Name ____________________

Physics 51 Section ___ Box # _____

Problem Set 4

1 October 2018

Collaborators:

HRK P28.10 Solo A total amount of positive charge Q is spread onto a nonconducting, flat, circular annulus of inner radius a and outer radius b. The charge is distributed so that the charge density (charge per unit area) is given by $\sigma = k/r^3$ where r is the distance from the center of the annulus to any point on it. Show that (with $V = 0$ at infinity) the potential at the center of the annulus is given by;

$$V = \frac{Q}{8\pi\epsilon_0}\left(\frac{a+b}{ab}\right)$$

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HRK 28.13 On a thin rod of length l lying along the x axis with one end at the origin $x = 0$, as in Fig. 28-46, there is distributed a charge per unit length given by $\lambda = kr$, where k is a constant r is the distance from the origin. (a) Taking the electrostatic potential at infinity to be zero, find V at the point P on the y axis. (b) Determine the vertical component E_y of the electric field at P from the result of part (a) and also by direct calculation. (c) Why cannot E_x, the horizontal component of the electric field at P, be found using the result of part (a)? (d) At what distance from the rod along the$y$ axis is the potential equal to the value at the left end of the rod?

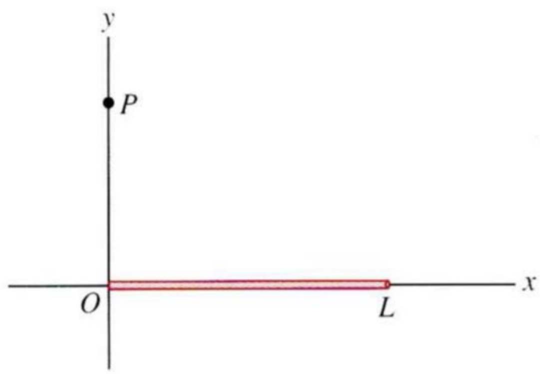

FIGURE 28-46. Problem 13.

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3. Need Thursday Lecture In lecture, we calculated the amount of electrostatic energy contained in the *interior* electric field of a uniform sphere of radius R and charge density ρ. The result was

$$U = \frac{2\pi\rho^2}{45\epsilon_0} R^5$$

For this problem, complete the calculation by calculating the energy stored in the *exterior* electric field, and verify that the *total* stored energy matched the work done to assemble the sphere.

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4. Consider an infinitely long line of charge with linear charge density λ. The line of charge is parallel to and a distance d above the infinite grounded conducting plane. Sketch the resulting electric field lines in the half-space above the plane,including any surface charges.Then using the concepts discussed in lecture, determine the electric field $E(x)$ at the surface of the plane as a function of the horizontal distance x from the from the perpendicular between the plane and line.

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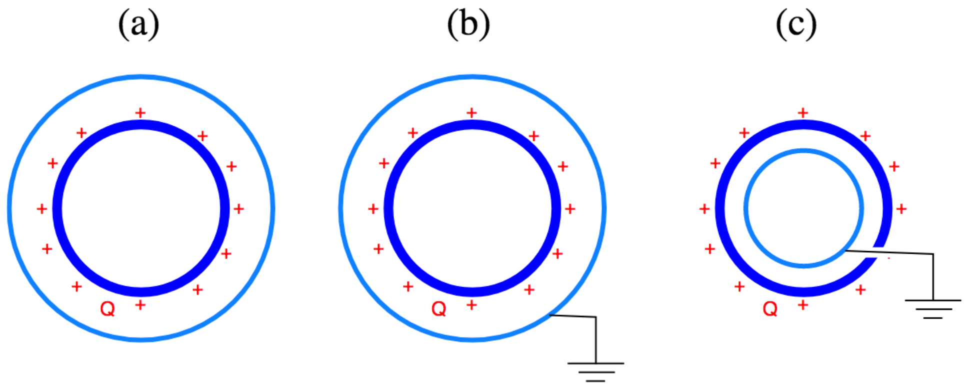
5. Consider a hollow conducting sphere that carries a net positive charge Q. Next, a second initially uncharged concentric conducting sphere is brought into proximity with the first (without touching it). In scenario (a), the second sphere is placed outside the first and left *ungrounded*. In scenario (b) , the second sphere is outside the first and grounded. In scenario c the second sphere is *inside* the first and also grounded.



For all three scenarios, describe the final arrangement of charge on the second sphere and the electric field (if any) outside the second sphere.

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6. Need Thursday Lecture A cylindrical capacitor is made from two long thing concentric metal cylinders of length L and radii a and b ($L >> a$ and $a > b$)

(a) Using the definition of capacitance $C = Q/V$, calculate the capacitance per unit length C/L of this configuration.

(b) Repeat the capacitance calculation, this time using the stored energy $U = \frac{1}{2}\frac{Q^2}{C}$.

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