# Physics – Grade 10

## Unit One – Electricity


# Chapter 5
# Generator and Receiver

Prepared & Presented by: Mr. Mohamad Seif

# OBJECTIVES

1. Define a generator
2. Identify the characteristics of a generator:

# Define a Generator

## What is a generator?

**A Generator: is an electric device that converts forms of energy into electric energy.**

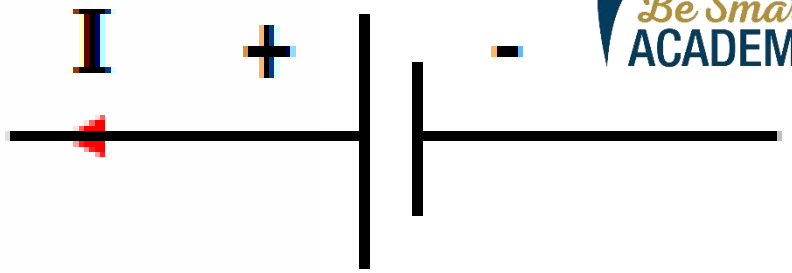
# Define a Generator

## Examples about generators:

| Name of Generator | Convert energy from …… to …… + …… | | |
|---|---|---|---|
| Thermal power stations | Chemical energy | Electric energy | thermal energy |
| Dry cell | Chemical energy | Electric energy | thermal energy |
| Solar cell | Radiant energy | Electric energy | thermal energy |

# Define a Generator

**The symbol of a generator is:**




**The current enters through the negative (-) pole and leaves through the positive (+) pole.**

# Characteristics of a generator:

A generator is represented by G( E, r) and characterized by:

- **Electromotive force (E in [V]):**

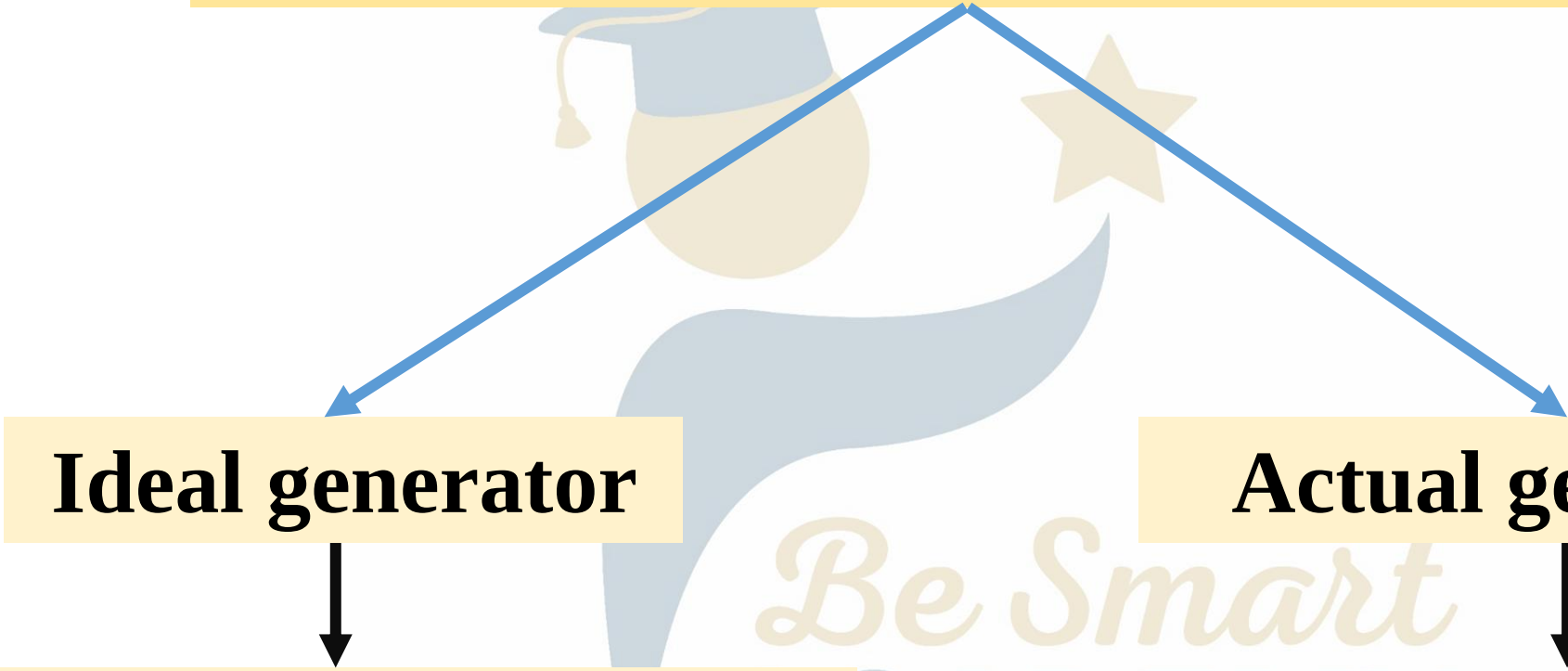
The maximum voltage across the terminals of the generator at no load.

- **Internal resistance (r in [Ω]):**

The internal resistance causes the heating of the generator while functioning due to Joule's effect.

# Characteristics of a generator:

## Types of generators



**Ideal generator**

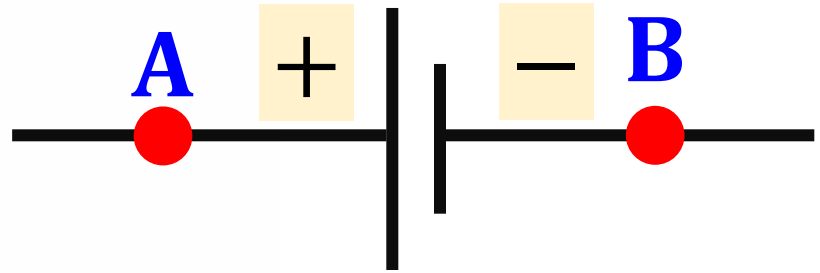
**generator with negligible internal resistance ($r = 0$)**

**Actual generator**

**generator with internal resistance ($r \neq 0$)**

# Characteristics of a generator:

**Application 1:** An electric current I leaves the generator from terminal A and enters the terminal B.



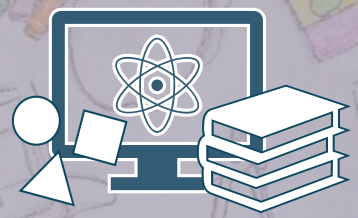

1. Which one is the positive pole? Justify

Because the current I leaves the terminal A, then A is the positive pole of the generator and B is the negative pole of the generator

2. The internal resistance of the generator is neglected, specify the type of this generator.

Since the internal resistance is neglected (r=0), the generator is ideal

# The End



# Physics – Grade 10

## Unit One – Electricity


## Chapter 5
## Generator and Receiver



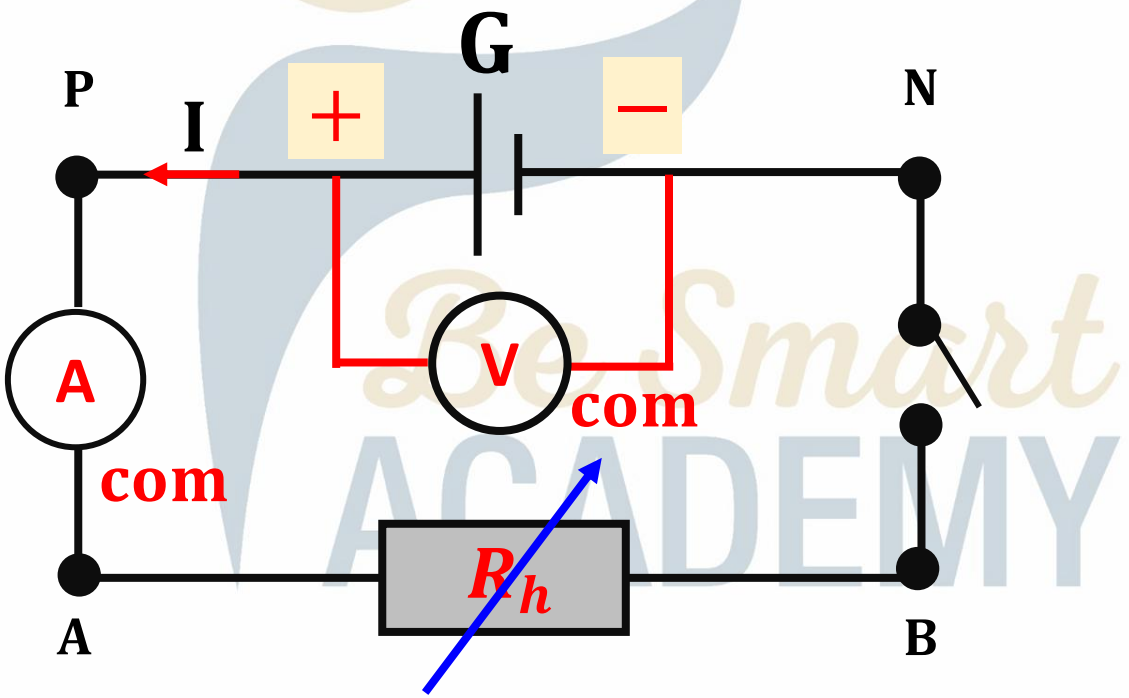
Prepared & Presented by: Mr. Mohamad Seif

# OBJECTIVES

1. Current – Voltage characteristic of a Generator

# Current – Voltage characteristic of a Generator

- Set up the following electric circuit that consists of generator G, rheostat, voltmeter, ammeter, connecting wires and a switch k.

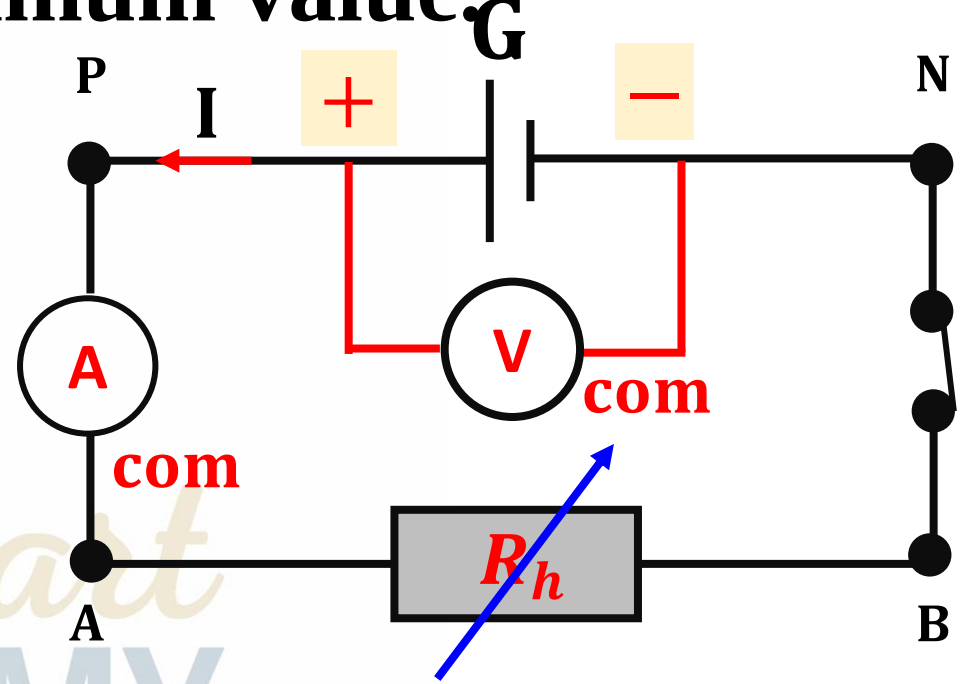


# Current – Voltage characteristic of a Generator

**When the switch is opened, the ammeter indicate zero, the voltmeter indicates the maximum value.**

**After closing the switch:**

- **Increase the resistance of the rheostat to a certain value and record the new values of I and V.**




- **Repeat this step a few times and tabulate the results.**

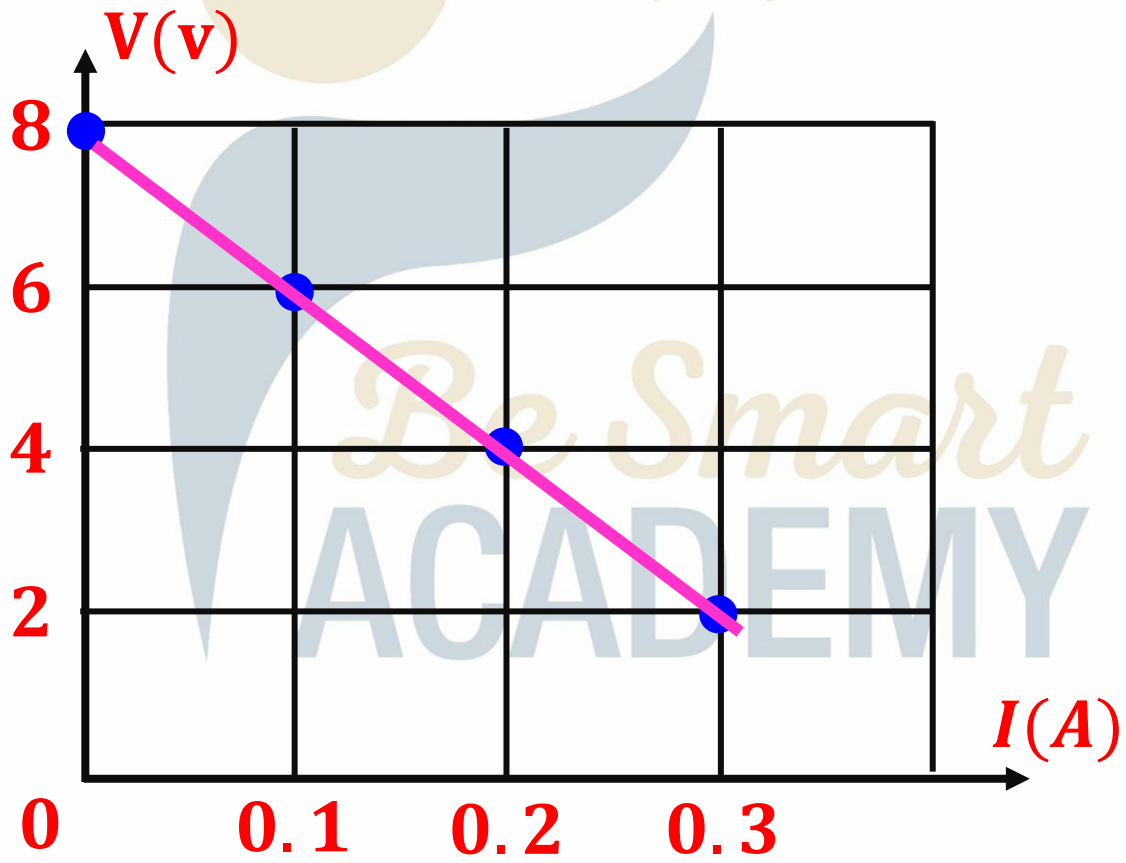
# Current – Voltage characteristic of a Generator

**The values of the current and the voltage are recorded in the following table**

| I(A) | 0 | 0.1 | 0.2 | 0.3 |
|---|---|---|---|---|
| V(v) | 8 | 6 | 4 | 2 |

# Current – Voltage characteristic of a Generator

| I(A) | 0 | 0.1 | 0.2 | 0.3 |
|---|---|---|---|---|
| V(v) | 8 | 6 | 4 | 2 |



# Current – Voltage characteristic of a Generator

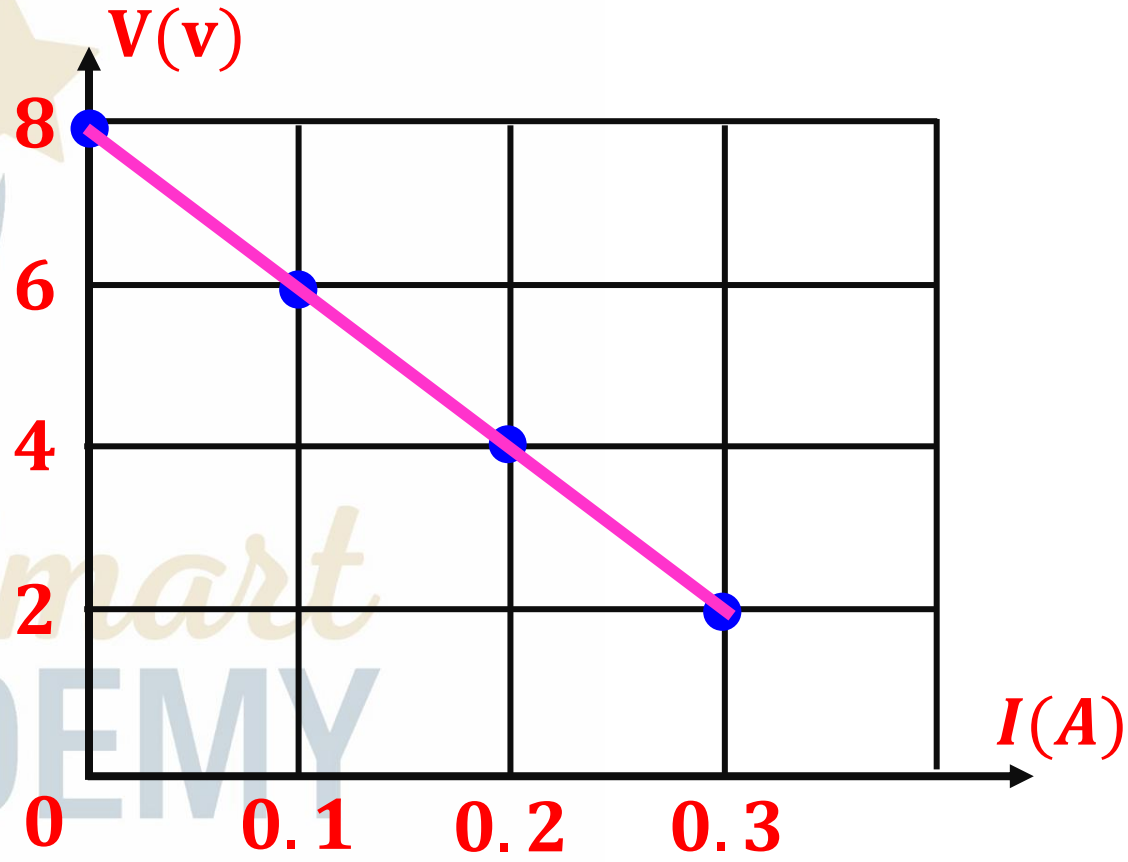
This graph is called the current-voltage characteristics of a generator.

The curve is a straight line of negative slope and NOT passing through the origin.

The equation of the St. Line is

$$U = a.I + b$$

$a$: is the slope of the curve ($a = -r$) and $b = E$.



# Current – Voltage characteristic of a Generator

$$\mathbf{U = a.I + b}$$

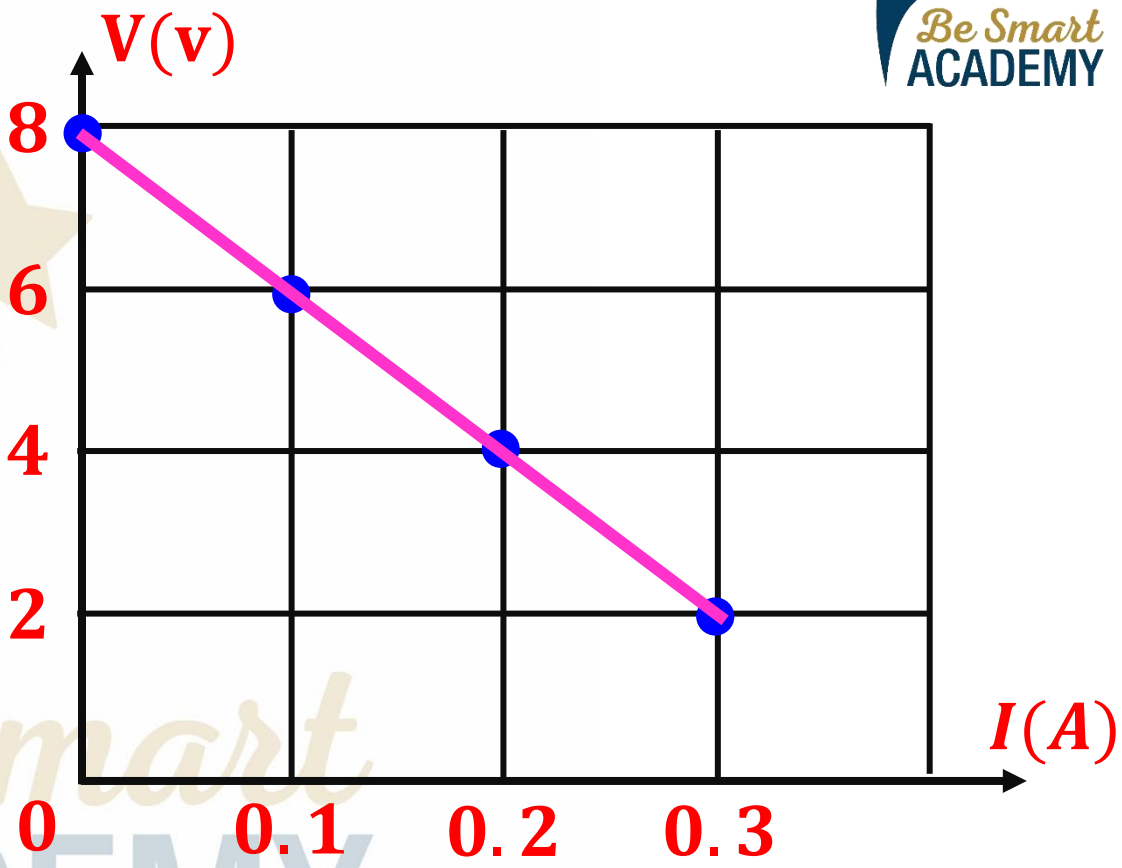
$$a = \frac{V_2 - V_1}{I_2 - I_1}$$

$$a = \frac{6 - 2}{0.1 - 0.3} = \frac{4}{-0.2}$$

$$a = -20V/A$$

$$a = -r = -20 \Rightarrow r = 20\Omega$$

b = E: is the y intercept $\Rightarrow b = 8V$



# Current – Voltage characteristic of a Generator

## Ohm's Law for a generator:

$$U_G = -rI + E$$

**E:** Electromotive force (maximum voltage), expressed in volts (V).

***r*:** The internal resistance of the generator, expressed in ohm (Ω)

# Current – Voltage characteristic of a Generator

## Application 2:

**To determine the characteristic values of a generator, we set up an electric circuit.**

**When we close the switch k, the values of V and I are recorded and tabulated as shown below.**

| I(mA) | 0 | 100 | 200 | 300 | 400 | 500 |
|---|---|---|---|---|---|---|
| V(V) | 5 | 4.5 | 4 | 3.5 | 3 | 2.5 |

# Current – Voltage characteristic of a Generator

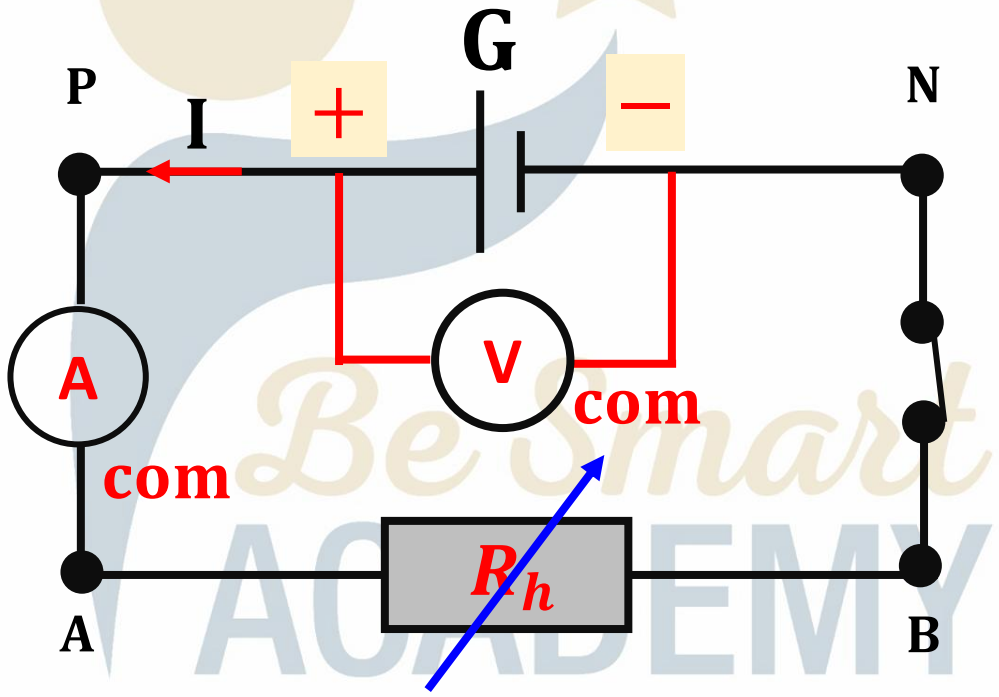
1. Draw a figure of the electric circuit.
2. Plot the graph of V as a function of I.

Scale: x-axis: $1cm \rightarrow 100mA$ and y – axis: $1cm \rightarrow 1V$.

3. Determine the equation of the obtained curve.
4. Deduce the electromotive force E and the internal resistance r of the generator.

# Current – Voltage characteristic of a Generator

## 1. Draw a figure of the electric circuit.



# Current – Voltage characteristic of a Generator

## 2. Plot the graph of U as a function of I.

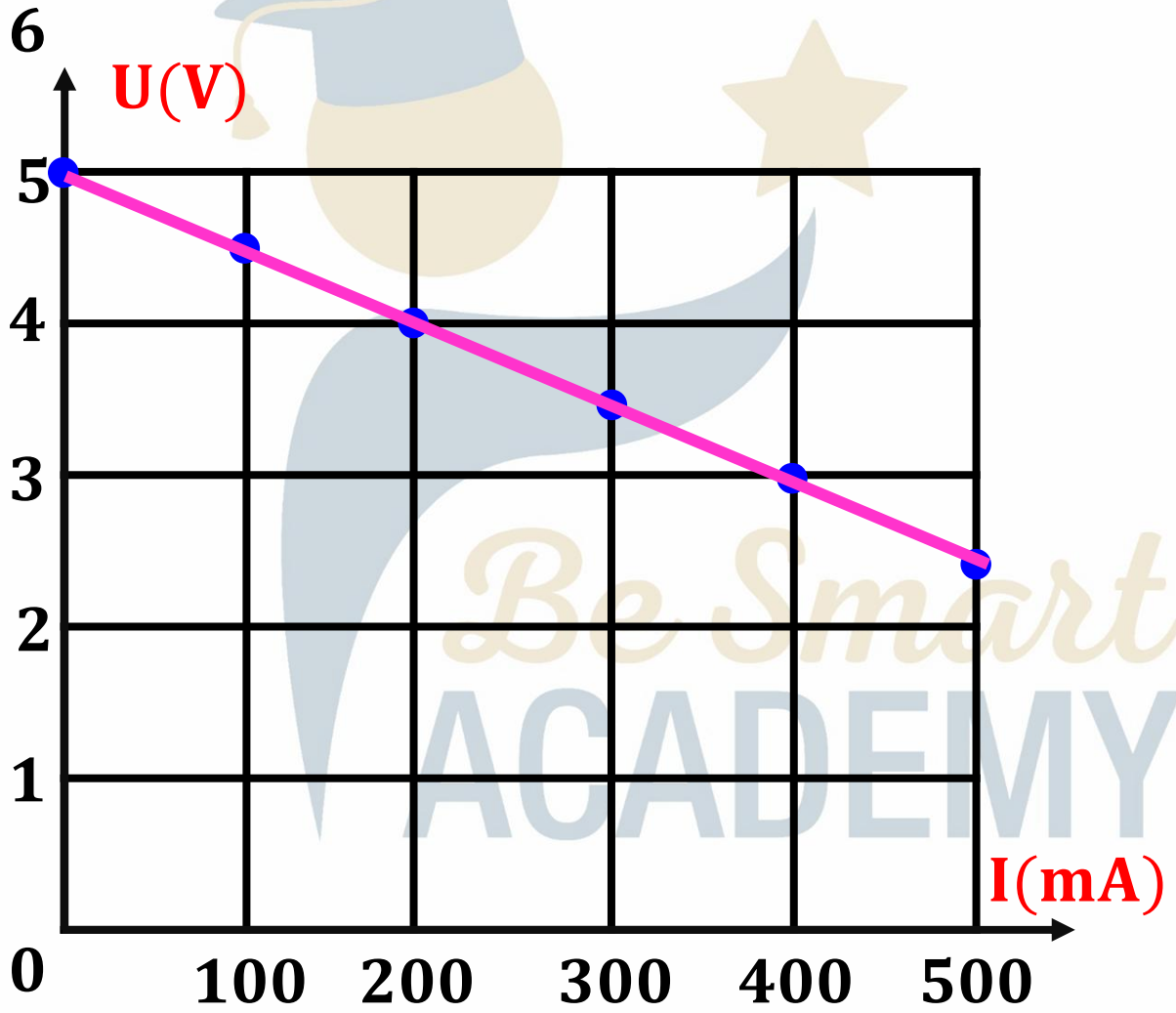
**Scale:**

**x-axis:** $1cm \rightarrow 100mA$

**y – axis:** $1cm \rightarrow 1V$

| I(mA) | 0 | 100 | 200 | 300 | 400 | 500 |
|---|---|---|---|---|---|---|
| V(V) | 5 | 4.5 | 4 | 3.5 | 3 | 2.5 |

# Current – Voltage characteristic of a Generator



# Current – Voltage characteristic of a Generator

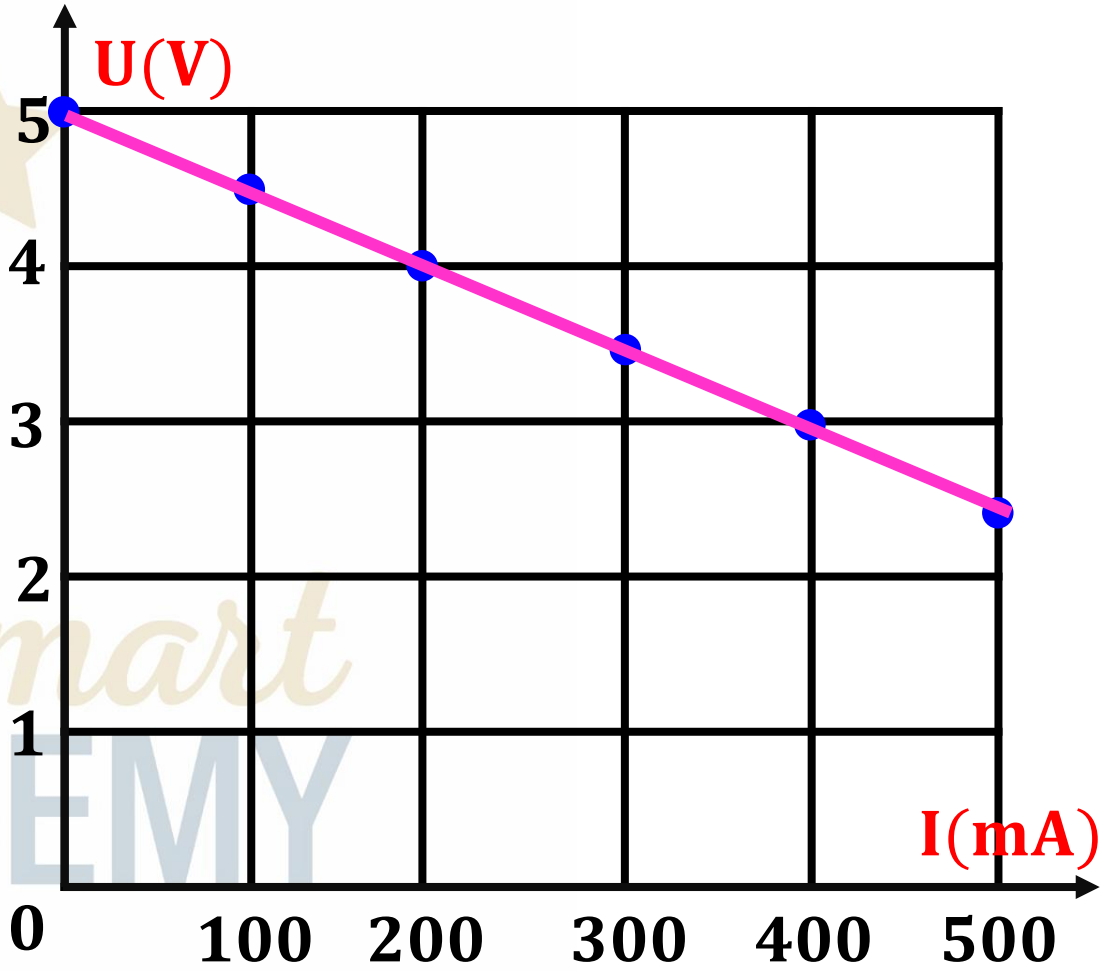
## 3. Determine the equation of the obtained curve

**The obtained curve is St. line of equation $U = aI + b$; where a is the slope and b is y intercept**

$$a = \frac{U_2 - U_1}{I_2 - I_1}$$

$$a = \frac{5 - 3}{(0 - 400) \div 1000}$$

$$a = \frac{2}{-0.4} \Rightarrow a = -5\ V/A$$



# Current – Voltage characteristic of a Generator

## 3. Determine the equation of the obtained curve

$U = aI + b$ ⇨ $U = -5I + b$

$b$ is y-intercept ⇨ $b = 5$

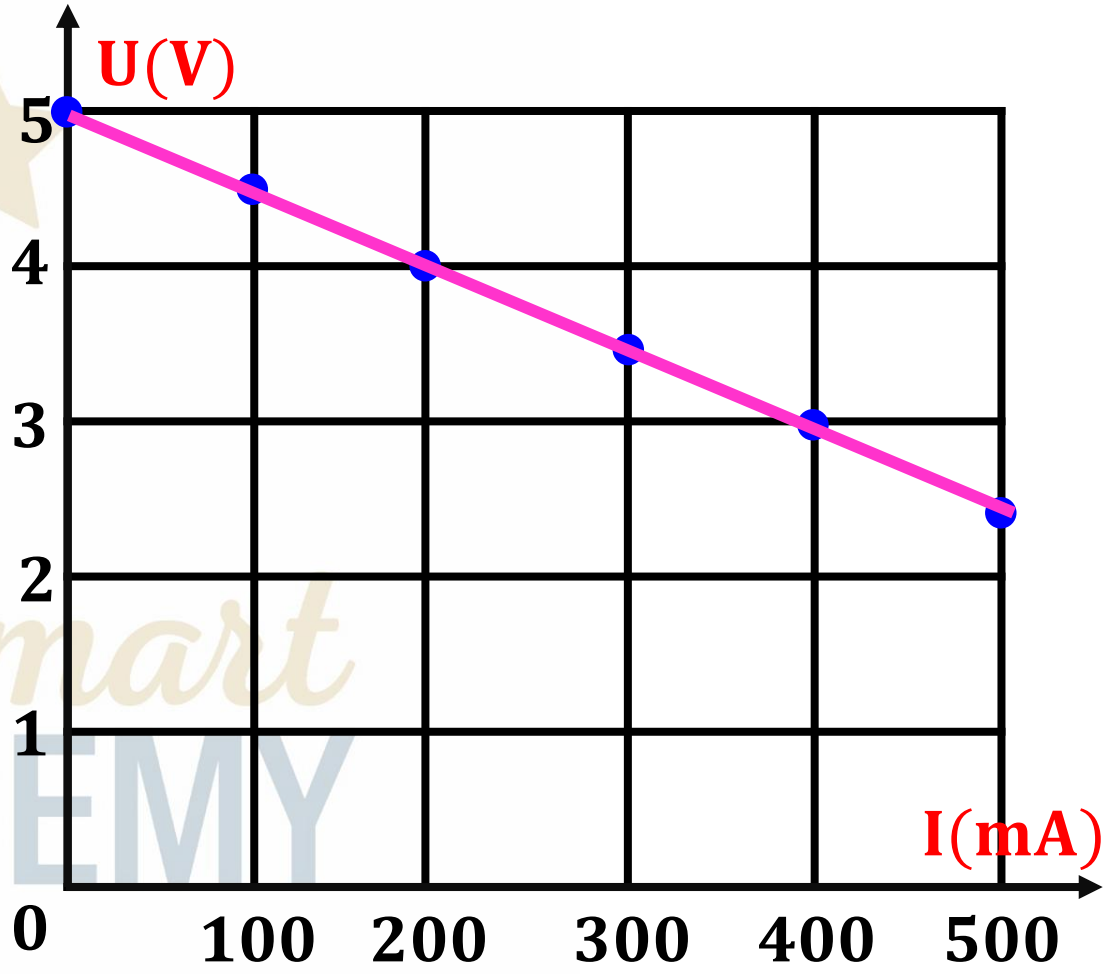
Substitute $(100mA;\ 4.5V)$ in the line equation: $U = -5I + b$

$$4.5 = -5(100 \div 1000) + b$$

$$4.5 = -5 \times 0.1 + b$$

$$4.5 = -0.5 + b$$

$$b = 5V$$




$$U = -4I + 5$$

# Current – Voltage characteristic of a Generator

**4.Deduce the electromotive force E and the internal resistance r of the generator**

**The equation of the obtained St. line** $U = -5I + 5$

**Ohm's law of the generator is** $U = -r.I + E$

**Compare the two equations to get:**

$-5 = -r$ ⇒ $r = 5\Omega$

$E = 5V$

# Be Smart Academy

# Physics – Grade 10

## Unit One – Electricity


## Chapter 5
## Generator and Receiver



Prepared & Presented by: Mr. Mohamad Seif

# OBJECTIVES

1. Define the receiver
2. Current – Voltage characteristic of a receiver

# Definition of a receiver

**Receiver is an electric device that converts the consumed electric energy into other forms of energy**

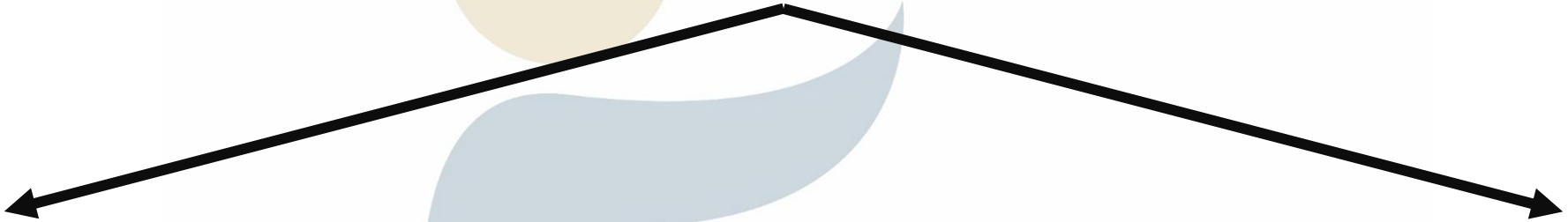
**Electric motor: electric motor converts electric energy to mechanical energy and thermal energy.**

**Fan: fan converts electric energy to mechanical energy and thermal energy.**

# Definition of a receiver

**A receiver can be represented by (E′; r’)**

**(E′; r’)**



**Back electromotive force, in [V]**

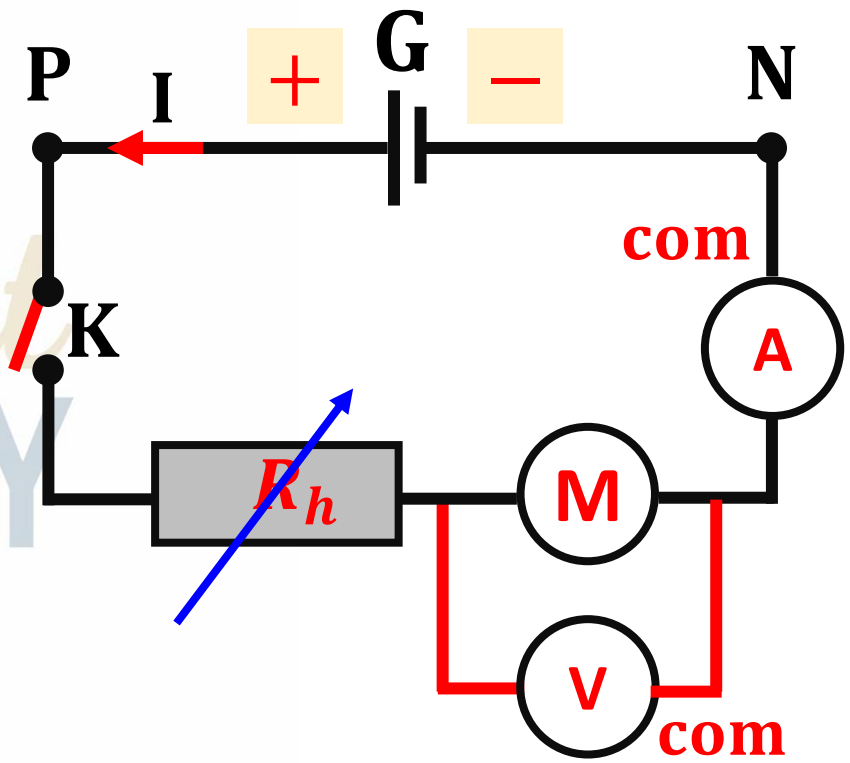
**The minimum voltage needed by the receiver to operate.**

**Internal resistance, in [Ω]**

**That causes the heating of the receiver while functioning due to Joule's effect.**

# Current – Voltage characteristic of a receiver

Set up the following electric circuit that consists of a generator G, rheostat ( $R_h$ ), electric motor (M), voltmeter, ammeter, connecting wires and switch k.




**When the switch (K) is opened:**

The ammeter and the voltmeter indicate zero values.

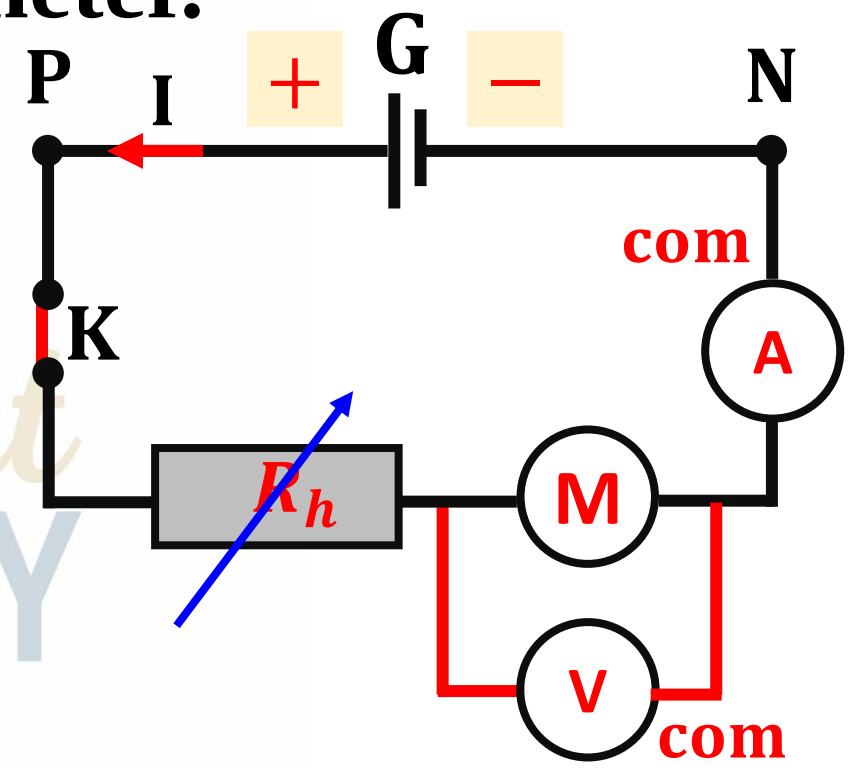
# Current – Voltage characteristic of a receiver

## When the switch (K) is closed:

**Give the rheostat's cursor different positions; then record the indications of the voltmeter and the Ammeter.**

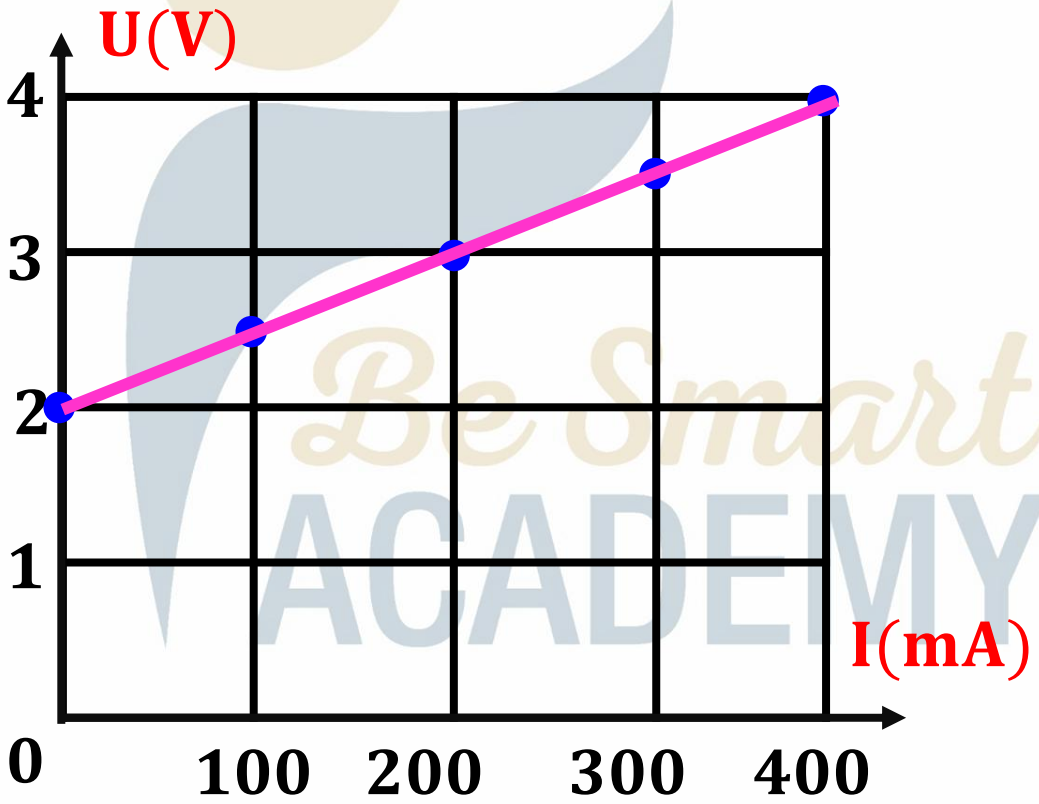
**The results are arranged in the following table:**

| I(mA) | 0 | 100 | 200 | 300 | 400 | 500 |
|---|---|---|---|---|---|---|
| U(V) | 3 | 3.5 | 4 | 4.5 | 5 | 5.5 |



# Current – Voltage characteristic of a receiver

| I(mA) | 0 | 100 | 200 | 300 | 400 |
|---|---|---|---|---|---|
| U(V) | 2 | 2.5 | 3 | 3.5 | 4 |



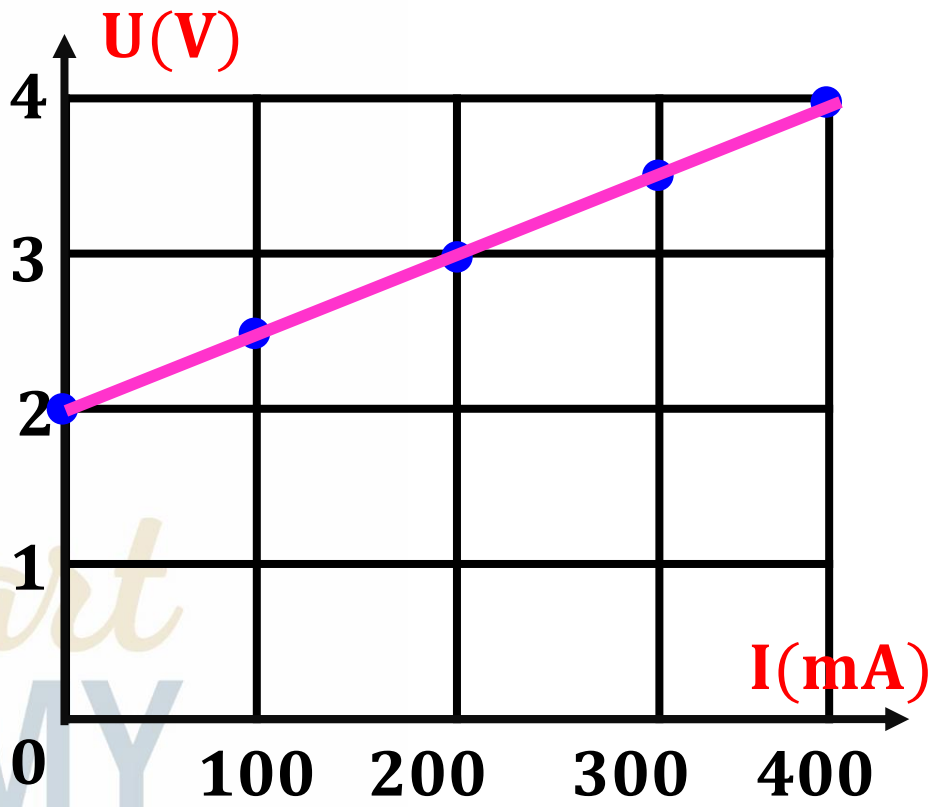
# Current – Voltage characteristic of a receiver

We obtain a straight Line of positive slope and NOT passing through the origin.

This straight Line is called the Current-voltage Characteristic of the Receiver.

The equation of this straight line is:

$$U = aI + b$$




$a$: is the slope of the straight line.

$b$: is a constant, y- intercept.

# Current – Voltage characteristic of a receiver

## Ohm's law of receiver:

$$U = r'I + E'$$

**By comparing the equation of St. line with ohm's law**

$$U = a.I + b$$

$$U = r'I + E'$$

$$a = r' \quad \text{And} \quad b = E'$$

# Current – Voltage characteristic of a receiver

## Application 3:

**To determine the characteristic values of a of an active load (D), we connect it, in series with a rheostat and a generator G. An ammeter used to measure the electric current in the circuit and a voltmeter is connected across the terminals of the load D to record its voltage.**

**When we close the switch k, and we move the the cursor of the rheostat, the different values U and I are recorded in the table below.**

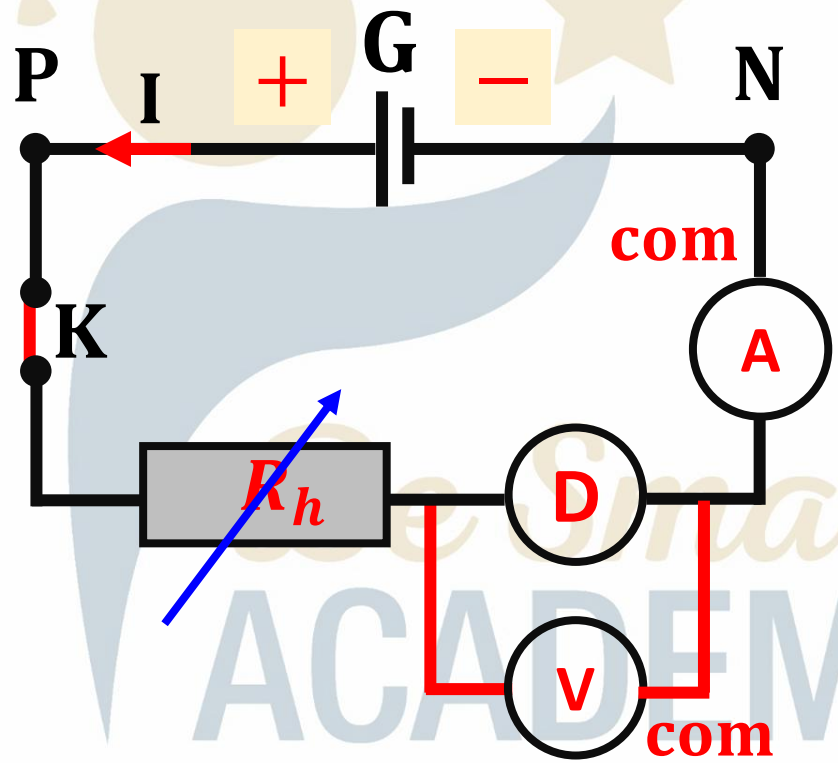
# Current – Voltage characteristic of a receiver

| I(mA) | 0 | 50 | 100 | 150 | 200 |
|---|---|---|---|---|---|
| U(V) | 2 | 3 | 4 | 5 | 6 |

1. Draw a diagram to represent the circuit of the experiment.
2. Draw the graph representing the voltage U as a function of the current I.
3. What is the shape of the obtained graph. Deduce the nature of the load (D).
4. Find the equation of the given straight line.
5. Determine the values of the characteristics of the load (D).

# Current – Voltage characteristic of a receiver

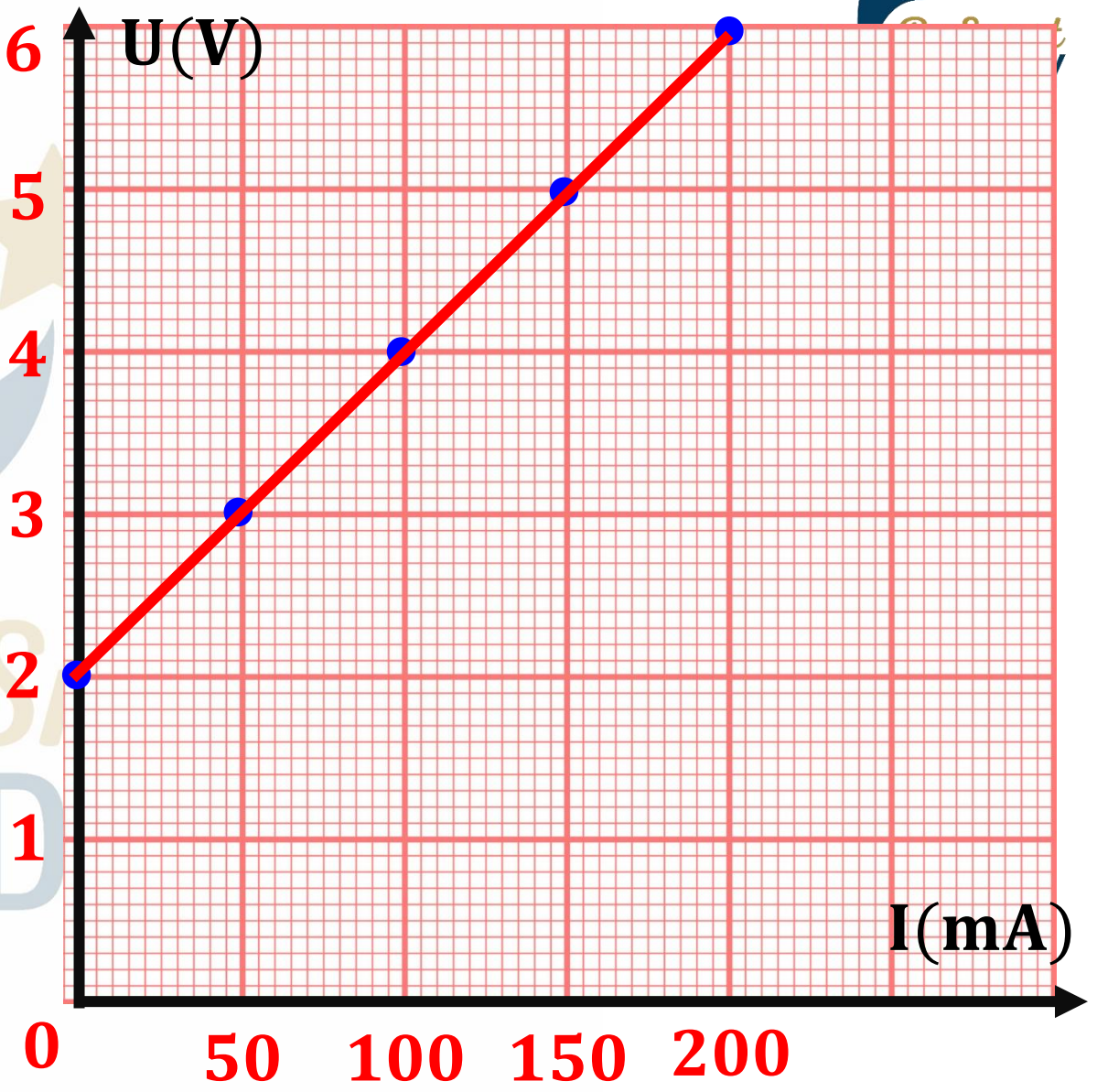
1.Draw a diagram to represent the circuit of the experiment.



# Current – Voltage characteristic of a receiver

2.Draw the graph representing the voltage U as a function of the current I.

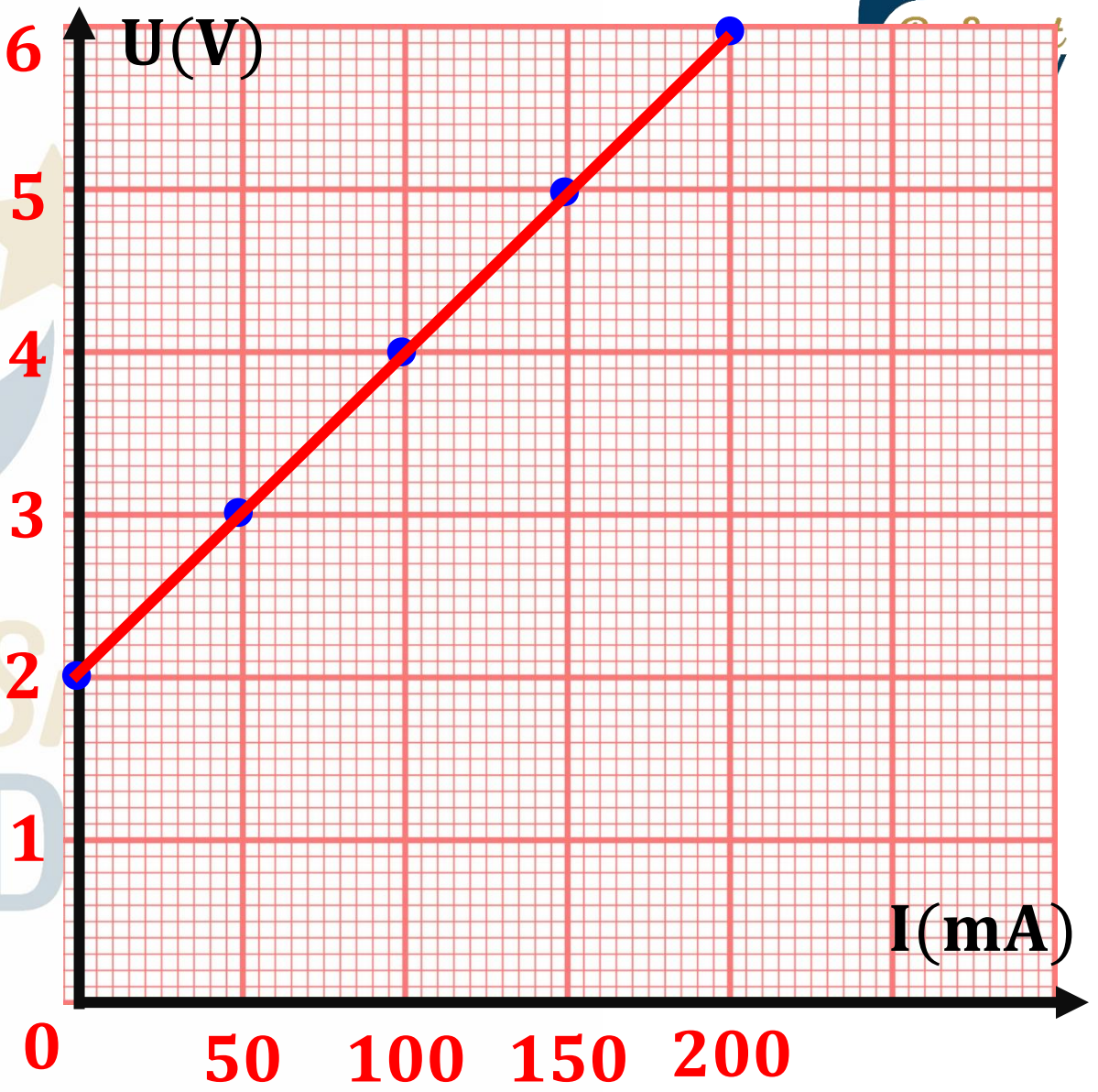
| I(mA) | 0 | 50 | 100 | 150 | 200 |
|---|---|---|---|---|---|
| U(V) | 2 | 3 | 4 | 5 | 6 |



# Current – Voltage characteristic of a receiver

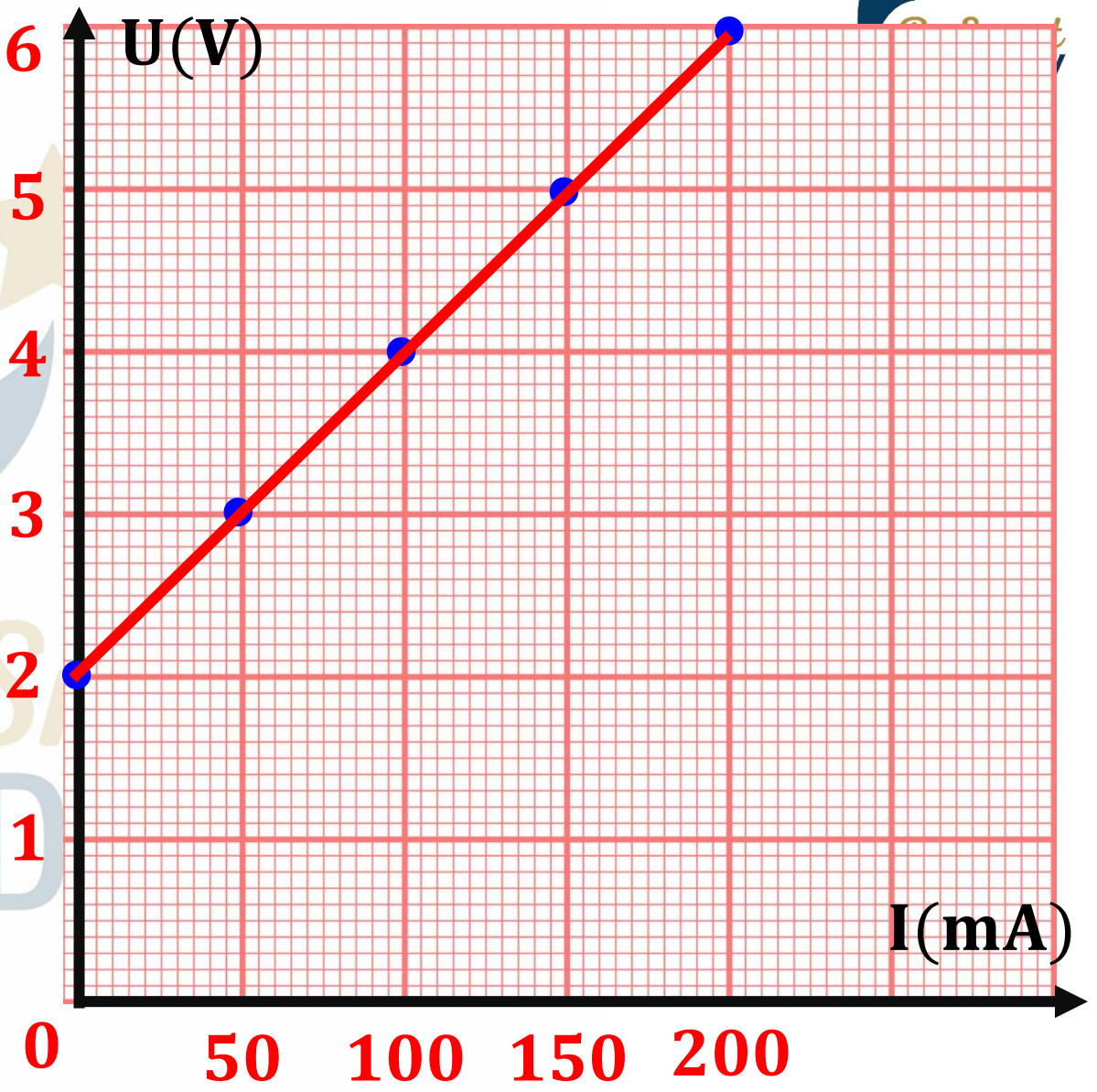
3. What is the shape of the obtained graph. Deduce the nature of the load (D).

The obtained graph is a St. line of positive slope and not passing through the origin.
(D) is a receiver, since its graph is a St. line of positive slope and not passing through the origin.



# Current – Voltage characteristic of a receiver

**4. Find the equation of the given straight line.**




**The equation of the St. line is:**

$$U = aI + b$$

$$slope = a = \frac{U_2 - U_1}{I_2 - I_1}$$

$$a = \frac{5 - 3}{(150 - 50) \div 1000}$$

$$a = \frac{2}{0.1} = 20V/A$$

# Current – Voltage characteristic of a receiver

$$a = 20V/A$$

$$U = 20I + b$$

b: is y-intercept then $b = 2$

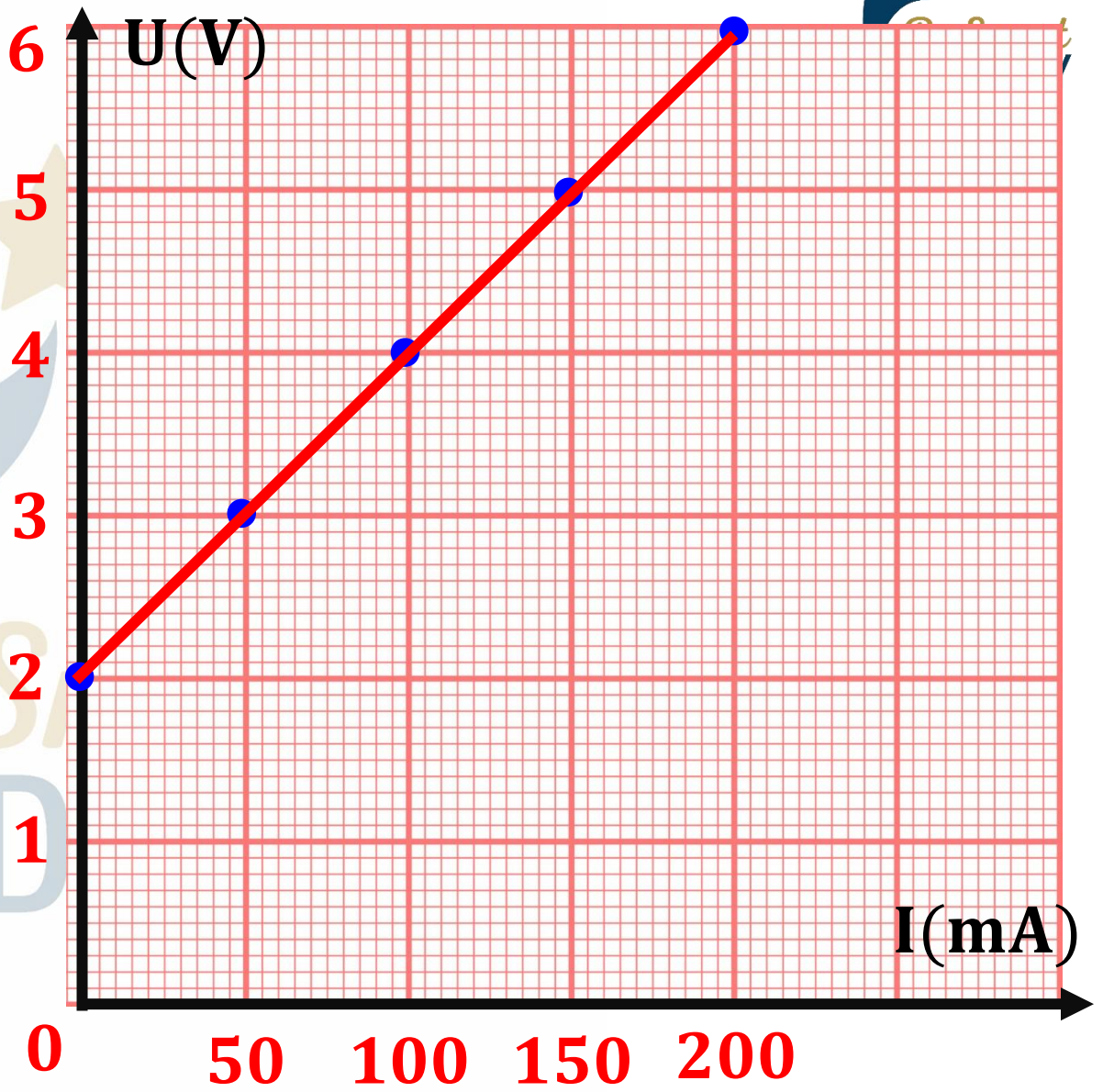
Substitute $(50mA;\ 3V)$ in the equation: $U = 20I + b$

$$3 = 20 \times (50 \div 1000) + b$$

$$3 = 20 \times (0.05) + b$$

$$3 = 1 + b \quad \Rightarrow \quad b = 2$$

$$U = 20I + 2$$



# Current – Voltage characteristic of a receiver

5. Determine the values of the characteristics of the load (D).

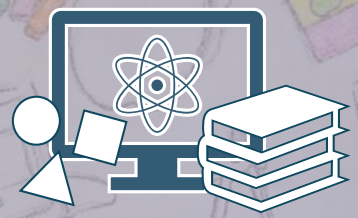
St. line: $U = 20I + 2$ Ohm's law is $U = r'I + E'$

Compare the two equations:

$$r' = 20\Omega$$

$$E' = 2V$$

# The End



# Physics – Grade 10

## Unit One – Electricity


## Chapter 5
## Generator and Receiver



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# OBJECTIVES

1. Power consumed by a Receiver
2. The efficiency of a motor

# Power consumed by a Receiver

The expression of consumed power by receiver is:

$$P = V \times I$$

But the voltage of a receiver is:

$$V = r'.I + E'$$

Then:

$$P = (r'I + E') \times I$$

$$\boxed{P = r'.I^2 + E'.I}$$

The power dissipated (lost) by the receiver due to Joule's effect:

$$P_{dis} = r'.I^2$$

The useful power delivered by the receiver:

$$P_{useful} = E'I$$

$$\boxed{P_{consumed} = P_{dis} + P_{useful}}$$

# Power consumed by a Receiver

## Blocked motor:

The voltage across a receiver is:

$$V = r'I + E'$$

**For a blocked motor:**

$$E' = 0V$$

$$V = r'I + E'$$

$$V = r'I$$

In this case the motor acts as a pure resistor.

# The efficiency of a motor

**The efficiency of a motor:**

$$\rho = \frac{p_{out}}{P_{in}} \times 100$$

$$\rho = \frac{P_{useful}}{P_{consumed}} \times 100$$

$$\rho = \frac{E'I}{V \times I}$$

$$\rho = \frac{E'}{V} \times 100$$

$E'$: back electromotive force of a receiver

V: voltage across the terminals of the receiver.

# Power consumed by a Receiver

## Application 4:

**An electric motor M is characterized by M( $8V$; $2\Omega$).**

**The motor M receives a current $I = 3A$ during its normal function.**

1. **Calculate the power lost by the motor.**
2. **Calculate the power used by the motor.**
3. **Deduce the power consumed by the motor.**
4. **Determine the efficiency of this motor**

# Power consumed by a Receiver

**M( $8V$; $2\Omega$); $I = 3A$**

1. Calculate the power lost by the motor.

$$P_{lost} = r' I^2$$

$$P_{lost} = 2 \times (3)^2$$

$$P_{lost} = 18 \text{ Watt}$$

2. Calculate the power used by the motor.

$$P_{used} = E' . I$$

$$P_{used} = 8 \times 3$$

$$P_{used} = 24 \text{ Watt}$$

# Power consumed by a Receiver

**M( $8V$; $2\Omega$); $I = 3A$**

**3. Deduce the power consumed by the motor**

$$P_{consumed} = P_{lost} + P_{used}$$

$$P_{consumed} = 18 + 24$$

$$P_{consumed} = 42 \text{ Watt}$$

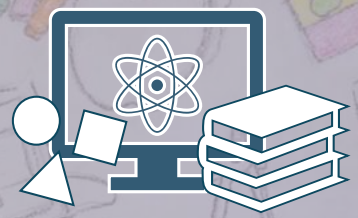
**4. Determine the efficiency of this motor**

$$\rho = \frac{P_{useful}}{P_{consumed}} \times 100$$

$$\rho = \frac{24}{42} \times 100$$

$$\rho = 57.14\%$$

# The End



# Physics – Grade 10

## Unit One – Electricity


## Chapter 5
## Generator and Receiver



Prepared & Presented by: Mr. Mohamad Seif

# OBJECTIVES

1. Generators in series
2. Generators in opposition

# Generators in series

The positive pole of $G_1(E_1; r_1)$ is connected to the negative pole of $G_2(E_2; r_2)$ then:

Both $G_1$ and $G_2$ act as a generator G(E; r), where:

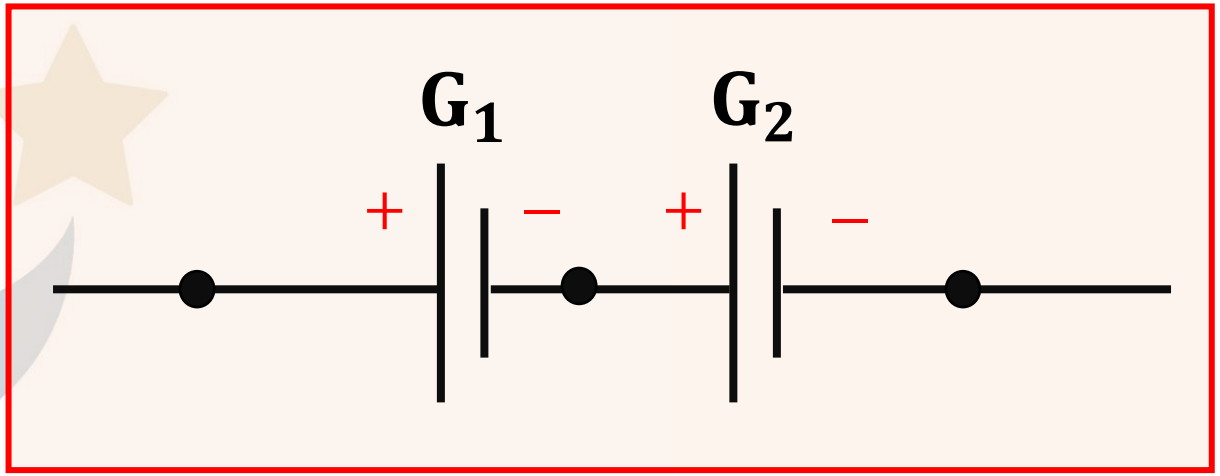
$$E = E_1 + E_2 \quad \text{and} \quad r = r_1 + r_2$$

# Generators in series

## Application 5:

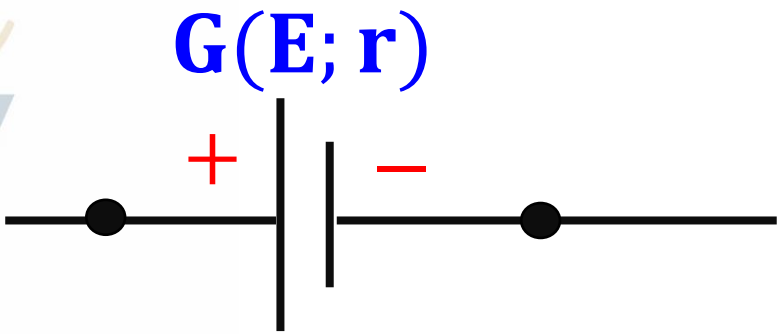
Consider two generators $G_1(5V; 1\Omega)$ and $G_2(8V; 2\Omega)$ connected as shown in the figure.

Identify the role of each one




**Both $G_1$ and $G_2$ acts as generators, since the negative pole of $G_1$ connected to positive pole of $G_2$**

**$G_1$ and $G_2$ can be replaced by G such that:**

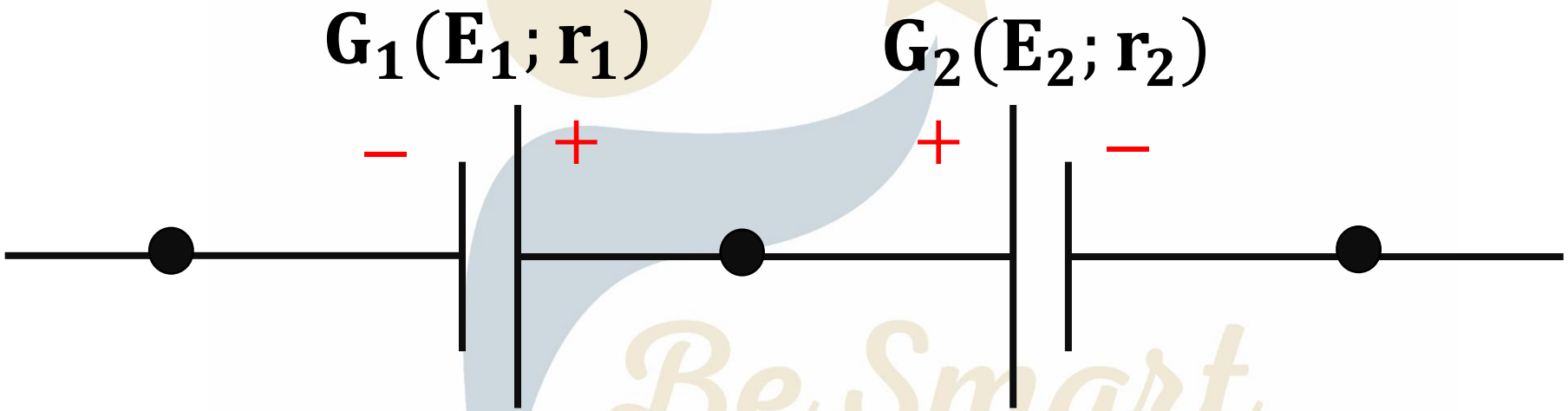



$$E = E_1 + E_2 \Rightarrow E = 5V + 8V \Rightarrow E = 13V$$

$$r = r_1 + r_2 \Rightarrow r = 1\Omega + 2\Omega \Rightarrow r = 3\Omega$$

# Generators in opposition

The positive pole of $G_1(E_1; r_1)$ is connected to the positive pole of $G_2(E_1; r_1)$ then:



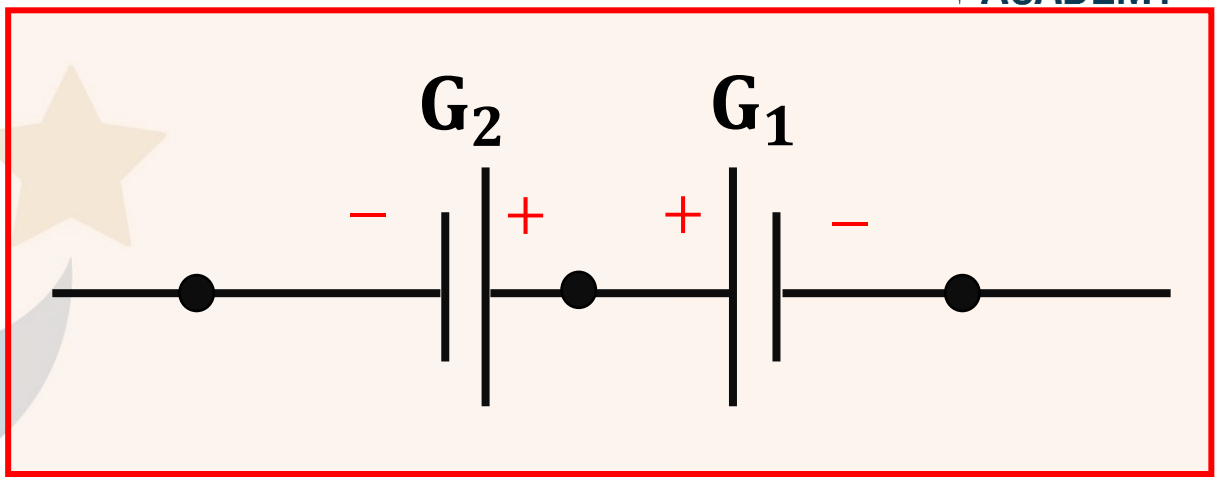

Then, the generator with higher electromotive force acts as a generator while the other acts as a receiver

# Generators in opposition

## Application 6:

Consider two generators $G_1(11V; 1\Omega)$ and $G_2(5V; 2\Omega)$ connected as shown in the figure.

Identify the role of each one




**The positive pole of $G_1$ is connected to positive pole of $G_2$:**

**The one with higher electromotive force acts as generator, while the other acts as receiver**

**Since $E_1 = 11V > E_2 = 5V$:**

**Then $G_1$ acts as a generator and $G_1$ acts as a receiver**

# The End