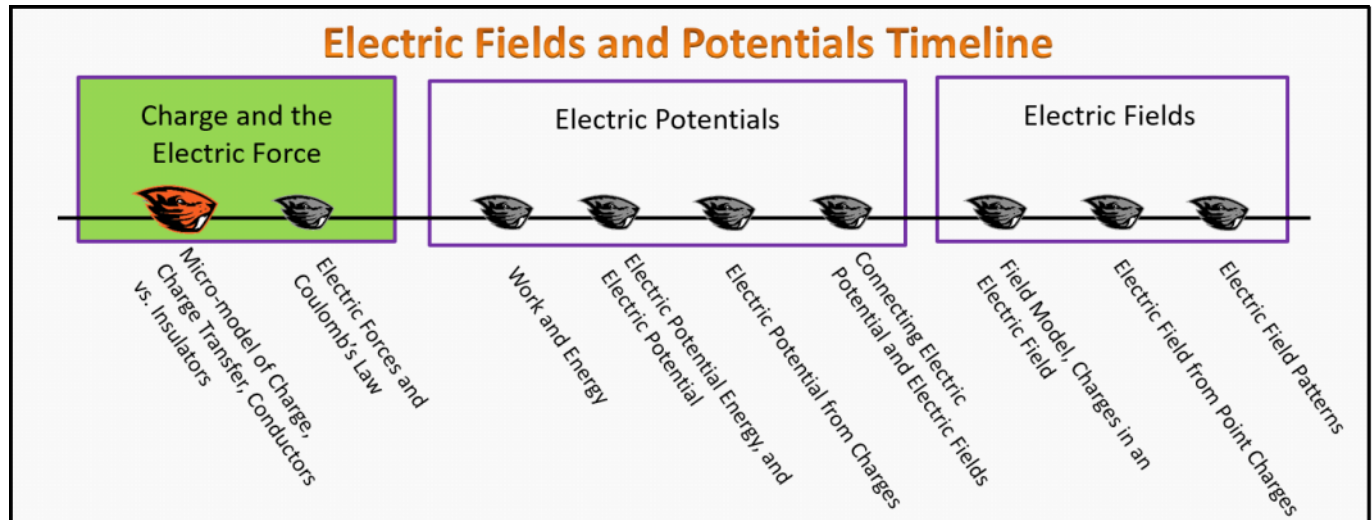


# Charge and the Electric Force

## Foundation Stage (CF.2.L1)

### Lecture 1

#### Micro-model of Charge, Charge Transfer, Conductors vs. Insulators



#### Textbook Chapters (\* Calculus version)

- **BoxSand** :: KC videos ( [Charges and the Electric Force](#) )
- **Knight** (College Physics : A strategic approach 3<sup>rd</sup>) :: 20.1 ; 20.2
- **\*Knight** (Physics for Scientists and Engineers 4<sup>th</sup>) :: 22.1 ; 22.2 ; 22.3
- **Giancoli** (Physics Principles with Applications 7<sup>th</sup>) :: 16-1 ; 16-2 ; 16-3 ; 16-4

#### Warm up

##### CF.2.L1-1:

**Description:** List types of forces.

**Learning Objectives:** [?] - Can you identify the objectives from the previous lecture, and this lecture, that this question is relevant to?

**Problem Statement:** Yell out types of forces that you know of.

## Selected Learning Objectives

1. Coming soon to a lecture template near you.

## Key Terms

- Electric Force
- Charge
- Coulombs
- Fundamental amount of charge
- Electron
- Proton
- Neutron
- Conductor
- Insulator
- Semi-conductor
- Charge transfer
- Charge by contact
- Triboelectric series
- Polarization
- Charge by induction

## Key Equations

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## Key Concepts

- Coming soon to a lecture template near you.

## Questions

# Act I: Charges and Forces

## CF.2.L1-2:

**Description:** Identify forces acting on an object. (3 minutes)

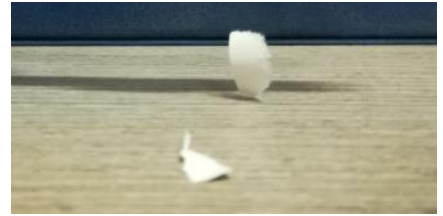
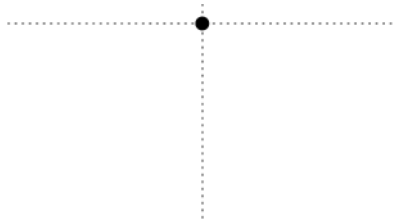
**Learning Objectives:** [?]

**Problem Statement:** A small piece of paper is observed to stand on its end when a plastic rod that was rubbed through hair is brought near it. Identify the forces acting on the paper.

- (1) Gravity
- (2) Normal
- (3) Electric Force
- (4) Magnetic Force



- (5) Buoyant Force
- (6) Tension



### CF.2.L1-3:

**Description:** Conceptual question about functional dependence of electric force. (2 minutes)

**Learning Objectives:** [?]

**Problem Statement:** Which of the following quantities does the electric force depend on?

- (1) Mass
- (2) Volume
- (3) Charge amount
- (4) Charge type
- (5) Distance

**CF.2.L1-4:**

**Description:** Identify dominate forces given a system. (3 minutes )

**Learning Objectives:** [?]

**Problem Statement:** Identify the dominate force in the given system.

**(a)** Which of the following forces dominate the interaction between electrons and protons in an atom or molecule?

- (1) Gravity
- (2) Electric Force
- (3) Magnetic Force
- (4) Tension
- (5) Normal

**(b)** Which of the following forces dominate the interaction between the Earth and the moon?

- (1) Gravity
- (2) Electric Force
- (3) Magnetic Force
- (4) Tension
- (5) Normal

**CF.2.L1-5:**

**Description:** Conceptual question identifying features of charges. (4 minutes)

**Learning Objectives:** [?]

**Problem Statement:** Which of the following are features of charges?



- (1) Charges come in positive, negative, and neutral.
- (2) Like charges repel.
- (3) Unlike charges attract.
- (4) Charges come in discrete quanta.
- (5) There is a fundamental minimum amount of charge.
- (6) Net charge is an integer multiple of the fundamental charge  $e = 1.6 \times 10^{-19}$  Coulombs.
- (7) The net charge of the universe is a constant.

**CF.2.L1-6:**

**Description:** Rank net charge of systems containing electrons and protons. (4 minutes)

**Learning Objectives:** [?]

**Problem Statement:** Rank the systems based on net charge from most negative to most positive.

<b>A</b> 1 Proton 	<b>B</b> 1 Electron 	<b>C</b> 18 Protons 20 Electron	<b>D</b> $1 \times 10^6$ Protons $1 \times 10^6$ Electron	<b>E</b> Glass ball missing 3 electrons
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**CF.2.L1-7:**

**Description:** Calculate number of electrons in a system given net charge. (4 minutes)

**Learning Objectives:** [?]

**Problem Statement:** A system of electrons only is found to have a net charge of  $-33 \mu\text{C}$ . How many electrons are in the system?  
(Hint:  $e = 1.6 \times 10^{-19} \text{ C}$ .)

## Act II: Conductors vs. Insulators

### CF.2.L1-8:

**Description:** Identify conductors and insulators. (3 minutes)

**Learning Objectives:** [?]

**Problem Statement:** Which of the following materials are conductors?

- (1) Silver
- (2) Copper
- (3) Aluminum
- (4) Iron
- (5) Rubber
- (6) Glass
- (7) Wood
- (8) Silicon

### CF.2.L1-9:

**Description:** Conceptual question about features of conductors and insulators. (2 minutes + 2 minutes)

**Learning Objectives:** [?]

**Problem Statement:** Features of common conductors and insulators.

(a) Which of the following are the particles responsible for charge transfer within a material?

- (1) Protons
- (2) Electrons
- (3) Neutrons
- (4) Phonons
- (5) Photons

(b) Match each statement to the material it describes: conductor, insulator, semi-conductor.

- (1) Has no freely moving electrons.
- (2) There are some electrons that are not bound to any given atom.
- (3) With a little added energy, some electrons can become freely moving.

## Act III: Charging by Contact

### CF.2.L1-10:

**Description:** Determine number of charges transferred via contact given change in charge amount. (3 minutes)

**Learning Objectives:** [?]

**Problem Statement:** Material **A** comes in contact with material **B**. It is noticed that the net

charge of material **A** increased by  $25e$ . Which of the following statements are true regarding this situation? Recall that  $e = 1.6 \times 10^{-19} \text{ C}$

- (1) Material **A** gained 25 protons.
- (2) Material **A** lost 25 protons.
- (3) Material **A** gained 25 electrons.
- (4) Material **A** lost 25 electrons.

### CF.2.L1-11:

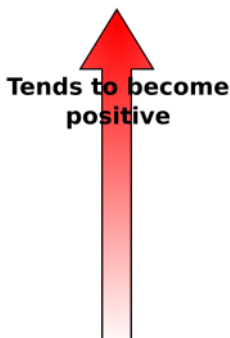
**Description:** Use triboelectric table to determine sign of charge after rubbing two materials together. (2 minutes + 3 minutes)

### Learning Objectives: [?]

**Problem Statement:** When two different materials touch each other (or rubbed against each other) charge is transferred between the two via electrons. A triboelectric table can be used to determine which of the two objects becomes positive (i.e. lose electrons) and which becomes negative (i.e. gains electrons).

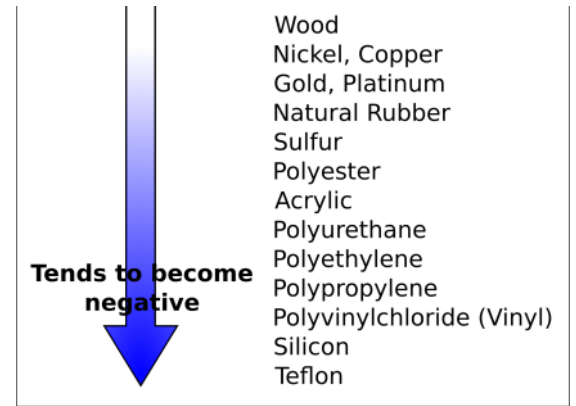
**(a)** Are humans normally net positive, net negative, or net neutral?

- (1) Positive
- (2) Negative
- (3) Neutral

Triboelectric Series	
	Air
	Human Skin
	Glass
	Human Hair
	Nylon
	Wool
	Lead
	Cotton
	Silk
	Aluminum
	Paper
	Steel

**(b)** Polyester is rubbed with vinyl. Which material becomes positive?

- (1) Polyester
- (2) Vinyl
- (3) Neither, they are both negative.



**CF.2.L1-12:**

**Description:** Conceptual question about location of charge after transfer via contact on conductors vs insulators. (3 minutes + 2 minutes)

**Learning Objectives:** [?]

**Problem Statement:** Electro fires an electron cannon at Groot and the Silver Surfer. The electron beam hits both Groot and the Silver Surfer on their right shoulders.

**(a)** Circle the region where the excess electrons from the cannon reside on Groot shortly after the cannon hit him



(b) Circle the region where the excess electrons from the cannon reside on the Silver Surfer shortly after the cannon hit him.



## Act IV: Polarization and Induction

### CF.2.L1-13:

**Description:** Conceptual question about polarization. (3 minutes)

**Learning Objectives:** [?]

**Problem Statement:** Below are physical representations of conductors and insulators. Which of the following systems are polarized?

<p><b>A</b></p>	<p><b>B</b></p>
<p><b>C</b></p>	<p><b>D</b></p>

**CF.2.L1-14:**

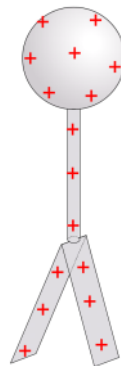
**Description:** Conceptual question about polarization. (4 minutes)

**Learning Objectives:** [?]

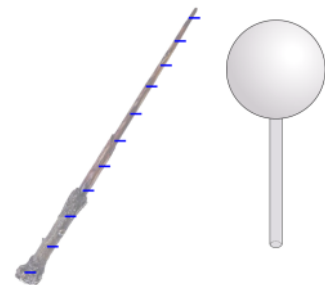
**Problem Statement:** An electroscope is positively charged by touching it with a positive metal rod. The electroscope leaves spread apart and the metal rod is removed. Then a negatively charged plastic rod is brought close to the top of the electroscope, but it doesn't touch. What happens to the thin leaves?

- (1) The leaves get closer together.
- (2) The leaves spread further apart.
- (3) The leaves don't move.
- (4) One leaf moves higher, the other lower.

Initial State



Final State



**CF.2.L1-15:**

**Description:** Conceptual question about polarization and insulators. (3 minutes)

**Learning Objectives:** [?]

**Problem Statement:** A rod is charged, but whether or not it is net negative or positive is unknown. When the rod is brought close to a neutral metal can, what do you expect to observe?

- (1) Nothing.
- (2) Can moves away from rod.
- (3) Can moved towards rod.
- (4) Can spontaneously combusts.
- (5) Need to know if rod is positive or negative to predict observation.

**CF.2.L1-16:**

**Description:** Conceptual question about polarization and conductors. (3 minutes)

**Learning Objectives:** [?]

**Problem Statement:** A rod is charged, but whether or not it is net negative or positive is unknown. When the rod is brought close to a neutral 2x4 piece of dry wood, what do you

expect to observe?

- (1) Nothing.
- (2) Wood moves away from rod.
- (3) Wood moved towards rod.
- (4) Wood spontaneously combusts.
- (5) Need to know if rod is positive or negative to predict observation.

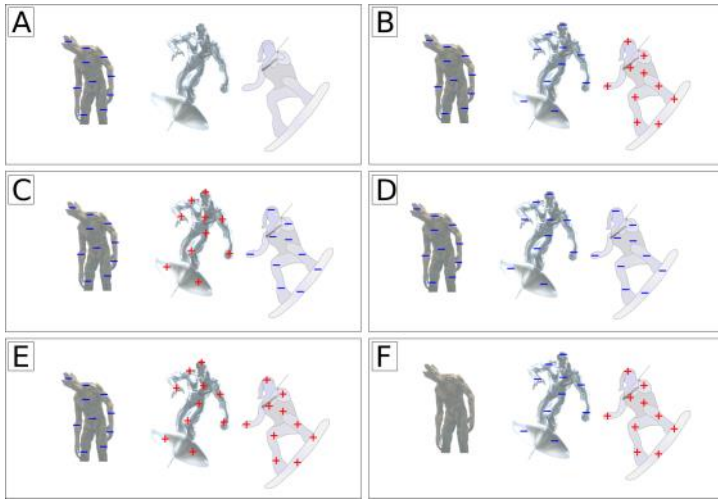
### CF.2.L1-17:

**Description:** Conceptual question about charging by induction. (3 minutes + 2 minutes)

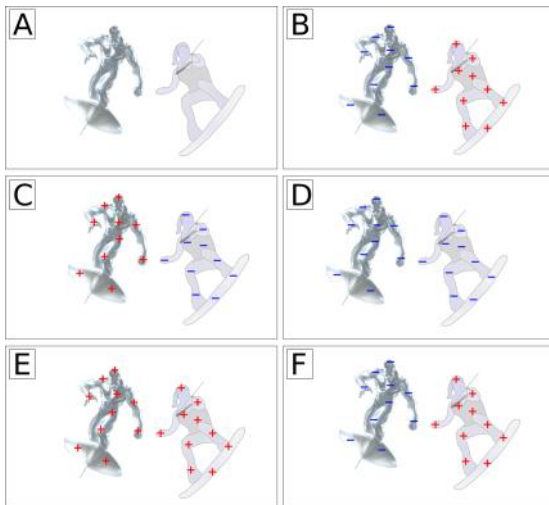
**Learning Objectives:** [?]

**Problem Statement:** The Silver Surfer and his girlfriend the Tungsten Wakeboarder are holding hands and are both net neutral. After battling Electro, Groot is net negative and walks towards the couple holding hands but does not touch them.

**(a)** Which of the following physical representations best describes this system if the couple stops holding hands while Groot is nearby?



**(b)** Which of the following physical representations best describes this system if Groot first walks away from the couple, then they stop holding hands?



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## Conceptual questions for discussion

1. **Coming soon to a lecture template near you.**
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## Hints

**CF.2.L1-1:** No hints.

**CF.2.L1-2:** No hints.

**CF.2.L1-3:** No hints.

**CF.2.L1-4:** No hints.

**CF.2.L1-5:** No hints.

**CF.2.L1-6:** No hints.

**CF.2.L1-7:** No hints.

**CF.2.L1-8:** No hints.

**CF.2.L1-9:** No hints.

**CF.2.L1-10:** No hints.

**CF.2.L1-11:** No hints.

**CF.2.L1-12:** No hints.

**CF.2.L1-13:** No hints.

**CF.2.L1-14:** No hints.

**CF.2.L1-15:** No hints.

**CF.2.L1-16:** No hints.

**CF.2.L1-17:** No hints.