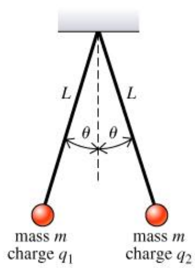
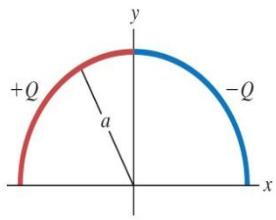
Fields 21.1

Two identical spheres are each attached to silk threads of length 0.500 m and hung from a common point. Each sphere has mass 10.00 g. The radius of each sphere is very small compared to the distance between the spheres, so they may be treated as point charges. One sphere is given positive charge q_1, and the other a different positive charge q_2 ($q_2 < q_1$); this causes the spheres to separate so that when the spheres are in equilibrium, each thread makes an angle $\theta = 22.0^{\circ}$ with the vertical. Draw a free-body diagram for each sphere when in equilibrium. Determine the magnitude of each force in your diagrams. Determine the product $q_1 q_2$. Now a wire is temporarily connected between the two spheres such that the total charge is conserved, but now each sphere has equal charge. The angle becomes $\theta = 32.0^{\circ}$. Determine the value of the original charges.



Fields 21.2

A semicircle of radius a is in the first and second quadrants, with the center of curvature at the origin. Positive charge +Q is distributed uniformly around the left half of the semicircle, and negative charge -Q is distributed uniformly around the right half of the semicircle in the following figure. What is the magnitude and direction of the net electric field at the origin produced by this distribution of charge?



Fields 21.3

A thin disk with a circular hole at its center, called an annulus, has inner radius R_1 and outer radius R_2. The disk has a uniform positive surface charge density σ on its surface. Determine the total electric charge on the annulus. 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 $\vec{E}$. Consider points above the annulus in the figure. A point particle with mass m and negative charge -q is free to move along the x-axis (but cannot move off the axis). The particle is originally placed at rest at x = 0.001 R_1 and released. Find the frequency of oscillations of the particle about the origin.