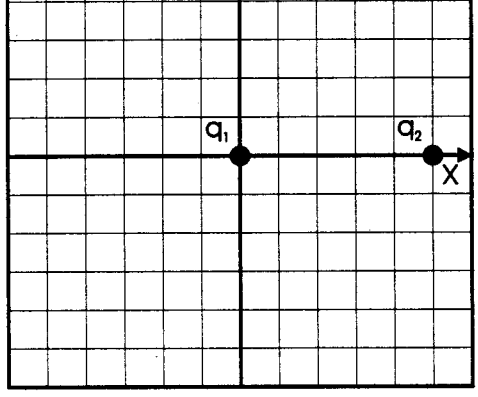
Chapter 1 Electrical Forces

In-Class Questions

Prerequisite Concepts:

- **Positive and negative charges; Coulomb's law: $F = kq_1q_2/r^2$**
- **Protons (+) and electrons (–)**
- **Superposition principle: $F_{net}=F_1+F_2 + . . . + F_n$**
- **Vector addition: $F_{netx}=F_{1x} + F_{2x} + . . . F_{nx}$**
- **Newton's second law, a = F/m**

Questions #1–2 refer to the figure below. Charge q_1 is located at the origin, and charge q_2 is located on the positive x axis, five meters from the origin. There are no other charges anywhere nearby.



1. If q_1 is positive and q_2 is negative, what is the direction of the electrical force on q_1?

   A. in the positive x direction
   B. in the negative x direction
   C. in the positive y direction
   D. in the negative y direction
   E. the force is not directed precisely along any of the coordinate axes, but at some angle
   F. there is no force in this case

2. If q_1 is positive and q_2 is positive, what is the direction of the electrical force on q_1?

   A. in the positive x direction
   B. in the negative x direction
   C. in the positive y direction
   D. in the negative y direction
   E. the force is not directed precisely along any of the coordinate axes, but at some angle
   F. there is no force in this case

3. In this figure, a proton is located at the origin, and an electron is located at the point (3m, 3m). What is the direction of the electrical force on the proton?

A. 

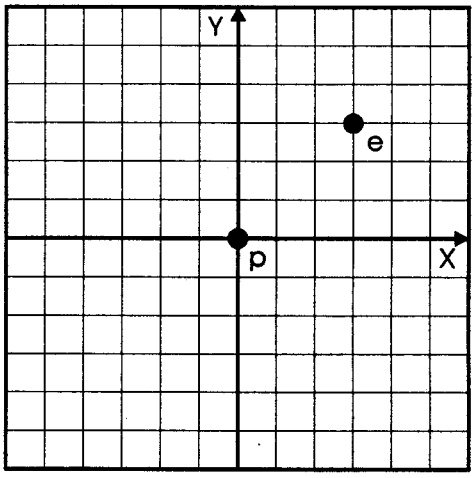
B. 

C. 

D.

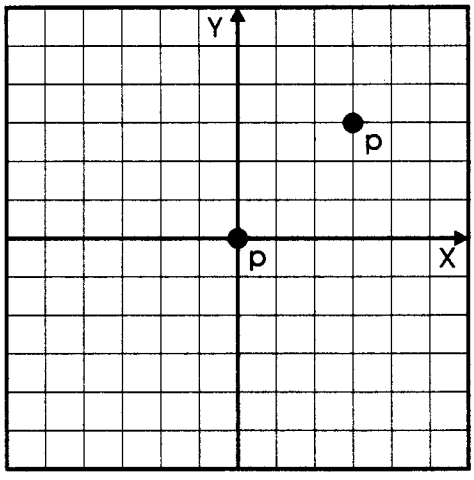
E. 

F. 

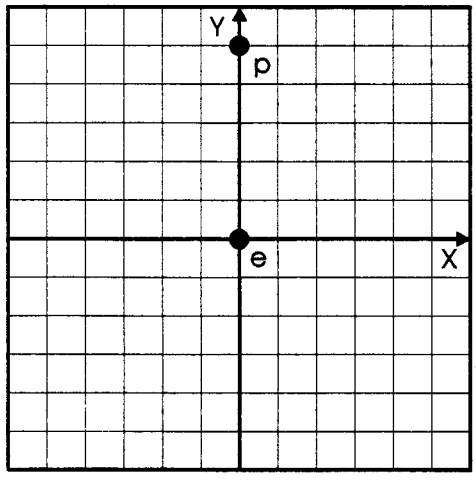


4. In this figure, a proton is located at the origin, and a proton is located at the point (3m, 3m). The vector representing the electrical force on the proton *at the origin* makes what angle with respect to the positive x axis?

A. 0°
B. 45°
C. 90°
D. 135°
E. 225°
F. 270°



5. In this figure, a proton is located at (0m, 5m) and an electron is located at the origin.



The electrical force on the electron is:

A. directed toward the positive-y direction, and has greater magnitude than the electrical force acting on the proton
B. directed toward the positive-y direction, and has smaller magnitude than the electrical force acting on the proton
C. directed toward the positive-y direction, and has magnitude equal to the electrical force acting on the proton
D. directed toward the negative-y direction, and has greater magnitude than the electrical force acting on the proton
E. directed toward the negative-y direction, and has smaller magnitude than the electrical force acting on the proton
F. directed toward the negative-y direction, and has magnitude equal to the electrical force acting on the proton

6. Two charged particles are separated by a certain distance, and exert an electrical force on each other. What will happen to the magnitude of this electrical force if the separation between the particles is *decreased*?

A. The force will decrease in magnitude.
B. The force will increase in magnitude.
C. The magnitude of the force will not change.
D. The magnitude of the force may decrease or increase, depending on whether the charges are like or unlike.
E. The magnitude of the force on one particle will increase, while that on the other particle will decrease.

7. Two particles with charges q_1 and q_2 are separated by a distance r. There are no other charges nearby. Consider the following actions:

   I. increase q_1

   II. increase q_2

   III. increase r

   IV. decrease r

   Which of the above actions will cause the magnitude of the force between the charges to *increase*?

   A. I and III only

   B. I and IV only

   C. II and III only

   D. II and IV only

   E. I and II and III

   F. I and II and IV

8. When two charged particles are separated by 2 meters, the magnitude of the electrical force between them is F. What will be the magnitude of this force if their separation is increased to 4 meters?

   A. 1/4 F

   B. 1/2 F

   C. F

   D. 2F

   E. 4F

   F. not enough information given to determine magnitude of force

9. Which of these will result in the repulsive force between two identical charged particles *increasing* by a factor of 8:

   A. double one of the charges

   B. double both of the charges

   C. double one of the charges and cut the particle separation in half

   D. triple one of the charges and cut the particle separation in half

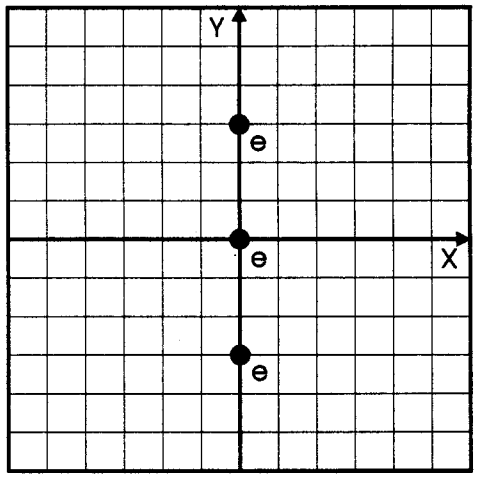
   E. triple both of the charges

   F. double both of the charges and double the particle separation

10. A 6-C charge and a 12-C charge are separated by 2 m; there are no other charges present. Compared to the electrical force on the 6-C charge, the electrical force on the 12-C charge is:

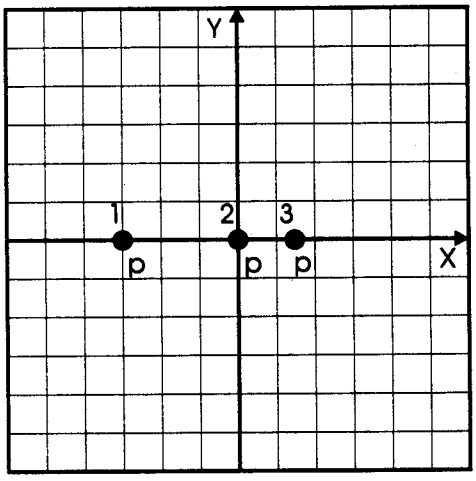
A. one-fourth as strong
B. one-half as strong
C. the same magnitude
D. two times as strong
E. four times as strong

11. In this figure, electrons are located on the y axis at y = 3 m, y = 0 m, and y = – 3 m. The direction of the net electrical force on the electron at the origin is:



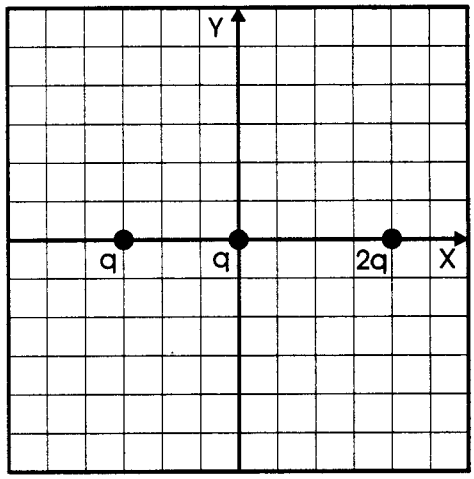
A. towards positive x
B. towards positive y
C. towards negative x
D. towards negative y
E. nowhere, since there is no net force on this electron

12. In this figure, protons are located on the x axis at x = – 3 m, x = 0 m, and x = 1.5 m. The direction of the net electrical force on the proton at the origin is:



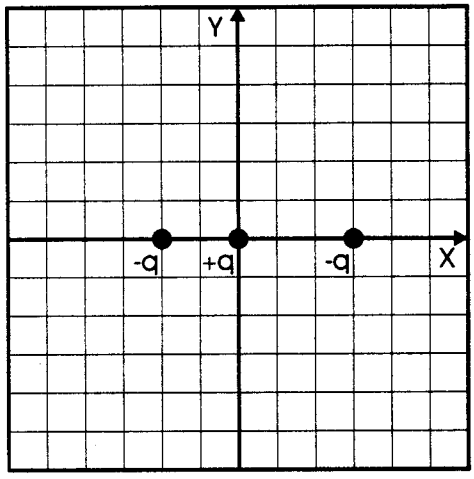
A. towards positive x
B. towards positive y
C. towards negative x
D. towards negative y
E. nowhere, since there is no net force on this proton

13. In this figure, positive charges of magnitude q, q, and 2q are located on the x axis as shown. The direction of the net electrical force on the positive charge at the origin is:



A. towards positive x
B. towards positive y
C. towards negative x
D. towards negative y
E. nowhere, since there is no net force on this proton

14. In this figure, particles with charges –q, +q, and –q are located on the x axis as shown. The direction of the net electrical force on the positive charge at the origin is:



A. towards positive x
B. towards positive y
C. towards negative x
D. towards negative y
E. nowhere, since there is no net force on this proton

15. A electron is fixed at the origin; there are no other charges present. If a negative charge is brought in and released at a nearby point, and allowed to move freely, then as it moves the magnitude of the force acting on this negative charge will:

A. always be zero
B. remain constant, but nonzero
C. always increase
D. always decrease, but never reach zero
E. sometimes increase and sometimes decrease
F. not enough information to decide

16. A electron is fixed at the origin; there are no other charges present. If a negative charge is brought in and released at a nearby point, and allowed to move freely, then as it moves the magnitude of the acceleration of this negative charge will:

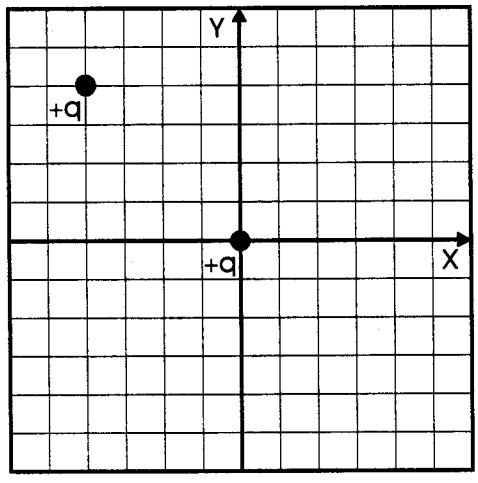
    A. always be zero
    B. remain constant, but nonzero
    C. always increase
    D. always decrease, but never reach zero
    E. sometimes increase and sometimes decrease
    F. not enough information to decide

17. A electron is fixed at the origin; there are no other charges present. If a negative charge is brought in and released at a nearby point, and allowed to move freely, then as it moves the speed of this negative charge will:

    A. always be zero
    B. remain constant, but nonzero
    C. always increase
    D. always decrease, but never reach zero
    E. sometimes increase and sometimes decrease
    F. not enough information to decide

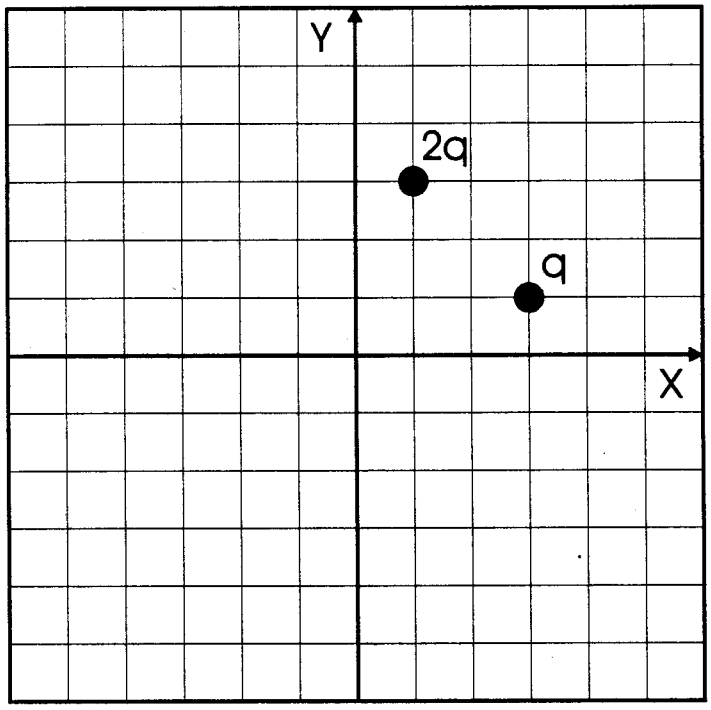
18. In this figure, a positive charge is located at the origin, and another positive charge is located at the point (–4m, 4m). The x component of the electrical force on the charge at the origin is:

    A. greater than zero
    B. equal to zero
    C. less than zero
    D. may be equal to, less than, or greater than zero, depending on the precise magnitude of the two charges.



In-Class Exercises

1. In this figure, two positively charged particles are shown. One of them has charge q, while the other has charge 2q.



Draw arrows on each charge to represent the electrical force due to the other charge. Pay close attention to the direction and length of the arrows.

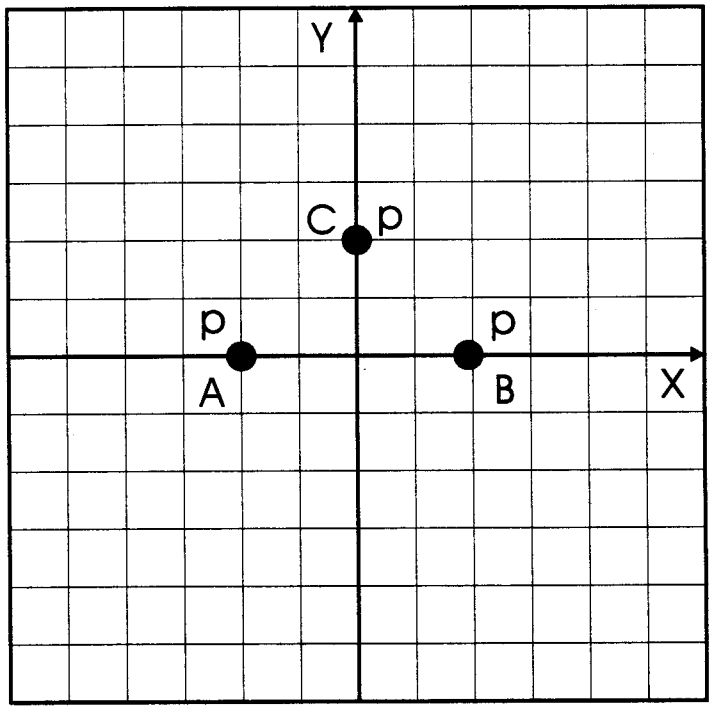
2. A 9-coulomb charge and a 3-coulomb charge are separated by 50 centimeters. What is the magnitude of the force between them, expressed in newtons?

Force = _____

3. When two charges are separated by 9 cm, the magnitude of the force between them is 27 N. If the charges are moved to a separation of 3 cm, what will be the magnitude of the force between them now?

Force = _____

4. Protons A, B, and C are located at the points (x = –2 m, y = 0 m), (x = 2 m, y = 0 m), and (x = 0 m, y = 2 m), as shown in the figure.

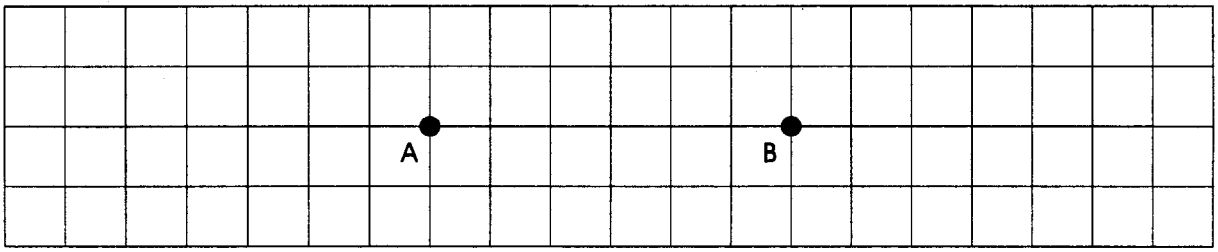


In black, draw and label on the figure two arrows representing the forces on the proton C at (x = 0 m, y = 2 m) due to protons A and B. In red, draw the *net* force vector on this proton C.

5. Charges q_1 and q_2 are separated by distance r, and exert force F on each other. $q_1^{initial} = q_1^{final}$ and $q_2^{initial} = q_2^{final}$; $r^{initial} = 2m$; $r^{final} = 4m$. $F^{initial} = 8N$; $F^{final} = ?$

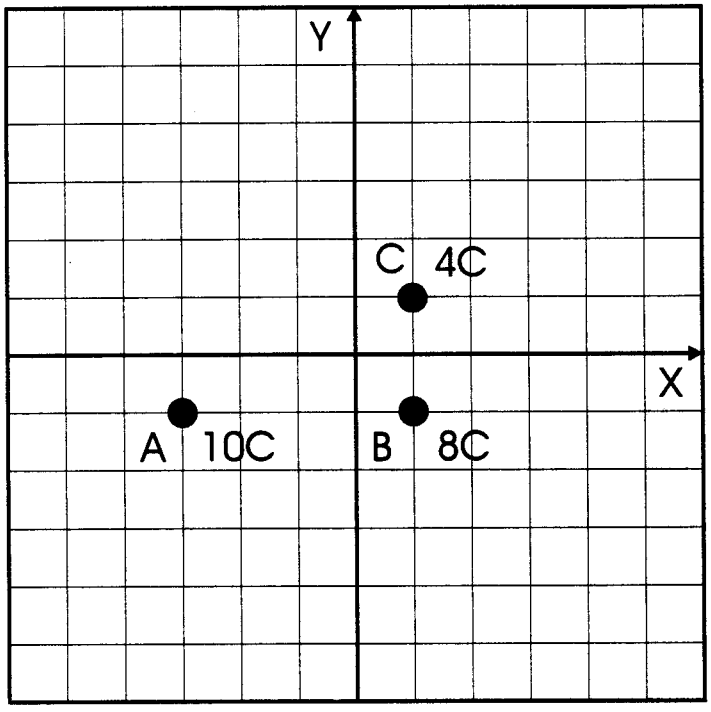
$F^{final} =$ _____

6. Charge A is 2C, and charge B is –4C. Draw arrows to represent the forces that A and B exert on each other. Pay close attention to the lengths of the arrows.



Homework Exercises

1. In this figure, charged particles A, B, and C are labeled with their respective charges. Draw and label arrows representing the electrical forces on each charge, due to the other two charges. Label the force on charge "A" due to charge "B" as "F_{AB}," etc. Make sure the relative lengths of the arrows correspond to the relative magnitudes of the respective forces.



2. Two identical particles are separated by 1 cm; they repel each other with a force of 10^{10} newtons. What is the magnitude of the charge on *each* particle?

Charge = _____

3. Two protons are separted by two meters. Determine the magnitude of the electrical force that they exert on each other, as well as the magnitude of their mutual gravitational force.

   Electrical force = _____

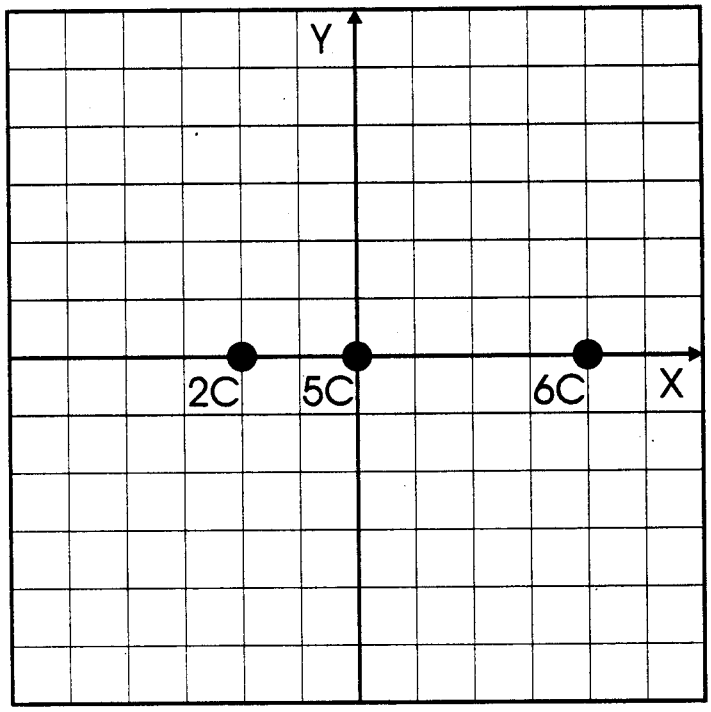
   Gravitational force = _____

   What is the ratio of the magnitude of the electrical force acting between them compared to the magnitude of the gravitational force?

   Electrical force/Gravitational force= _____

4. Three negative charges are sitting on the x axis, as shown in the figure below. A 2-C charge is at x = – 2 m; a 5-C charge is at the origin, and a 6-C charge is at x = 4 m.

   In black, draw and label two arrows representing the electrical forces on the charge at the origin due to the other two charges. Label the force due to the 2-C charge "F_2," and the other one "F_6." In red, draw an arrow representing the *net* electrical force on the charge at the origin. Make sure the lengths of the arrows correspond the relative magnitudes of the forces.



5. A 6-C charge and a particle with a 9-C charge are separated by 3 m. Suppose they are now moved to a separation of 1 m; the repulsive force on the 6-C charge will now be different from the original value. The force on the 6-C charge will go back to the original value if the charge on the other particle is changed to what value?

New value of 9-C charge = _____

6. A 1-C charge is located at the origin, and another 1-C charge is located at the point (1m, 1m). What are the x and y components of the electrical force (F_x and F_y) on the charge at the origin?

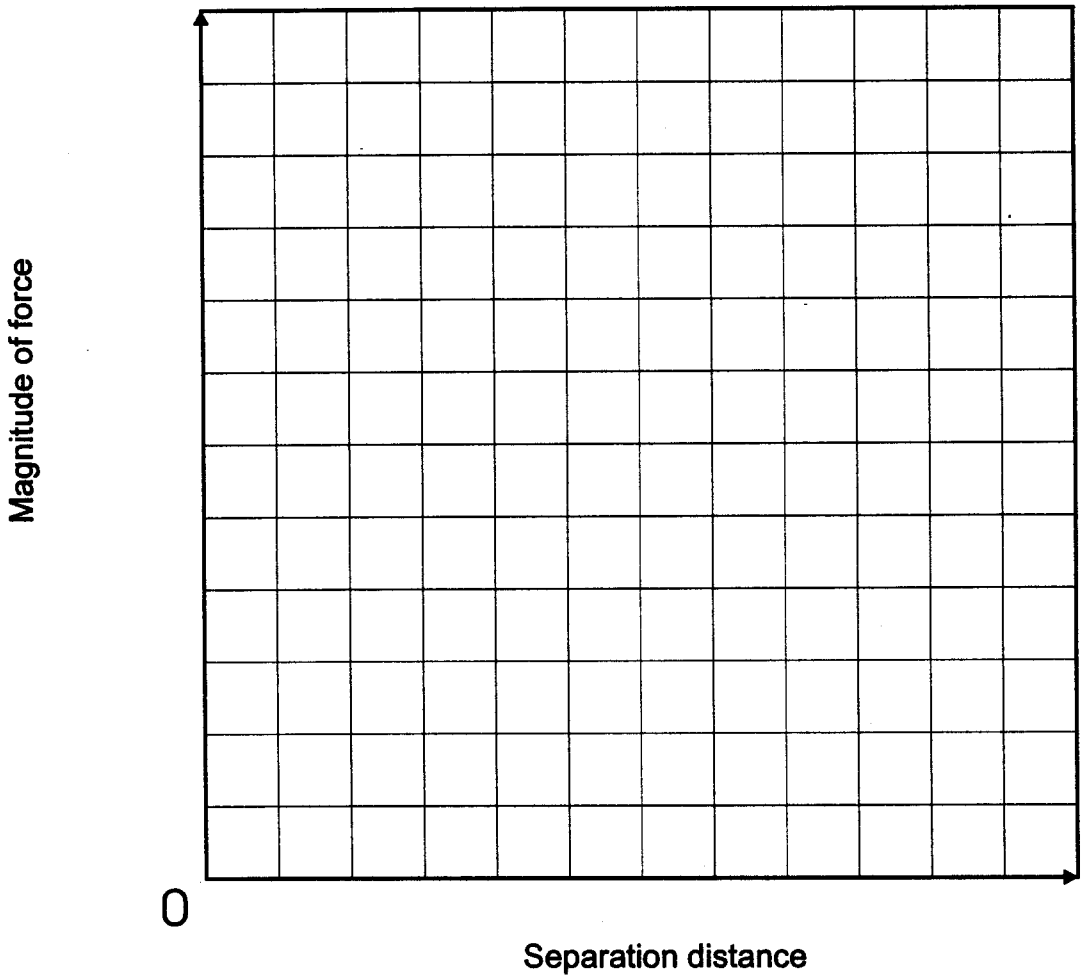
F_x = _____

F_y = _____

7. A 2-μC charge and a 3-μC charge are placed near to each other, and then allowed to move apart (as they repel each other). On the grid below, draw an accurate graph of the magnitude of the electrical force that the charges exert ***on each other***

   Let the y-axis represent the magnitude of force, and the x-axis represent separation distance. Plot the graph for separation distances from 1 m to 10 m, at intervals of 1 m. Plot *(on the same graph)* the magnitude of the force acting on the 2-μC charge with a ***red*** line, and that for the 3-μC charge with a ***blue*** line.

   Make sure you label all of your axes with appropriate units!



8. Now assume that the 2-μC (charge #1) is fixed to a position 1 m away from the 3-μC charge, but somehow charge #1 starts to increase in magnitude. That is, it starts at 2 μC, then increases to 3 μC, 4 μC, 5 μC, and 6 μC.

   Plot a graph of the magnitude of electrical force acting on the 3-μC charge as a function of the amount of charge on charge #1. Put magnitude of force on the y axis, and magnitude of charge #1 on the x axis. (The magnitude of charge #1 varies from 2 μC to 6 μC.). *Answer this question: how will the magnitude of the force on charge #1 compare to that on the 3-μC charge during this process? That is, will it be larger, smaller, or the same?*

   Make sure you label all of your axes with appropriate units!