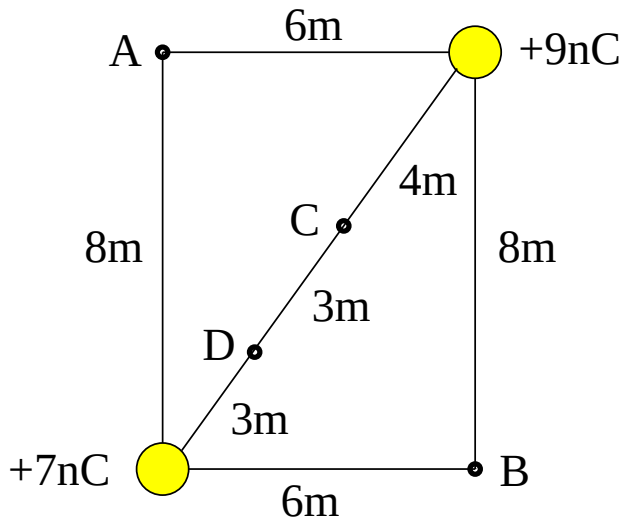
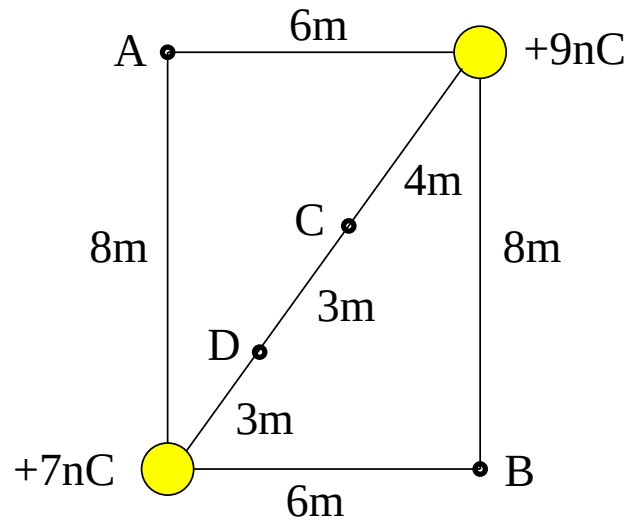
Unit Exam I: Problem #1 (Fall '16)

Consider two point charges positioned as shown.
(a) Find the magnitude of the electric field at point C $[D]$.
(b) Draw the field direction at point C $[D]$ by an arrow.
(c) Find the electric potential at point A $[B]$.



Unit Exam I: Problem #1 (Fall '16)

Consider two point charges positioned as shown.
(a) Find the magnitude of the electric field at point C $[D]$.
(b) Draw the field direction at point C $[D]$ by an arrow.
(c) Find the electric potential at point A $[B]$.

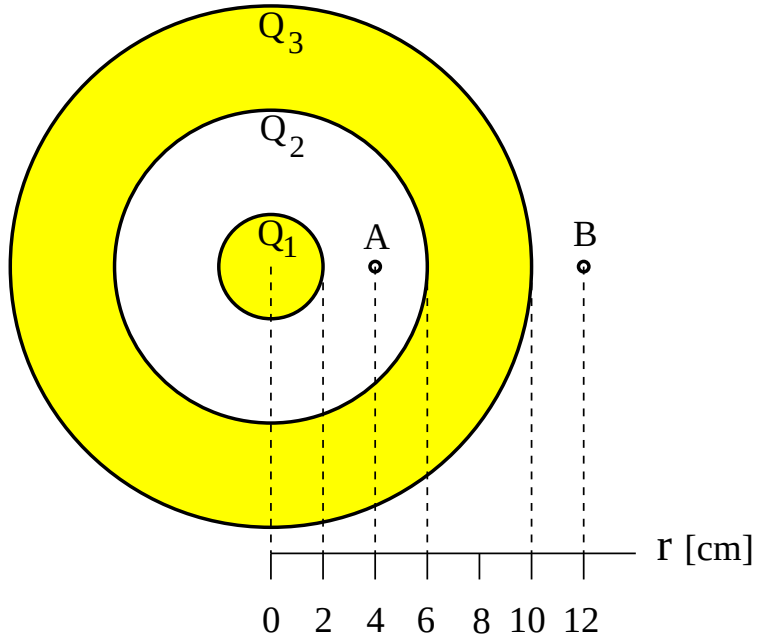


Solution:

- $E_C = k\dfrac{9\text{nC}}{(4\text{m})^2} - k\dfrac{7\text{nC}}{(6\text{m})^2} = 5.06\text{V/m} - 1.75\text{V/m} = 3.31\text{V/m}.$
  $[E_D = k\dfrac{7\text{nC}}{(3\text{m})^2} - k\dfrac{9\text{nC}}{(7\text{m})^2} = 7.00\text{V/m} - 1.65\text{V/m} = 5.35\text{V/m}].$
- Down/left along diagonal [Up/right along diagonal].
- $V_A = k\dfrac{9\text{nC}}{6\text{m}} + k\dfrac{7\text{nC}}{8\text{m}} = 13.50\text{V} + 7.88\text{V} = 21.4\text{V}.$
  $[V_B = k\dfrac{9\text{nC}}{8\text{m}} + k\dfrac{7\text{nC}}{6\text{m}} = 10.1\text{V} + 10.5\text{V} = 20.6\text{V}].$

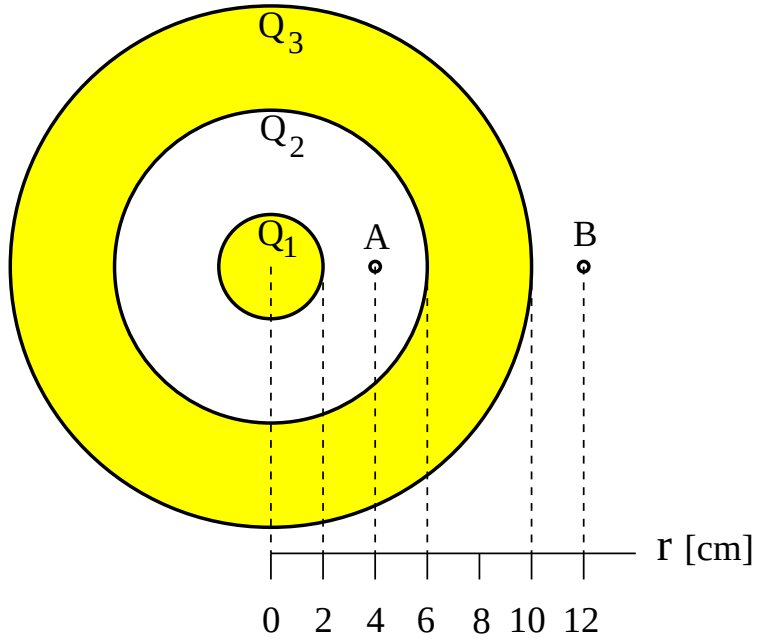
Unit Exam I: Problem #2 (Fall '16)

Consider a conducting sphere and a conducting spherical shell as shown in cross section. The charges on the two surfaces of the shell are
$Q_2 = -5$nC and $Q_3 = +2$nC [$Q_2 = +4$nC and $Q_3 = -3$nC].
(a) Find the charge Q_1 on the surface of the conducting sphere.
(b) Find magnitude and direction of the electric field at point A.
(c) Find magnitude and direction of the electric field at point B.



Unit Exam I: Problem #2 (Fall '16)

Consider a conducting sphere and a conducting spherical shell as shown in cross section. The charges on the two surfaces of the shell are
$Q_2 = -5$nC and $Q_3 = +2$nC [$Q_2 = +4$nC and $Q_3 = -3$nC].
(a) Find the charge Q_1 on the surface of the conducting sphere.
(b) Find magnitude and direction of the electric field at point A.
(c) Find magnitude and direction of the electric field at point B.



Solution:

(a) Gauss' law implies that
$Q_1 = -Q_2 = +5$nC [$Q_1 = -Q_2 = -4$nC].

(b) $E_A = k\dfrac{5\text{nC}}{(4\text{cm})^2} = 28.1 \times 10^3 \text{N/C}$ (right)

[$E_A = k\dfrac{4\text{nC}}{(4\text{cm})^2} = 22.5 \times 10^3 \text{N/C}$ (left)].

(c) $E_B = k\dfrac{2\text{nC}}{(12\text{cm})^2} = 1.25 \times 10^3 \text{N/C}$ (right)

[$E_B = k\dfrac{3\text{nC}}{(12\text{cm})^2} = 1.88 \times 10^3 \text{N/C}$ (left)].

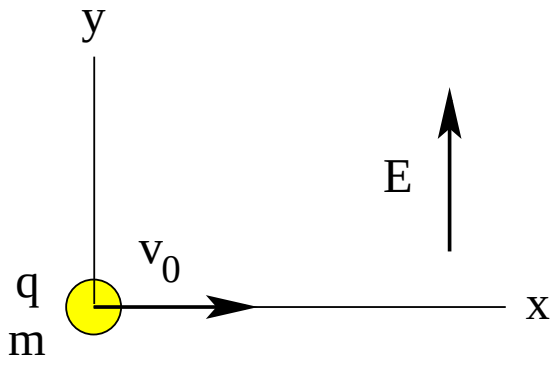
Unit Exam I: Problem #3 (Fall '16)

Consider a region of uniform electric field E. A particle with charge q and mass m is projected at time $t = 0$ with initial velocity v_0. The specifications are $m = 3$g, $q = 2$mC, $v_0 = 4$m/s, $E = 5$N/C. [$m = 2$g, $q = 3$mC, $v_0 = 5$m/s, $E = 4$N/C]. Ignore gravity.

(a) Find the components F_x and F_y of the electric force acting on the particle at time $t = 1.5$s.

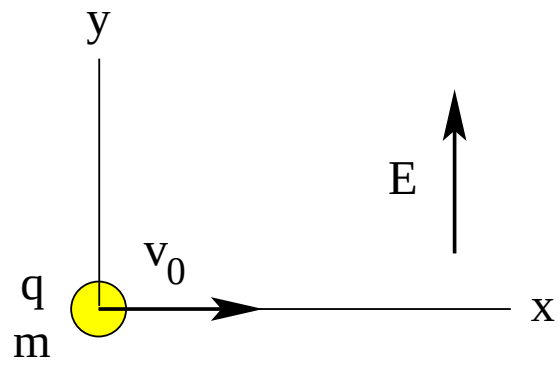
(b) Find the components v_x and v_y of the velocity at time $t = 1.5$s.

(c) Find the kinetic energy at time $t = 1.5$s.



Unit Exam I: Problem #3 (Fall '16)

Consider a region of uniform electric field E. A particle with charge q and mass m is projected at time $t = 0$ with initial velocity v_0. The specifications are $m = 3$g, $q = 2$mC, $v_0 = 4$m/s, $E = 5$N/C. [$m = 2$g, $q = 3$mC, $v_0 = 5$m/s, $E = 4$N/C]. Ignore gravity.
(a) Find the components F_x and F_y of the electric force acting on the particle at time $t = 1.5$s.
(b) Find the components v_x and v_y of the velocity at time $t = 1.5$s.
(c) Find the kinetic energy at time $t = 1.5$s.



Solution:

(a) $F_x = 0, \quad F_y = qE = 10\text{mN}$
$[F_x = 0, \quad F_y = qE = 12\text{mN}].$

(b) $v_x = v_0 = 4\text{m/s}, \quad v_y = \dfrac{F_y}{m}t = 5\text{m/s}$

$[v_x = v_0 = 5\text{m/s}, \quad v_y = \dfrac{F_y}{m}t = 9\text{m/s}].$

(c) $K = \dfrac{1}{2}(3 \times 10^{-3}\text{kg})[(4\text{m/s})^2 + (5\text{m/s})^2] = 61.5\text{mJ}$

$[K = \dfrac{1}{2}(2 \times 10^{-3}\text{kg})[(5\text{m/s})^2 + (9\text{m/s})^2] = 106\text{mJ}].$