Name______________________________

Sept. 26, 2012

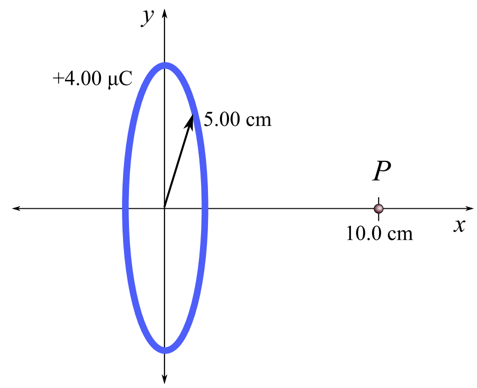
Quiz #2 — Fall 2012

Phys 2120 – Sec 4

1. If a uniform ring of charge has radius R and total charge Q, the electric potential on the axis a distance x from the center is given by

$$V(x) = \frac{kQ}{\sqrt{x^2 + R^2}}$$

(where we make the choice that the potential is zero at infinity).



a) Show why this expression is true. (At least, give an argument as to *why* it is correct.)

Since the ring is a distribution of charge, we need to get the potential by doing the integral $V = k\int \frac{dq}{r}$ where r is the distance from us to the bit of charge dq. But for points on the axis, every piece of the ring is at the same distance, which from the Pythagorean theorem is $\sqrt{x^2 + R^2}$. This constant factor can be taken outside the integral leaving

$$V = \frac{k}{\sqrt{x^2 + R^2}} \int dq = \frac{k}{\sqrt{x^2 + R^2}} Q$$

since the total charge is Q.

b) For a uniform ring of charge of radius 5.00 cm and total charge 4.00 μC, find the value of the potential at a point P on the axis at a distance of 10.0 cm from the center.

For $x = 10.0\ \mathrm{cm} = 0.100\ \mathrm{m}$ the formula then gives

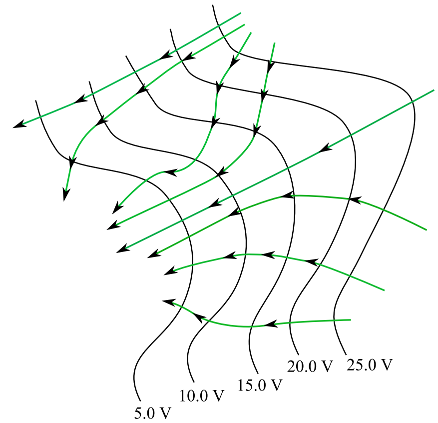
$$V = \frac{kQ}{\sqrt{x^2 + R^2}} = \frac{(8.99 \times 10^9\ \frac{\mathrm{N \cdot m^2}}{\mathrm{C^2}})(4.00 \times 10^{-6}\ \mathrm{C})}{\sqrt{(0.100\ \mathrm{m})^2 + (0.050\ \mathrm{m})^2}} = \boxed{3.2 \times 10^5\ \mathrm{V}}$$

c) For this ring, find the work required to bring a 3.00 μC charge from infinity to the point P.

As potential at infinity is zero, the work required is

$$W_{ext} = \Delta U = q\Delta V = (3.00 \times 10^{-6}\ \mathrm{C})(1.2 \times 10^4\ \mathrm{V}) = \boxed{9.7 \times 10^{-1}\ \mathrm{J}}$$

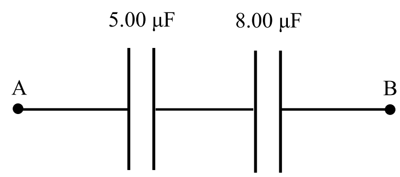
2. For a certain charge distribution we have an electric potential with equipotential lines are shown at the right.



On the figure, sketch in the electric field lines. Include arrows showing direction of the field and write a short explanation for your choices.

Field lines added to figure. The electric field lines are perpendicular to the equipotential lines everywhere and they are directed from the high-potential points to the low-potential points.

3. Two capacitors, with values $5.00\,\mu$F and $8.00\,\mu$F are connected as shown here.



When a potential difference of 50.0 V is applied across points A and B, what is the charge that is stored on the outer plates of the capacitor combination?

The series combination of capacitors is equivalent to $C_{\rm eq}$, with

$$\frac{1}{C_{\rm eq}} = \frac{1}{C_1} + \frac{1}{C_2} = \frac{1}{(5.00\,\mu\mathrm{F})} + \frac{1}{(8.00\,\mu\mathrm{F})} \qquad \Longrightarrow \qquad C_{\rm eq} = 3.08\,\mu\mathrm{F}$$

With $50.0\ \mathrm{V}$ applied to the points A and B the charge stored in this single capacitor is

$$Q = CV = (3.08 \times 10^{-6}\ \mathrm{F})(50.0\ \mathrm{V}) = 1.54 \times 10^{-4}\ \mathrm{C}$$

You must show all your work and include the right units with your answers!

$$c = 2.998 \times 10^8 \tfrac{\mathrm{m}}{\mathrm{s}} \qquad k = \frac{1}{4\pi\epsilon_0} = 8.99 \times 10^9\ \tfrac{\mathrm{N \cdot m^2}}{\mathrm{C^2}} \qquad \epsilon_0 = 8.85 \times 10^{-12}\ \tfrac{\mathrm{C^2}}{\mathrm{N \cdot m^2}}$$

$$\oint \mathbf{E} \cdot d\mathbf{A} = \frac{q_{\rm encl}}{\epsilon_0} \qquad \Delta U = q\Delta V \qquad \Delta V_{AB} = -\int_A^B \mathbf{E} \cdot d\mathbf{r} \qquad V = \frac{kq}{r} = \frac{q}{4\pi\epsilon_0 r}$$

$$E_x = -\frac{\partial V}{\partial x} \quad \text{etc.} \qquad Q = CV \qquad C_{\rm par-pl} = \frac{\epsilon_0 A}{d} \qquad C_{\rm diel} = \kappa C_0 \qquad u_E = \tfrac{1}{2}\epsilon_0 E^2$$

$$C_{\rm parallel} = C_1 + C_2 + C_3 + \dots \qquad C_{\rm series}^{-1} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \dots$$