# 2nd Year Physics

# Chapter # 18

# Electronics



**Written by:**

**Mr. Shahroze Saleem**

**M. Phil (Physics), B. Ed.**

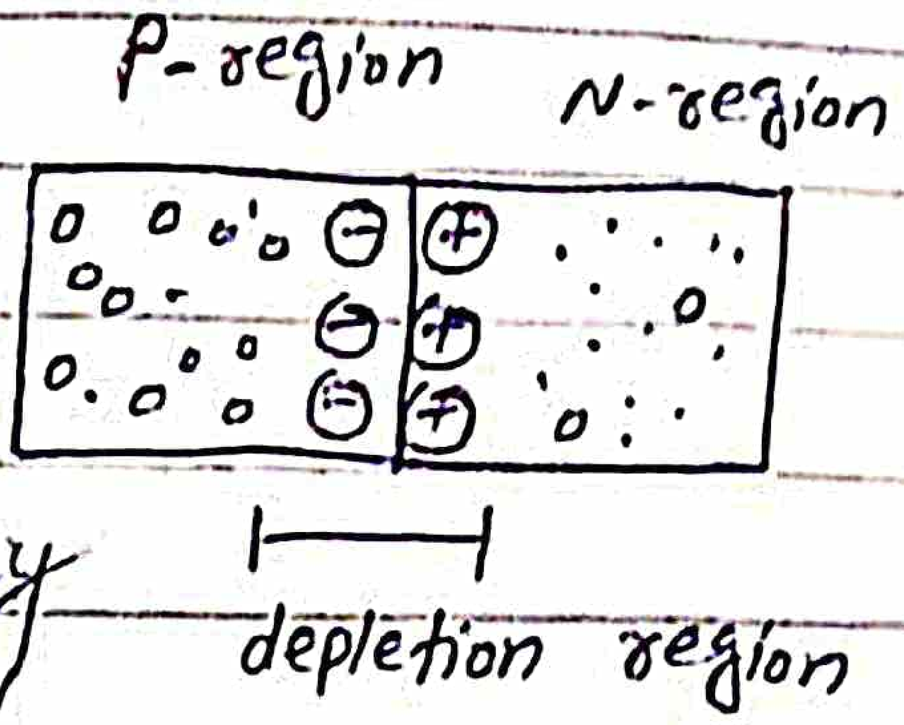
**Lecturer, Chenab College Jhang.**

# Ch#18

# Electronics

## PN Junction:

A p-n junction is formed when the crystal of germanium and silicon is grown in such a way that is one half is doped with trivalent impurity and the other half with the pentavalent impurity. One of the most important building blocks of electronic devices is the p-n-junction. Its n-region contain free electrons as majority charge carrier and p-region contain holes as majority charge carrier.

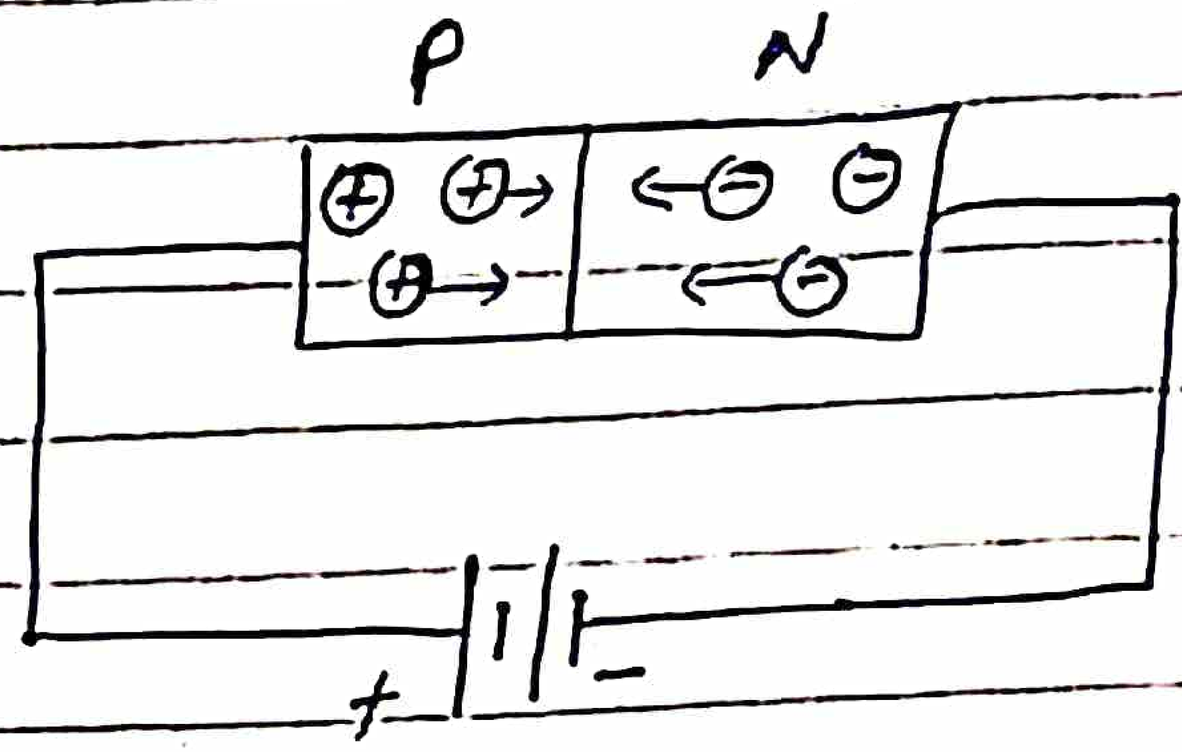



## Depletion region / Potential barrier.

Just after the formation of the junction the free electrons in the n-region because of their random motion diffuses into p-region as a result of this diffusion the region is formed around the junction in which charge carriers are not present called depletion region. Due to charge on the ion the P.D develops across the depletion region. Its value is 0.7V in case of Si, and 0.3V in case of Ge. This P.D is called potential barrier.

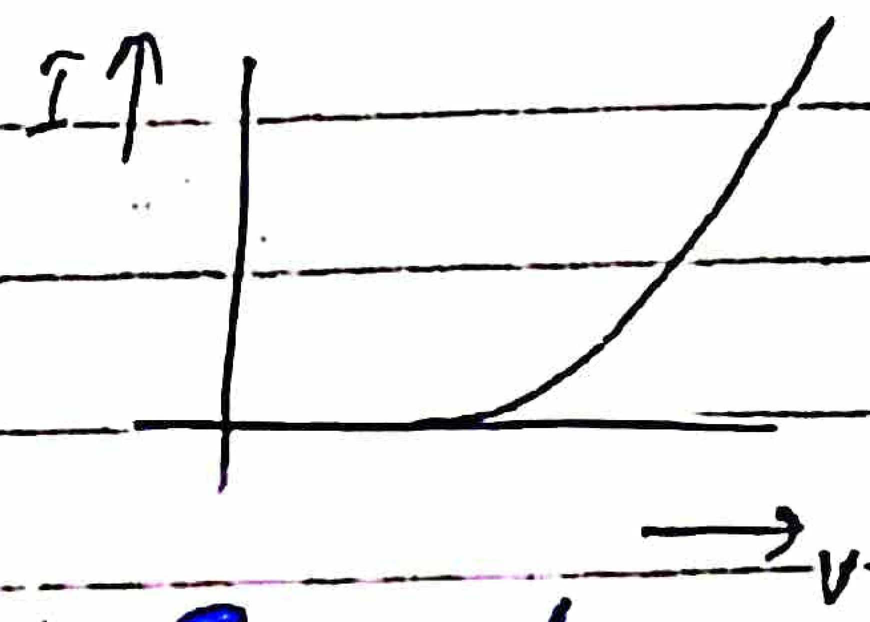
## Forward Biased PN Junction:

When the P-type of PN-junction is connected to the positive terminal of battery and N-type is connected to the negative terminal then this biasing is called forward biasing.




In the forward biasing, current flows due to majority charge carriers and called forward current. The resistance in this biasing is called forward resistance.

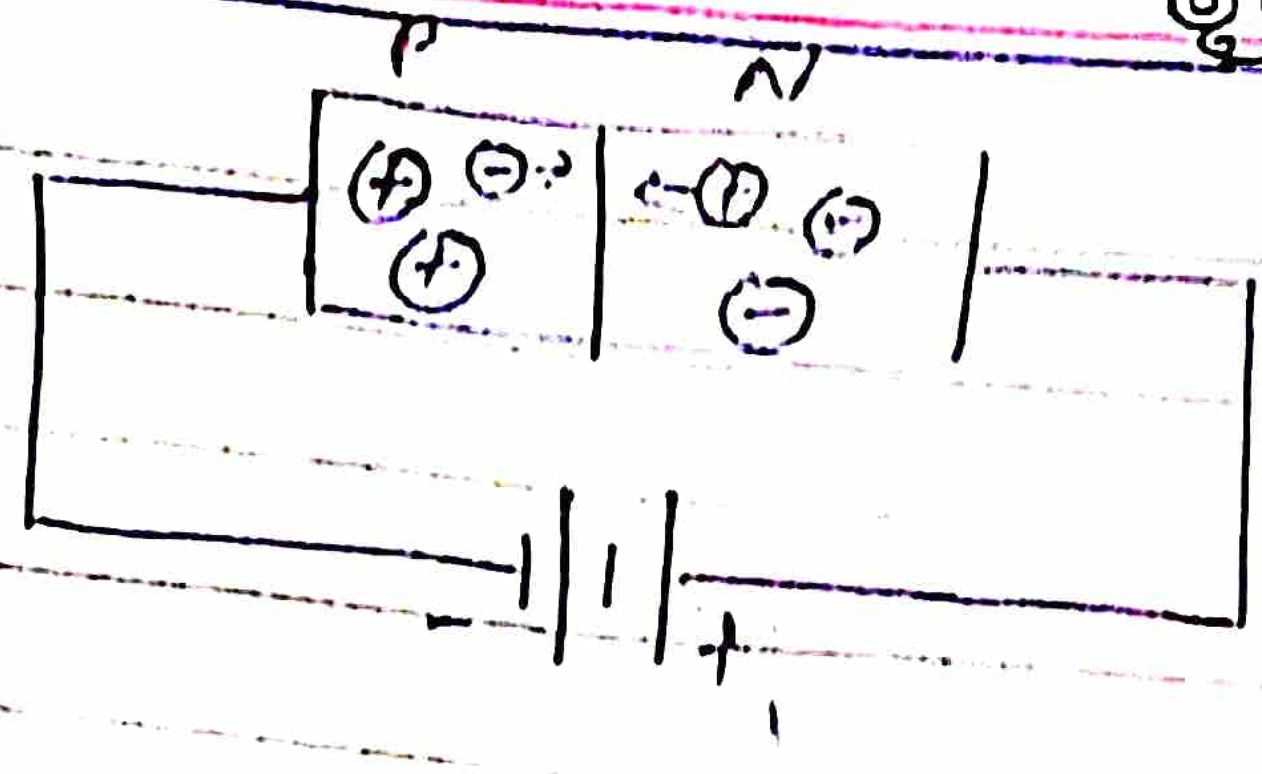
$$r_f = \frac{\Delta V_f}{\Delta I_f}$$



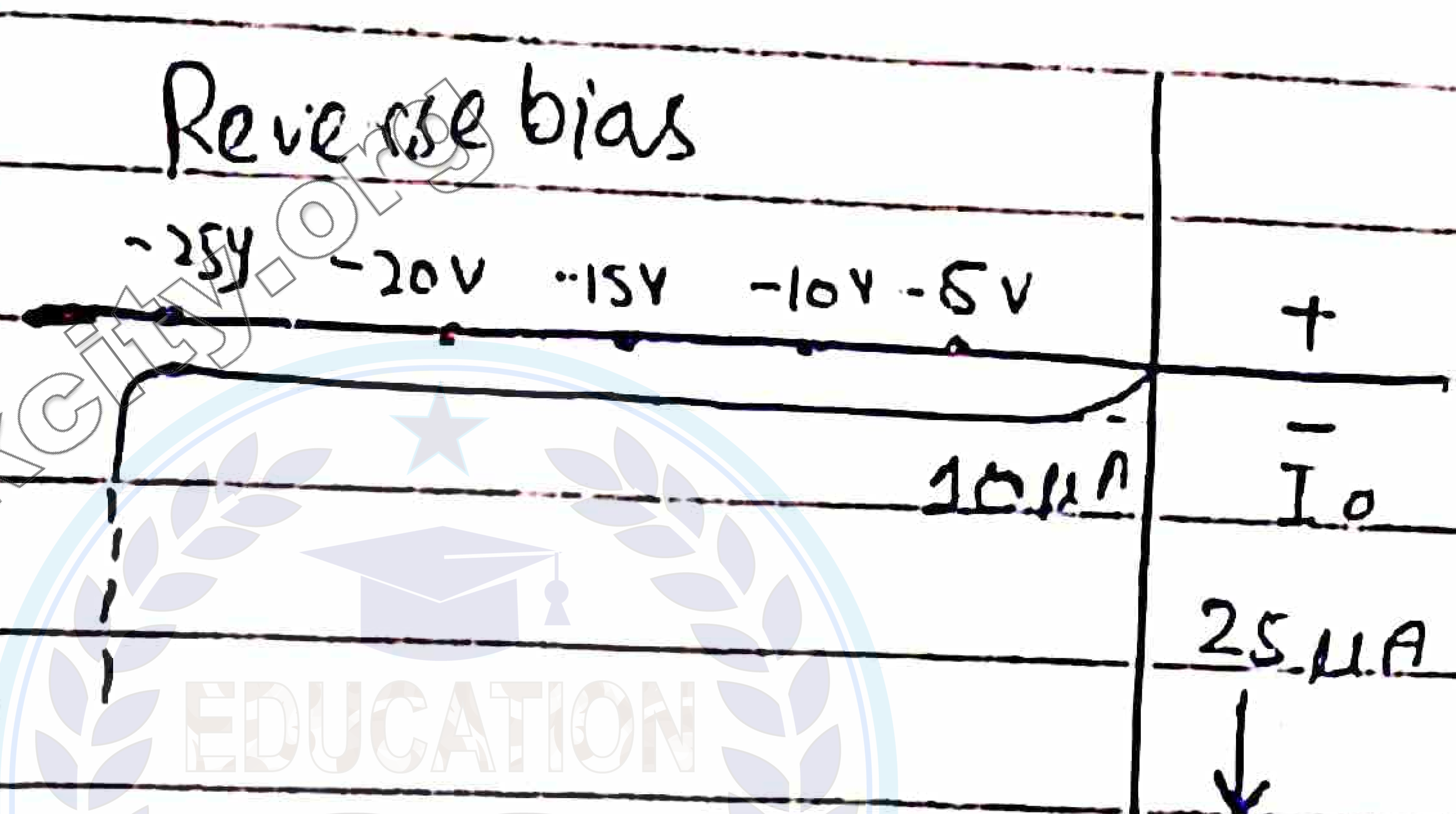

## Reverse Biased PN Junction:

When the P-type of PN-junction is connected to the negative terminal of battery and N-type is connected to the positive terminal then this biasing is called reverse biasing. In the reverse biasing, current flows due to minority charge carriers. and called reverse

current.
The resistance for reverse biasing is large of the order of several mega ohms.




## What will happen if the reverse voltage is increased?




As the reverse Voltage is increased, The kinetic energy of The minority chargo carrier with which They cross a depletion region also increases till it sufficent to break a covalent bond As The covalent bond breaks more electron-hole pair are Created Thus minority Charge Carriers begin to multiply due to which the reverse Current begin to increase till a point is reached when the junction breaks down and

reverse current raises sharply.
After breakdown the reverse current will rise to very high value which will damage the junction



## Rectification:

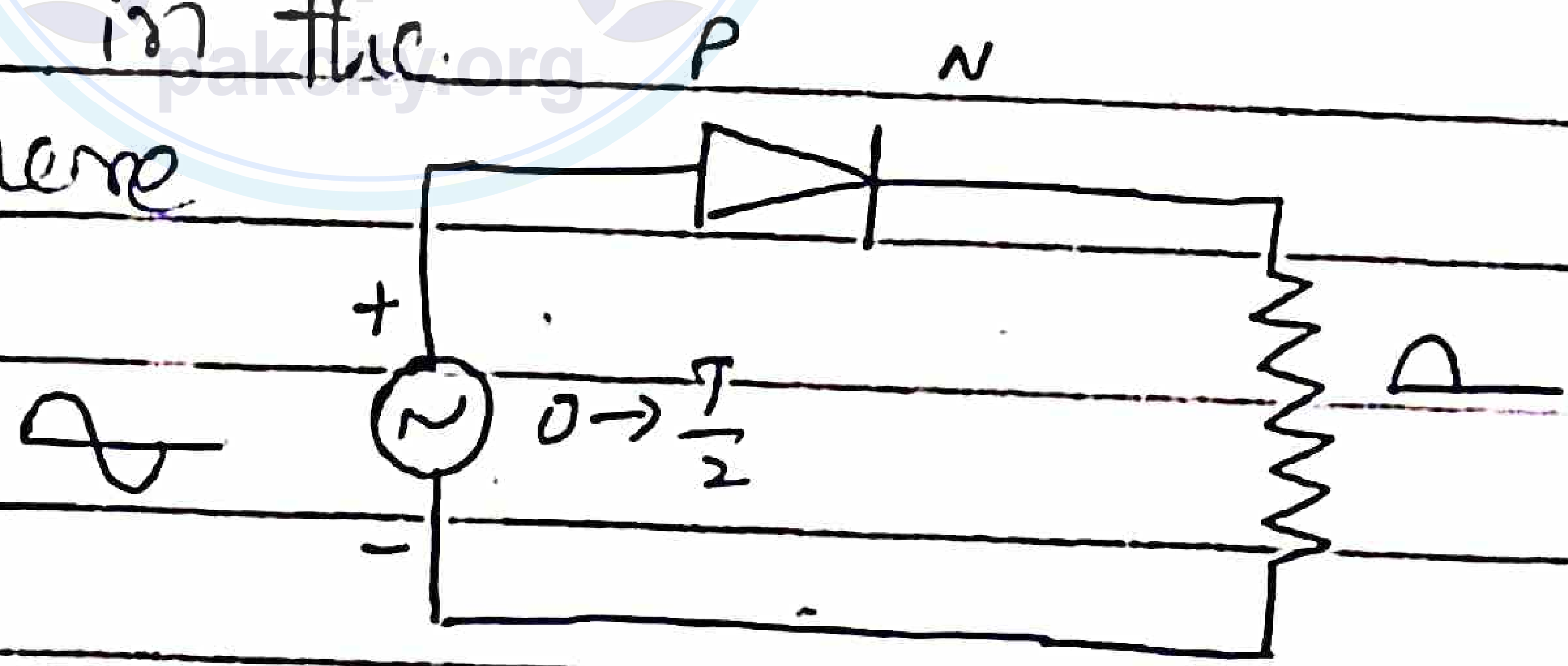
The process of converting alternating current into direct current is called rectification.

There are two common types of rectification.

i- Half wave rectification
ii- Full wave rectification

## i- Half Wave Rectification:

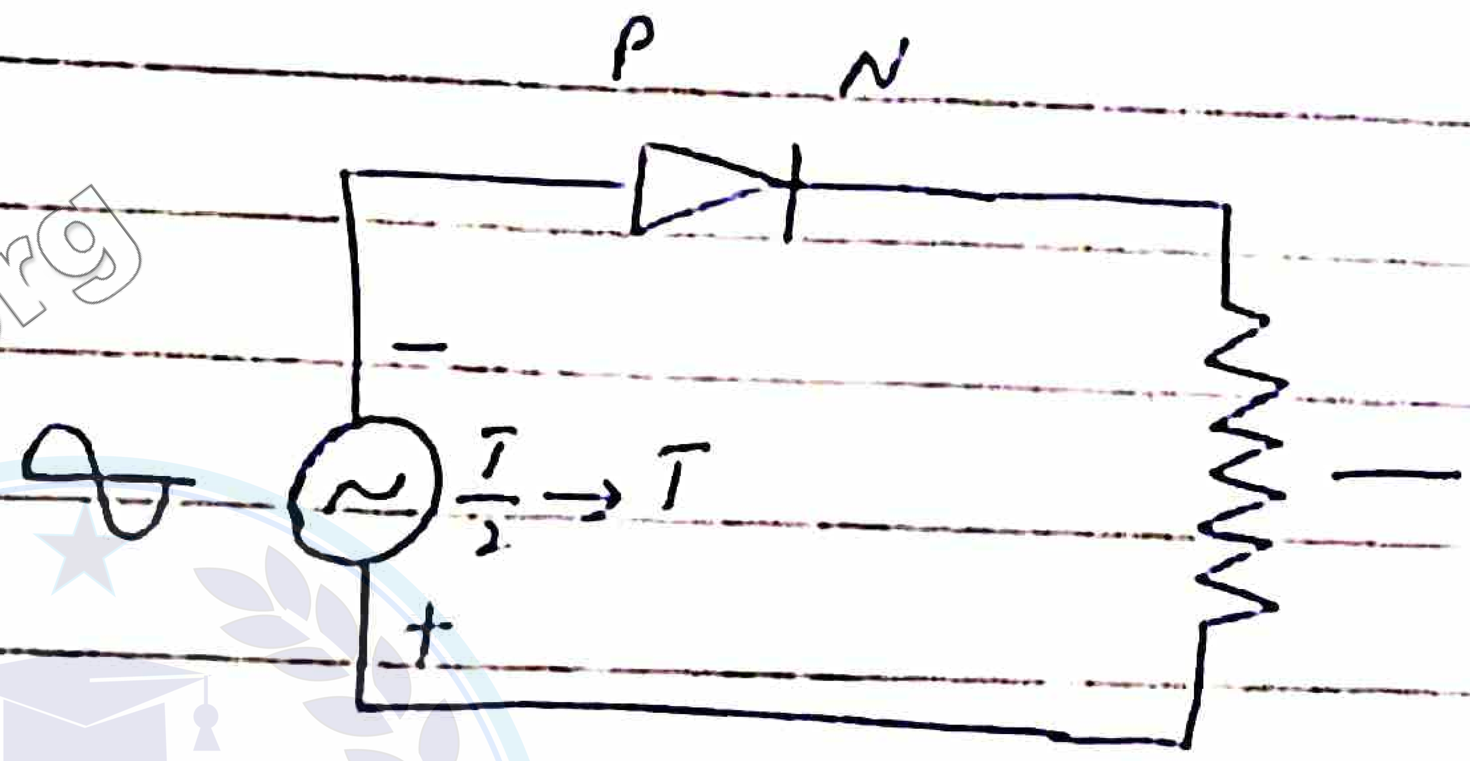
A half wave rectification is shown in the figure where an alternating voltage of period (T) called input voltage is applied to a diod D which is connected in series with a load resistance R causes a potential drop across it which varies in accordance with the alternating voltage.



## During the positive half cycle:

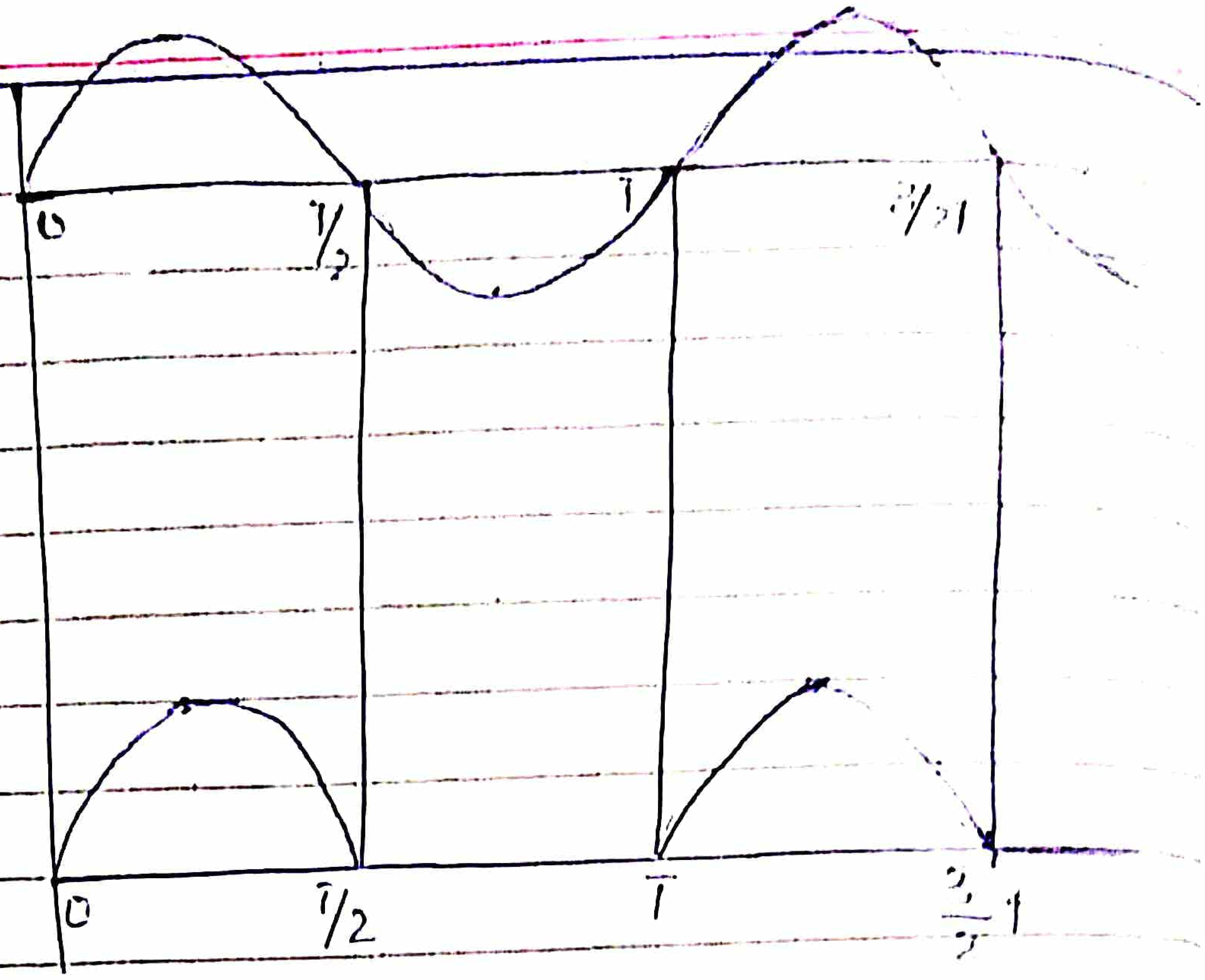
During the positive half cycle of the input alternating voltage i.e. during the interval $0 \to T/2$ the diod is forward bised so it offer a very low resistance and current flow through R. The flow of the current through R causes a potential drop across it which varies in accordance with the alternating input.

## During the negative half cycle:




During the negative half cycle i.e. during the period $T/2 \to T$, the diod is reverse bised. So, it offer a very high resistance. Practically no current flows through R and potential drop across it is almost zero.

⇒ The same event repeat during the next cycle and so on. The current through R flows in only one direction which means it is a direct current. However



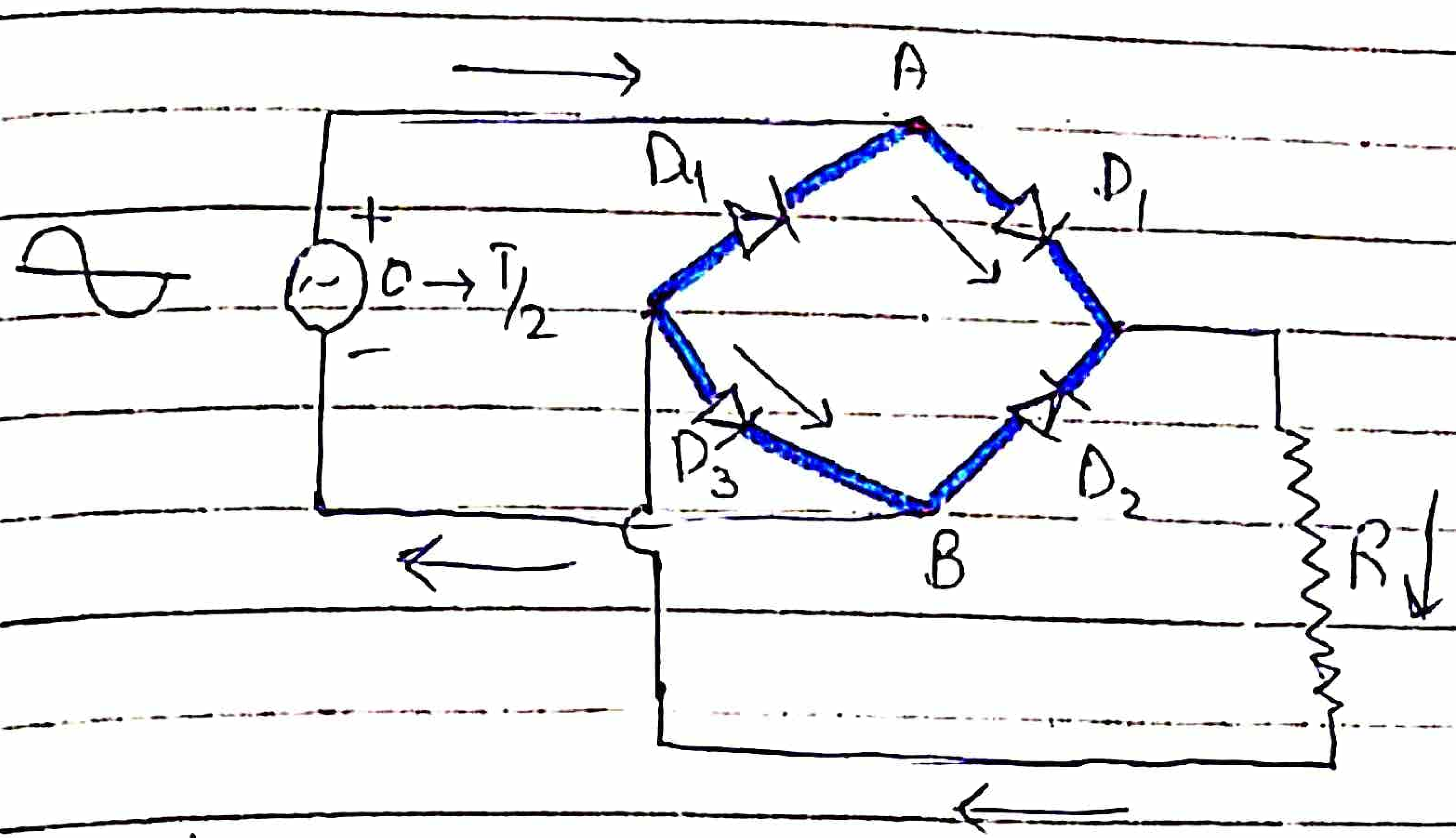

the current flows in pulses. The voltage which appears across load resistance R is known as output voltage.

## Full-wave Rectification:-

Both halves of the input voltage cycle can be utilized using full wave rectification. Its circuit consist of four diodes connected in a bridge type arrangement. To understand the operation of the circuit, recall that a diode conducts only when it is forward biased.

## During the positive half cycle:

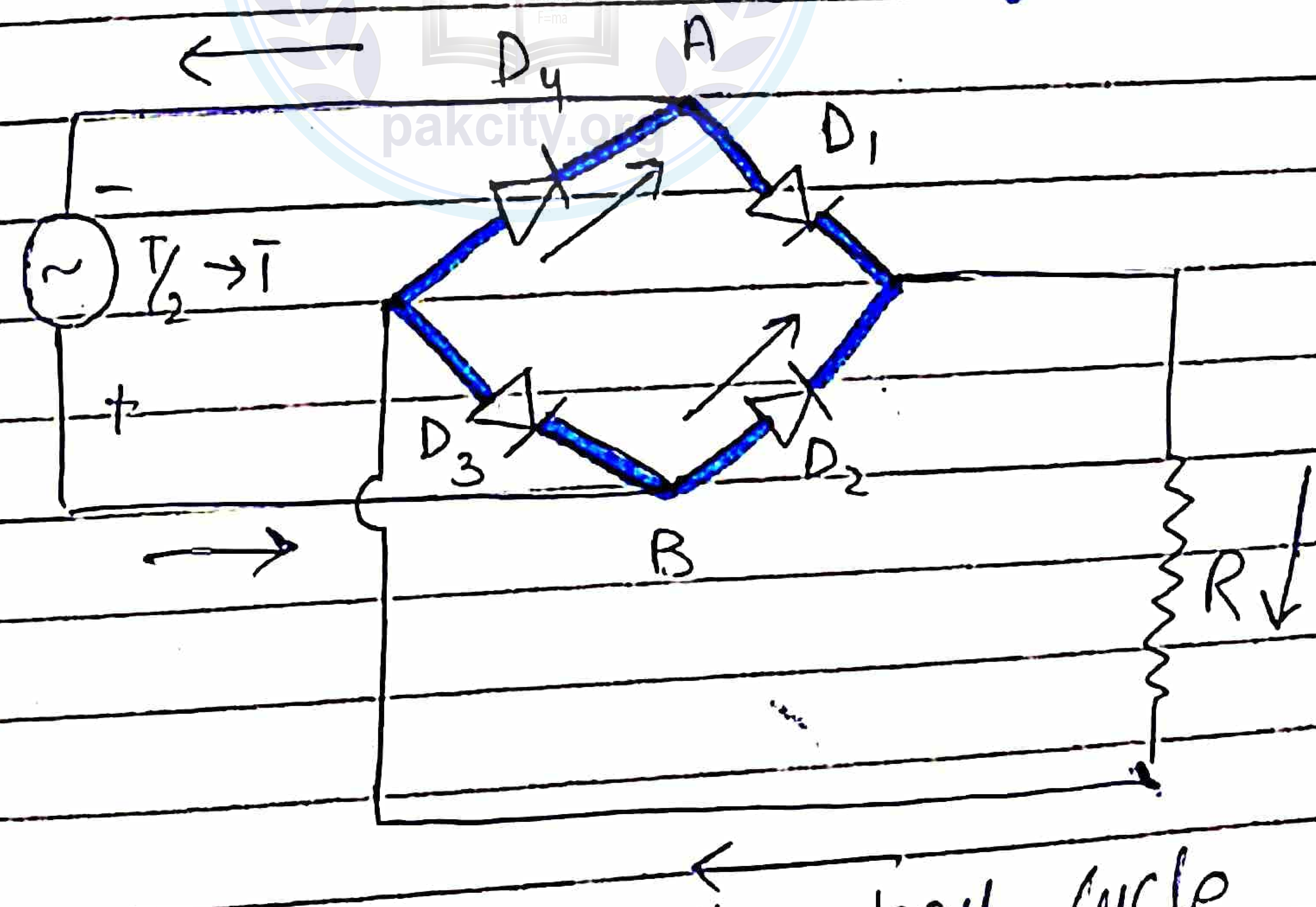
During the positive half cycle i.e: during the time 0 → T/2 the terminal A of the bridge is positive with respect to its other terminal B. Now the



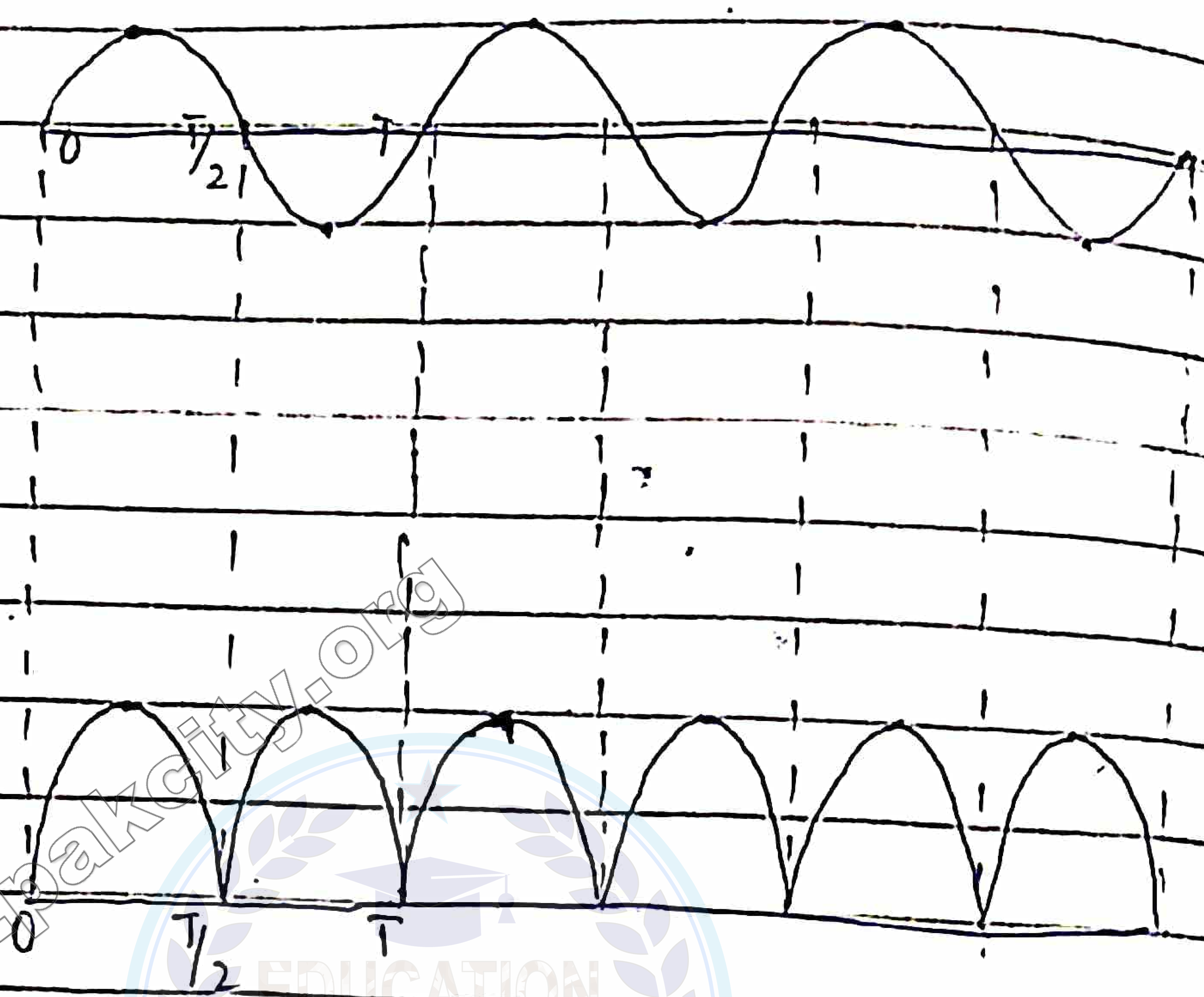

Diodes $D_1$ and $D_3$ become forward biased and conduct. A current flows through the circuit in the direction shown by an arrows.



## During the negative half cycle:




During the negative half cycle i.e: during the time interval $T/2 \rightarrow T$. Terminal A is negative and B is positive. Now the Diodes $D_4$ and $D_2$ conduct and current flows through the circuit in the path shown by the arrow.

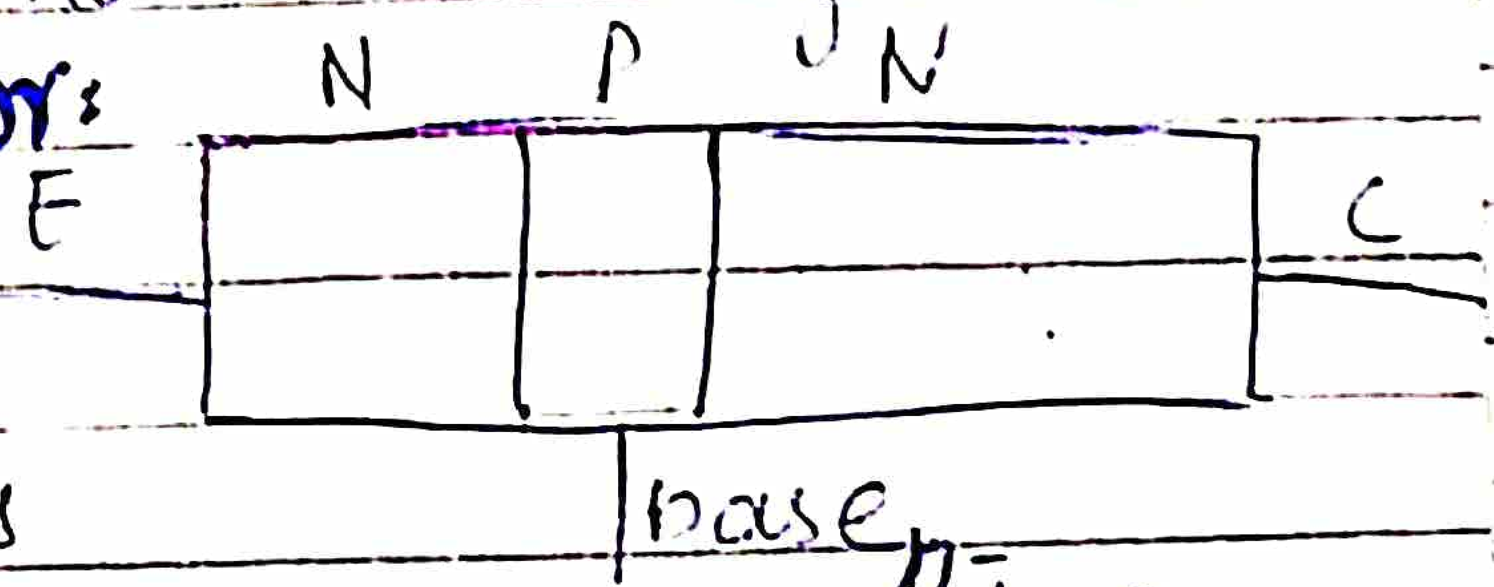



⇒ By comparing both the figures it can be seen that direction of the current flows through the load Resistance R is the same in both the halves of the cycle. Thus both halves of the alternating input voltage send a unidirectional current through R. The input and output voltage are shown in the fig. However the output voltage is not smooth but pulsating. It can be made smooth by using a circuit known as filter.

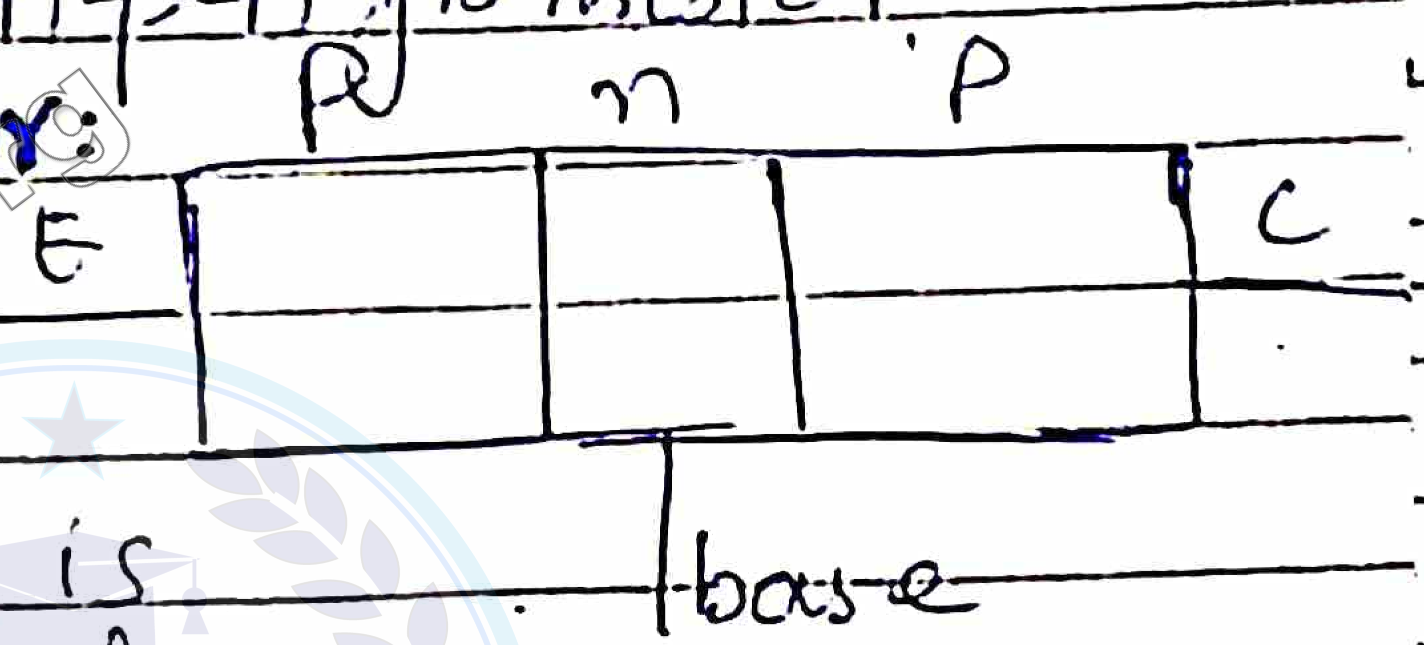
## Transistor.

**Defination:** A transistor consist of the single crystal of germanium or silicon which is grown in such a way that is has three regions.

**n-p-n transistor:** The central region is p-type which is sandwhiched between two p-type regions. called n-p-n transistor.



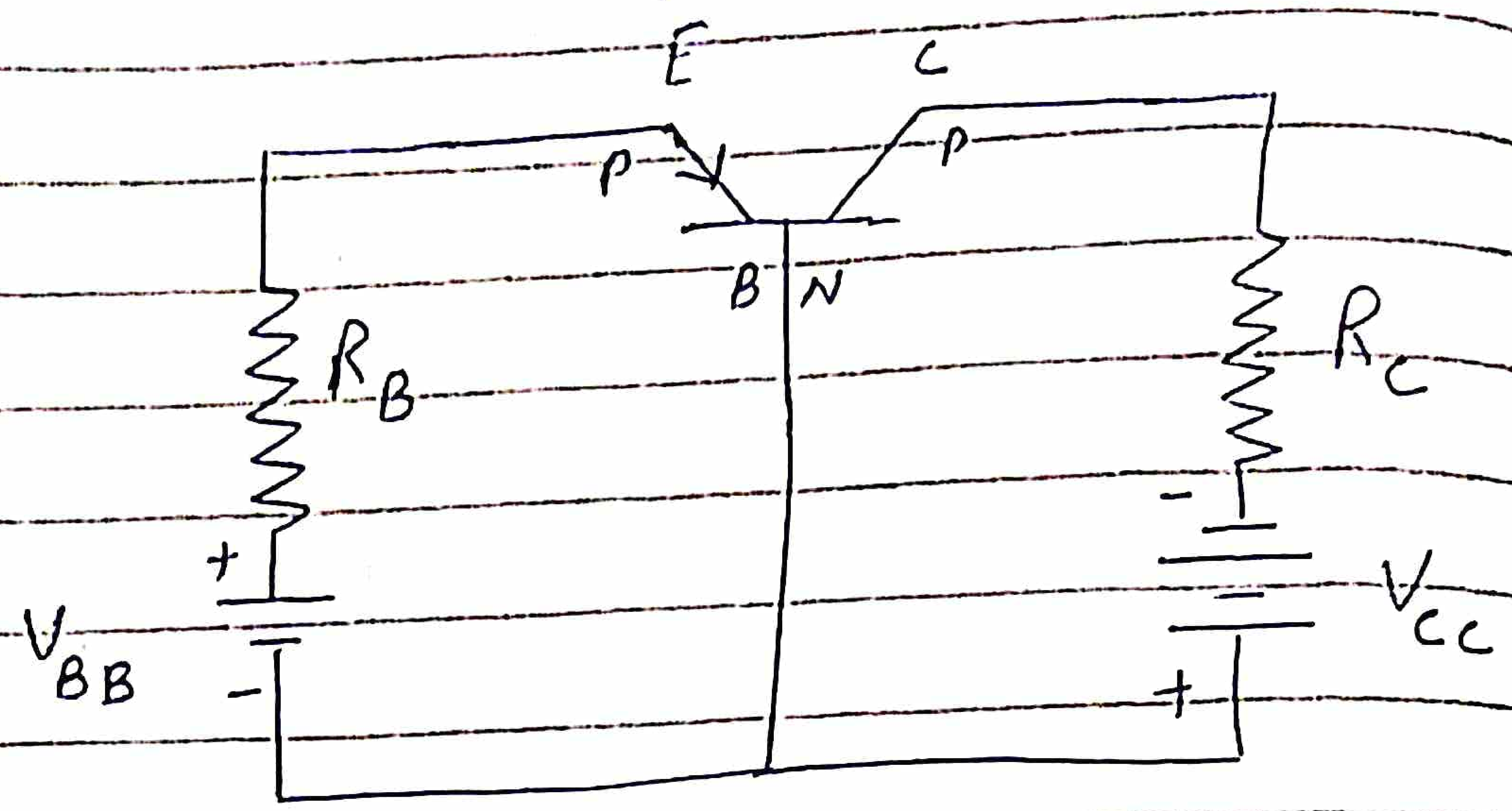

**p-n-p transistor:** The central region is n-region which is sandwhiched between two p-type regions called p-n-p transistor

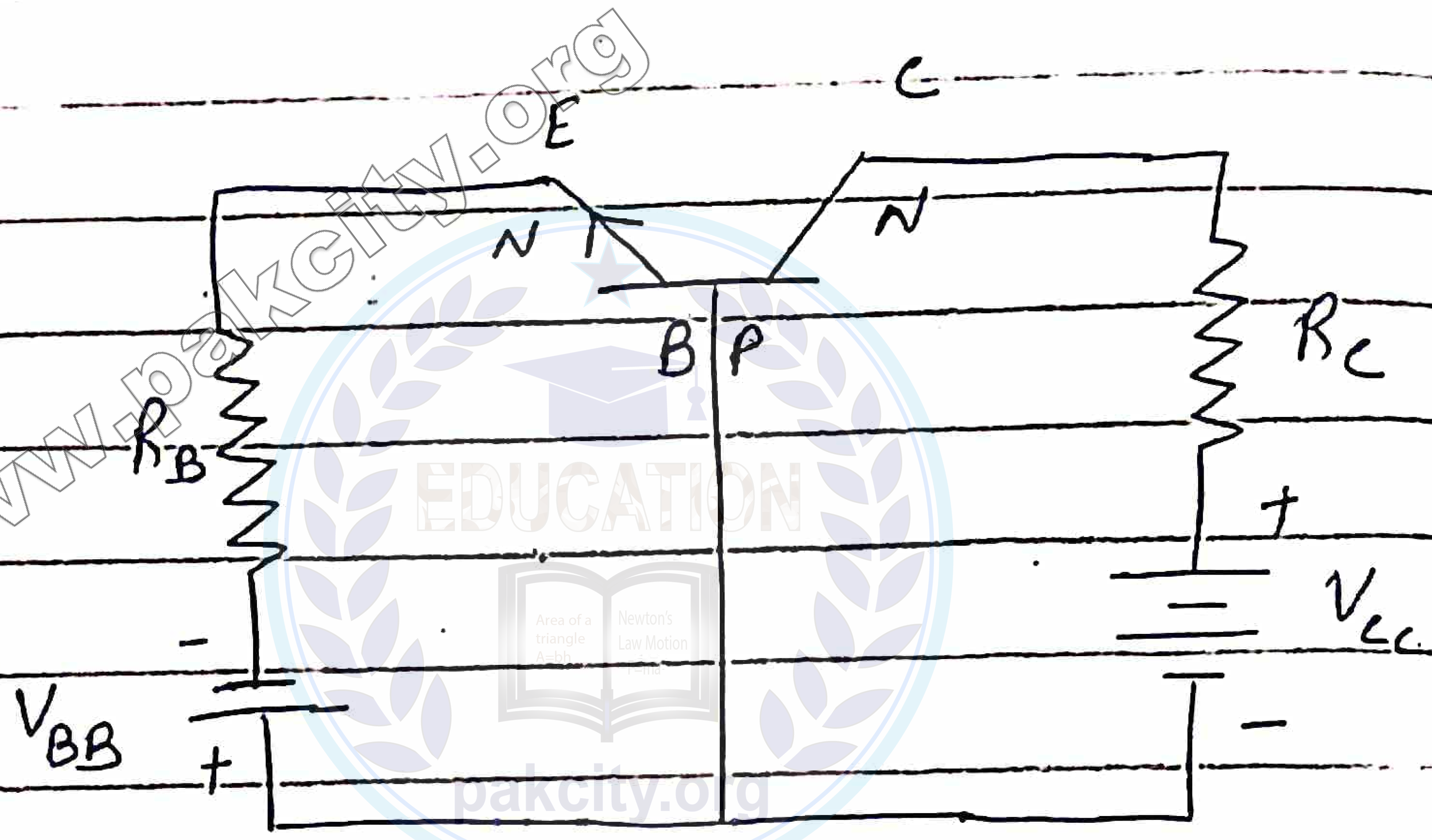





→ The central region is known as base and the other two regions called emmitter and collector usually the base is very thin of the order of $10^{-6}m$. The emmiiter and collector has greater concentration of impurity. The collector is comparitively larger then the emitter. The emitter has greater concentration of impurity as compared to the collector.

# Operation of transistor:



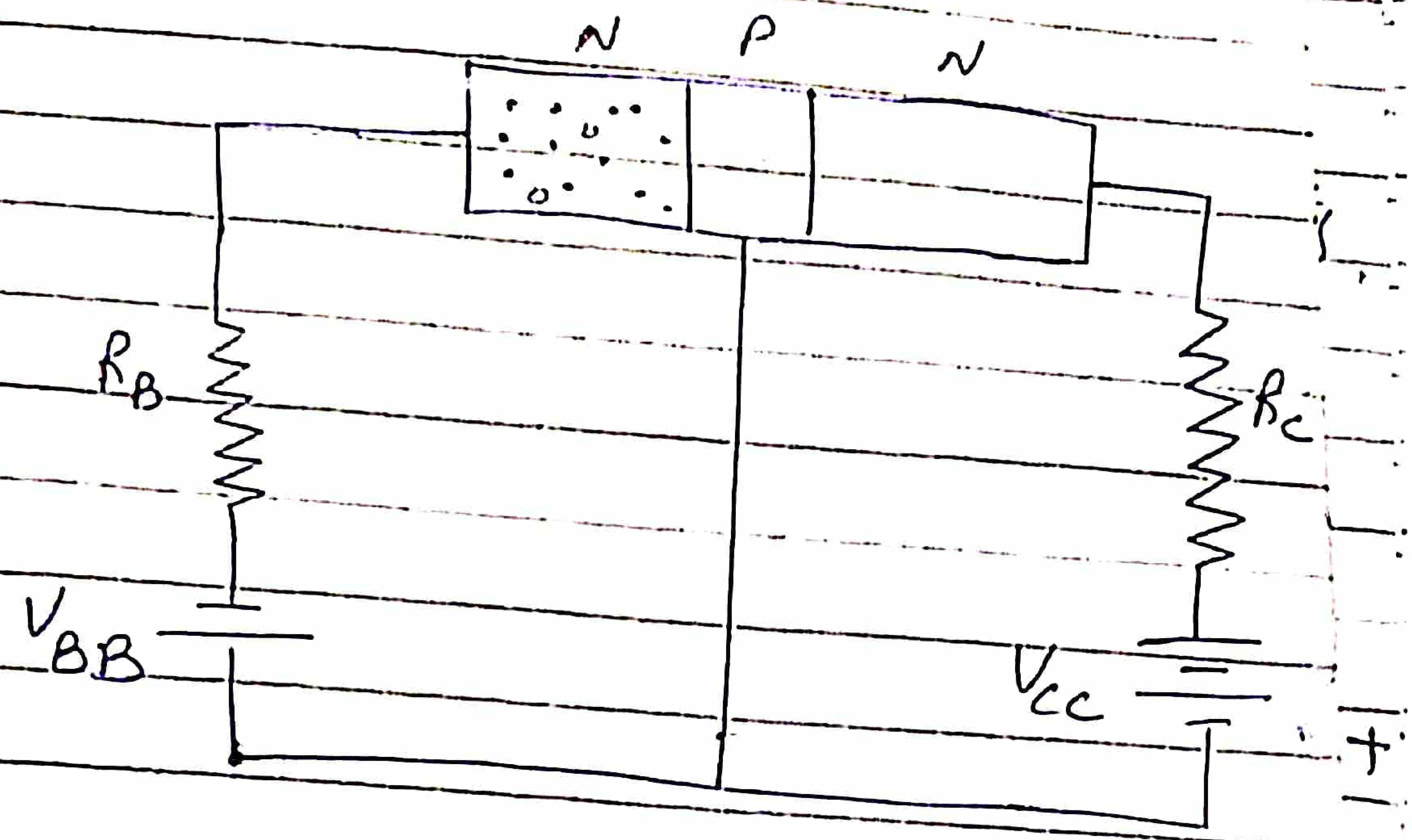


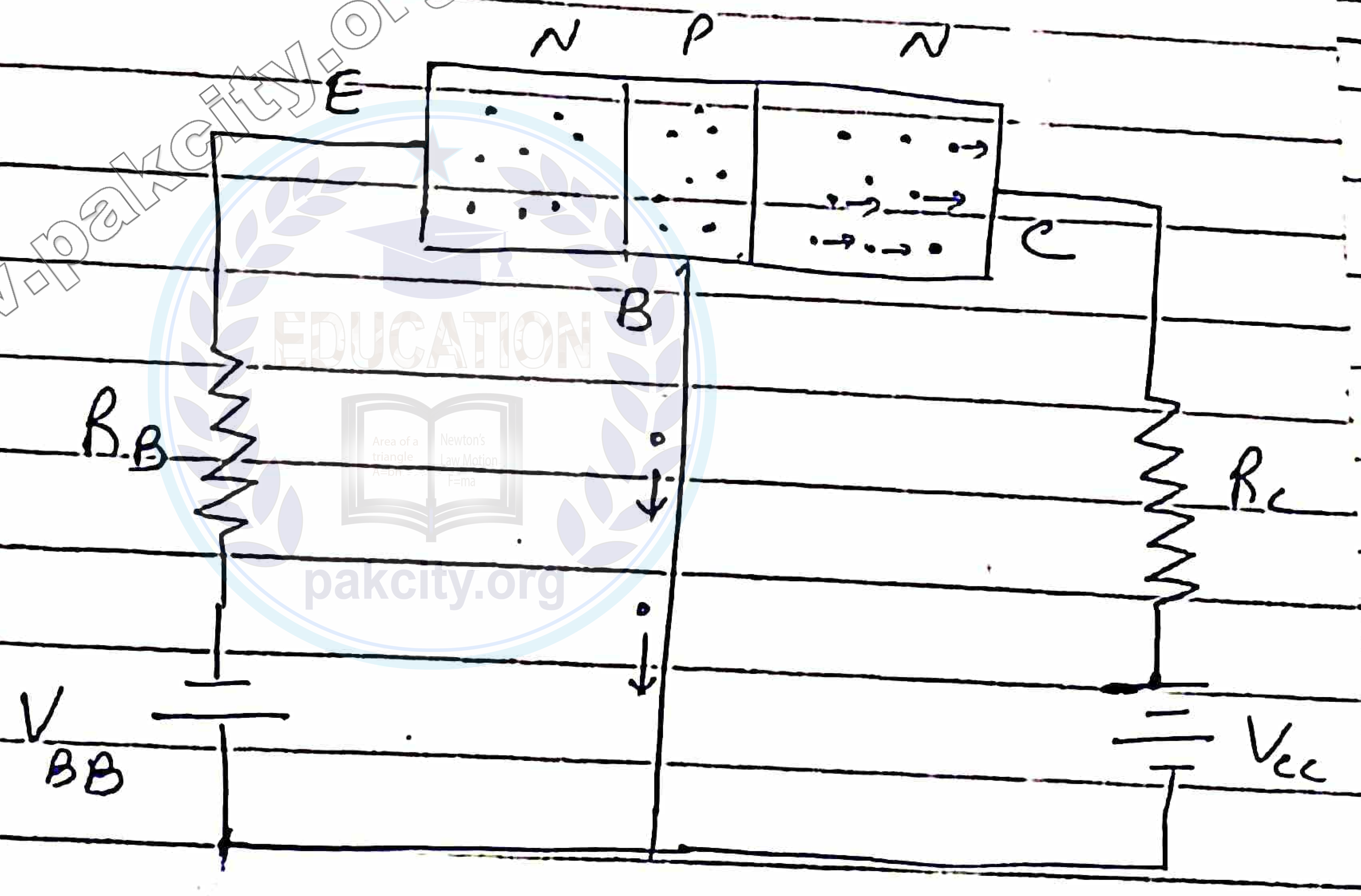

→ The emitter-base junction is forward biased.

→ The collector-base junction is reverse biased.

→ The potential of battery $V_{CC}$ must be greater than battery $V_{BB}$.

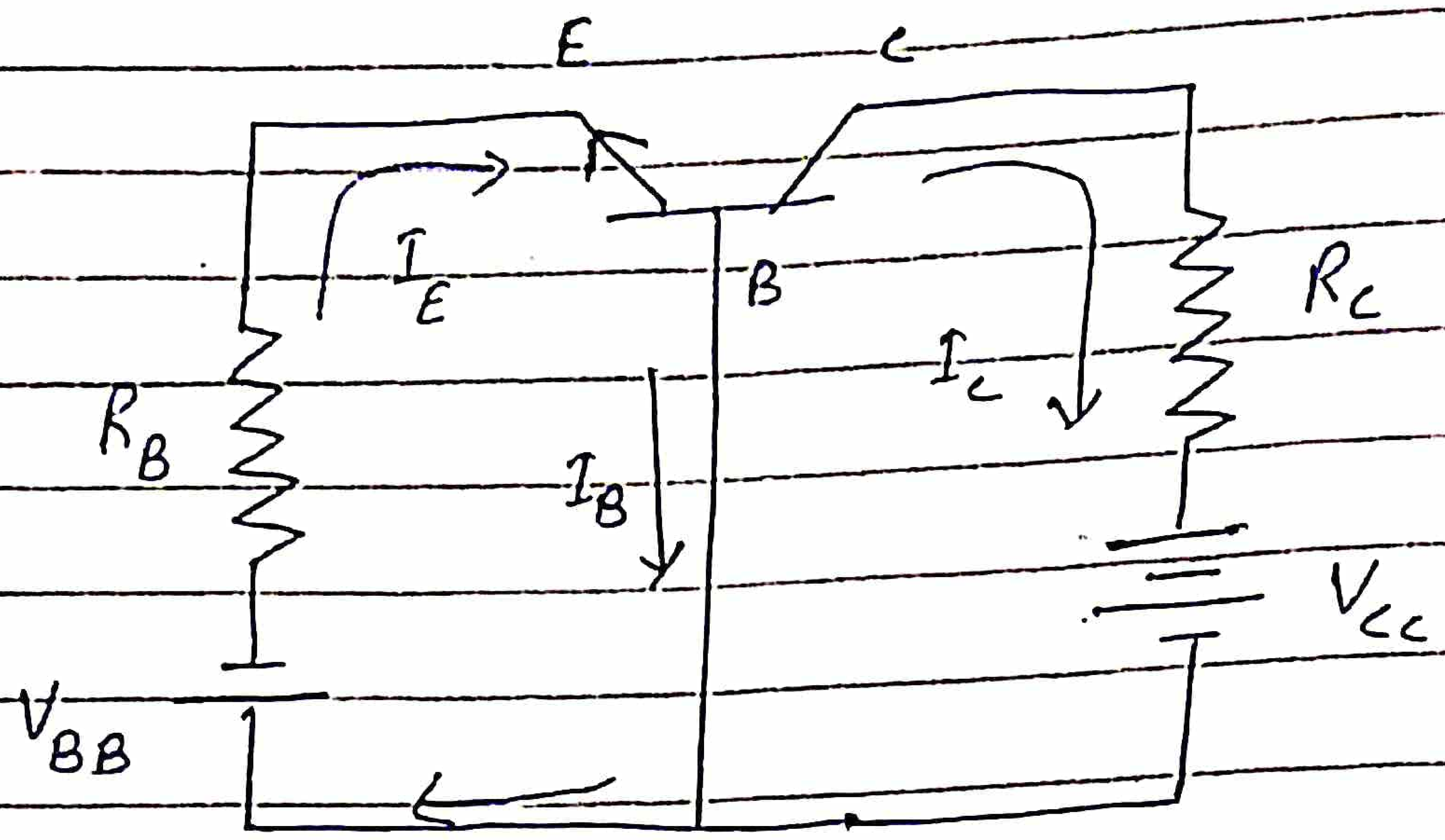
# Current flow in NPN transistor:






The electrons from the emitter move towards the base. The size of base is very small so electrons will not stay there for long time Moreover, the battery $V_{cc}$ has greater potential and it will attract the electrons.




→ The emitter current $I_E$ is divided into base current $I_B$ and collector current $I_C$. so,

$$I_E = I_C + I_B$$

→ The collector current is greater than base current.

$$I_C > I_B$$

→ The ratio of collector current $I_C$ to base current $I_B$ is a constant called current gain of transistor.

$$\beta = \frac{I_C}{I_B}$$

Its value is large

of the order of hundreds. There is no unit of current gain of transistor.

## Specially designed p-n junctions

Three most commonly used such as diods are

→ light emmiting diode
→ photo diode
→ photo Voltaic cell.



## light emmiting Diode:

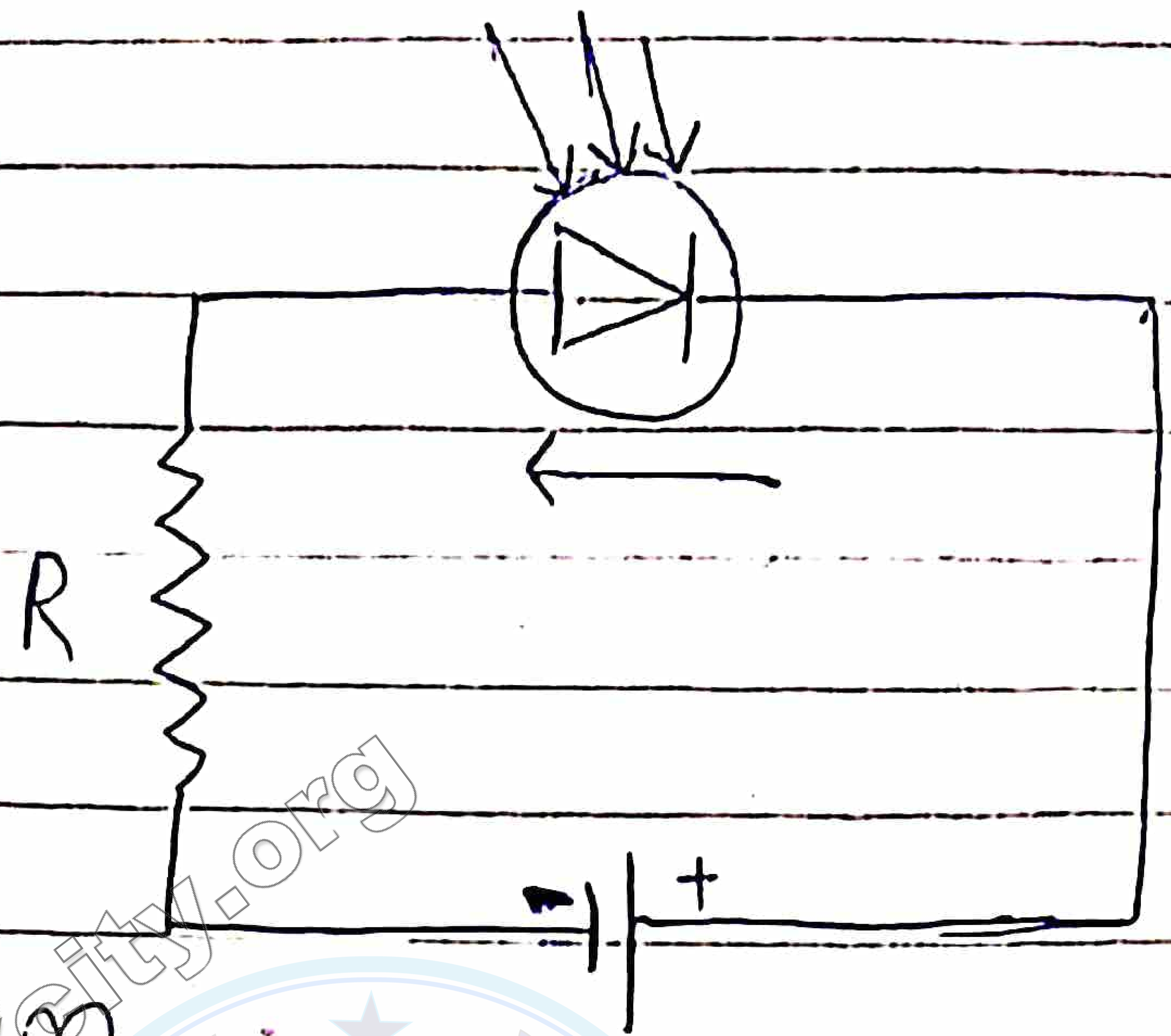
light emitting diode (LED) are made from special semi-conductors such as gallium arsenide and gallium arsenide phosphide in which the potential barrier between p and n sides is such that when an electron combines with the hole during forward biased conduction, a photon of visible light emitted. These diodes are commonly used ~~in~~ as small light sources. A specially formed array of seven LED's is used for displaying digits in electronic ~~applicatio~~ appliances.

# Photo Diode:

## Definition:

Photo diode is used for detection of light. It is operated in the reverse biased condition

## Working:



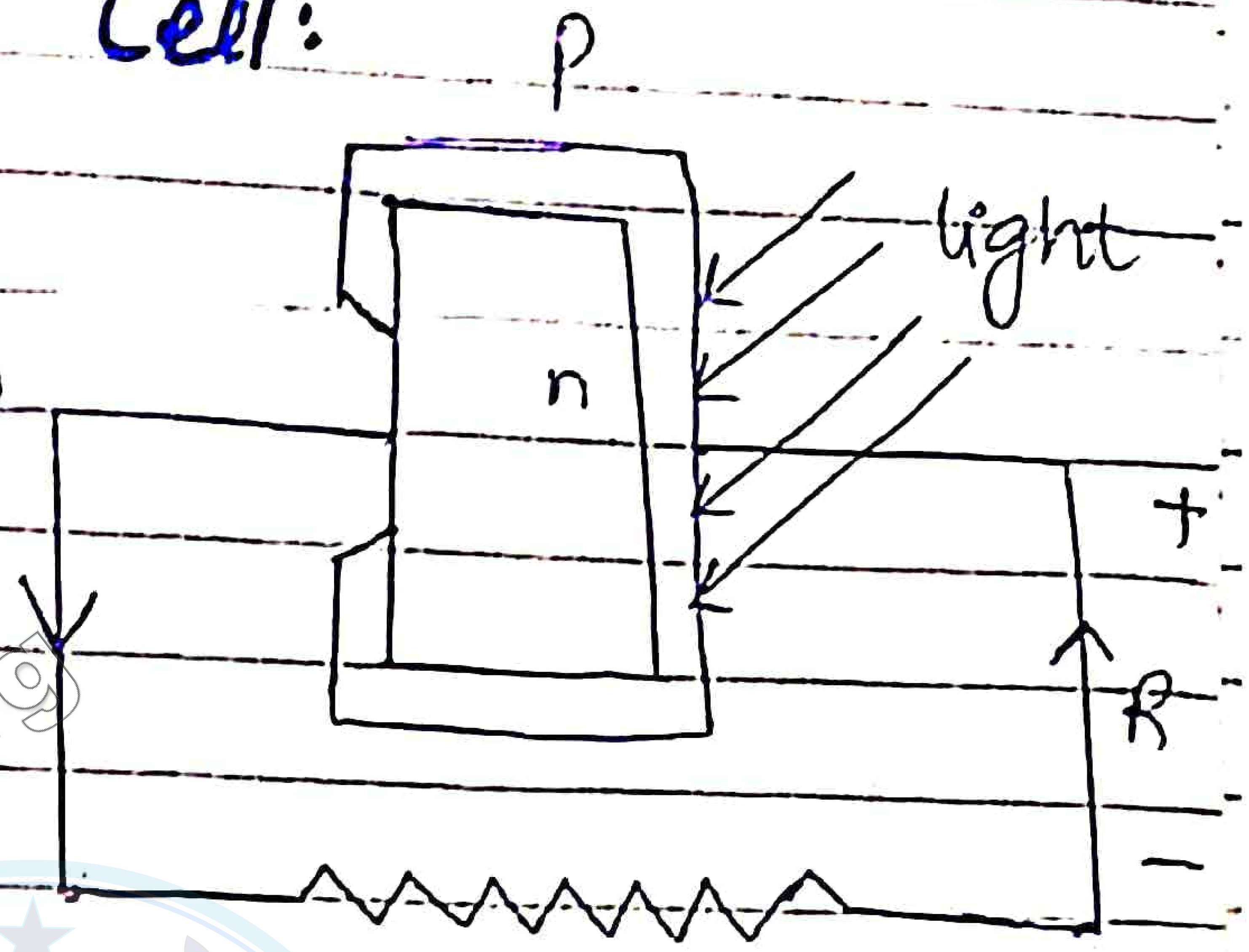

A photo diode symbol is shown in the figure. When no light is incident on the junction, the reverse current I is almost negligible but when p-n junction is exposed to light, the reverse current increased with the intensity of light

## Uses:-

A photo diodes can turn its current ON and OFF in nano-seconds. Hence it is one of the fastest photo-detection devices. Applications of photo diode include

- → Detection of both visible and invisible light
- → Automatic switching
- → logic circuits.
- → Optical communication equipments.

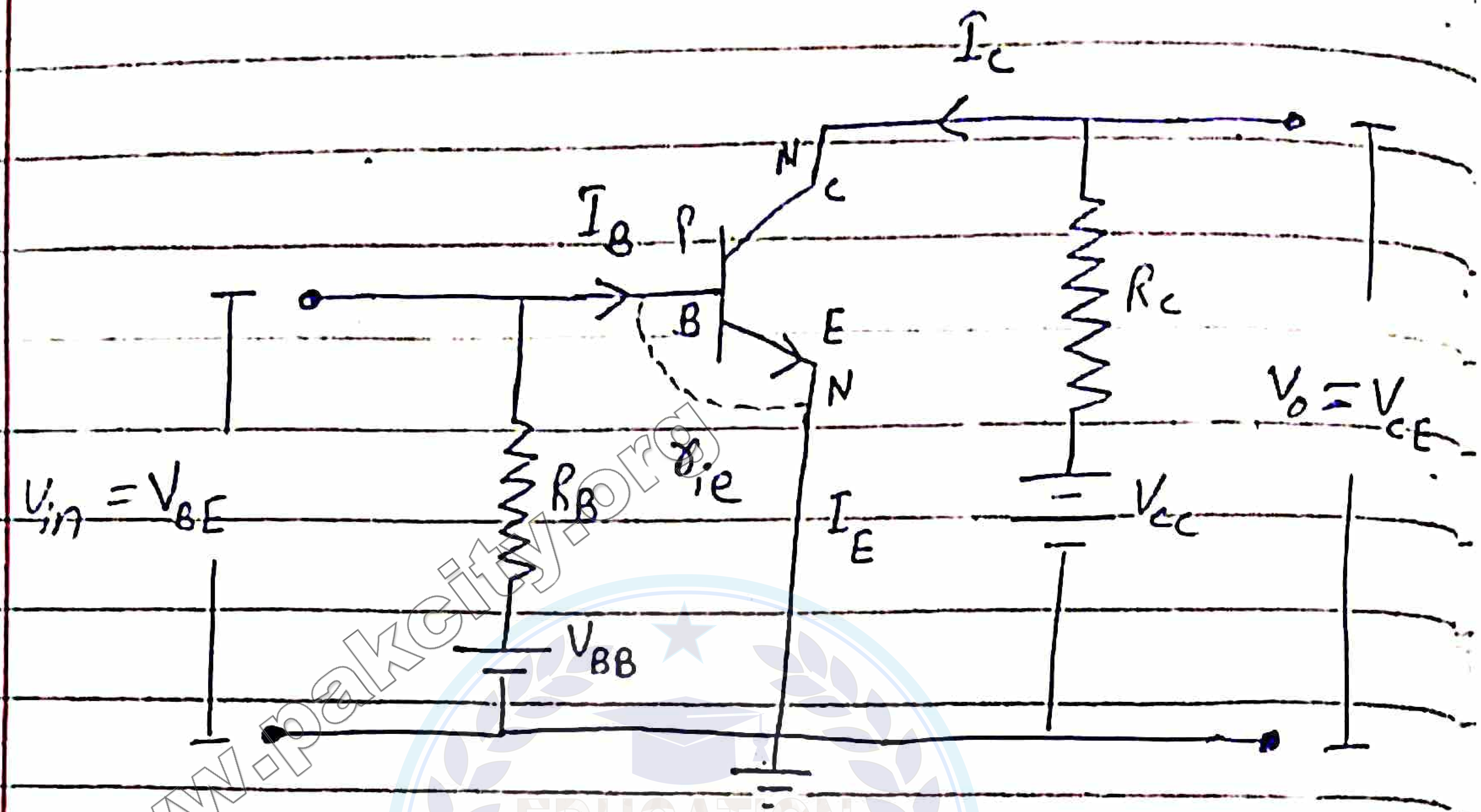
## Photo Voltaic Cell:




It consist of thick n-region covered by a thin p-region. When such a p-n junction having no external biased is exposed to light, absorbed photons generate electron-hole pairs, It results in to an increase percentage of minority charge carriers in both the p and n regions and when they diffuse close to the junction, the electric field due to junction potential barrier sweeps them across the junction, It cause the current flows through the external circuit R. The current is proportional to intensity of light.

# Transistor As An Amplifier:

An amplifier is an electrical circuit that increases the input signal. ~~A~~ ~~[illegible]~~ The transistor can also be used as an amplifier as discussed below.






Consider a NPN-transistor for which emitter is grounded as shown in the figure. The emitter base junction is forward biased with battery $V_{BB}$ and collector base junction is reverse biased by battery $V_{CC}$. The input voltage is given by $V_{BE}$ and output voltage is obtained as $V_{CE}$. The input resistance $r_{ie}$ is across base emitter junction. As the base current is $I_B$ and collector current is $I_C$, the current gain of transistor $\beta$ is given by:

$$\beta = \frac{I_C}{I_B}$$

$$\Rightarrow \quad I_C = \beta I_B$$

According to Ohm's law:

$$I_B = \frac{V_{BE}}{r_{ie}}$$

So,

$$I_C = \frac{\beta V_{BE}}{r_{ie}} \rightarrow (1$$

According to Kirchhoff's voltage rule:

$$V_{CC} = I_C R_C + V_{CE}$$

$$V_{CC} - I_C R_C = V_{CE}$$

$$V_{CE} = V_{CC} - I_C R_C$$

Put the value of $I_C$ from eq. (1

$$V_{CE} = V_{CC} - \frac{\beta V_{BE}}{r_{ie}} R_C$$

This is the expression for output voltage. So,

$$V_o = V_{CC} - \beta \frac{V_{BE}}{r_{ie}} R_C \rightarrow (2$$

When the small input signal is provided the output signal will also change and increased. Let the input increases from the $V_{BE}$ to $V_{BE} + \Delta V_{in}$, the base current will also increase from $I_B$ to $I_B + \Delta I_B$, the collector current will also increase from $I_C$ to $I_C + \Delta I_C$ and output will also increase from $V_o$ to $V_o + \Delta V_o$. Now above expression will become,

$$V_o + \Delta V_o = V_{CC} - \frac{\beta (V_{BE} + \Delta V_{in})}{r_{ie}} R_C$$

$$V_o + \Delta V_o = V_{CC} - \frac{\beta V_{BE}}{r_{ie}} R_C - \frac{\beta \Delta V_{in}}{r_{ie}} R_C \rightarrow (3$$

Now subtracting eq. (2 from eq. (3

$$V_o + \Delta V_o - V_o = V_{CC} - \frac{\beta V_{BE}}{r_{ie}} R_C - \frac{\beta \Delta V_{in}}{r_{ie}} R_C - V_{CC} + \frac{\beta V_{BE}}{r_{ie}} R_C$$

$$\Delta V_o = - \frac{\beta \Delta V_{in}}{r_{ie}} R_C$$

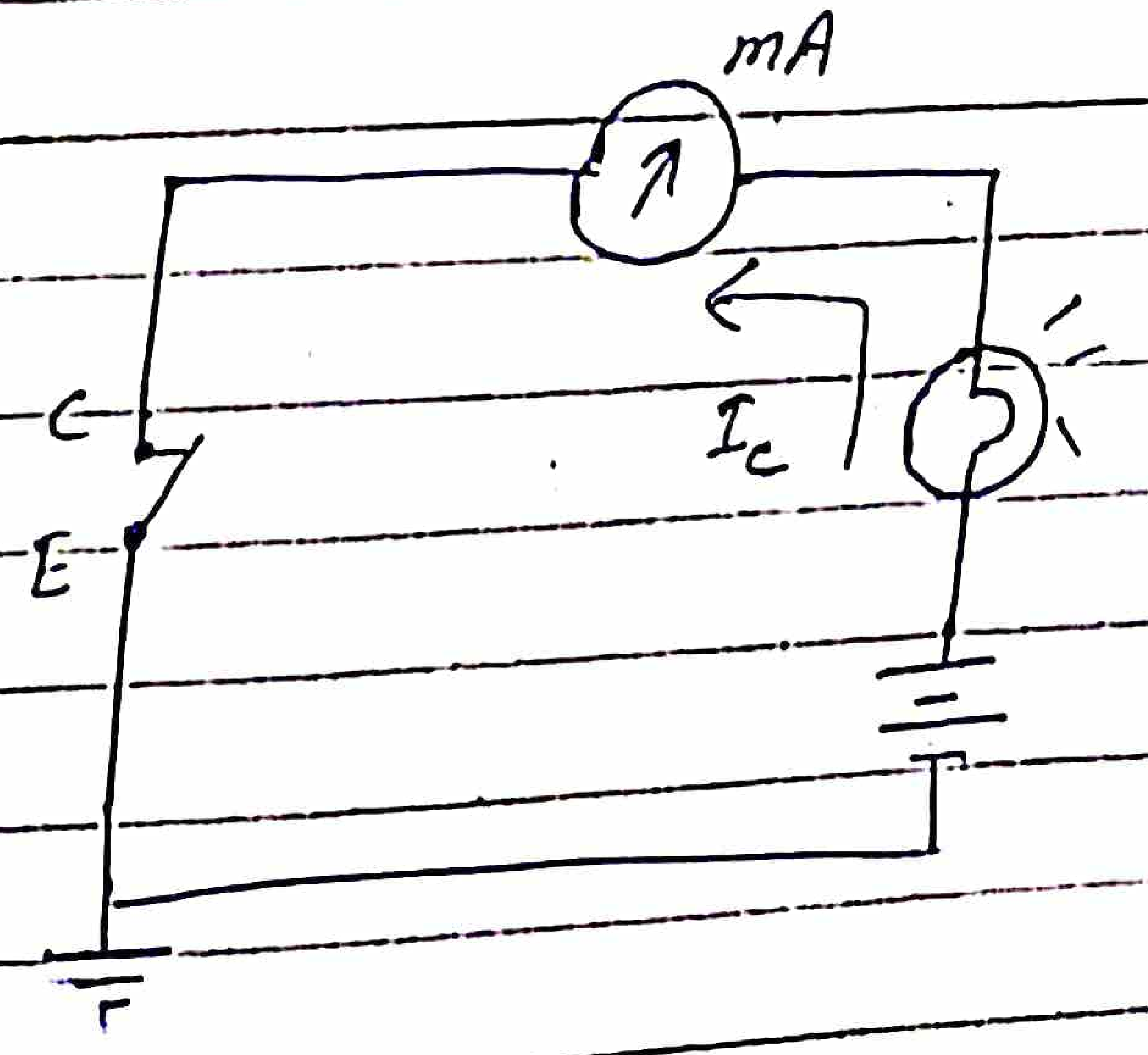
$$A = \frac{\Delta V_o}{\Delta V_{in}} = -\frac{\beta R_c}{r_{ie}}.$$

This is the expression for the gain of amplifier. Its value is of the order of hundreds, so input voltage is amplified. Negative sign shows that there is a phase shift of 180° between the input and output signals.

## Transistor As A Switch:

As a switch can turn off or ON the circuit. A transistor can also be used as a switch. When the input current $I_B$ flows in the transistor the output current $I_c$ also becomes to flow. In this way the collector-emitter junction acts as a switch.

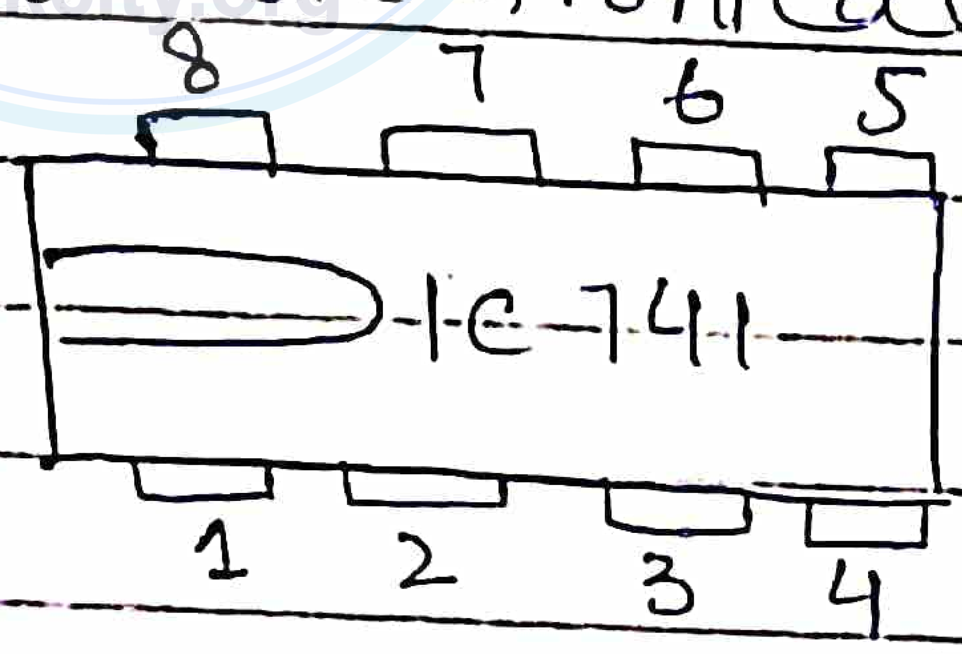




# Operational Amplifier.

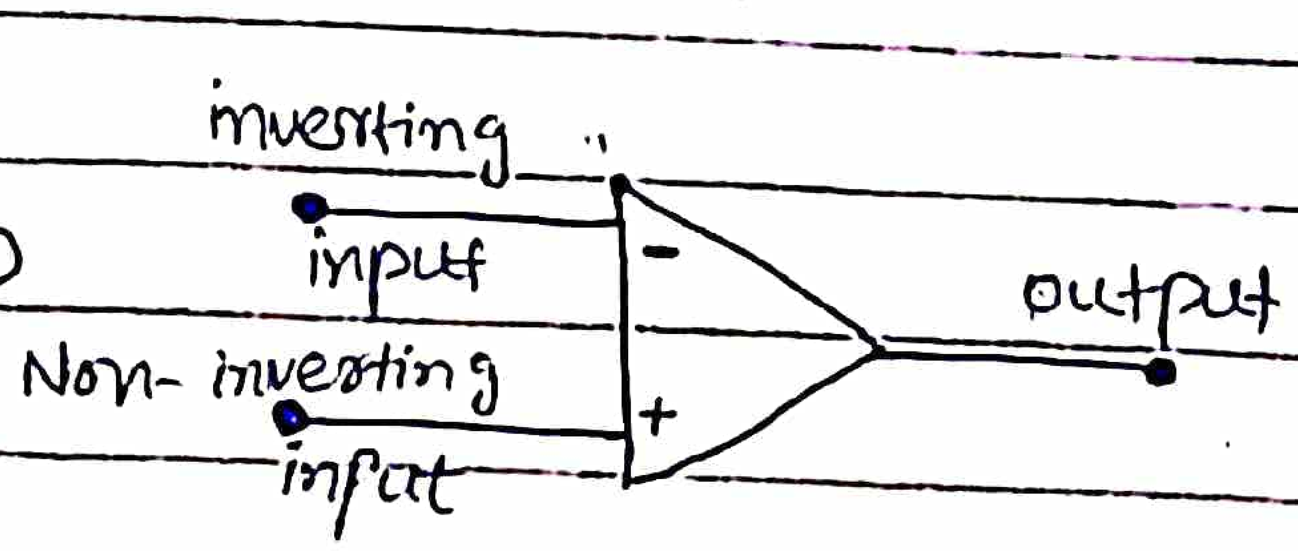
## Defination:

Instead of making amplifier circuit by discrete components, the whole amplifier is integrated on a small silicon chip and enclosed in a capsule. Pins connected with working terminals such as input, output and power supply projected outside the capsule. The enclosed circuit of the amplifier is used by integrated amplifier is known as operational amplifier (op-amp) as it is some times used to perform mathematical operations electronically.




## Symbol:

The op-amp is usually represented by its symbol shown



in the figure. It has two input terminals. One is known as inverting (–) and other is non-inverting (+).

Types:

There are two types:

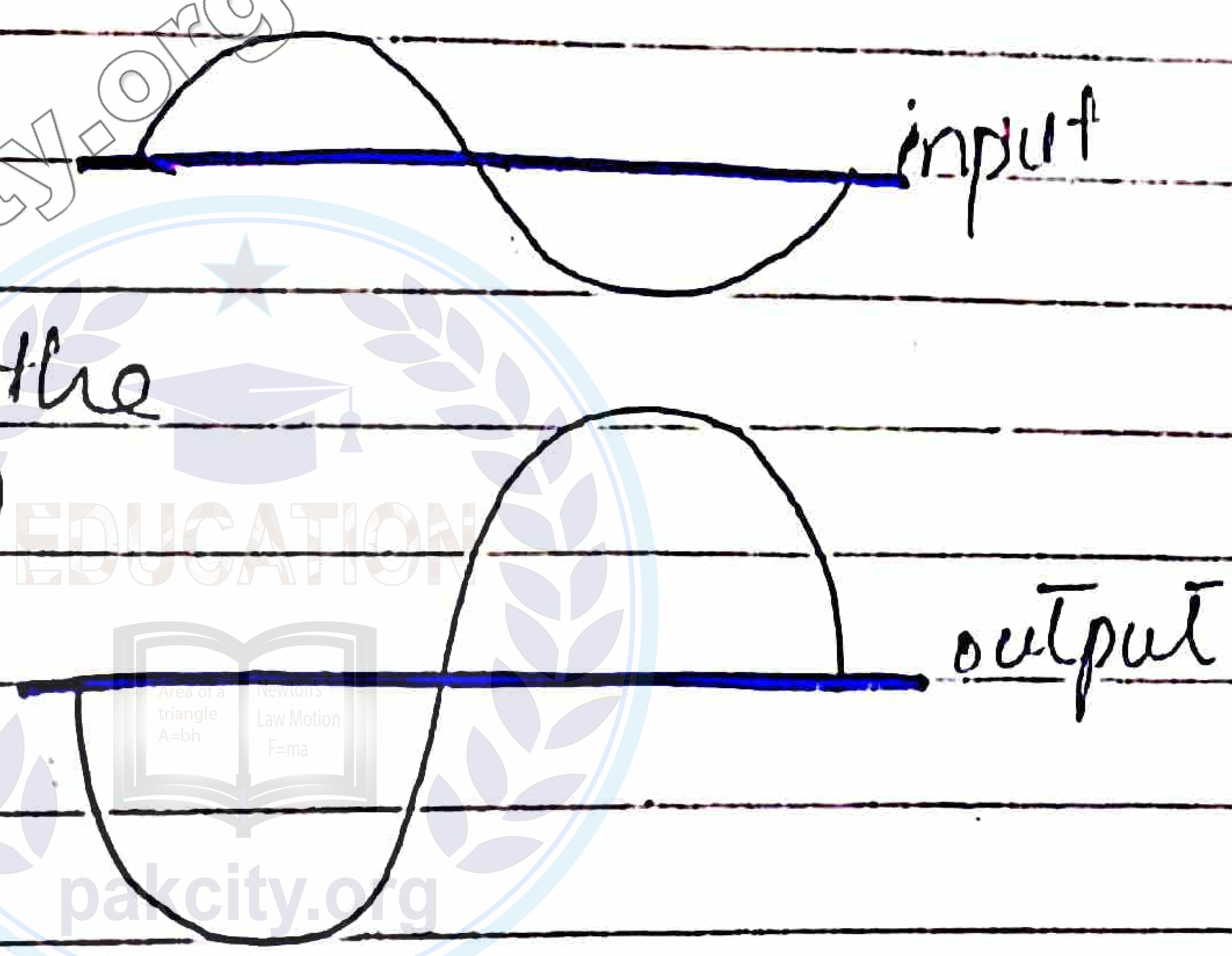
→ inverting terminal

→ Non-inverting Terminal

**inverting input (–) Terminal:**



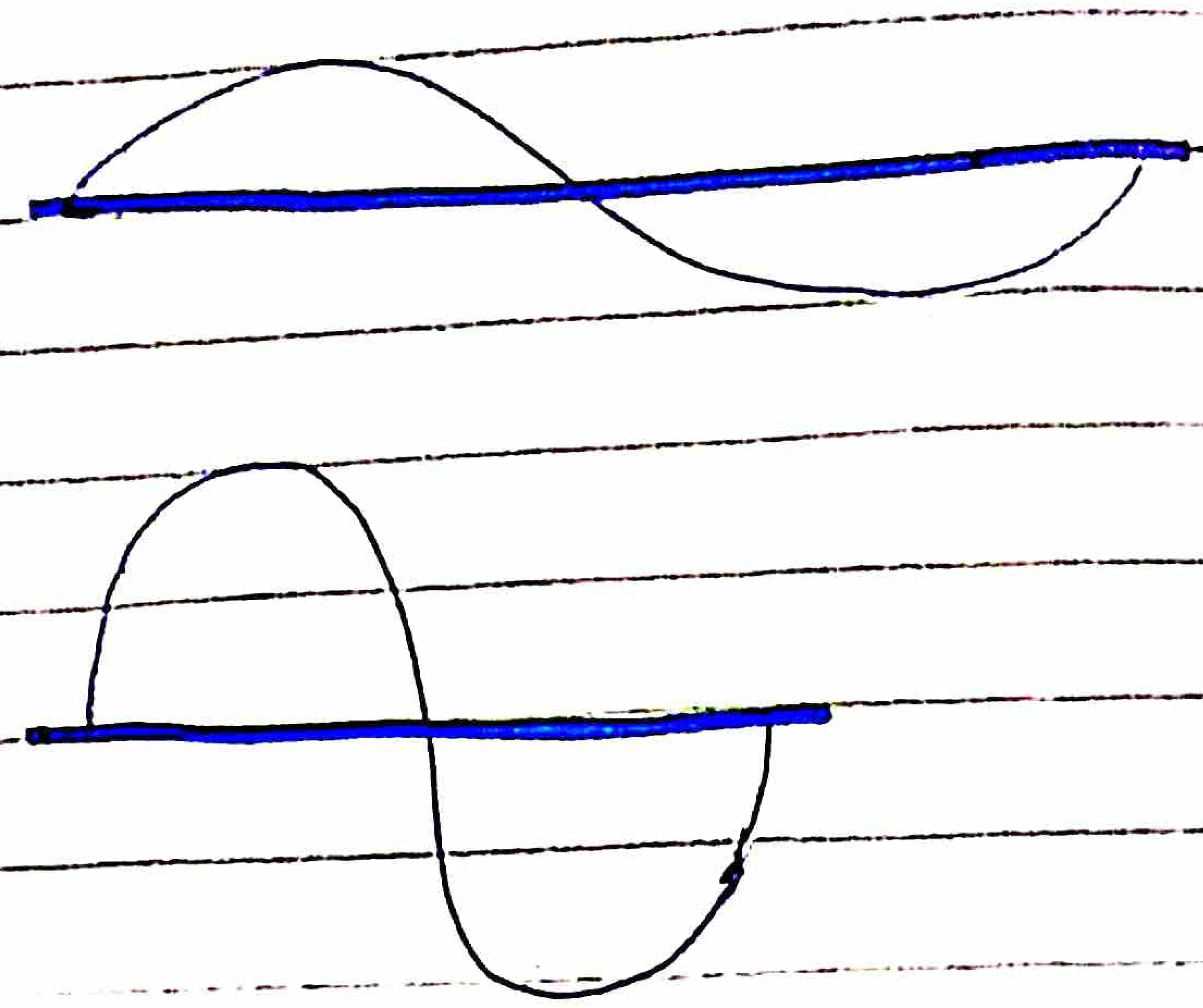
A signal that is applied on the inverting (–) input appears after amplification,




at the output terminal with the phase shift of 180° it can be seen that the signal is inverting as it appear as the output that is why this terminal is known as inverting.

**Non-inverting input (+) terminal:**

If the signal is applied on non-inverting input (+) terminal it is amplified at the output with out any change of phase

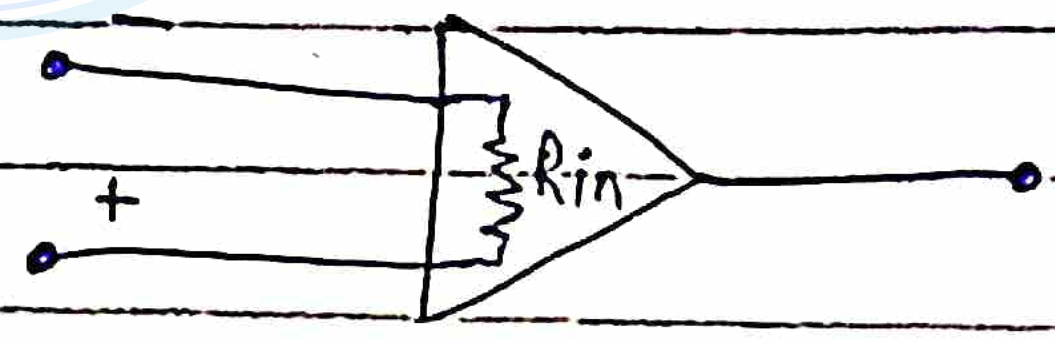



★ Charactaristics:

An op-amp has large number of characteristic parameter. We will discuss only three of them.

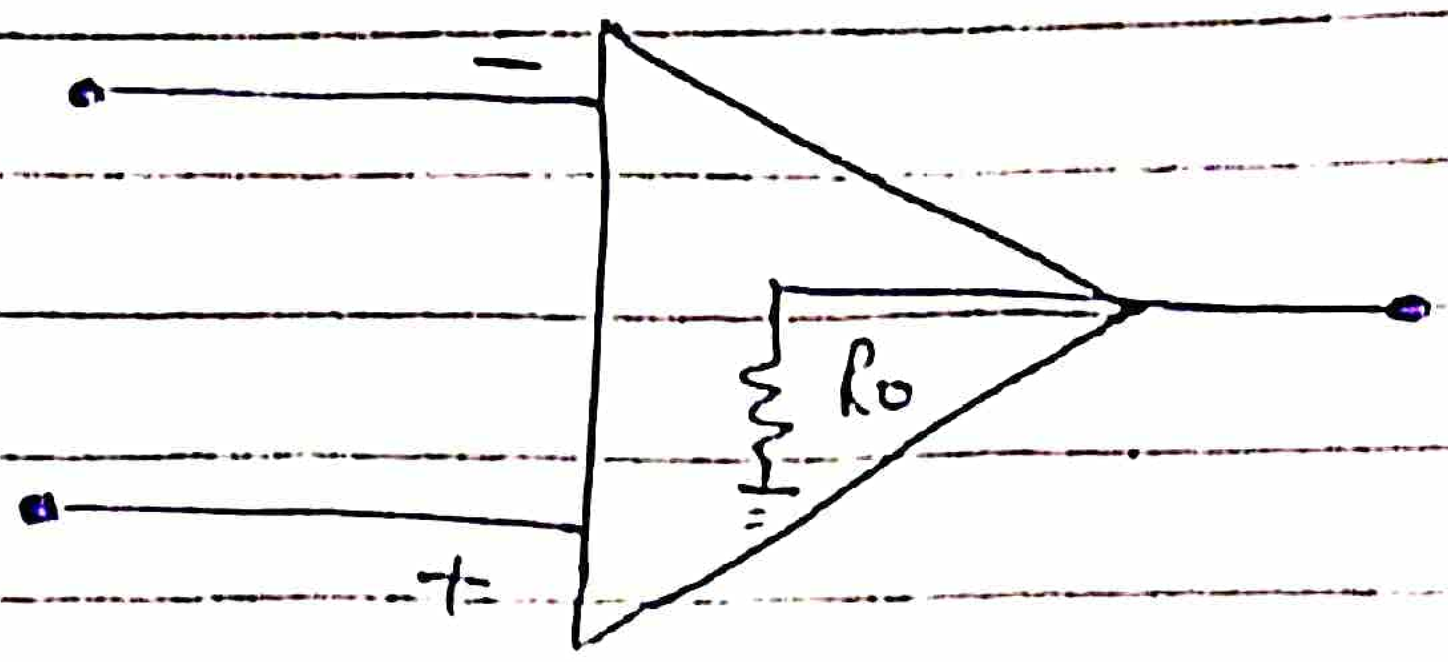
⇒ Input Resistance:

It is the resistance b/w the (+) and (−) inputs of the amplifier.



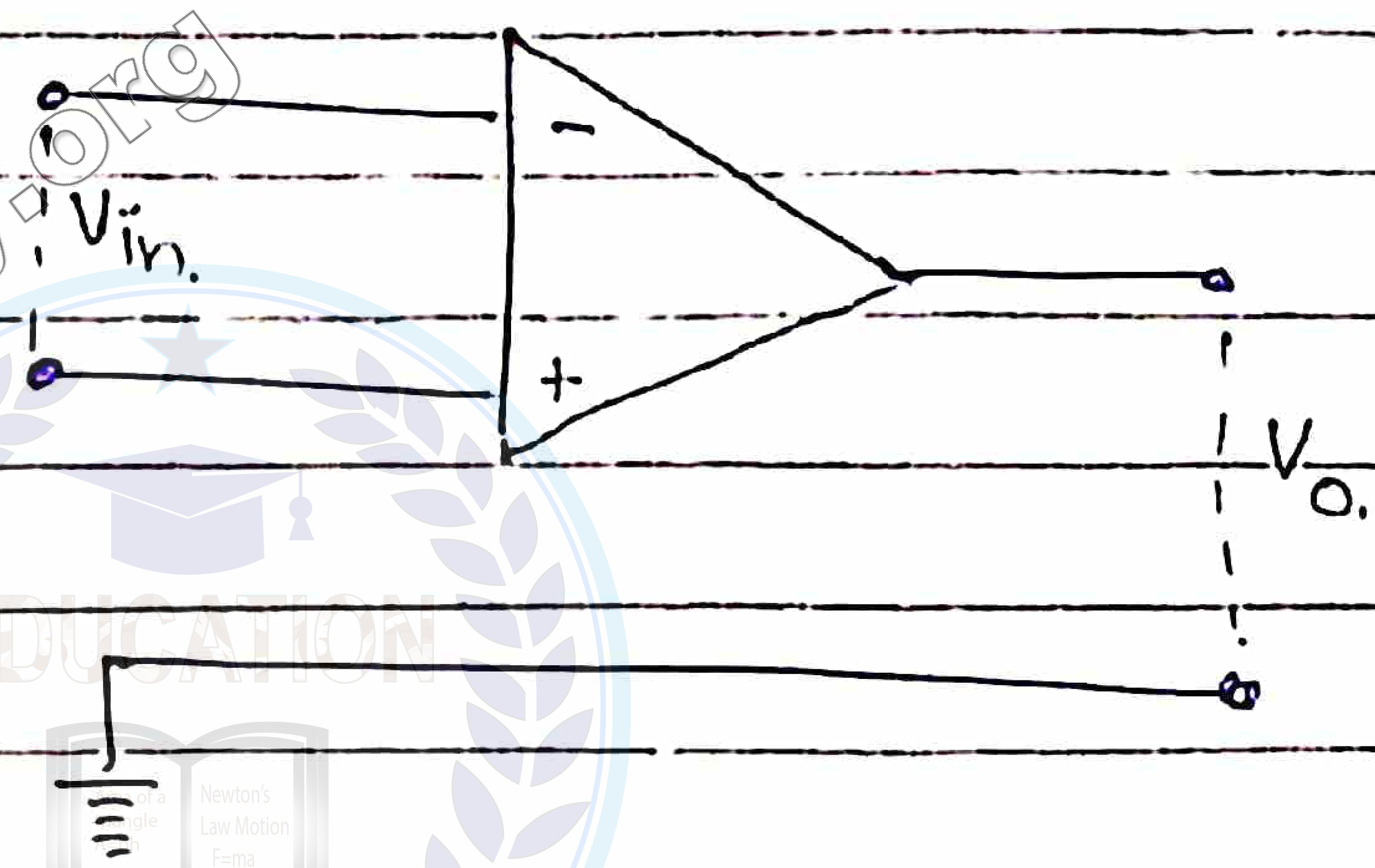

Its value is very high of the order of several mega ohms. Due to high value of input resistance $R_{in}$ practically no current flows b/w the two input terminals. It is very important feature of op-amp

## ⟹ Output Resistance:




It is the resistance b/w the output terminal and ground. Its value is only the few ohms.

## ⟹ Open loop gain:




It is the ratio of the output voltage Vo ~~of~~ to the voltage difference b/w non-inverting and inverting inputs when there is no external connection b/w the output and input.

$$A = \frac{V_o}{V_+ - V_-}$$

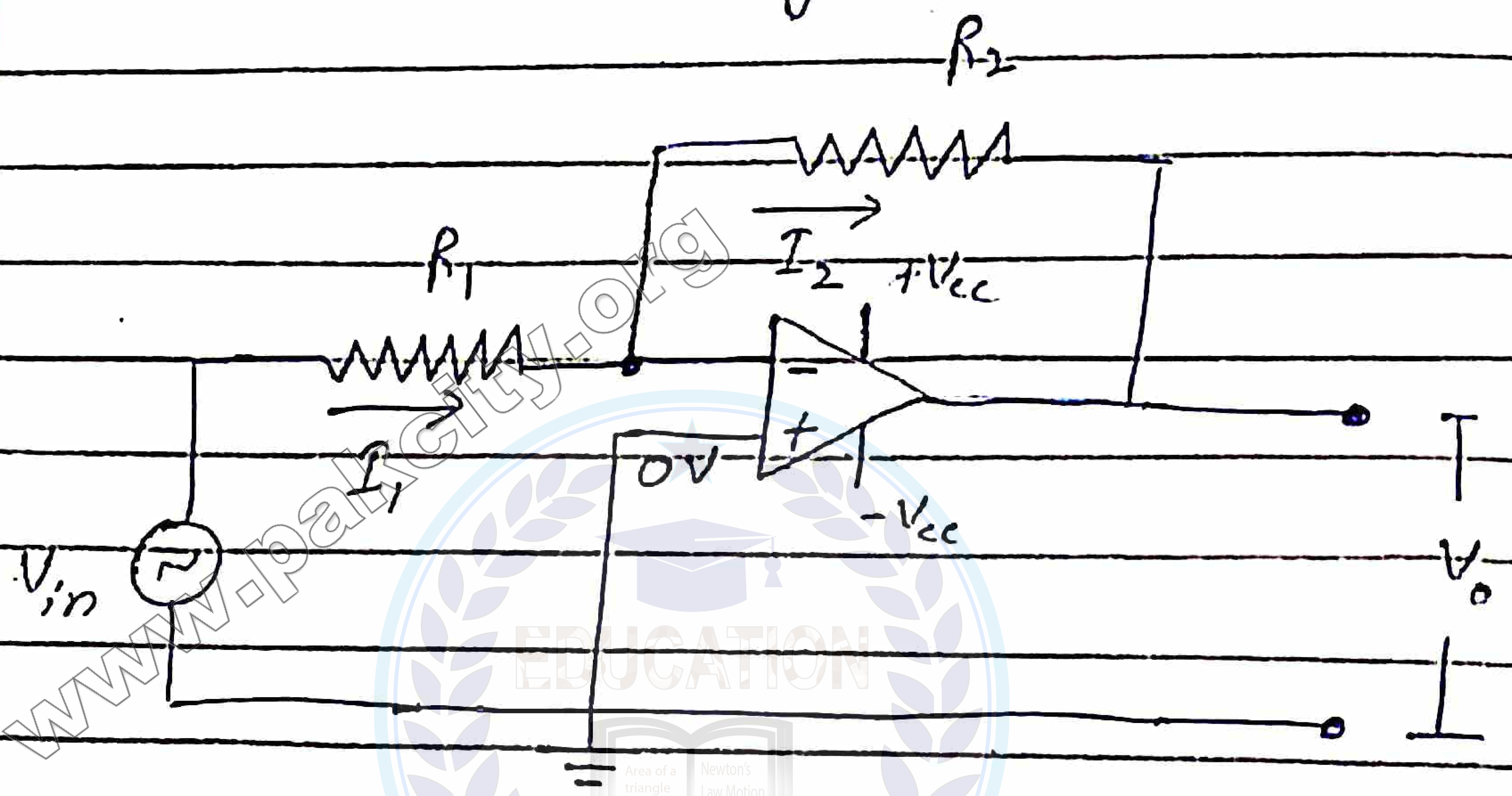
$$= \frac{V_o}{V_i}$$

The open loop gain of amplifier

is very high. It is of the order of $10^5$.

## Op-Amp As Inverting Amplifier:

When the op-amp is used as inverting amplifier the input signal is provided at the inverting terminal while the non-inverting terminal is grounded.






As the open loop gain is very high of the order of $10^5$. So, the difference of input voltages may be taken as zero.

$$V_+ - V_- \approx 0$$

$$V_+ \approx V_-$$

Now the inverting terminal is also virtually grounded

$$V_+ \approx V_- \approx 0V$$

Now we will calculate the currents $I_1$ and $I_2$ flowing through $R_1$ and $R_2$ respectively.

current through $R_1 = I_1 = \frac{V_{in} - V_-}{R_1}$

$$I_1 = \frac{V_{in} - 0}{R_1}$$

$$I_1 = \frac{V_{in}}{R_1}$$

current through $R_2 = I_2 = \frac{V_- - V_0}{R_2}$

$$I_2 = \frac{0 - V_0}{R_2}$$





$$I_2 = -\frac{V_0}{R_2}$$

According to Kirchhoff's first rule, the current flowing towards a point is equal to the current flowing away from that point. So,

$$I_1 = I_2$$

$$\frac{V_{in}}{R_1} = -\frac{V_0}{R_2}$$

$$-\frac{R_2}{R_1} = \frac{V_0}{V_{in}}$$

$$\frac{V_o}{V_{in}} = -\frac{R_2}{R_1}$$

This is the expression for closed loop gain $G_I$ of inverting amplifier.

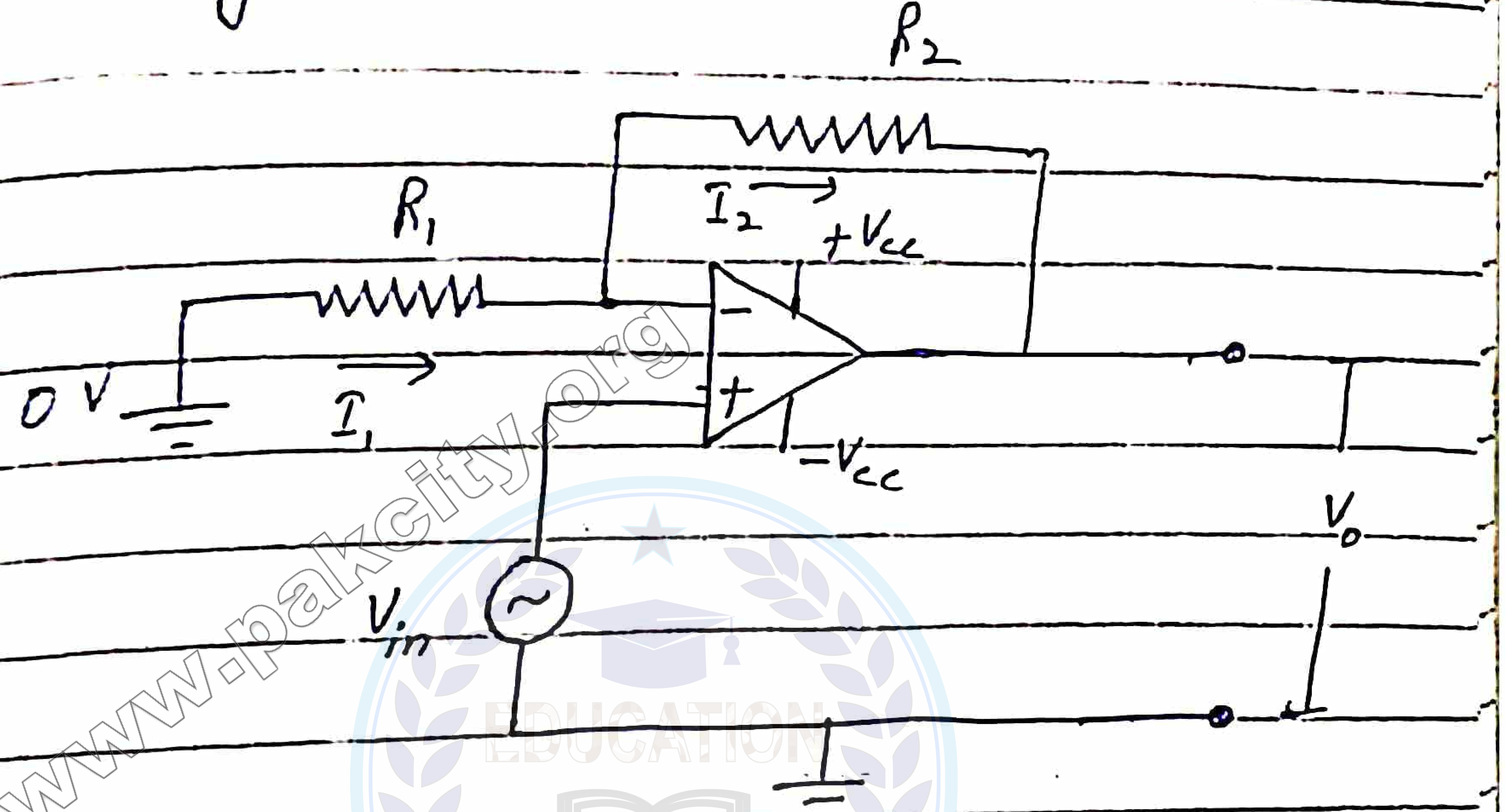
$$G_I = -\frac{R_2}{R_1}$$

## Result:

The negative sign indicates that the output signal is 180° out of phase with respect to input signal. It is interesting to note that the closed loop gain depends upon two externally connected resistances $R_1$ and $R_2$. The gain is independent of the circuit inside the amplifier.

# Op-Amp As Non-Inverting Amplifier:

When the op-amp is used as non-inverting amplifier, the input signal is provided at the non-inverting (+) terminal while the inverting (−) terminal is grounded.




As the open loop gain is very high of the order of $10^5$. The difference of input voltages may be taken as zero.

$$V_+ - V_- \approx 0$$

so,

$$V_+ \approx V_- \approx V_{in}$$

Now we will calculate currents $I_1$ and $I_2$ flowing through resistors $R_1$ and $R_2$ respectively.

current flowing through $R_1$

$$I_1 = \frac{0 - V_-}{R_1}$$

$$I_1 = -\frac{V_{in}}{R_1}$$

current flowing through $R_2$

$$I_2 = \frac{V_- - V_o}{R_2}$$

$$I_2 = \frac{V_{in} - V_o}{R_2}$$

According to Kirchhoff's first rule, the current flowing towards a point is equal to the current flowing away from that point.



$$I_1 = I_2$$

$$-\frac{V_{in}}{R_1} = \frac{V_{in} - V_o}{R_2}$$

$$-\frac{V_{in}}{R_1} = \frac{V_{in}}{R_2} - \frac{V_o}{R_2}$$

$$\frac{V_o}{R_2} = \frac{V_{in}}{R_2} + \frac{V_{in}}{R_1}$$

$$\frac{V_o}{R_2} = V_{in}\left(\frac{1}{R_2} + \frac{1}{R_1}\right)$$

$$\frac{V_o}{V_{in}} = R_2\left(\frac{1}{R_2} + \frac{1}{R_1}\right)$$

$$\frac{V_o}{V_{in}} = \frac{R_2}{R_2} + \frac{R_2}{R_1}$$

$$\frac{V_o}{V_{in}} = 1 + \frac{R_2}{R_1}$$

This is the expression for closed loop gain of non-inverting amplifier.

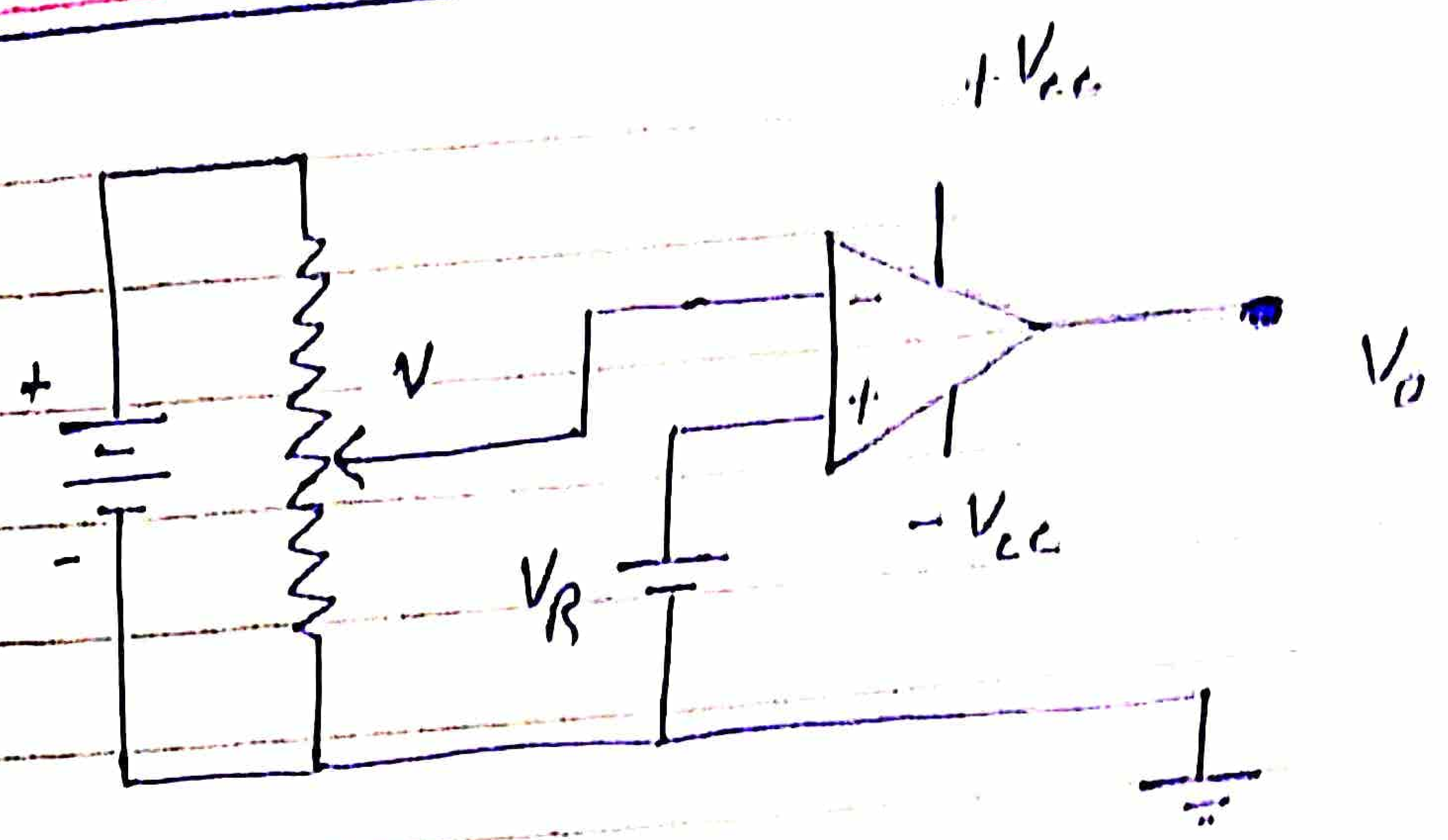
$$G = 1 + \frac{R_2}{R_1}$$

**Result:**
The gain of the amplifier is independent of the internal structure of the op-amp. It just depends upon the two extremely connected resistances $R_1$ and $R_2$. The positive sign of gain indicates that the input and output signals are in phase.



## Op-Amp As A Comparator:

Op-amp can be used to compare two voltages. Consider the op-amp, $V_R$ reference voltage is applied at the non-inverting (+) terminal while a variable potential difference $V$ is applied at the inverting terminal.




when
$V_- > V_+$ or $V > V_R$
then
$$V_o = -V_{cc}$$

when
$V_- < V_+$ or $V < V_R$
then
$$V_o = +V_{cc}$$



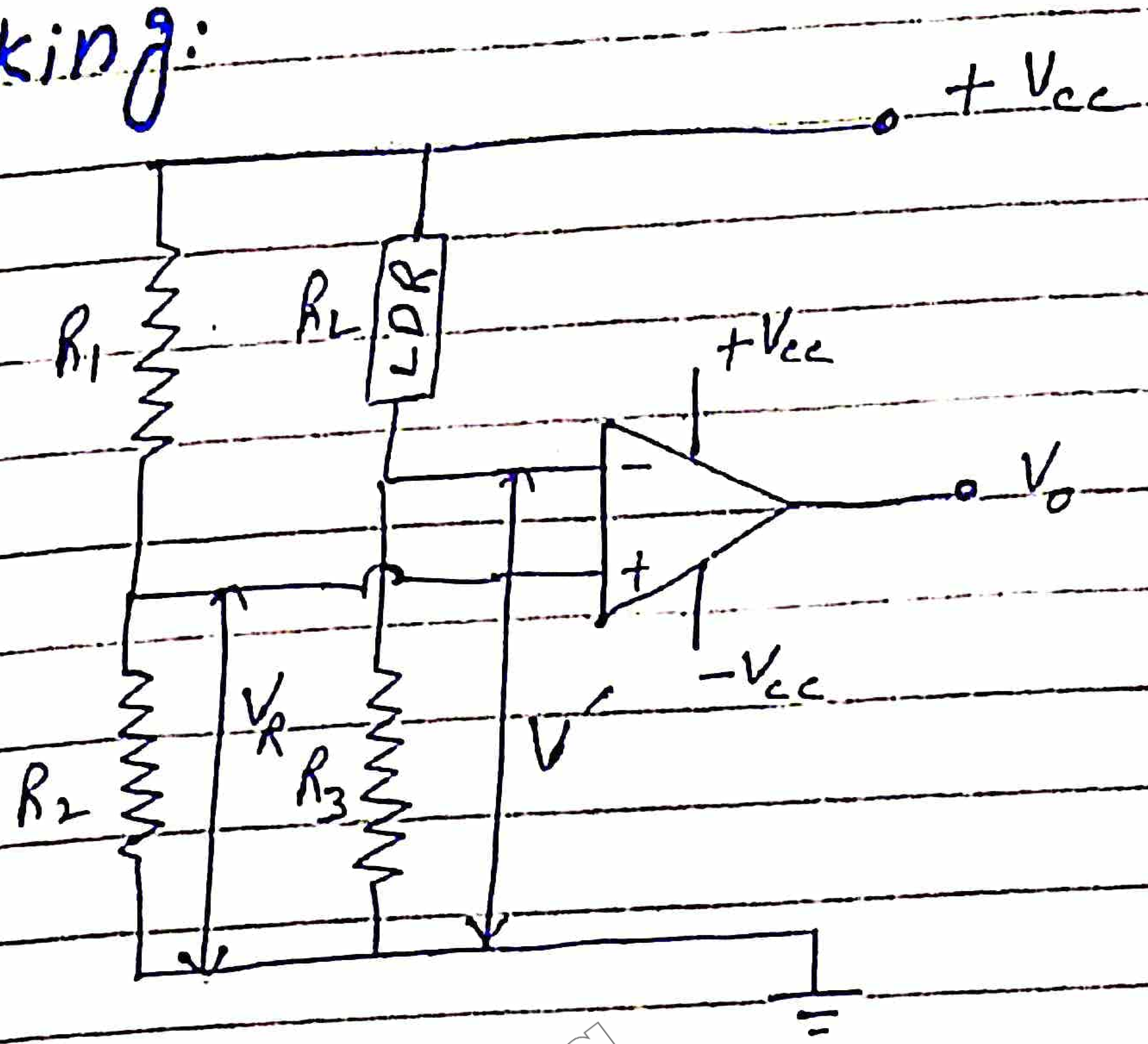
## Comparator As A Night Switch:

**Switch:** A night switch is an automatic switch that on the circuit at night time and off at day time.

**LDR:** Light dependent resistance is a variable resistor whose value changes with the intensity of light falling on it. If light falls on LDR, $R_L$ will be small. If light does not fall on LDR

$R_L$ will be large.

**Working:**






Consider the circuit used for comparator as a night switch. $V'$ is provided at the inverting terminal (−) and reference voltage $V_R$ is provided at the non-inverting (+) terminal of op-amp. $R_1$ and $R_2$ act as potential divider and

$$V_R = \frac{R_2}{R_1 + R_2} \times V_{cc}$$

Similarly, $R_L$ and $R_3$ act as potential divider and

$$V' = \frac{R_3}{R_L + R_3} \times V_{cc}$$

## During day time:

During day time when light is falling upon LDR, $R_L$ is small. $V'$ will be large such that $V' > V_R$ so that $V_0 = -V_{cc}$. The output of the op-amp is connected with a relay ~~tent~~ system which energizes only when $V_0 = +V_{cc}$ and then it turns on the street lights. Thus when $V_0 = -V_{cc}$ the light will not be switched ON.



## During Night time:

As it gets darker $R_L$ become large and $v'$ decreases. When $V'$ becomes just less then $V_R$, the output of the op-amp switches to $+V_{cc}$ when energizes the relay system and the street lights turns ON.

# Digital systems.

A digital system deals with quantities or variables which have only two discrete values or states. Following are the examples of such quantities

- A switch can be either open or close
- The answers of the question can be either yes or No
- A certain statement can be either true or false.
- A bulb can be either off and on.





# Logic Gates:

The electronic circuits which implement the various logic operation are known as logic gates. In these gates the high or low states i.e. 1 and 0 state are simulated by certain voltages level. Ideally one particular voltage level represents the high (1) and another voltage level represents the low (0)

# Boolean algebra:

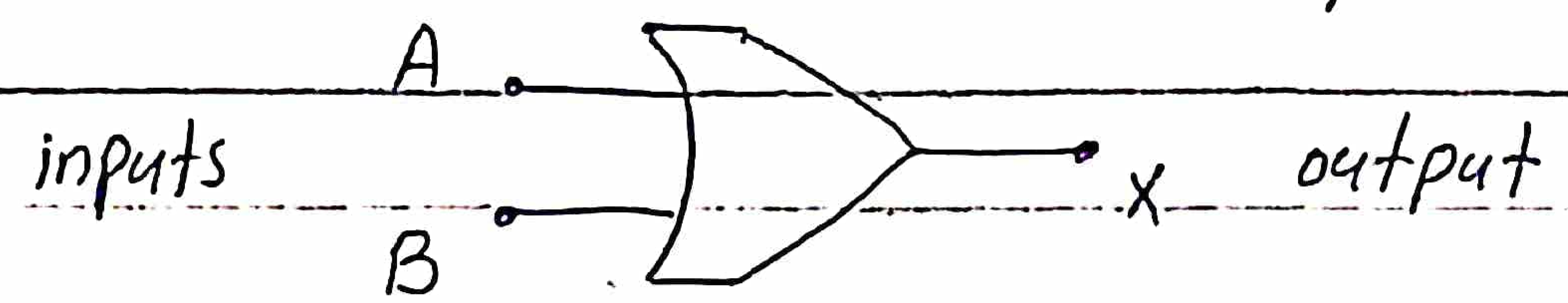
We require a special algebra known as Boolean algebra for the manipulation of the quantities which have only two values 1 and 0. Boolean expression is based upon three basic operations namely

- OR operation
- AND operation
- NOT operation

# OR Gate:

**Defination:** The logic gate for which output is 0 when all the inputs are 0. while output is 1 when any one or all the inputs are 1. is called OR-gate. It consists one output and two or more inputs.

**Symbol:**






## Boolean Expression:

$$X = A + B$$

Here (+) is not simple addition. It is Boolean function.

## Truth Table:

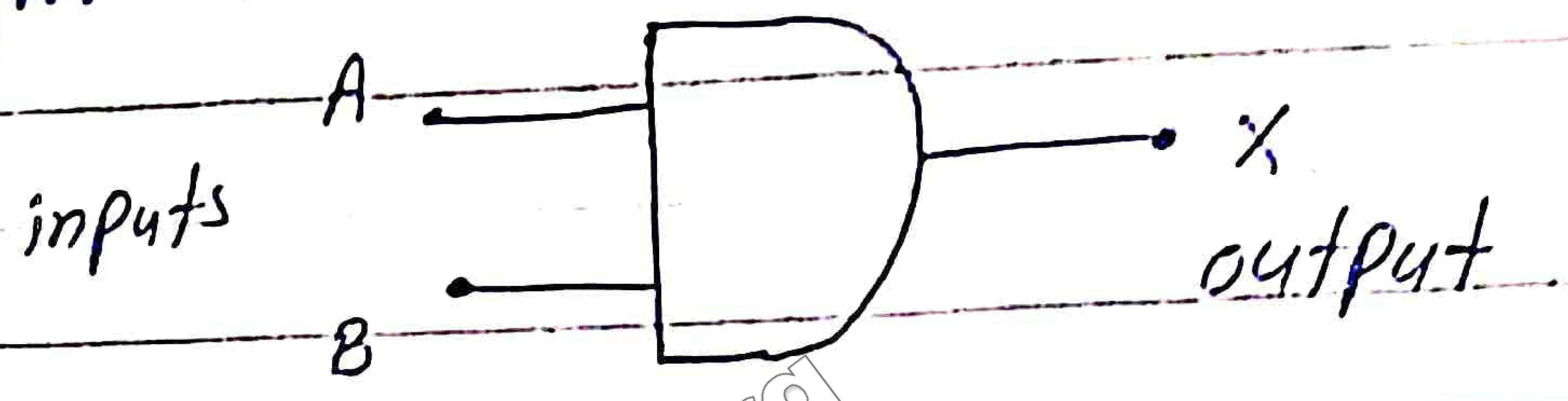
The combination of all possible inputs and outputs for a logic operation is called truth table.

| inputs | | output |
|---|---|---|
| A | B | X = A+B |
| 0 | 0 | 0 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 1 |

# AND Gate:

**Defination:** The logic gate for which output is 1 when all the inputs are 1. while output is 0 when anyone or all the inputs are 0. is called AND-gate. It consists of one output and two or more inputs.

**Symbol:**




**Boolean expression:**

$$X = A \cdot B$$

Here $(\cdot)$ is not simple multiplication. It is Boolean function.

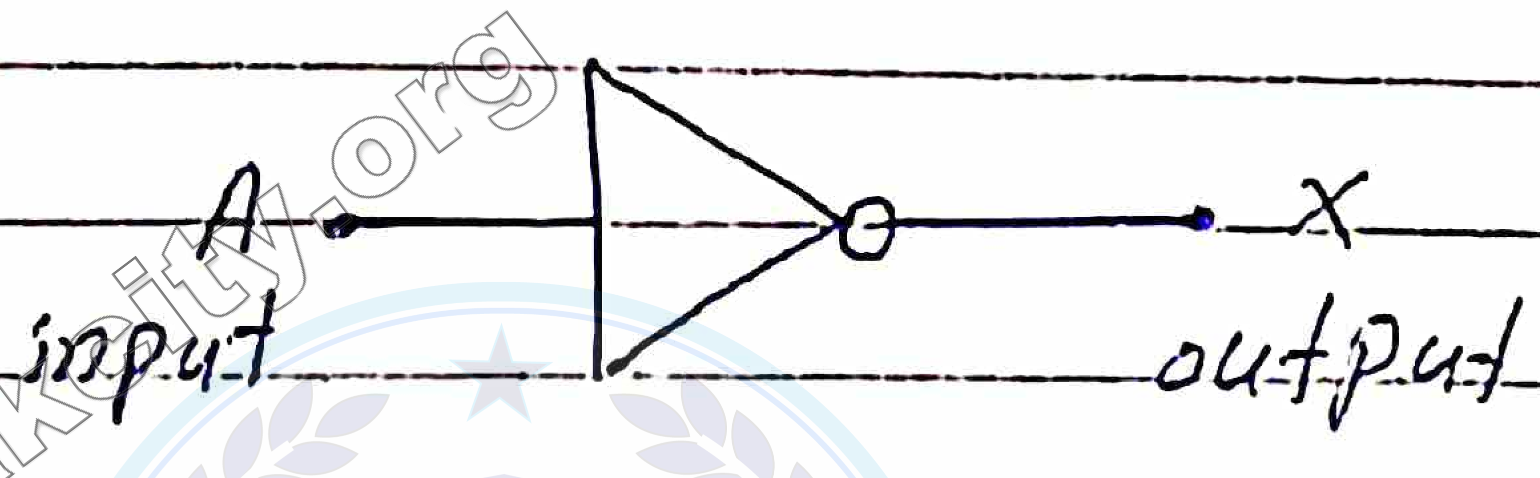
**Truth Table:** – Def –

| inputs | | output |
|---|---|---|
| A | B | $X = A \cdot B$ |
| 0 | 0 | 0 |
| 0 | 1 | 0 |
| 1 | 0 | 0 |
| 1 | 1 | 1 |

# NOT Gate:

**Defination:** The logic gate for which output is 1 when input is 0 and output is 0 when input is 1. is called NOT gate. It consists of only one input and one output. It is also called inverter.

## Symbol:






## Boolean expression:

$X = \overline{A}$ is inversted.

Bar shows that value of variable

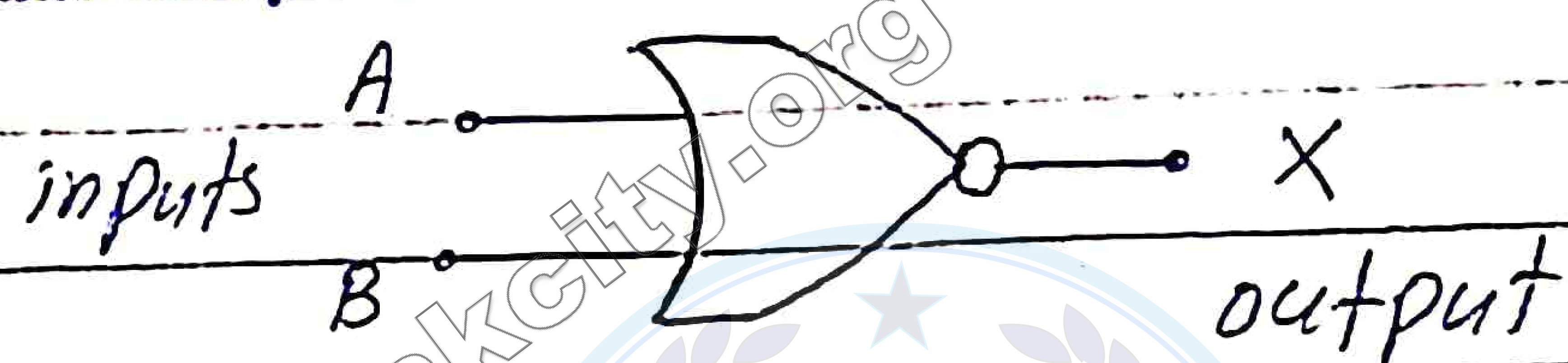
## Truth Table: — Def —

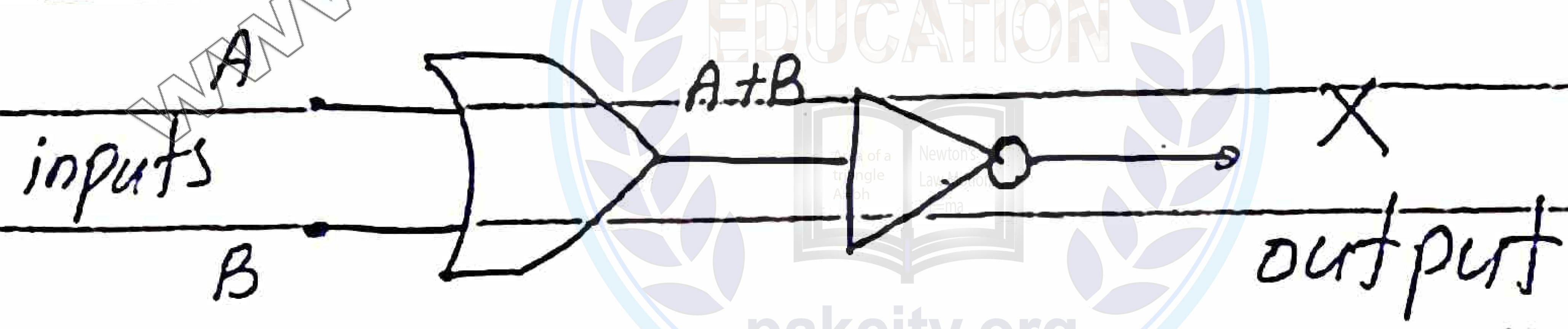
| input | output |
|---|---|
| A | $X = \overline{A}$ |
| 0 | 1 |
| 1 | 0 |

# NOR Gate:

**Defination:** The logic gate for which output is 1 when all the inputs are 0 and output is 0 when anyone or all the inputs are 1. It consists of one output and two or more inputs. It is combination of OR-gate and NOT-gate.

**Symbol:**




**Boolean expression:**

$$X = \overline{A+B}$$

Here (+) is not for simple addition, it is for Boolean function. And bar shows that value of variable is inverted.

## Truth Table: -Def-

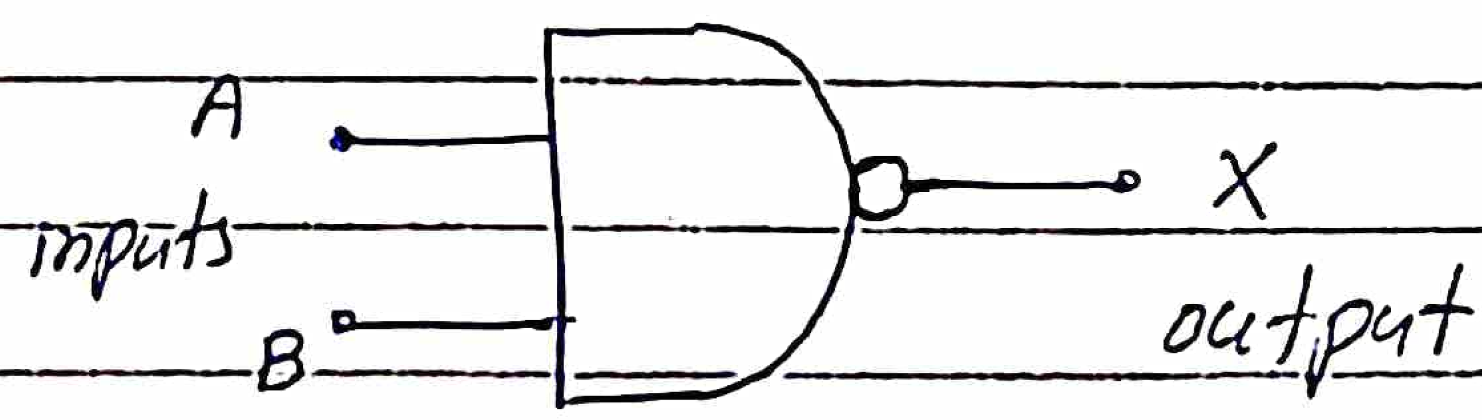
| inputs | | | output |
|---|---|---|---|
| A | B | A+B | $X=\overline{A+B}$ |
| 0 | 0 | 0 | 1 |
| 0 | 1 | 1 | 0 |
| 1 | 0 | 1 | 0 |
| 1 | 1 | 1 | 0 |

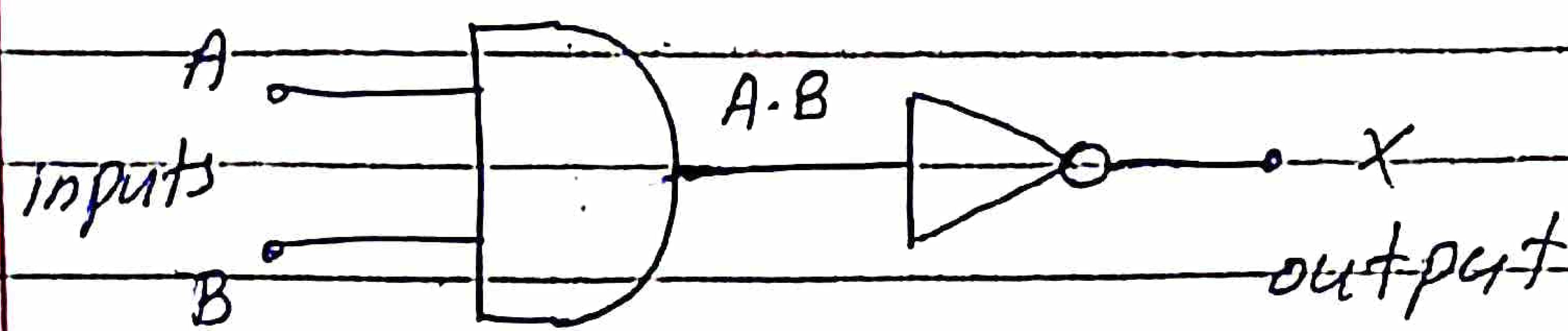


## NAND Gate:

**Defination:** The logic gate for which output is 0 when all the inputs are 1 and output is 1 when anyone and all the inputs are 0. It consist of one output or two or more inputs. It is combination of NOT and AND gate.

**Symbol:**



## Booleam expression:.

$$X = \overline{A \cdot B}$$

Here (·) is not for simple multiplication. It is Booleam function and Bar shows that it is inverted.

## Truth table —Def—

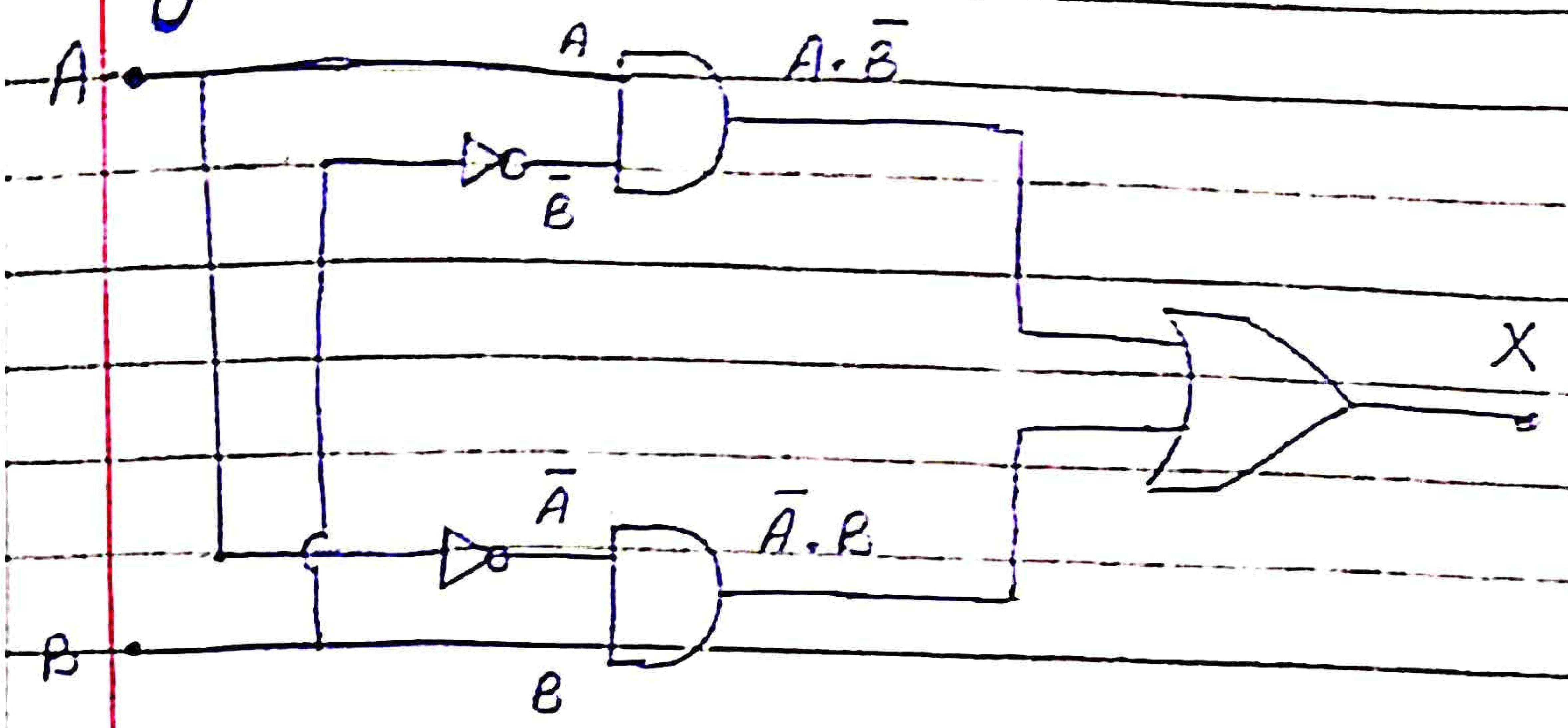
| inputs | | | output |
|---|---|---|---|
| A | B | A·B | $X = \overline{A \cdot B}$ |
| 0 | 0 | 0 | 1 |
| 0 | 1 | 0 | 1 |
| 1 | 0 | 0 | 1 |
| 1 | 1 | 1 | 0 |



## Exclusive OR Gate (XOR):

**Defination:** The logic gate in which output is 0 when all the inputs are same (0 or 1) and output is 1 when the inputs are different is called exclusive OR-gate. It consists of two AND gates, two NOT gates and one OR gate.

Symbol:




Boolean expression:

$$X = A \cdot \bar{B} + \bar{A} \cdot B$$

Here (·) is not for simple multiplication and (+) is not for simple addition. It is a boolean function and Bar shows that it is inverted.

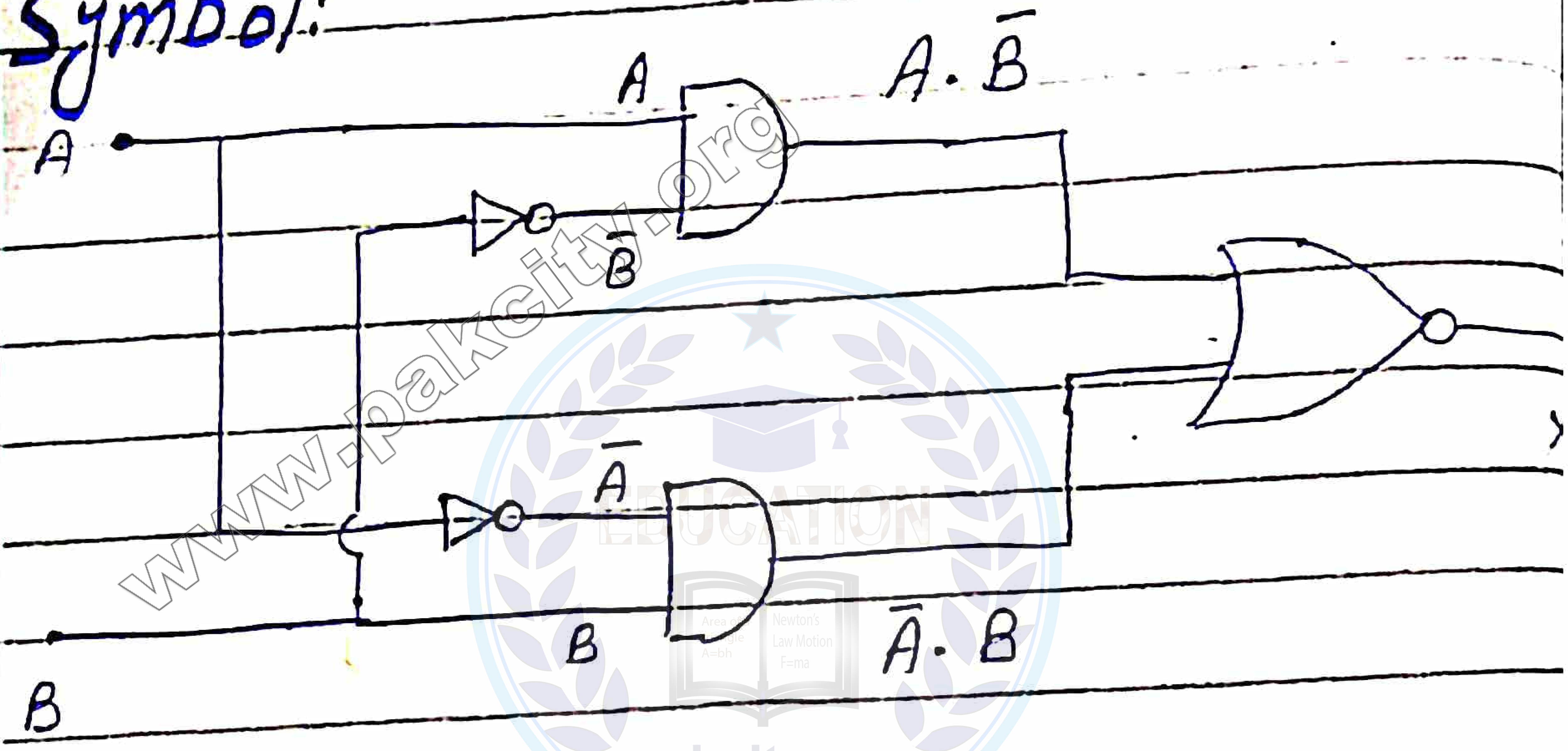
Truth table: — Def —

| inputs | | | | | | output |
|---|---|---|---|---|---|---|
| A | B | $\bar{A}$ | $\bar{B}$ | $A \cdot \bar{B}$ | $\bar{A} \cdot B$ | $X = A \cdot \bar{B} + \bar{A} \cdot B$ |
| 0 | 0 | 1 | 1 | 0 | 0 | 0 |
| 0 | 1 | 1 | 0 | 0 | 1 | 1 |
| 1 | 0 | 0 | 1 | 1 | 0 | 1 |
| 1 | 1 | 0 | 0 | 0 | 0 | 0 |

# Exclusive NOR gate (XNOR):

**Defination:** The logic gate in which output is 1 when all the inputs are same and output is 0 when the inputs are different (0 or 1) is called exclusive NOR gate. It consists of two AND gates, three NOT gates and one OR gate.

**Symbol:**






**Boolean expression:**

$$X = \overline{A\cdot\bar{B} + \bar{A}\cdot B}$$

Here (·) is not for simple multiplication and (+) is not for simple addition. It is Boolean function and Bar shows that it is inverted.

# Truth Table: —Def—



| inputs | | | | | | | output |
|---|---|---|---|---|---|---|---|
| A | B | $\bar{A}$ | $\bar{B}$ | $\bar{A}\cdot B$ | $A\cdot\bar{B}$ | $A\cdot\bar{B}+\bar{A}\cdot B$ | X |
| 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 |
| 0 | 1 | 1 | 0 | 1 | 0 | 1 | 0 |
| 1 | 0 | 0 | 1 | 0 | 1 | 1 | 0 |
| 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 |

## Applications of gates in control System:



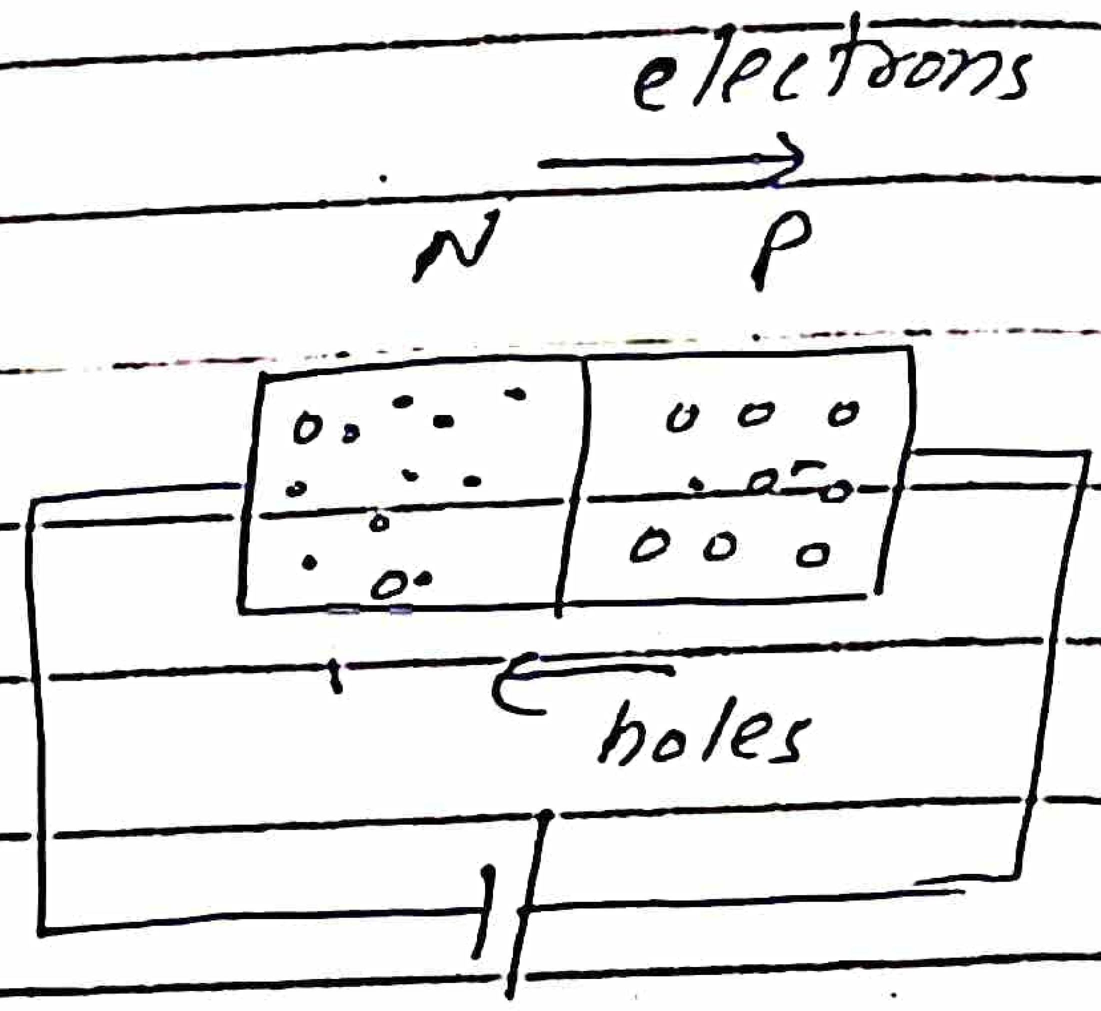
**Sensors:**
As gates operate with electrical Voltages only, so some devices are required which monitor/control the changes. These devices are known as sensors. For example in the example of night switch.

**LDR:** light dependent Resistance (LDR) is a sensor for light because it can convert changes in the intensity of light in to electric Voltage.

## Microphone:-

A thermistor is a sensor for temperature. A microphone is a sound sensor.

# Short Questions

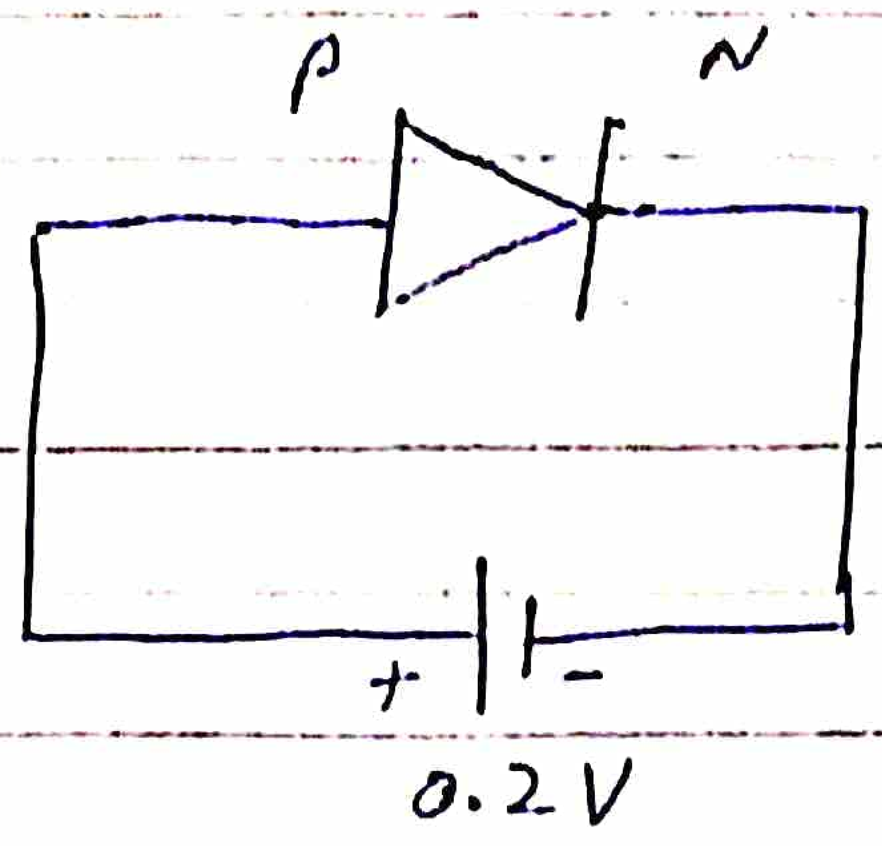



**18.1** In the N-type substance electrons are majority charge carriers and P-type has holes as majority charge carriers. For the PN junction the motion of electrons in N-type substance and motion of holes in P-type substance is opposite. For example, as the shown figure, electrons move right side and holes move towards left.

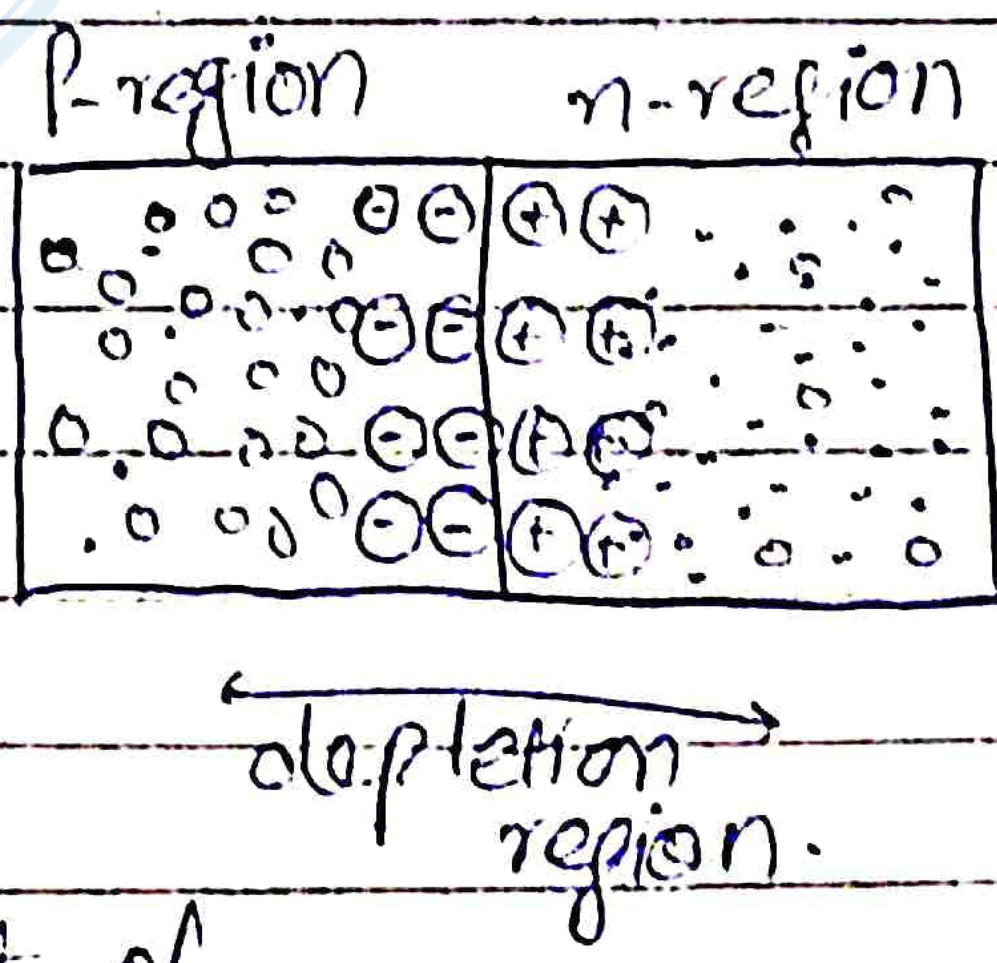
**18.2** There is no net charge on a N-type or P-type substance. Because they are formed by adding pentavalent or trivalent impurity to the

Si or Ge crystal. The impurity is neutral. So, the formed material will also be neutral.

**18.3** The anode of a diode is 0.2V positive with respect to its cathode. It is forward biased. Because anode is connected to positive terminal and cathode is connected to negative terminal of battery.




**18.4** Just after the formation of the junction the free electron in the n-region because of their random motion diffuses into P-region. As a result of this diffusion the region is formed around the junction in which a charge carrier are not present called depletion region.



**18.5** Due to forward biasing of a diode, the width of depletion region decreases because electrons move to produce forward current.

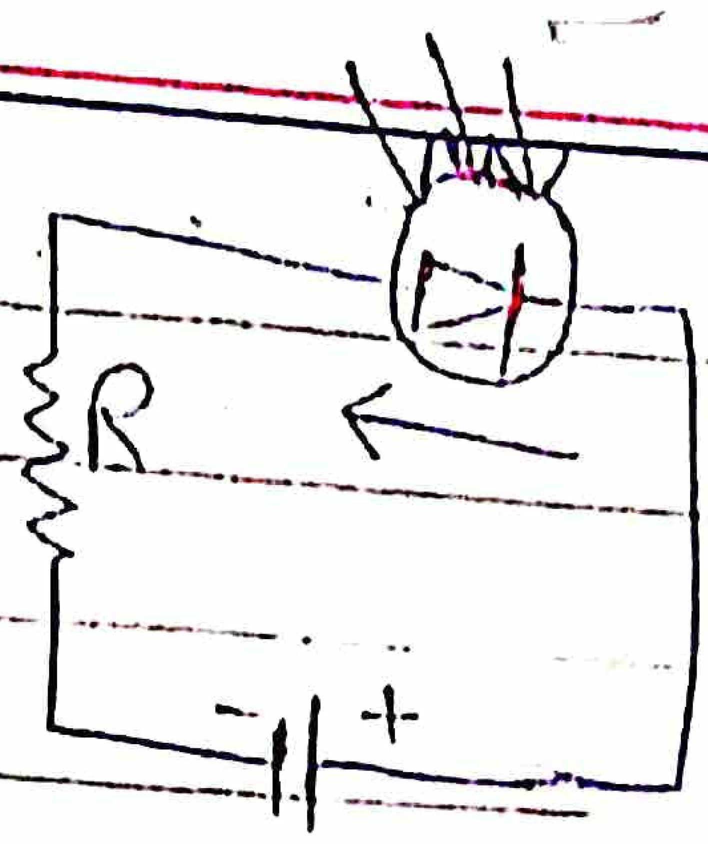
Due to reverse biasing of the diode, the width of depletion region increases because very small current flows due to minority charge carriers.

→ Just after the formation of the junction the free electron in the n-region diffuses into p-region due to their random motion. As a result of this diffusion the region is formed around the junction called depletion region.

**18.6** The rays emitted by the ordinary silicon diode do not lie in the visible region. So, we say that they do not emit light. Moreover, their body is not made in such a way that they emit light.

**18.7** Photo diode are used for detection of light. It is operated in the rerverse biased condition. A photodiode symbol is shown in the figure.

When no light is incident on the junction the reverse current I is almost negligible but when its p-n junction is exposed to light, the reverse current increases with the intensity of light.




**18.8** The base current in a transistor is very small. Because

i- The size of base is very small of the order of $10^{-6}m$

ii- The battery at collector $V_{cc}$ attracts more electrons towards it.



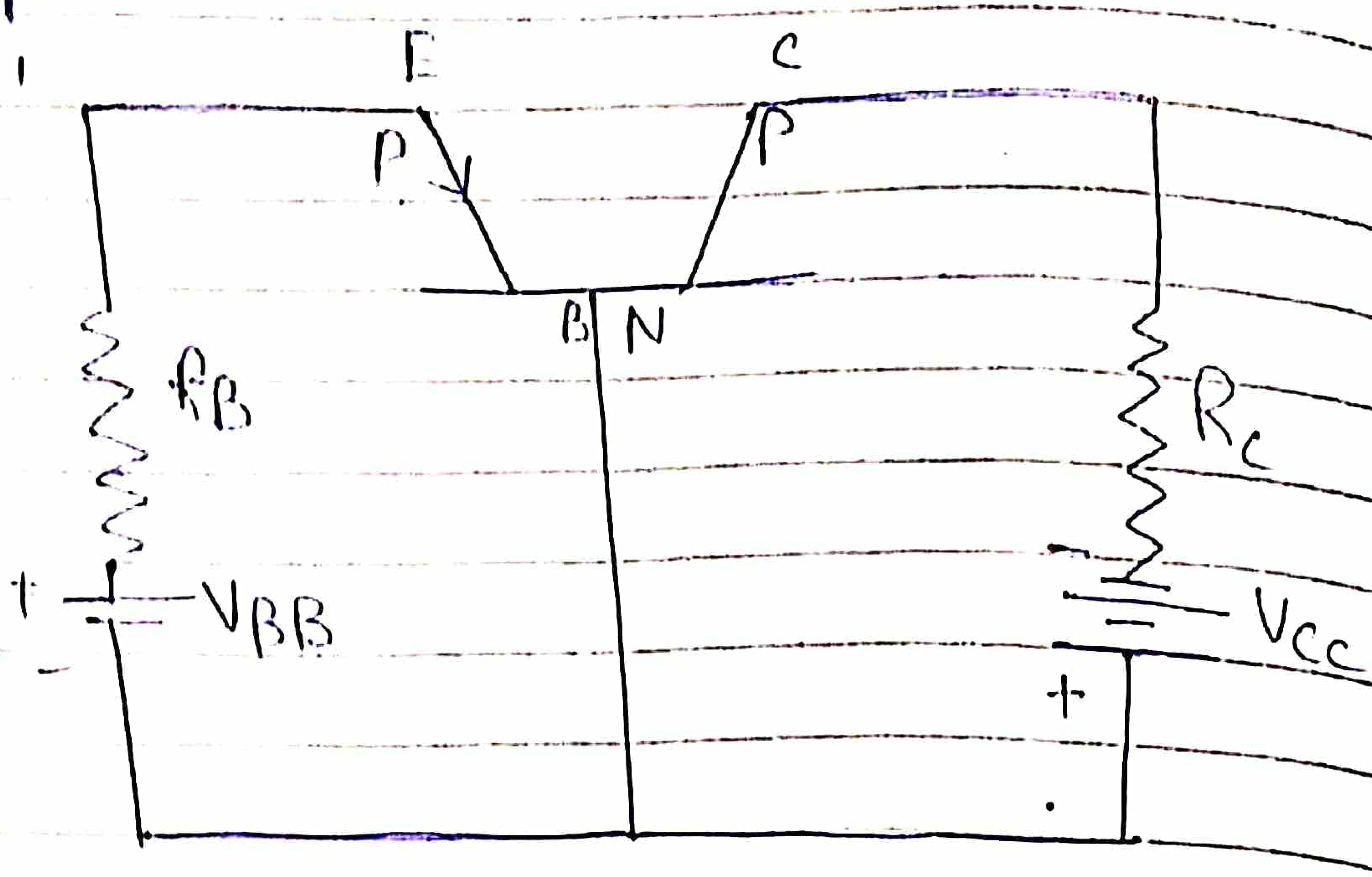
**18.9**

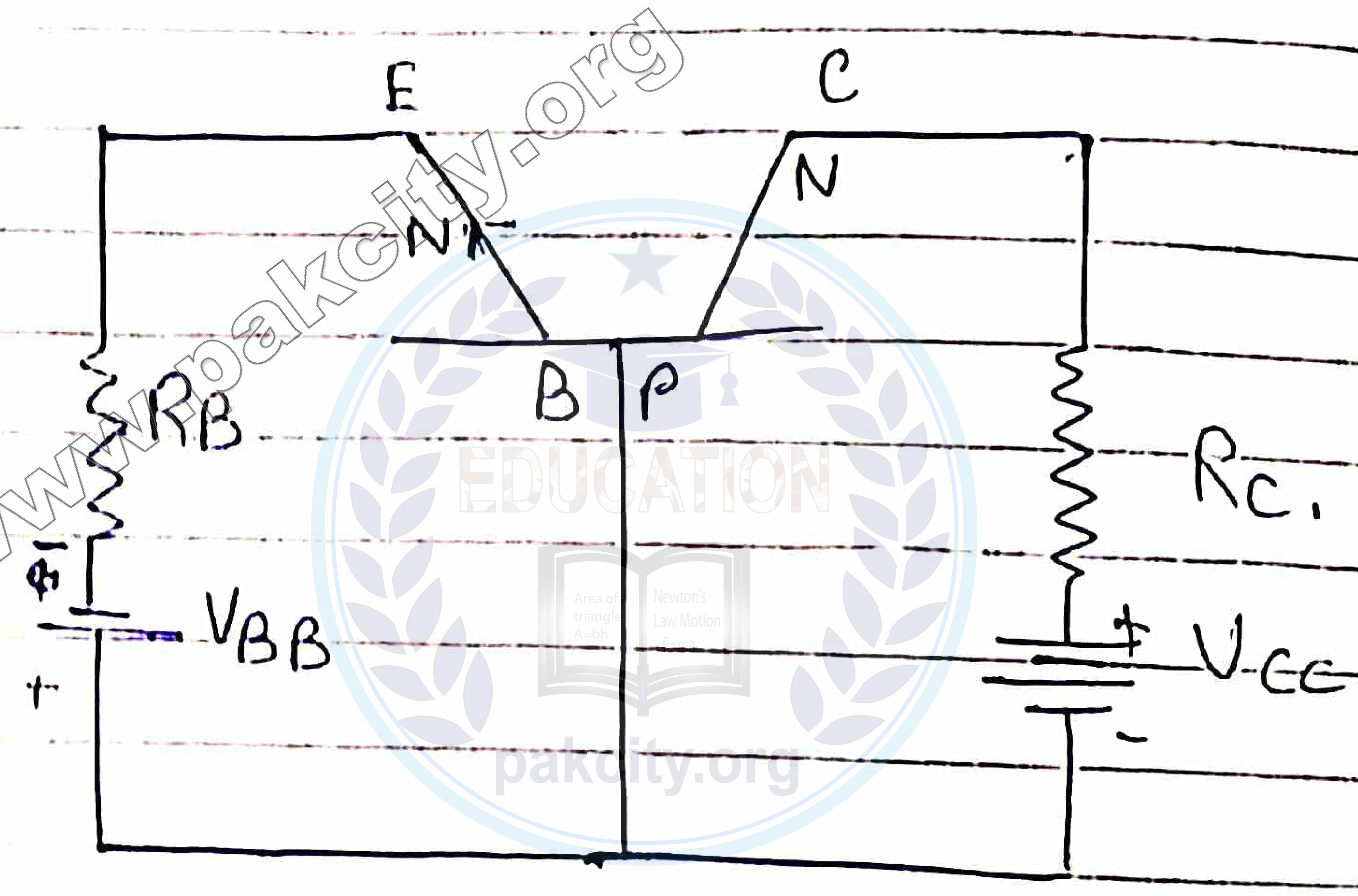
→ The emmitter-base junction is forward biased.

→ The collector-base junction is reverse biased.

→ The potential of the battery $V_{CC}$ must be greater then the battery $V_{BB}$.

ii






**18.10**



As the open loop gain is very high of the order of $10^5$ so, the difference of the input voltage may be taken as zero.

$$V_+ - V_- \approx 0$$

$$V_+ \approx V_-$$

Now the inverting terminal is also virtually grounded

$$V_+ \approx V_- \approx 0\,V$$

$$G = -\frac{R_2}{R_1}$$

The gain of inverting amplifier is given.

18.11-

input: 1, output: 0 → AND gate

input: 0, output: 1 → OR gate

# Numericals

## 18.1 Data

base current $= I_B = 100\ \mu A$

$I_B = 100 \times 10^{-6} A = 10^{-4} A$

collector current $= I_c = ?$

emitter current $= I_E = ?$

$\frac{I_c}{I_E} = ?$, current gain $= \beta = 100$

**Solution**

$$\beta = \frac{I_c}{I_B}$$

$$\beta I_B = I_c$$

$$I_c = (100)(10^{-4})$$

$$I_c = 0.01\ A$$

$$= 10 \times 10^{-3}\ A$$

$$\boxed{I_c = 10\ mA}$$

As

$$I_E = I_c + I_B$$

$$= 0.01 + 10^{-4}$$

$$I_E = 0.0101\ A$$

$$= 10.1 \times 10^{-3}\ A$$

$$\boxed{I_E = 10.1\ mA}$$

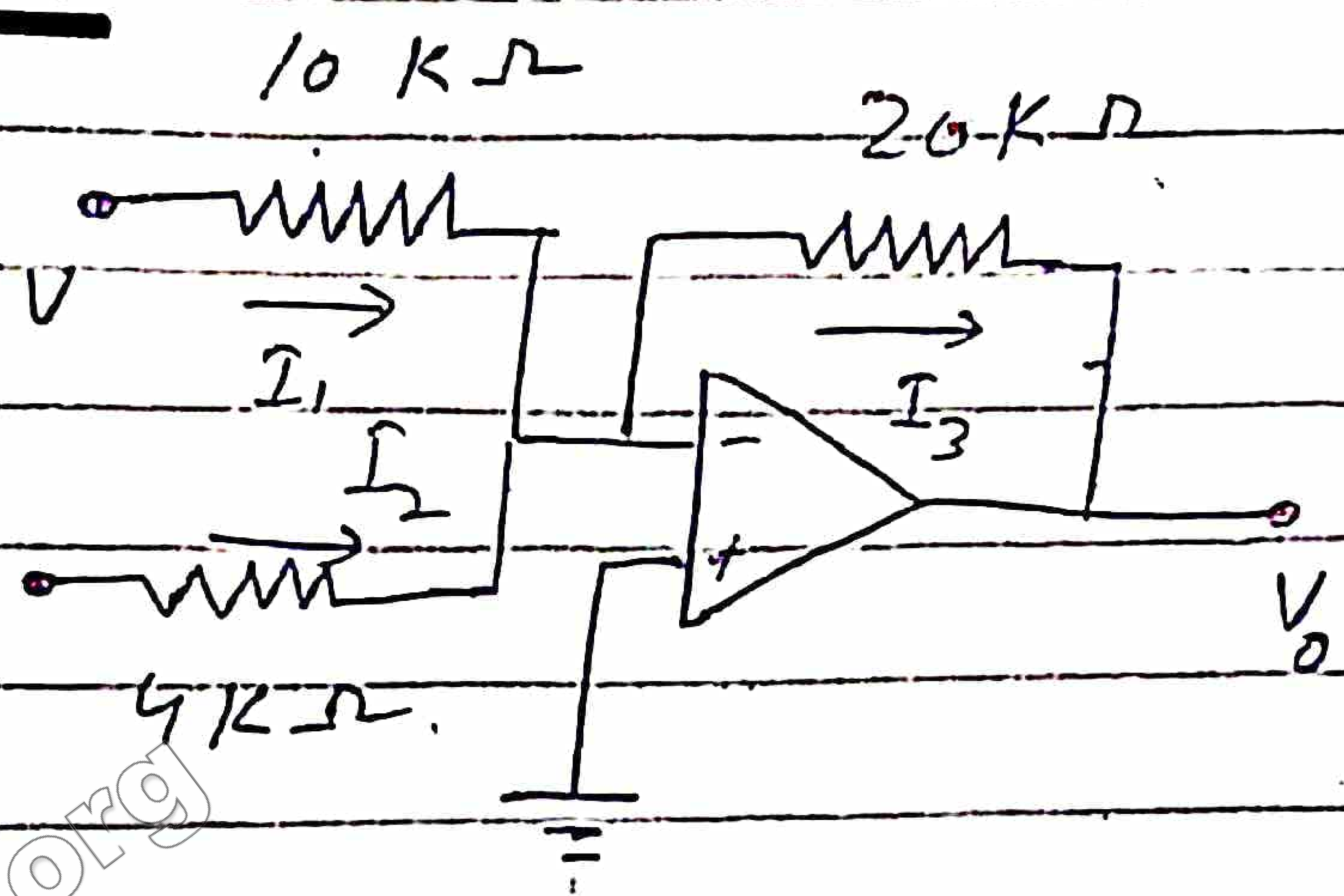
$$\frac{I_C}{I_E} = \frac{10}{10.1}$$

$$\boxed{\frac{I_C}{I_E} = 0.99}$$



## 18.4 Data

$V_- \approx V_+ = 0$




$V_o = ?$



## Solution

$$I_1 = \frac{5-0}{10000}$$

$$I_1 = 5 \times 10^{-4}\ A$$

Now

$$I_2 = \frac{-2-0}{4000}$$

$$I_2 = -5 \times 10^{-4}\ A$$

Now

$$I_3 = \frac{0-V_0}{20000} = -\frac{V_0}{20000}$$

According to Kirchhoff's first rule:

$$I_1 + I_2 = I_3$$

$$(5\times10^{-4}) - (5\times10^{-4}) = -\frac{V_o}{20000}$$

$$0 = -\frac{V_o}{20000}$$

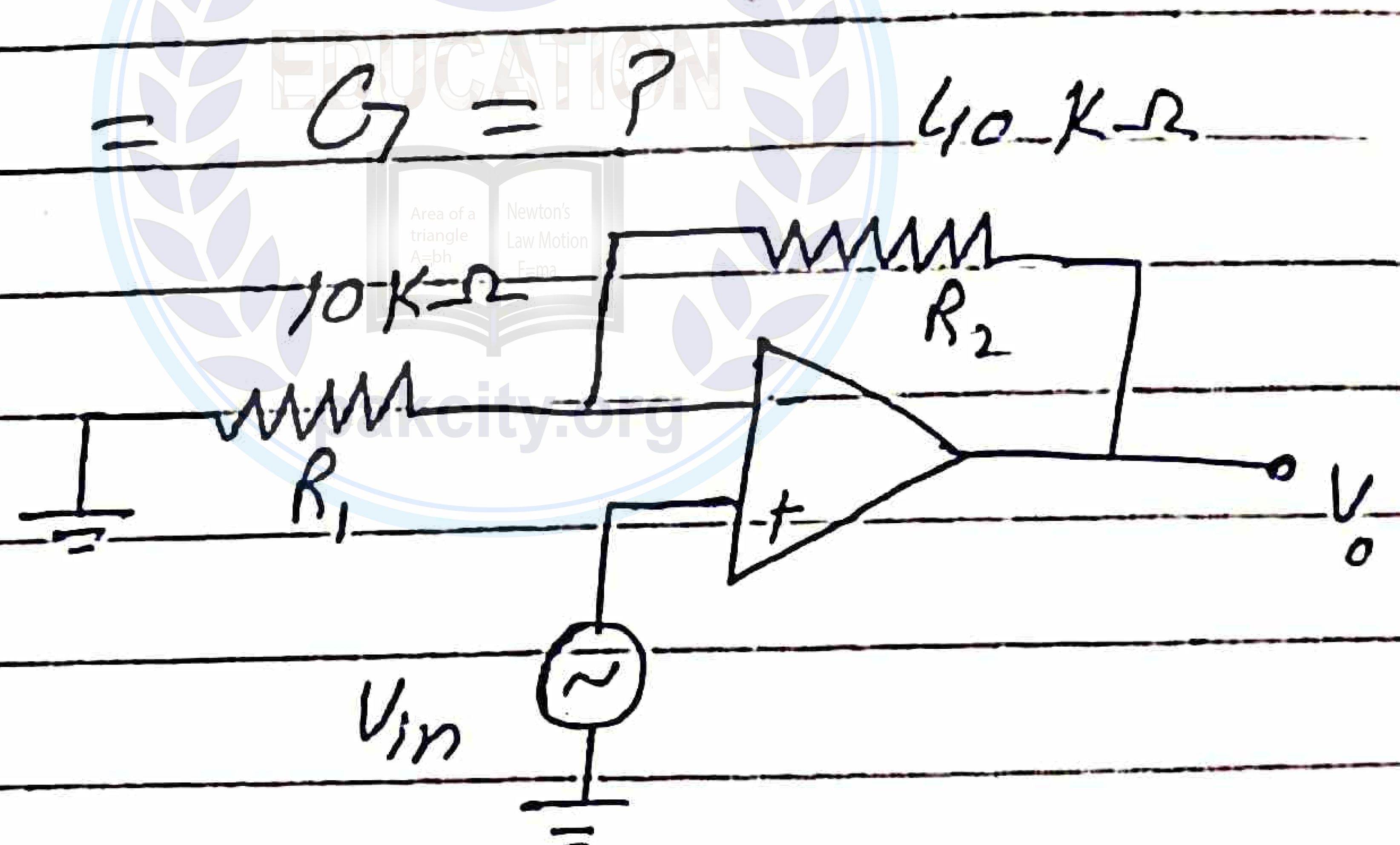
$$V_o = (0)(20000)$$

$$\boxed{V_o = 0}$$



**18.5 Data**

gain = G = ?




$R_1 = 10\ K\Omega = 10000\ \Omega$

$R_2 = 40\ K\Omega = 40000\ \Omega$

**Solution** For non inverting amplifier

$$G = 1 + \frac{R_2}{R_1} = 1 + \frac{40000}{10000}$$

$$G = 1 + 4 \Rightarrow \boxed{G = 5}$$