Unit 19 *Homework Problems*

Learning Goals:

F.19 Apply Coulomb's law, with correct vector notation, to find the net electric field at a point given a distribution of charges or vice versa

19-1) It is said that objects with like charges repel each other. You should have observed that after the sticky sides of two pieces of scotch tape are pulled quickly off a table the tapes repel each other. Perhaps each tape has a different type of charge and the rule has been stated backwards. Why do you believe that the charges on the two tapes are like types of charges? **Note**: It is not acceptable to answer "because like charges repel and I observed the repulsion" – this is circular reasoning.

19-2) It is said that objects of unlike charges attract each other. You should have observed that after the sticky side of a piece of scotch tape is pulled quickly off the smooth side of another piece of tape the tapes attract each other. Perhaps each tape has the same type of charge and the rule has been stated backwards. Why do you believe that the charges on the two tapes are different? **Note**: It is not acceptable to answer "because unlike charges attract and I observed the attraction" – this is circular reasoning.

19-3) (a) Explain the phenomenon of induction that you studied in Activity 19.2.3. For example, explain how a metal conductor such as a hanging ball of aluminum foil can be attracted to a charged insulator *even though the ball of foil has no net charge so that it is electrically neutral.*

(b) Can two metal balls with no net charge attract each other? Explain.

(c) Can the process of induction cause a neutral conductor to be *repelled* from a charged insulator? Explain.

19-4) Please complete the ranking task entitled "Two Electric Charges—Electric Force" shown at the end of this assignment.

19-5) Please complete the ranking task entitled "Fixed and Suspended Charges—Angle" shown at the end of this assignment.

19-6) A +4.0 μC point charge is in the *x-y* plane at the point (3.0 m, 0.0m) while a +10. μC point charge is at the point (0.0 m, 1.0 m). **Note**: The Coulomb is a very large unit of charge and so microcoulombs or μC are often used in calculations. A μC is 10^{-6} C.

(a) Express the Coulomb force on the +10. μC point charge due to the +4.0 μC charge in vector notation.

(b) What is the magnitude of the force?

19-7) Please complete the ranking task entitled "Uniform Electric Field—Electric Force on the Same Charge" shown at the end of this assignment.

19-8) Please complete the ranking task entitled "Uniform Electric Field—Electric Force on Various Charges" shown at the end of this assignment.

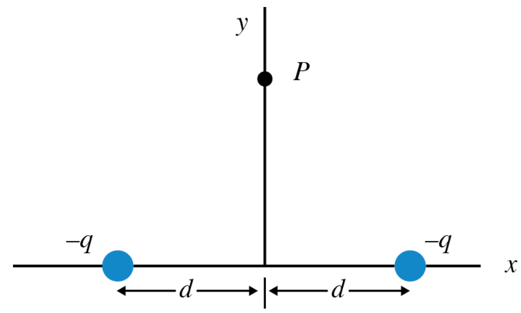
19-9) (a) Play Electric Field Hockey at difficulty level 2 and use as few charges as possible to get the ball into the goal. Print and hand in a map (*i.e.*, a sketch or printout) of your fixed charge configuration and moving charge path. Write your name and the problem number on the map of your screen configuration. At the bottom of the map describe whether the motion for your charge is dominated by short-range interactions or long-range interactions and explain the evidence for your conclusions.

(b) Place one more charge as far away as possible in a way that makes as dramatic a change as possible in the path of the moving charge. Print and hand in this new chart.

19-10) The figure to the right shows two objects of charge $-q$ arranged symmetrically about the y-axis. Each produces an electric field at point P.

(a) Are the magnitudes of the fields equal? Why or why not?

(b) Does each electric field point toward or away from the charged object producing it? Why or why not?

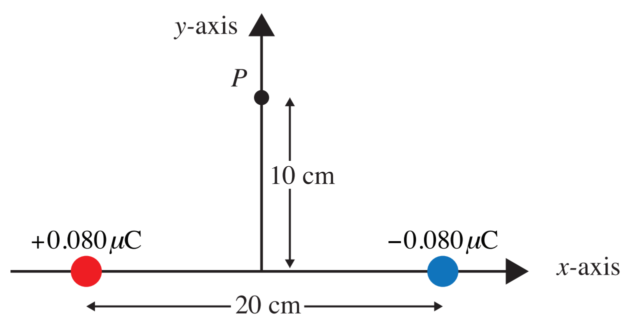


(c) Is the magnitude of the net electric field equal to the sum of the magnitudes of the two field vectors (that is, equal to 2E)? Why or why not?

(d) Do the x-components of the two fields add or cancel? Why or why not?

(e) Do the y-components of the two fields add or cancel? Why or why not?

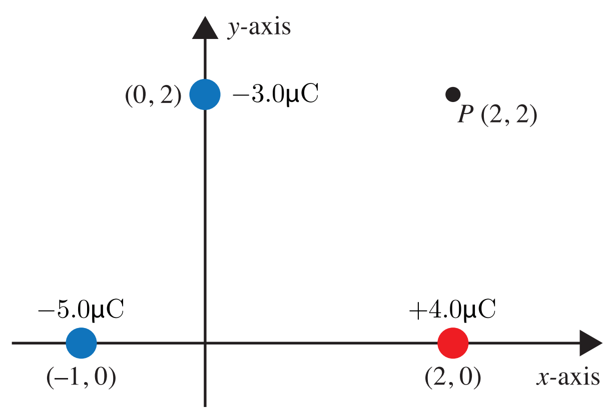
19-11) Two point objects with charges of +0.080 μC and –0.080 μC respectively are separated by 20.0 cm as shown in the figure on the right. Find the net electric field 10.0 cm directly above a point midway between the objects. Use vector notation to express the result. **Hint**: The net electric field has an x-component but no y-component. Why?



19-12) Three point objects of charge of $q_A = -3.0\mu\text{C}$, $q_B = +4.0\mu\text{C}$, and $q_C = -5.0\mu\text{C}$ respectively are located as shown on the right at (0.0 m, 2.0 m), at (2.0 m, 0.0 m), and at (-1.0 m, 0.0 m).

We would like to know the electric field at point P (2,2).

(a) Determine the electric field vector $\vec{E}_A$ due to object A of charge $q_A = -3.0\mu\text{C}$ **(*i.e.*, you need to give your answer in vector notation!)**.



(b) Determine the electric field vector $\vec{E}_{\mathrm{B}}$ due to object B of charge $q_B = +4.0\mu\mathrm{C}$.

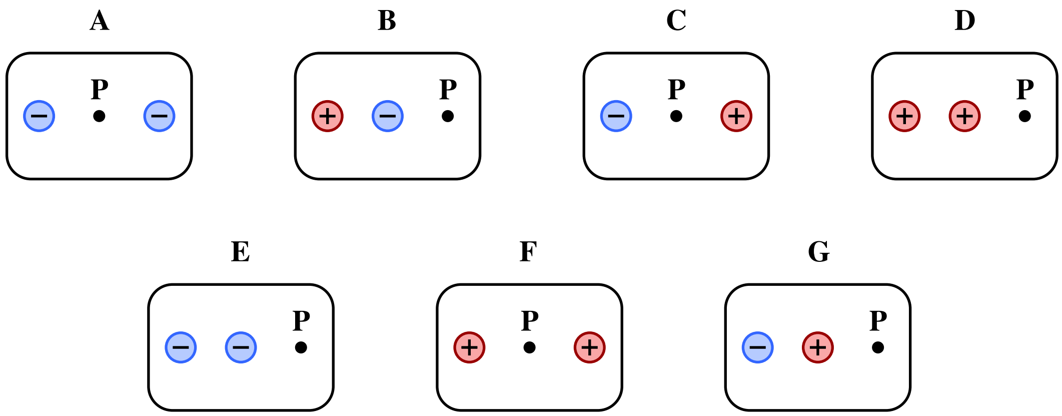
(c) Determine the electric field vector $\vec{E}_{\mathrm{C}}$ due to object C of charge $q_C = -5.0\mu\mathrm{C}$.

(d) Determine the total electric field $\vec{E}$, *i.e.*, the sum of the electric fields $\vec{E}_{\mathrm{A}}$, $\vec{E}_{\mathrm{B}}$, and $\vec{E}_{\mathrm{C}}$.

RANKING TASKS

19-4) Two Electric Charges—Electric Force
Given below are seven arrangements of two electric charges. In each figure, a point labeled P is also identified. All of the charges are the same size, 20 C, but they can be either positive or negative. The charges and point P all lie on a straight line. The distances between adjacent items, either between two charges or between a charge and point P, are all 5 cm. There are no other charges in this region. For this problem, we are going to place a +5 C charge at point P.

Rank these arrangements from greatest to least on the basis of the magnitude of the electric force on the +5 C charge when it is placed at point P, that is, put first the arrangement that will exert the largest force on the +5 C charge at point P, and put last the arrangement that will exert the smallest force on the +5 C charge when it is placed at point P. If two or more arrangements exert the same magnitude force, rank them together.



Largest 1________2________3________4________5________6________7________ Smallest

Or, all of these arrangements exert the same magnitude force on the +5 C charge._________

Or, all of these arrangements will exert zero force on the +5 C charge._________

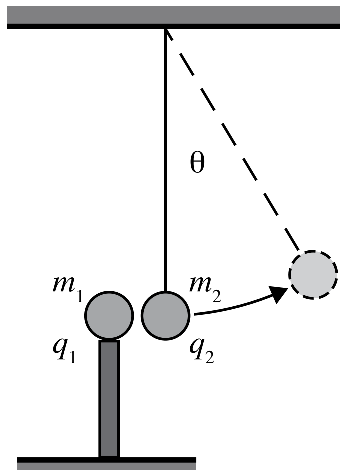
Please explain the reasoning for your ranking.

How sure were you of your reasoning? (circle one)
Basically guessed Sure Very Sure

1 2 3 4 5 6 7 8 9 10

19-5) Fixed and Suspended Charges—Angle
m_1 is a stationary sphere with charge q_1. m_2 is suspended from the ceiling by a string and has charge q_2. m_1 and m_2 are conducting spheres of the same size but varying masses. q_1 and q_2 have the same sign.

From the combinations below, rank the angle the string will form with the vertical from highest to lowest value. If two or more combinations form the same angle, rank them together.



A. $m_1 = 1$; $q_1 = 1$ $m_2 = 1$; $q_2 = 1$	D. $m_1 = 2$; $q_1 = 1$ $m_2 = 2$; $q_2 = 1$
B. $m_1 = 2$; $q_1 = 1$ $m_2 = 2$; $q_2 = 2$	E. $m_1 = 1$; $q_1 = 2$ $m_2 = 2$; $q_2 = 2$
C. $m_1 = 1$; $q_1 = 2$ $m_2 = 1$; $q_2 = 2$	F. $m_1 = 1$; $q_1 = 1$ $m_2 = 1$; $q_2 = 2$

Highest 1________2________3________4________5________6________Lowest

Or, all of the angles are the same. _______

Please carefully explain your reasoning.

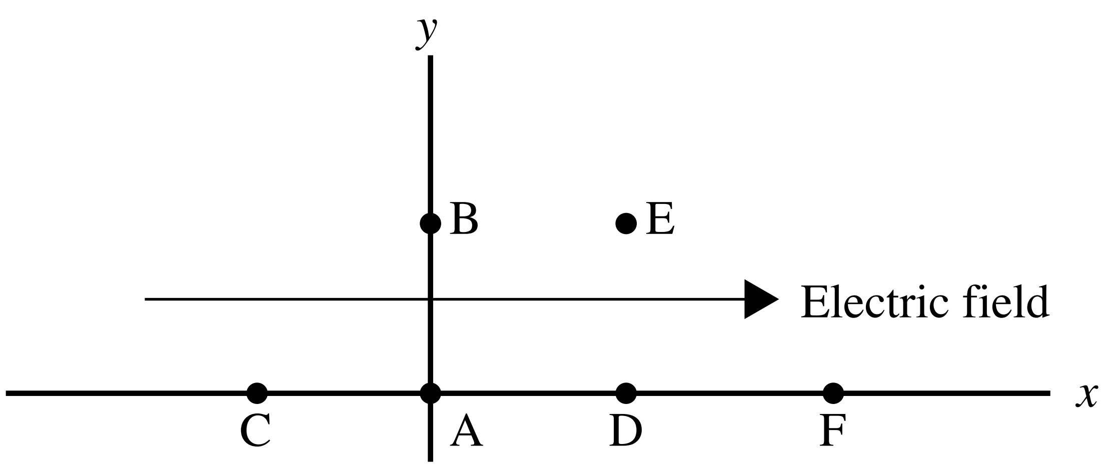
How sure were you of your reasoning? (circle one)
Basically guessed Sure Very Sure

1 2 3 4 5 6 7 8 9 10

19-7) Uniform Electric Field—Electric Force on Same Charge

We have a large region of space that has a uniform electric field in the x direction. At the point (0, 0) m, the electric field is $\vec{E} = 30\,\mathrm{N/C}\,\hat{x}$ and the electric potential is V = 100 volts. Rank the magnitude of the electric force from largest to smallest on a 5 Coulomb charge when it is placed at each of the following points. If the 5 C charge experiences the same magnitude electric force at two or more points, rank them together.

A: (0, 0) m   B: (0, 3) m   C: (-3, 0) m   D: (3, 0) m   E: (3,3) m   F: (6, 0) m



Largest 1________2________3________4________5________6________Smallest

Or, the 5 C charge will experience the same magnitude electric force at all of these points. ____________

Or, the 5 C charge will not experience an electric force at any of these points. ____________

Please explain the reasoning of your ranking.

How sure were you of your reasoning? (circle one)

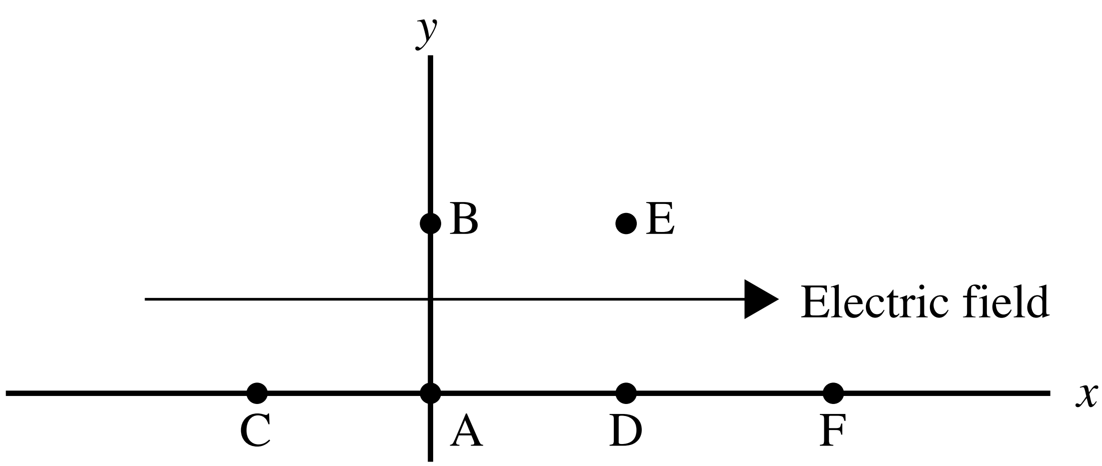
Basically guessed   Sure   Very Sure

1 2 3 4 5 6 7 8 9 10

19-8) Uniform Electric Field—Electric Force on Various Charges

We have a large region of space that has a uniform electric field in the x direction. At the point (0,0) m, the electric field is $\vec{E} = 30\,\text{N/C}\,\hat{x}$ and the electric potential is V = 100 volts. Rank the magnitude of the electric force from largest to smallest on the charges listed if placed at the points specified. Each charge is placed at its specified point separately. If two or more charges experience the same magnitude electric force, rank them together.

A: (0, 0) m	B: (0, 3) m	C: (–3, 0) m	D: (3, 0) m	E: (3,3) m	F: (6, 0) m
$q = +2$ C	$q = +2$ C	$q = +2$ C	$q = +4$ C	$q = +4$ C	$q = +2$ C



Largest 1________2________3________4________5________6________Smallest

Or, all of the charges have the same magnitude electric force acting on them. __________

Or, none of these charges would experience an electric force. __________

Please explain the reasoning of your ranking.

How sure were you of your reasoning? (circle one)

Basically guessed Sure Very Sure

1 2 3 4 5 6 7 8 9 10