Early E. C.: / 1
Total HW Points Unit 10: / 24
Total Lab Points Unit 10: / 28
Unit 10 Apps.: / 5
Late, Incomplete, No Work, No Units Fee? Y / N

Unit 10 – Electrostatics

Essential Fundamentals of Electrostatics

1. Voltage is analogous to 'electric pressure,' which moves charges.

Add more here!

Equation Sandbox

In Unit 10, some of the following equations will be used. Practice isolating variables to prepare for it.

Possible 10.1 Pts: 7
Late, Incomplete, No Work, No Units Fee: -1 - 2 -3
Final Score: / 7

10.1 Problems – Electric Charge & Conservation
Section 15.1 – 15.2 – of your book.

1. What is the net charge of an object that has 1.0 million excess electrons?

2. In walking across a carpet, you acquire a net charge of – 50 μC. How many excess electrons do you have?

3. An initially neutral electroscope is charged by induction by bringing it near a negatively charged object. If 3.22 E 8 electrons flow through the ground wire to Earth and the ground wire is then removed, what is the net charge on the electroscope?

4. A glass rod rubbed with silk acquires a charge of –8.0 E -10 C.
   A. How many electrons have been transferred from the silk?

   B. How much mass has the glass rod gained?

5. A rubber rod acquires a charge of -4.8 E -9 C when rubbed with fur.
   A. Is the charge on the fur (1) positive, (2) zero, or (3) negative? Why?

   B. What is the charge on the fur, and how much mass is transferred to or from the rod?

Possible 10.2 Pts:	6
Late, Incomplete, No Work, No Units Fee:	-1 - 2 -3
Final Score:	/ 6

10.2 Problems – Electric Force
Section 15.3 of your book.

1. A. Two identical point charges are a fixed distance apart. By what factor would the magnitude of the electric force between them change if one of their charges were doubled and the other halved?

   B. What if both their charges were halved?

   C. How about one charge was halved and the other left unchanged?

   D. Finally, one charge doubled, one tripled, and the radius increased to three times the original value?

2. A. What is the force between the following charges, spaced 0.55 m apart: -1.25 E -9 C and +13.8 E -5 C?

   B. Is the force attractive or repulsive?

3. The distance between neighboring singly charged sodium (loses one electron) and chloride (gains one electron) ions in crystals of table salt (NaCl) is 2.82 E -10 m. What is the attractive electric force between the ions?

Possible 10.3 Pts:	6
Late, Incomplete, No Work, No Units Fee:	-1 - 2 -3
Final Score:	/ 6

10.3 Problems – Electric Fields
Section 15.4 of your textbook.

1. A. If the distance from a charge to a measuring point is doubled, is the magnitude of the electric field (1) increased, (2) decreased, or (3) the same compared to the initial value? Explain.

   B. If the original electric field due to a charge is 1.0 E -14 N/C, what is the magnitude of the new electric field at twice the distance from the charge?

2. An electron is acted on by two electric forces, one of 2.7 E -14 N acting upward and a second of 3.8 E -14 N acting to the right. What is the magnitude and direction of the electric field at the electron's location? Hint: This is a vector addition problem.

3. Draw the electric field produced if point A has charge of +2 Q, and point B has charge of –3 Q.

4. A. A parallel plate has an electric field of 13.5 N/C with a plate area of 0.20 m^2. What is the charge on one of the plates?

   B. For the previous problem, how much would the charge have to be to maintain the same field strength if the plate area were halved?

Possible 10.4 Pts: 5
Late, Incomplete, No Work, No Units Fee: -1 - 2 -3
Final Score: / 5

10.4 Problems – Electric Potential Energy
Section 15.5 – 15.6 of your textbook.

1. Yay?

Possible 10.5 Pts: 5
Late, Incomplete, No Work, No Units Fee: -1 - 2 -3
Final Score: / 5

<u>10.5 Problems – Conductors</u>

Section 15.5 – 15.6 of your textbook.

1. A solid conducting sphere is surrounded by a thick, spherical conducting shell with a small air gap between them. A total charge +Q is placed at the center of the sphere and released.
   A. After equilibrium is reached, the inner surface of the shell will have (1) negative, (2) zero, (3) positive charge.

   B. In terms of Q, how much charge is on the interior of the sphere?

   C. How much charge is on the surface of the sphere?

   D. The inner surface of the shell?

   E. The outer surface of the shell?

2. In the previous problem, what is the electric field direction (make a drawing where possible):
   A. In the interior of the solid sphere?

   B. Between the sphere and the shell?

   C. Inside the shell?

   D. Outside the shell?

3. Three identical conducting spheres are placed side-by-bide without touching. The first sphere has a charge of 2 C, and it briefly touches the second. The second sphere briefly touches the third, and then the third briefly touches the first. What is the charge on each sphere?

AP Physics 1	10.1 - Lightning Rod Challenge
Reminder: Update Table of Contents	**Correction Credit: Half**

Lab Overview

You (or you and only one partner) must build the tallest lightning rod possible, and equip it with a grounding wire that allows it to disperse electric charge.

Challenge Specifications

You will be provided with exactly 10.0 grams of modeling clay, 1.0 m of thin wire, and as many toothpicks as you need to build your tower.

You will all have 20 minutes to build your towers.

During testing, we will hook the Van De Graaf generator up to the grounding wire in such a way as to test the effectiveness of the tower. Hopefully we will see St. Elmo's Fire if the designs are good enough! Also, I will run a fan at varying distances from your tower. The closer the fan gets to the tower before the tower collapses, the better rating your tower will receive.

Performance Requirements

1. The tower must measure at least 30.0 cm tall.
2. The tower must withstand (not topple or collapse) the fan (on high) at a distance of 1.5 meters, for a duration of 10 seconds.
3. Your tower must have a grounding wire that goes from table to top.

Lightning Rod Challenge (10.1) Guide		
Table of Contents, Title/Date, Complete Synopsis, Two Purposes		/ 2
Performance:	Height > 30.0 cm	/ 2
	Wind Resistant	/ 2
	Grounding Wire	/ 1
	Design/Model Match	/ 1
Mission 1: Tower Drawing	Full Page	/ 2
	Labels	/ 1
	Neatly Drawn	/ 1
Extra Credit:	Height > 50 cm	+ 1
	Hurricane Resistant	+ 1
	Tallest	+ 1
Question 1: How was your tower good? How could it be improved?		/ 2
Question 2: Electric field strength and direction 50.0 cm away?		/ 2
Work Not Shown Fee:		-1 -2 -3
Late Lab Fee:		-4
Total:		**/ 16**

Mission 1: In your Lab book, design and draw your tower. Your design must match the actual model that you build for full credit. Your drawing should be a full page, and labeled (with dimensions) where necessary.

Questions. Rephrase and answer in complete sentences for full credit.

1. What features of your tower were good? How could your tower's performance have been improved?

2. Say that the tip of your tower has a total negative charge of 6.28 E -12 C on it. What is the electric field strength and direction of the field 50.0 cm away (3 points)?

Winning Design Extra Credit:

Tower exceeds 50.0 cm: +1.

Tallest tower: +1.

If towers above 20 cm withstand hurricane force winds for 10 seconds at ½ meters distance: +1.

AP Physics 1	Unit 10.2 Lab - Electrostatic Force
Reminder: Update Table of Contents	Correction Credit: Half

Lab Overview

In groups, measure the force required to cause a charged balloon to hover in an electric field.

Electric Force Lab (10.2) Scoring Guide		
Table of Contents, Title/Date, Complete Synopsis, Two Purposes		/ 2
Mission 1: Electric Force Data Table	Data Table	/ 1
	Balloon/String Mass	/ 1
	Distance from Balloon	/ 1
	Force of Gravity Calc.	/ 2
Question 1: Charge on Balloon		/ 3
Question 2: Electron Calculation		/ 2
Question 3: Sources of Error		/ 2
No Work Shown Fee		-1 -2 -3
Late Lab Fee:		-3
Total:		/ 14

Materials

1 – Base Plate
2 – Upright Attachments
2 – Threaded Uprights
2 – Skew Connectors
1 – Crossbar
Balloon
Sewing Thread
Cloth Strip
Ruler
Mettler AC 100 Lab Balance

Mission 1: Electric Force

Report all measurements in a data table.

Assemble the experimental setup as seen at the front of the room.

Obtain and record the mass of your balloon and string BEFORE inflation. The balloon can develop a static charge during inflation that affects the scale's performance. Also, make sure scale is well-zeroed. Inflate the balloon, attach the string to it, and rub it on the cloth. With a little luck, your balloon should adhere to the cloth when you release it. Next, you will have to determine exactly how far away the balloon can go from the cloth before it falls. To do this, mark the string at a set point when the balloon is touching the cloth. Now pull on the string slowly until the balloon JUST falls, and measure the amount of string you pulled to achieve this.

If your system doesn't work, sometimes you may have to ground it. To do this, take a long threaded rod and touch one of the water faucets to it. Rub the other end of the rod on your cloth, then take your balloon and touch it to the faucet. Water faucets are grounded objects, and should neutralize any charge buildup on both components of your system. If it still doesn't work, let me know.

The distance from the cloth to the balloon at the point of falling marks the point where the force of gravity is exactly balanced by the electric force. Calculate and report the force of gravity acting on your balloon – show your work for full credit.

To clean up, dismantle your system, and return parts to the front of the room. Leave the balloon's string with me, but please keep the balloon.

Questions: Rephrase and write in complete sentences for full credit.

1. Using Coulomb's Law and the gravitational force you calculated earlier, calculate the charge on the balloon, assuming that the charge removed from the balloon equals the charge gained by the cloth. (3 Points)

2. How many electrons were moved during charging? (1 Point)

3. What are sources of error in this lab? Address assumptions you made for calculations, as well as the equation you used in Question 1. (2 Points)

AP Physics 1	Unit 10 - Electrostatics				
Application Problems, AP Test Preparation Questions					
Presentation Points:	/ 5	Late Fee:	-2	Completion (Booklet Check)	/ 5

Your grade on this problem set depends on the presentation you provide for your assigned problems, and whether **<u>all</u>** problems are complete when you submit your Booklet at the end of the Unit.

Application Problems

1. Explain how charging by friction, conduction, induction, and polarization work, and provide examples.

2. How many electrons will it take to make 2.5 E -5 C of negative charge?

3. Two charges are put near each other. One's charge is – 4q, and the other is + 6q. Map the electric field that surrounds the two charges. Do the same if the charges were both positive

4. What is the electric field strength between two parallel plates with areas of 0.13 m^2, and a charge of 1.4 E -9 C on the negative plate?

5. What is the electric force exerted between a charge of 4.2 E -8 C and -5.4 E -7 C, separated be a distance of 4.2 mm? Is it attractive or repulsive?

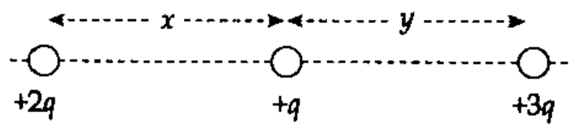
6. How many electrons would have to be placed on a 4.6 E -12 kg object to make it hover in an electric field of 4.5 E -3 N/C?

AP Test Questions

1. If the distance between two positive point charges is tripled, then the strength of the electrostatic repulsion between them will decrease by a factor of
   a) 3 b) 6 c) 8 d) 9

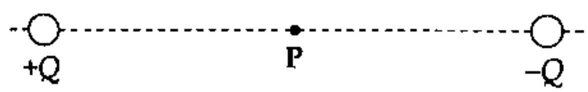
2. Two 1 kg spheres each carry a charge of magnitude 1 C. How does F_E, the strength of electric force between the spheres, compare to F_G, the strength of their gravitational attraction?
   a) $F_E < F_G$ b) $F_E = F_G$ c) $F_E > F_G$
   d) If the charges on the spheres are of the same sign, then $F_E >$; but if the charges on the spheres are of the opposite sign, then $F_E < F_G$.

3. The figure shows three point charges, all positive. If the net electric force on the center charge is zero, what is the value of y/x?



   a) 4/9 b) √(2/3) c) √(3/2) d) 3/2

4. The figure shows two point charges, +Q and –Q. If the negative charge were absent, the electric field at Point P due to +Q would have strength E. With –Q in place, what is the strength of the total electric field at P, which lies at the midpoint of the line segment joining the charges?



   a) 0 b) E/2 c) E d) 2E

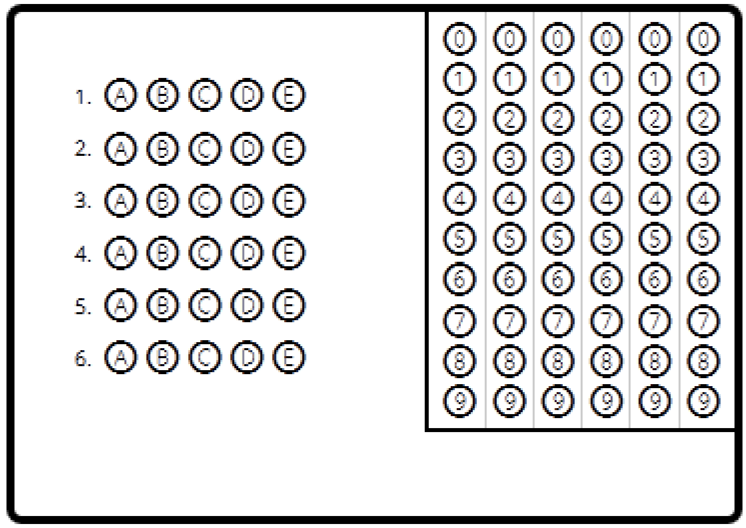
5. A sphere of charge +Q is fixed in position. A smaller sphere of charge +q is placed near the larger sphere and released from rest. The small sphere moves away from the large sphere with
   a) decreasing velocity and decreasing acceleration.
   b) decreasing velocity and increasing acceleration.
   c) increasing velocity and decreasing acceleration.
   d) increasing velocity and increasing acceleration.

6. An object of charge +q feels an electric force $\mathbf{F}_E$ when placed at a particular location in an electric field, **E**. Therefore, if an object of charge –2q were placed at the same location where the first charge was, it would feel an electric force of
   a) $-\mathbf{F}_E/2$ b) $-2\mathbf{F}_E$ c) $-2q\mathbf{F}_E$ d) $-2\mathbf{F}_E/q$

7. A charge of –3Q is transferred to a solid metal sphere of radius r. Where will this excess charge reside?
   a) –Q at the center, and –2Q on the outer surface. b) –3Q at the center.
   c) –3Q on the outer surface.
   d) –Q at the center, –Q in a ring of radius ½ r, and –Q on the outer surface.

AP Physics 1		Unit 10 Review - Electrostatics					
Points:	**/ 12**	**Late or Incomplete Fee:**	**-2 -4 -6**	**Correction Credit:**		**Final Score:**	

Solve these problems here, THEN enter your responses in the bubble sheet provided.
Each question is worth two points.



1. How many electrons have been removed from an object with a charge of + 1.23 nC (nanocoulombs)?
A. 1.60 E 9 electrons B. 6.55 E 9 electrons
C. 7.68 E 9 electrons D. 9.80 E 9 electrons
E. 4.8 E 9 electrons

2. What is the force between two charged objects separated by a distance of 2.1 cm, one with a charge of +1.2 E -6 C and one with a charge of – 2.3 E -6 C?
A. – 72 N B. – 56 N C. 72 N
D. 56 N E. 62 N

3. Consider two charges: one of +1.2 E -6 C and one with a charge of – 2.3 E -6 C? Will the two objects attract, repel, or ignore each other?
A. Attract B. Repel C. Ignore

4. Find the electric field strength at a point 3.5 cm from a charge of 1.33 E -5 C?
A. 5.55 E 7 N/C B. 7.82 E 7 N/C C. 9.76 E 7 N/C D. 8.26 E 7 N/C E. 6.24 E 7 N/C

5. How far away from a point charge of 4.5 E -8 C will its field strength be 4.5 N/C?
A. 9.5 m B. 4.5 m C. 12.8 m D. 135 cm E. 1.96 m

6. What is the electric field strength between two parallel plates with equal areas of 1.3 E -3 m^2, and 7.5 E 5 electrons on the negative plate?
A. 2.3 N/C B. 4.5 N/C C. 6.8 N/C D. 10.4 N/C E. 11.8 N/C