# Experiment II – Electric Field

The electric field, like the gravitational field, is an abstract representation of a force or interaction. In order to understand physical phenomena it is useful to develop a graphical representation of the electric field using electric field lines.

Activity 1   The pictures below show the electric field lines of two different point charges: one positive, one negative. The charge in the top drawing is a +2 µC charge and that in the bottom is –5 µC.
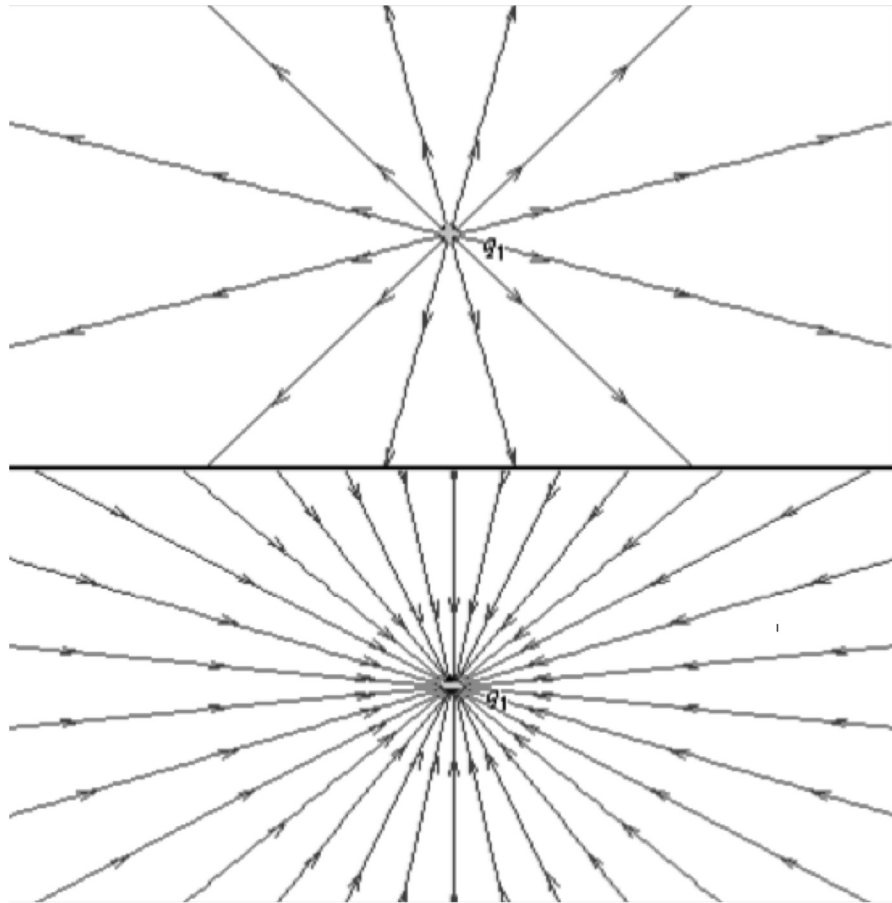
Write rules describing the representation of electric fields by field lines in the box below. Consider in particular:

1. The direction of the field lines as indicated by the arrows;
2. The places where field lines start and end relative to the signs of the source charges;
3. The separation or spacing between the field lines in a particular region relative to the strength of the field;
4. The number of field lines starting or ending on a charge relative to the magnitude and sign of the charge; and
5. The presence or absence of an electric field line between the drawn electric field lines.

Next, consider the field lines of a configuration of two charges of equal magnitude but of opposite sign. This combination of charges is called an *electric dipole.*
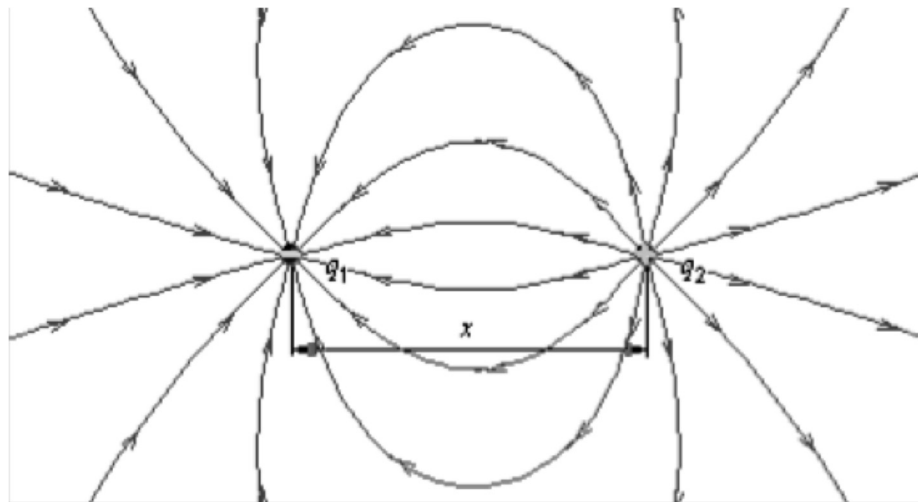
Check rules that you developed about the representation of electric fields by field lines on the two-charge configuration. Make sure that your rules are consistent with each of the 5 points mentioned on the previous page. If necessary, revise your rules.

Activity 2   Predicting Electric Fields

Now that we have developed some understanding of the rules for drawing electric field lines, let's attempt to sketch the field lines of different charges. For each example be sure to follow your rules and do not forget to draw arrows indicating the direction of the field lines. The charges are located on the x-axis at the positions indicated.

1. $Q_1 = 2\ \mu C$ at $x = 0$ and $Q_2 = 2\ \mu C$ at $x = 2$ (sketch below)

a. Is the electric field zero at $x = 1$, $y = 0$? Explain why or why not.

b. Is the electric field zero at $x = 1$, $y = 1$? Explain why or why not.

2. $Q_1 = 5$ μC at $x = 0$, $Q_2 = 1$ μC at $x = 2$ (sketch below)

    a. Is the electric field zero at $x = 1$, $y = 0$? Explain.

    b. Are there places on the x-axis where the electric field is zero? If so, determine the location(s).

Instructor Initials: _____   Date: _____

Integrals

(1) Planet Imogene [Herdman] consists of a thin cylinder of length L and mass M. A moon is oriented along the axis of planet Imogene as shown, with mass m and a distance Z away from the near end of the planet. What is the gravitational acceleration that planet Imogene exerts on the moon?

(2) Planet Uriah [the Hittite] consists of a thin semicircular line of radius R and linear mass density (kg/m) of δ. A moon is oriented at the center of the semicircle. What is the gravitational acceleration that planet Uriah exerts on the moon?
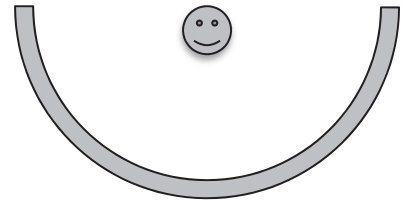
(3) Planet Vanilla [ice cream] is a solid cone of uniform mass density ρ (kg/m³). What is the gravitational acceleration that planet Vanilla exerts on the star? What is the x-component of the gravitational force that planet Vanilla exerts on the moon? Assume that D is much smaller than any of A, B, or H.

$$F_{gravity} = \frac{Gm_1 m_2}{R^2}$$
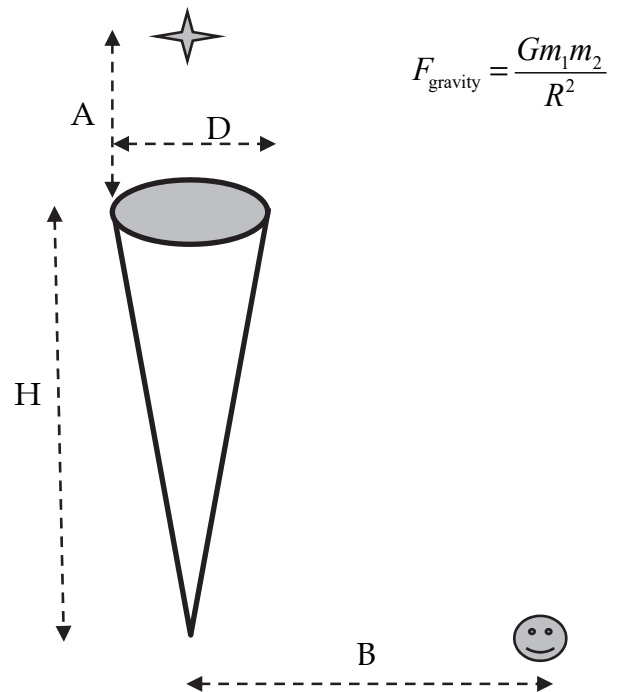
Electric Field

(1) **Field lines.** Draw arrows specifying the direction of the electric force on an <u>electron</u> placed at A, B or C. Use the length of the arrows to indicate the relative strength of the forces.
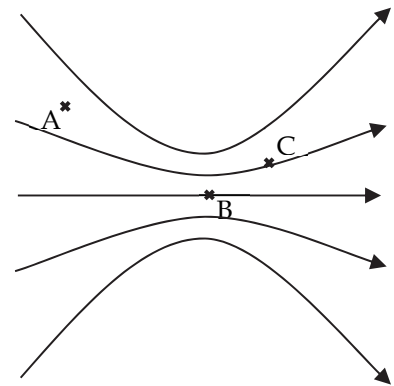
(2) **Symmetry.** Use symmetry to determine the direction of the electric field at the location indicated by the dot for each charge distribution (a-d). Note there is no charge at the dot; it just marks the location.

a) $+Q$

b) $-Q$ $+Q$

c) $-Q$

d) $+2Q$ $+Q$
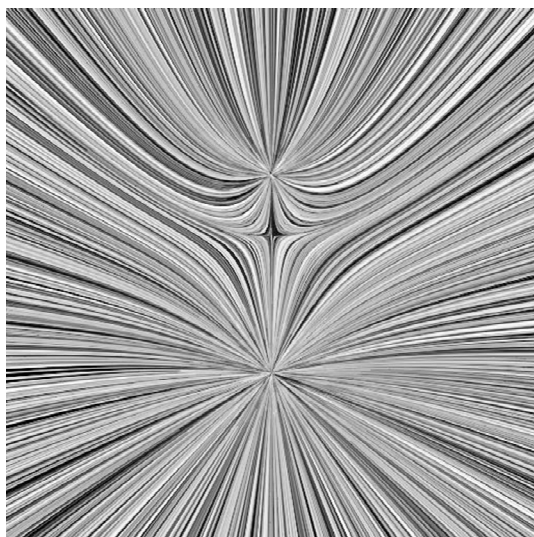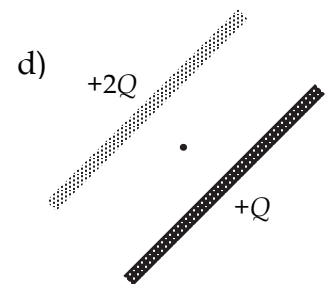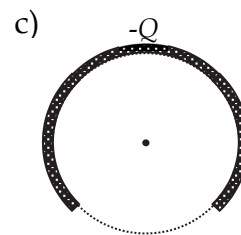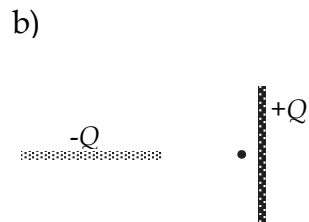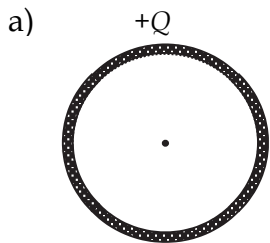
(3) **Finding the electric field of a continuous charge distribution by direct integration.**

a) **A thin line charge**. Find the y-component of the electric field E at point P due to the line charge. <u>An integral table is provided.</u>
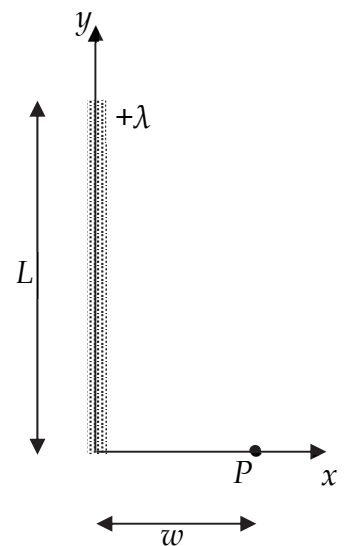
b) **A thin semi-circle of charge.** Find the electric field E at the center of the circle of which the semi-circle is a part. (Often, this is just phrased as "find the electric field at the center of the circle", even if the charge distribution is not a full circle.) The circle has radius R and a charge density of $-\lambda$.