SPH3U7: Picturing Fields

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One of the reasons why electrostatic forces seem so mysterious is that they have an effect at a distance, without any objects being in contact. We are familiar with one other force that also has this property. Which force is that?

A: Gravity vs. Electricity – Fight!

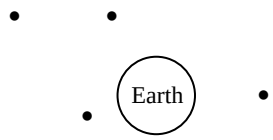
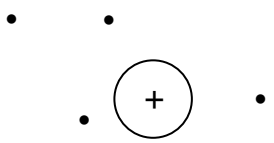
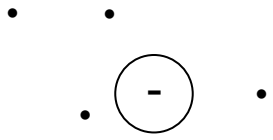
1. **Represent and Reason**. Imagine two point-like charged objects of mass m_1 and m_2 that have electric charges q_1 and q_2, respectively. Complete the table below that compares their electric and gravitational interactions.

	What property of the objects determines whether they participate in the interaction?	What is the direction of the force between the interacting objects?	Write an expression for the magnitude of the force that one object exerts on the other.	How does the magnitude of the force depend on properties of the objects?	How does the magnitude of the force depend on the distance between the objects?
Gravitational		It is an attractive force.		It is directly proportional to the masses m_1 and m_2.	
Electric	The electric charge determines whether they will interact.				

One way of explaining how gravity can have an effect on objects far away is with the idea of a *field*. We say that the earth has a gravitational field that extends throughout space and that the earth is the *source* of the field. The earth acts on distant objects through its gravitational field.

B: Picturing the Electric Field

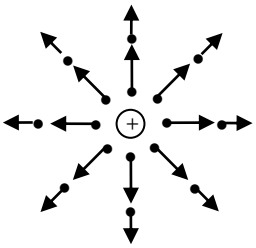
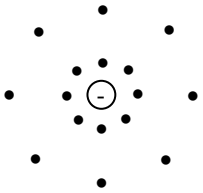
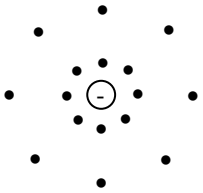
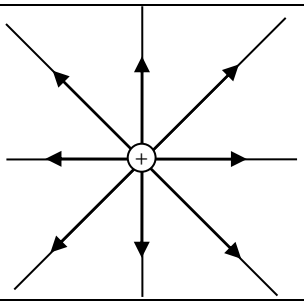
1. **Represent and Reason**. For each situation pictured below, represent with arrows the gravitational force or the electric force that a test particle would experience due to the sources at the points shown. In the study of electricity we will always choose **all test particles (test charges) to have a positive charge**.

The planet Earth	An object with a large positive charge	An object with a large negative charge
		

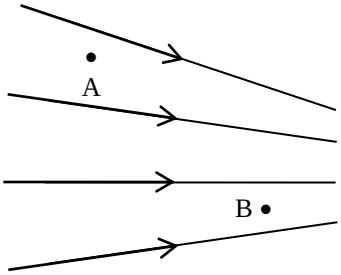
A force field (a field representing forces) is a way of representing the force vectors due to a source at every point in space. This would require many, many vectors so instead we draw *field lines*. To do this we use a set of rules for **electric** fields:

(1) Electric field lines follow the "path" of the vectors. The vector is always tangent to the field line.
(2) E-field lines start on positively charged objects and end on negatively charged objects.
(3) The magnitude of the field at a point is represented by the density or concentration of the lines near that point.
(4) A corollary to this idea is that the number of lines leaving or terminating on a charged object is proportional to the magnitude of its electric charge.

2. **Represent and Reason**. The table below gives four examples of point-like charges objects. Study the given examples and draw E-field vectors and E-field lines for each source.

	(a) a charge of $+q$	(b) a charge of $+2q$	(c) a charge of $-q$	(d) a charge of $-2q$
Electric Field Vectors				
Electric Field Lines				

3. **Apply.** A region of space has an electric field as shown to the right. Note that we do not know the location of the source of this field. A particle with a **negative** charge is placed at point A and then at point B. Draw the force vectors at positions A and B. Explain how to decide the direction of the force on the particle at that position in space. Explain in terms of the field line density how you determined the lengths of the vectors.



C: Problem Solving

In the diagram below, beads 1 and 2 carry charges 1.0 nC (nanocoulombs) and 2.0 nC, respectively. P is just a point in space, not a charge. The electric force exerted on bead 2 by bead 1 is 12 N. The overall electric force that would be felt by a 2.5 nC charge at point P is 20 N; but a 2.5 nC particle is not present for now.

First let's think about the effect of bead 2 on bead 1.

1. **Reason.** Find the electric force exerted by bead 2 on bead 1. Yes, you have enough information; use a basic law of physics!

2. **Calculate.** Find the electric field due to bead 2 at the location occupied by bead 1.

3. **Reason.** Is your D#2 answer greater than, less than, or equal to the electric field due to bead 1 at the location occupied by bead 2? Explain.