Chapter 18 & 19: Electrostatics Review

Chapter 18: Electrostatic Forces and Fields

**(Do NOT include signs on charges or use absolute values)**

1. Electric Charge Concepts:

- protons and electrons - conservation of charge - electroscopes

- elementary charge - conductors and insulators - charging by induction

- quantization of charge - charging by contact

**Forces and Fields are VECTORS**

2. Electrostatic Force Between Two Point Charges Q and q separated by a distance r:

Q q

r2

F = k

- Like charges repel, opposite charges attract

- Be able to find the electrostatic force given a) 2 charges

b) 3 or more charges in a line or plane

Q

r2

3. Electric Field: E = E = k (field created **E**net = Σ **E** (vector sum)

F

q

by point charge)

- Field lines are always drawn from positive to negative charges. (from high to low electric potential)

- The electric field is constant between parallel plates.

- Be able to find the electric field due to a) a point charge

b) 2 or more point charges

# Chapter 19: Electrical Potential and Electrical Potential Energy

**(Include signs on charges!)**

**Energy and Potential are SCALARS**

1. Electric Potential Energy (Ue)

a) When an external force is applied to move a charge at a constant speed through and electric field, the work done by that force is equal to the change in electric potential energy.

Wnc=ΔEk+ΔUe

ΔEk=0J (constant speed)

Wnc =ΔUe

b) When the only force acting on a charge is the force causing the electric field, then the work done by that electrostatic force is the net work which is equal to the change in kinetic energy. Also since Wnc is zero the change in EK is equal to negative change in Up.

Wnet = ΔEk = -ΔUp = - qΔV

c) Electric potential energy (of a point charge q at a distance r from point charge Q) relative to EPE = 0 at infinity.

Ue = k

Qq

r

2. Electric Potential (V)

ΔUe

q

ΔV = Potential difference

ΔV = Ed Potential difference in a **UNIFORM** electric field. (e.g. between parallel plates)

V = k Potential (due to a point charge Q at a distance r) relative to V = 0 at infinity.

Q

r

Vtotal = Σ V (scalar sum)

**For all calculations of vector quantities, DO NOT INCLUDE SIGN for the charges! Sign implies direction!**

**For all calculations of scalar quantities, INCLUDE SIGN for the charges!**

**Practice Questions** (Extremely helpful for your upcoming test)

1. What happens when a positively charged rod is brought near a negatively charged electroscope?

2. And aluminum nail has an excess charge of + 5.0 μC. How many electrons must be added to the nail to make it electrically neutral?

3. The force between two equal charges at a separation of 2.0 x 10-2 m is 25 N. How big is each charge?

4. Point A is 5 mm from the positive plate. Point B is 10 mm from the negative plate. The parallel plates are 25 mm apart. a. What is the electric field strength at A and at B? (magnitude and direction)

b. What is the potential at A and B? (Assume 0V at the negative plate)

**A**

**B**

V = 60.0 Volts

s=25mm

5. What is the magnitude of the force on an electron in an electric field of 500.0 N/C @ 16oS of E? What is the direction of the force?

6. What is the magnitude of the electric field strength at the point P midway between the positive and negative 5.0 μC charges which are 15 cm apart?

15 cm

P

7. A helium nucleus is located in a constant, vertical electric field. The nucleus has a charge of + 2e and a mass of 6.6 x 10-27 kg. What is the magnitude of the electric field such that the electric force exactly balances the weight of the helium nucleus so that it remains stationary? (Hint: The electrostatic force up must equal the force of gravity down)

8. An electric field of 500.0 N/C exists between two large metal plates that are 30.0 cm apart. What is the potential difference between the plates?

9. Relative to zero at infinity, what is the electric potential energy of an electron 7 x 10-11 m away from a proton?

10. What is the electric potential relative to infinity, 50 cm from a 2.0 x 10-5 C charge?

11. Two point charges are arranged along the x axis as shown in the figure.

a. At which value(s) of x is the electric potential equal to zero?

b. At which value(s) of x is the electric field equal to zero

- 5.0 C

+ 3.0 C

x

1.0 m

0

12. What speed would a proton gain if it starts from rest at the positive plate and moves across the 50.0 V potential difference parallel plates shown, from the positive to the negative plate?

2.5 cm

V = 50.0 V

13. An electron between two metal plates 60.0 mm apart experiences an acceleration of 1.0 x 1012 m/s2. What is the voltage across the plates?

14. Two point charges are held at the corners of a rectangle as shown in the figure. The lengths of sides of the rectangle are 0.500 m and 0.900 m. Assume that the electric potential is defined to be zero at infinity.

0.500 m

- 6.00 C

+ 4.00 C

0.900 m

A

B

N

S

E

W

a) What is the electric field at point A?

b) What is the electric potential at point A?

c) How much work is required to move a charge of + 3.00μC from infinity to point A?

15. Draw the electric field around these pairs of point charges:

a) b)

16. Draw the equipotential lines around these pairs of point charges:

a) b)

17. What speed would a proton gain if it starts from rest at the positive plate and moves across the 50.0 V potential difference parallel plates shown, from the positive to the negative plate?

V = 50.0 V

18. A proton is fired into the region between the plates shown below travelling horizontally at 1.8x106m/s.

V = 2500.0 V

The plates are separated by 2.00mm and are 7.00mm long. The proton is deflected downward.

a. Label the plates + and -.

b. Using standard conventions, what is the potential of each plate?

c. What is the electric field between the plates?

d. What is the force on a proton between the plates?

e. What is the acceleration of the proton between the plates?

f. What is the horizontal component of the proton’s velocity when it leaves the plates?

g. How much time will the proton spend between the plates?

h. What is the vertical component of the proton’s velocity when it leaves the plates?

i. What is the y-displacement of the proton while it is between the plates?

j. What is the velocity of the proton as it leaves the plates?

19. A proton is fired into the region between the plates shown below travelling horizontally at 2.4x106m/s.

-

V = 3500.0 V

+

The plates are separated by 3.00mm and are 8.00mm long. Find the velocity of the proton as it leaves the plates.

20. A proton is fired into the region between the plates below. The proton enters the region horizontally at 9.6x105m/s. The plates are separated by 5.00mm and are 1.2cm long.

The proton leaves the plates with a speed of 9.85x105m/s. Find the potential difference across the plates.

21. Charge A is a -4.00x10-14C point charge. It is released from rest 14.0mm to the left of a fixed -3.00x10-7C charge. After travelling 9.00mm the speed of charge A is 2.0x105m/s.

a. What is the mass of charge A?

b. What direction is it travelling?

0.40m

-8.00µC

22. Consider the diagram to the right. The -8.00µC sphere is on an insulating base

and is fixed in place. The other sphere is a 95g conductor attached to the end of a

uniform 1.1m long, 140g rigid insulating beam. The beam is attached to the ground with

a frictionless hinge. The entire system is in equilibrium.

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Determine the amount and polarity of the charge on the 95g sphere.