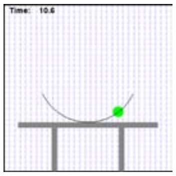
Worksheet for Exploration 23.3: Adding Fields



A charged bead is placed on a circular wire frame as shown. The center of the circle is at the point (0 m, 1m). In addition to gravity, you can add a uniform electric field in the x direction **(position is given in meters, time is given in seconds, and the electric field strength is given in N/C)**. Restart. The force field is shown using arrows as in Illustration 23.1.

Enter a value for the electric field and click the *set value and play* button to begin the animation. The bead will move unless it is at an equilibrium position. You can set the instantaneous velocity to zero but the bead will again begin to move unless you happen to damp it at an equilibrium point. Pause the animation, zero the velocity, drag the bead, and play the animation as many times as you like. If the electric field is small enough so it is similar in size to the gravitational field, you can see the field vector at an angle with the horizontal as it is the vector sum of the gravitational force (m**g**) and the electric force (q**E**). Determine the charge on the bead if the mass is 10 grams.

a. Notice that the bead oscillates about an equilibrium position. Find a value of the electric field that gives you an equilibrium position somewhere on the wire. Zero the velocity to get the bead to stop at that equilibrium position.
   i. Make sure you use a non-zero E field.

E=________ $x_{equil.}$=_______ $y_{equil.}$=________

b. Draw a force diagram and show that the y component of the normal force of the wire on the bead must be equal to the weight of the bead, while the x component of the normal force must be equal to the force due to the electric field (q**E**).
   i. Your diagram should have F_g, F_E, and $F_{wire.}$
   ii. Once you have your diagram then think about appropriate coordinate system and components.

c. Since the normal force is perpendicular to the wire (and therefore points to the center of the wire circle), find the angle that the normal makes with either the horizontal or vertical and then show that the ratio of the gravitational force to the electric force is simply the tangent of the angle that the normal force makes with the horizontal. Therefore, you can find the electrical force (qE) required to keep the bead at equilibrium.
   i. Select at least one set of simulation conditions (E field), stop the ball at equilibrium, and verify that your prediction formula works.