Electric charge, force, and energy

Eugenia Etkina
Experiment videos by G.Planinsic

Please rename yourself with the country and the short school/college, see my name as an example.

Links to today's materials

Workshop folder

https://drive.google.com/drive/folders/1TW7Ypsq06PmRkMAkHxHUXk66x5s0ylLH

OALG Chapter 17

https://docs.google.com/document/d/17AIQxw3jq4Z-8NhaC-VNUA6W_Z87G_87/edit

What interactions have we studied so far? What was common about them?
Have you observed magnets? What did you notice?

https://mediaplayer.pearsoncmg.com/assets/_frames.true/sci-OALG-20-1-1

Possible needs to know

Why do our clothes get stuck together when we take them out of a dryer?

Why does our hair look different in dry weather compared to rainy days?

How does a photocopier work?

https://youtu.be/Tnz06t74K0w

https://youtu.be/IFzAKnugOow but we have better videos now

Team 1 Record the observations, if some experiments are not here, add

Object 1	Object 2	Outcome
Styrofoam stick rubbed with plastic	Styrofoam stick rubbed with plastic	Repel
Styrofoam stick rubbed with plastic	Plastic that rubbed it	attract
Styrofoam stick rubbed with fur	Styrofoam stick rubbed with fur	repel
Styrofoam stick rubbed with fur	Fur that rubbed it	Attracted

Team 2 Record the observations, if some experiments are not here, add

Object 1	Object 2	Outcome
Styrofoam stick rubbed with plastic	Styrofoam stick rubbed with plastic	Repel
Styrofoam stick rubbed with plastic	Plastic that rubbed it	Attract
Styrofoam stick rubbed with fur	Styrofoam stick rubbed with fur	Repel
Styrofoam stick rubbed with fur	Fur that rubbed it	Attract

Team 3 Record the observations, if some experiments are not here, add

Object 1	Object 2	Outcome
Styrofoam stick rubbed with plastic	Styrofoam stick rubbed with plastic	repel
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Styrofoam stick rubbed with fur	Fur that rubbed it	attract

Team 4 Record the observations, if some experiments are not here, add

Object 1	Object 2	Outcome
Styrofoam stick rubbed with plastic	Styrofoam stick rubbed with plastic	repel
Styrofoam stick rubbed with plastic	Plastic that rubbed it	attract
Styrofoam stick rubbed with fur	Styrofoam stick rubbed with fur	repel
Styrofoam stick rubbed with fur	Fur that rubbed it	attract

Put here all the patterns that you found

Objects either repel or attract

When objects are rubbed with the same material, they repel

2 objects that rubbed against each other attract each other

Names

Electric interactions - why ELECTRIC?

https://www.youtube.com/watch?v=QNapBwPlGug

What is the Ancient Greek word for amber?

Names for Electric charge - history

Resinous electricity: Negative charge - on resin rubbed with fur

Virtuous electricity: Positive charge - on glass rubbed with silk

How can we explain why the clothes taken out of the dryer stick together?

But we still do not know the mechanism!

All together OALG 17.1.3

Equipment: 2 plastic (PVC) tubes or balloons, hanging set-up, rubbing materials (dry paper towel and felt or fleece), plastic comb, Scotch tape, small pieces of paper and small pieces of aluminum foil used in a kitchen.

Design and conduct experiments to examine how neutral (un-rubbed) objects (PVC tubes, balloons), small pieces of paper and small pieces of aluminum foil) interact with rubbed objects such as PVC tubes, balloons, plastic combs, etc.

a. Record your results for all experiments in words and with a picture. Do your results depend on the type of rubbed object? Do your results depend on whether the neutral object is plastic or metal? Remember to describe what you see in as much detail as possible without fancy words, and without trying to explain anything.

b. What is similar in the behaviors of pieces of paper and pieces of aluminum foil when a charged object approaches them? What is different?

c. What can you say about interactions of charged objects with uncharged objects? (Describe the pattern(s) you noticed.)

All together

OALG 17.2.1 Explain

In Activities 17.1.1 and 17.1.2 you found a consistent pattern: Identical objects rubbed with a second material repel each other. The second material in turn attracts the objects it rubbed. What mechanism might explain why rubbing objects makes them attract or repel each other?

Team 1 OALG 17.2.2

Your friend Hrvoje says that electric interactions are the same as magnetic interactions because magnets also attract and repel each other. Consequently, he believes that when you rub objects, they become magnetized. What experiment(s) will allow you to test Hrvoje's idea?

Describe experiments here and their outcomes IF Hrvoje's idea is correct.

Team? ?Using a permanent magnet rubbed on small amounts of different materials

Team 1: The rubbed object should interact with the two poles of a magnet (attracted by one end and repelled by the other repelled)

Would have to specify bar or horseshoe magnet.

Rub implys action in both directions / action needs to specified to get resul

Team 2 OALG 17.2.2

Your friend Hrvoje says that electric interactions are the same as magnetic interactions because magnets also attract and repel each other. Consequently, he believes that when you rub objects, they become magnetized. What experiment(s) will allow you to test Hrvoje's idea?

Describe experiments here and their outcomes IF Hrvoje's idea is correct.

Put a magnet next to a rod (styrofoam, metal, whatever) rubbed with e.g. wool/plastic. If the interaction is the same, then one end of the magnet will attract the rod and the other end will repel the rod. If the interaction is NOT the same, then something else will happen (either nothing or both ends attract the rod). (we can compare outcomes to 2 magnets interacting with eachother)

Team 3 OALG 17.2.2

Your friend Hrvoje says that electric interactions are the same as magnetic interactions because magnets also attract and repel each other. Consequently, he believes that when you rub objects, they become magnetized. What experiment(s) will allow you to test Hrvoje's idea?

Describe experiments here and their outcomes IF Hrvoje's idea is correct.

Use compass to see how it is affected by charged styrofoam, if it is affected (points to other direction than Earth magnetic pole) HOW? then it is magnetic, if it is not affected than it is not magnetic interaction. There is no prediction, right?

Take two magnets and rubbed them with plastic and fur: we expect the behave the same way if the phenomena is the same. do they behave as styrofoam?

Team 4 OALG 17.2.2

Your friend Hrvoje says that electric interactions are the same as magnetic interactions, because magnets also attract and repel each other. Consequently, he believes that when you rub objects, they become magnetized. What experiment(s) will allow you to test Hrvoje's idea?

Describe possible experiments here and write clear predictions of their outcomes IF Hrvoje's idea is correct.

Testing Exp.: **1) Use a rubbed styrofoam to interact with a fridge, 2) and both ends of a magnet**

Predictions: **1) It will should stick to the fridge. 2) It should attract and repel different ends of a magnet.**

All together - Testing Hrvoje's idea

a. We decided to test Hrvoje's idea by using a magnet on a pivot with a set of materials that can be charged positively and negatively. Watch the following videos of the experiments that we conducted https://mediaplayer.pearsoncmg.com/assets/_frames.true/sci-OALG-17-2-2 and decide which ones can be used to reject Hrvoje's idea and which ones cannot. Explain how you made your decision.

b. Make a judgment about Hrvoje's idea.

Team 1

OALG 17.3.1 Observe and explain

a. Watch the experiments at https://youtu.be/wpAUPjiErmM
and at https://mediaplayer.pearsoncmg.com/assets/_frames.true/sci-OALG-17-3-1.
b. Describe your observations for each of the experiments.

c. Think of what model of the internal structure of the conducting and dielectric materials could explain your observations?

d. Watch the experiment at http://islephysics.net/pt3/experiment.php?topicid=10&exptid=190. Do you need to adjust the model that you devised to explain the outcome of this experiment?

d. Read and interrogate subsections "Conductors" and "Dielectrics" in Section 17.3. Use the text in these subsections to revise your explanations if necessary. Here, see the screen shots of the textbook pages at https://drive.google.com/drive/folders/1TW7Ypsq06PmRkMAkHxHUXk66x5s0ylLH

Team 1

Team 2

OALG 17.3.1 Observe and explain

a. Watch the experiments at https://youtu.be/wpAUPjiErmM
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Team 2 whiteboard

b) All styrofoam pieces got stuck on the metal/ceramic plate.
When there was a conductive rod between the charged object and the conductive sphere, the sphere always got attacted to the conductive rod, regardless of the charge of the chraged object.
When there was a non-conductive rod between the charged object and the conductive sphere, nothing happens.

c) in the conductive rod there's free charges that can move around. If we bring a positive charged object next to a conductive rod, the negative charges will move towards the positive rod which leaves the other end positively charged.

d) apparently non conductive materials also have some charge.

Team 3

OALG 17.3.1 Observe and explain

a. Watch the experiments at https://youtu.be/wpAUPjiErmM
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Team 3

Video 1: Charged styrofoam stick to styrofoam, charged styrofoam stick to metal plate. Both behaved same.

We can explain it by redistribution of charges.

Video 2: In second video we did not have contact.With the conducting rod, the sphere was attracted to the rod. With the dielectric rod, the sphere was not attracted to the rod.

Video 3: even without contact the neutral plastic bottle seems to feel the electric charge of the rubbed rod

Team 4

OALG 17.3.1 Observe and explain

a. Watch the experiments at https://mediaplayer.pearsoncmg.com/assets/_frames.true/sci-OALG-17-3-1.

b. Describe your observations for each of the experiments.

c. Think of what model of the internal structure of the conducting and dielectric materials could explain your observations?

d. Watch the experiments at https://youtu.be/wpAUPjiErmM and http://islephysics.net/pt3/experiment.php?topicid=10&exptid=190. Do you need to adjust the model that you devised to explain the outcome of this experiment?

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Team -4 :

Possible model for the 2 materials:

Metal: the charge can move across the metal body

Dielectric material: The charge cannot

metal rod conducts the attraction

and the dielectric rod doesn't

Observation: Both metal and and dielectric plate attract both + and - charged styrofoam

Team 1

OALG 17.3.4 Observe and explain

An electroscope consists of a metal ball attached to a metal rod that passes from the outside through an insulating support into a glass-fronted metal enclosure. A very lightweight metal needle is connected on a pivot on the metal rod (see the photo on the right).

a. Watch the following two experiments https://mediaplayer.pearsoncmg.com/assets/_frames.true/sci-OALG-17-3-4a and record the outcomes.
Explain the behavior of the electroscope needle (1) when the charged rod touches the electroscope and (2) then when it is brought closer to the charged electroscope without touching.

b. Watch the following experiment https://mediaplayer.pearsoncmg.com/assets/_frames.true/sci-OALG-17-3-4b and explain the outcome. What can you tell about the electric properties of a human body based on the outcome of the experiment?

Team 2

OALG 17.3.4 Observe and explain

An electroscope consists of a metal ball attached to a metal rod that passes from the outside through an insulating support into a glass-fronted metal enclosure. A very lightweight metal needle is connected on a pivot on the metal rod (see the photo on the right).

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Team 3

OALG 17.3.4 Observe and explain

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Team 4

OALG 17.3.4 Observe and explain

An electroscope consists of a metal ball attached to a metal rod that passes from the outside through an insulating support into a glass-fronted metal enclosure. A very lightweight metal needle is connected on a pivot on the metal rod (see the photo on the right).

a. Watch the following two experiments https://mediaplayer.pearsoncmg.com/assets/_frames.true/sci-OALG-17-3-4a and record the outcomes.
Explain the behavior of the electroscope needle (1) when the charged rod touches the electroscope and (2) then when it is brought closer to the charged electroscope without touching.

b. Watch the following experiment https://mediaplayer.pearsoncmg.com/assets/_frames.true/sci-OALG-17-3-4b and explain the outcome. What can you tell about the electric properties of a human body based on the outcome of the experiment?

https://docs.google.com/document/d/17AIQxw3jq4Z-8NhaC-VNUA6W_Z87G_87/edit

Team 1 OALG 17.4.1

Changing charge 1

Charges (q_1, q_2)	Distance	Force
1, 1 (unit)	1 (unit)	1 (unit)
1/2, 1	1	1/2
1/4, 1	1	1/4

Changing charge 2

Charges (q_1, q_2)	Distance	Force
1, 1 (unit)	1 (unit)	1 (unit)
1, 1/2	1	1/2
1, 1/4	1	1/4

Changing distance

Charges (q_1, q_2)	Distance	Force
1, 1 (unit)	1 (unit)	1 (unit)
1, 1	2	1/4
1, 1	3	1/9
1, 1	4	1/16

Force is directly proportional to each charge

Force is inversely proportional to the square of the distance

Team 2 OALG 17.4.1

https://docs.google.com/document/d/17/
VNUA6W_Z87G_87/edit

the force is directly proportional to the 1st charge (2nd and 3rd row), to the 2nd charge (4th and 5th row) and from 6th and 7th row we see that it's directly proportional to the product of the charges q1 and q2.

from the last 3 rows we see that it's inversely proportional to the square of the distance between the charges.
F ∝ q1*q2/r^2

b) compared to the eq.
F=q1q2/r^2 * k_c,

Team 3 OALG 17.4.1

The force is equal to the product of the charges divided by the square of the distance. The charges and distance are independent variables, and force dependent.

Charges (q_1, q_2)	Distance	Force
1, 1 (unit)	1 (unit)	1 (unit)
1/2, 1	1	1/2
1/4, 1	1	1/4
1, 1/2	1	1/2
1, 1/4	1	1/4
1/2, 1/2	1	1/4
1/4, 1/4	1	1/16
1, 1	2	1/4
1, 1	3	1/9
1, 1	4	1/16

Team 4 OALG 17.4.1

https://docs.google.com/document/d/17AIQxw3jq4Z-8NhaC-VNUA6W_Z87G_87/edit If 1) one charge (q1) change, the other charge (q2) doesn't, and the distance, r, doesn't, then the force change with the same ratio.

2) If both charge change, and the distance doesn't, the force will change with the product of the ratio.

3) if the charge doesn't change, and distance increases, and the force decrease the square of the distance.

Mathematically: F $\propto$ q1 x q2, and 1/ r^2

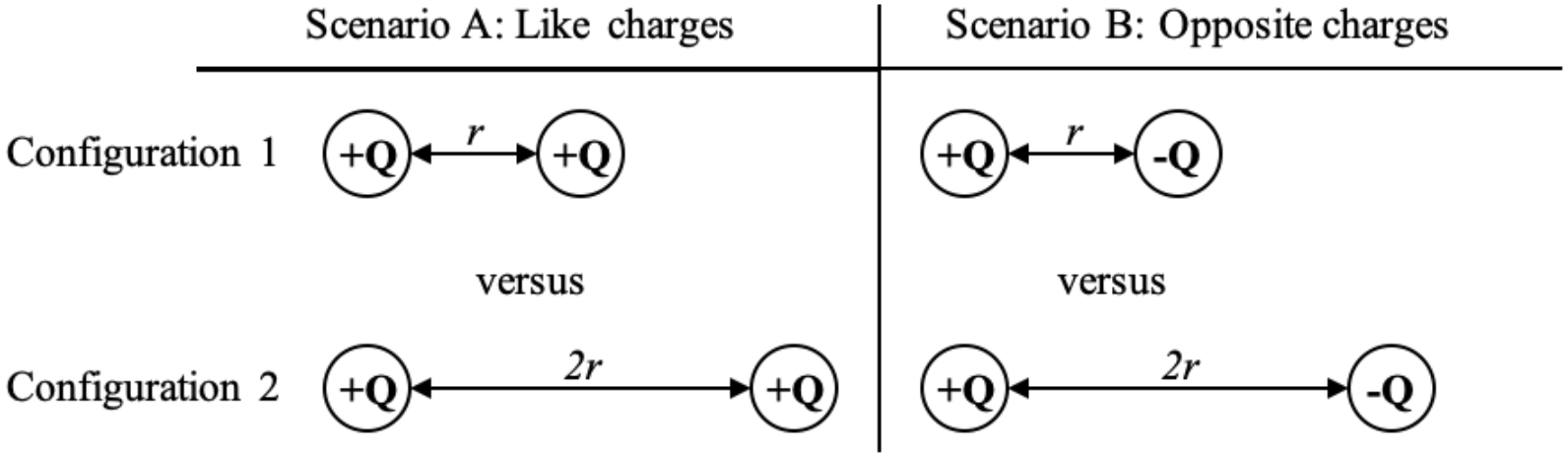
Read but do not do

OALG 17.4.3 https://docs.google.com/document/d/17AIQxw3jq4Z-8NhaC-VNUA6W_Z87G_87/edit

All together

OALG 17.5.1 Represent and reason

In the diagram below, two different configurations of charged objects for two different scenarios are shown. In configuration 2, the two objects are further apart than in configuration 1. Scenario A involves 2 objects carrying the same charge, and scenario B involves 2 objects with opposite charge. If we consider the two charged objects together as a system, which configuration (1 or 2) has more electrical potential energy? Study scenarios A and B separately from each other, i.e., compare configuration 1 to configuration 2 in scenario A, then *separately* compare configuration 1 to configuration. 2 in scenario B. Draw diagrams and energy bar charts as needed and justify your reasoning by using physics you already understand.



Team 1 Observe the following experiments and represent the process with work-energy bar charts

Watch the video
https://youtu.be/2riPqY8-otI

Choose the system to be two Styrofoam balls and the initial state when the balls are at rest apart from each other and and the final state when the pulled ball is moving with some speed toward the stationary ball. Now think if the initial state is when the balls are infinitely far apart and the final when the moving ball is rushing towards the stationary ball.

Team 2 Observe the following experiments and represent the process with work-energy bar charts

Watch the video
https://youtu.be/2riPqY8-otI

Choose the system to be two Styrofoam balls and the initial state when the balls are at rest apart from each other and and the final state when the pulled ball is moving with some speed toward the stationary ball. Now think if the initial state is when the balls are infinitely far apart and the final when the moving ball is rushing towards the stationary ball.

Team 3 Observe the following experiments and represent the process with work-energy bar charts

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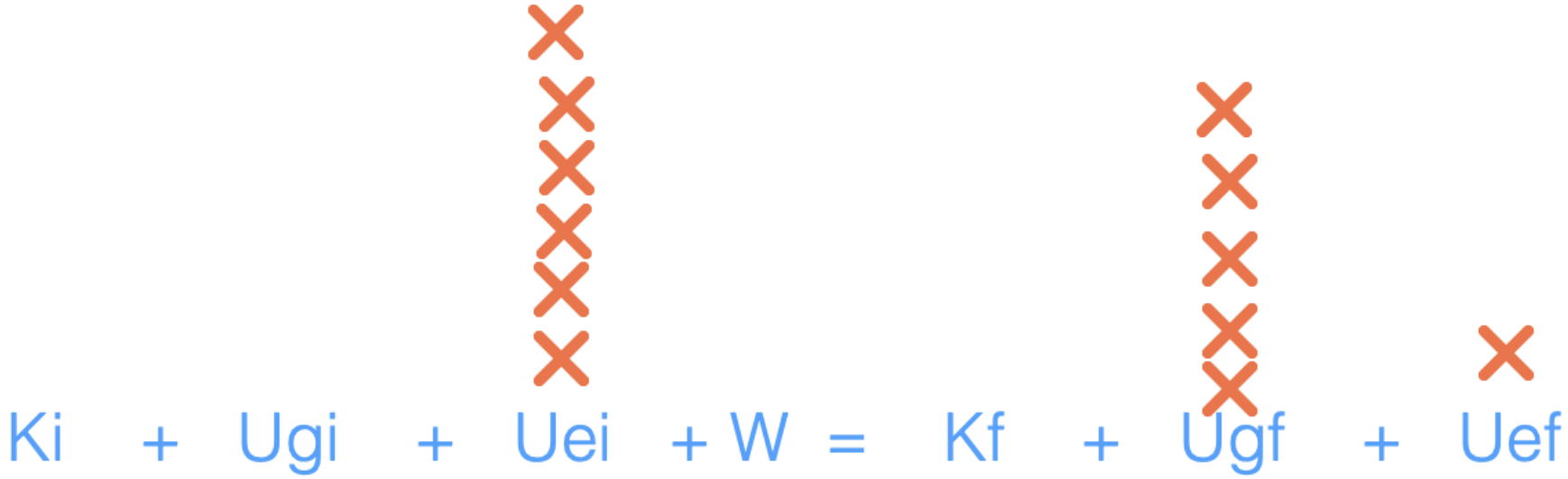
Choose the system to be two Styrofoam balls and the initial state when the balls are at rest apart from each other and and the final state when the pulled ball is moving with some speed toward the stationary ball. Now think if the initial state is when the balls are infinitely far apart and the final when the moving ball is rushing towards the stationary ball.

Team 4 Observe the following experiments and represent the process with work-energy bar charts

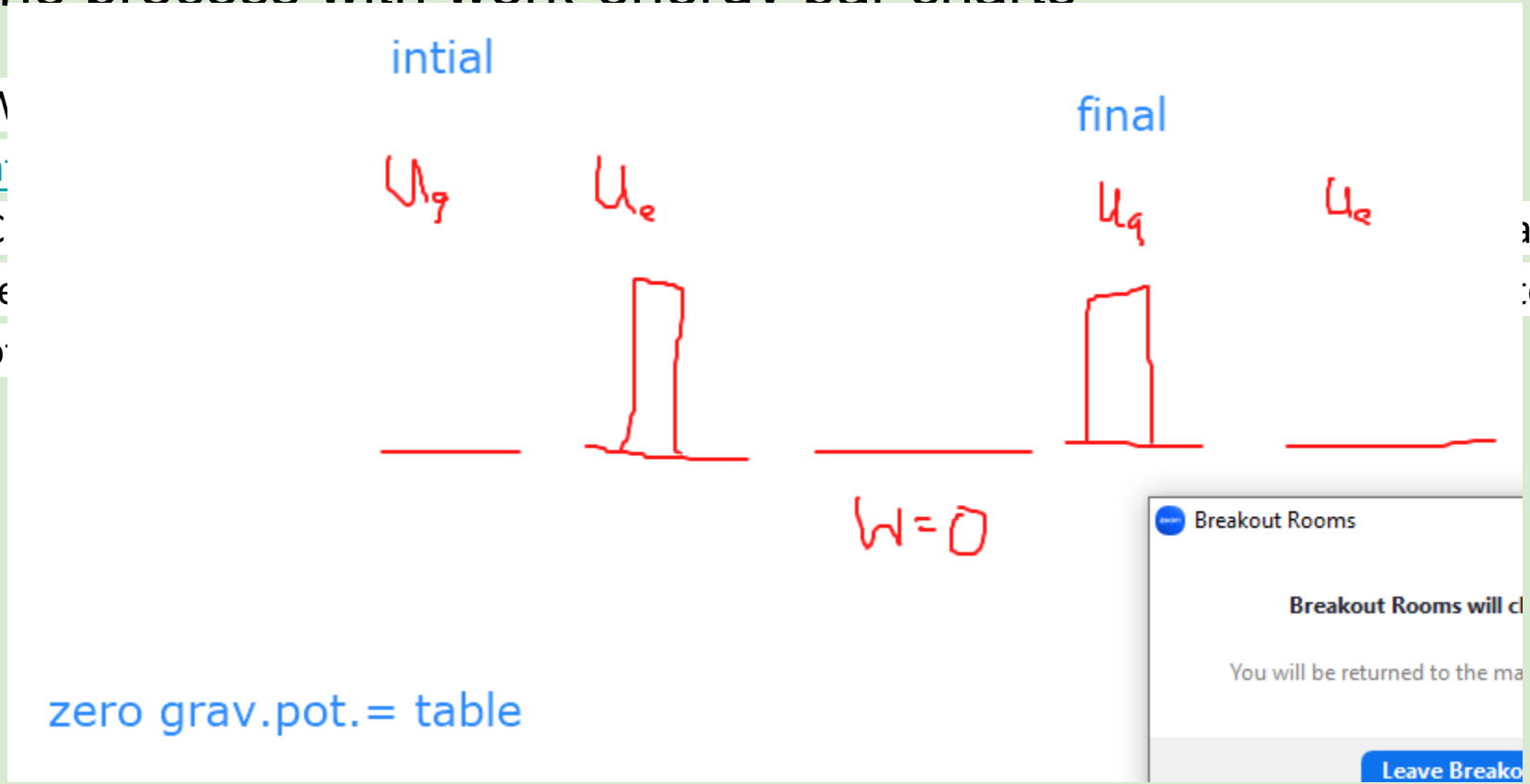
Watch the video
https://youtu.be/2riPqY8-otI

Choose the system to be two Styrofoam balls and the initial state when the balls are at rest apart from each other and and the final state when the pulled ball is moving with some speed toward the stationary ball. Now think if the initial state is when the balls are infinitely far apart and the final when the moving ball is rushing towards the stationary ball.

Team 1 Observe the following experiments and represent the process with work-energy bar charts



Team 2 Observe the following experiments and represent the process with work-energy bar charts

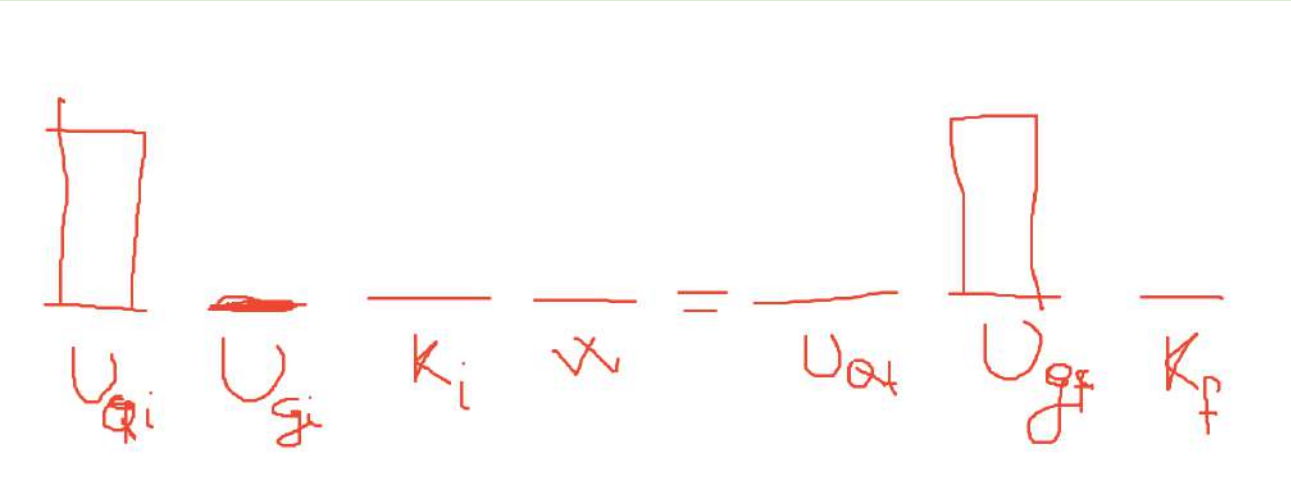


Team 3 Observe the following experiments and represent the process with work-energy bar charts

Watch the video.

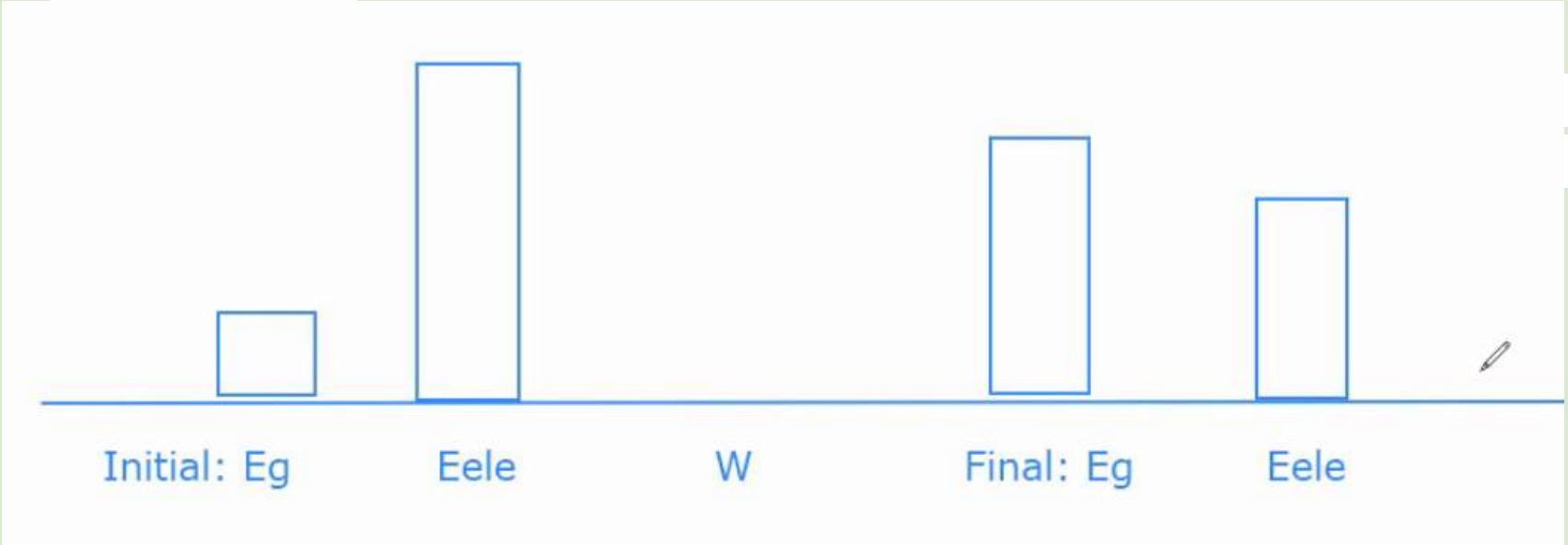
https://www.youtube.com/watch?v=xOKqrZIFx_0

Choose the system to be two Styrofoam balls and the initial state when the balls are at rest next to each other and and the final state when the moving ball is at rest on the top of the incline.



Team 4 Observe the following experiments and represent the process with work-energy bar charts

Watch the video.



at

top

How can we draw *F*-vs-*r* graph for two interacting charge objects and *U*q-vs-*r* graph for two interacting charged objects (consider both cases of like and unlike charges)?

What are the most important things that you will take away from today's workshop?

the bar charts for electrical energy too!

Use of more efficient materials to achieve more consistent outcomes.

and I love that last video that even illustrates that mix of Ug and Ue!!

Working on analogic reason for confuting idea from magnetism to electrostatic phenomena

Explanation of how electric potential energy can be negative

The activities to see how it's about the change of energy not energy itself

Use styrofoam with plastic/fur to get opposite charges reliably.

Using more videos (instead) will save time for students to exercise reasoning and multiple representation skills

Better explain why we consider potential energy zero at infinity

Understanding negative energy of attraction.

The magnet experiment with prediction and results works really well with ISLE approach.

Charging styrofoam balls to roll uphill is an ingenious observational experiment!!