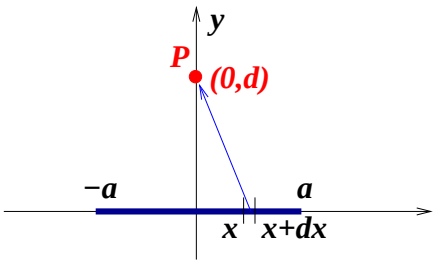
Physics 33-107 **Assignment 2** Due Thursday, January 31, 2008

Name: _____ Section: _____

Special problem:

(1) A non-conducting line segment of charge lies on the x-axis between $-a$ and a. It is *not* uniformly charged. The charge per unit length at any position x along the line segment depends on x and is given by $\lambda(x) = Q_0 x^3/L^4$. The charge density is zero beyond the range $-a \le x \le a$.



(a) Consider the infinitesimal element of charge indicated in the figure, which extends from x to $x + dx$. Find the amount of charge dQ contained in that element. Use this to find the total charge on the segment.

(b) Find the electric field which the infinitesimal charge element dQ at x causes at point P located on the y-axis a distance d away from the line segment. Be sure to give your answer as a vector. As part of your calculation, you should find the unit vector which points in the direction from the charge element towards point P.

(c) Now assume $d = 0$. Find the total electric field at point P. Take $Q_0 = 1.0\,\mu\text{C}$, $L = 10.0\,\text{cm}$, $a = 1.0\,\text{m}$. Be sure to express your answer as a vector. (The answer is *not* zero! Be careful to get signs right, particularly for $x < 0$. For example, $(x^2)^{3/2} = |x|^3 \neq x^3$. You may want to break up the integration into two separate integrals covering positive and negative x.)

(d) Again, assuming $d = 0$, what charge Q_2 would experience a force of $900\,\text{N}\,\hat{\boldsymbol{\imath}}$ if it were placed at the origin?

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(2) Textbook 21.50 A point charge $q_1 = -4.00\,\text{nC}$ is at the point $x = 0.600\,\text{m}, y = 0.800\,\text{m}$, and a second point charge $q_2 = +6.00\,\text{nC}$ is at the point $x = 0.600\,\text{m}, y = 0$. Calculate the magnitude and direction of the net electric field at the origin due to these two point charges.

(3) Textbook 21.55 A ring-shaped conductor with radius $a = 2.50\,\text{cm}$ has a total positive charge $Q = +0.125\,\text{nC}$ uniformly distributed around it, as shown in Fig. 21.21 of the textbook. The center of the ring is at the origin of coordinates O and the ring lies in the yz-plane. (a) What is the electric field (magnitude and direction) at point P, which is on the x-axis at $x = 40.0\,\text{cm}$? (b) A point charge $q = -2.50\,\mu\text{C}$ is placed at the point P described in part (a). What are the magnitude and direction of the force exerted *by* the charge q *on* the ring? (Hint: use Newton's third law.)

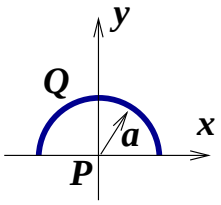
(4) Textbook 21.57 Two horizontal, infinite, plane sheets of charge are separated by a distance d. The lower sheet has negative charge with uniform surface charge density $-\sigma < 0$. The upper sheet has positive charge with uniform surface charge density $\sigma > 0$. What is the electric field (magnitude, and direction if the field is nonzero) (a) above the upper sheet? (b) below the lower sheet? (c) between the sheets?

(5) Textbook 21.93 A uniformly charged disk of surface charge density σ (see Fig. 21.26) has radius $R = 2.50\,\text{cm}$ and carries a total charge of $4.0 \times 10^{-12}\,\text{C}$. The center of the disk is at the origin and the disk lies in the yz plane. The electric field on the x-axis is given by

$$E_x = \frac{\sigma}{2\varepsilon_0}\left[1 - \frac{1}{\sqrt{(R^2/x^2)+1}}\right].$$

(a) Find the electric field (magnitude and direction) on the x-axis at $x = 0.20\,\text{cm}$. (b) Is the magnitude of the electric field you calculated in part (a) larger or smaller than the electric field 0.20 cm from an infinite sheet of charge with the same charge per unit area as the disk? Briefly explain your answer. (c) What is the percent difference between the electric field produced by the finite disk and by an infinite sheet with the same charge per unit area at (i) $x = 0.20\,\text{cm}$? (ii) $x = 0.40\,\text{cm}$?

(6) Textbook 21.96 Positive charge Q is uniformly distributed around a semicircle of radius a (see Fig. 21.49). Find the electric field (magnitude and direction) at the center of curvature P.



(7) Textbook 22.6 The cube shown has sides of length $L = 10.0\,\text{cm}$. The electric field is uniform, has a magnitude $E = 4.00 \times 10^3\,\text{N/C}$, and is parallel to the xy-plane at an angle of 36.9° measured from the $+x$-axis toward the $+y$-axis. (a) What is the electric flux outward through each of the six cube faces $S_1, S_2, S_3, S_4, S_5, S_6$? (b) What is the electric flux outward through all faces of the cube?