Chapter 2 Electric Fields

In-Class Questions

Prerequisite Concept:

- **Definition of electric field: E = F/q**

[Note: All gravitational forces may be ignored in this chapter]

1. Which of these is a *sure* indication that there is an electric field present everywhere in a certain region of otherwise empty space:

   A. A charged particle anywhere in the region always remains motionless.

   B. A charged particle anywhere in the region always moves with constant velocity.

   C. A charged particle in the region never changes its direction of motion.

   D. A charged particle anywhere in the region always experiences a nonzero electrical force.

   E. None of the above is a sure indication of the presence of an electric field.

2. How can you determine whether an electric field is present in a particular region of space which appears to be completely empty?

   A. Shoot an uncharged particle into the region and see whether it speeds up, slows down, or changes direction.

   B. Shoot a charged particle into the region and see whether it speeds up, slows down, or changes direction.

   C. Hold a charged particle just *outside* the region and see whether it experiences an attractive or repulsive force.

   D. Move a charged particle into the region and see whether its charge increases or decreases.

   E. There is no way to determine whether an electric field is present in a region of space that appears to be completely empty.

3. A proton is placed at the origin, and then released and allowed to move freely. It begins to move along the positive x axis. From this one can conclude that the electric field at the origin points:

   A. toward the positive x direction.

   B. toward the negative x direction.

   C. toward the positive y direction.

   D. toward the negative y direction.

   E. in a direction not along either the x or y axes.

   F. There is not enough information to determine the direction of the electric field at the origin.

4. An electron is placed at the origin, and then released and allowed to move freely. It begins to move along the positive x axis. From this one can conclude that the electric field at the origin points:

   A. toward the positive x direction.

   B. toward the negative x direction.

   C. toward the positive y direction.

   D. toward the negative y direction.

   E. in a direction not along either the x or y axes.

   F. There is not enough information to determine the direction of the electric field at the origin.

5. In a certain region of space, the electric field is zero everywhere. This means that, if a charged particle is located anywhere in this region:

   A. the particle can not be moving.

   B. the particle experiences no net electrical force.

   C. the particle experiences a repulsive electrical force.

   D. the particle experiences an attractive electrical force.

   E. the particle is always forced back toward one particular location.

6. Throughout a certain region of space, the electric field has uniform magnitude and direction. This means that, wherever a particular charged particle is placed at rest in this region and then allowed to move freely, it will always:

   i. remain motionless.

   ii. move with constant speed.

   iii. move in an unchanging direction.

   iv. move with constant magnitude of acceleration.

   A. i only

   B. ii only

   C. ii and iii only

   D. iii and iv only

7. In the neighborhood of an isolated charged particle, the electric field:

   A. has uniform magnitude and direction.

   B. has uniform magnitude, but points in many different directions.

   C. has uniform direction, but greater magnitude near the particle.

   D. has uniform direction, but smaller magnitude near the particle.

   E. points in many different directions, and has greater magnitude near the particle.

   F. points in many different directions, and has smaller magnitude near the particle.

8. When a charge q is placed at a certain point in an electric field, it experiences a force toward the west of magnitude F. If instead a charge 2q were placed at that same point, what force would it experience?

   A. a force toward the east, of magnitude F/2

   B. a force toward the east, of magnitude F

   C. a force toward the east, of magnitude 2F

   D. a force toward the west, of magnitude F/2

   E. a force toward the west, of magnitude F

   F. a force toward the west, of magnitude 2F

9. When a charge q is placed at a certain point in an electric field, it experiences a force toward the west of magnitude F. If instead a charge –q/2 were placed at that same point, what force would it experience?

   A. a force toward the east, of magnitude F/2

   B. a force toward the east, of magnitude F

   C. a force toward the east, of magnitude 2F

   D. a force toward the west, of magnitude F/2

   E. a force toward the west, of magnitude F

   F. a force toward the west, of magnitude 2F

10. An electron is placed at the origin. The direction of the electric field at the point x = 0 m, y = 3 m, is:

    A. towards positive x.
    B. towards positive y.
    C. towards negative x.
    D. towards negative y.
    E. not along either the x or the y axes.
    F. There is not enough information to determine the direction of the electric field.

11. Electrons are located on the y axis at y = 3 m and y = – 3 m. The direction of the net electric field 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 electric field at the origin.

12. Electrons are located at the points (x = – 1 m, y = 0 m) and (x = 1 m, y = 0 m). The direction of the net electric field at the point (x = 0 m, y = 1 m) is:

    A. towards positive x.
    B. towards positive y.
    C. towards negative x.
    D. towards negative y.
    E. not along either the x or the y axes.
    F. There is not enough information to determine the direction of the electric field.

13. A proton is placed at the origin. The direction of the electric field at the point x = 2 m, y = 2 m, with respect to the positive *x* axis, is:

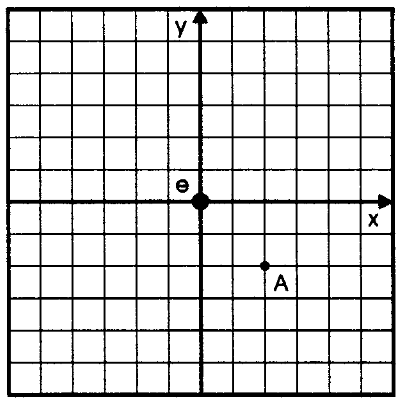
    A. 30°
    B. 45°
    C. 120°
    D. 135°
    E. 210°
    F. 225°
    G. 300°
    H. 315°

14. A strong electric field in a certain region points toward positive x. An electron is released at the origin, and then a long time later a proton is released at the origin. When released,

A. the electron will move toward positive x, and the proton will move toward negative x
B. the electron will move toward negative x, and the proton will move toward positive x
C. the electron will move toward positive y, and the proton will move toward negative y
D. the electron will move toward negative y, and the proton will move toward positive y
E. both the electron and the proton will move toward positive x
F. both the electron and the proton will move toward negative x
G. both the electron and the proton will move toward positive y
H. both the electron and the proton will move toward negative y
I. neither the electron nor the proton will move from their initial position

15. An electron is located at the origin as shown. Which arrow best describes the direction of the electric field at point A?

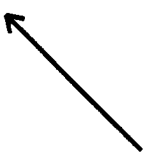
A. ↑
B. ↗
C. ↖
D. ↙
E. ↘
F. there is no field at point A

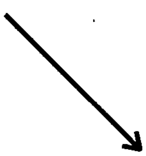


16. A proton is located at the origin as shown. The electric field is shown at a nearby point. Which arrow best fits the electric field vector at point B?

A. 

B. 

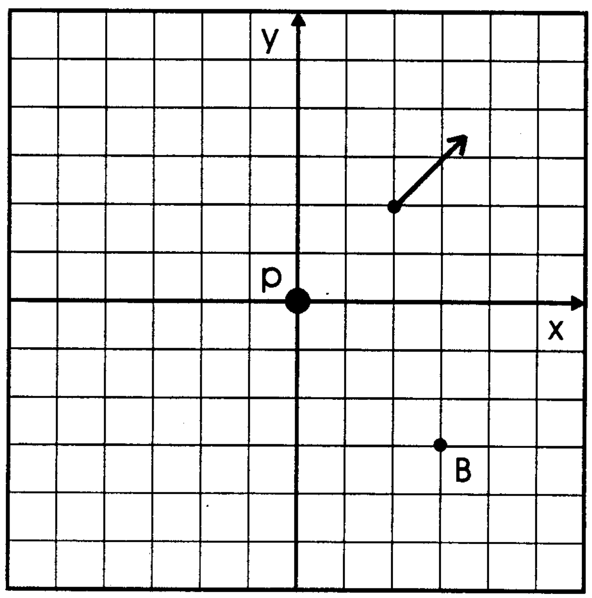
C. 

D. 

E. 

F. 

G. there is no field at point B



17. Which of these statements about electric fields is ***not true***?

   A. The electric field at a point can be completely described by a number, which corresponds to the ***magnitude*** of the electric field.

   B. The electric field at a point would exert the same ***magnitude*** of force on an electron placed at that point, as it would on a proton placed at that same point.

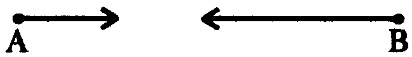
   C. Electric fields do not exert forces on uncharged particles.

   D. Electric fields can exist in a vacuum (i.e., in "empty space").

   E. Electric fields are produced by electric charges.

18. Charge A is 2C and charge B is –4C. They are sitting in a uniform electric field. Which of these diagrams correctly shows the forces that are exerted on charges A and B ***by the electric field*** (<u>*not*</u> by each other)?

   A. 

   B. 

   C. 

   D. 

   E. 

   F. 

19. Which of these charges is experiencing the electric field with the ***largest*** magnitude?

   A. A 2C charge acted on by a 4N electric force.

   B. A 3C charge acted on by a 5N electric force.

   C. A 4C charge acted on by a 6N electric force.

   D. A 2C charge acted on by a 6N electric force.

   E. A 3C charge acted on by a 3N electric force.

   F. A 4C charge acted on by a 2N electric force.

   G. All of the above are experiencing electric fields with the same magnitude.

In-Class Exercises

1. The box below encloses a region of space in which the electric field is uniform in magnitude and direction, and is directed toward the right side of the box. Using red pen or pencil, draw arrows representing the magnitude and direction of electrical force that would be experienced by a small positive charge q placed at different locations within the box. Draw at least six arrows.

2. In the same box, using blue pen or pencil, draw arrows representing the magnitude and direction of electrical force that would be experienced by a small negative charge –q (same magnitude of charge as in #1) placed at different locations within the box. Draw at least six arrows.

3. Identical 2-C charges are located at the points A (–3m, 0m) and B (1m, 0m).

   A. What is the magnitude of the electric field $\mathbf{E_A}$ at the origin due to the charge at (–3m, 0m)?

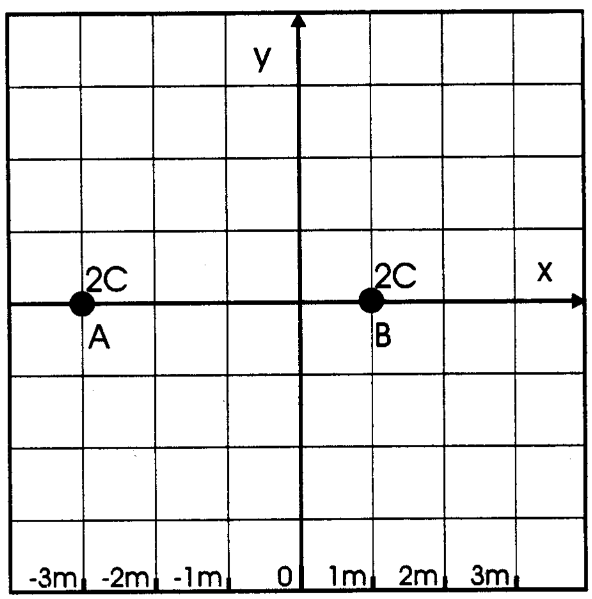
   Answer: __________

   B. What is the magnitude of the electric field $\mathbf{E_B}$ at the origin due to the charge at (1m, 0m)?

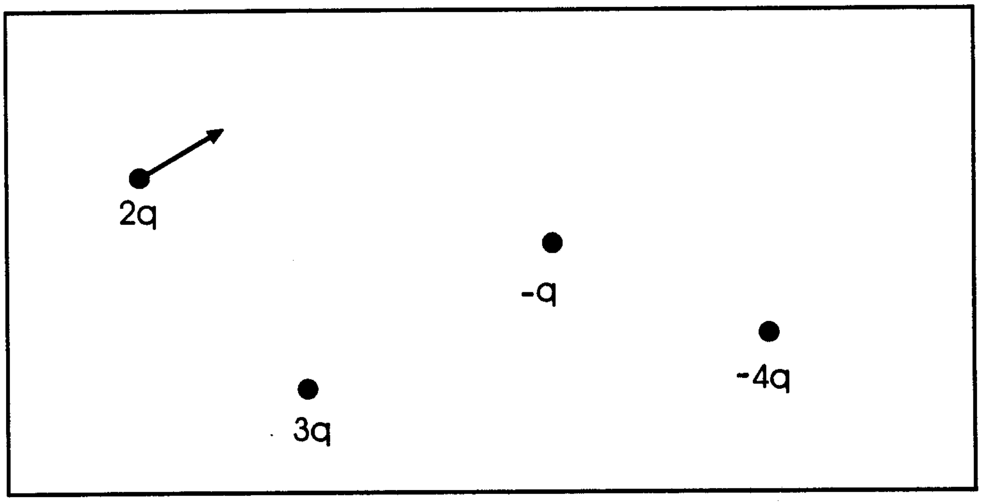
   Answer: __________

   C. What is the magnitude of the net electric field $\mathbf{E_{net}}$ at the origin? In red, draw arrows representing $\mathbf{E_A}$, $\mathbf{E_B}$, and $\mathbf{E_{net}}$.

   Answer: __________

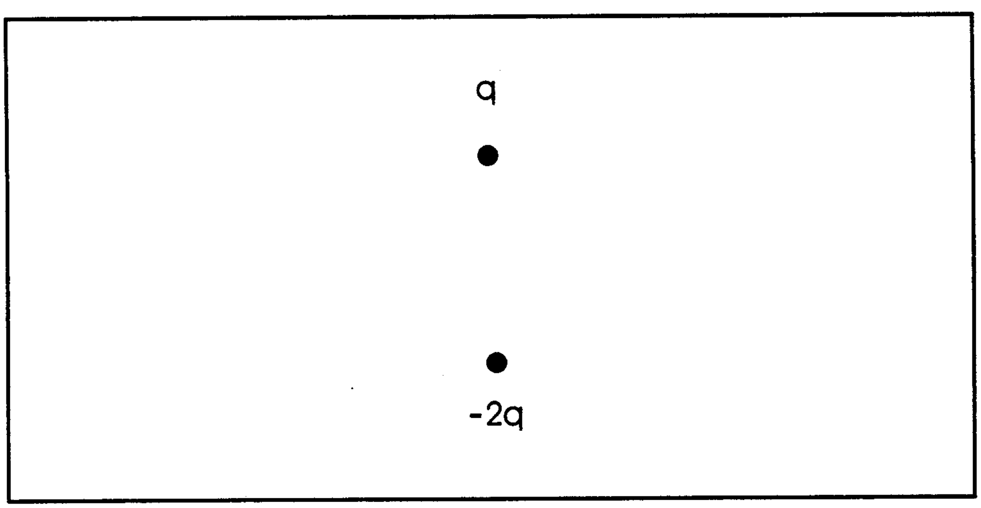


4. In the box below, there is a uniform electric field present. Several charges are located in the box. The vector representing the force due to the uniform field is shown for the 2q charge. Draw the vectors corresponding to the forces due to the uniform electric field on the other three charges. Make sure that the lengths of the arrows correctly correspond to the magnitudes of the vectors.

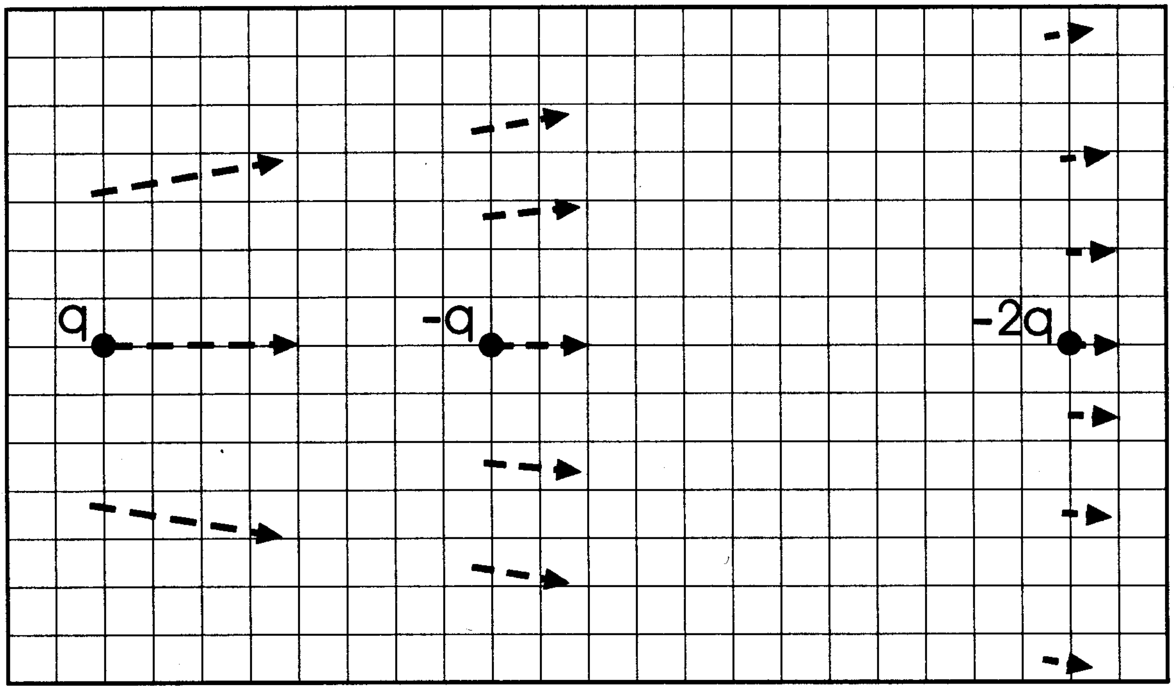


5. In the box below, there is a uniform electric field present; it points toward the right side of the box. A charge q and a charge –2q are placed at the positions indicated, then released and allowed to move freely. The mass of the charge q is ***twice*** the mass of the charge –2q. (Here, the forces that the charges exert on ***each other*** are assumed to be ***much*** smaller than the forces due to the uniform electric field.)

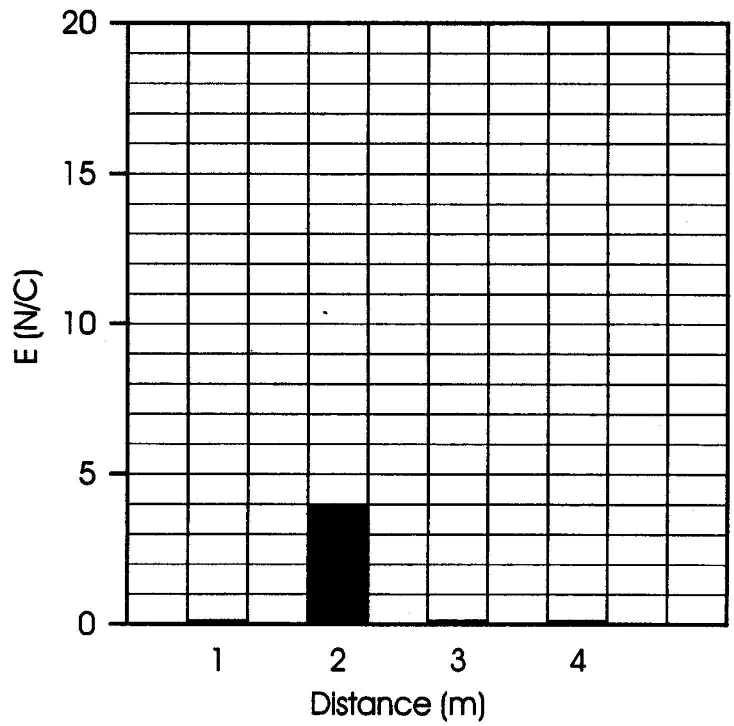
Draw dotted lines to indicate the paths that each of the charges will follow as they move in the box. Draw, in black, a series of arrows along these paths to represent the forces due to the uniform electric field experienced by the charges as they travel through the box. Then, in red, draw a series of arrows along the dotted lines to indicate the acceleration vectors of each charge as they move along their paths. In all cases, make sure that the lengths of the arrows correctly correspond to the magnitudes of the vectors.



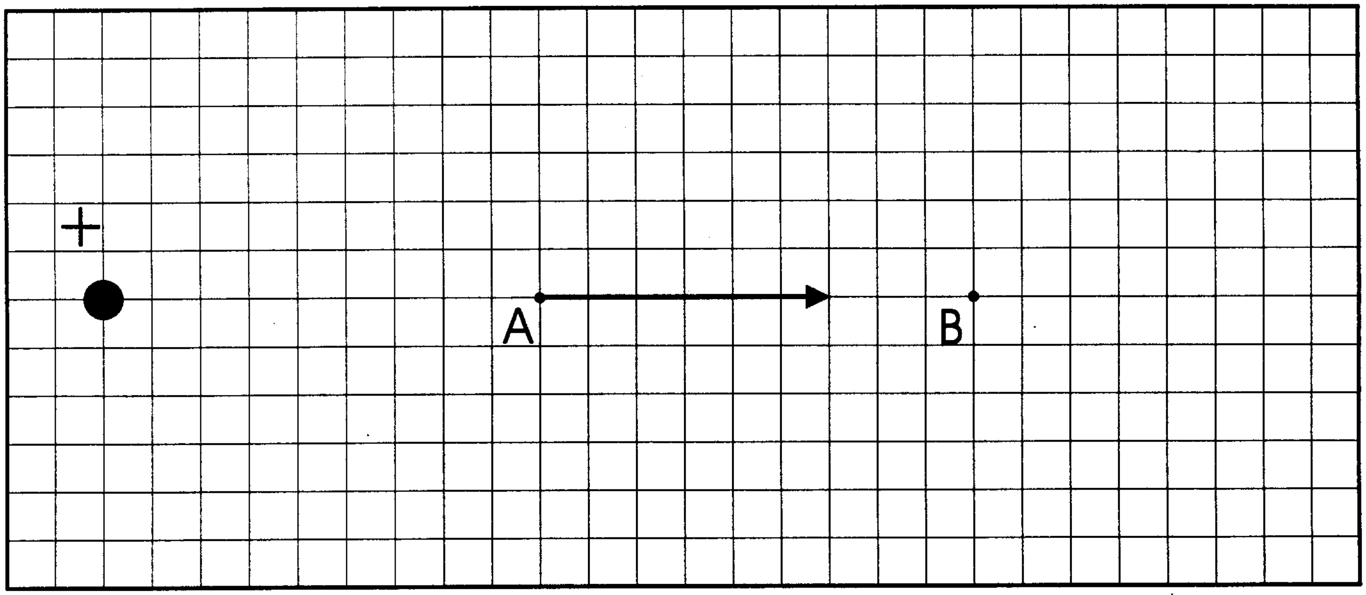
6. Inside the box below, there is a nonuniform electric field caused by a large positive charge outside of the box (far to the left). Some of the electric field vectors (dashed arrows) are shown inside the box. There are three small charges located at the points shown; the charges are q, –q, and –2q as indicated. In red, draw arrows representing the electric forces (due to the electric field) experienced by these charges. You can choose any length for the arrows, but you must make sure that the ***relative*** lengths of the arrows compared to each other correctly match the relative magnitudes of the corresponding vectors.



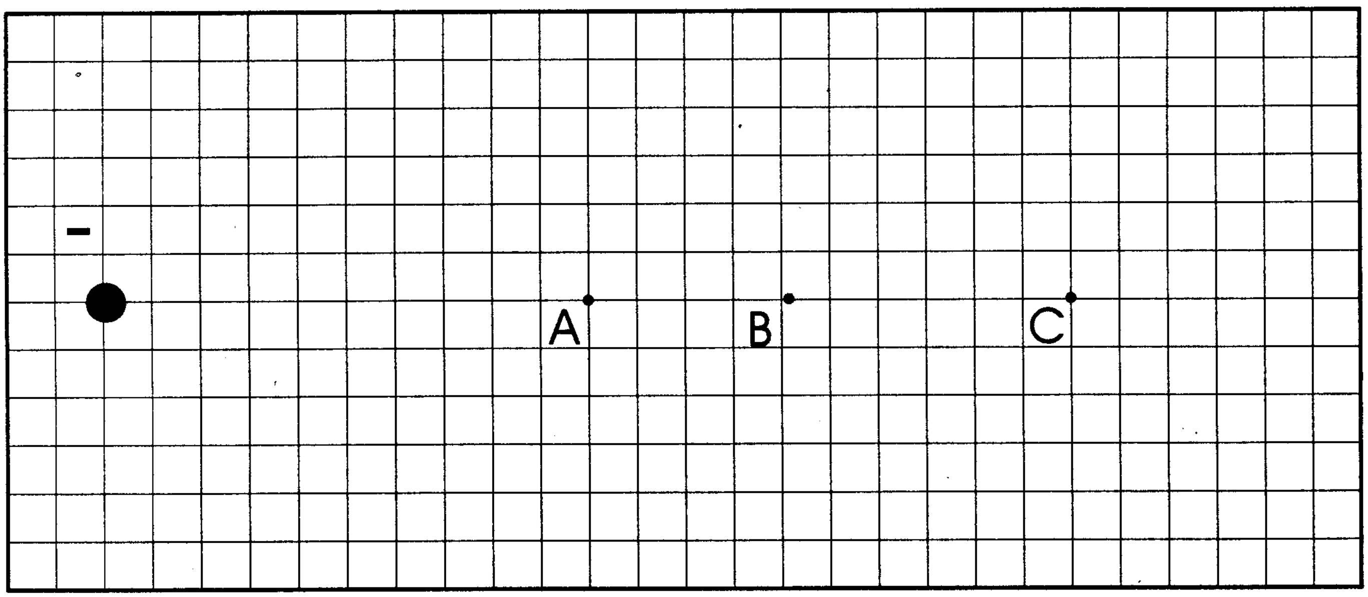
7. On the bar chart below, the electric field magnitude at a point 2 meters from an isolated point charge is shown. Fill in the chart to show the corresponding magnitudes at 1, 3, and 4 meters.



8. In the box below a positive charge is present. The electric field vector at point A is shown. Draw the appropriate electric field vector at point B.



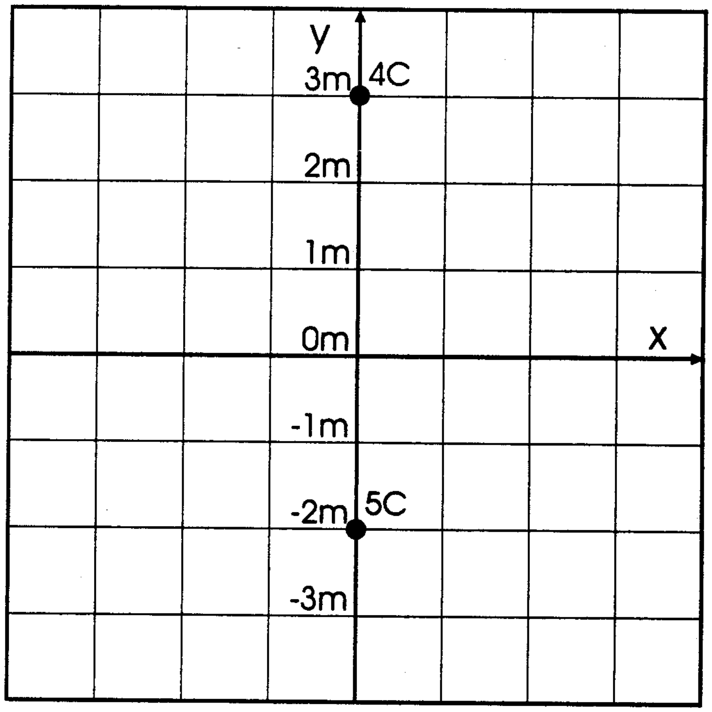
9. In the box below a negative charge is shown. Draw arrows at points A, B, and C to represent the electric field at those points. You can choose any length for the arrows, but you must make sure that the ***relative*** lengths of the arrows compared to each other correctly match the relative magnitudes of the corresponding electric field vectors.



Homework Exercises

1. A 4-C charge is located at the point (0m, 3m), and a 5-C charge is located at the point (0m, –2m). No other charges are around. All five questions relate to this system. Select all answers from the following list: ($k = 9 \times 10^9$)

A. $20k/25$
B. $20k/5$
C. $5k/25$
D. $5k/5$
E. $5k/4$
F. $5k/2$
G. $4k/25$
H. $4k/9$
I. $4k/3$
J. $(5/4 + 4/9)\ k$
K. $(5/4 - 4/9)\ k$
L. $(5/2 + 4/3)\ k$
M. $(5/2 - 4/3)\ k$



A. What is the magnitude of the electrical force on the 4-C charge due to the 5-C charge, in newtons? Draw an arrow on the diagram to represent this force, and label it $\mathbf{F_5}$.

Answer: ________

B. What is the magnitude of the electrical force on the 5-C charge due to the 4-C charge, in newtons? Draw an arrow on the diagram to represent this force, and label it $\mathbf{F_4}$.

Answer: ________

C. What is the magnitude of the component of the electric field at the origin that is due only to the 5-C charge (in N/C)? Draw an arrow on the diagram to represent this field, and label it $\mathbf{E_5}$.

Answer: ________

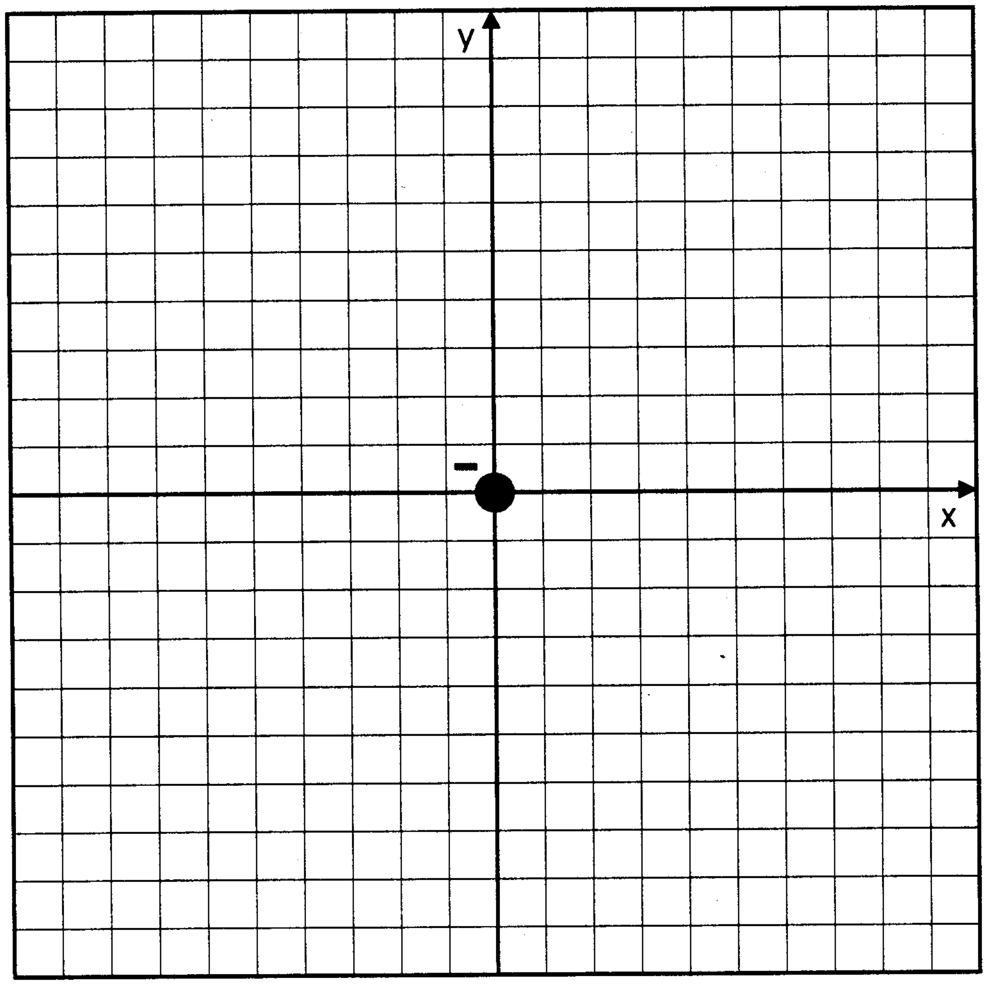
D. What is the magnitude of the component of the electric field at the origin that is due only to the 4-C charge (in N/C)? Draw an arrow on the diagram to represent this field, and label it $\mathbf{E_4}$.

Answer: ________

E. What is the magnitude of the *net* electric field at the origin, due to both of the charges (in N/C)? Draw an arrow on the diagram to represent this field, and label it $\mathbf{E_{net}}$.

Answer: ________

2. A negative charge is located at the origin of the figure below. In red pen or pencil, draw arrows at different locations representing the magnitude and direction of the electrical field at those points. Use a ruler to ensure that the lengths and directions of your arrows relative to each other are correct. Draw at least 12 arrows, at least three different distances from the origin. *Suggestion:* Draw four arrows each at distances of 2, 4, and 8 cm from the charge at the origin.



3. The six diagrams below show the electric force acting on the charge in each case; the sign and magnitudes of the charges are indicated. Rank the magnitudes of the electric fields in the six diagrams, from smallest magnitude to largest magnitude. Rank A, B, C, D, E, and F, starting with smallest magnitude; if two or more are the same, put an "equals" sign ["="] between them; e.g., [A, B=C, D, E, F] means: A is smallest, F is largest, and B is equal to C, but is smaller than D]:

Ranking of E-field magnitude: (smallest)______________________________(largest)

Explain your reasoning:____

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