Tutorial Instructor's Guide

Abstract concepts: Fields

Equipment: *None.*

I. In this part the students define and interpret a "wind field," which will provide an analogy for electric field in the next section.

A. Students are usually able to say that while the larger kite "catches" more wind, the wind itself is the same for both kites; so there is a sense in which the wind is stronger on the larger kite, and another sense in which the wind is the same. They mostly have no trouble filling in the table in Part 5 and are able to choose 6 N/m^2 as the single number to represent the wind field at point A.

   Students **and TAs** have the most trouble with question 8: They tend to either give a vocabulary name (like "pressure"), or they tell you the units ("force per unit area" or "Newtons per meter squared"). Neither of these is the intent of the question. The kind of answer to look for tells what the number 6 means physically in this situation: *It's the number of Newtons felt by a one-square-meter piece of kite.* Or, *It's the amount of force felt by a unit area of the kite.* If they just say "It's the force per unit area," it's hard to tell whether they have the physical meaning in mind or just the mathematical calculation. Help the students (and TAs!) understand what's expected – something that tells you what's happening physically – and why it's important. That is the main issue at the checkpoint.

B. Most students easily recognize that both Lisa and Marge are right and in fact sometimes have trouble telling the difference between the two. Try asking, *What size kite is each person picturing?*

C. Students should recognize that the wind *force* depends on both the fan and the kite, but the wind *field* depends only on the fan.

II. In this part the students apply the field ideas that they developed for wind to the analogous case of electric field.

A. Students usually do well with these questions. They sometimes have trouble with the last one ("In what ways are wind fields and electric fields similar? Different?"). Some good answers for similarity include: They both depend only on the "source" (the fan and/or charges); they both are regions of influence that extend past the source; they both result in forces on objects; both can either attract or repel. Some differences: One is made of stuff that's getting pushed (air), whereas the other has no material passing out of the source; one affects objects that have an area facing the source, the other affects electrical charges. **Ask TAs for other ideas.**

B. Students **and TAs** have trouble with #4; they tend to agree. In fact, it's not correct to talk about "the force at point A" since the force is not associated with a point in space but is instead an interaction between two objects. Two possible restatements would be: (1) "The electric field at point B is greater than the electric field at point A," or (2) "The electric force on an object at point B is greater than the electric force on the same object would be if it were at point A."

III. This part quantifies the concept of electric field.

A. Students find this part pretty easy.

B. Students **and TAs** have the same problem with this part that they had with the analogous questions about wind: They have trouble saying what the number means physically, and tend to instead report how to calculate the number or what its units are. Good answers include *It's the number of Newtons felt by a one-nanocoulomb charge.* Or, *It's the amount of force felt by a unit charge.* If they just say "It's the force per unit charge" or "It's the netwons per coulomb," it's hard to tell whether they have the physical meaning in mind or just the mathematical calculation.

IV. The point of this question is for students to reflect on the fact that their intuition is a good basis for even this very abstract material.

This tutorial is pretty short. Consider having the students do the first couple pages of the Potential *tutorial when they finish* Fields.