

Unit 5 ~ Learning Guide Name: _____

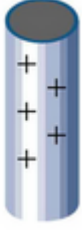
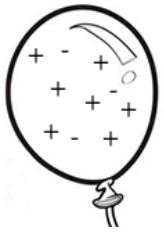
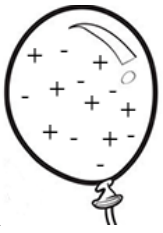
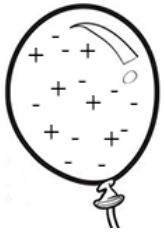
Instructions:

Using a pencil, complete the following notes as you work through the related lessons. Show ALL work as is explained in the lessons. You are required to have this package completed BEFORE you write your unit test. Do your best and ask questions if you don't understand anything!

Electrostatics

1. Neutrons have _____ charge, while protons are _____, and electrons are _____.
2. Within an atom, the _____ are able to move significantly, while the _____ and _____ can't.
3. Electrons are attracted to _____ charges.
4. Electrons are repelled by _____ charges.
5. An object has no net charge (ie. is neutral) if the number of _____ and _____ are equal.
6. When an object is negatively charged, it's due to excessive _____.
7. When an object is positively charged, it's due to missing _____.
8. Electrons are (*repelled by* / *attracted to*) the positive pole on a battery (circle one).
9. Electrons are (*repelled by* / *attracted to*) the negative pole on a battery (circle one).
10. An _____ can detect a charge, but can't determine if it's positive or negative.
11. An electrical charge can build up when a bunch of _____ are built-up on an object (negative charge) OR if the object loses a bunch of _____ (positive charge).
12. If a built-up charge isn't moving, we call it _____ electricity (due to the lack of any movement).
13. When a charge is discharged to the Earth, whether through a water pipe or wire or the ground itself, we call it _____.
14. When you are charged, your hair stands up because like charges _____ so each hair is trying to get away from other hairs and your head.
15. Charging involving rubbing is called "charging by _____", charging by contact is called "charging by _____", and charging without any touch is called "charging by _____".

16. Consider the following items. Each positive represents billions of protons, while each negative represents billions of electrons.

Rod-A	Rod-B	Balloon-A	Balloon-B	Balloon-C
				
			neutral	
electrons protons	electrons protons	electrons < protons	electrons protons	electrons protons

- Complete the bottom two rows of the table above. (positive, negative, or neutral in the first row) and (<, >, or =) in the second.
- If Rod-A touches Balloon-B, describe (in pictures or steps) what would happen?
- If Balloon-C is brought close to Balloon-B, describe (in pictures or steps) what would happen?
- If Rod-B touches Balloon-A, describe (in pictures or steps) what would happen?
- Describe how you could use Rod-A, along with two Balloon-B's to make two charged balloons.

Coulomb's Law:

1. What is the smallest unit of charge (in Coulombs)? Where does it exist (in positive and negative) form?
2. Explain how Coulomb's law provides a quantitative understanding to the forces involved in charging balloons that were discussed earlier.
3. We know that two positive charges repel each other. Determine the force between two charges which are both +1C and separated by 1m.
4. Why do we normally measure charge in μC instead of Coulombs?
5. Determine the force between two charges ($2.5 \mu\text{C}$ and $-4.3 \mu\text{C}$) which are separated by 4 cm.
6. Compare the general magnitude of the force of gravity and the electrostatic force. Consider the constants in each equation to explain the difference (use the equation for the universal force of gravity). Why do we often think of gravity as being bigger?

7. Find the force of attraction between objects of $4.0\ \mu\text{C}$ and $-5.0\ \mu\text{C}$ when they are $0.20\ \text{m}$ apart. How does this change when the distance is doubled?

8. A small sphere of mass $0.050\ \text{kg}$ is seen to accelerate away from a charge of $16\ \mu\text{C}$ at a rate of $1150\ \text{m/s}^2$ when placed $10\ \text{cm}$ apart.
 - a) What is the charge on the small sphere?

 - b) Describe the motion of the small sphere as it moves away from the $16\ \mu\text{C}$ charge. In particular, discuss how the sphere accelerates as they separate. Whenever possible, back up your reasoning with an equation.

9. Use Coulomb's Law to help explain why charged objects are attracted to neutral objects.

10. Demonstrate (show work) with Coulomb's Law what happens to the magnitude of the force between two charges Q_1 and Q_2 separated by a distance R if:

- (a) one of the charges is doubled?
- (b) both charges are doubled?
- (c) separation distance is doubled?
- (d) separation distance is tripled?
- (e) both charges are doubled and separation distance is doubled?
- (f) both charges are doubled and separation distance is halved?

11. Two small spheres are located 0.50 m apart. Both have the same charge on them. If the repulsive force is 5.0 N, what charge is on the spheres, in μC ?

12. Let's compare this electrical force to the force of gravity. Imagine you could place 1g of electrons 1.0 m away from another 1g of electrons. Calculate:

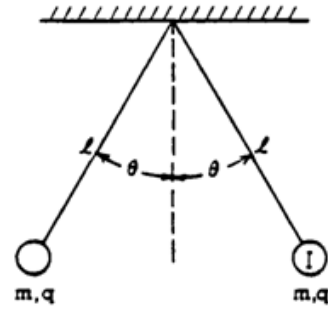
- (a) the **electrical force** of repulsion between the two charge collections.
- (b) the **gravitational force** of attraction between them.

(c) the **ratio** of the electrical force to the gravitational force. .

(d) Discuss whether you think gravity would play a major part in holding atoms together. Refer to your results above.

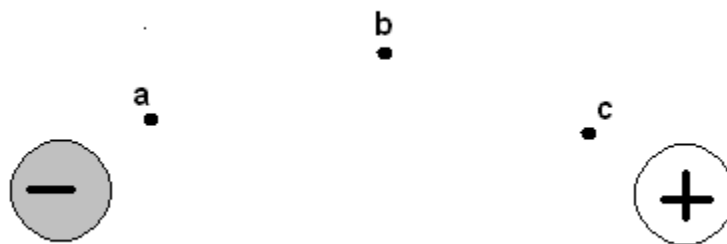
13. One electron has a mass of 9.1×10^{-31} kg. How many coulombs of charge would there be in 1 kg of electrons? How much force would this charge exert on another 1 kg of electrons 1.0 km away? (This is strictly an imaginary situation.)

3. Consider two small spheres, each of mass m and positive charge q , hanging from light threads of lengths ℓ .
- On the diagram draw and label all forces on sphere I. Label the distance, r , that you would use to determine the magnitude of the electric force acting between both spheres.
 - Determine the mass, m , for the charges, q if $q = 400\mu\text{C}$, $\ell = 2\text{m}$, and $\theta = 30^\circ$.



Electric Fields:

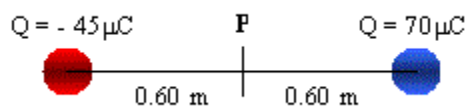
- $E = kQ/R^2$ is the equation for the electric field surrounding point charges.
 - What is the relationship between E and the distance away from the charge, R ? Explain with an example.
 - Sketch electric field lines around each charge and pass one through the three points, then draw a vector showing the resulting force at each point (ie. F_a , F_b , and F_c).



2. Calculate the electric field strength 1.2 m away from a $7.5 \mu\text{C}$ charge.

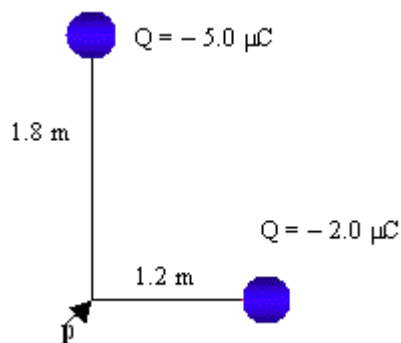
3. A charge experiences a force of $-2.0 \times 10^{-2} \text{ N}$ in an electric field of strength 45000 N/C . Calculate the size of the charge. Is it created by a surplus or shortage of electrons? How many electrons involved?

4. Find the electric field at point P in the diagram below.



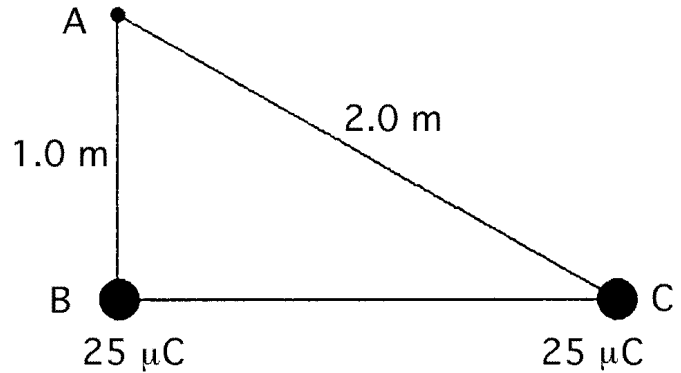
5. An electron carries a charge of $-1.6 \times 10^{-19} \text{ C}$. If a force of $3.2 \times 10^{-17} \text{ N}$ causes the electron to move upward, what is the magnitude and direction of the electric field

6. Calculate the electric field strength at point P in the diagram below.



7. Consider the diagram.

- a. Sketch the electric field vectors from each charge at location A. Be sure to sketch them roughly to scale. Show the direction of the Net Electric Field. Lightly sketch in the field lines onto the diagram above.
- b. Determine the angles of the vectors above and label them on the diagram above.



- c. What is the resultant electric field strength E at point A? Give both the magnitude and the direction.
- d. If an electron was placed at location A what would be its acceleration? Give both magnitude and direction.
- e. Discuss the similarities and differences between Electric Force as opposed to Electric Field.

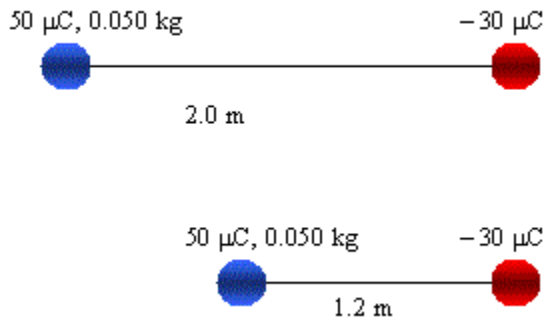
8. Sketch two oppositely charged parallel plates. Draw in the electric field lines being sure to adhere to the rules regarding their direction and relative strength. Discuss how the field between the plates near the positive plate compares to the field near the negative plate.

9. For the above set of plates why can't we use the formula $E=kQ/r^2$ to determine the value of the electric field between the plates? What formula should we use?

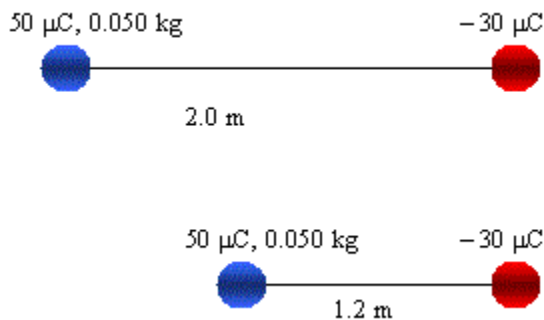
Electric Potential Energy:

1. Recall that electric/gravitational fields and forces are vector quantities (with direction). Potential Energy, though, is a scalar quantity.
 - a. Compare the formula to determine the gravitational potential energy between two planets with the formula to determine the electrical potential energy between two charges.
 - b. Potential energy is negative if the mass/charge moves in the same direction as the gravitational/electrical _____ (decreasing the stored energy).
 - c. Potential energy is positive if the mass/charge moves in the opposite direction as the gravitational/electrical force (_____ the stored energy).
 - d. Gravitational potential energy is always _____ as two masses move away from each other and _____ as they move closer.
 - e. Electrical potential energy is _____ if two oppositely charged objects move away from each other.
 - f. Electrical potential energy is _____ if two similarly charged objects move away from each other.
 - g. Electrical potential energy is _____ if two oppositely charged objects move towards each other.
 - h. Electrical potential energy is _____ if two similarly charged objects move towards each other.
2. Find the potential energy of two protons which are 10^{-10} m apart.

3. A $50\ \mu\text{C}$ charged sphere of mass $0.050\ \text{kg}$ is stationary and $2.0\ \text{m}$ away from a $-30\ \mu\text{C}$ charged sphere. The $50\ \mu\text{C}$ charged sphere is released and allowed to approach the other. When it is $1.2\ \text{m}$ away, what is the speed of this sphere?

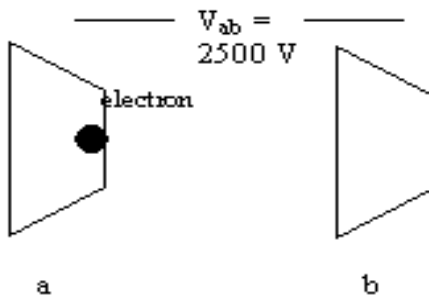


4. How much work is needed to bring a $+5.0\ \mu\text{C}$ point charge from infinity to a point $2.0\ \text{m}$ away from a $+25\ \mu\text{C}$ charge?
5. How much potential energy would an electron in a hydrogen atom lose if it fell toward the nucleus from a distance of $7.5 \times 10^{-11}\ \text{m}$ to a distance of $5.0 \times 10^{-11}\ \text{m}$?
6. A $50\ \mu\text{C}$ charged sphere of mass $0.050\ \text{kg}$ is $2.0\ \text{m}$ away from a $-30\ \mu\text{C}$ charged sphere. The $50\ \mu\text{C}$ charged sphere is moved to a point $1.2\ \text{m}$ away. What is the change in energy of this sphere?

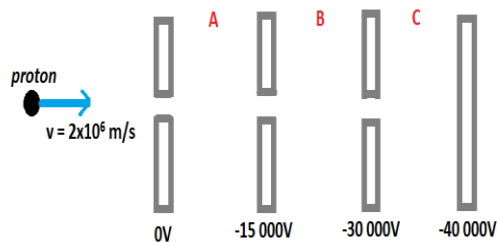


Voltage:

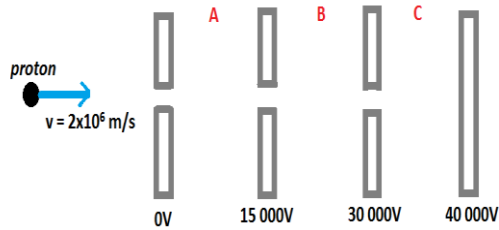
1. When working with electricity, we often use the term potential interchangeably with voltage. This is NOT the same thing as potential energy (though pretty close). Describe the difference between potential (or voltage) and potential energy.
2. An electron-volt, eV, is a unit of measure. What quantity does the electron volt measure? What is the conversion between eV and the standard unit for this quantity?
3. An electron is accelerated by a voltage of 2500 V between plates a and b, as shown. What is the electron's change in energy when reaching plate b if it starts from rest? What is the electron's speed when reaching plate b?



4. A proton moving at $3.0 \times 10^4 \text{ m/s}$ is accelerated by a potential difference of 200V, what is its final velocity?
5. A proton is moving at a speed of $2 \times 10^6 \text{ m/s}$ towards a series of charged parallel plates as shown below. What is the final velocity of the proton upon striking the -40000V plate on the right?

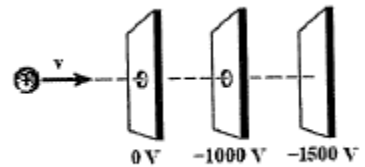


6. A proton is moving at a speed of 2×10^6 m/s towards a series of charged parallel plates as shown below. In what section (A, B, or C) will the proton stop?



7. A proton is travelling at a speed of 4×10^5 m/s moves into a series of charged parallel plates as shown below.

- a. What is the impact speed on the third plate?



- b. The same proton is fired again at the same speed towards a very large nucleus (parallel plates removed) and comes to rest 0.15 nm away from the atom. What is the charge of the atom?

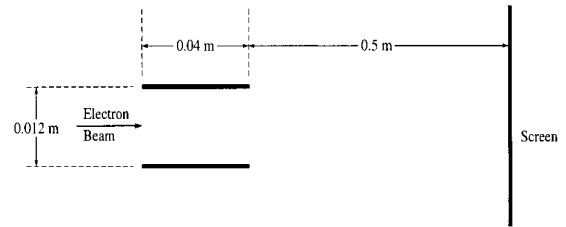
- c. What might this nucleus be? (use the periodic table)

- d. Why can you not use high-school kinematics to get the answer above for this situation?

CRTs:

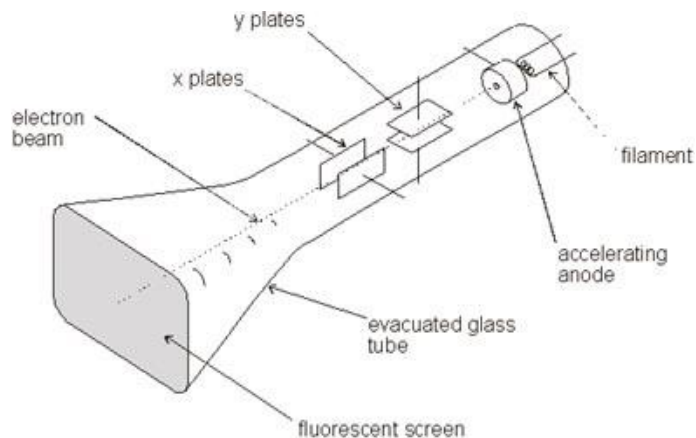
1. In a television set, electrons are first accelerated from rest through a potential difference in an electron gun. They then pass through deflecting plates before striking the screen.
 - a. Determine the potential difference through which the electrons must be accelerated in the electron gun in order to have a speed of 6.0×10^7 m/s when they enter the deflecting plates.

The pair of horizontal plates shown is used to deflect electrons up or down in the television set by placing a potential difference across them. The plates have length 0.04 m and separation 0.012 m, and the right edge of the plates is 0.50 m from the screen. A potential difference of 200 V is applied across the plates, and the electrons are deflected toward the top of the screen. Assume that the electrons enter horizontally midway between the plates with a speed of 6.0×10^7 m/s and that fringing effects at the edges of the plates and gravity are negligible.



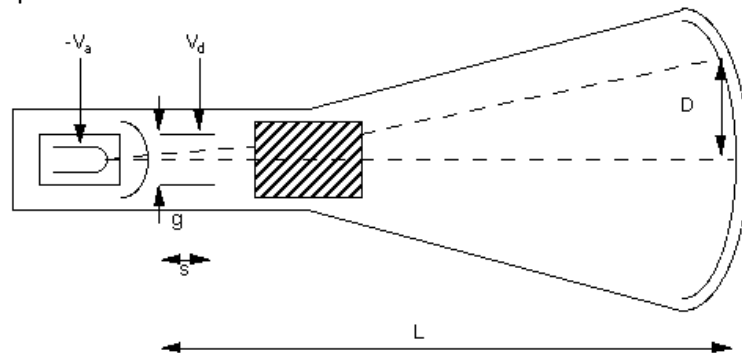
- b. Which plate in the pair must be at the higher potential (positive) for the electrons to be deflected upward? Justify your answer.
- c. Considering only an electron's motion as it moves through the space between the plates, compute the time required for the electron to move through the plates.
- d. What is the force on the electron's while between the plates?
- e. What is the vertical displacement of the electron while it is between the plates?
- f. Determine the force of gravity on the electron and compare it with the electrical force. Is it a reasonable assumption to neglect gravity in this question?

- g. Compare the path of the electron between the plates with a Type 1 projectile.
- h. What adjustment could be made to increase the overall deflection of the electron?
- i. What adjustment could be made to cause the electron to deflect downwards?
2. A simple Cathode Ray tube is depicted below. Describe the function of each labelled part (i.e. how it affects the electron's motion).



Part:	Function:
filament	
Accelerating anode (V_a applied here)	
Y plates (V_{dy})	
X Plates (V_{dx})	
Fluorescent screen	

3. For the simple CRT depicted below, describe how each suggested change in V_a or V_d would affect the final deflection position of the electron beam.



<i>Change in Voltage</i>	<i>Effect on deflection, D</i>
V_d is halved	
V_a is tripled	
V_d is increased by 1.5x and its polarity is reversed	
V_a is quadrupled, V_d is doubled	

4. In a CRT, the deflection on the screen is 2.4 cm when the accelerating voltage is 480 V and the deflecting voltage is 36 V. What deflection will you see in the screen if the accelerating voltage is 960 V and the deflecting voltage is 18 V?

Answers:

Electrostatics:

1)no, pos, neg 3)pos 5)elect,prot 7)elect 9)repelled 11)elect,elect 13)grounded
15)friction,conduction,induction 16)a)+,-,+, ,-,<,>,<,> b)-e) ask if unsure 17)description and/or photo

Coulomb's Law:

1) 1.6×10^{-19} C, electron, proton 2) magnitude of attraction/repulsion 3) 9×10^9 N 5) 60 N 7) -4.5 N, quarter 8) 4.0×10^{-6} C 10) a) 2F b) 4F c) F/4 d) F/9 e) F f) 16 11) $12 \mu\text{C}$ 12) a) 2.9×10^{26} N b) 6.7×10^{-17} N c) $4.3 \times 10^{42} : 1$ 13) 1.8×10^{11} C, 2.8×10^{26} N

Coulomb's Law in 2D:

1) c) 0.39 N [down, or between the pos charges] 2) 9.5 N at 35° E of N 3) b) 63.6 kg

Electric Fields:

1) a) inverse-square b) tangents at points 2) 4.7×10^4 N/C 3) -4.4×10^{-7} C, 2.8×10^{12} electrons 4) 2.88×10^6 N/C [left] 5) 2.0×10^2 N/C [down] 6) 1.9×10^4 N/C @ 48° N of E 7) b) 30° c) 2.6×10^5 N/C [11° W of N] d) 4.57×10^{16} m/s² [opposite direction] 8) uniform 9) not point charges (more like infinite point charges) $E=V/d$

Electrical Potential Energy:

1) b) force c) increasing d) increased, decreased e) increased f) decreased g) decreased h) increased 2) 2.3×10^{-18} J 3) 13.4 m/s 4) 0.56 J 5) -1.6×10^{-18} J or -10 eV 6) 4.5 J

Voltage:

2) 1.6×10^{-19} J 3) -4.0×10^{-16} J, 3.0×10^7 m/s 4) 2.0×10^5 m/s 5) 3.4×10^6 m/s 6) B as $\Delta V = 21000$ V 7) 6.7×10^5 m/s, 1.39×10^{-17} C, R_a , force varies with d

CRTs:

8) a) 10200 V b) top c) 6.67×10^{-10} s d) 2.67×10^{-15} N e) 6.5×10^{-4} m h) increase voltage i) switch polarity (+/-), 9) research, 10) a) D/2, b) D/3, c) 1.5D on opposite side (bottom), d) D/2, 11) 0.60 cm