

Electrostatics Test Review

Name _____

AP Physics B

BASIC CONCEPTS

charge-inducing combinations (hard rubber [-] with fur [+] and so forth)
charge flow and behavior on conductors and insulators, including charge separation and grounding
charging by conduction and induction
attractive and repulsive forces between charges; inverse-square behavior of Coulomb's Law
electric field size and direction for both single charges and charge distributions
rules for field lines (lines of force)
work and the electric field; potential difference (voltage) and its relationship to work and the electric field

STUDY AIDS notes; Chapter 18 and 19.1-19.3; electrostatics worksheet; homework; this review sheet

BASIC EQUATIONS

$$F = \frac{kq_1q_2}{d^2} \quad \text{where } k=9.0 \times 10^9 \text{ Nm}^2/\text{C}^2 \quad \mathcal{E} = \frac{F}{q} \quad (\mathcal{E} \text{ is measured in N/C or V/m})$$
$$\mathcal{E}_{PT. CHARGE} = \frac{kq}{d^2} \quad V = \frac{W}{q} = \mathcal{E}d$$

COULOMB'S LAW

Two point charges q_1 and q_2 separated a distance d apart will attract or repel each other with a force given by the formula below, called Coulomb's law. The constant k is taken to be $9 \times 10^9 \text{ Nm}^2/\text{C}^2$. $F = \frac{kq_1q_2}{d^2}$

ELECTRIC FIELDS

An electric field exists at any point in space where a test charge, if placed at that point, would experience an *electrical* force. The direction of the electric field at a point is the same as the direction of the force experienced by a positive test charge placed at that point. Electric field lines can be used to sketch the fields. These lines of force indicate direction and strength of the field. The lines always emanate from positive charges and end on negative ones. If a charge q is placed at a point where the electric field due to other charges is \mathcal{E} , the charge will experience a force F given by $F = q\mathcal{E}$. The units of \mathcal{E} are N/C or V/m.

The electric field due to a point charge is found by substituting Coulomb's law into the previous equation to get the result at right. $\mathcal{E}_{PT. CHARGE} = \frac{kq}{d^2}$

POTENTIAL

The potential difference from one point, A , to another point, B , is the work done against electrical forces in carrying a unit positive test charge from A to B . We represent the potential difference from A to B by $V_B - V_A$ or by V . Its units are those of work per charge (joules/coulomb), called *volts*.

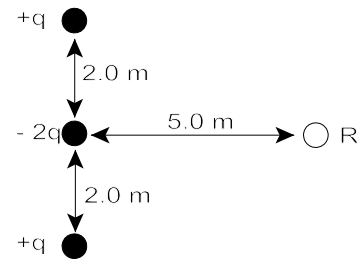
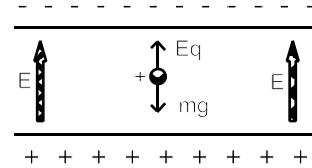
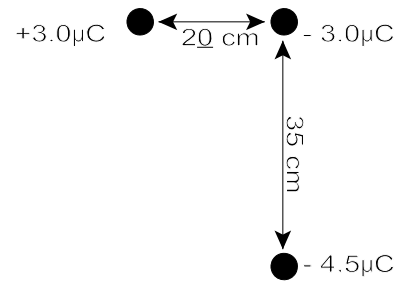
The work W done in transporting a charge q from one point, A , to a second point, B , is $W = q(V_B - V_A) = qV$

ELECTRIC POTENTIAL ENERGY: In order to carry a charge q from infinity to a point where the potential is V , work in the amount qV must be done. This work appears as electrical potential energy.

POTENTIAL RELATED TO FIELD: Because the field \mathcal{E} is force per unit charge and V is work per unit charge, \mathcal{E} and V are interrelated in the same way as force and work. If an electrical field is uniform, the magnitude of the potential difference between two points a distance d apart is $V = \mathcal{E}d$. The field between two large, parallel oppositely charge plates is uniform. If the separation of the plates is d , then the potential difference between the plates is $\mathcal{E}d$.

REVIEW PROBLEMS

- Three charges are located as shown. What is the size and direction of the net force vector on the $-3.0 \times 10^{-6} \text{ C}$ charge?
2.3 N at 26° N of W
- Determine the acceleration of a proton ($q = +1.6 \times 10^{-19} \text{ C}$, $m = 1.67 \times 10^{-27} \text{ kg}$) due to an electric field of intensity 500 N/C .
 $4.8 \times 10^{10} \text{ m/s}^2$
- A charge of $+q$ is located 1.5 m to the right of point P. Where would you have to place a charge of $+2q$ so the electric field at P would be zero?
2.1 m left of P
- As shown in the figure, a charged particle remains stationary between two charged plates. The plates are 2.00 cm apart and the mass of the particle is $4.00 \times 10^{-13} \text{ kg}$ and its charge is $2.40 \times 10^{-18} \text{ C}$. Find the potential difference between the plates.
32,700 V
- A cloud has a potential difference relative to a tree of 900 MV . During a lightning storm, a charge of 100 C travels through this potential difference. How much work was done on this charge?
 $9.00 \times 10^{10} \text{ J}$
- At right is a diagram of three fixed charges. If $q = 1.0 \times 10^{-8} \text{ C}$, what is the electric field at point R?
1.4 N/C to the west

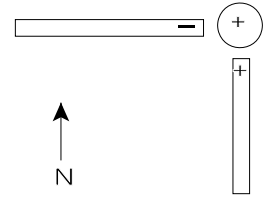


Electrostatics Test Concepts Review

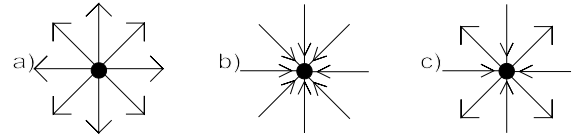
Write the letter corresponding to the best answer in the blank to the left of each question.
Answers are on the back.

- _____ 1. When the distance between two charges is halved, the electrical force between them...
A) quadruples. B) doubles. C) halves. D) reduces to one fourth.
- _____ 2. If you comb your hair and the comb becomes negatively charged, ...
A) electrons were transferred from the comb onto your hair.
B) electrons were transferred from your hair onto the comb.
C) protons were transferred from the comb onto your hair.
D) protons were transferred from your hair onto the comb.
- _____ 3. Which statement correctly describes how to charge something **negatively** by **conduction**?
A) Touch it with a positively charged object.
B) Touch it with a negatively charged object.
C) Momentarily ground it with a positively charged object nearby.
D) Momentarily ground it with a negatively charged object nearby.
- _____ 4. If a neutral conductor is touched by a rubber rod with a negative charge on it, what will happen?
A) Electrons will flow from the conductor onto the rubber rod.
B) Electrons will flow from the rubber rod onto the conductor.
C) Protons will flow from the conductor onto the rubber rod.
D) Protons will flow from the rubber rod onto the conductor.
- _____ 5. Protons and electrons...
A) repel each other. B) attract each other. C) have no effect on each other.
- _____ 6. Coulomb's law says that the force between any two charges depends...
A) inversely on the product of the charges.
B) directly on the square of the distance between the charges.
C) directly on the product of the charges.
D) inversely on the square root of the distance between the charges.
- _____ 7. In a good insulator, electrons are usually...
A) free to move around.
B) free to move around after an impurity has been added.
C) semi-free to move around.
D) tightly bound in place.
- _____ 8. A leaf electroscope is neutral. As a negative charge is brought close to the electroscope, the leaves spread apart because the approaching negative charge...
A) attracts and pulls electrons away from them.
B) attracts and pulls protons away from them.
C) pushes electrons down onto them.
D) pushes protons down onto them.
- _____ 9. The reason a pith ball will be attracted to a charged rubber rod is that...
A) the rod is positive and attracts electrons in the pith ball.
B) the rod is negative and repels electrons in the pith ball, attracting the nearer protons.
C) the rod is positive and repels electrons in the pith ball, attracting the nearer protons.
D) the rod is negative and attracts electrons in the pith ball.

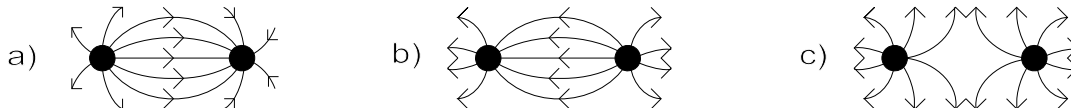
10. A positively charged metal ball was motionless on a flat table. Two charged rods were brought up the ball as shown in the diagram. In what compass direction did the ball move?
- A) northwest
B) northeast
C) southwest
D) southeast



11. Which figure at right shows lines of force about a negative charge?



12. Which diagram represents a possible electric field surrounding two unlike charges?



13. In a typical lightning bolt the potential difference between discharge points is about ten billion volts (10^{10} V) and about thirty coulombs (30 C) of charge is transferred. How much energy is released?
- A) 3×10^8 J B) 3×10^{11} J C) 3×10^{-9} J D) none of the above
14. The electric field around an isolated electron has a certain strength 1 cm from the electron. The electric field strength 2 cm from the electron is _____ as much.
- A) one-fourth B) half C) twice D) four times
15. In which case would electrical potential energy be built up and stored in the electric field?
- A) A positive charge is moved toward a negative charge.
B) A positive charge is moved toward a positive charge.
C) A negative charge is moved away from a negative charge.
D) none of the above
16. A positive charge is brought very near to an uncharged conductor which is insulated from the ground. The conductor is then grounded while the charge is kept near. If the nearby charge is taken away and only then is the ground connection removed, the conductor retains...
- A) a net negative charge.
B) a net positive charge.
C) no net charge.

Answers:

- 1 A
2 B
3 B
4 B
5 B
6 C
7 D
8 C
9 B
10 A
11 B
12 A
13 B ($10 \times 10^{10} \neq 10^{10}$)
14 A
15 B
16 C

Electrostatics Test Review

ADDITIONAL PRACTICE PROBLEMS

Name _____

AP Physics B

- Two equally charged pith balls are 3 cm apart and repel each other with a force of 4×10^{-5} N. Compute the charge on each ball.
approximately 2×10^{-9} C
- Three point charges are placed at the following points on the x-axis: $+2.0 \mu\text{C}$ at $x=0$, $-3.0 \mu\text{C}$ at $x=40.0$ cm, $-5.0 \mu\text{C}$ at $x=120$ cm. Find the amount of force (a) on the $-3.0 \mu\text{C}$ charge, (b) on the $-5.0 \mu\text{C}$ charge.
0.55 N; 0.15 N
- Four equal-magnitude point charges ($3.0 \mu\text{C}$) are placed at the corners of a square that is 40.0 cm on a side. Two, diagonally opposite each other, are positive and the other two are negative. Find the size and direction of the force on either negative charge.
0.46 N inward along the diagonal
- One charge ($+5.00 \mu\text{C}$) is placed at $x=0.00$, and a second charge ($+7.00 \mu\text{C}$) farther along the x-axis. The net force from the charges is zero at $x=45.8$ cm. Where is the $+7.00 \mu\text{C}$ charge located on the x-axis?
 $x = 100$ cm
- A charge, $+6.00 \mu\text{C}$, experiences a force of 2.00×10^{-3} N in the $+x$ -direction at a certain point in space. (a) What was the electric field there before the charge was placed? (b) Describe the force a $-2.0 \mu\text{C}$ charge would experience if it were used in place of the $+6.00 \mu\text{C}$ charge.
333 N/C in the $+x$ -direction; 6.7×10^{-4} N in the $-x$ -direction
- Determine the acceleration of a proton ($q=+e$, $m=1.67 \times 10^{-27}$ kg) in an electric field of intensity 5.00×10^2 N/C. How many times is this acceleration greater than g ?
 4.8×10^{10} m/s²; 4.9×10^9
- A tiny, 0.60 g ball carries a charge of magnitude $8.0 \mu\text{C}$. It is suspended by a thread in a downward electric field of intensity 300.0 V/m. What is the amount of tension in the thread if the charge on the ball is (a) positive, (b) negative?
 8.3×10^{-3} N; 3.5×10^{-3} N
- What is the potential at 3.0 cm from a point charge of 5.0×10^{-8} C?
15,000 V
- Two parallel plates are connected to a 120 V battery. They are 2.0 cm apart. Find a) the size of the field between the plates, b) the amount of force experienced by an electron between the plates, c) the amount of electric potential energy lost by the electron as it moves from the negative to the positive plate, and d) the speed of the electron just before it strikes the positive plate. ($e^- = -1.60 \times 10^{-19}$ C; $m_e = 9.11 \times 10^{-31}$ kg.)
a) 6000 V/m b) 9.6×10^{-16} N c) 1.92×10^{-17} J d) 6.5×10^6 m/s