

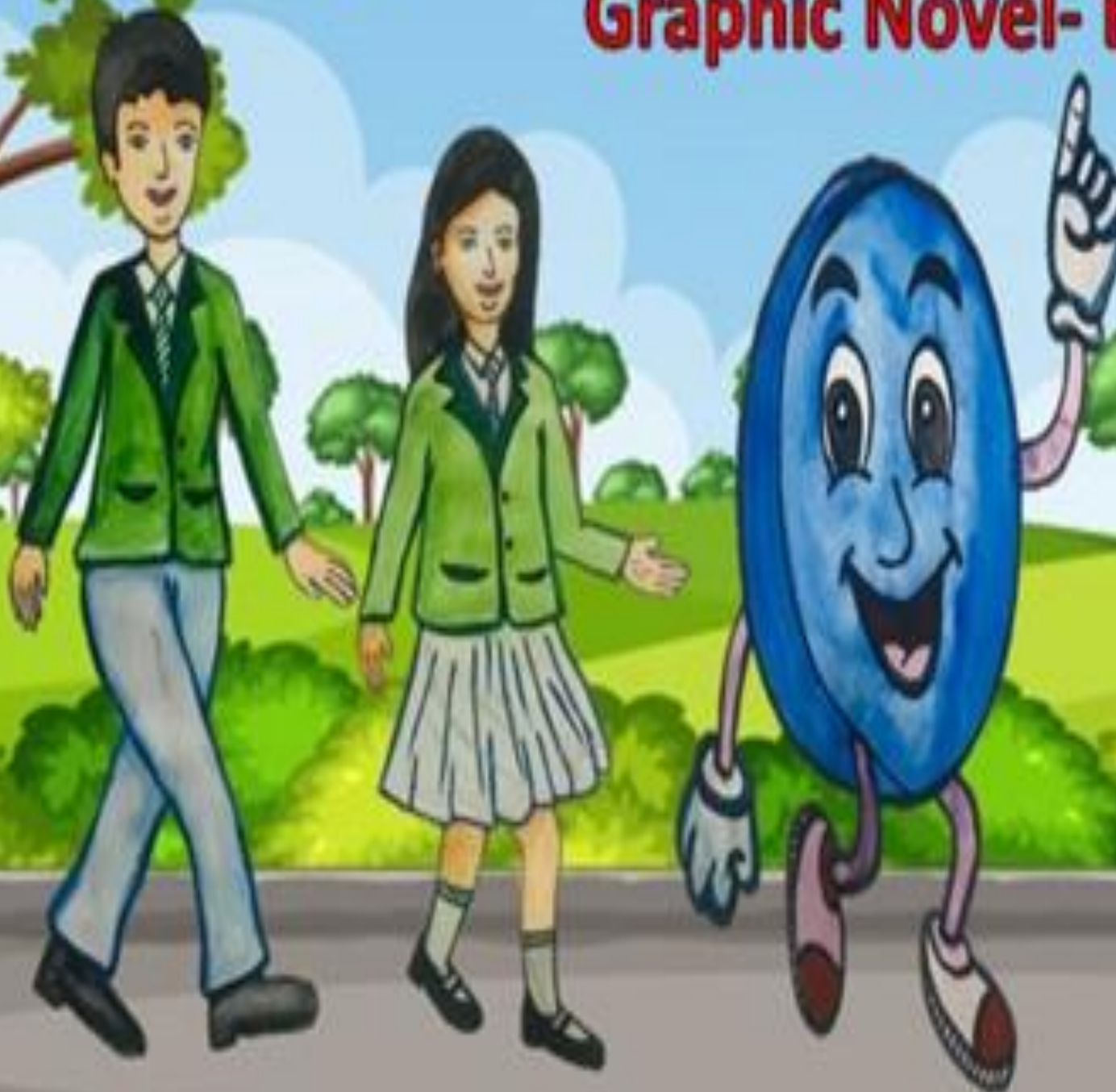


DELHI PUBLIC SCHOOL, SAHIBABAD

Affiliated to CBSE

PRESENTS

Graphic Novel- ELECTRICITY



CLASS-10
SUBJECT-PHYSICS
CHAPTER NAME-ELECTRICITY

PREFACE

This graphic novel, a novel step in 21st century, skills and engage learners in exploratory and learner – friendly way in true sense. It explains the basic concepts of Electricity in the way of graphics in such a clear, stimulating and comprehensive manner. The content in the book give the detailed study of Charges, Electric Current, Electric Circuits, Ohm's law, Resistivity, Potential Difference, Heating effect of current, Power, in the way of wonderful graphics and dialogues. The concepts are explained by imagining a city of electrons where the activity of electrons constitute the electricity.



To access the comic book and additional interactive digital content, download DIKSHA app from Google Play store on your Android smartphone or tablet



FROM THE DIRECTOR PRINCIPAL'S DESK

Innovation is crucial to the continuing success of any organization. Covid has brought in numerous innovations and opportunities this year . The entire education community has reinvented itself . Technology has connected the stakeholders across the world at all levels and has affected the educational practices . Graphic Novel uses Story telling as an innovative pedagogy which is a step towards meta cognition and meta learning. The pedagogy encourages the student led , art and technology integrated learning in a joyful manner building competencies amongst the students. My deep appreciation for Mr. Sandeep Sethi (Director Education, M.S.M.S.II, Museum Trust) for bringing the teachers together. My talented and innovative team of teachers of DPS Sahibabad have created this wonderful creative tool of learning and am extremely proud of them .

Dr Jyoti Gupta
Director Principal
DPS Sahibabad

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LEARNING OUTCOMES CHAPTER - ELECTRICITY

Class -10

Content Area/Concepts	Learning Objectives
Electric current & circuit	Evaluate the charge flowing through a conductor in a given time, in order to calculate current flowing through it.
Electric Potential and Potential Difference	Determine work done in moving a charge across two points, in order to calculate potential difference between two points.
Circuit Diagram	Identify the electrical components and their functions in order to build a functioning circuit.
Ohm's Law	Plot a graph between voltage and current in order to prove ohm's law & find resistance.
Factors on which resistance depends	Define resistivity and its range for different materials, in order to classify substances as conductors, alloys and insulators.
Resistance of a system of resistors	Determine the resultant resistance in a series and a parallel combination, in order to identify the suitable combinations like house etc.
Heating effect of electric	Explain and calculate the heating effect of electric

STORYLINE: THE PLOT

The story revolves around three lead characters, i.e. Tarun, Sonali and Huron (electron)

Tarun and Sonali are Grade-10 students who are curious to know about scientific facts, their objectives, and outcomes.

One day, Sonali and Tarun drink a chemical (smelling like a tasty drink) prepared by their chemistry teacher, and due to which their size shrinks and they become smaller than insects.

- To save their life from insects they reached an adjacent physics lab where they climbed a hanging wire. They became small like electrons and fell inside the wire.

STORY BOARD

Electric current & circuit

Electric Potential and Potential Difference

Circuit Diagram

Ohm's Law

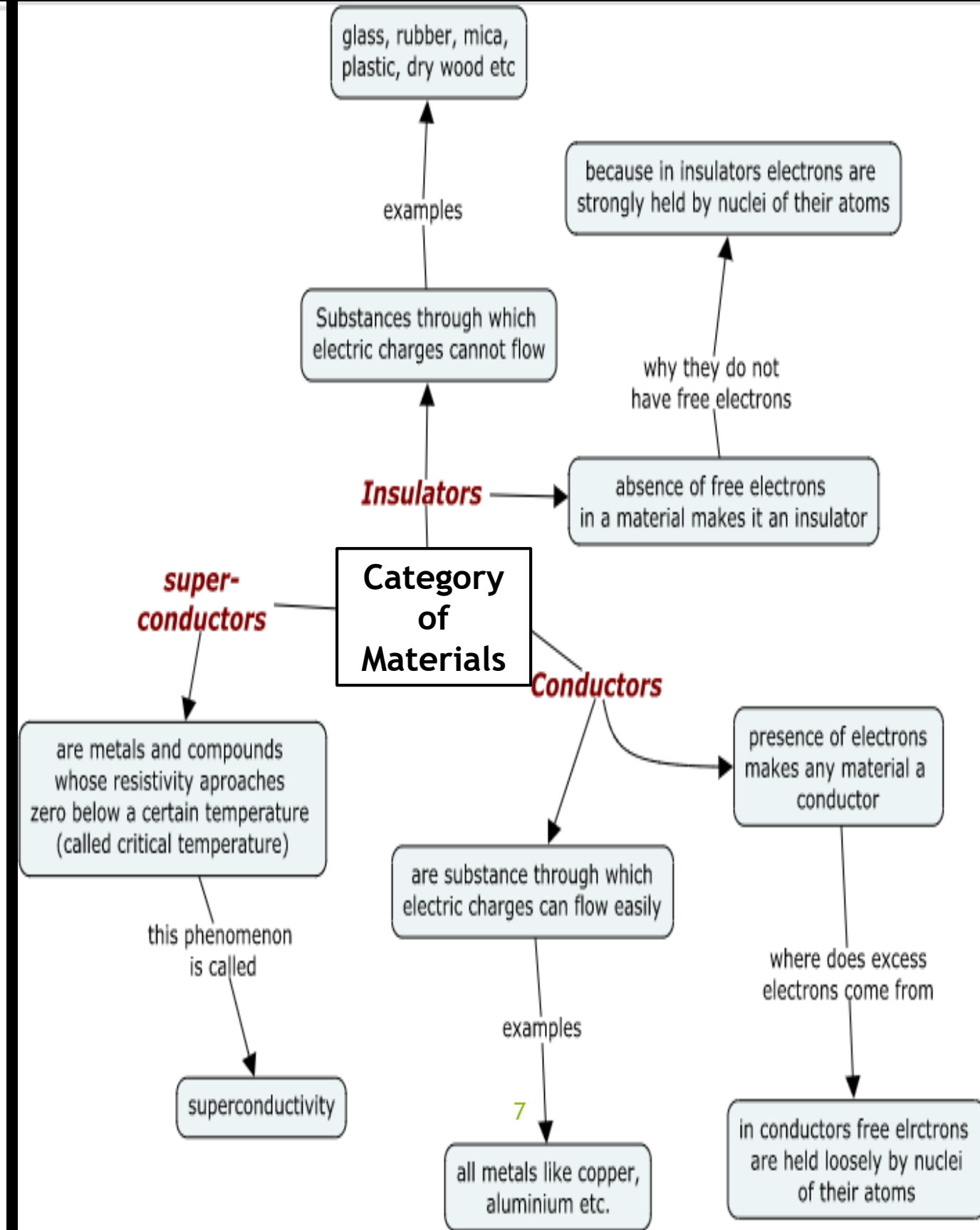
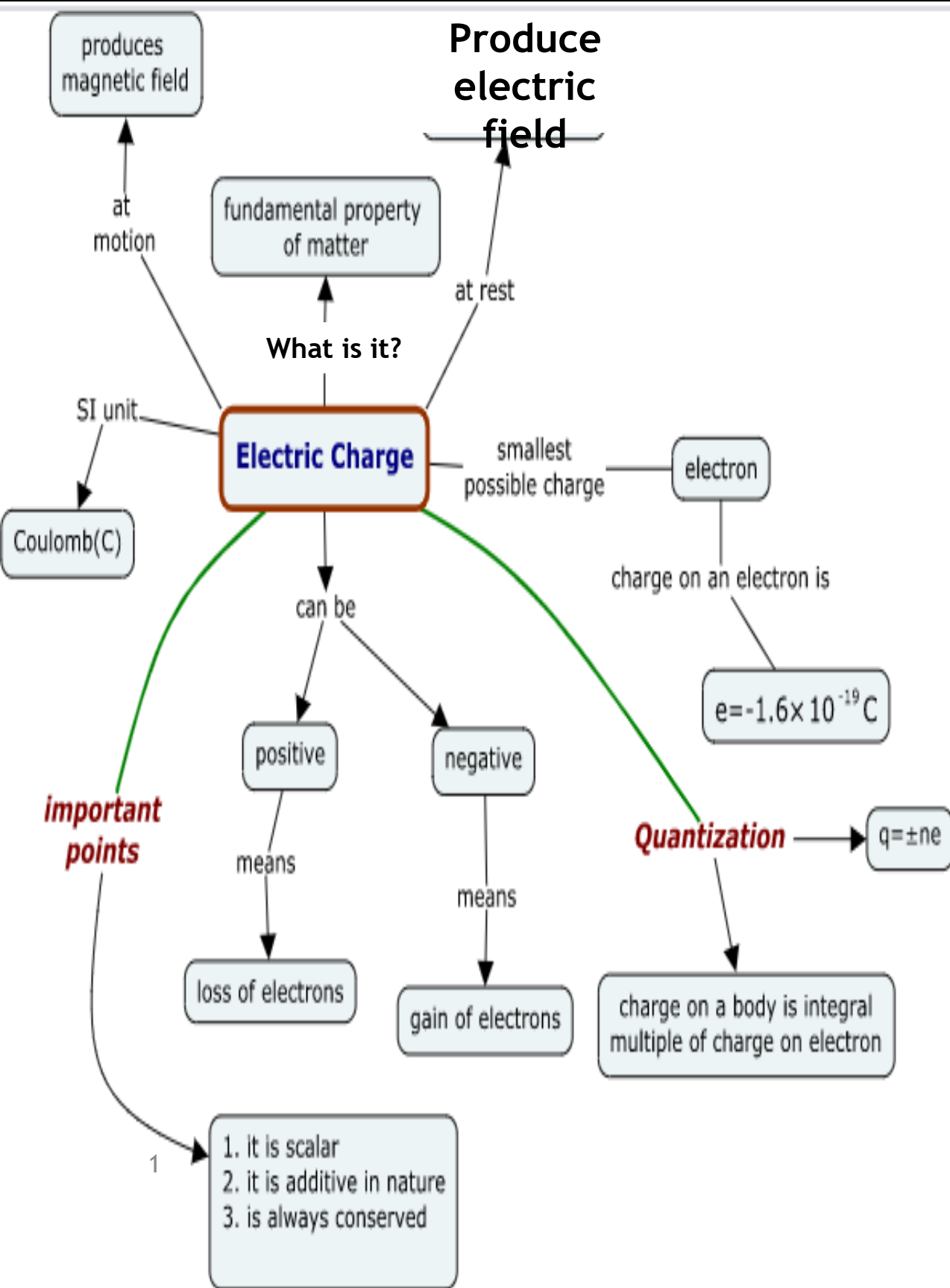
Factors on which resistance depends

Resistance of a system of resistors

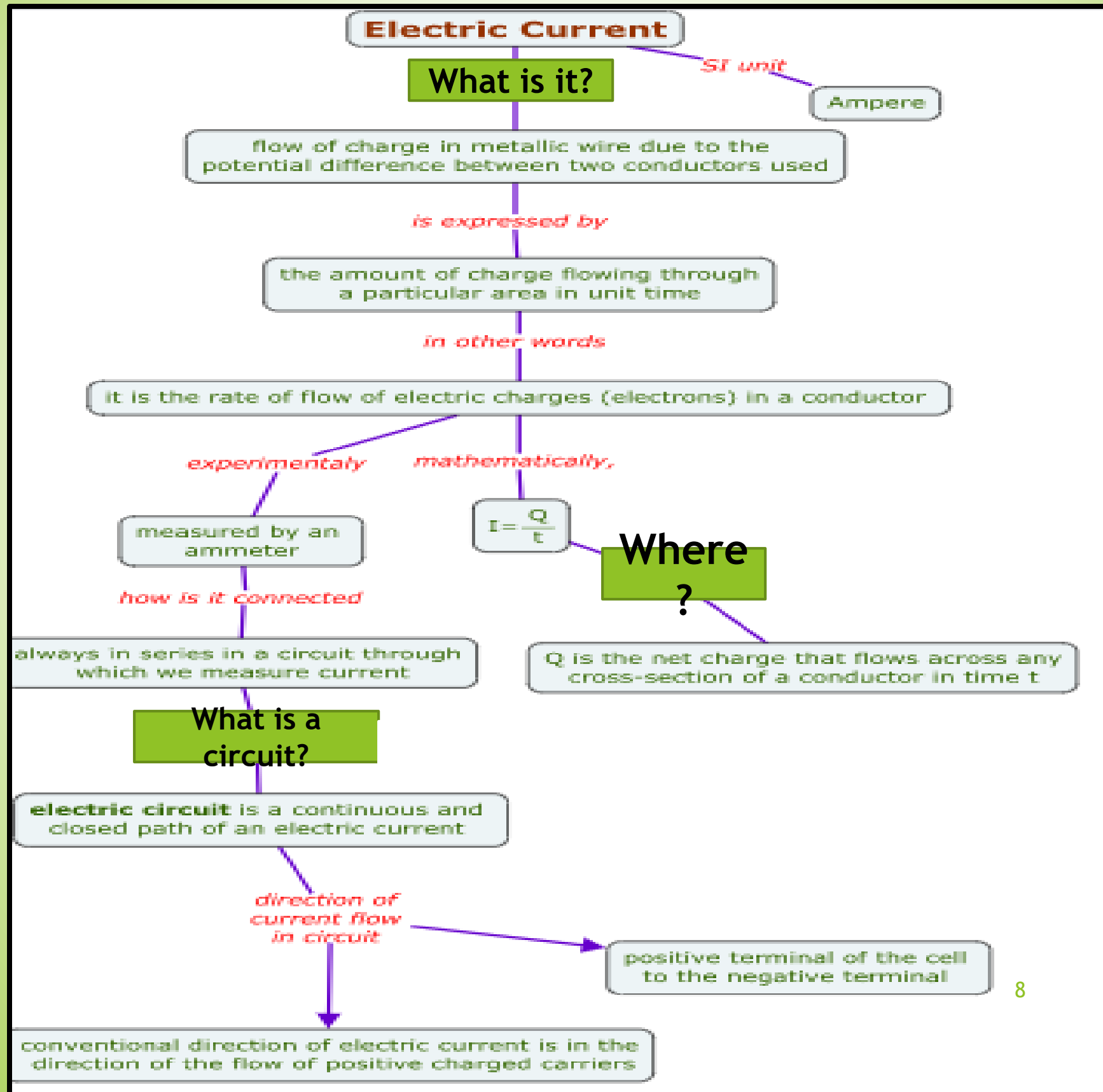
Heating effect of electric current

Power

MIND MAP



MIND MAP



CHARACTERS

Huron:

He is the main character of the story. He was discovered by J.J. Thomson. Huron is an electron which is a negatively charged particle found in the atoms of all the elements.



Sonali (Student):

She is a Grade-10 student who is very questioning and curious child.



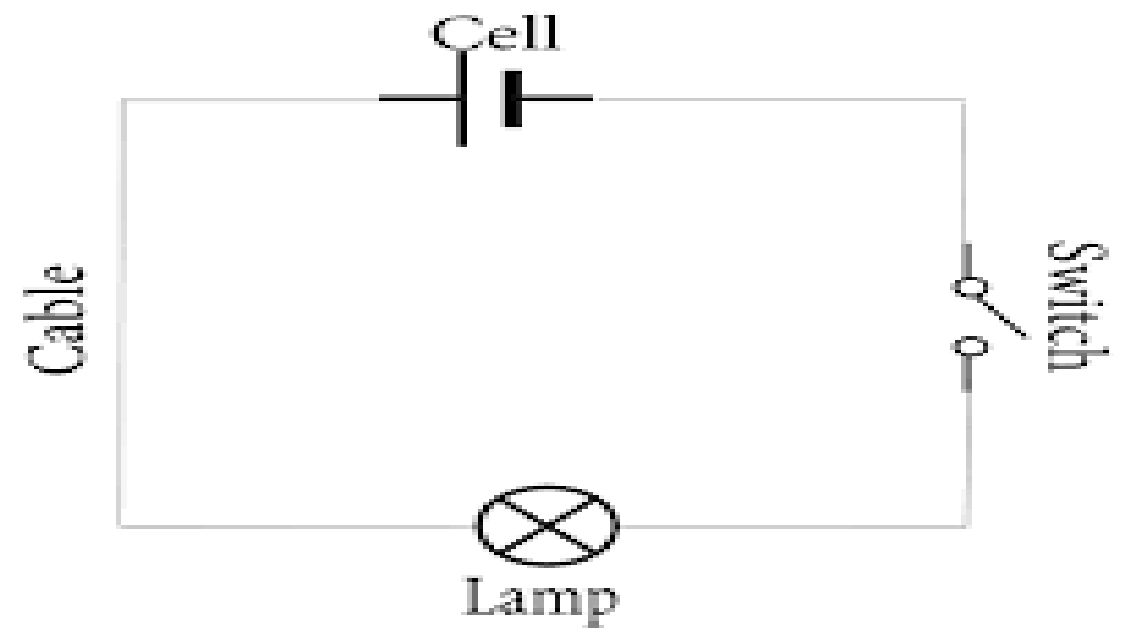
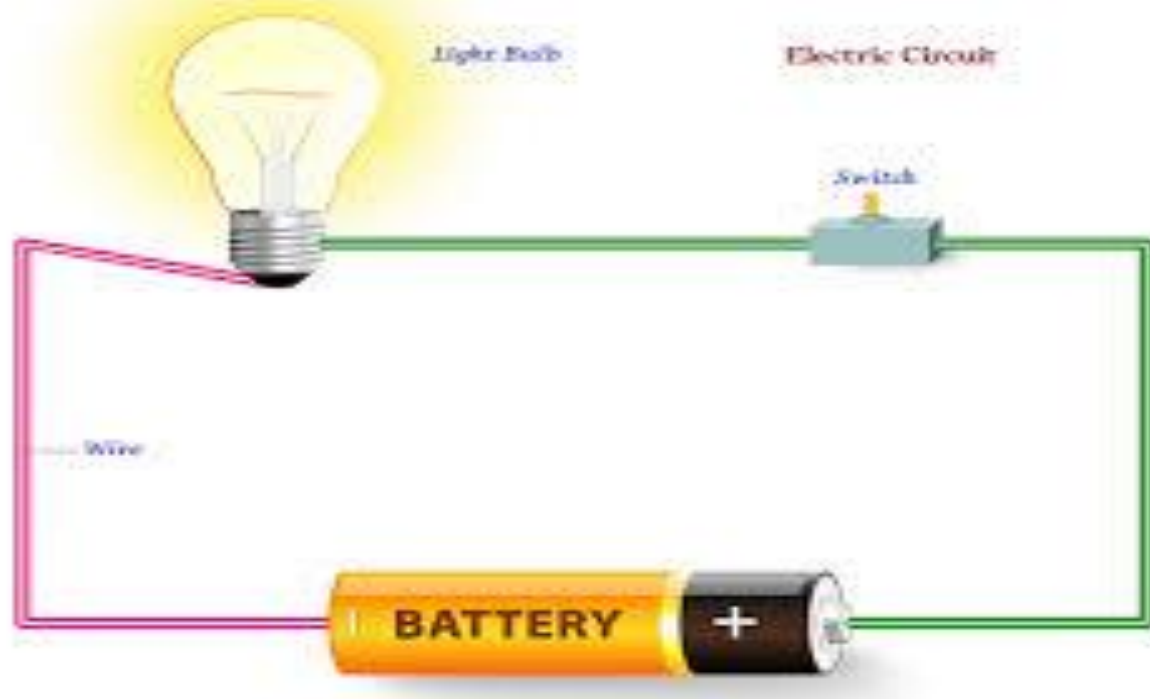
Tarun (Student):

He is a Grade-10 student who loves to explore the scientific facts.



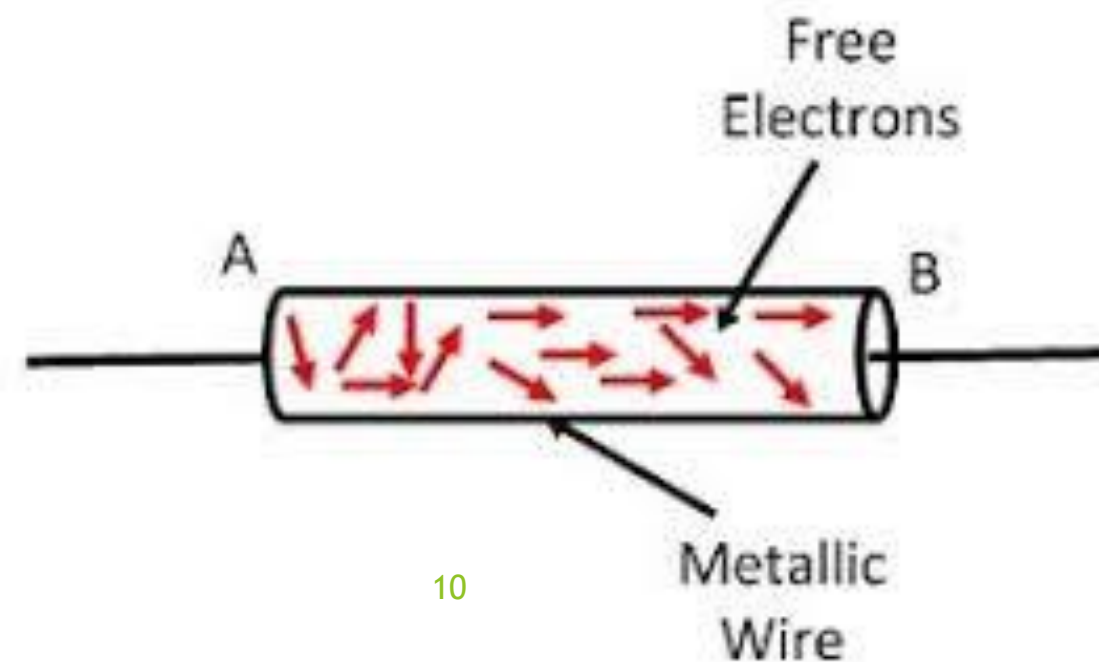
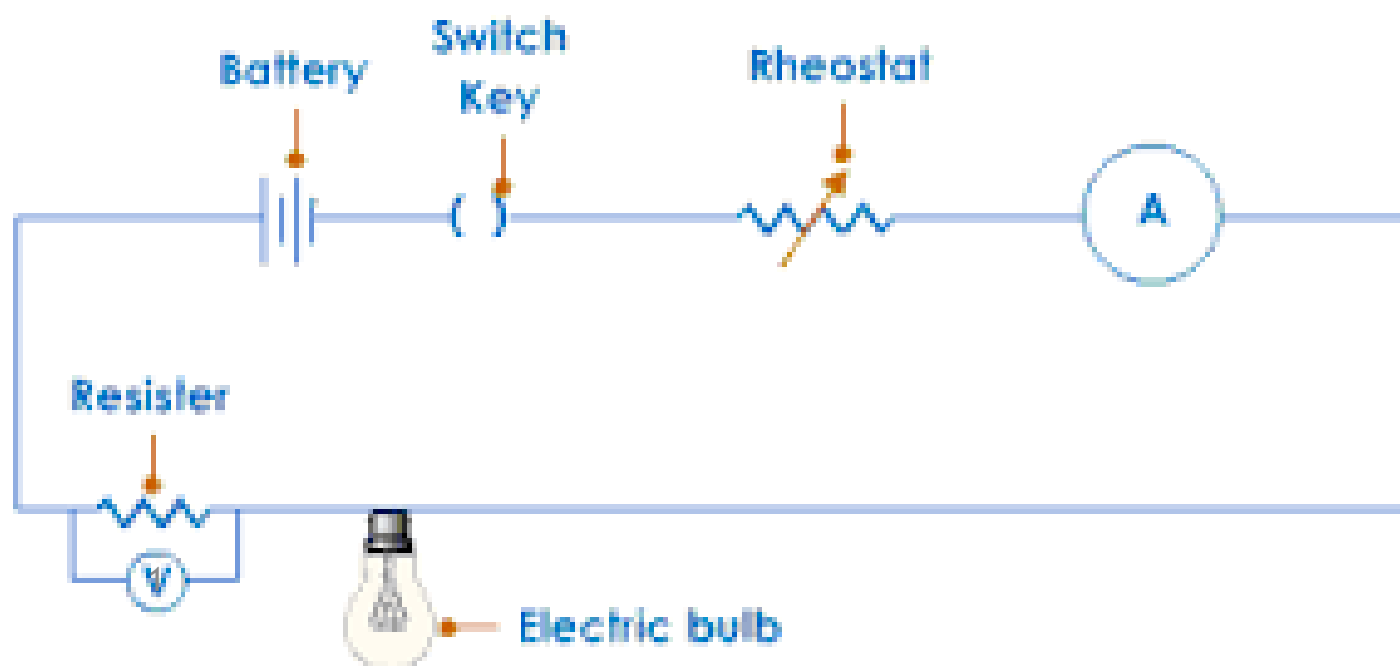
Mrs. Sarita Tiwari (Chemistry Teacher):

Mrs. Sarita Tiwari is Ph.D.(Chemistry).She is enthusiastic and committed Chemistry teacher.



CHAPTER -1

ELECTRIC CURRENT AND CIRCUIT



It was a bright sunny day. Both the students are holding files in their hands

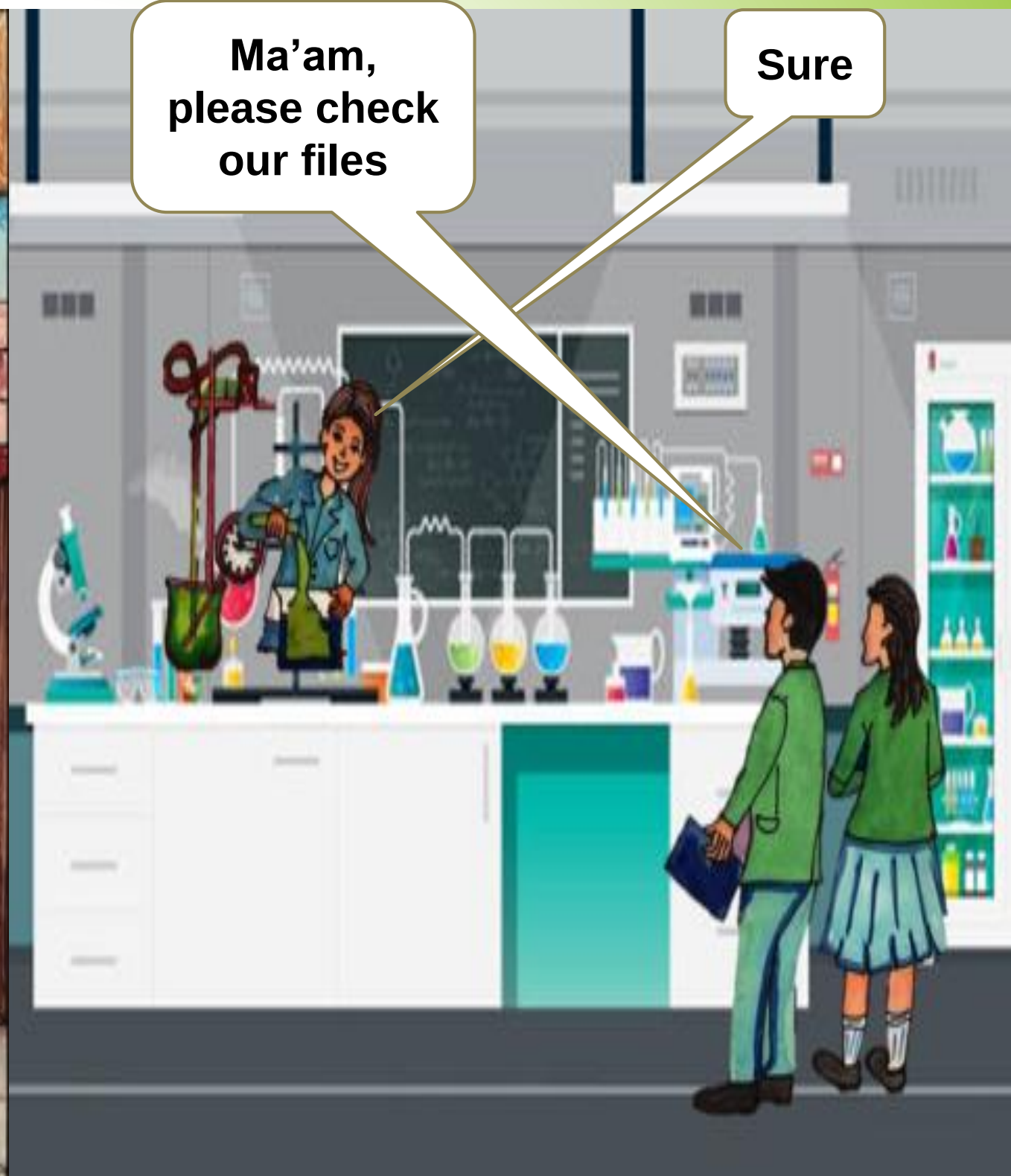
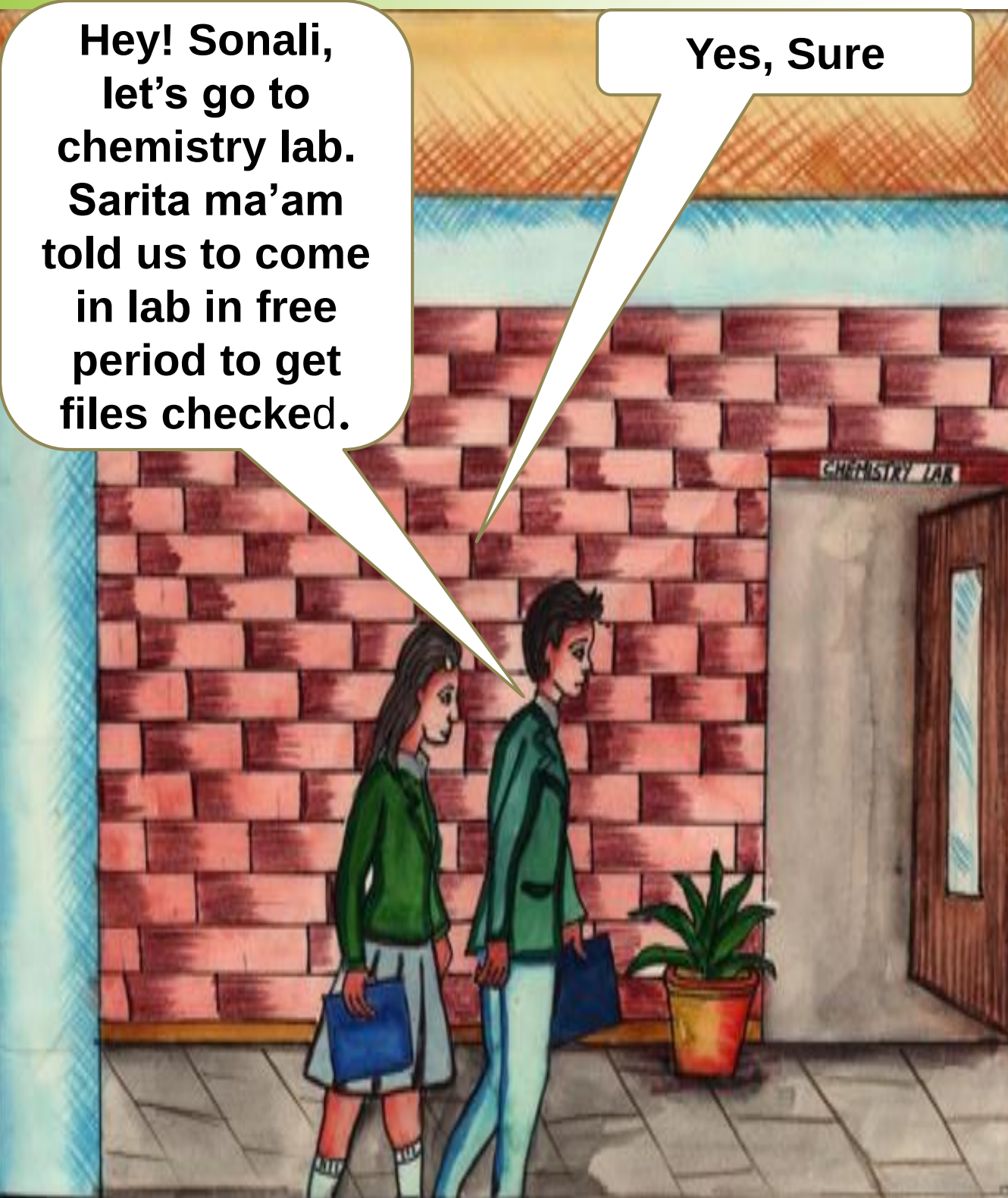
Hey! Sonali, let's go to chemistry lab. Sarita ma'am told us to come in lab in free period to get files checked.

Yes, Sure

Sarita ma'am is mixing two chemicals while answering

Ma'am, please check our files

Sure



Ma'am got a call and had to go out of the lab for some work.

**Yes...Yes..please
wait, I am
coming.**



**Students wait, I am returning in
a few minutes, do not touch
anything in lab the lab.**



Both drink the chemical and become so small that small insect seems like giant

Yup! Sonali see this.... Ma'am is making a tasty drink here! Let's taste it.

Wow! Tarun, Some pleasant smell is coming.

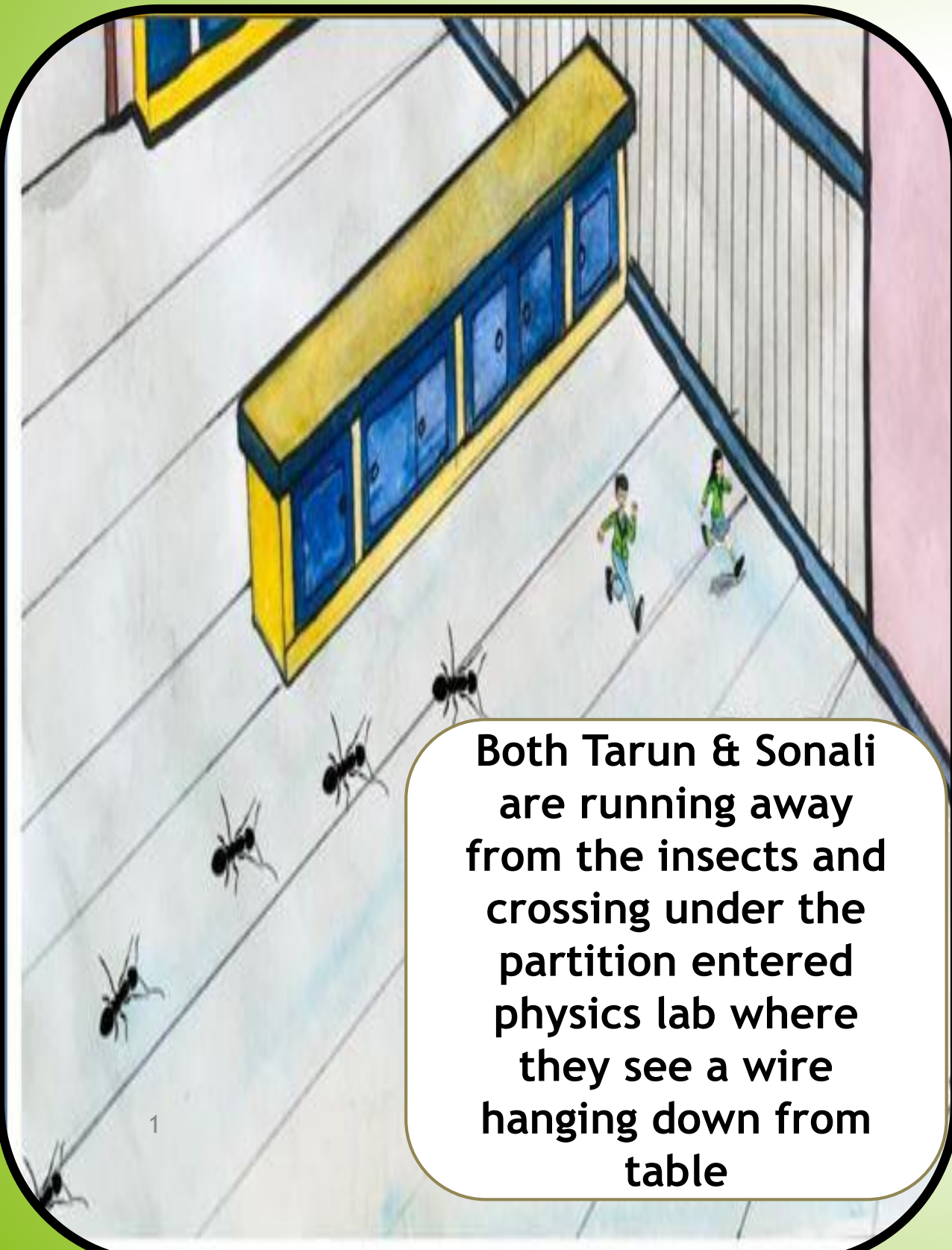


Oh my God! We are shrinking.

OMG! an insect is coming towards us



They both run towards the wire, Tarun is climbing the wire.

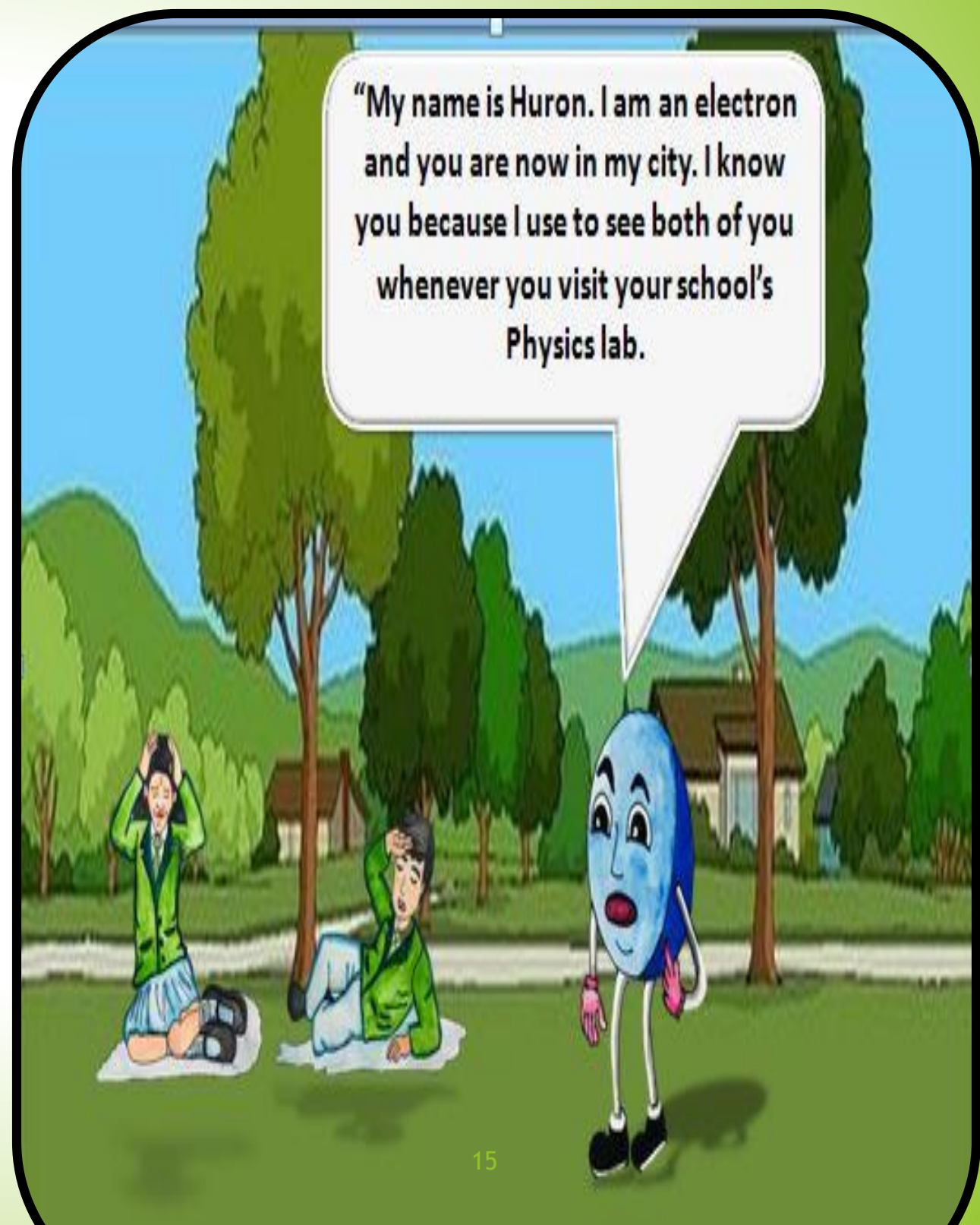


Here we are assuming that Huron is aware of the human world. As Tarun & Sonali use to visit the labs frequently so Huron knows them well.



"Yes! You are right,
But who are you?
Where are we? How
do you know so much
about us? Are we
dead?"

Hello! Tarun and Sonali.
..Wake up. Are you okay?
How did you come here?
I guess you might drink
something from the
chemistry lab. Did you?



"My name is Huron. I am an electron
and you are now in my city. I know
you because I use to see both of you
whenever you visit your school's
Physics lab."

A cartoon illustration of a blue, bean-shaped character with a face, arms, and legs, representing an electron. It is standing on a grassy lawn in a park-like setting with trees and a house in the background. The character is wearing pink gloves and shoes. It is talking to a young man and a young woman who are standing and listening. The man is wearing a green jacket and light blue pants, and the woman is wearing a green jacket and a blue skirt. There are three speech bubbles in this panel.

Forsooth! Huron, we are eager to see your city. I am fascinated that we are going to learn electricity from electron itself.

Wow! It is fascinating.

Not to worry! You are just shrunk and will regain your original size in some time. Let me show you my city and will tell you how our activities constitute a current.

A cartoon illustration of the same blue electron character running towards the young man and young woman. The character is now much larger, indicating it has grown back to its original size. It is still wearing the same pink gloves and shoes. The background is the same park setting. There is one speech bubble in this panel.

Ok...Come with me. Do you know I have a charge of $e=1.6 \times 10^{-19}$ Coulomb and my counterpart proton also has the same charge 1.6×10^{-19} Coulomb.

The difference is that I (Electron) am negative, and Proton is positive. Electrons move in the inter atomic space inside the conductor. Protons don't move at all as they are strongly bound in the nucleus.

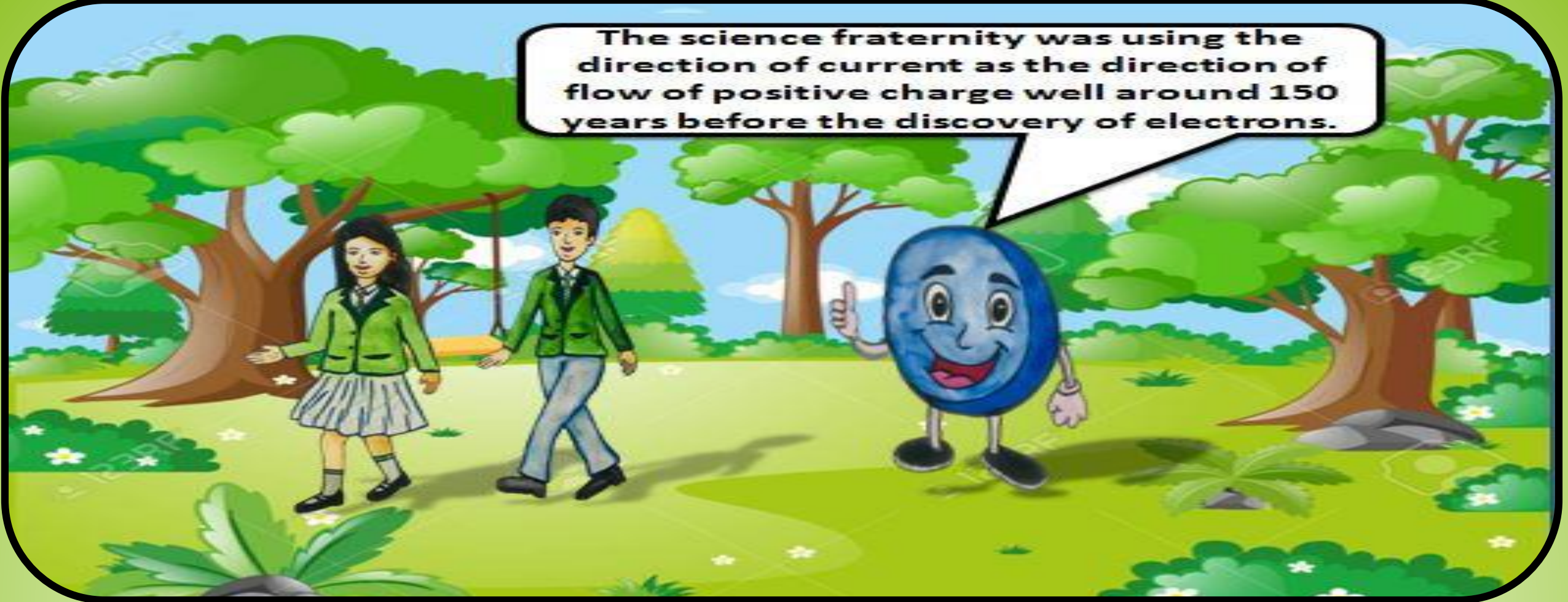


But Akhilesh Sir told us that the direction of current is in the direction of flow of positive charge. And you are saying that protons don't move at all. I am confused, Huron.

Don't get tangled Sonali. The flow of negative charge in one direction is equivalent to the flow of positive charge in opposite direction.

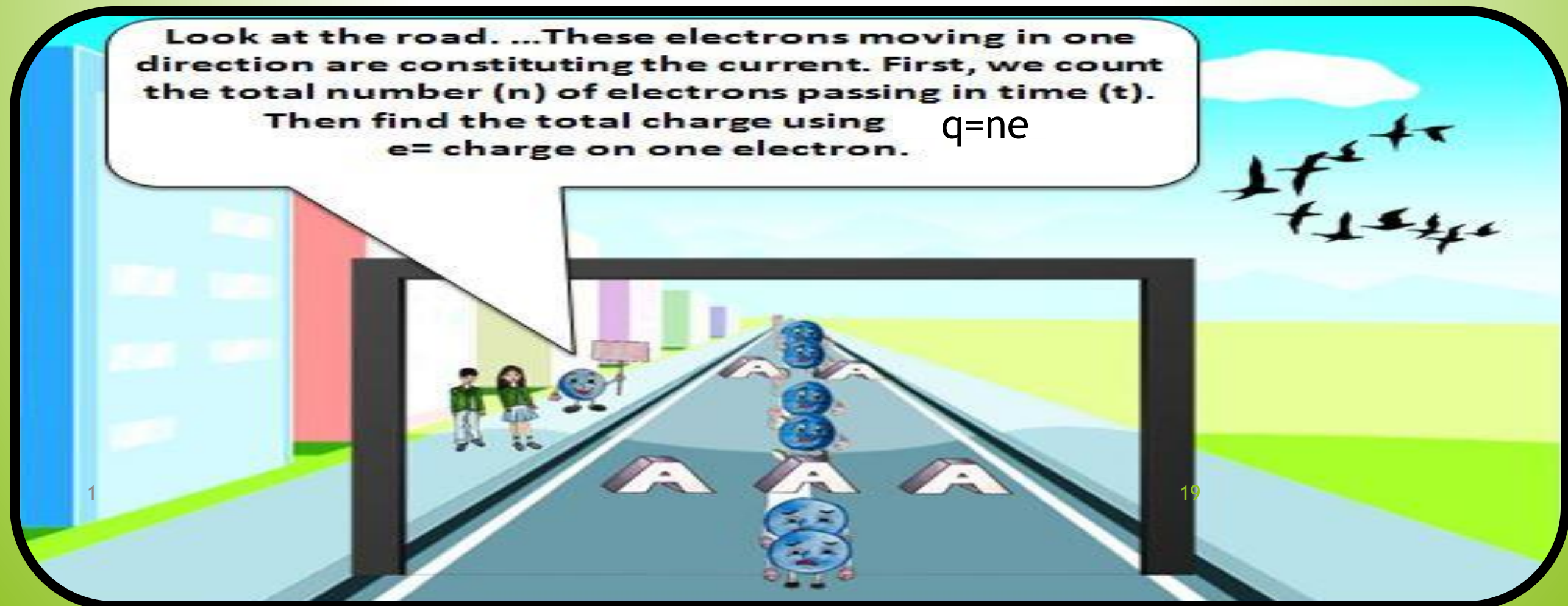


The science fraternity was using the direction of current as the direction of flow of positive charge well around 150 years before the discovery of electrons.



Hence the convention of opposite direction was adopted in spite of changing thousands of books.



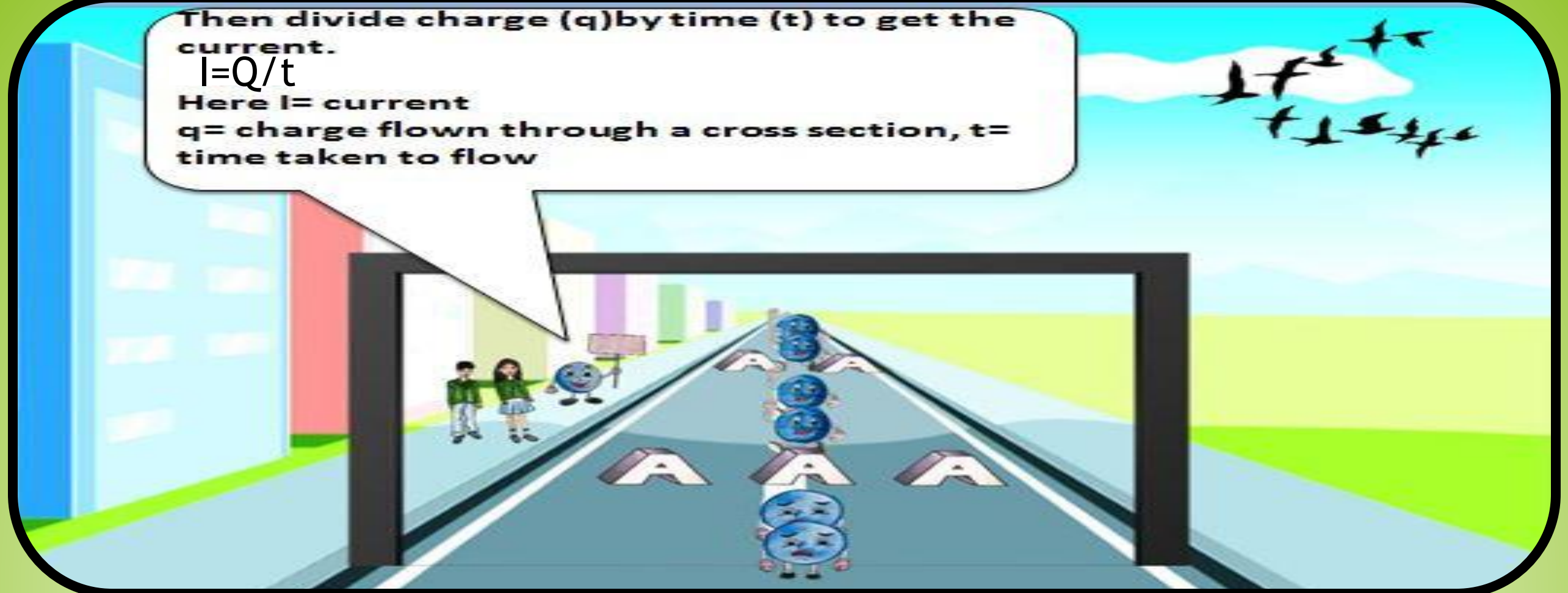


Then divide charge (q) by time (t) to get the current.

$$I = Q/t$$

Here I = current

q = charge flown through a cross section, t = time taken to flow



Huron, I know the unit of current is Ampere, right?

It is coulomb per second also!

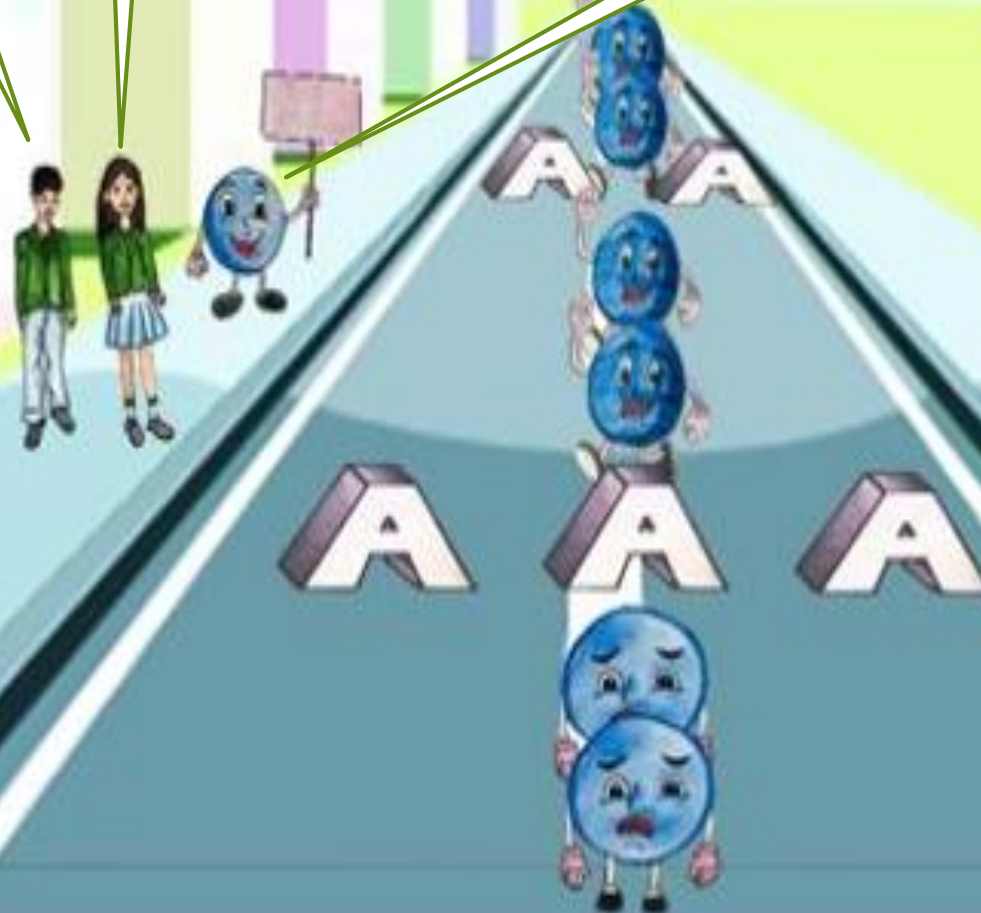
Well done! You both are absolutely right.



Huron, I know
the unit of
current is
Ampere, right?

It is
coulomb
per
second
also!

“Well done! You
both are
absolutely
right.”

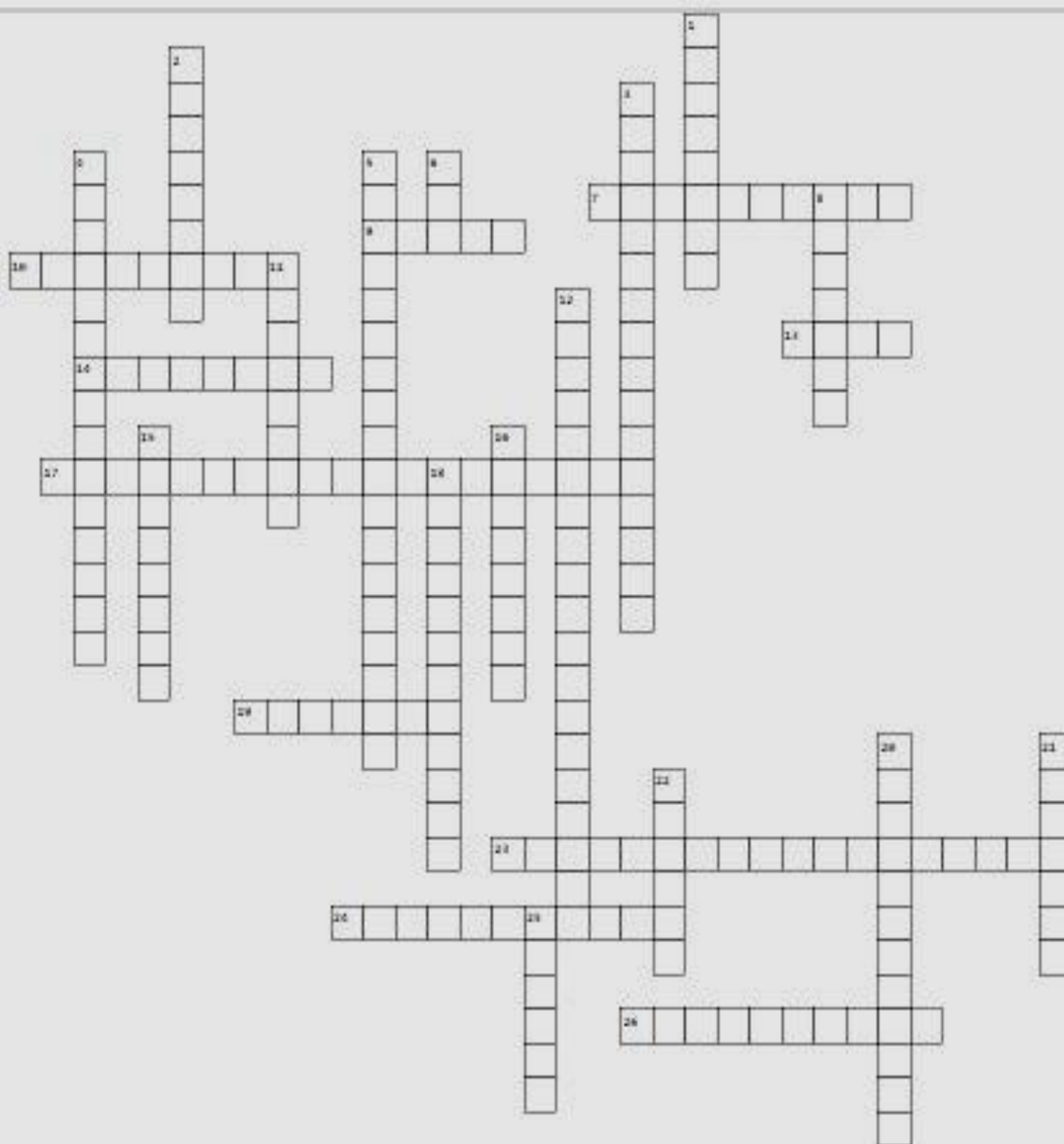


Questionnaire

- 1. What does an electric circuit mean?**
- 2. Define the unit of current.**
- 3. Calculate the number of electrons constituting one coulomb of charge.**
- 4. A current of 0.5 A is drawn by a filament of an electric bulb for 10 minutes. Find the amount of electric charge that flows through the circuit.**

UNSCRAMBLE

- RURTNEC**
- TUICRIC**
- IREW**
- TISHCW**



Across

- 7. _____ energy changed to heat and light energy in the filament bulb
- 9. conductor that obeys Ohm's Law is called _____ conductor
- 10. instrument used to measure potential difference
- 13. SI unit of potential difference and emf
- 14. flow from negative terminal of the battery to the positive terminal
- 17. work done per unit charge across a component
- 19. rate of flow of charge
- 23. work done per unit charge around a complete circuit by a source
- 24. Ohm's Law states that current is directly proportional to the potential difference provided that _____ is constant
- 26. ratio of potential difference to the current in the conductor

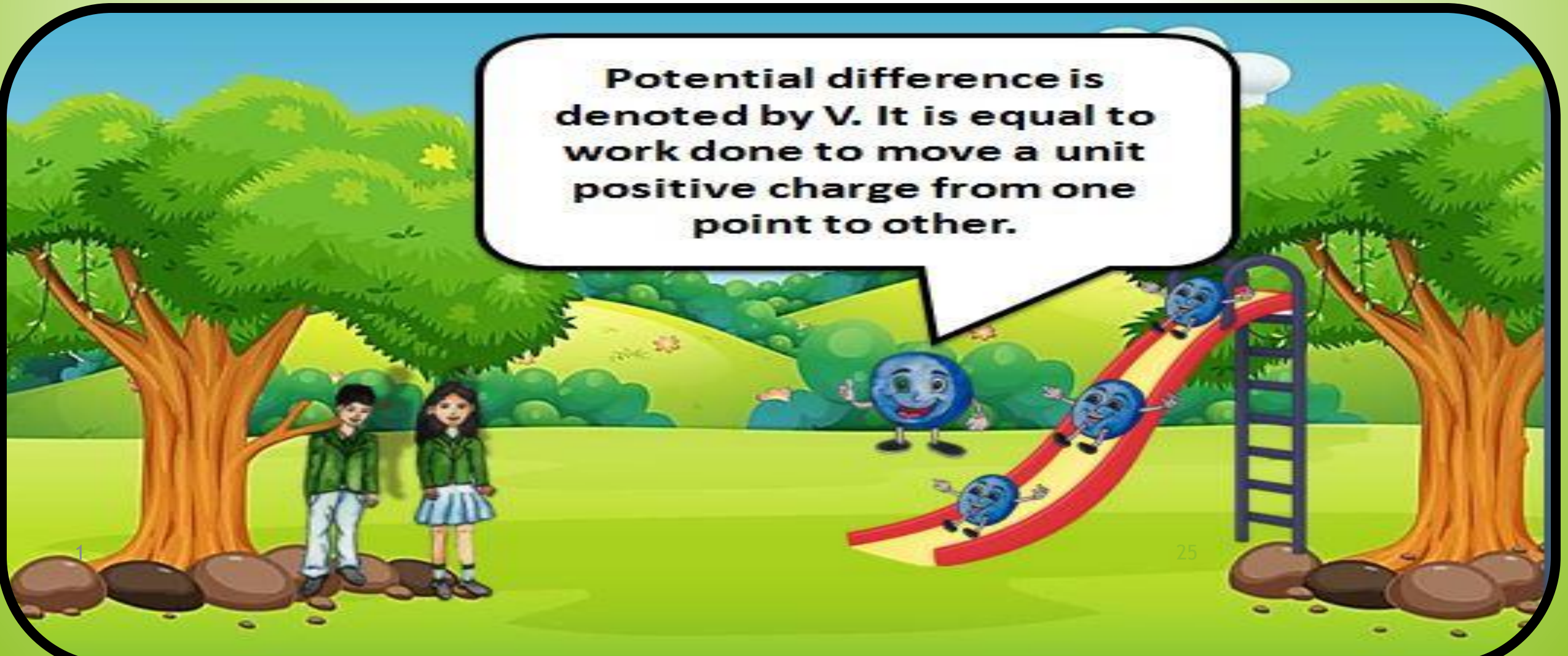
Down

- 1. in the battery _____ energy converted to electrical energy when circuit is closed
- 2. voltmeter is connected _____ to the component
- 3. ampere also can be expressed as _____
- 4. volt also can be expressed as _____
- 5. another factor that affect the resistance in a wire other than length, temperature and material of the wire
- 6. unit of resistance
- 8. SI unit of charge
- 11. a variable resistor
- 12. flow from positive terminal of the battery to the negative terminal
- 15. component in the circuit that reduces the flow of charge
- 16. resistance can be found from the _____ of V-I graph
- 18. a component that does not obey Ohm's law
- 20. coulomb also can be expressed as _____

CHAPTER 2

Potential Difference

Potential difference is denoted by V . It is equal to work done to move a unit positive charge from one point to other.



POTENTIAL DIFFERENCE : Potential difference is denoted by V . It is equal to work done to move a unit positive charge from one point to other.



Potential
difference (V)
between two
points

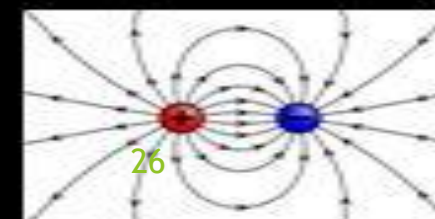
=

Work
done (W)
Charge (Q)

The SI unit of electric potential difference is
volt (V)



(W)



(Q)

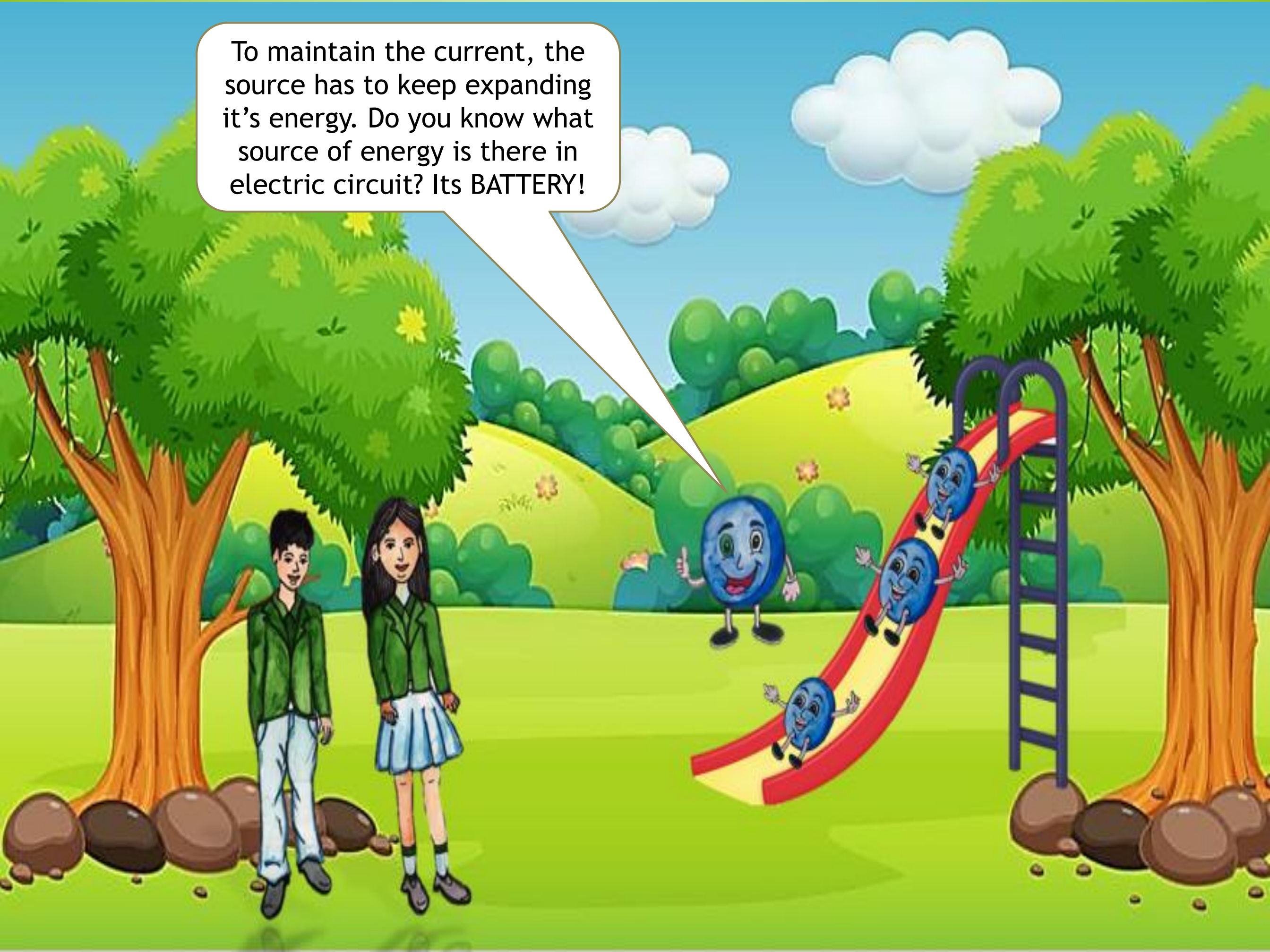
OK

Look at these particles and consider them as positive charge because definition of Potential difference is given by +ve charge only.

As you can see that due to the difference of height these kids are coming from top to bottom. Similarly, the positive charge move from high potential (denoted by '+') to low potential (denoted by '-'), hence constitute current.



To maintain the current, the source has to keep expanding its energy. Do you know what source of energy is there in electric circuit? Its BATTERY!



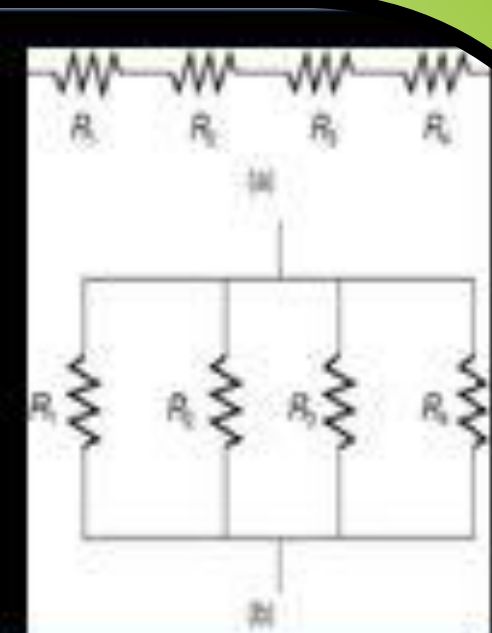
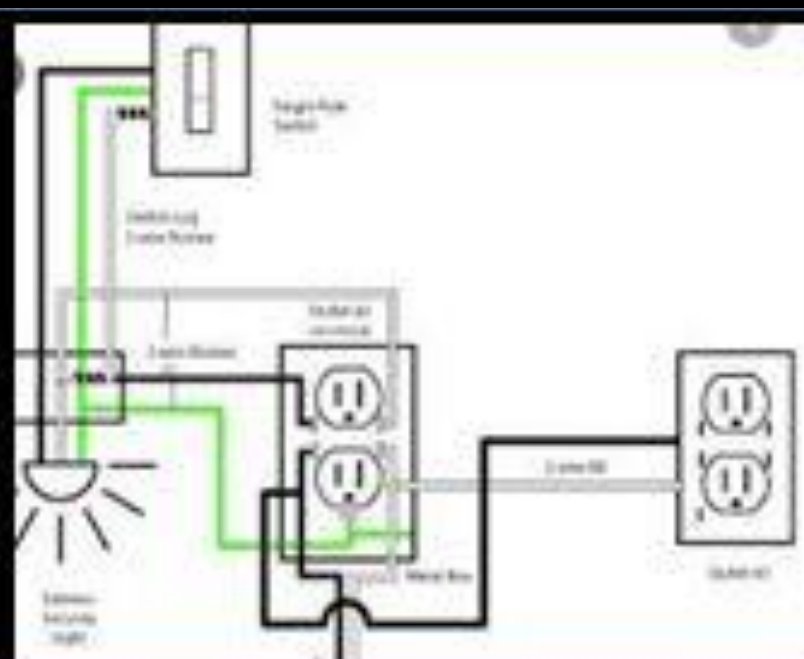
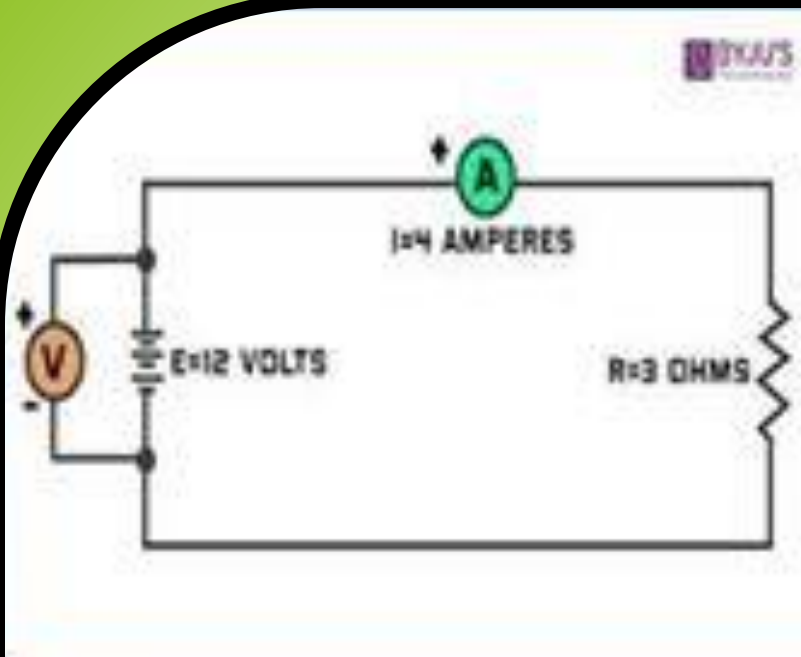
Questionnaire

a. Fill in the blanks

1. $\text{JOULE} = \text{VOLT} \times \dots\dots\dots$
2. The amount of work done to move a unit charge from one point to other is called $\dots\dots\dots$ between two points.
3. $\dots\dots\dots$ is the unit of potential difference.
4. In formula $V = W/Q$, W is work done, Q is charge and V is $\dots\dots\dots$

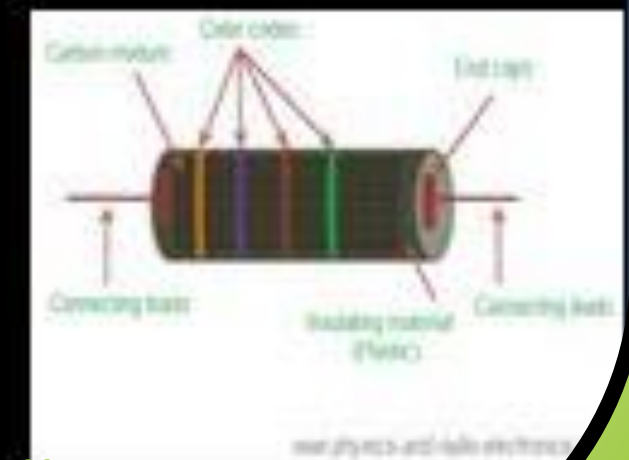
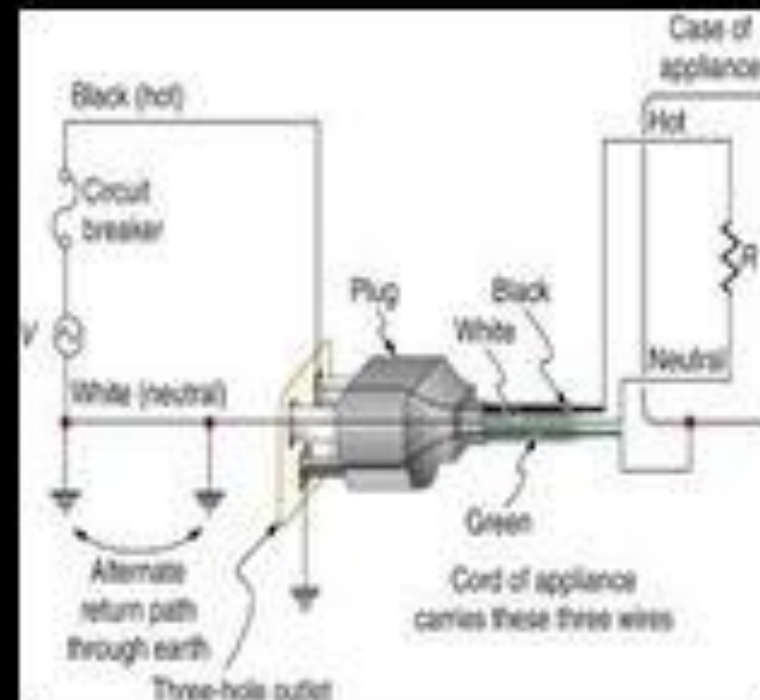
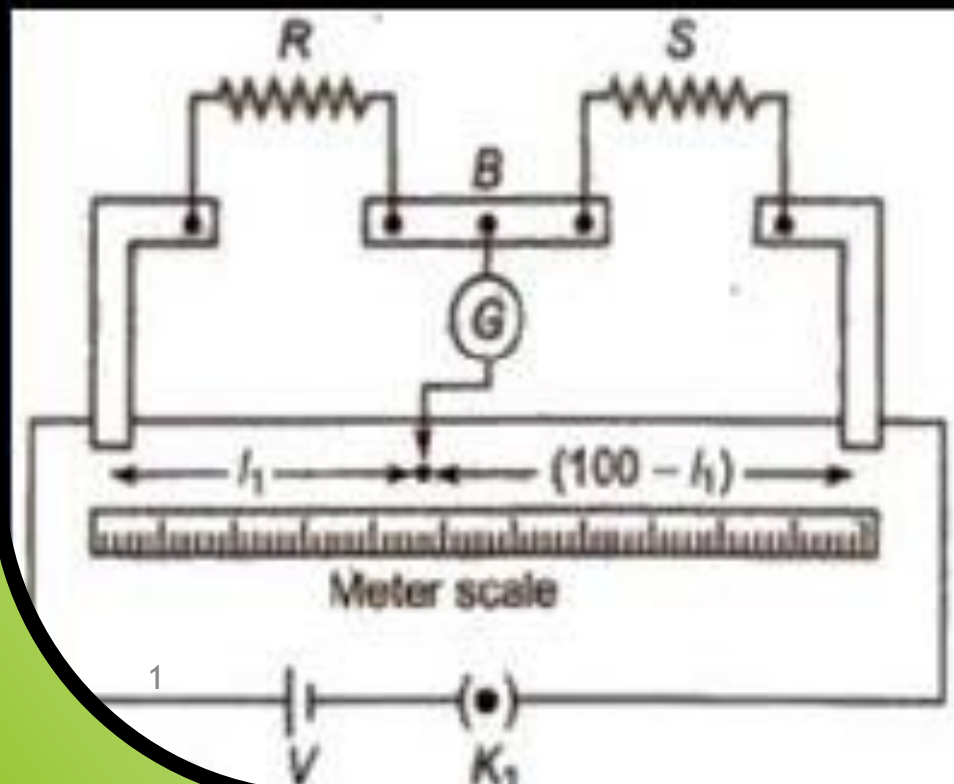
b. Answer the following

1. Name a device that helps to maintain a potential difference across a conductor.
2. What is meant by saying that the potential difference between two points is 1 V?
3. How much energy is given to each coulomb of charge passing through a 6 V battery?



CHAPTER – 3

CIRCUIT DIAGRAM





Huron,
please tell
us about
circuit
diagram!

Do you know
Sonali, the
switches, bulbs,
wires you use in
your daily life
are having some
specific symbols?

INTRODUCTION OF VARIOUS EQUIPMENTS WITH THEIR SYMBOLS

NAME

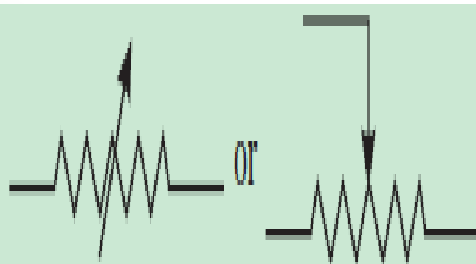
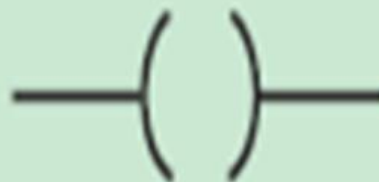
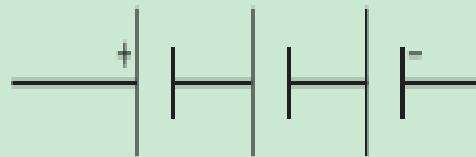
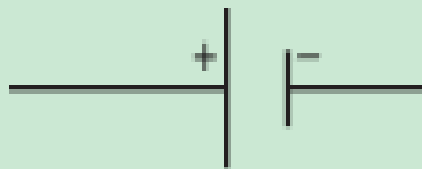
An Electric Cell

A battery

Plug key or switch (open)

Variable resistance or rheostat

SYMBOL



EQUIPMENT

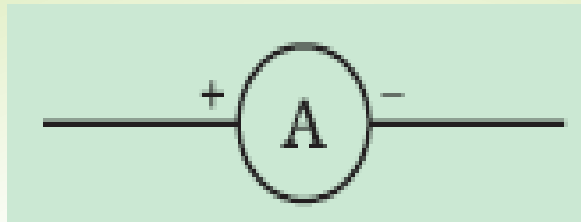


NAME

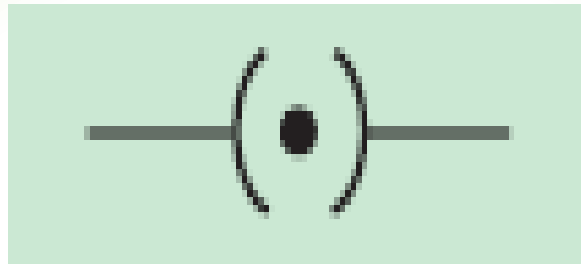
SYMBOL

EQUIPMENT

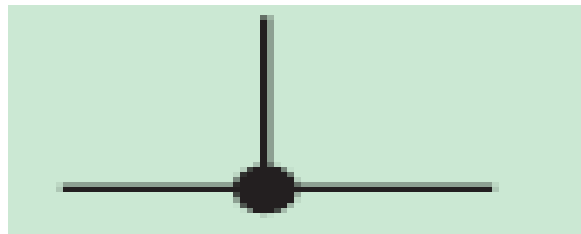
Ammeter



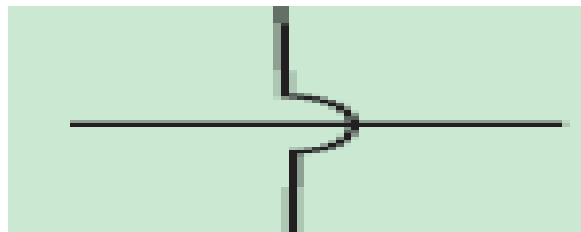
Plug key or
switch (closed)



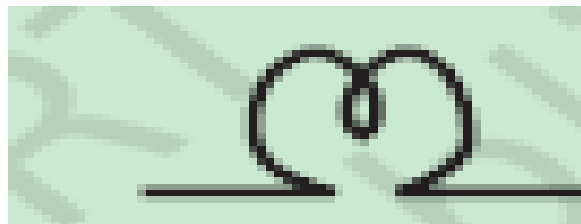
A Wire joint



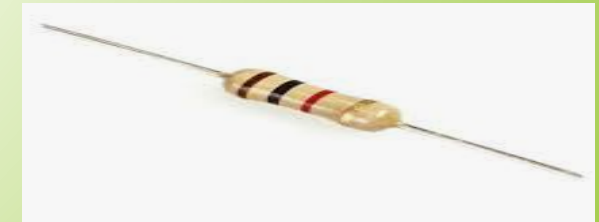
Wire crossing
without joining



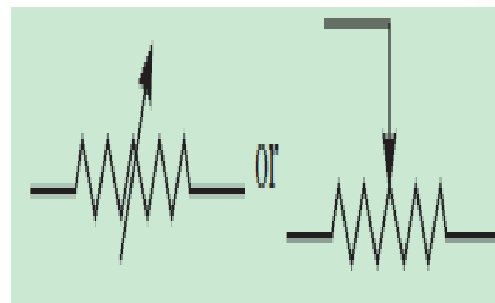
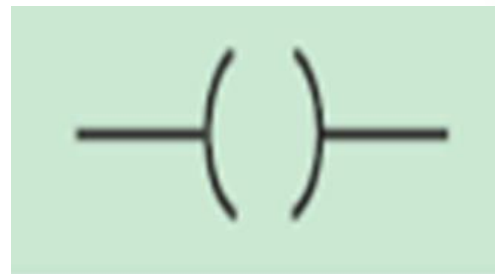
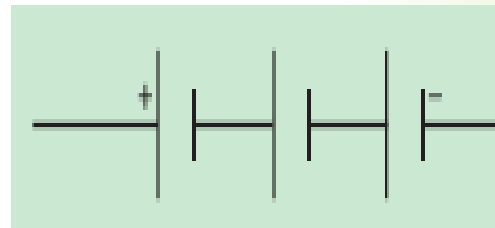
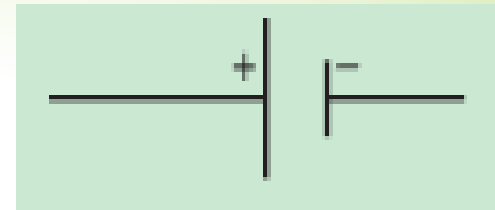
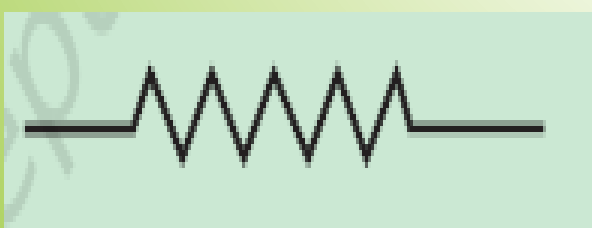
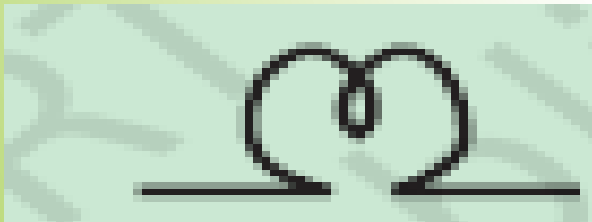
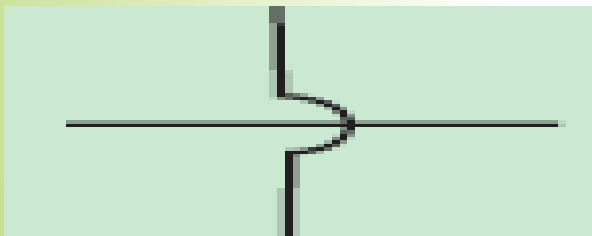
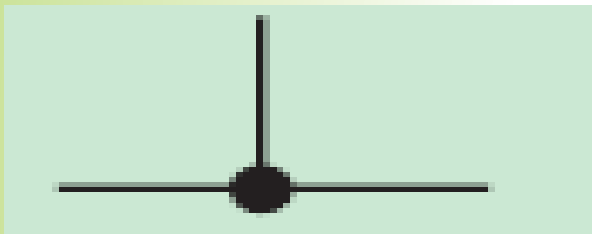
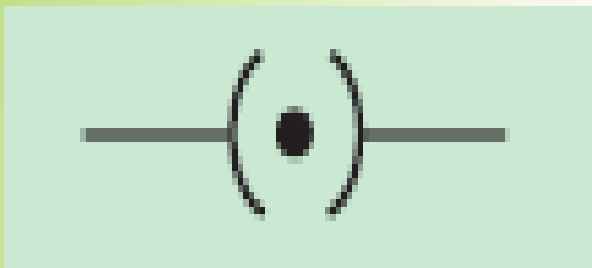
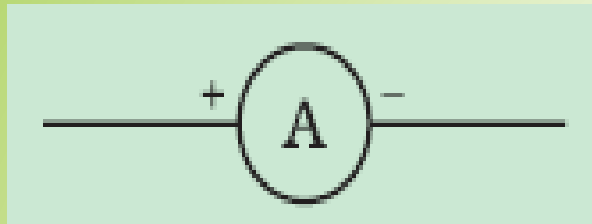
Electric Bulb



A resistor of
resistance R



Recognize the name of given electrical components



CHAPTER – 4

OHM'S LAW



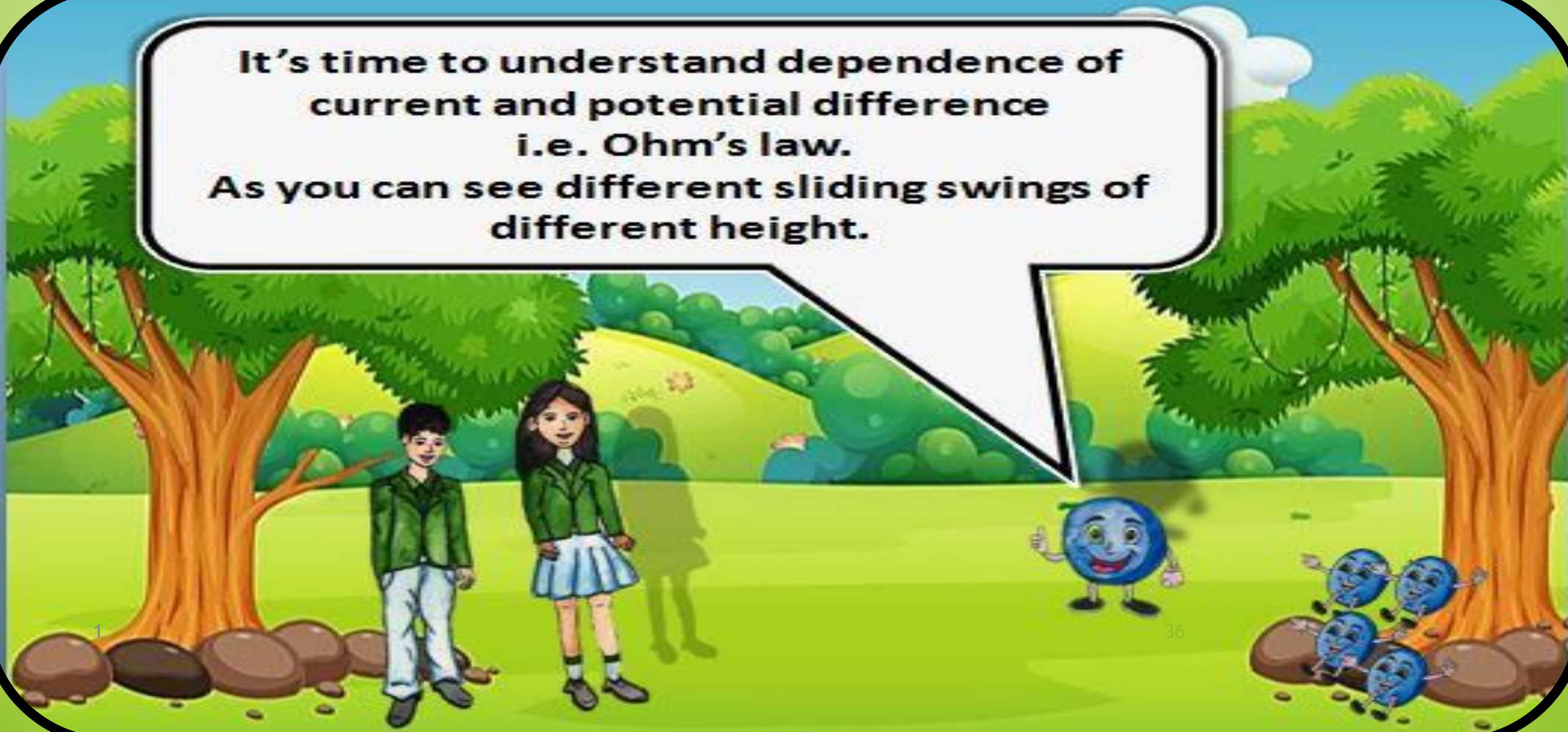
The potential difference, V , across the ends of a given metallic wire in an electric circuit is directly proportional to the current flowing through it, provided its temperature remains the same.

Ohm's
Law

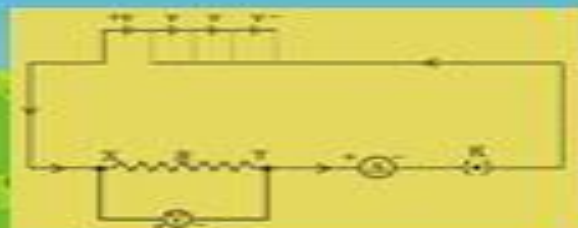
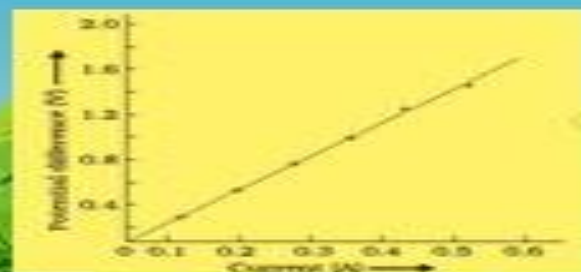
$$I = \frac{V}{R}$$

Electric current = Voltage / Resistance

It's time to understand dependence of current and potential difference i.e. Ohm's law.
As you can see different sliding swings of different height.

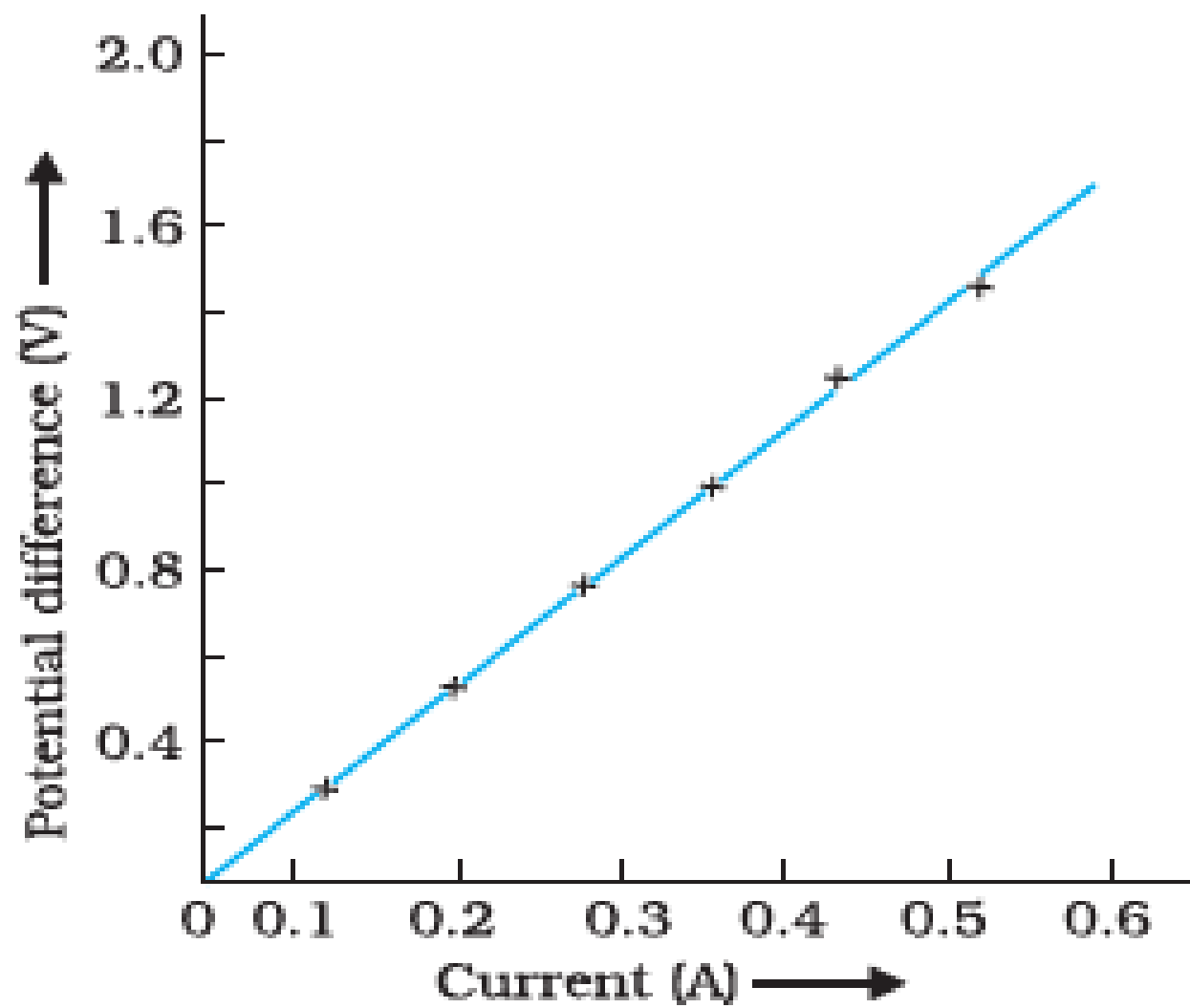
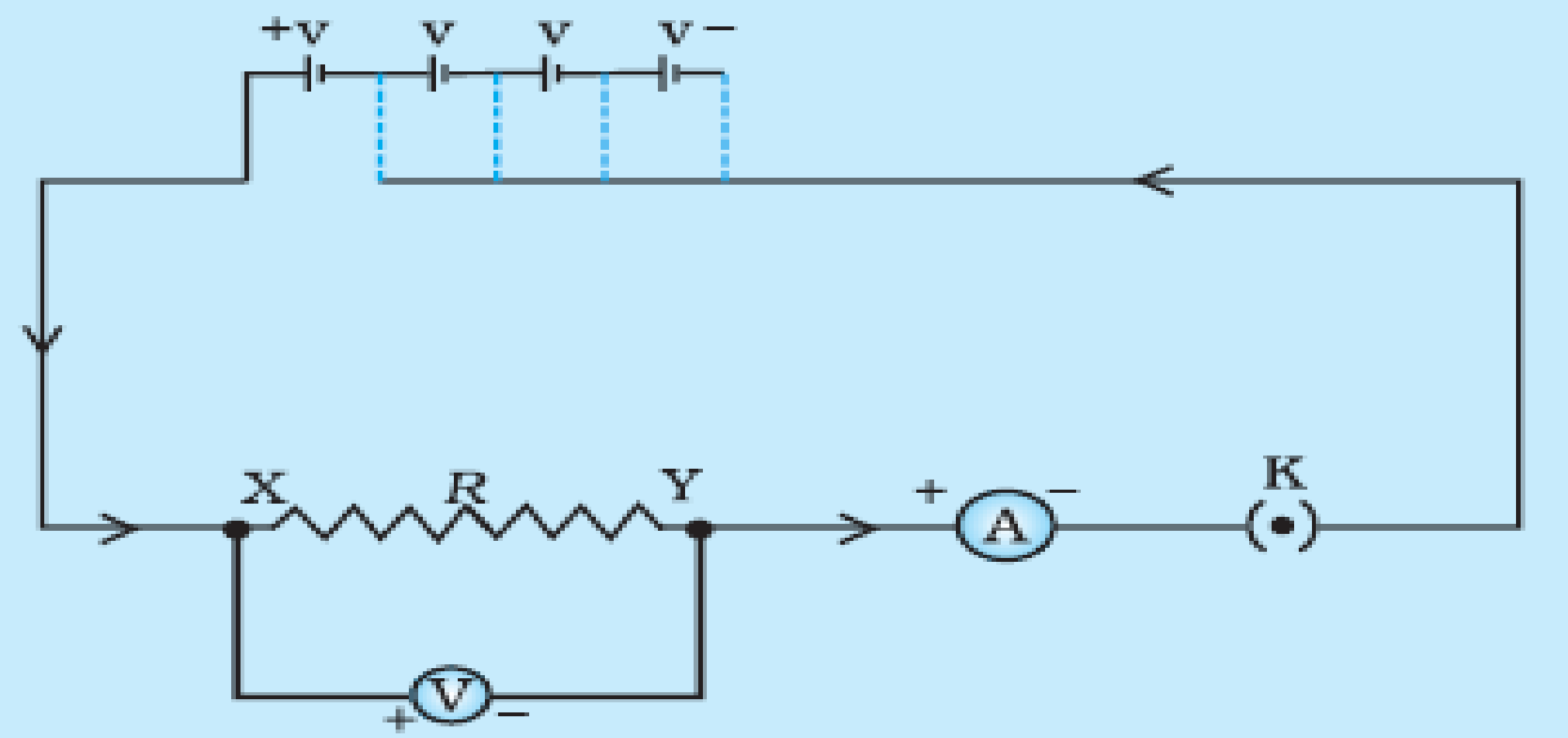


Height is analogous to a potential difference. The speed of children is analogous to current. More is the potential difference; the more is the flow of current. Similarly more is the height of the slide more will be the speed of children.



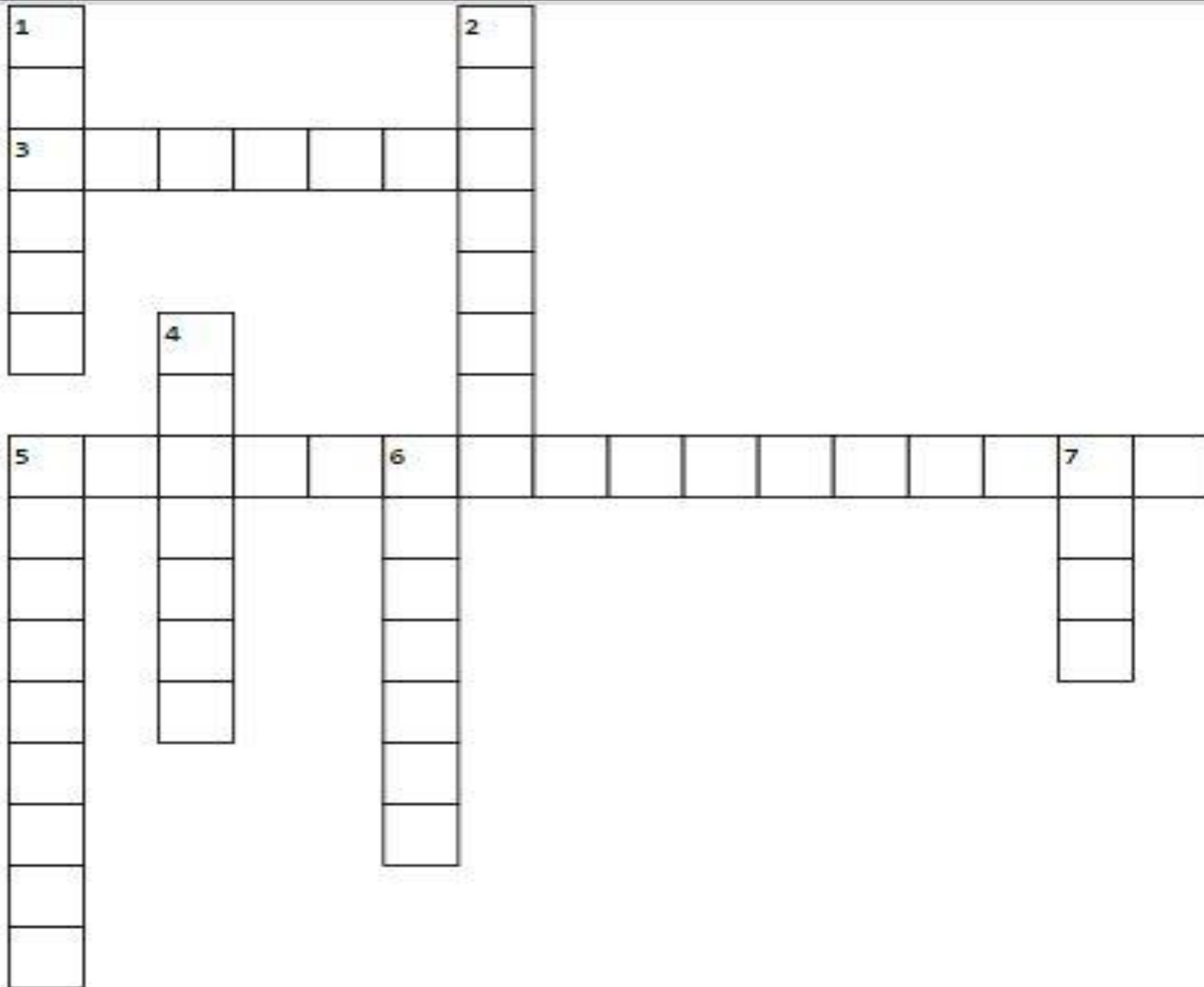
We can draw a graph between voltage and current. We just have to take a circuit where we can change voltage, measure voltage and current with the help of a voltmeter and ammeter.





The graph between current and voltage is always a straight line in accordance with the Ohm's Law.





Across

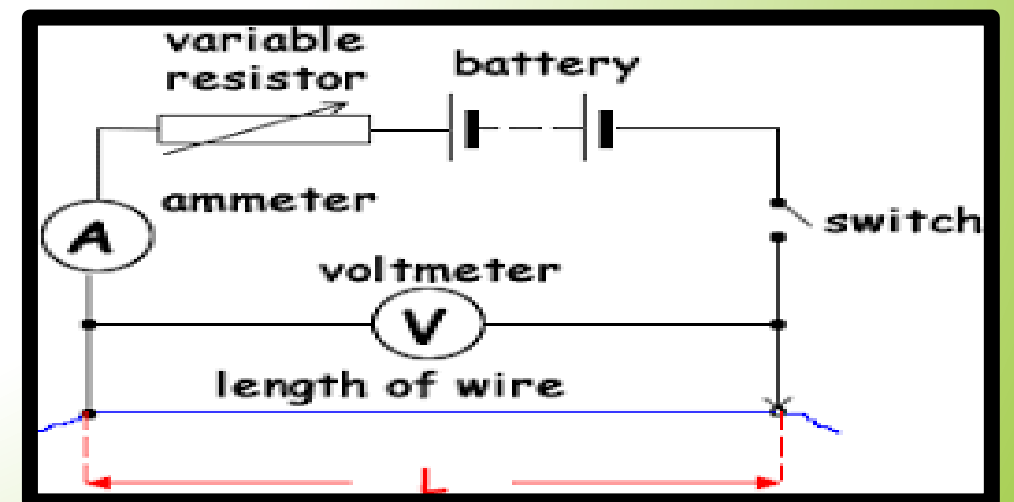
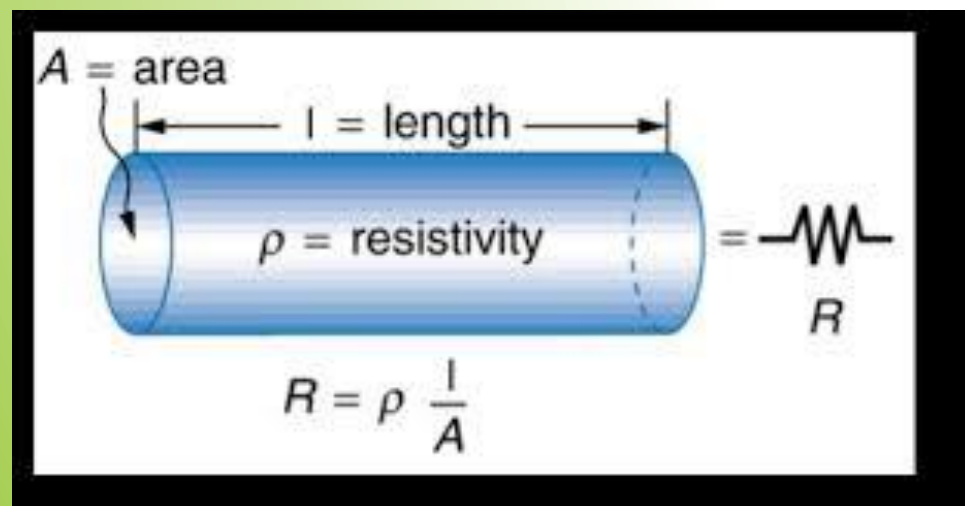
3. Used to measure current in a circuit
5. This symbol represents a ...

Down

1. Current(Amps) x Time (Seconds)
= _____(Coulombs)
2. Circuit components can be arranged in series or in ...
4. The flow of electrons in a circuit is called this
5. Used to measure voltage across components in a circuit
6. A collection of cells is called a ...
7. Resistance is measured in ...

CHAPTER - 5

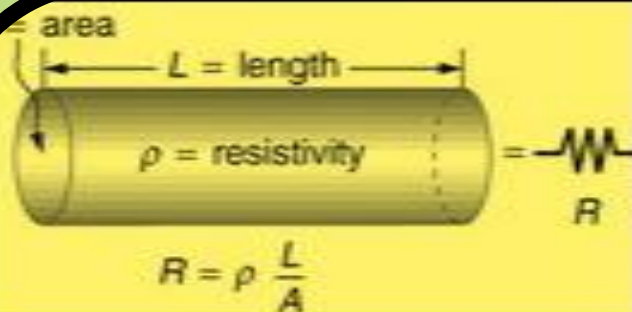
RESISTIVITY



The ratio of voltage and current is called RESISTANCE.

Champs ! There is one interesting fact that $R=V/I$, but Resistance (R) depends neither on voltage (V) nor on current (I)?

Really! but equation $R=V/I$ says that it depends.



Here ρ (rho) is a constant of proportionality and is called the **ELECTRICAL RESISTIVITY** of the material of the conductor. The SI unit of resistivity is $\Omega \text{ m}$. It is a characteristic property of the material.

Oh! Here is the catch. Resistance of a conductor depends on three factors:

- ❖ Length of the conductor
- ❖ Area of cross section
- ❖ Resistivity of material.



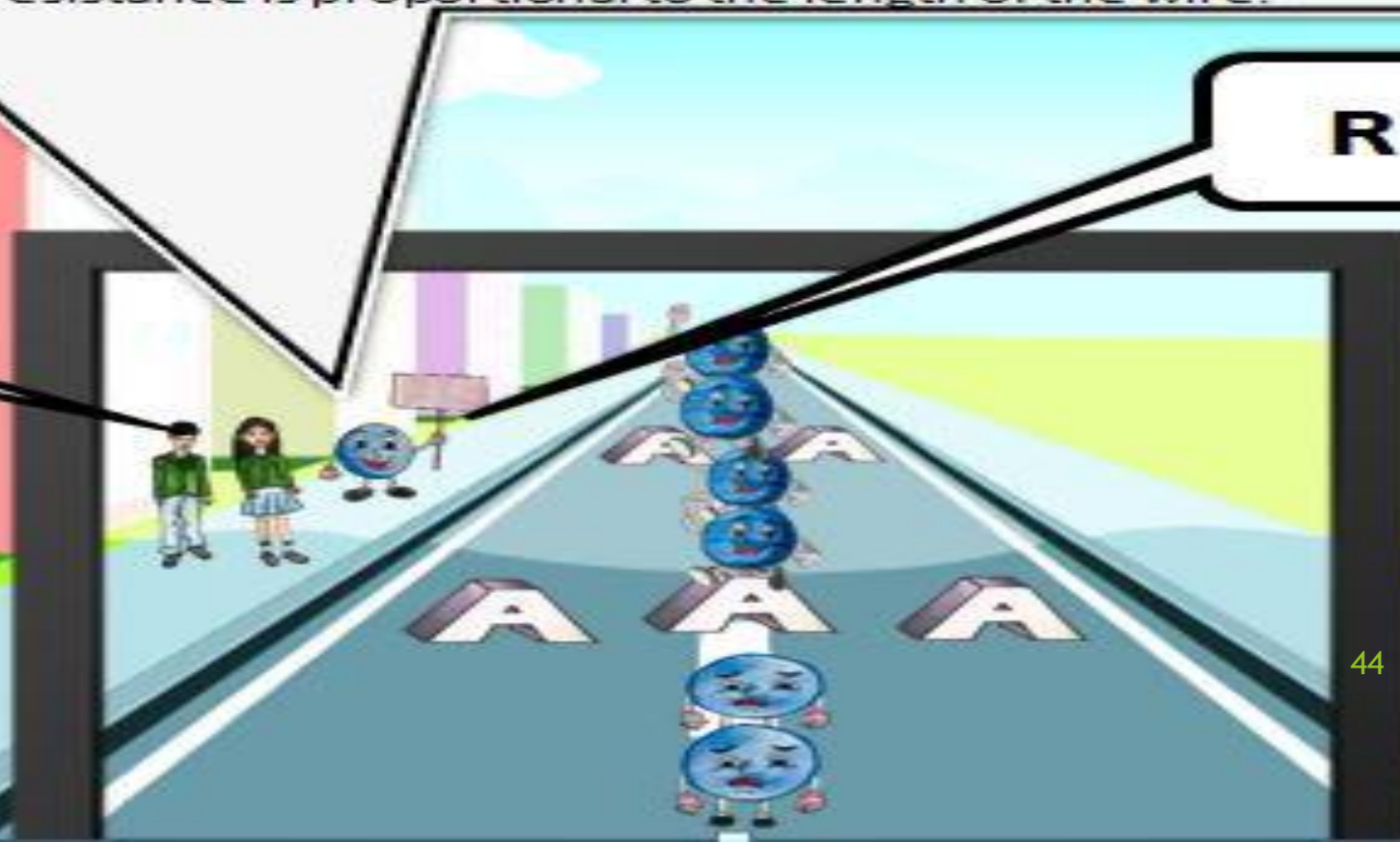
Champs! Just remember one thing, more is resistance less is current and vice-versa. Because resistance is basically an obstacle to the flow of current. Come with me. I will show you this in my city.



Champs! Try to understand this concept. Here, the electrons get tired due to continuous movement on the long road. So, there is a decrease in speed too. One more thing to observe is because the road is narrow, the number of electrons crossing per second is also less. Hence, less current and high resistance. It proves that resistance is proportional to the length of the wire.

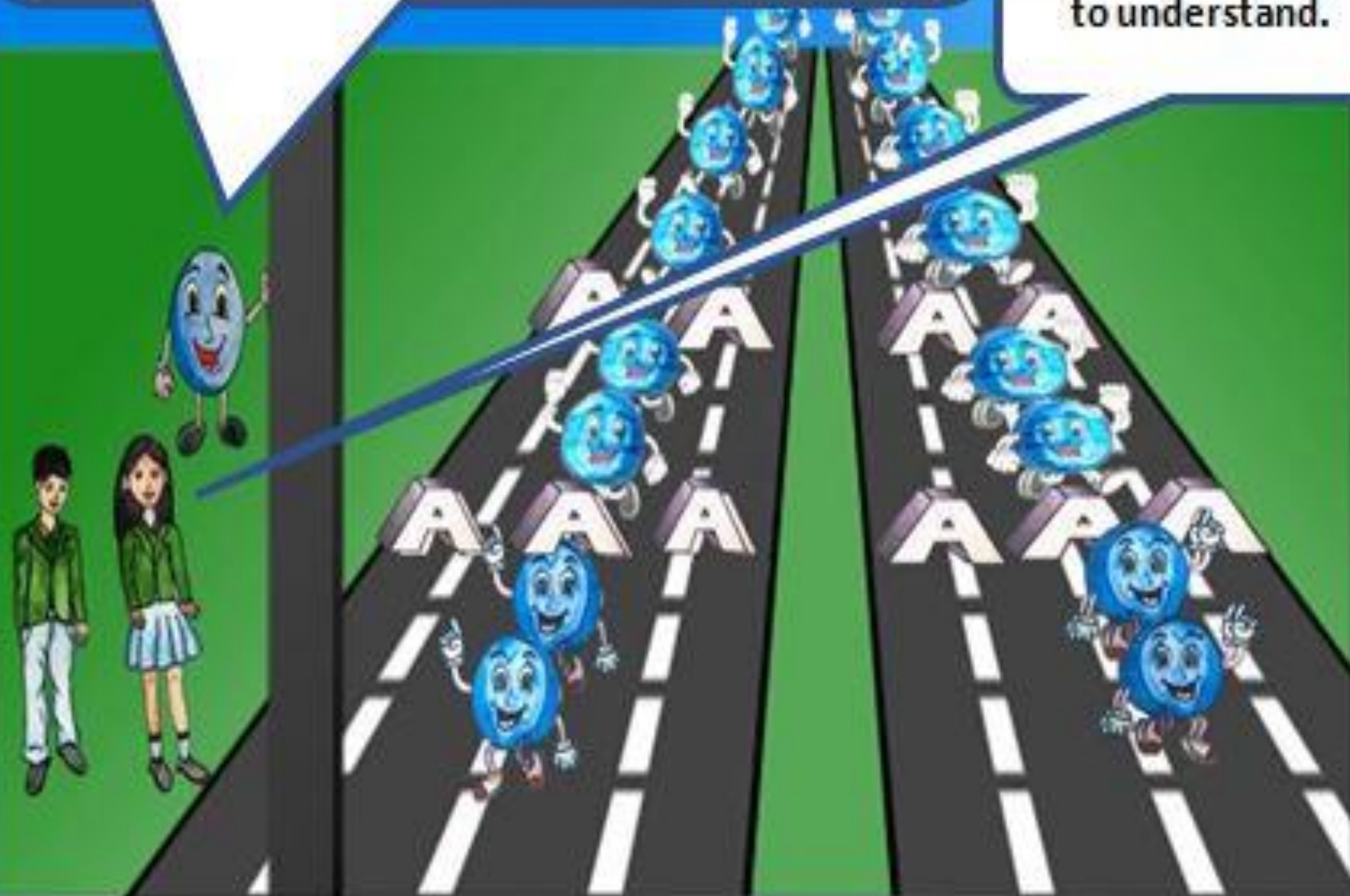
Wow! You explained so perfectly.

$$R \propto L$$

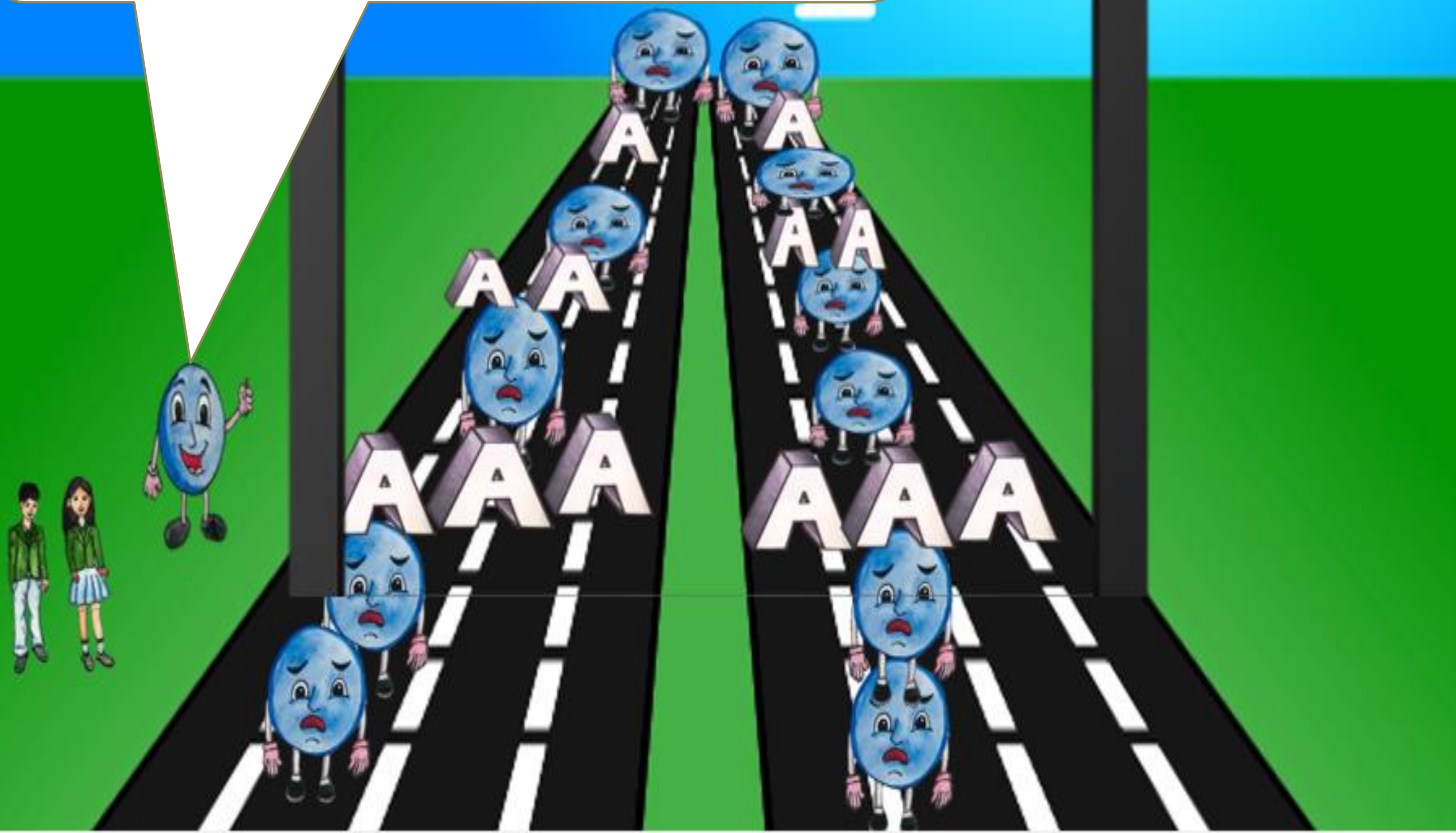


Now look at this broad road, which is short in length. Electrons are moving fast and also the number of electrons crossing per second is more in number. Hence more current and lower resistance. It proves resistance is inversely proportional to the area of the cross-section. i.e : $R \propto (1/A)$

Wow! A perfect way to understand.



Let's move to another road. Here there are too many hurdles. These hurdles are representing RESISTIVITY. These hurdles will give rise to more RESISTIVITY and will reduce the speed of electrons. So, the lesser is the speed of the electron more will be the RESISTANCE, hence lesser will be the current. It proves Resistance is directly proportional to resistivity. $R \propto \rho$



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Across

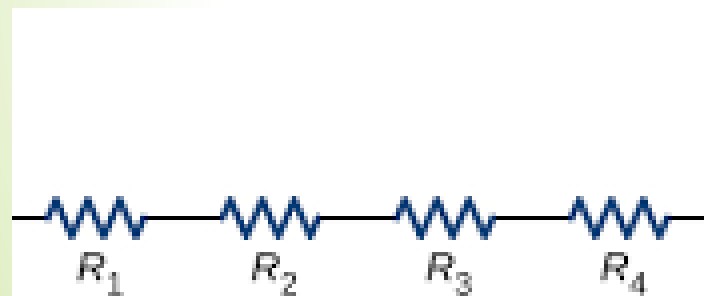
2. current x resistance
5. As increases, resistance increases because the metal ions vibrate more.
6. The unit of voltage.
8. The device which measures current in a circuit.
9. A component that only allows current to flow in one direction.

Down

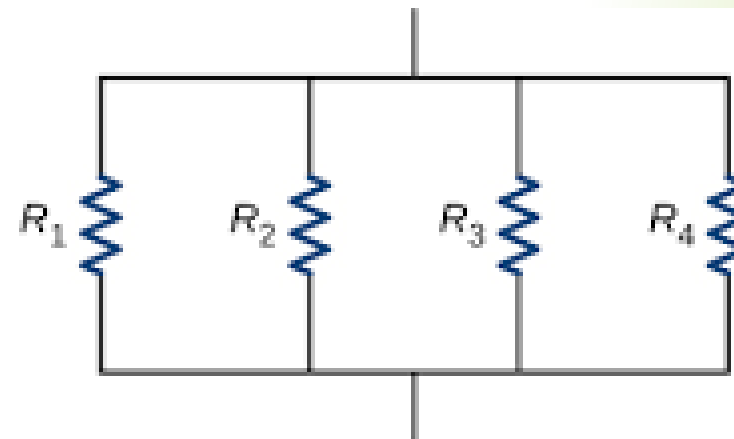
1. Ohm's law states that current is directly to voltage for a fixed resistor
3. The unit of current.
4. I increase the resistance in a circuit, the current
7. energy transferred = current x voltage x
10. The unit of resistance.

CHAPTER - 6

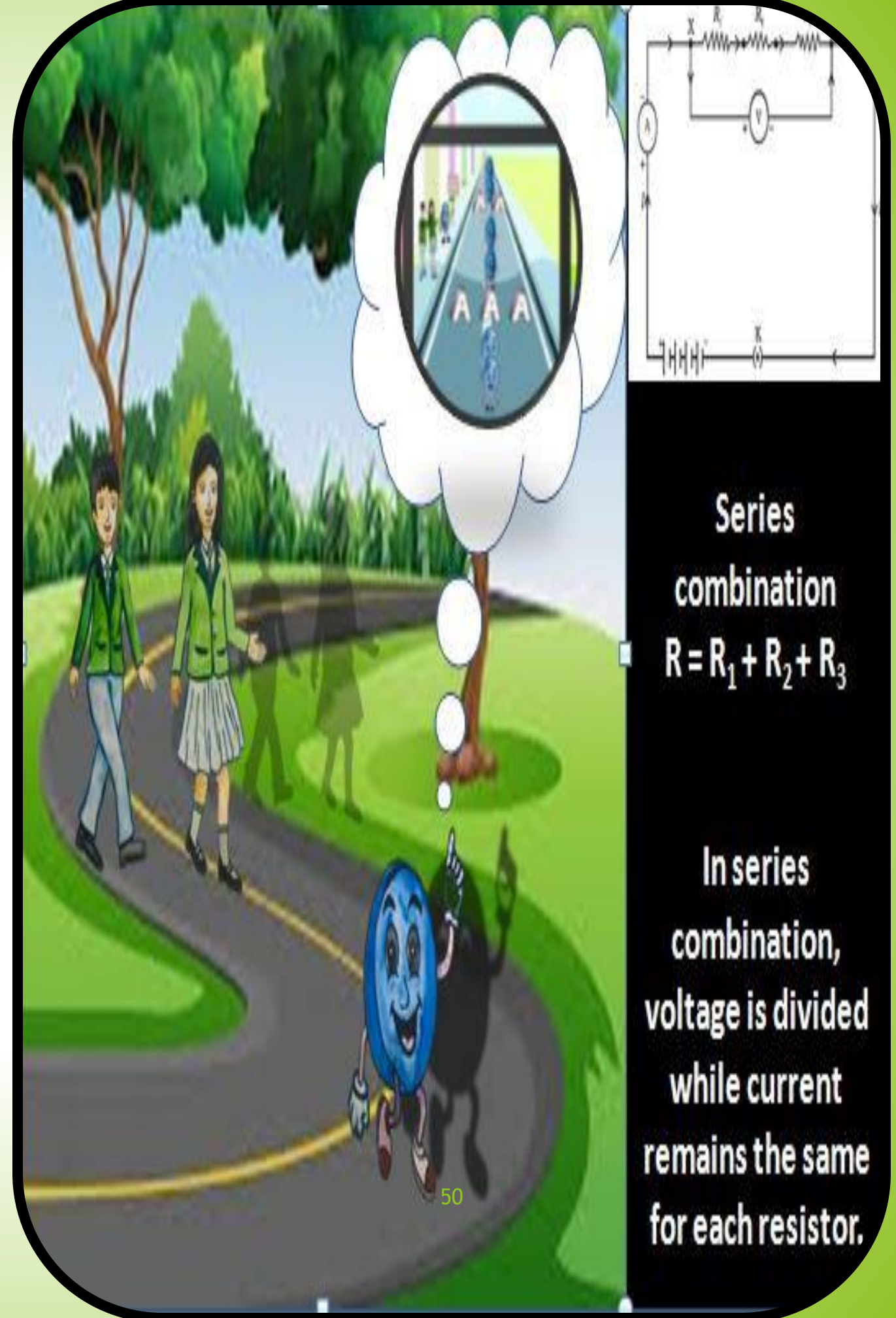
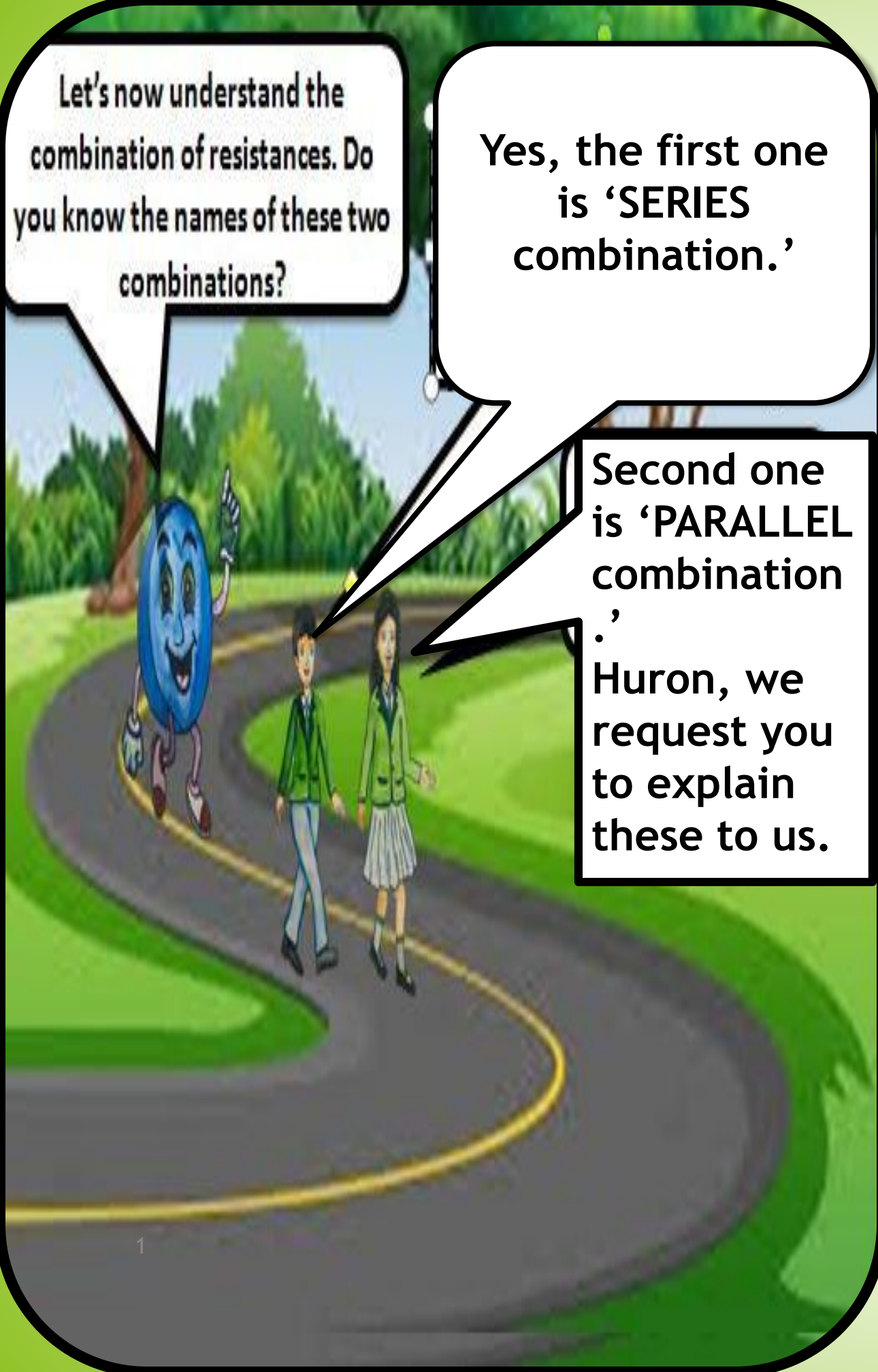
Series and Parallel combination of resistors



(a) Resistors connected in series



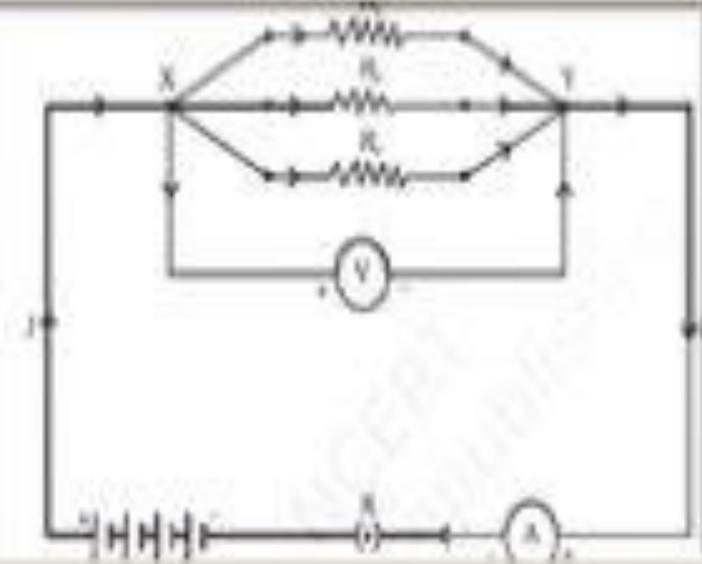
(b) Resistors connected in parallel



I always had doubts in it but now all clear.

Me too!

In parallel combination, the path to electrons is getting wider so their resistance decreases.Let's take example of wider road, when road becomes wider then there is decrease in net resistance.



Parallel combination

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

In Parallel combination, voltage remains the same and current is divided.

Questionnaire

- 1. What are the advantages of connecting electrical devices in parallel with the battery instead of connecting them in series?**
- 2. What is (a) the highest, (b) the lowest total resistance that can be secured by combinations of four coils of resistance $4\ \Omega$, $8\ \Omega$, $12\ \Omega$, $24\ \Omega$?**
- 3. An electric lamp of $100\ \Omega$, a toaster of resistance $50\ \Omega$, and a water filter of resistance $500\ \Omega$ are connected in parallel to a $220\ \text{V}$ source. What is the resistance of an electric iron connected to the same source that takes as much current as all three appliances, and what is the current through it?**

CHAPTER -7

Heating effect of electric current

The work done in moving the charge Q through a potential difference V is VQ . Therefore, the source must supply energy equal to VQ in time t . Hence the power input to the circuit by the source is

$$P = VQ/t = VI$$

Or the energy supplied to the circuit by the source in time t is $P \times t$, that is, VIt . What happens to this energy expended by the source? This energy gets dissipated in the resistor as heat. Thus for a steady current I , the amount of heat H produced in time t is

$$H = VIt.$$

Tarun, let's make it simple. When there is a rapid movement in the body, it heats up, which means our energy dissipated in the form of heat. Similarly, when electrons run through the electric wire or circuit their energy is dissipated in the form of heat.

Sonali, can you give me any example of real-life applications of heating effect of current.

Yes, Electric heater, Electric Iron

Geyser, blower, Electric cattle.

Questionnaire

1. 100 J of heat is produced each second in a $4\ \Omega$ resistance. Find the potential difference across the resistor.
2. Why does the cord of an electric heater not glow while the heating element does?
3. An electric iron of resistance $20\ \Omega$ takes a current of 5 A. Calculate the heat developed in 30 s.

CHAPTER - 8

Power

Power = Rate of doing work is power. This is also the rate of consumption of energy.

The power P is given by

$$P = VI$$

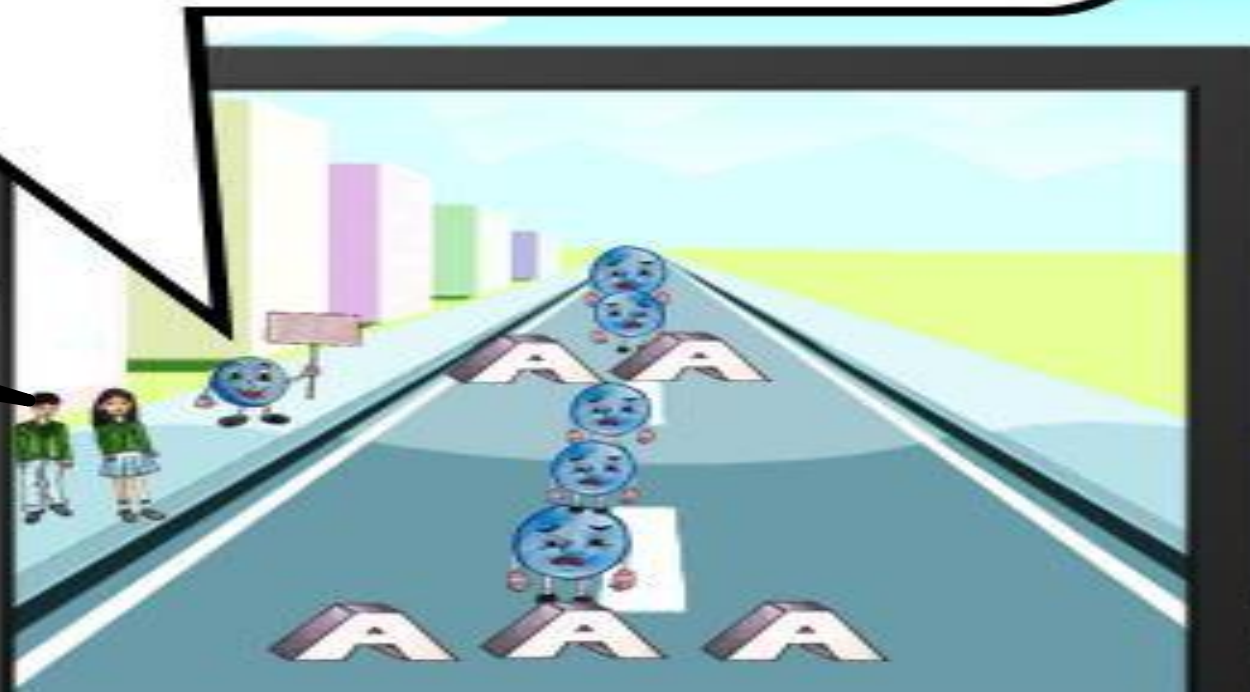
$$\text{Or } P = I^2 R = V^2 / R$$

The SI unit of electric power is watt (W)

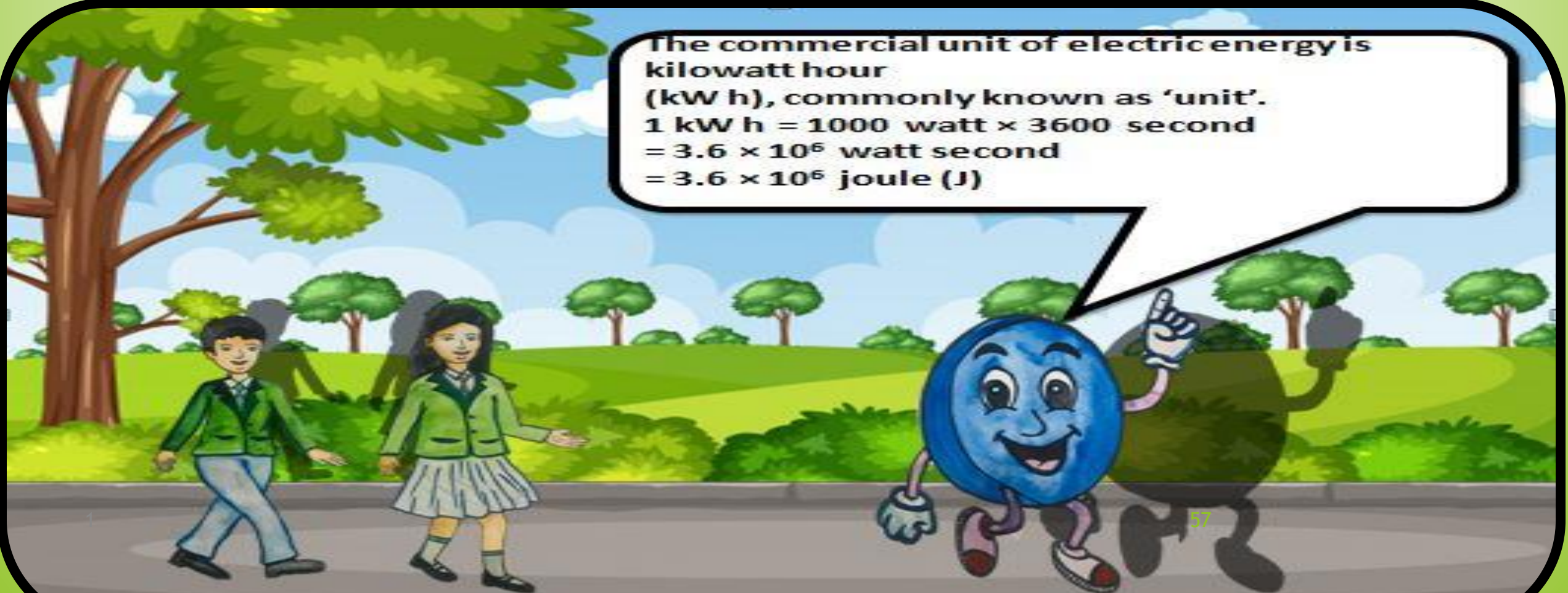
$$W = P \times t$$

The unit 'watt' is very small therefore, in actual practice we use a much larger unit called 'kilowatt'. It is equal to 1000 watts. Tarun, you would have heard many times that the household electricity bill comes in UNITS. Do you know what a UNIT is?

Not Exactly Huron
.....Please
explain to us.



The commercial unit of electric energy is kilowatt hour (kW h), commonly known as 'unit'.
 $1 \text{ kW h} = 1000 \text{ watt} \times 3600 \text{ second}$
 $= 3.6 \times 10^6 \text{ watt second}$
 $= 3.6 \times 10^6 \text{ joule (J)}$



While Huron was explaining all this to the kids, four hours have passed while learning about electricity.

Gracia Huron,
this will be
an
unforgettable
day of my
life.

Yes, Huron.
Drake.

Children, I have explained
all the concepts and
learning objectives of
chapter Electricity to you.
Hope you enjoyed it.

Kids, the effect of the chemical is
diminishing. Now, you will attain
your original size.

Wao! We are
back to the
pavilion.

Let's tell our
exclusive
story to our
friends!

Okay,
let's go.



Questionnaire

1. An electric bulb is connected to a 220 V generator. The current is 0.50 A. What is the power of the bulb?
2. What determines the rate at which energy is delivered by a current?
3. An electric motor takes 5 A from a 220 V line.
Determine the power of the motor and the energy consumed in 2 h.
4. An electric refrigerator rated 400 W operates 8 hour/day. What is the cost of the energy to operate it for 30 days at Rupees 3.00 per kW h?

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Glossary

Current: Rate of flow of positive charge.

Electric Potential: Work done per unit charge.

Electric Circuit: An arrangement of power source key, voltmeter, ammeter etc.

Electric Power: Rate of consumption of energy.

One commercial Unit of Energy: Energy consumed by an equipment of 1 kW power in one hour(one kWh)

Voltmeter: An instrument for the measurements of Potential Difference.

Ammeter: An instrument for the measurement of electric current.

Key: A device to make or break the electric circuit.

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DISCLAIMER

- **This novel is published as a supportive reading material to enable the students to have a better understanding of the topic. The characters used in this graphic novel are fictional and resemblance of any character or incident is merely a coincidence. Art work is done by teachers.**

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FROM THE PRINCIPAL'S (Academics) DESK

- I extend a hearty welcome to all the exuberant readers of Graphic Novel ‘ELECTRICITY. This high-quality graphic novel (GN) on Power Sharing can make positive literacy contributions to the lives of school students. Reading graphic novels may be a “way in” for helping children who are difficult to reach through traditional print text. The obvious distinction between graphic novels and text-based novels is that graphic novels permit their images to do the vast majority of the storytelling, with dialogue bubbles and narration boxes to help elaborate the story. Moreover it emphasizes on integrated art learning that is necessary to understand the concepts. I wholeheartedly appreciate the arduous endeavors of all the subject teachers, language teachers, art teachers, techno team of DPS, Sahibabad involved in this project. The combination of dedication, pragmatic approach and innovative thinking enabled us to fabricate this effective teaching tool. The readers will definitely find it useful in learning and understanding more about Electricity. Last but not the least, I would like to express my sincere gratitude to Mr. Sandeep Sethi (Director Education, M.S.M.S. II, Museum Trust) without whose unconditional support and persistent guidance, this would have not been accomplished so compellingly. I hope this aesthetic, artistic and edifying piece of work will fulfill its purpose of making learning enjoyable and effective.*

Ms. Yogita Kapil

Principal(Academics)

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Affiliated to CBSE

Thank
you

