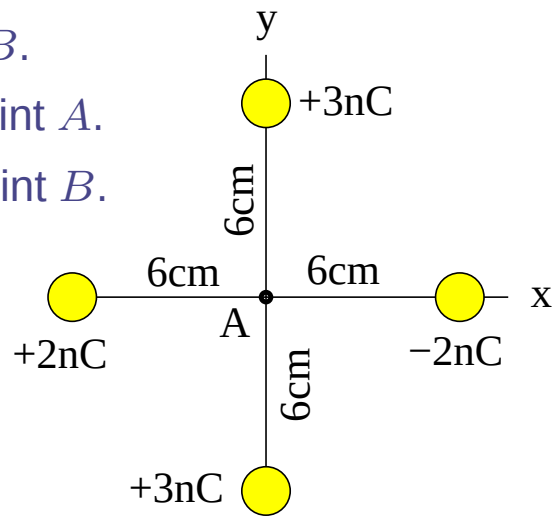
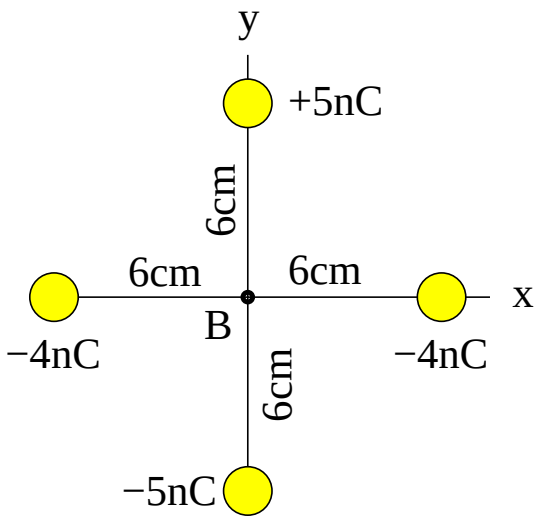
# Unit Exam I: Problem #1 (Fall '17)

Consider point charges positioned in two coordinate systems as shown.

- Find the electric field $\mathbf{E}_A$ at point $A$.
- Find the electric field $\mathbf{E}_B$ at point $B$.
- Find the electric potential $V_A$ at point $A$.
- Find the electric potential $V_B$ at point $B$.



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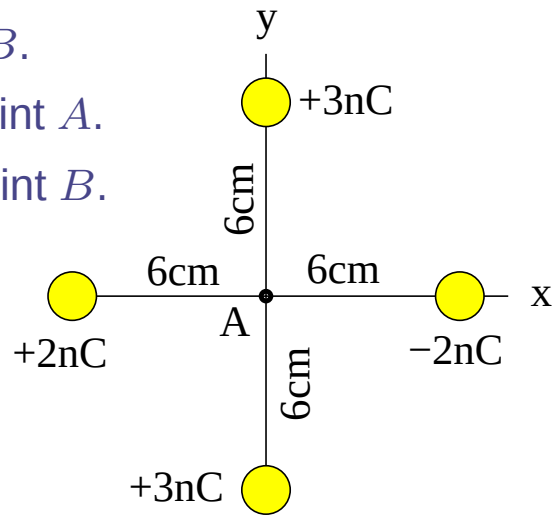
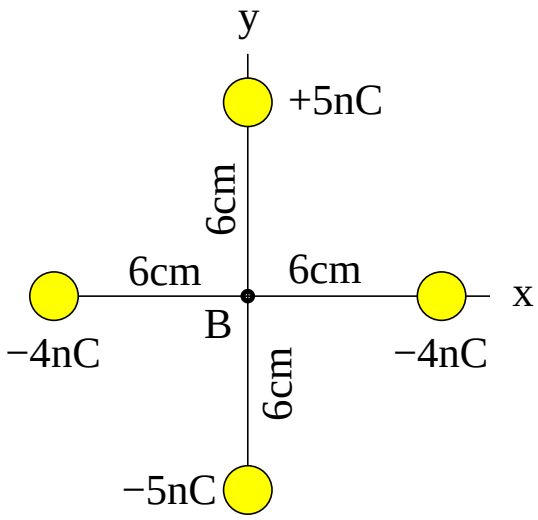



**Solution:**

$$\mathbf{E}_A = 2k\frac{|2\text{nC}|}{(6\text{cm})^2}\,\hat{\mathbf{i}} = 1.00\times 10^4\,\text{N/C}\,\hat{\mathbf{i}}$$

$$\mathbf{E}_B = -2k\frac{|5\text{nC}|}{(6\text{cm})^2}\,\hat{\mathbf{j}} = -2.50\times 10^4\,\text{N/C}\,\hat{\mathbf{j}}$$

$$V_A = 2k\frac{3\text{nC}}{6\text{cm}} = 9.00\times 10^2\text{V}$$

$$V_B = 2k\frac{(-4\text{nC})}{6\text{cm}} = -12.0\times 10^2\text{V}$$

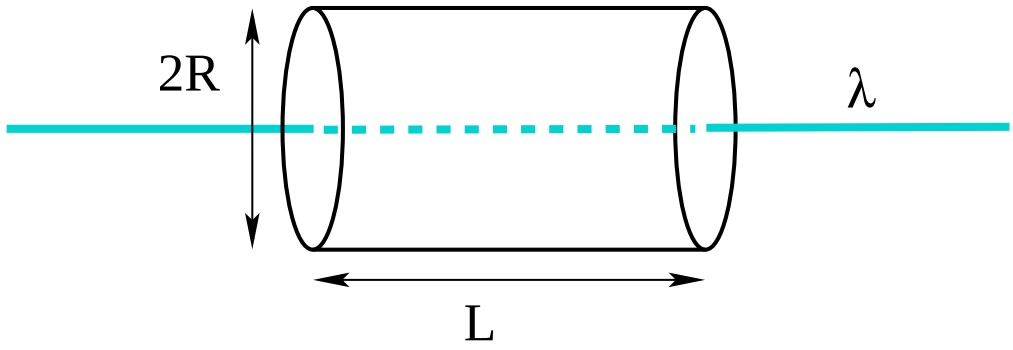
# Unit Exam I: Problem #2 (Fall '17)

Consider a long charged rod with charge per unit length $\lambda = 3\mu\mathrm{C/m}$ [$\lambda = 2\mu\mathrm{C/m}$]. A Gaussian cylinder of radius $R = 4\mathrm{cm}$ [$R = 5\mathrm{cm}$] and length $L = 12\mathrm{cm}$ [$L = 15\mathrm{cm}$] is placed with its axis along the rod as shown.

(a) Find the area $A$ of the Gaussian cylinder.

(b) Find the electric charge $Q_{in}$ inside the cylinder.

(c) Find the electric flux $\Phi_E$ through the Gaussian cylinder.



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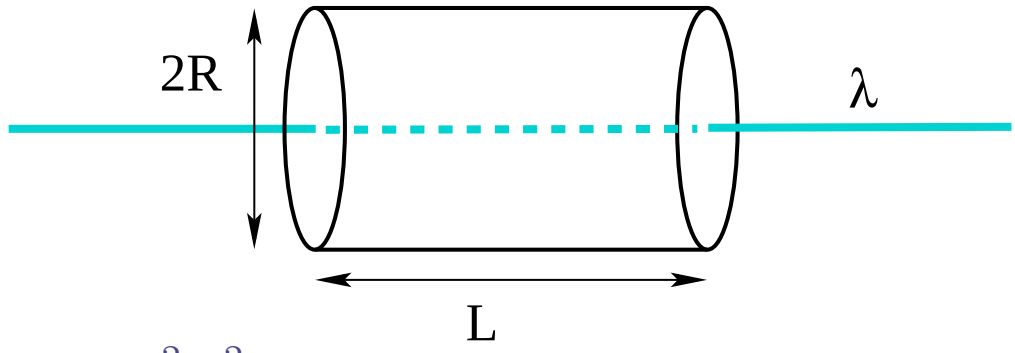



**Solution:**

(a) $A = 2 \times \pi(4\text{cm})^2 + 2\pi(4\text{cm})(12\text{cm}) = 4.03 \times 10^{-2}\text{m}^2$

$[A = 2 \times \pi(5\text{cm})^2 + 2\pi(5\text{cm})(15\text{cm} = 6.28 \times 10^{-2}\text{m}^2]$

(b) $Q_{in} = \lambda L = (3\mu\text{C/m})(12\text{cm}) = 0.36\mu\text{C}$ $[Q_{in} = \lambda L = (2\mu\text{C/m})(15\text{cm}) = 0.30\mu\text{C}]$

(c) $\Phi_E = \dfrac{Q_{in}}{\epsilon_0} = 4.07 \times 10^4\text{Nm}^2/\text{C}$ $[\Phi_E = \dfrac{Q_{in}}{\epsilon_0} = 3.39 \times 10^4\text{Nm}^2/\text{C}]$

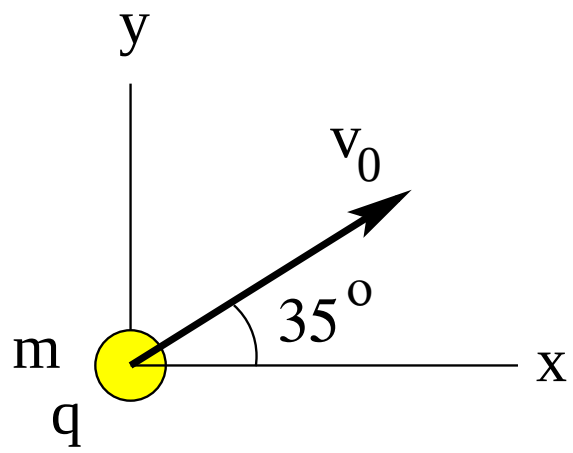
# Unit Exam I: Problem #3 (Fall '17)

In a region of uniform electric field $\mathbf{E} = 9\mathrm{N/C}\,\hat{\mathbf{i}} + 7\mathrm{N/C}\,\hat{\mathbf{j}}$, a charged particle $(m = 0.02\mathrm{kg},\ q = 4\mathrm{mC})$ is projected at time $t = 0$ with initial speed $v_0 = 6\mathrm{m/s}$ in the direction shown. If we write $\mathbf{a} = a_x\,\hat{\mathbf{i}} + a_y\,\hat{\mathbf{j}}$ for the acceleration and $\mathbf{v}(t) = v_x(t)\,\hat{\mathbf{i}} + v_y(t)\,\hat{\mathbf{j}}$ for the velocity of the particle ...

(a) find $a_x$ and $a_y$,

(b) find $v_x(0)$ and $v_y(0)$,

(c) find $v_x(6\mathrm{s})$ and $v_y(6\mathrm{s})$.



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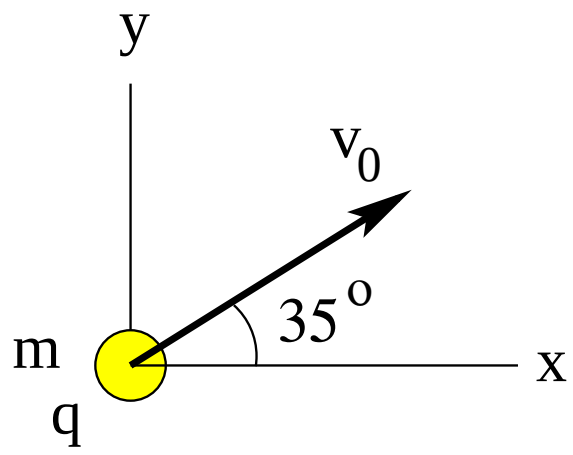


(a) find $a_x$ and $a_y$,

(b) find $v_x(0)$ and $v_y(0)$,

(c) find $v_x(6\mathrm{s})$ and $v_y(6\mathrm{s})$.

**Solution:**

(a) $a_x = \dfrac{4\times10^{-3}\mathrm{C}}{2\times10^{-2}\mathrm{kg}}(9\mathrm{N/C}) = 1.80\mathrm{m/s^2}.$

$a_y = \dfrac{4\times10^{-3}\mathrm{C}}{2\times10^{-2}\mathrm{kg}}(7\mathrm{N/C}) = 1.40\mathrm{m/s^2}.$

(b) $v_x(0) = v_0\cos 35^\circ = (6\mathrm{m/s})(0.819) = 4.91\mathrm{m/s}.$

$v_y(0) = v_0\sin 35^\circ = (6\mathrm{m/s})(0.574) = 3.44\mathrm{m/s}.$

(c) $v_x(6\mathrm{s}) = 4.91\mathrm{m/s} + (1.80\mathrm{m/s^2})(6\mathrm{s}) = 15.7\mathrm{m/s}.$

$v_y(6\mathrm{s}) = 3.44\mathrm{m/s} + (1.40\mathrm{m/s^2})(6\mathrm{s}) = 11.8\mathrm{m/s}.$