

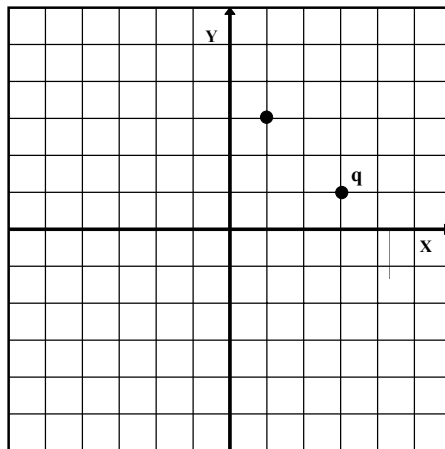
PHYSICS 112 - SUMMER 2005 - EXAM 1

Name: _____ Recitation Section Number: _____

SHOW YOUR WORK! Full credit will be given only if you explain how you arrived at your answer. Either show your work (especially in a calculation) or give a short explanation. Nothing elaborate is required. Numerical answers can be estimated (one significant figure).

1. (6 points) The graph below has grid marks which are 1.0 m apart. A positive charge $q = 2.0 \mu\text{C}$ is located at the position shown, ($x = 3.0 \text{ m}$, $y = 1.0 \text{ m}$).

(a) [1 point] At the other point shown, indicate the direction of the electric field due to the charge q .



(b) [2 points] What is the numerical value of the electric potential (due to the charge q) at the point ($x = 3.0 \text{ m}$, $y = -1.0 \text{ m}$)?

(c) [2 points] If a charge of magnitude $2q$ is placed at the second point, what will be the magnitude (in joules) of the force on the charge $2q$?

(d) [1 point] Mark on the diagram some point P where the electric field is directed in the $+y$ direction.

2. [8 points] As shown below, three charges are located close together at the vertices of an equilateral triangle (meaning they are equidistant from each other).

(a) Draw arrows representing the electrical forces on each of the charges due to each of the other charges, and then draw another arrow representing the total electric force on each charge. Make the length of the arrows approximately equal to the relative magnitude of the force. (q represents a positive charge.) Assume no other charges are present.

$2q \oplus$

$\odot - 3q$

$\oplus q$

(b) What is the total electric force on the system (the total or net electric force on all three charges)?

3. [4 points] A small object with a mass of 2.0×10^{-6} kg and a charge of 2.0×10^{-6} C is placed in a constant electric field of magnitude 2×10^3 N/C. Determine the magnitude of the electrical force on the object and the magnitude of its acceleration.

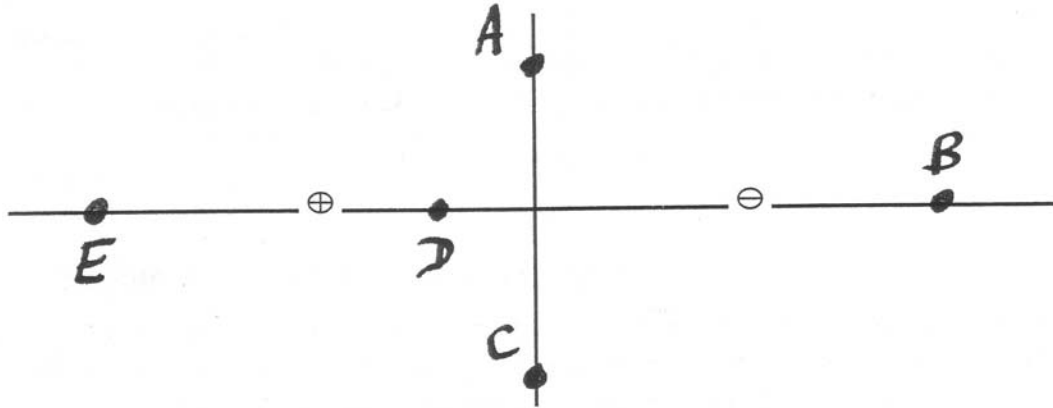
4. (6 points) When two charged particles are separated by 4.0 m, they have an electric potential energy of -36 J.

(a) [2 points] What can you tell about the signs of these charges? Is the force between them attractive or repulsive?

(b) [2 points] Determine the magnitude of the force between them. (Yes, it can be done from just the information given!)

(c) [2 points] Suppose the particles, starting from rest, are allowed to move freely until they are only 2.0 m apart. Determine the values of their electric potential energy and total kinetic energy when they are 2.0 m apart. Remember to show your work!

5. (8 points) Electric charges that are equal in magnitude but opposite in sign are located the same distance from the origin, the positive charge on the negative x axis and the negative charge on the positive x axis, as shown on the diagram below.



(a) [5 points] Identify the points whose electric potential V are positive, negative, and zero, and explain why.

Positive:

Negative:

Zero:

(b) [3 points] Determine the direction of the electric field at the following points:

A:

B:

E:

6. [8 points: 1 point each] A positive charge is fixed at the origin and a negative charge, free to move, is initially at rest some distance away on the $+x$ axis. Determine:

(a) The direction ($+x$, $-x$, $+y$, $-y$, etc.) of the electric field at the initial location of the negative charge (if there is no force, say zero):

(b) The direction of the initial force on the negative charge:

(c) The direction of the initial acceleration of the negative charge:

(d) What happens to the magnitude of the acceleration of the negative charge as time passes (increases, decreases, remains constant):

(e) The sign of the electric potential energy of the system (positive, zero, or negative):

(f) What happens to the magnitude of the electric potential energy as the negative charge moves (increases, decreases, remains constant):

(g) The change in electric potential energy (positive, negative, or zero):

(h) What happens to the speed of the negative charge as it moves (increases, decreases, remains zero, remains constant):

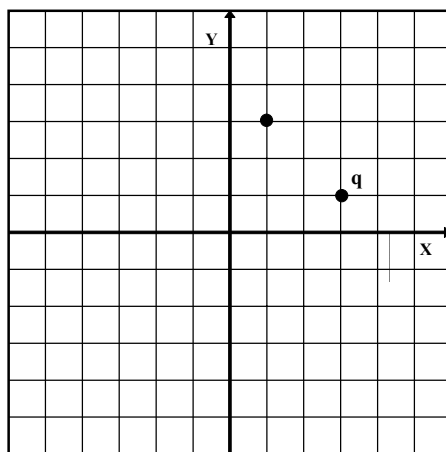
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SHOW YOUR WORK! Full credit will be given only if you explain how you arrived at your answer. Either show your work (especially in a calculation) or give a short explanation. Nothing elaborate is required. Numerical answers can be estimated (one significant figure).

1. (7 points) The graph below has grid marks which are 1.0 m apart. A positive charge $q = 2.0 \mu\text{C}$ is located at the position shown, ($x = 3.0 \text{ m}$, $y = 1.0 \text{ m}$).

(a) [1 point] At the other point shown, indicate the direction of the electric field due to the charge q .

At the other point, the field is directed up and to the left, at an angle of 135° , in the direction away from the positive charge q .



(b) [2 points] What is the numerical value of the electric potential (due to the charge q) at the point ($x = 3.0 \text{ m}$, $y = -1.0 \text{ m}$)?

This is 2.0 m away from the charge q , so the electric potential is

$$V = kq/r = (9 \times 10^9)(2 \times 10^{-6})/(2.0) \text{ V} = 9000 \text{ V}.$$

(c) [2 points] If a charge of magnitude $2q$ is placed at the second point, what will be the magnitude (in newtons) of the force on the charge $2q$?

$$\begin{aligned} F &= k(q)(2q)/r^2 \\ &= (9 \times 10^9 \text{ N m}^2 \text{ C}^{-2})(2.0 \times 10^{-6} \text{ C})(4.0 \times 10^{-6} \text{ C})/(2.0^2 \text{ m}^2 + 2.0^2 \text{ m}^2) \\ &= 9 \times 10^{-3} \text{ N} \end{aligned}$$

(d) [1 point] Mark on the diagram some point P where the electric field of the charge q is directed in the $+y$ direction.

You can mark any point directly above the charge q , such as the point ($x = 3 \text{ m}$, $y = 3 \text{ m}$).

2. [8 points] As shown below, three charges are located close together at the vertices of an equilateral triangle (meaning they are equidistant from each other).

(a) Draw arrows representing the electrical forces on each of the charges due to each of the other charges, and then draw another arrow representing the total electric force on each charge. Make the length of the arrows approximately equal to the relative magnitude of the force. (q represents a positive charge.) Assume no other charges are present.

$2q \oplus$

$\ominus - 3q$

$\oplus q$

(b) What is the total electric force on the system (the total or net electric force on all three charges)? Zero.

3. [4 points] A small object with a mass of 2.0×10^{-6} kg and a charge of 2.0×10^{-6} C is placed in a constant electric field of magnitude 2×10^3 N/C. Determine the magnitude of the electrical force on the object and the magnitude of its acceleration.

$$F = qE = (2.0 \times 10^{-6} \text{ C})(2 \times 10^3 \text{ N/C}) = 4.0 \times 10^{-3} \text{ N.}$$

$$a = F/m = (4.0 \times 10^{-3} \text{ N})/(2.0 \times 10^{-6} \text{ kg}) = 2.0 \times 10^3 \text{ m/s}^2.$$

4. (6 points) When two charged particles are separated by 4.0 m, they have an electric potential energy of -36 J .

(a) [2 points] What can you tell about the signs of these charges? Is the force between them attractive or repulsive?

The negative value of the electric potential energy means that one charge is positive and the other is negative. The force between them is thus an attractive force.

(b) [2 points] Determine the magnitude of the force between them. (Yes, it can be done from just the information given!)

Given: $r = 4.0\text{ m}$ and $PE = kQ/r = -36\text{ J}$.

Then $F = kQ/r^2 = (PE)/r = (-36\text{ J})/(4.0\text{ m}) = 9.0\text{ N}$.

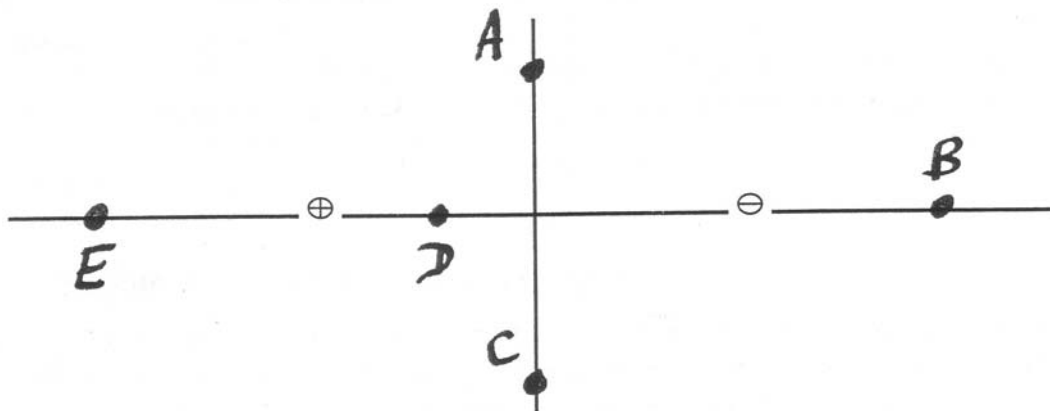
(c) [2 points] Suppose the particles, starting from rest, are allowed to move freely until they are only 2.0 m apart. Determine the values of their electric potential energy and total kinetic energy when they are 2.0 m apart. Remember to show your work!

New electric potential energy: -72 J . Half as far away, so PE is twice as much.

$\Delta PE = (PE)_f - (PE)_i = -72\text{ J} - (-36\text{ J}) = -36\text{ J}$ so (using conservation of mechanical energy) $\Delta KE = -\Delta PE = +36\text{ J}$.

The final total kinetic energy is 36 J .

5. (8 points) Electric charges that are equal in magnitude but opposite in sign are located the same distance from the origin, the positive charge on the negative x axis and the negative charge on the positive x axis, as shown on the diagram below.



(a) [5 points] Identify the points whose electric potential V are positive, negative, and zero, and explain why.

Positive: E and D

Negative: B

Zero: A and C

(b) [3 points] Determine the direction of the electric field at the following points:

A: to the right (\rightarrow)

B: to the left (\leftarrow)

E: to the left (\leftarrow)

6. [8 points: 1 point each] A positive charge is fixed at the origin and a negative charge, free to move, is initially at rest some distance away on the $+x$ axis. Determine:

(a) The direction ($+x$, $-x$, $+y$, $-y$, etc.) of the electric field (due to the positive charge) at the initial location of the negative charge (if there is zero field, say zero):

It is in the $+x$ direction (away from the positive charge at the origin)

(b) The direction of the initial force on the negative charge: $-x$

(c) The direction of the initial acceleration of the negative charge: $-x$

(d) What happens to the magnitude of the acceleration of the negative charge as time passes (increases, decreases, remains constant): increases

(e) The sign of the electric potential energy of the system (positive, zero, or negative): negative (one charge is positive, the other negative, so their product is negative).

(f) What happens to the magnitude of the electric potential energy as the negative charge moves (increases, decreases, remains constant):

It becomes larger in magnitude, so it increases.

(g) The change in electric potential energy (positive, negative, or zero): negative.

(h) What happens to the speed of the negative charge as it moves (increases, decreases, remains zero, remains constant): It will increase, because it is accelerated towards the positive charge.