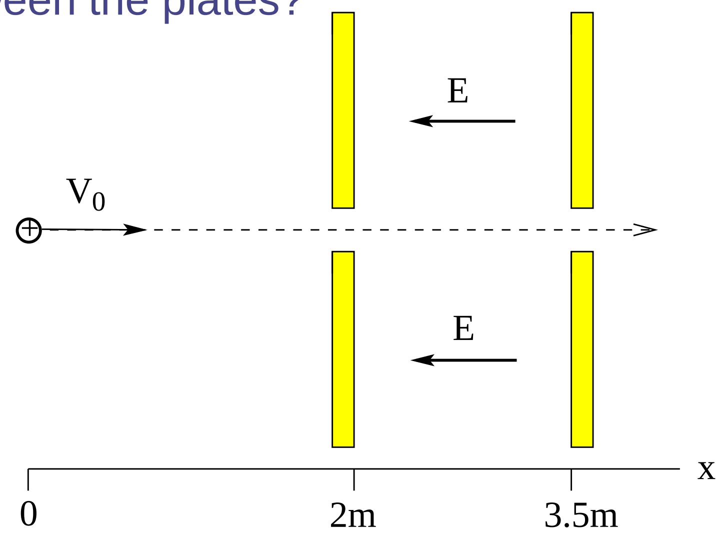
(c) $V = k\frac{8\text{nC}}{2\text{m}} + k\frac{7\text{nC}}{2\text{m}} = 67.5\text{V}.$

$V = k\frac{6\text{nC}}{2\text{m}} + k\frac{5\text{nC}}{2\text{m}} = 49.5\text{V}.$

Unit Exam I: Problem #2 (Fall '18)

Two oppositely charged plates positioned as shown produce between them a uniform electric field $E = 1.4$N/C [$E = 2.3$N/C] in the direction shown. A proton $(m = 1.67 \times 10^{-27}\text{kg}$, $q = 1.60 \times 10^{-19}\text{C})$ is launched at $x = 0$ with initial velocity $v_0 = 3.5 \times 10^4$m/s [$v_0 = 4.2 \times 10^4$m/s] as shown. The proton enters and exits the region of electric field through holes in the plates.

(a) At what time after launch does the proton reach the first plate?
(b) What is the acceleration of the proton between the plates?
(c) What is the potential difference between the plates?
(d) Does the proton gain or lose kinetic energy as it travels between the plates?
(e) What is the amount ΔK of gain or loss?



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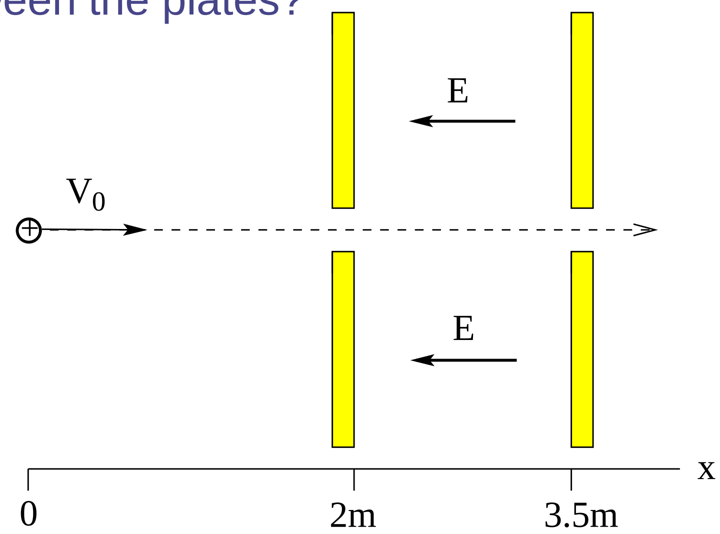


Solution:

(a) $t = \dfrac{(2\mathrm{m})}{v_0} = 5.71 \times 10^{-5}\mathrm{s} \quad [4.76 \times 10^{-5}\mathrm{s}]$.

(b) $a = -\dfrac{qE}{m} = -1.34 \times 10^8\mathrm{m/s^2} \quad [-2.20 \times 10^8\mathrm{m/s^2}]$.

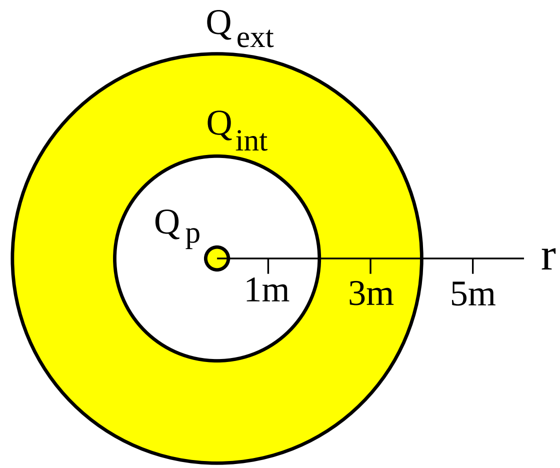
(c) $|\Delta V| = E(1.5\mathrm{m}) = 2.1\mathrm{V} \quad [3.45\mathrm{V}]$.

(d) loss

(e) $\Delta K = -q|\Delta V| = -3.36 \times 10^{-19}\mathrm{J} \quad [-5.52 \times 10^{-19}\mathrm{J}]$.

Unit Exam I: Problem #3 (Fall '18)

A point charge $Q_\mathrm{p} = 7\mathrm{nC}$ [$Q_\mathrm{p} = 8\mathrm{nC}$] is surrounded by a conducting spherical shell with a 2m inner radius and a 4m outer radius. There is zero net charge on the shell.
(a) What is the magnitude of the electric field E at radius $r = 1$m?
(b) What is the charge Q_int on the inner surface of the shell?
(c) What is the magnitude of the electric field E at radius $r = 3$m?
(d) What is the charge Q_ext on the outer surface of the shell?
(e) What is the electric flux Φ_E through a Gaussian sphere of radius $r = 5$m.



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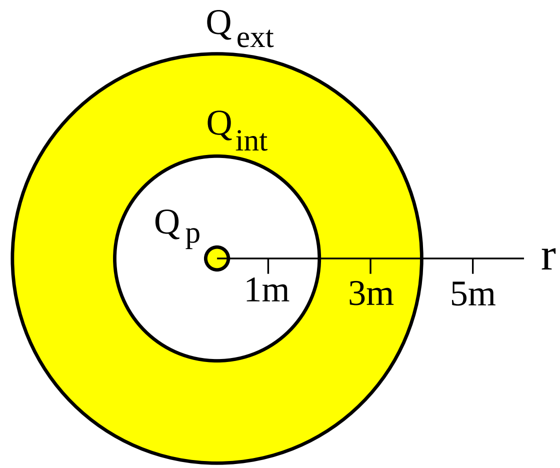

Solution:

(a) $E = \dfrac{kQ_\mathrm{p}}{(1\mathrm{m})^2} = 63\mathrm{N/C} \quad [72\mathrm{N/C}]$.

(b) $Q_\mathrm{int} = -Q_\mathrm{p} = -7\mathrm{nC} \quad [-8\mathrm{nC}]$.

(c) $E = 0$.

(d) $Q_\mathrm{ext} = -Q_\mathrm{int} = +7\mathrm{nC} \quad [+8\mathrm{nC}]$.

(e) $\Phi_E = \dfrac{Q_\mathrm{p}}{\epsilon_0} = 791\mathrm{Nm}^2/\mathrm{C} \quad [904\mathrm{Nm}^2/\mathrm{C}]$.