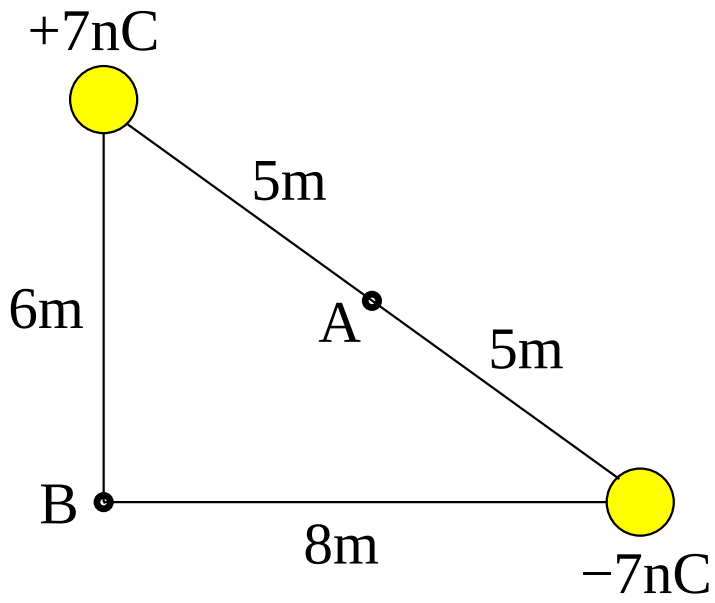
Unit Exam I: Problem #1 (Fall '10)

Consider two point charges positioned as shown.



(a) Find the magnitude of the electric field at point A.

(b) Find the electric potential at point A.

(c) Find the magnitude of the electric field at point B.

(d) Find the electric potential at point B.

Solution:

(a) $E_A = 2k\dfrac{|7\text{nC}|}{(5\text{m})^2} = 2(2.52\text{V/m}) = 5.04\text{V/m}.$

(b) $V_A = k\dfrac{(+7\text{nC})}{5\text{m}} + k\dfrac{(-7\text{nC})}{5\text{m}} = 12.6\text{V} - 12.6\text{V} = 0.$

(c) $E_B = \sqrt{\left(k\dfrac{|7\text{nC}|}{(6\text{m})^2}\right)^2 + \left(k\dfrac{|7\text{nC}|}{(8\text{m})^2}\right)^2} \Rightarrow E_B = \sqrt{(1.75\text{V/m})^2 + (0.98\text{V/m})^2} = 2.01\text{V/m}.$

(d) $V_B = k\dfrac{(+7\text{nC})}{6\text{m}} + k\dfrac{(-7\text{nC})}{8\text{m}} = 10.5\text{V} - 7.9\text{V} = 2.6\text{V}.$

Unit Exam I: Problem #2 (Fall '10)

A point charge Q_p is positioned at the center of a conducting spherical shell of inner radius $r_{int} = 3\text{m}$ and outer radius $r_{ext} = 5\text{m}$. The charge on the inner surface of the shell is $Q_{int} = -4\text{nC}$ and the charge on the outer surface is $Q_{ext} = +3\text{nC}$.

(a) Find the value of the point charge Q_p.

(b) Find direction (up/down/none) and magnitude of the electric field at point A.

(c) Find direction (up/down/none) and magnitude of the electric field at point B.

(d) Find direction (up/down/none) and magnitude of the electric field at point C. [not on exam]

Solution:

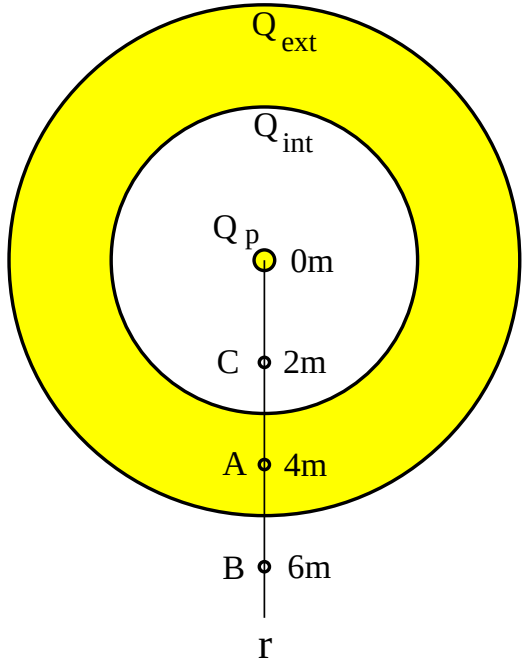
(a) $Q_p = -Q_{int} = +4\text{nC}$.

(b) $E_A = 0$ inside conductor (no direction).

(c) $E_B[4\pi(6\text{m})^2] = \dfrac{Q_p + Q_{int} + Q_{ext}}{\epsilon_0}$

$\Rightarrow\ E_B = k\dfrac{3\text{nC}}{(6\text{m})^2} = 0.75\text{N/C}$ (down).

(d) $E_C[4\pi(2\text{m})^2] = \dfrac{Q_p}{\epsilon_0}$ $\Rightarrow\ E_C = k\dfrac{4\text{nC}}{(2\text{m})^2} = 9\text{N/C}$ (down).



Unit Exam I: Problem #3 (Fall '10)

An electron ($m = 9.11 \times 10^{-31}$kg, $q = -1.60 \times 10^{-19}$C) and a proton ($m = 1.67 \times 10^{-27}$kg, $q = +1.60 \times 10^{-19}$C) are released from rest midway between oppositely charged parallel plates. The plates are at the electric potentials shown.

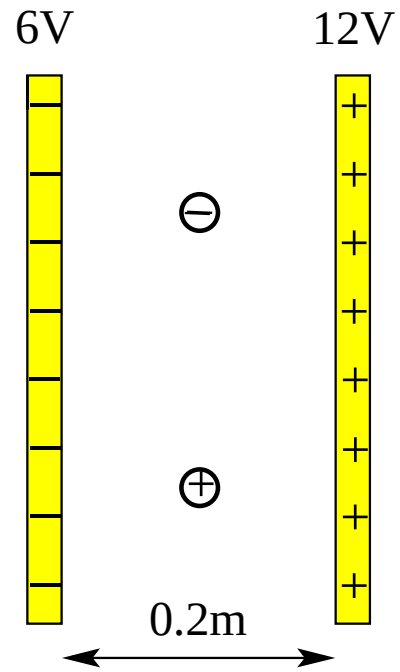
(a) Find the magnitude of the electric field between the plates.

(b) What direction (left/right) does the electric field have?

(c) Which particle (electron/proton/both) is accelerated to the left?

(d) Why does the electron reach the plate before the proton?

(e) Find the kinetic energy of the proton when it reaches the plate.



Solution:

(a) $E = 6\text{V}/0.2\text{m} = 30\text{V/m}.$

(b) left

(c) proton (positive charge)

(d) smaller m, equal $|q|$ $\Rightarrow$ larger $|q|E/m$

(e) $K = |q\Delta V| = (1.6 \times 10^{-19}\text{C})(3\text{V}) = 4.8 \times 10^{-19}\text{J}.$