

Chapter Questions

Electric Charge Classwork

1. What happens to a plastic rod when it is rubbed with a piece of animal fur? What happens to the piece of fur?
2. How many types of electric charge are there? What are they named?
3. How can you tell when two objects, after being rubbed together, have each acquired an electric charge? How will the magnitude of the charge on each compare with one another? How about the sign of the charge on each?
4. What happens when two glass rods are rubbed with silk and they are brought close to each other?

Homework

5. What happens between a plastic rod rubbed with a piece of animal fur and a glass rod rubbed with a piece of silk when they are brought close to each other?
6. What happens when two glass rods are rubbed with silk and they are brought close to each other?
7. Who assigned the convention of the charge remaining on a glass rod after being rubbed by silk as negative?

Atomic Structure and Source of Charge Classwork

8. Which particle of an atom carries a positive charge? Which carries the negative charge?
9. When a neutral atom captures a free electron, what is the net charge on the atom? What do we call this type of atom?
10. What is most of the atom composed of?
11. Is it possible to add $0.5e$ of charge to an object? Explain.

Homework

12. Eight electrons orbit a neutral oxygen atom. How many protons are in the nucleus?
13. When an electron is removed from a neutral atom, what is the net charge on the atom? What is this type of atom called?
14. A glass rod obtains a positive charge after being rubbed by silk. Is this due to the glass gaining protons, or losing electrons? Explain.
15. Describe two ways that you can give an electroscope a positive charge.

Conduction and Induction; Electroscope Classwork

16. A student has a positively charged glass rod but she wants to charge an electroscope negatively. What should she do to accomplish that? Why does that work?
17. A student brings a negatively charged plastic rod near a tiny piece of paper that is resting on a tabletop. Will the paper be attracted or repelled? Explain why.

18. Why is it that when you take off a sweater in a dark room you can see tiny sparks and hear a crackling sound?

Homework

19. A positively charged rod attracts a metal ball suspended at the end on an insulating string. Explain the mechanism of attraction.
20. An electroscope (insulated from ground) is charged negatively and a charged rod is brought very close but does not touch the electroscope. As a result the leaves move further apart. What kind of electric charge is on the rod?
21. Two light paper strips are suspended at the ends of two insulating strings, and are far apart from each other. One paper strip is charged and the other is not charged. Design an experiment to determine which strip is charged.
22. A student touches an electroscope with his hand at the same time he brings a positively charged rod close to the electroscope without touching. When he removes his hand first and then moves the rod away from the electroscope the leaves move apart. Why? What type of charge is on the leaves?

Electric Force (Coulomb's Law)

Classwork

23. Will two charged objects interact on the Moon, where there is no atmosphere?
24. If the distance between two charged objects is doubled, what happens to the electrical force between them?
25. When performing calculations using Coulomb's Law, why is the force of gravity usually neglected?

Homework

26. Two charges repel each other with a force of F_0 . One of the charges is replaced with another charge that is three times its magnitude. What is the new force between these charges in terms of F_0 ?
27. Compare and contrast Coulomb's Law with Newton's Law of Universal Gravitation.
28. Does the mass of a charged object affect the electrical force between it and another charged object?

Chapter Problems

Coulomb's Law

Classwork (Use $k = 9 \times 10^9 \text{ Nm}^2/\text{C}^2$)

1. Two positive charges of 1 mC and 10 mC are separated by a distance of 10 m. Find the direction and the magnitude of electrostatic force between the charges. Describe the direction in terms of "the charges attract each other," or "the charges repel each other."
2. A particle with a charge of $+7.4 \mu\text{C}$ is separated from another charged particle with a charge of $-3.6 \mu\text{C}$ by a distance of 1.4 m. Find the direction and the magnitude of electrostatic force between the particles.
3. A $+1.4 \text{ nC}$ charge exerts a repulsive force of 20.0 mN on a second charge which is located a distance of 2.2 m away from it. What is the magnitude and sign of the second charge?

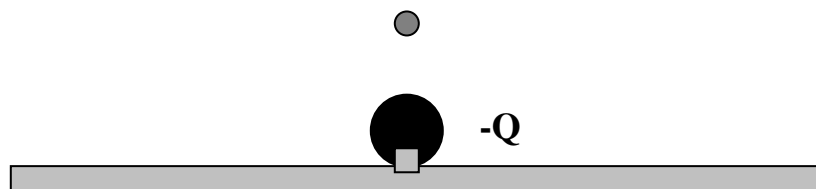
4. Two spherical objects, whose centers are 8.0 cm apart, have equal negative charges and repel each other with a force of 9.0 mN. What is the charge on each of them? How many extra electrons are on each of them?
5. Two conducting spheres have net charges of $+9.00\ \mu\text{C}$ and $-7.00\ \mu\text{C}$ and attract each other with a force of 4.00 mN. The spheres are brought in contact and then moved apart to the initial distance. What is the new force between the spheres? Is this force attractive or repulsive?

Homework

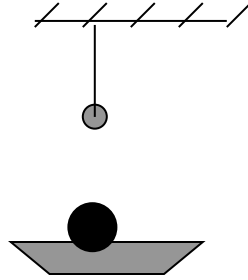
6. Two negative charges of $2.5\ \mu\text{C}$ and $9.0\ \mu\text{C}$ are separated by a distance of 25 cm. Find the direction (in terms of repulsive or attractive) and the magnitude of the electrostatic force between the charges.
7. Two charges of $+2.6\ \mu\text{C}$ and $-5.4\ \mu\text{C}$ experience an attractive force of 6.5 mN. What is the separation between the charges?
8. What is the distance between two charges, $+7.8\ \mu\text{C}$ and $+9.2\ \mu\text{C}$, if they exert a force of 4.5 mN on each other?
9. A $-4.2\ \mu\text{C}$ charge exerts an attractive force of 1.8 mN on a second charge which is a distance of 2.4 m away. What is the magnitude and sign of the second charge?
10. Two equal negative point charges repel each other with a force of 18.0 mN. What is the charge on each object if the distance between them is 9.00 cm? How many extra electrons are on each object?
11. Two charged conducting spheres have net charges of $+4.0\ \mu\text{C}$ and $-8.0\ \mu\text{C}$ and attract each other with a force of 16 mN. The spheres are brought into contact and then moved apart to the initial distance. What is the new force between the spheres? Is this force attractive or repulsive?
12. What is the ratio of the electrostatic force to the gravitational force between two electrons?

General Problems

Classwork



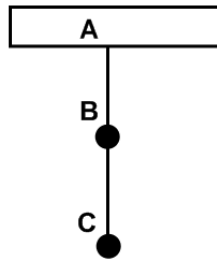
13. A conducting sphere is carrying a negative charge of $-6.0\ \mu\text{C}$ and is placed on an insulated tabletop. A 0.20 g oil drop is floating in the air, 1.5 m above the sphere.
 - a. Draw a free-body diagram showing all the forces acting on the drop.
 - b. What is the sign of the net charge of the drop?
 - c. Determine the magnitude of the electric charge on the drop.
 - d. If we double the charge on the drop what will be its initial acceleration?



14. A 0.140 kg metal ball is suspended at the end of a string and carries a positive charge of +10.0 nC. A charged sphere with a negative charge of -25.0 μC is placed at 5.00 cm below the ball.

- Draw a free-body diagram showing all the forces acting on the ball.
- Find the tension force in the string.
- If the maximum tension force that the string can withstand is 3.00 N, how much charge must be added to the ball in order to break the string?
- What will be the tension force in the string if we changed the charge on the sphere from -25.0 μC to +25.0 μC and leave the charge of the suspended ball at +10.0 nC?

Homework



15. Two identical balls (B and C) with a mass of 0.500 g are suspended from two strings as show above. The balls carry equal charges, +10.0 nC each and are separated by a distance of 4.00 cm.

- Draw a free-body diagram and show all forces applied on ball C.
- Find the tension force in the string BC.
- Draw a free-body diagram and show all forces applied on ball B.
- Find the tension force in string AB.
- Answer questions a, b, c and d for the situation when the balls have equal but opposite charges (charge on B is positive and charge on C is negative).

Classwork



16. A positive charge $Q_1 = 2.6 \mu\text{C}$ is located at a point $X_1 = -3.0 \text{ m}$ and a positive charge $Q_2 = 1.4 \mu\text{C}$ is located at a point $X_2 = +4.0 \text{ m}$.
- Draw free body diagrams for the electric force acting on Q_1 and Q_2 .
 - Find the magnitude of the electric force between Q_1 and Q_2 .
 - Find the magnitude and direction of the electric force acting on Q_1 .
 - Find the magnitude and direction of the electric force acting on Q_2 .



17. **A positive charge $Q_1 = 7.4 \mu\text{C}$ is located at a point $X_1 = -2.0 \text{ m}$, a negative charge $Q_2 = -9.7 \mu\text{C}$ is located at a point $X_2 = 3.0 \text{ m}$ and a positive charge $Q_3 = 2.1 \mu\text{C}$ is located at a point $X_3 = 9.0 \text{ m}$.
- Draw free body diagrams for the electric force acting on Q_1 , Q_2 and Q_3 .
 - Find the magnitude of the force between Q_1 and Q_2 .
 - Find the magnitude of the force between Q_1 and Q_3 .
 - Find the magnitude of the force between Q_2 and Q_3 .
 - Find the magnitude and direction of the net electric force on charge Q_1 .
 - Find the magnitude and direction of the net electric force on charge Q_2 .
 - Find the magnitude and direction of the net electric force on charge Q_3 .

Homework



18. **A negative charge $Q_1 = -25 \mu\text{C}$ is located at a point $X_1 = -2.0 \text{ m}$, a positive charge $Q_2 = 15 \mu\text{C}$ is located at a point $X_2 = 3.0 \text{ m}$ and a positive charge $Q_3 = 18 \mu\text{C}$ is located at a point $X_3 = 9.0 \text{ m}$.
- Draw free body diagrams for the electric force acting on Q_1 , Q_2 and Q_3 .
 - Find the magnitude of the force between Q_1 and Q_2 .
 - Find the magnitude of the force between Q_1 and Q_3 .
 - Find the magnitude of the force between Q_2 and Q_3 .
 - Find the magnitude and direction of the net electric force on charge Q_1 .
 - Find the magnitude and direction of the net electric force on charge Q_2 .
 - Find the magnitude and direction of the net electric force on charge Q_3 .

Answers

Chapter Questions

1. The plastic rod becomes negative, and the fur becomes positive (the magnitude of each charge is the same).
2. Two. Positive and negative.
3. Bring them near a neutral object, and see if they attract the new object by inducing an opposite charge in it. The magnitude of the charge on each object is the same, and it is of opposite sign.
4. They repel each other.
5. They attract each other.
6. They repel each other.
7. Benjamin Franklin.
8. Proton. Electron.
9. Negative. Ion.
10. Empty space.
11. No. The smallest free charge has a magnitude of "e."
12. Eight.
13. Positive. Ion.
14. The glass loses electrons. Protons are too massive to move, they are physically deep within the nucleus. Only electrons move.
15. Conduction via a positively charged rod, or Induction via a negatively charged rod and a ground.
16. Place the charged rod near the top of a grounded electroscope. Remove the ground with the rod still there. Electrons will move up the ground wire from the Earth to the Electroscope. When the ground wire is removed, the electrons remain behind on the Electroscope for a net negative charge.
17. The bits of paper will be attracted since the negatively charged rod will locally polarize the paper, pushing its electrons further from the surface, leaving behind a positive charge which is attracted to the rod. .
18. Electrons are moving between the sweater and the shirt due to friction. This is evidenced by sparks.
19. The metal ball is insulated from ground, so the positively charged rod attracts electrons from the far side of the sphere to the near side, and then the ball is attracted to the rod.
20. Negative. The rod repels more negative charges from the top of the Electroscope to the leaves, forcing them apart further.
21. Put a positive rod near each paper slip, without touching. If one repels, then it has a positive charge. If both are attracted, then the test is inconclusive. Take a negative rod and then the paper that is repelled has a negative charge. The neutral paper is attracted to both negative and positive rods.
22. This is charging by induction. Negative.
23. Yes. Electric force does not require a physical medium.
24. Decreases by a factor of four.
25. Electric force is very much greater than gravitational force.
26. $3F_0$
27. Both depend on the inverse square of the distance between the masses/charges. Gravity is always attractive. Electric Force is attractive or repulsive, and is much stronger than gravity.
28. No.

Chapter Problems

1. 900 N, repulsive
2. 1.3×10^{-1} N, attract
3. 7.7 mC, positive
4. -8.0×10^{-8} C,
 5.0×10^{11} electrons
5. 6.36×10^{-5} N,
repulsive
6. 3.24 N, repulsive
7. 4.4 m
8. 12 m
9. 2.7×10^{-7} C, positive
10. -1.27×10^{-7} C, 7.95×10^{11} electrons
11. 2.0×10^{-3} N repulsive
12. $kq_e q_e / Gm_e m_e$
 $= 4.2 \times 10^{42}$

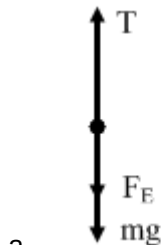
General Problems

13.



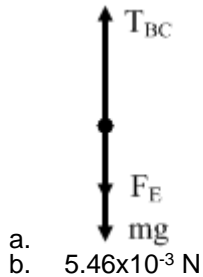
- a.
- b. Negative
- c. 8.2×10^{-8} C
- d. 9.8 m/s^2 upward

14.

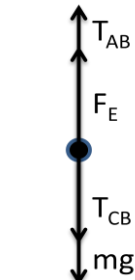


- a.
- b. 2.27 N
- c. 8.00×10^{-9} C
- d. 0.472 N

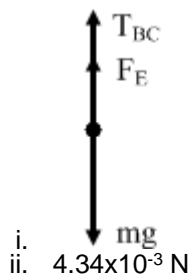
15.



- a.
- b. 5.46×10^{-3} N



- c.
- d. 9.80×10^{-3} N
- e.

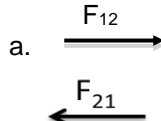


- i.
- ii. 4.34×10^{-3} N



- iii.
- iv. 9.80×10^{-3} N

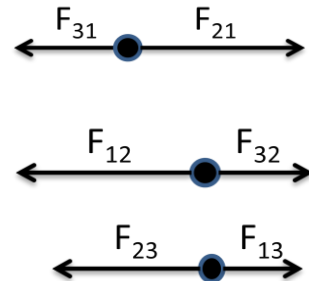
16.



- a.
- b. 6.7×10^{-4} N
- c. -6.7×10^{-4} N (to the left)
- d. 6.7×10^{-4} N (to the right)

17.

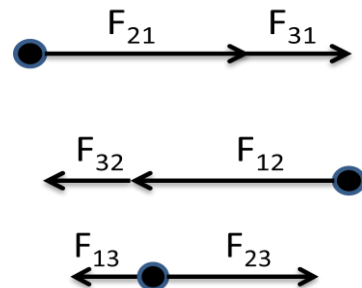
a.



- b. 2.6×10^{-2} N
- c. 1.2×10^{-3} N
- d. 5.1×10^{-3} N
- e. $+2.5 \times 10^{-2}$ N (to the right)
- f. -2.1×10^{-2} N (to the left)
- g. -3.9×10^{-2} N (to the left)

18.

a.



- b. 1.4×10^{-1} N
- c. 3.3×10^{-2} N
- d. 6.8×10^{-2} N
- e. $+1.7 \times 10^{-1}$ N (to the right)
- f. -2.1×10^{-1} N (to the left)
- g. $+3.5 \times 10^{-2}$ N (to the right)