

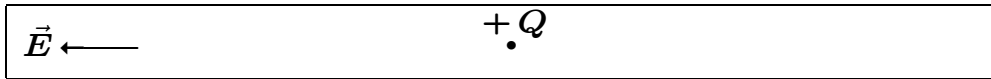
PHYSICS 112 - SPRING 2004 - EXAM 1

Name: _____ Recitation Section Number: _____

NO CALCULATORS ON THIS EXAM. Put away all calculators, cell phones, electronic equipment of all kinds. Use only your favorite writing instrument and your brain.

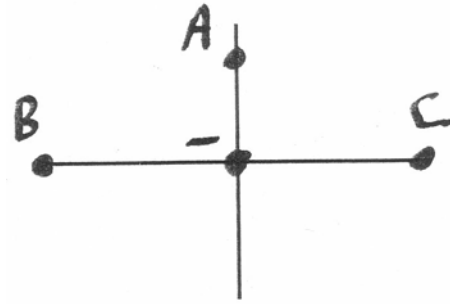
SHOW YOUR WORK! Full credit will be given only if you explain how you arrived at your answer, even on a questions with answers to select from. Either show your work (especially in a calculation) or give a short explanation. Nothing elaborate is required.

1. (12 points total) In the box shown below there is a uniform electric field of constant magnitude 3000 N/C directed to the left. A positive electric charge $+Q = 2.0 \mu\text{C}$ is present in this region and is initially at rest.



- (a) Dash in the path that the charge will follow after being released from rest.
- (b) Determine the magnitude and direction of the initial electric force acting on the charge, and describe how this force changes.

2. (10 points total) A negative charge $Q = -2.0 \mu\text{C}$ is located at the origin, as shown in the diagram to the right. Points A, B, and C are located, respectively, 2.0 m, 3.0 m, and 3.0 m from the origin. Determine the following quantities, giving both the magnitude and direction of the vectors requested and the magnitude (including the correct sign) for the scalars:



(a) (3 points) The electric field at point A (show it on the diagram):

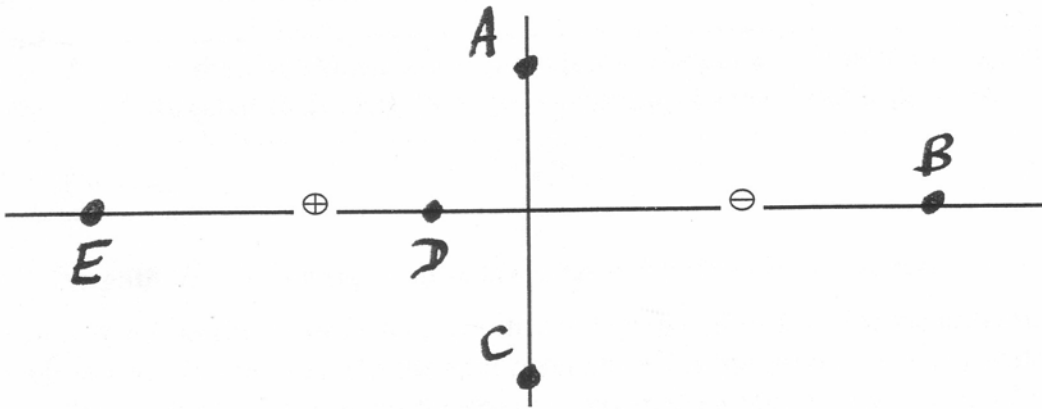
(b) (2 points) The electric potential at point B:

(c) (5 points) Now suppose a charge $q = -3.0 \mu\text{C}$ is placed at point C. Determine:

the force on q :

the electric potential energy of the system:

3. (10 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. Show the contributions of the two charges to the electric fields at the points A, B, C, D and E, and also indicate the net or total electric field at each point. For clarity, label the contributions of the positive charge by $+$ and those of the negative charge by $-$, and the total field with a T (for total).



4. (8 points) A positive charge Q is fixed at a certain point. Another charge q with mass $m = 2.0$ kg is initially at rest 1.2 m away from Q . Their electric potential energy is -32 J.
 (a) What is the sign of charge q ?

(b) The charge q is released from rest, and a short time later has a speed of 4.0 m/s. Determine its kinetic and potential energies at that time, and the distance between the two charges at that time.

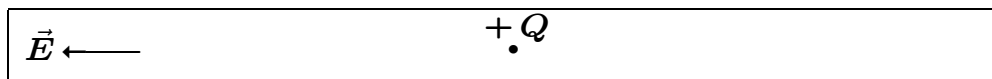
KE =

PE =

Distance apart =

PHYSICS 112 - SPRING 2004 - EXAM 1 - Solutions

1. (12 points total) In the box shown below there is a uniform electric field of constant magnitude 3000 N/C directed to the left. A positive electric charge $+Q = 2.0 \mu\text{C}$ is present in this region and is initially at rest.



(a) Dash in the path that the charge will follow after being released from rest.

The dash should extend to the left, because the positive charge will move in the direction of the electric field, which is to the left, in accordance with $F = qE$.

(b) Determine the magnitude and direction of the initial electric force acting on the charge, and describe how this force changes.

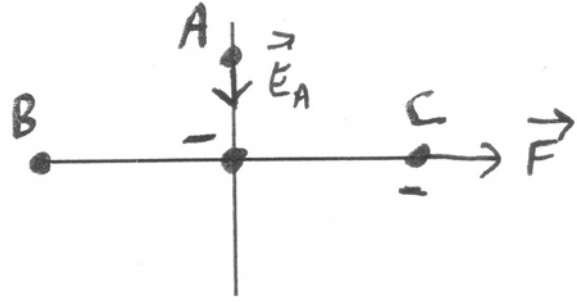
The magnitude of the initial electric force is

$$F = qE = (2.0 \times 10^{-6} \text{ C})(3000 \text{ N/C}) = 6.0 \times 10^{-3} \text{ N.}$$

The direction of the initial force is to the left.

Since the electric field is uniform the electric force does not change.

2. (10 points total) A negative charge $Q = -2.0 \mu\text{C}$ is located at the origin, as shown in the diagram to the right. Points A, B, and C are located, respectively, 2.0 m, 3.0 m, and 3.0 m from the origin. Determine the following quantities, giving both the magnitude and direction of the vectors requested and the magnitude (including the correct sign) for the scalars:



(a) (3 points) The electric field at point A (show it on the diagram):

The magnitude of the electric field is

$$E = k|Q|/r^2 = (9 \times 10^9)(2 \times 10^{-6})/(2.0)^2 \text{ N/C} = 4.5 \times 10^3 \text{ N/C} = 4500 \text{ N/C}.$$

Its direction is towards the negative charge at the origin, or in the $-y$ direction.

(b) (2 points) The electric potential at point B:

$$V = kQ/r = (9 \times 10^9)(-2.0 \times 10^{-6})/(3.0) \text{ V} = -6.0 \times 10^3 \text{ V} = -6000 \text{ V}.$$

(c) (5 points) Now suppose a charge $q = -3.0 \mu\text{C}$ is placed at point C. Determine:

the force on q :

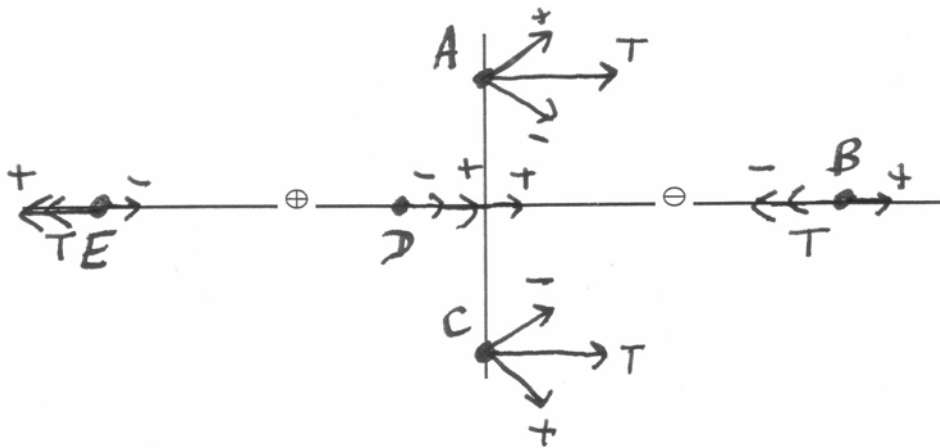
Its magnitude is $F = k|q_1q_2|/r^2 = (9 \times 10^9)(2.0 \times 10^{-6})(3.0 \times 10^{-6})/(3.0)^2 \text{ N} = 6.0 \times 10^{-3} \text{ N}.$

Its direction is away from the negative charge at the origin, or towards $+x$.

the electric potential energy of the system:

$$\text{PE} = kq_1q_2/r = (9 \times 10^9)(-2.0 \times 10^{-6})(-3.0 \times 10^{-6})/(3.0) \text{ J} = +18 \times 10^{-3} \text{ J}$$

3. (10 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. Show the contributions of the two charges to the electric fields at the points A, B, C, D and E, and also indicate the net or total electric field at each point. For clarity, label the contributions of the positive charge by + and those of the negative charge by -, and the total field with a T (for total).



4. (8 points) A positive charge Q is fixed at a certain point. Another charge q with mass $m = 2.0$ kg is initially at rest 1.2 m away from Q . Their electrical potential energy is -32 J.
 (a) What is the sign of charge q ?

It must be negative, since the electrical potential energy is negative.

(b) The charge q is released from rest, and a short time later has a speed of 4.0 m/s. Determine its kinetic and potential energies at that time, and the distance between the two charges at that time.

$$\text{KE} = \frac{1}{2}mv^2 = (0.5)(2.0 \text{ kg})(4.0 \text{ m/s})^2 = 16 \text{ J.}$$

$$\text{PE} = \text{TE} - \text{KE} = -32 \text{ J} - (16 \text{ J}) = -48 \text{ J} \text{ because TE is just the initial PE } (-32 \text{ J}).$$

$$\text{Distance apart} = 0.8 \text{ m.}$$

This is because the final PE of -48 J is $1.5 = 3/2$ of the initial PE of -32 J, so since the PE is proportional to $1/r$, the final r must be $1/1.5 = 2/3$ of the initial r , or $(2/3)(1.2 \text{ m}) = 0.8 \text{ m}$.