Elementary Physics; Second semester

This file is for students working together in one team of the same section.

This is a shared file, hence collaborating students can and have to edit it. Based on your work, you select the answers to the questions in the file and then enter your choices in the WebAssign assignment correspondent to the lab section.

This manual has elements that have been developed as possible extra exercises and may not be used in the actual laboratory exercise (at the discretion of the TF).

This file represents the work of team # from the lab section .

Students in the team:

Name

Name

Name

Name

Name

Lab 1: Electric charge, Coulomb's Law

In order to present your work, you need to write in this shared file your name (at the top of this page), your lab section and your team number.

When this file is completed, you should save its copy on your computer.

Please, navigate to the shared folder, go into folder Unit 1, and download to your computer folder All_Files.

Please NOTE! In this file, for ALL questions in a textual format you can delete wrong answers and only leave your team answer, or simply select your team answer and change the font to bold or underline, or use any other means to indicate your team answer.

Every student has the right to disagree with the team answer and enter in the WebAssign his/her own answer.

A TF is here to help you to master this lab, but when needed students also should be actively asking TA for help.

Part 1: In this part you will be "experimenting" with various objects to study electrostatic properties of conductors and dielectrics.

I. Follow this link to open a Java simulation:

https://phet.colorado.edu/sims/html/balloons-and-static-electricity/latest/balloons-and-static-electricity_en.html

1. Predict what will happen if you "grab" the balloon with the mouse , "rub" it against the coat. What will be happening with the charges? What particles will be moving and what particles will stay?

Lab 1 Q1
1. Protons will be moving between the objects and electrons will stay.
2. Electrons will be moving between the objects and protons will stay.
3. Both electrons and protons will be moving between the objects.
4. Neither electrons nor protons will be moving between the objects.

2. Predict, what will happen if *after* you did the part I (i.e. "rubbed" the balloon against the coat) you will move the balloon away from the coat, place it between the coat and the wall, and then release the balloon? Note: you may refer to the triboelectric series at the end of the manual (the balloon material is similar to polyethylene and the coat is like wool).

Lab 1 Q2
1. The balloon will remain at rest.
2. The balloon will move to the left.
3. The balloon will move to the right.
4. The balloon will explode.

3. Now use the applet and check your predictions.

Lab 1 Q3
1. All my predictions were correct.
2. Some of my prediction were wrong.
3. All my predictions were wrong.

Part II

In this part we will "play" with an electroscope.

4. Watch video L1V1. In the video you see a rod that was rubbed with a material and then used to charge an electroscope. Pay attention to the names of the rod and the material and refer to the triboelectric series table at the end of the manual to establish the charge of the electroscope.

Lab 1 Q4
What is the charge on the electroscope?
1. Positive
2. Negative
3. Zero

5. Predict what will you observe if a neutral dielectric will be brought close to the plate of the electroscope.

Lab 1 Q5
1. The state of the electroscope will not change (the moving arm of the electroscope will not move).
2. The moving arm of the electroscope will be moving closer to the vertical (fixed) arm.
3. The moving arm of the electroscope will be moving away from the vertical (fixed) arm.
4. We don't have enough information to predict.

6. Predict what will you observe if a neutral conductor will be brought close to the plate of the electroscope.

Lab 1 Q6
1. The state of the electroscope will not change (the moving arm of the electroscope will not move).
2. The moving arm of the electroscope will be moving closer to the vertical (fixed) arm.
3. The moving arm of the electroscope will be moving away from the vertical (fixed) arm.
4. We don't have enough information to predict.

7. Predict what will you observe if a negatively charged rod will be brought close to the plate of the electroscope.

Lab 1 Q7
1. The state of the electroscope will not change (the moving arm of the electroscope will not move).
2. The moving arm of the electroscope will be moving closer to the vertical (fixed) arm.
3. The moving arm of the electroscope will be moving away from the vertical (fixed) arm.
4. We don't have enough information to predict.

Predict what will you observe if a positively charged rod will be brought close to the plate of the electroscope.

Lab 1 Q8
1. The state of the electroscope will not change (the moving arm of the electroscope will not move).
2. The moving arm of the electroscope will be moving closer to the vertical (fixed) arm.
3. The moving arm of the electroscope will be moving away from the vertical (fixed) arm.
4. We don't have enough information to predict.

Watch video L1v2 and check your predictions.

Lab 1 Q9
1. All my predictions were correct.
2. Some of my predictions were correct.
3. None of my predictions were correct.
4. My teammates made me to change my predictions from right to wrong.

8. Watch video L1V3. In the video you see the same rod that was rubbed with the same material as in video L1vV1. But now the electroscope is charge by induction.

Lab 1 Q10
What is the charge on the electroscope?
1. Positive
2. Negative
3. Zero

9. Predict, what will happen with the electroscope if now it will be rubbed with a negatively charge rod.

Lab 1 Q11

1. The state of the electroscope will not change (the moving arm of the electroscope will not move).
2. The moving arm of the electroscope will be moving closer to the vertical (fixed) arm.
3. The moving arm of the electroscope will be moving away from the vertical (fixed) arm.
4. We don't have enough information to predict.

Watch video L1v4 and check your prediction.

Lab 1 Q12

1. My prediction was correct.
2. My prediction was wrong.

Part III: Discovering the Coulomb's Law

Watch video L1V5.

Go to the following link http://physics.bu.edu/ulab/prelabs/prelab_coulomb_new.html.

Below is the copy of the table from the main page: note in our table the notations are *different* from the variables in the app!

Distance between charges (r)						
Position of the blue rectangle (x)						
$1/r^2$						
δx (note that $\delta x = 10 - x$)						

Click on Simulation.

The picture above represents the *spring* in its *equilibrium* state (not stretched and not compressed). In the simulation, the length of a free spring is 10 units, hence the *elongation/contraction* of the spring, δx, is equal to $\delta x = 10 - x$ (x is the x-coordinate of the blue rectangle).

Follow the instructions for the simulation and fill in the table; make sure you start from the shortest possible distance between the charges. You need to assume that when you place the blue rectangle at any location, it is being held at that location by a screw (or a hand) - until you move it again. The spring and the moving charge are acting on the charge at the origin. When the sum of the two forces acting on the charge (from a spring and from the moving charge) is NOT zero, the charge is being held at the origin by an invisible hand. But as soon as the sum of the two forces acting on the charge (from a spring and from the moving charge) is equal to zero, the invisible hand releases the charge and it remains in equilibrium acted upon by only two forces.

NOTE: the values of r (the distance between the two red charges) and x (the x-coordinate of the blue box) should be measured when the charge at the origin is in equilibrium and only two forces are acting on it.

Let us use the following notations:

F_C = the magnitude of the Coulomb force actin between the two charges.

F_{El} = the magnitude of the elastic force acting from the spring on the charge at the origin.

Lab 1 Q13

When the charge at the origin is in equilibrium and only two forces are acting on it

1. $F_C < F_{El}$ 2. $F_C = F_{El}$ 3. $F_C > F_{El}$

Lab 1 Q14

According to the Hook's Law

1. F_{El} is constant 2. F_{El} is proportional to x 3. F_{El} is proportional to x^2

4. F_{El} is is proportional to δx 5. F_{El} is proportional to δx^2 6. the Hook's Law is wrong

Lab 1 Q15

According to the Coulomb's Law

1. F_C is constant 2. F_C is proportional to $1/r$ 3. F_C is proportional to $1/r^2$

4. F_C is proportional to r 5. F_C is proportional to r^2 6. the Coulomb's Law is wrong

Based on your answers to Q 13 – 15 predict the relationship between δx and r.

Lab 1 Q16

1. δx is constant 2. δx is proportional to r 3. δx is proportional to r^2
4. δx is proportional to $1/r$ 5. δx is proportional to $1/r^2$ 6. Not enough information

Let us define a new variable $y = 1/r^2$

Based on your answer to Q16 predict the relationship between δx and y.

Lab 1 Q17

1. δx is constant 2. δx is proportional to y 3. δx is proportional to y^2
4. δx is proportional to $1/y$ 5. δx is proportional to $1/y^2$ 6. Not enough information

Open LoggerPro file L1f1.cmbl, enter in the file your data for x and r, and use the appropriate fit to check your prediction for Q 16.

Then open LoggerPro file L1f2.cmbl, enter in the file your data for x and r, and use the appropriate fit to check your prediction for Q 17.

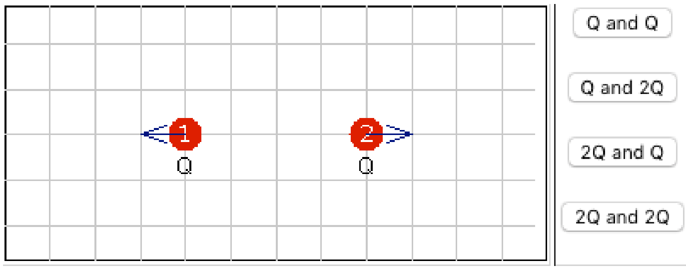
Open LoggerPro file L1f1.cmbl, enter in the file your data for x and r, and use the appropriate fit to check your prediction.

Lab 1 Q18

1. Both my predictions was correct. 2. One of my predictions was correct.
3. Both my predictions were wrong. 4. I do not have Logger Pro.

Part IV: Using the Coulomb's Law

A.

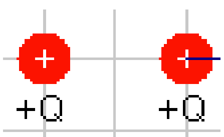


In the picture above, you see two identical charges (Q and Q) and a force acting on each charge from another charge. If the magnitude of the force is $|F|$, predict the magnitude of the force acting between charges when one or both charges are changed.

Use the table for your predictions.

Q	**Q**	
Q	**2Q**	
2Q	**Q**	
2Q	**2Q**	

Open the following link: http://physics.bu.edu/~duffy/semester2/c01_magnitude.html

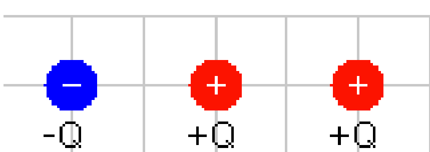


In the picture on the left you see two identical positive charges. The magnitude of the force between the charges is $|F|$.

Use the applet to check your predictions.

Lab 1 Q19
1. My prediction was correct.
2. My prediction was wrong.

B.



In the next picture on the left three charges have the same magnitude, but the charge on the left is negative. The two charges on the right are the same as in the previous picture, and we just added one more charge (which is negative). Predict, i.e. calculate (in terms of $|F|$) the magnitude of the force acting on the charge on the right.

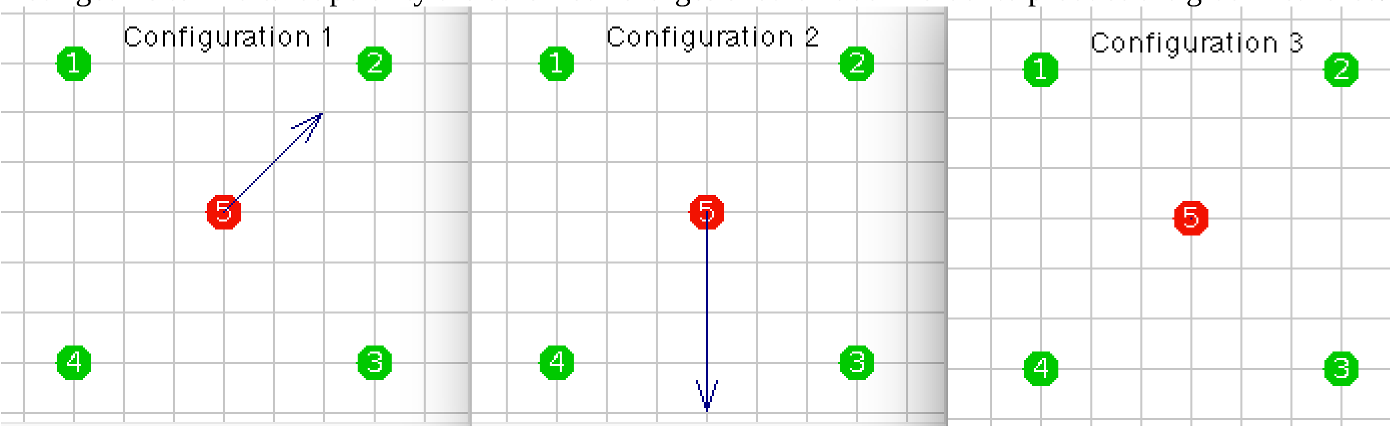
F_{net} =

Follow to the link: http://physics.bu.edu/~duffy/semester2/c01_coulomb1D.html and check your prediction (first click on "Two positives" and note the force; then click on "All three (with force)" and compare the force with your result).

Lab 1 Q20
1. My prediction was correct.
2. My prediction was wrong.

C.

Below, in each of the three pictures you see five charges with the same magnitude. The charge in the middle (red) is always positive, but other charges (green) have an unknown polarity. In each picture an arrow represents the net force acting on the positive charge in the middle (in the last case there is no net force). Your goal is to find what polarity the other four charges should have in order to produce the given net force.



For each configuration, select the possible set or sets of polarities for 4 charges; if there are several correct selections, indicate in this file all of them, and enter in the WA one answer of your choice.

Lab 1 Q21

Configuration 1

1.	$q_1 > 0$	$q_2 > 0$	$q_3 > 0$	$q_4 > 0$	2.	$q_1 > 0$	$q_2 > 0$	$q_3 > 0$	$q_4 < 0$
3.	$q_1 > 0$	$q_2 > 0$	$q_3 < 0$	$q_4 > 0$	4.	$q_1 > 0$	$q_2 > 0$	$q_3 < 0$	$q_4 < 0$
5.	$q_1 > 0$	$q_2 < 0$	$q_3 > 0$	$q_4 > 0$	6.	$q_1 > 0$	$q_2 < 0$	$q_3 > 0$	$q_4 < 0$
6.	$q_1 > 0$	$q_2 < 0$	$q_3 < 0$	$q_4 > 0$	8.	$q_1 > 0$	$q_2 < 0$	$q_3 < 0$	$q_4 < 0$
9.	$q_1 < 0$	$q_2 < 0$	$q_3 < 0$	$q_4 < 0$	10.	$q_1 < 0$	$q_2 < 0$	$q_3 < 0$	$q_4 > 0$
11.	$q_1 < 0$	$q_2 < 0$	$q_3 > 0$	$q_4 < 0$	12.	$q_1 < 0$	$q_2 < 0$	$q_3 > 0$	$q_4 > 0$
13.	$q_1 < 0$	$q_2 > 0$	$q_3 < 0$	$q_4 < 0$	14.	$q_1 < 0$	$q_2 > 0$	$q_3 < 0$	$q_4 > 0$
14.	$q_1 < 0$	$q_2 > 0$	$q_3 > 0$	$q_4 < 0$	16.	$q_1 < 0$	$q_2 > 0$	$q_3 > 0$	$q_4 > 0$

Lab 1 Q22

Configuration 2

1.	$q_1 > 0$	$q_2 > 0$	$q_3 > 0$	$q_4 > 0$	2.	$q_1 > 0$	$q_2 > 0$	$q_3 > 0$	$q_4 < 0$
3.	$q_1 > 0$	$q_2 > 0$	$q_3 < 0$	$q_4 > 0$	4.	$q_1 > 0$	$q_2 > 0$	$q_3 < 0$	$q_4 < 0$
5.	$q_1 > 0$	$q_2 < 0$	$q_3 > 0$	$q_4 > 0$	6.	$q_1 > 0$	$q_2 < 0$	$q_3 > 0$	$q_4 < 0$
6.	$q_1 > 0$	$q_2 < 0$	$q_3 < 0$	$q_4 > 0$	8.	$q_1 > 0$	$q_2 < 0$	$q_3 < 0$	$q_4 < 0$
9.	$q_1 < 0$	$q_2 < 0$	$q_3 < 0$	$q_4 < 0$	10.	$q_1 < 0$	$q_2 < 0$	$q_3 < 0$	$q_4 > 0$
11.	$q_1 < 0$	$q_2 < 0$	$q_3 > 0$	$q_4 < 0$	12.	$q_1 < 0$	$q_2 < 0$	$q_3 > 0$	$q_4 > 0$
13.	$q_1 < 0$	$q_2 > 0$	$q_3 < 0$	$q_4 < 0$	14.	$q_1 < 0$	$q_2 > 0$	$q_3 < 0$	$q_4 > 0$
14.	$q_1 < 0$	$q_2 > 0$	$q_3 > 0$	$q_4 < 0$	16.	$q_1 < 0$	$q_2 > 0$	$q_3 > 0$	$q_4 > 0$

Lab 1 Q23

Configuration 3

1.	$q_1 > 0$	$q_2 > 0$	$q_3 > 0$	$q_4 > 0$	2.	$q_1 > 0$	$q_2 > 0$	$q_3 > 0$	$q_4 < 0$
3.	$q_1 > 0$	$q_2 > 0$	$q_3 < 0$	$q_4 > 0$	4.	$q_1 > 0$	$q_2 > 0$	$q_3 < 0$	$q_4 < 0$
5.	$q_1 > 0$	$q_2 < 0$	$q_3 > 0$	$q_4 > 0$	6.	$q_1 > 0$	$q_2 < 0$	$q_3 > 0$	$q_4 < 0$
6.	$q_1 > 0$	$q_2 < 0$	$q_3 < 0$	$q_4 > 0$	8.	$q_1 > 0$	$q_2 < 0$	$q_3 < 0$	$q_4 < 0$
9.	$q_1 < 0$	$q_2 < 0$	$q_3 < 0$	$q_4 < 0$	10.	$q_1 < 0$	$q_2 < 0$	$q_3 < 0$	$q_4 > 0$
11.	$q_1 < 0$	$q_2 < 0$	$q_3 > 0$	$q_4 < 0$	12.	$q_1 < 0$	$q_2 < 0$	$q_3 > 0$	$q_4 > 0$
13.	$q_1 < 0$	$q_2 > 0$	$q_3 < 0$	$q_4 < 0$	14.	$q_1 < 0$	$q_2 > 0$	$q_3 < 0$	$q_4 > 0$
14.	$q_1 < 0$	$q_2 > 0$	$q_3 > 0$	$q_4 < 0$	16.	$q_1 < 0$	$q_2 > 0$	$q_3 > 0$	$q_4 > 0$

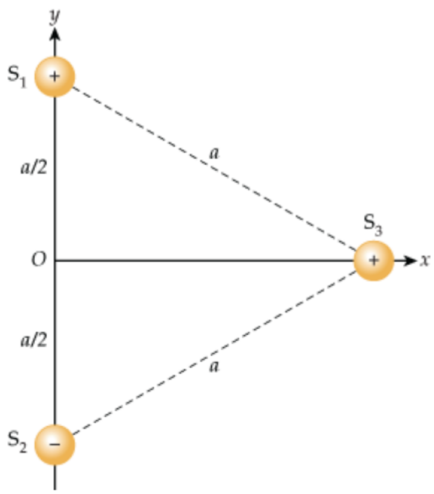
Go to the following link http://physics.bu.edu/~duffy/semester2/c01_coulomb2D.html and check your predictions (click on "Net + All").

Lab 1 Q24

1. All my predictions were correct.
2. Some of my predictions were correct.
3. None of my predictions were correct.
4. My teammates made me to change my predictions from right to wrong.

Practice Exercise 1

In the picture on the left, three charges have the same magnitude of 10 nC. Distance *a* is 10 cm. Calculate the magnitude of the net force acting on charge S_3. Find the angle between the force and the positive x-direction.



Lab 1 Q25

The magnitude of the net force acting on charge 3

$F_3 =$

Lab 1 Q26

The angle between the net force 3 and the positive x-direction (enter the value with the smallest magnitude, remember, for angles CWW means "+"; CW means "-").

$\alpha =$

Lab 1 Q27

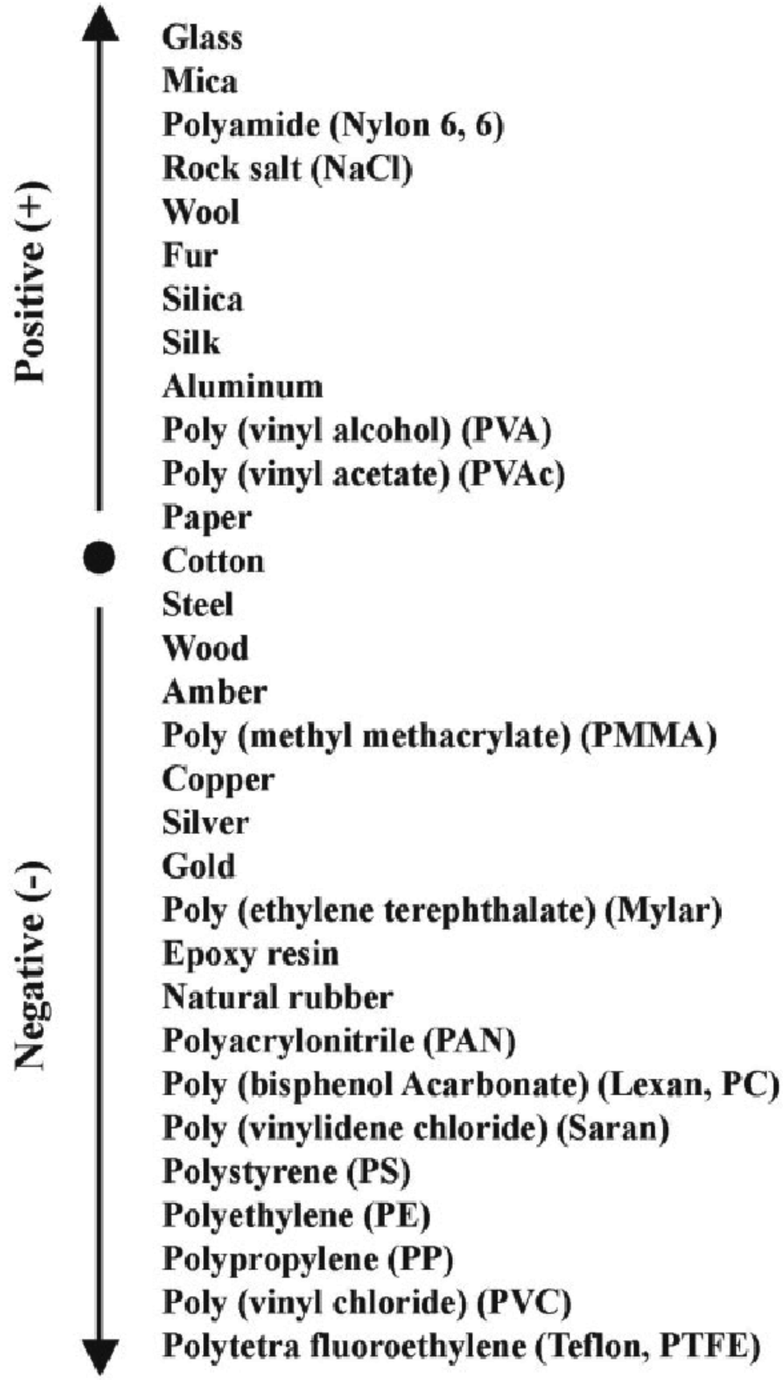
The magnitude of the net force acting on charge S_1

$F_1 =$

Lab 1 Q28

The angle between the net force 1 and the positive x-direction (enter the value with the smallest magnitude, remember, for angles CWW means "+"; CW means "-").

$\alpha =$


Positive (+)
Negative (-)
Glass
Mica
Polyamide (Nylon 6, 6)
Rock salt (NaCl)
Wool
Fur
Silica
Silk
Aluminum
Poly (vinyl alcohol) (PVA)
Poly (vinyl acetate) (PVAc)
Paper
Cotton
Steel
Wood
Amber
Poly (methyl methacrylate) (PMMA)
Copper
Silver
Gold
Poly (ethylene terephthalate) (Mylar)
Epoxy resin
Natural rubber
Polyacrylonitrile (PAN)
Poly (bisphenol Acarbonate) (Lexan, PC)
Poly (vinylidene chloride) (Saran)
Polystyrene (PS)
Polyethylene (PE)
Polypropylene (PP)
Poly (vinyl chloride) (PVC)
Polytetra fluoroethylene (Teflon, PTFE)