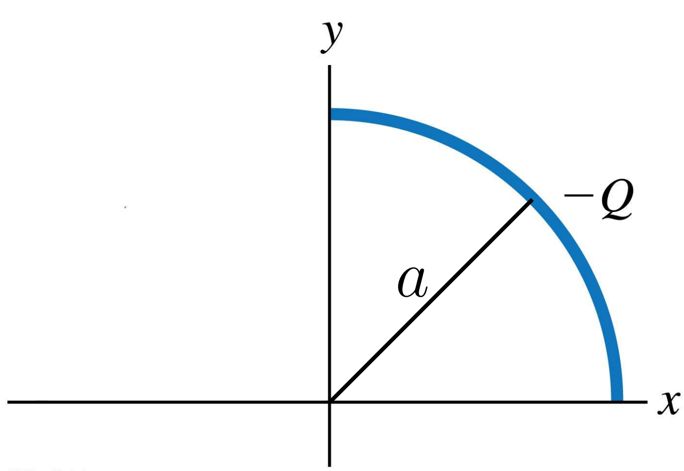
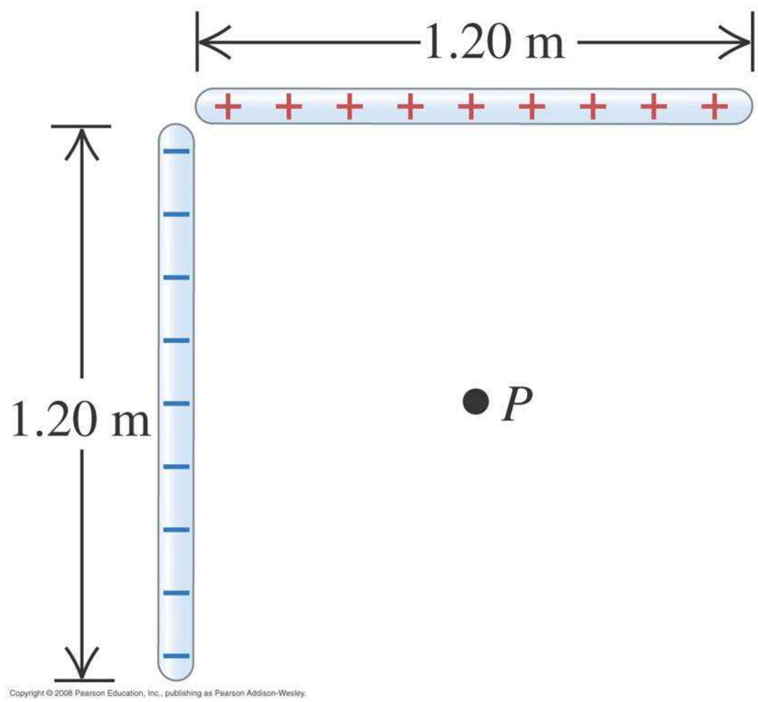
Physics 161
Summer 2013
Homework Assignment #2
Due June 14

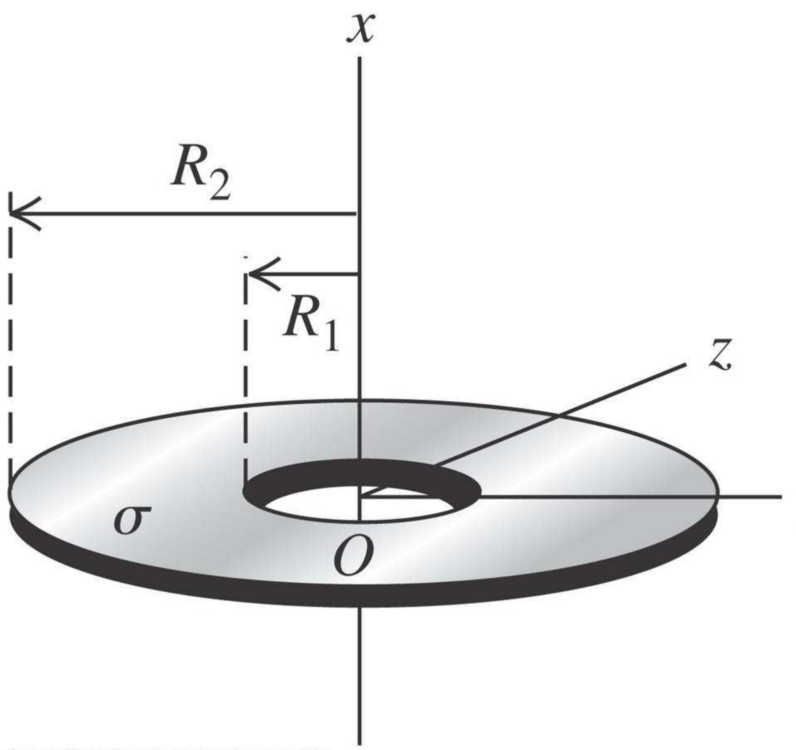
#1 Negative charge $-Q$ is distributed uniformly around a quarter-circle of radius a that lies in the first quadrant, with the center of curvature at the origin. (a) In terms of the variables Q and a, use integration to find an algebraic expression for the $x-$ and $y-$ components of the net electric field at the origin. (b) Find an algebraic expression for the magnitude and direction of the electric field at the origin. (c) For $Q = 50\,\mu C$ and $a = 5.0\,cm$, find the numerical value for the electric field's magnitude at the origin.



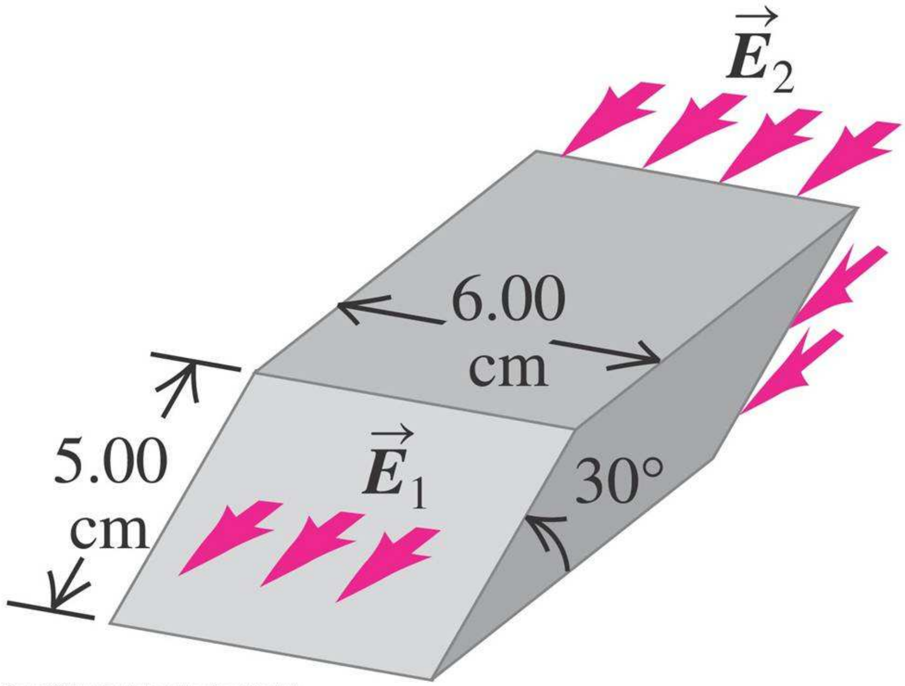
#2 Two 1.20-m nonconducting wires meet at a right angle. One segment carries $+5\,\mu C$ of charge distributed uniformly along its length, and the other carries $-5\,\mu C$ distributed uniformly along it, as shown in Fig. 21.50. (a) Use integration to find the magnitude and direction of the electric field these wires produce at point P, which is $60.0\,cm$ from each wire. (b) If an electron is released at P, what are the magnitude and direction of the net force that these wire exert on it?



#3 A thin disk with a circular hole at its center, called an *annulus*, has inner radius R_1 and outer radius R_2 (Fig 21.51). The disk has a uniform positive surface charge density σ on its surface. (a) Determine the total electric charge on the annulus. (b) The annulus lies in the yz-plane, with its center at the origin. For an arbitrary point on the x-axis (the axis of the annulus), find the magnitude and direction of the electric field.

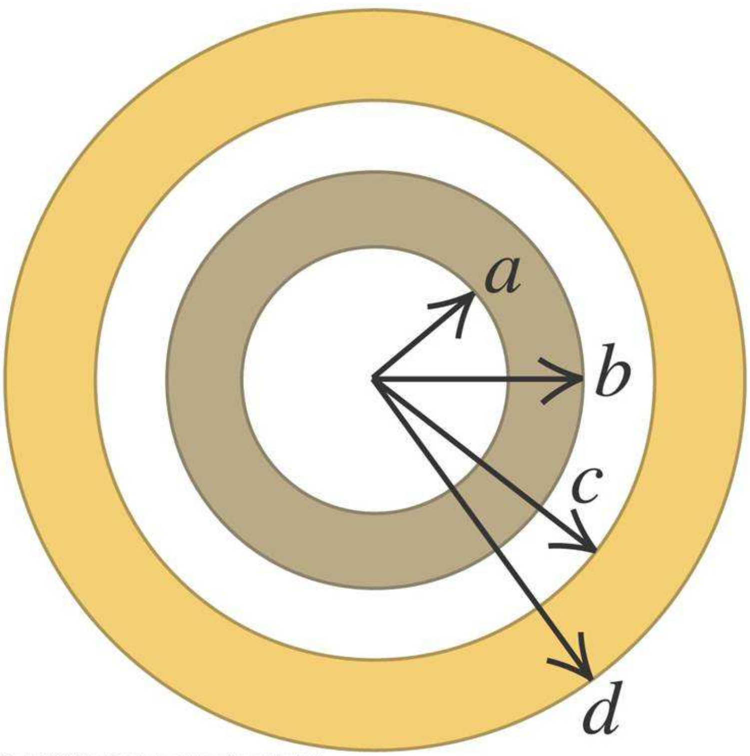


#4 The electric field $\vec{\mathbf{E}}_1$ at one face of a parallelepiped is uniform over the entire face and is directed out of the face. At the opposite face, the electric field $\vec{\mathbf{E}}_2$ is also uniform over the entire face. The two faces in question are inclined at 30.0° from the horizontal, while $\vec{\mathbf{E}}_1$ and $\vec{\mathbf{E}}_2$ are both horizontal; $\vec{\mathbf{E}}_1$ has a magnitude of $3.50 \times 10^4\,N/C$, and $\vec{\mathbf{E}}_2$ has a magnitude of $7.50 \times 10^4\,N/C$. (a) Assuming that no other electric field lines cross the surface of the parallelepiped, determine the net charge contained within. (b) Is the electric field produced only by the charges within the parallelepiped, or is the field also due to charges outside the parallelepiped? How can you tell?



#5 A very long, solid cylinder with radius R has positive charge uniformly distributed throughout it, with charge per unit volume ρ. (a) Using Gauss's law, derive the expression for the electric field inside the volume at a distance r from the axis of the cylinder in terms of the charge density ρ. (b) What is the electric field at a point outside the volume in terms of the charge per unit length λ in the cylinder? (c) Compare the answers to part (a) and (b) for $r = R$. (d) Graph the electric-field magnitude as a function of r from $r = 0$ to $r = 3R$.

#6 **Concentric Spherical Shells** A small conducting spherical shell with inner radius a and outer radius b is concentric with a larger conducting spherical shell of inner radius c and outer radius d. The inner shell has total charge $+q$, and the outer shell has charge $+5q$. (a) Using Gauss's law find the total charge on (i) the inner surface of the small shell; (ii) the outer surface of the small shell; (iii) the inner surface of the large shell; (iv) the outer surface of the large shell? (b) Calculate the electric field (magnitude and direction) in terms of q and the distance r from the common center of the two shells for (i) $r < a$; (ii) $a < r < b$; (iii) $b < r < c$; (iv) $c < r < d$; (v) $r > d$. (c) Show your results in a graph of the radial component of E as function of r.



#7 **A Uniformly Charged Slab** A slab of insulating material has thickness $2d$ and is oriented so that its faces are parallel to the yz-plane and given by the planes $x = d$ and $x = -d$. The y- and z-dimensions of the slab are very large compared to d and may be treated as essentially infinite. The slab has a uniform positive charge density ρ. (a) Explain why the electric field due to the slab is zero at the center of the slab ($x = 0$). (b) Using Gausss law, find the electric field due to the slab (magnitude and direction) at all points in space.

#8 A nonuniform, but spherically symmetric distribution of charge has a charge density $\rho(r)$ given as follows:

$$\begin{aligned} \rho(r) &= \rho_0 \left(1 - r^2/R^2\right) && \text{for } r \leq R \\ \rho(r) &= 0 && \text{for } r \geq R \end{aligned}$$

where ρ_0 is a positive constant. (a) Show that the total charge contained in the charge distribution is Q if $\rho_0 = 15Q/(8\pi R^3)$. (b) Show what the electric field in the region $r > R$ is identical to that produced by a point charge Q at $r = 0$. (c) Obtain an expression for the electric field in the region $r \leq R$. (d) Show that the two electric field equations give the same value at $r = R$.

HINT: For spherically symmetric charge distributions, you need to multiply ρ by $4\pi r^2$ before integrating dr.