nitude of the force at various locations around the rod. What is the direction and relative magnitude of the electric field around the rod? To complete the suggested observations you will need the following:

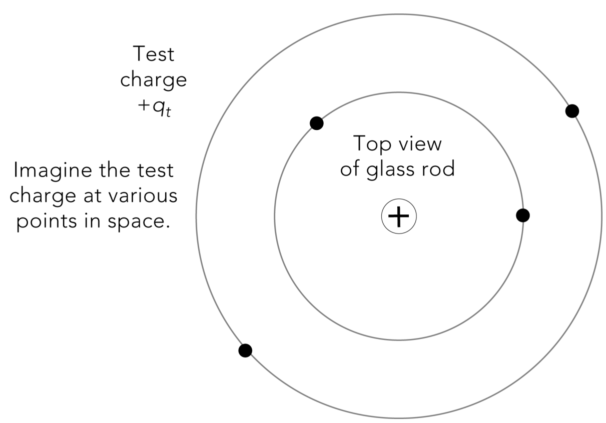
- 1 threaded, metal-coated Styrofoam ball (with low mass)
- 1 plastic rod
- 1 piece of fur
- 1 glass rod
- 1 polyester cloth
- 1 ruler

| Recommended Group Size: | 2 | Interactive Demo OK?: | N |
|---|---|---|---|

**Note:** By convention physicists always place the tail of the $E$-field vector at the point in space of interest rather than at the charged object that causes the field.

### 19.7.1. Activity: Electric Field Vectors from a Positively Charged Rod

Make a qualitative sketch of some electric field vectors around the rod at the points in space marked on the following diagram. The length of each vector should roughly indicate the *relative* magnitude of the field (that is, if the $E$-field is stronger at one point than another, make its vector longer). Of course, the direction of the vector should indicate the direction of the field. Don't forget to put the tail of the vector at the location of interest, not at the location of the glass rod.




### 19.7.2. Activity: Electric Field from a Negatively Charged Rod

Use the hard plastic rod to create an electric field resulting from a negative charge distribution. Sketch the electric field vectors at the indicated points in space; show both the *magnitude* and *direction* of the vectors.

**d.** Explain why $k$, $q^{\text{tot}}$, and $L$ can be pulled out of the integral so that

$$E_x^{\text{tot}} = \frac{kq^{\text{tot}}}{L}\int_d^{d+L} \frac{1}{x^2}\,dx\ .$$

**e.** Perform the integration to show that $E_x^{\text{tot}} = \frac{kq^{\text{tot}}}{L}\int_d^{d+L} \frac{1}{x^2}\,dx = \frac{kq^{\text{tot}}}{d\left(L+d\right)}$

**f.** Calculate the "exact" value for the electric field magnitude $E$ at point $P$ by substituting the values for $L$, $d$, and $q^{\text{tot}}$ shown in Fig. 19.12. into the equation

$$E_x^{\text{tot}} = \frac{kq^{\text{tot}}}{d\left(L+d\right)} =$$

**g.** How does the numerical value you calculated in 19.9.2.b. compare to the "exact" value you just calculated? Compute the percent discrepancy. How could you make the numerical method more "exact?"

The first set of calculations for the $E$-field along the axis of the rod was relatively easy because all the electric field vectors lie along a single line. In order to do a calculation of the $E$-field at point $P'$ perpendicular to the axis of the rod that lies along a line bisecting the rod, we have to consider both the $x$- and $y$-components of the electric field resulting from the charge on each element. Thus, in general, $\vec{E}_n = E_{nx}\hat{i} + E_{ny}\hat{j}$ .

### 19.9.4. Activity: The Electric Field ⊥ to the Axis of the Rod

**a.** Explain why the $x$-component of the total $E$-vector at point $P'$ should be zero. **Hint:** The argument used is known as a symmetry argument.