

PHYSICS 112 - SPRING 2003 - EXAM 1 - February 12, 2003

Name: _____ Recitation Section Number: _____

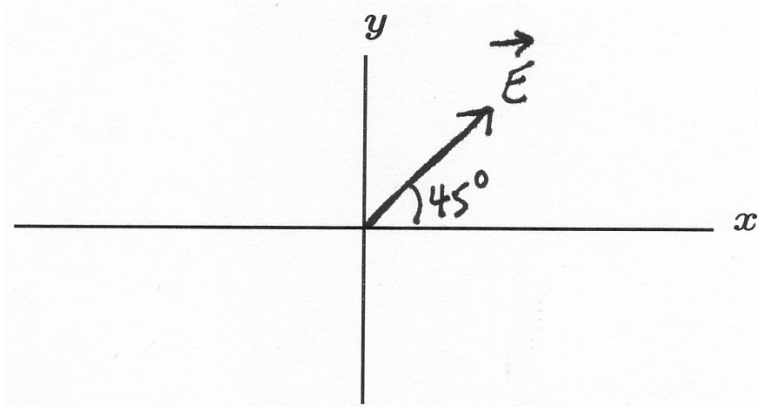
SHOW YOUR WORK! Although some of these problems are multiple-choice, full credit will be given only if you explain how you arrived at your answer. Either show your work (especially in a calculation) or give a short explanation. Nothing elaborate is required.

1. (6 points) Two electric charges are 3 m apart. Suppose that the forces that they exert on each other have magnitude 12 N, and that their electrical potential energy is -36 J. What will be the corresponding quantities if they are moved to a separation of 6 m?

Magnitude of forces at 6 m separation:

Electrical potential energy at 6 m separation:

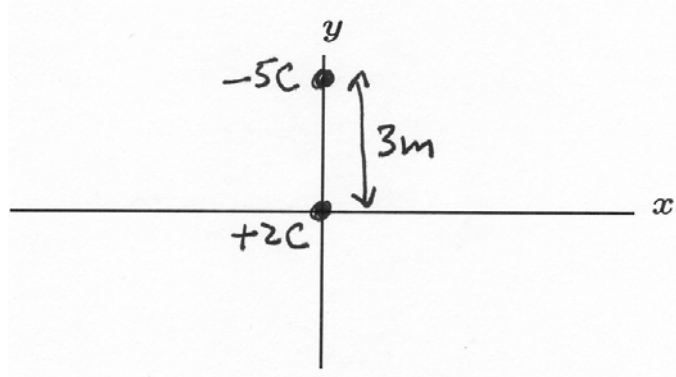
2. (6 points) The diagram shows the electric field at the origin. Indicate on the diagram by a point labeled N where a single negative electric charge might be located if it (by itself) produces this electric field. Indicate on the diagram by P_1 and P_2 where two identical positive charges might be located on the axes if they together produce this electric field.



3. (6 points) A charge Q_1 is fixed at the origin and another charge Q_2 is located 2 m away. Charge Q_2 is at rest, and the electrical potential energy of the system is 12 J. If charge Q_2 moves away from the origin, what will be its kinetic energy when it is 4 m away from the origin?

0 J 2 J 4 J 6 J 8 J 10 J 12 J 16 J 24 J

The following diagram is to be used with the rest of the problems on this exam. It shows a positive electric charge of $+2\text{ C}$ at the origin and a -5 C charge located at $y = +3\text{ m}$ on the positive y axis.



4. (6 points) On the diagram, draw vectors showing the forces on the two charges, making sure they are in the correct directions and have approximately the correct relative magnitudes (lengths). Also determine the magnitude of the force of the negative charge on the positive charge:

$1 \times 10^9\text{ N}$ $1 \times 10^{10}\text{ N}$ $5 \times 10^{10}\text{ N}$ $9 \times 10^{10}\text{ N}$

5. (6 points) On the diagram, show the electric fields (label them E_5 and E_2) due to each charge and the total electric field (E) at a point A in the first quadrant. Make sure they are in the correct directions and have approximately the correct relative magnitudes (lengths.)

6. (4 points) Determine the electrical potential energy of the system of the two charges.

$$-9 \times 10^{10} \text{ J} \quad -3 \times 10^{10} \text{ J} \quad +3 \times 10^{10} \text{ J} \quad +9 \times 10^{10} \text{ J}$$

7. (6 points) Determine the electric potential at the point B at $(0, -2 \text{ m})$ on the negative y axis.

$$-18 \times 10^9 \text{ V} \quad -9 \times 10^9 \text{ V} \quad 0 \text{ V} \quad +9 \times 10^9 \text{ V} \quad +18 \times 10^9 \text{ V}$$

PHYSICS 112 - SPRING 2003 - EXAM 1 - February 12, 2003 - Questions and Solutions

SHOW YOUR WORK! Although some of these problems are multiple-choice, 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.

1. (6 points) Two electric charges are 3 m apart. Suppose that the forces that they exert on each other have magnitude 12 N, and that their electrical potential energy is -36 J. What will be the corresponding quantities if they are moved to a separation of 6 m?

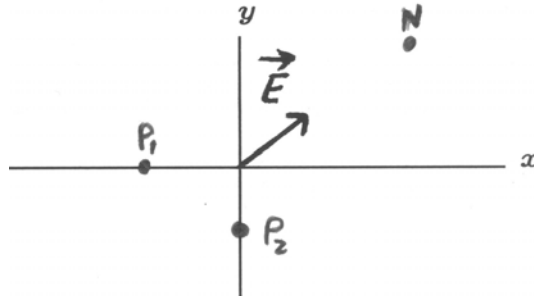
Magnitude of forces at 6 m separation:

Electric forces are inversely proportional to the square of the separation ($F \propto 1/r^2$), so doubling the separation changes r by a factor of 2, r^2 by a factor of 4, and $1/r^2$ by a factor of $1/4$. So the forces should have a magnitude of $1/4$ of 12 N, or 3 N.

Electrical potential energy at 6 m separation:

Electric potential is inversely proportional to the separation ($EPE \propto 1/r$), so doubling the separation changes r by a factor of 2 and $1/r$ by a factor of $1/2$. So the new potential should have a magnitude of $1/2$ of -36 J, or -18 J.

2. (6 points) The diagram shows the electric field at the origin. Indicate on the diagram by a point labeled N where a single negative electric charge might be located if it (by itself) produces this electric field. Indicate on the diagram by P_1 and P_2 where two identical positive charges might be located on the axes if they together produce this electric field.



A single negative charge would have to be on the line in the first quadrant starting from the origin and going up at a 45° angle.

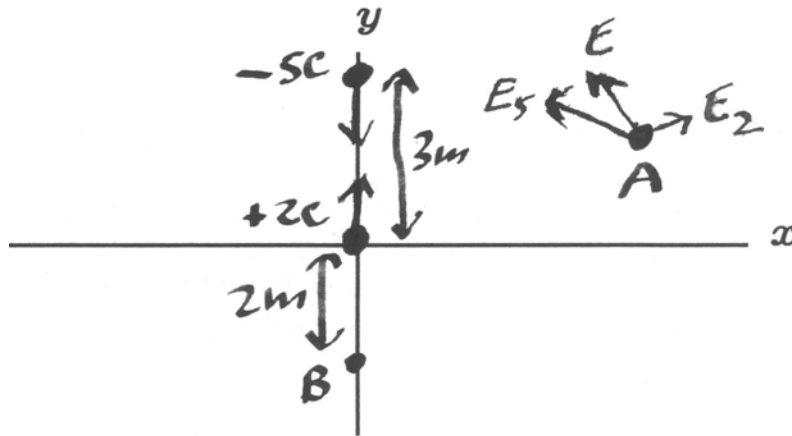
Two identical positive charges on the axes would produce this electric field if they were on the $-x$ and $-y$ axes, at the same distance from the origin.

3. (6 points) A charge Q_1 is fixed at the origin and another charge Q_2 is located 2 m away. Charge Q_2 is at rest, and the electrical potential energy of the system is 12 J. If charge Q_2 moves away from the origin, what will be its kinetic energy when it is 4 m away from the origin?

0 J 2 J 4 J 6 J 8 J 10 J 12 J 16 J 24 J

Initially, when Q_2 is at rest, its KE is 0, and since the PE is 12 J, the total energy $TE = 12$ J. When it is twice as far away from the origin, its PE will be half as much (6 J), but since the TE is the same, the KE must be 6 J at that point so that $TE + KE$ remains 12 J.

The following diagram is to be used with the rest of the problems on this exam. It shows a positive electric charge of $+2$ C at the origin and a -5 C charge located at $y = +3$ m on the positive y axis.



4. (6 points) On the diagram, draw vectors showing the forces on the two charges, making sure they are in the correct directions and have approximately the correct relative magnitudes (lengths). Also determine the magnitude of the force of the negative charge on the positive charge:

1×10^9 N 1×10^{10} N 5×10^{10} N 9×10^{10} N

The forces on the two charges should be directed towards each other, since the two charges have opposite signs. The magnitudes of these forces are the same, and both are

$$F = k|q_1q_2|/r^2 = (9 \times 10^9)(2)(5)/(3)^2 \text{ N} = 10 \times 10^9 \text{ N or } 1 \times 10^{10} \text{ N.}$$

5. (6 points) On the diagram, show the electric fields (label them E_5 and E_2) due to each charge and the total electric field (E) at the point A. Make sure they are in the correct directions and have approximately the correct relative magnitudes (lengths.)

The electric field E_5 is towards the negative charge, and the electric field E_2 is away from the positive charge. The total electric field is then the vector sum of these, as shown.

6. (4 points) Determine the electrical potential energy of the system of the two charges.

$$-9 \times 10^{10} \text{ J} \quad -3 \times 10^{10} \text{ J} \quad +3 \times 10^{10} \text{ J} \quad +9 \times 10^{10} \text{ J}$$

$$\text{EPE} = kq_1q_2/r = (9 \times 10^9)(2)(-5)/(3) \text{ J} = -30 \times 10^9 \text{ J} = -3 \times 10^{10} \text{ J}$$

7. (6 points) Determine the electric potential at the point B at (0, -2 m) on the negative y axis.

$$-18 \times 10^9 \text{ V} \quad -9 \times 10^9 \text{ V} \quad 0 \text{ V} \quad +9 \times 10^9 \text{ V} \quad +18 \times 10^9 \text{ V}$$

Let $r_1 = 2 \text{ m}$ be the distance of B from charge $q_1 = +2 \text{ C}$ and $r_2 = 2 \text{ m} + 3 \text{ m} = 5 \text{ m}$ be the distance from B to charge $q_2 = -5 \text{ C}$. Then:

$$\begin{aligned} \text{EP or } V &= kq_1/r_1 + kq_2/r_2 = (9 \times 10^9)(2)/(2) \text{ V} + (9 \times 10^9)(-5)/(5) \text{ V} \\ &= (9 \times 10^9) \text{ V} - (9 \times 10^9) \text{ V} = 0 \text{ V}. \end{aligned}$$