Name_____ Section_____ Date_____

CONCEPTUAL PHYSICS: Hewitt/Baird | **Tech Lab**

Electrostatics | Field Manipulation Challenge Simulation

Electric Field Hockey

Purpose

To use a simulation to gain a sense of the vector nature of the electric field and the consequence of the inverse square law that governs electrostatic force by completing a series of game-like challenges

Apparatus

computer
PhET simulation: "Electric Field Hockey" (available at http://phet.colorado.edu)

Discussion

In the space around a charged object is an "aura" generally described as an electric field. The electric field is a vector quantity, so the fields about multiple charges add vectorially. If they have the same direction, the fields add (Figure 1.a) and if they have opposite directions, they subtract, and may even cancel each other (Figure 1.b). And if the directions are at angles to each other, their effects combine and act at a new angle (Figure 1.c).

Figure 1.a. Same direction—fields add

Figure 1.b. Opposite direction—fields cancel

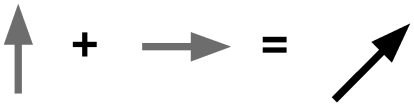


Figure 1.c. Different directions—fields add to a different direction

Software

In Electric Field Hockey, a player guides a charged puck into the goal (bracket). The player must strategically place positive and negative charges on the "rink" so that when the puck is released, it will be propelled by electric forces into the goal. Clicking the on-screen "Start" button sets the puck free. The charges placed on the rink are fixed in place and will not move.

Procedure

Step 1: Start the computer and allow it to complete its start-up cycle.

Step 2: Locate and start the PhET "Electric Field Hockey" simulation. Ask your instructor for assistance if you have difficulty.

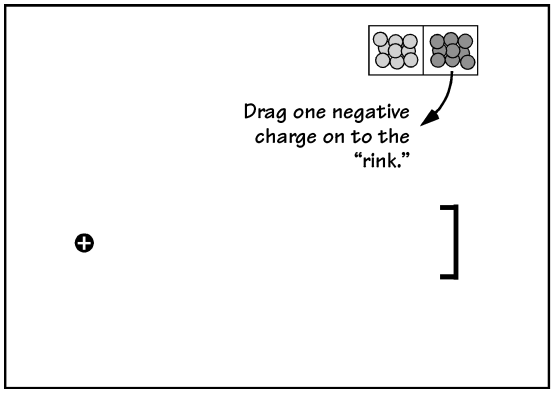
Step 3: From the selections available near the bottom of the simulation window,

a. leave "Puck is positive" selected.
b. activate the "Trace." Leave the other checkboxes unchecked.
c. set the mass slider control to 100. (Doing so makes it easier to follow the action on the screen.)
d. leave the simulation in "Practice" mode for now.
e. Complete the practice exercises that follow.

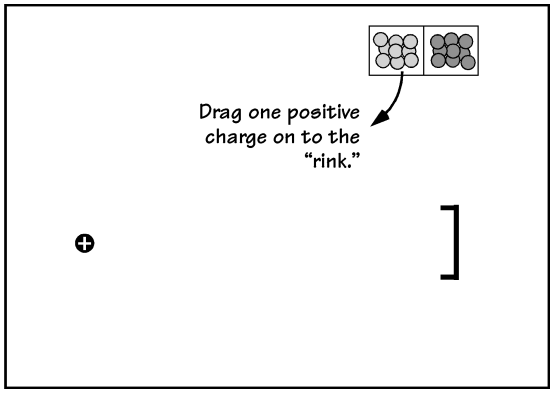
Continue until lab time runs out or you win the prized and highly coveted Coulomb Cup (completion of Level 3).

Optional (if using the activity as a time-limited competition): When you score a prescribed goal, leave the trace on the screen and call the instructor over for a verification/stamp. ***After*** the group's papers have been stamped, click the on-screen "Clear" button and move to the next exercise.

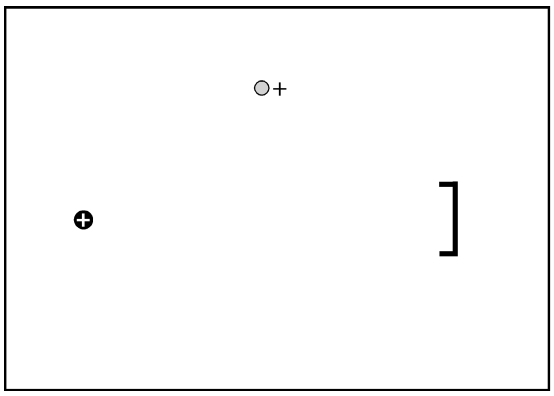
More curriculum can be found in Pearson Addison Wesley's **Conceptual Physics Laboratory Manual: Activities · Experiments · Demonstrations · Tech Labs** by Paul G. Hewitt and Dean Baird. ISBN: 0321732480



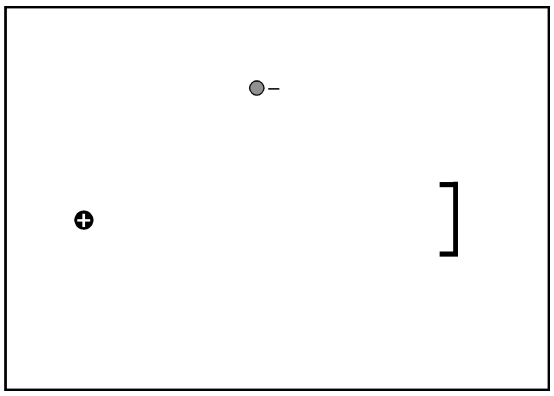
PRACTICE 1: Use one negative charge to score a goal. Sketch the location of your goal-scoring charge placement.



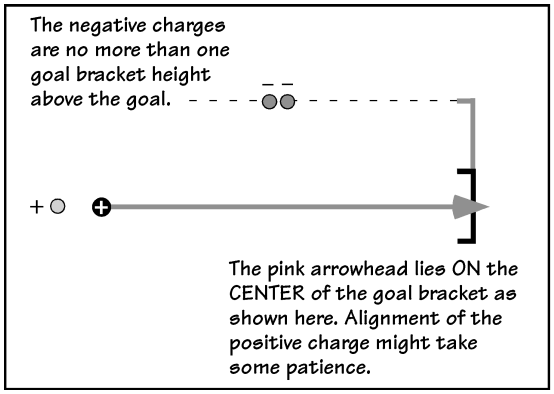
PRACTICE 2: Use one positive charge to score a goal. Don't forget the sketch on this and all the rest of the configurations.



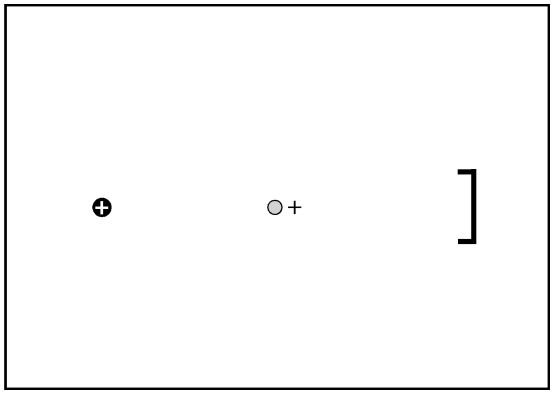
PRACTICE 3: Place one positive charge as shown. (It forms an isosceles triangle with the puck and goal. Use one additional positive charge to score a goal.



PRACTICE 4: Place one negative charge as shown. (It forms an isosceles triangle with the puck and goal. Use one additional positive charge to score a goal.



PRACTICE 5 - The Double Negative: Place two negative charges and one positive charge as shown. The positive charge produces a force vector on the puck that extends <u>exactly to the center of the goal</u>. Use one additional negative charge to score.



PRACTICE 6 - Positively Blocked: Place one positive charge as shown. (It's the midpoint on a straight line connecting the puck and goal.) Use two additional positive charges to score a goal. Note: this one requires patience and is sensitive to small changes!

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Details and Hints

1. Do not place charges closer than one centimeter from one another. Placement of a charge closer than that to the puck is acceptable. Do not place any charges inside the goal bracket.

2. The puck must stay "in bounds" (on the visible portion of the rink) from beginning to end.

3. To stop the simulation and reset the puck, click the on-screen "Reset" button. To remove all placed charges on the screen, click the on-screen "Clear" button.

4. If your experimental configuration does not score a goal within ten seconds, click the on-screen "Reset" button. A repeating, cyclical pattern can be mesmerizing to watch, but the clock is ticking.

5. If the puck wanders off the rink, click the on-screen "Reset" button.

6. Notice that small changes in the charge configuration can have large consequences for the resulting path taken by the puck.

7. After scoring a goal, activate the field display (click the on-screen "Field" checkbox) and replay the goal. You may leave the field activated or deactivate it before proceeding on to the next configuration.

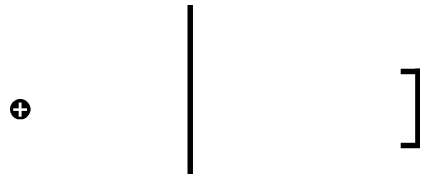
8. If the program crashes, click "Ignore" in the crash alert box. Restart the simulation from the web page (as you did to start the simulation the first time).

Step 4: Once you have completed the practice exercises above, select Difficulty 1 from the choices at the bottom of the Electric Field Hockey window. As you proceed through the following exercises, pay particular attention to the difficulty level and stated restrictions, if any.

Difficulty 1 – Freestyle: Use as many charges as you like to score a goal. No sketch needed. _____

Difficulty 2 – Freestyle: Use as many charges as you like to score a goal. No sketch needed. _____

Difficulty 1 – Limited: Use only two positive charges to score a goal. Sketch your solution.



Difficulty 1 - Q-tip Dipole –/+: Arrange charges as shown in Figure 2. Use as many additional charges as you like. Sketch your solution.

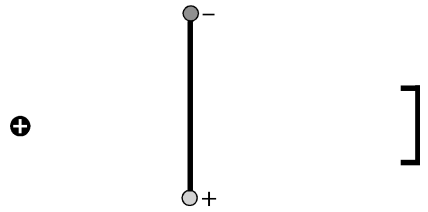


Figure 2

Difficulty 2 – Exclamation Double Point Limited: Arrange the charges as shown in Figure 3. Then use no more than two positive and two negative charges to score a goal. Sketch your solution.

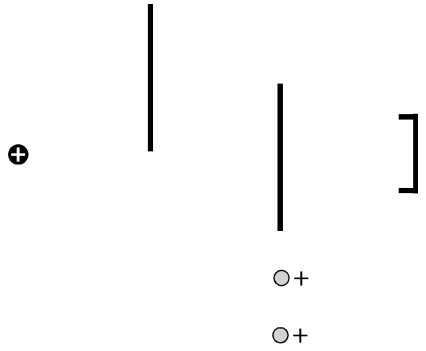


Figure 3

Going Further

Difficulty 3 - Freestyle: Use as many charges as you like to score a goal. No sketch needed. _____

Summing Up

1. If you could use only one charge to play goalie (to block goals from being made), what kind of charge would you use and where would you place it? Draw a diagram and explain your answer.

_____

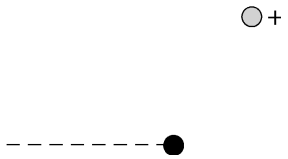
_____

_____

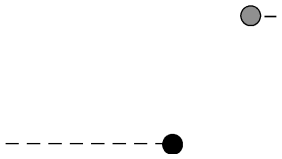
_____

2. Show the continuation of the path that will be followed by the positive puck in each case below.

a.



b.



c.