Name:

Physics 51

Homework #6

September 19, 2016

28-P8, 28-P11, 28-P13, SUP4*

28-P8 Figure 28-42 shows, edge-on, an "infinite" sheet of positive charge density σ.

(a) How much work is done by the electric field of the sheet as a small positive test charge q_0 is moved from an initial position on the sheet to a final position located a perpendicular distance z from the sheet?

(b) Use the result from (a) to show that the electric potential of an infinite sheet of charge can be written

$$V = V_0 - (\sigma/2\epsilon_0)\, z,$$

where V_0 is the potential at the surface of the sheet.

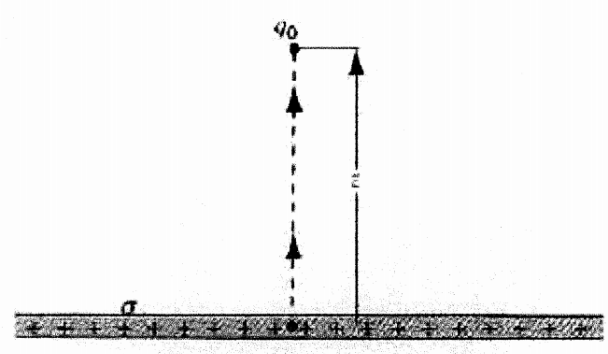

FIGURE 28-42. Problem 8.

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28-P11 For the charge configuration of Fig. 28-44, show that $V(r)$ for points on the vertical axis, assuming $r \gg d$, is given by

$$V = \frac{1}{4\pi\epsilon_0}\frac{q}{r}\left(1 + \frac{2d}{r}\right).$$

(Hint: The charge configuration can be viewed as the sum of an isolated charge and a dipole.) Set $V = 0$ at infinity.

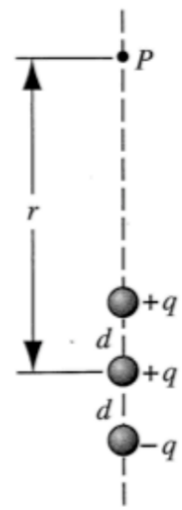

FIGURE 28-44. Problem 11.

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28-P13 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 a distributed a charge per unit length given by $\lambda = kr$, where k is a constant and 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 one-half the value at the left end of the rod?

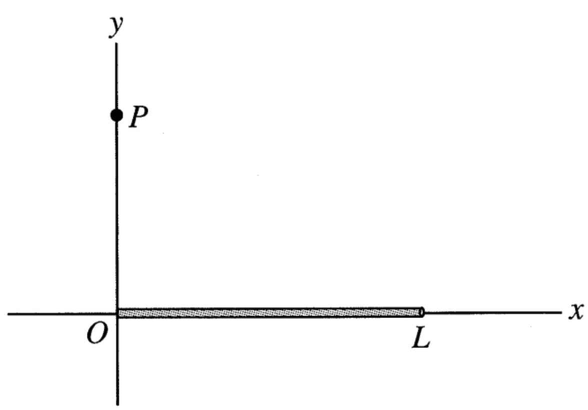

FIGURE 28-46. Problem 13.

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SUP4*

(a) Calculate the energy density of the electric field at a distance r from an electron (presumed to be a particle) at rest.

(b) Assume now that the electron is not a point but a sphere of radius R over whose surface the electron charge is uniformly distributed. Determine the energy associated with the external electric field in vacuum of the electron as a function of R.

(c) If you now associate this energy with the mass of the electron, you can, using $E_0 = mc^2$, calculate a value for R. Evaluate this radius numerically; it is often called the *classical radius* of the electron.

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