Construction:

- **Substrate:-** The JFET is typically fabricated on a silicon substrate, which provides the foundation for the device.

- **N-type Channel:-** An n-type region is created in the silicon substrate, forming the channel through which current will flow. This is achieved by doping the substrate with impurity atoms that introduce extra electrons.

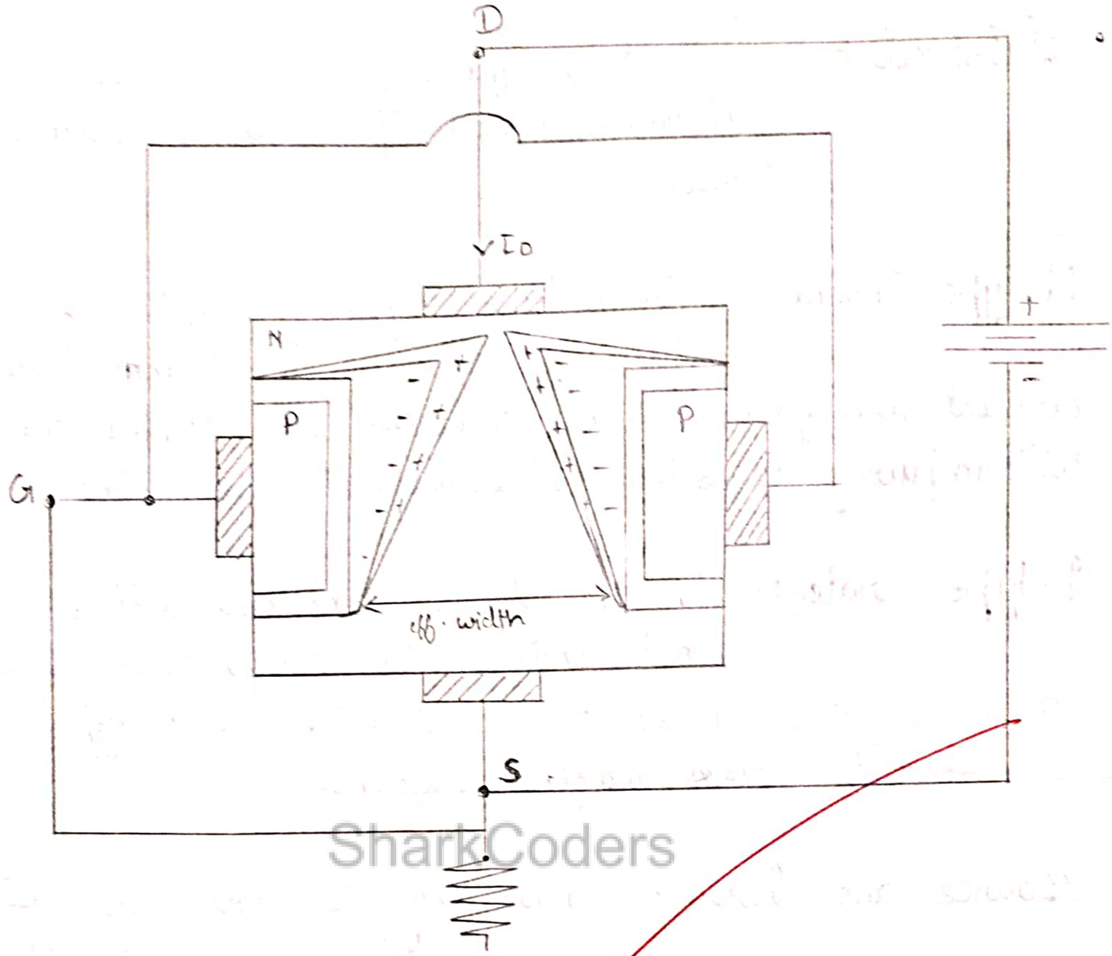
- **P-type Gates:-** Two p-type regions are diffused or implanted into the ends of the n-type channel. These regions form the gate terminals of the JFET. The p-type doping introduces ~~to~~ extra holes into these regions.

- **Source and Drain:-** Ohmic contacts are made ~~of~~ to the ends of the n-type channel, creating the source and drain terminals. These contacts allow for the flow of current into and out of the channel.

- **Gate Isolation:-** The gate regions are often isolated from the channel by a layer of oxide or other insulating material. This helps to prevent unwanted leakage currents and improve the device's performance.

- **Overall Structure:** The final structure of an N-channel JFET resembles a bar-shaped device with the source and drain terminals at opposite ends and the gate ~~terminals~~ terminals connected to the p-type regions.

3.3 Working of n-channel JFET



Working :

1. No Gate Voltage –

- When no gate voltage is applied, the p-n junctions at the gate terminals are reverse biased.
- This creates depletion regions at the junctions, extending into the n-type channel.
- The depletion region consists of regions depleted of majority carriers (electrons in this case).
- Despite the depletion regions, the channel is still conductive due to the remaining electrons.
- Current can flow between the source and drain terminals.

2. Negative Gate Voltage –

- Applying a negative voltage to the gate increases the reverse bias at the p-n junctions.
- This causes the depletion regions to widen, extending further into the n-type channel.
- As the depletion regions widen, the effective width of the n-type channel decreases.
- This narrowing of the channel reduces the number of electrons available to conduct current.

- As a result, the drain current decreases.

3. Pinch-Off –

- At a sufficiently high negative gate voltage, the depletion regions extend so far into the channel that they meet in the middle.

- This effectively pinches of the channel, creating a region with no free carriers.

- At pinch-off, no current can flow between the source and drain, regardless of the applied drain-source voltage.

- The JFET is in cutoff mode at this point.

Key Points –

- The gate voltage controls the width of the depletion regions, which in turn controls the channel's conductivity.

- A negative gate voltage increases the depletion region, narrowing the channel and reducing drain current.

- At pinch-off, the channel is completely depleted, and no current can flow.

- The JFET's operation is based on the principles of semiconductor physics and the behaviour of p-n junctions.

Characteristics:

- High Input Impedance – JFETs have a high input impedance due to the reverse-biased p-n junctions at the gate.

- Low Noise – JFETs are known for their low noise characteristics, making them suitable for applications where noise is a critical factor.

- Wide Range of Applications – JFETs are used in a variety of electronic circuits, including amplifiers, oscillators, and switches.

In summary, an N-channel JFET operates by controlling the width of a semiconductor channel using a reverse-biased p-n junction. This allows it to regulate the flow of current through the device, making it a versatile component in many electronic applications.

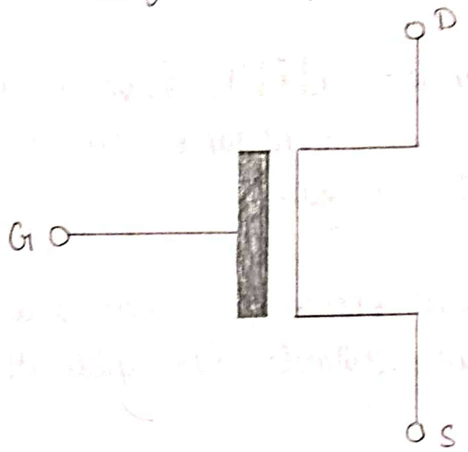
Q9. Describe the construction & working of n-channel E-MOSFET.

An N-Channel Enhancement-Mode MOSFET (NMOSFET) is a type of field effect transistor (FET) that controls the flow of current through a semiconductor channel using an electric field applied to a gate terminal.

P.T.O

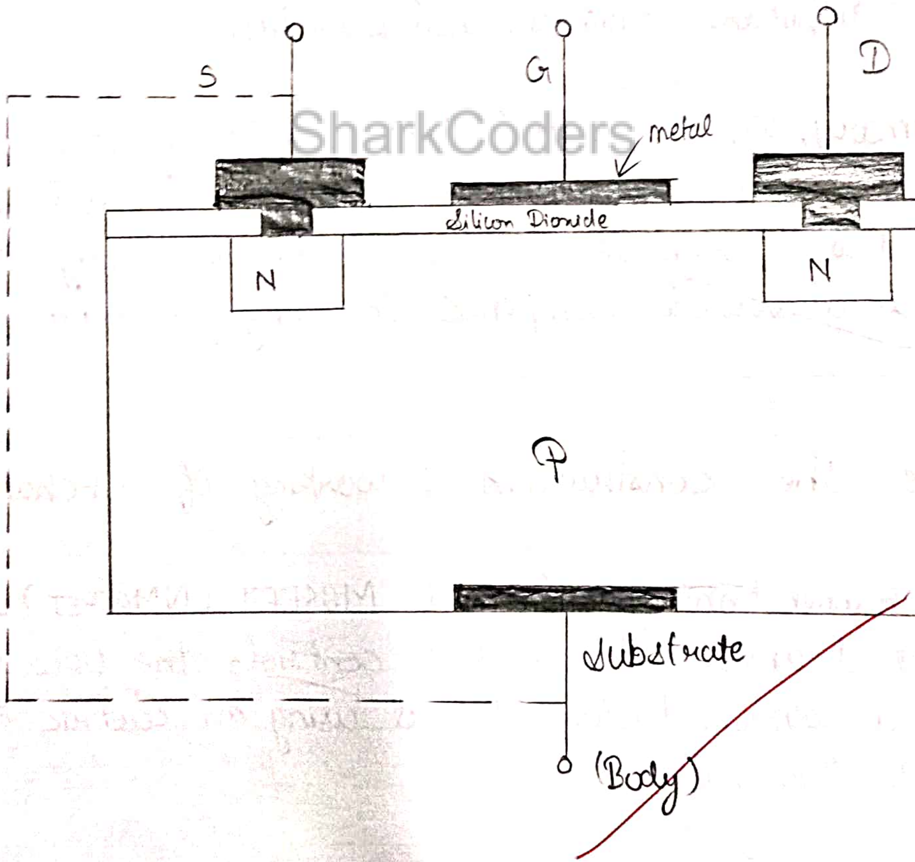
a3. →

3.1 Symbol of n-channel E-MOSFET



- G → Gate
- D → Drain
- S → Source

3.2 Construction of n-channel EMOSFET



Construction:

- Substrate :- Typically made of p-type silicon, providing the base material for the device.

- N-type Source and Drain:- Heavily doped n-type regions diffused or implanted into the substrate. These regions act as the terminals where current enters and exits the device.

- Gate :- A metal electrode (often aluminium or polysilicon) separated from the channel by a thin layer of insulating oxide (usually silicon dioxide). The gate controls the flow of current through the channel.

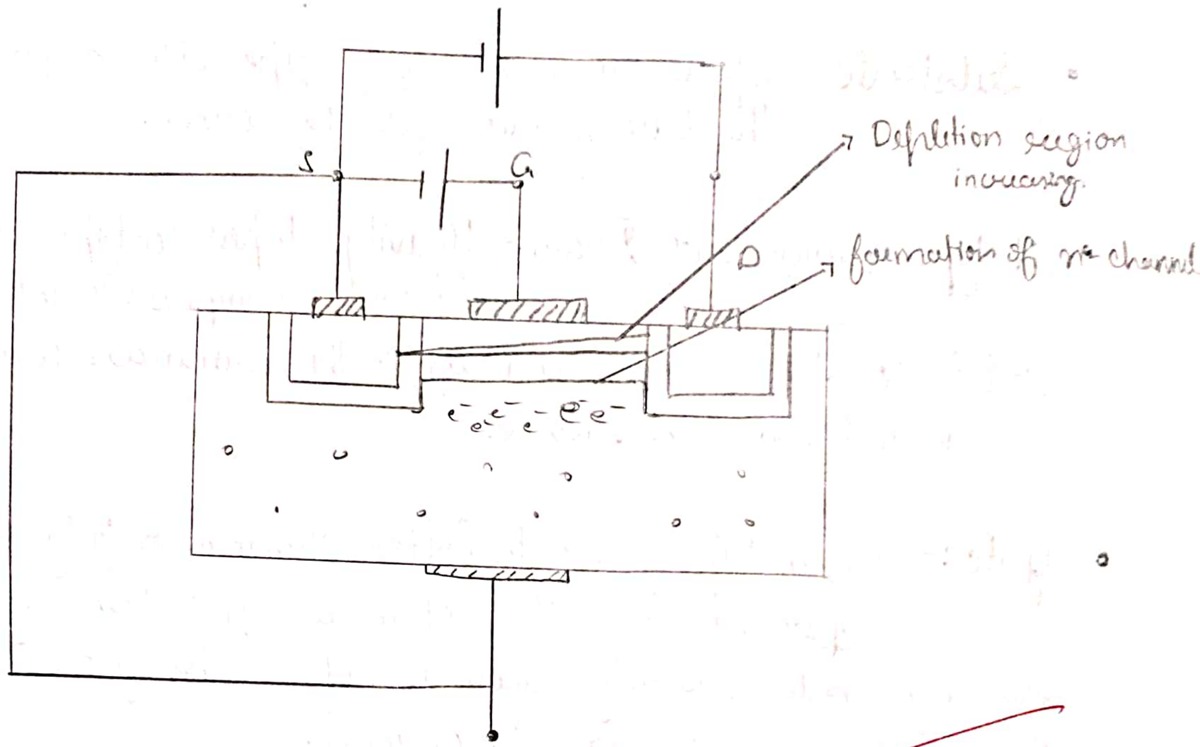
- Channel:- A region between the source and drain that can be induced or depleted depending on the gate voltage. In an NMOSFET, the channel is initially non-conductive.

Working:

1. No Gate Voltage: In the enhancement mode, the channel is initially non-conductive. There is no direct connection between the source and drain.

2. Positive Gate Voltage: When a positive gate voltage is applied to the gate, an electric field is created across the oxide layer. This field attracts electrons from the p-type substrate into the region between the source and drain, forming a temporary n-type channel.

9.2 Working of n-channel E-MOSFET



3. Increasing Gate Voltage:- As the gate voltage increases, more electrons are attracted to the channel, increasing its conductivity. This allows current to flow between the source and drain.

4. Cut-off:- When the gate voltage is zero or negative, the channel is depleted of electrons, and no current can flow.

Explanation:-

1. Channel Formation:- The gate voltage creates an electric field that inverts the surface of the p-type substrate beneath the gate, forming a temporary n-type channel.

2. Carrier Flow:- When a positive voltage is applied to the gate, electrons from the n-type source region are attracted to the channel, creating a conductive path.

3. Current Flow:- As the gate voltage increases, the channel becomes more conductive, allowing more current to flow from the source to the drain.

Key Points:-

- The gate voltage controls the conductivity of the channel.
- A positive gate voltage voltage creates an n-type channel, preventing

- A negative gate voltage depletes the channel, preventing current flow.
- NMOSFETs have a high input impedance and low power consumption.
- They are widely used in digital and analog circuits due to their versatility and high performance.

#/ Characteristics:

- High Input Impedance:- MOSFETs have high input impedance.
- Low Power Consumption:- MOSFETs consume very little power when in the off state.

- High Switching Speed:- MOSFETs can switch off and on very quickly.
- Wide Range of Applications:- MOSFETs are used in various electronic circuits.

In Summary, an MOSFET is a semiconductor device that controls the flow of current through a channel using an electric field applied to a gate terminal. Its high performance and versatility makes it a ~~cruel~~ crucial component in modern electronics systems.

Assinment - III

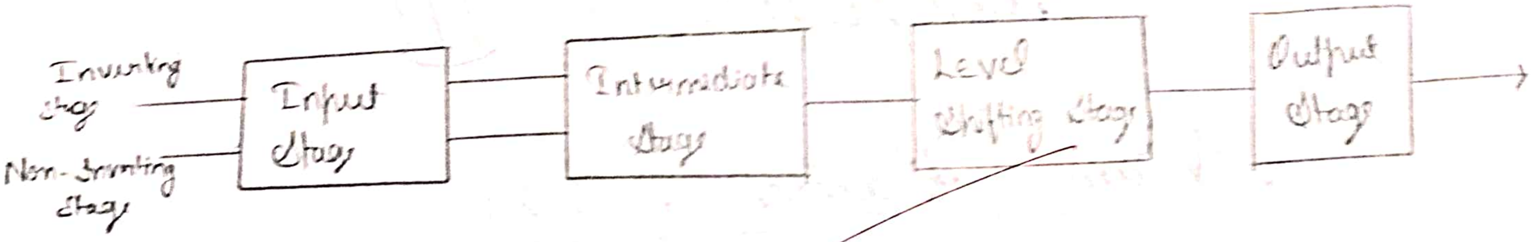
Name :- Kashish Valecha

Roll No :- 27

Division :- F

Subject :- Basic Electronics

Q1. (1.1) Block Diagram:



Q.1. Operational Amplifier:

An operational amplifier (op-amp) is a versatile integrated circuit (IC) widely used in analog circuits. It's essentially a high gain, direct-coupled differential amplifier with a high input impedance and a low output impedance.

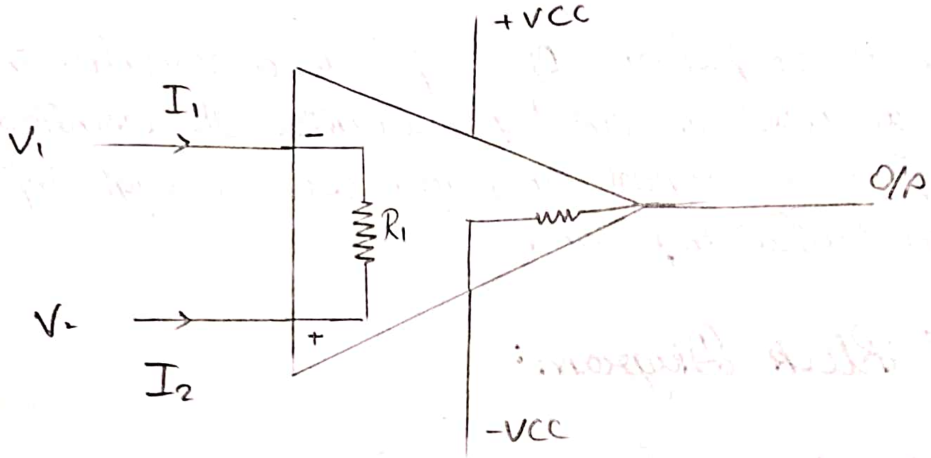
#: Stages of Block Diagram:

- Input Stage: The main function of OP-amp is, at first it creates a difference between the two input signals then amplifies the differentiated signal. So, in the input stage, the differential amplifier creates the difference. In this stage, the differential amplifier also provides the high input impedance which is necessary for the op-amp. We can see in this stage the dual input balanced balanced output differential amplifier is used which increases the voltage for the next stage of operation.

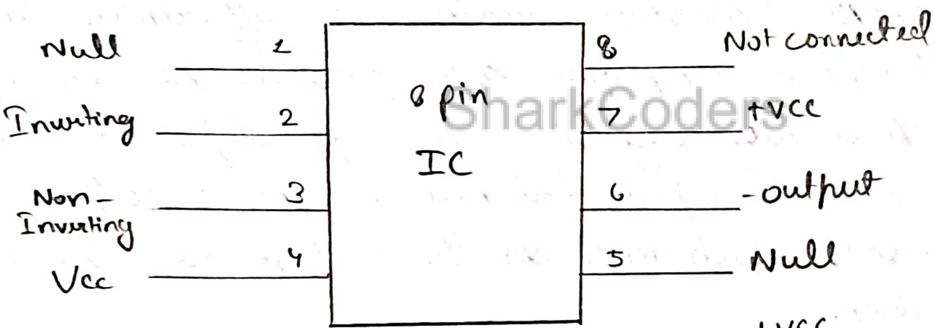
- Intermidiate Stage: The output of the input stage is used as the input of the Intermidiate Stage. In this stage, the direct coupling happens. So, in this stage, the DC voltage is greater than the ground potential or 0V.

- Level Shifting Stage: As in this stage the shifting of voltage level happens that is why it is called level shifting stage. In this stage the op-amp adjusts the DC voltage level of output signal without affecting its AC component. To ensure that AC component of the signal is not affected; a capacitor is placed in parallel with the resistor. The capacitor has high impedance to DC so, it blocks the DC component of the ~~si~~ signal.

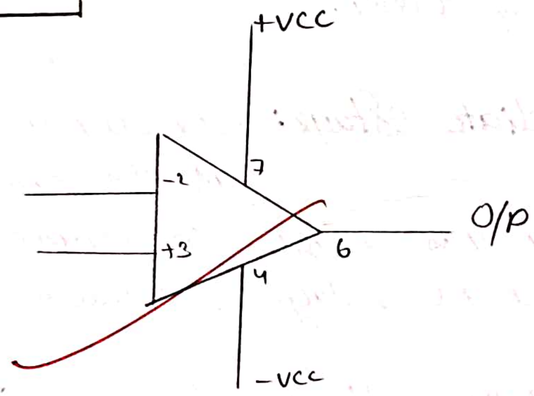
Q.2. 2.1 Infinite Input Resistance



2.2 Pin Diagram Of IC



Symbol:-



- **Output Stage:** In this stage, the push-pull amplifier is used. The output of the level-shifting stage is given to the input of the push-pull amplifier. The push-pull amplifier increases the output voltage and high current-delivering capability of the operational amplifier.

Q2. Explain the characteristics of OP-amp in detail.

1. **Infinite Voltage Gain** – The infinite voltage gain of an ideal OP-amp means that it can amplify the input voltage to an arbitrarily large output voltage. This property is useful in application where a high gain is required, such as in audio amplifier or signal processing circuits.
   It is ~~called~~ denoted by - A_v and $$A_v = \frac{V_o}{V_d}$$

2. **Infinite Input resistance** – Input resistance in that the total resistance, measured b/w two input terminals. It is the ratio of input voltage to input current and is assumed to be infinite to prevent any current and is assumed to be infinite to prevent any current flowing from the source ~~supply~~ into the amplifier input circuitary ($I_{in} = 0$).

3. **Zero op-amp resistance** – The output resistance for an ideal op-amp is zero because in that way the output voltage remains unaffected even if the external load draws out any current.

4. Zero offset voltage – The voltage which appears across the output when both the input voltage are zero that voltages is called to be an offset voltage still we get some voltage at output.

5. Infinite Bandwidth – Bandwidth - Distance b/w two maximum frequency. An ideal opamp has infinite bandwidth, which means that it can amplify any frequency signals from 0 to infinity hertz (Hz) without attenuation.

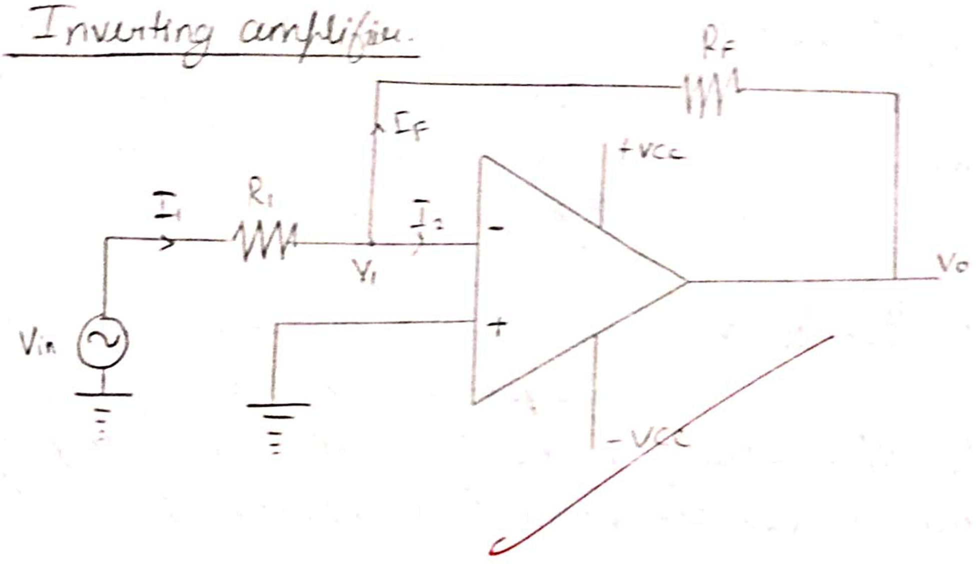
6. Infinite CMRR – CMRR also known as Common Mode Rejection Ratio for a differential amplifier. It is a metric that measures how well a device can reject common-mode signals, which are signals that appear simultaneously and in phase on both inputs.

$$CMRR = \frac{|AV|}{|AC|}$$

7. Infinite Slewrate – It measures that the working of an amplifier by checking the responses to the change in input signals. It is a theoretical characteristic of an ideal operational amplifiers that ~~describle~~ describes its ability to instantly change its output voltage in responses to a change in input voltage. $S = \left.\frac{dV_0}{dt}\right|_{max}$

8. Zero PSRR – also called Power Supply Rejection Ratio, is a parameter which specifies the dependance of the op-amp output on the change in the input power supply voltage.

(a) Inverting amplifier.



Q3. a) Explain Op-amp as an inverting amplifier.

The configuration of inverting amplifier:
By applying KCL at node V_1

$$I_1 = I_F + I_2$$

$$I_2 = 0$$

$$I_1 = I_F$$

$$\frac{V_{in} - V_1}{R_1} = \frac{V_1 - V_0}{R_F}$$

According to Vgc

$$V_1 = 0$$

$$\therefore \frac{V_{in}}{R_1} = \frac{-V_0}{R_F}$$

$$\Rightarrow \frac{V_{in}}{R_1} = \frac{-V_0}{R_F}$$

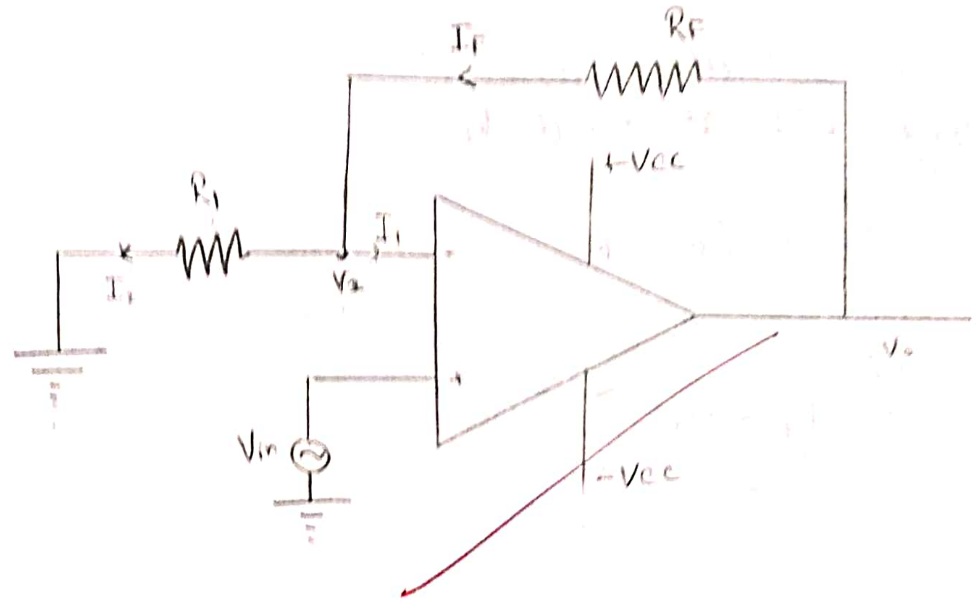
$$\Rightarrow \frac{R_F}{R_1} = \frac{-V_0}{V_{in}}$$

$$\Rightarrow \frac{V_0}{V_{in}} = \frac{-R_F}{R_1}$$

$$\Rightarrow \boxed{V_0 = \left[\frac{-R_F}{R_1}\right] V_{in}}$$

The inverting amplifier is Input signals is applied to the inverting terminal ~~with~~ while the non-inverting is grounded.

(b) Non-Inverting Amplifier



b) Explain op-amp as a Non-inverting amplifier.

By applying KCL at node V_1

$$I_1 + I_2 = I_F$$

$$\frac{V_0 - V_1}{R_F} = 0 + \frac{V_1 - 0}{R_1}$$

$$\frac{V_0 - V_1}{R_F} = \frac{V_1}{R_1}$$

Acc. to VSGr $V_2 = V_1$

$$\frac{V_0 - V_1}{R_F} = \frac{V_1}{R_1}$$

$$\frac{V_0}{R_F} - \frac{V_1}{R_F} = \frac{V_1}{R_1}$$

$$\frac{V_0}{R_F} = \frac{V_1}{R_1} + \frac{V_1}{R_F}$$

$$V_0 = V\left[\frac{1}{R_1} + \frac{1}{R_F}\right] V_1 R_F$$

$$V_0 = \left[\frac{R_1 + R_F}{R_1}\right] V_1$$

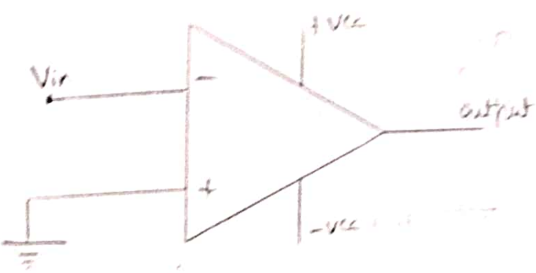
Now, $\frac{V_0}{V_1} = 1 + \frac{R_F}{R_1}$, we know that, $\frac{V_0}{V_1} = A_V$

$$\therefore A_V = 1 + \frac{R_F}{R_1}$$

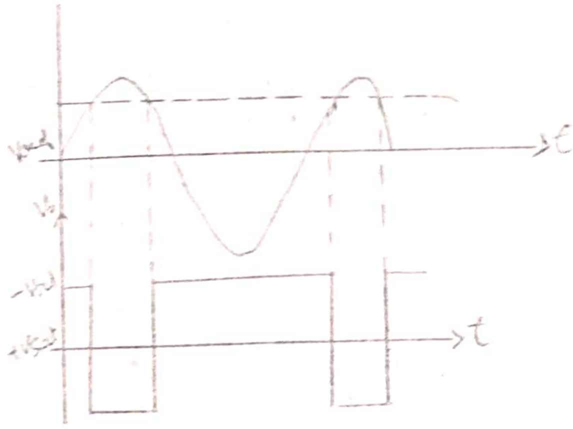
∴ Configuration of the amplifier takes input signal and amplifies the diff. b/w them.

- Gain formula = $A_V = 1 + \frac{R_F}{R_1}$

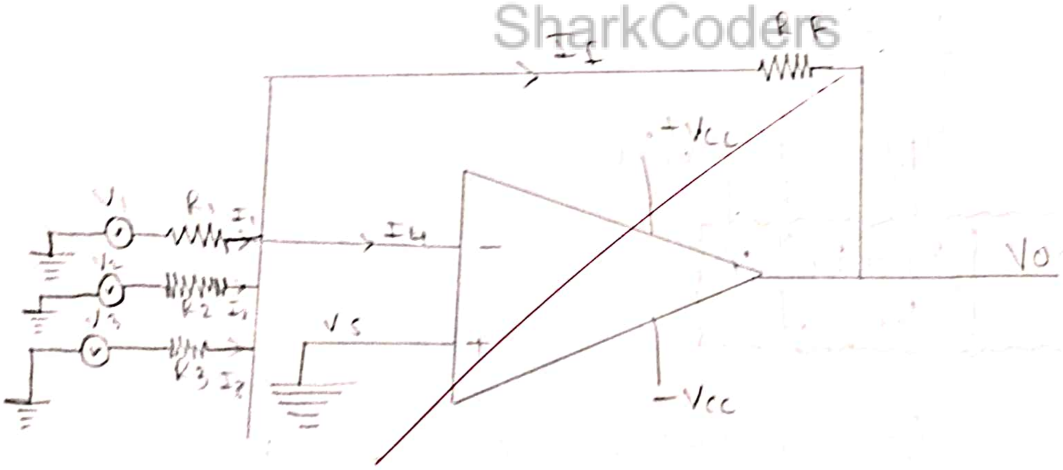
(C1) Comparator



(C2) Waveform



d] Adder



c) Explain op-amp as an comparator.

A comparator is a circuit which compares a signal voltage applied at one input of the op-amp with a known refrence voltage at other input.

Figure (C1) shows that circuit diagram of an inverting comparator with the refrence voltage if applied at the non-inverting input. The input signals applied at the inverting input when the input voltage Vin is less than the refrence voltage Vref, the output voltage is at maximum level -Vce3. when the input voltage in Vin is less than the refrence voltage Vin is greater that the refrence voltage Vref, the output voltage is at maximum positive level +Vsat (=Vcc). The input and output waveforms are shown below Vref=0.

When Vref is set to zero, the comparator is called zero crossing detector.

d) Explain op-amp as an adder.

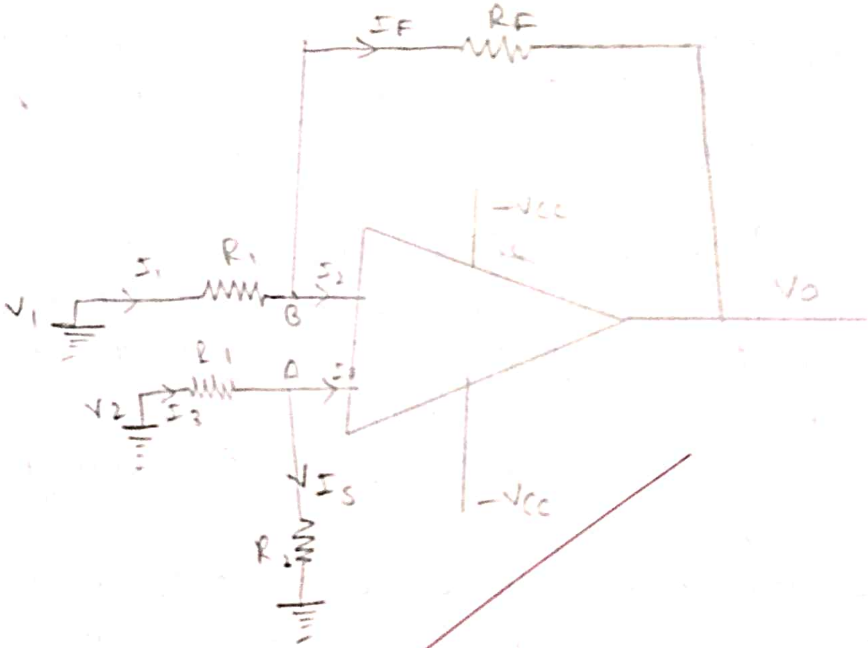
An operation amplifier (op-amp) can be used as an adder or summing amplifier, to produce an out voltage that is the sum of two or more input voltages.

Applying KCL at node V_G.

$$I_1 + I_2 + I_3 = I_4 + I_F$$

$$\frac{V_1 - V_G}{R_1} + \frac{V_2 - V_G}{R_2} + \frac{V_3 - V_G}{R_3} = 0 + \frac{V_G + V_0}{R_F}$$

c] Subtractor



Acc. to VGC $V_S = 0$, $V_{01} = 0$

$$\frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3} = \frac{-V_0}{R_F}$$

$$V_0 = -R_F\left(\frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3}\right)$$

if we consider,

$$R_1 = R_2 = R_3 = R_F$$

$$\therefore \boxed{V_0 = -(V_1 + V_2 + V_3)}$$

e) Explain op-amp as a substractor.

Applying KCL at A :- $I_3 = I_4 + I_5$

$$\frac{V_2 - V_A}{R_1} = 0 + \frac{V_A - 0}{R_2}$$

$$\frac{V_2 - V_A}{R_1} = \frac{V_A}{R_2}$$

$$\frac{V_2}{R_1} = \frac{V_A}{R_2} + \frac{V_A}{R_1} \Rightarrow \frac{V_2}{R_1} = V_A\left(\frac{1}{R_2} + \frac{1}{R_1}\right)$$

$$V_A = \frac{V_2}{R_1}\left(\frac{R_2 R_1}{R_1 + R_2}\right)$$

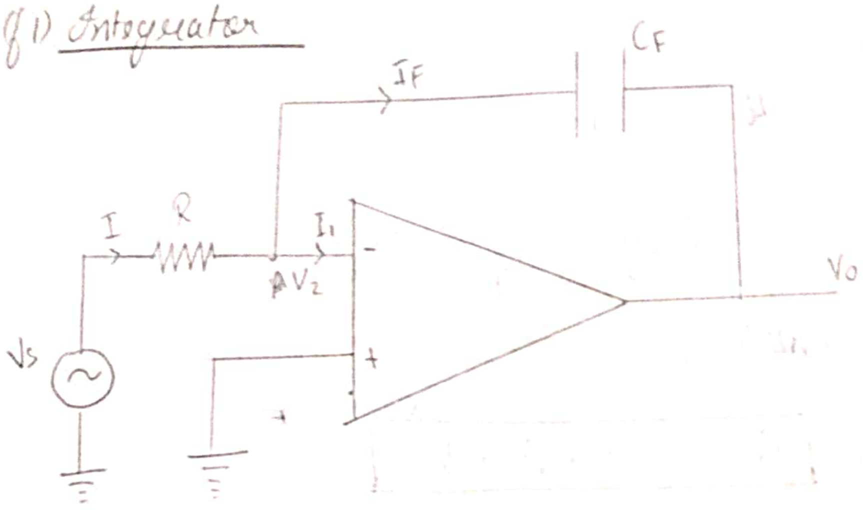
$$\boxed{V_A = \frac{V_2 R_2}{R_1 + R_2}} \quad \text{—— (1)}$$

Apply KCL at B:- $I_1 = I_2 + I_F$

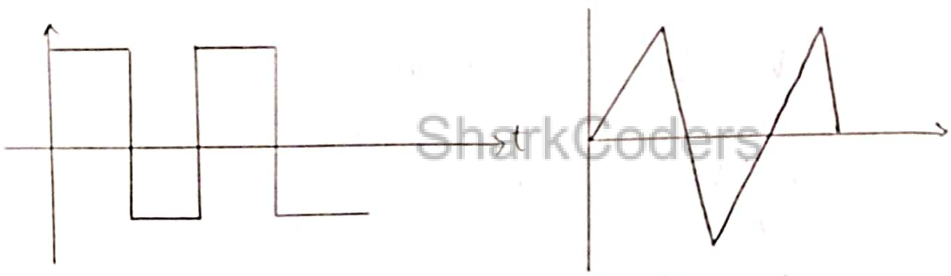
$$\frac{V_1 - V_B}{R_1} = 0 + \frac{V_B - V_0}{R_F}$$

$$\Rightarrow \frac{V_1}{R_1} - \frac{V_B}{R_1} = \frac{V_B}{R_F} - \frac{V_0}{R_F}$$

(f) f1) Integrator



(f2) Waveforms



$$\Rightarrow \frac{V_B}{R_F} + \frac{V_B}{R_1} = \frac{V_1}{R_1} + \frac{V_0}{R_F}$$

$$\frac{V_0}{R_F} = V_B\left(\frac{R_1 + R_F}{R_1 R_F}\right) - \frac{V_1}{R_1}$$

Substituting value of eq ① to V_B

$$\frac{V_0}{R_F} = \frac{V_2 R_2}{R_2 + R_1}\left(\frac{R_1 + R_F}{R_1 R_F}\right) - \frac{V_1}{R_1}$$

$$\boxed{V_0 = \frac{R_2}{R_1}(V_1 - V_2)}$$

f) Explain op-amp as an Integrator.

An op-amp integrator performs mathematical integration. It can convert a square wave to a triangular wave, a triangle wave to a sin wave, or a sin wave to a cosine wave. The amplitude of the output signals is influenced by the resistance of the input resistor and the capacitance of the feedback capacitor.

Apply KCL at node A –

$$I = I_1 + I_F$$

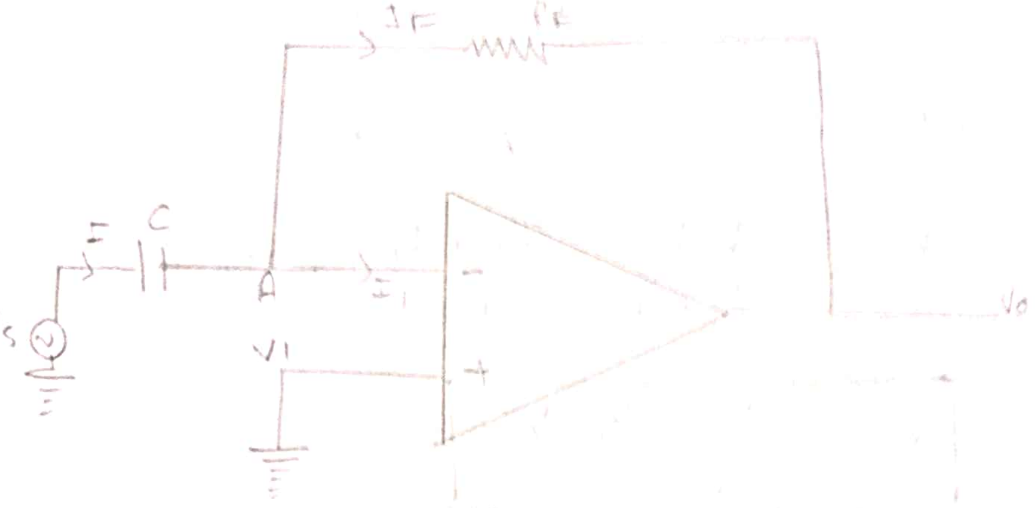
$$\frac{V_s - V_2}{R} = 0 + \frac{dQ}{dt}$$

$$\frac{V_s - V_2}{R} = \frac{d(C_F V)}{dt}$$

by VGC. $V_1 = V_2 = 0V$

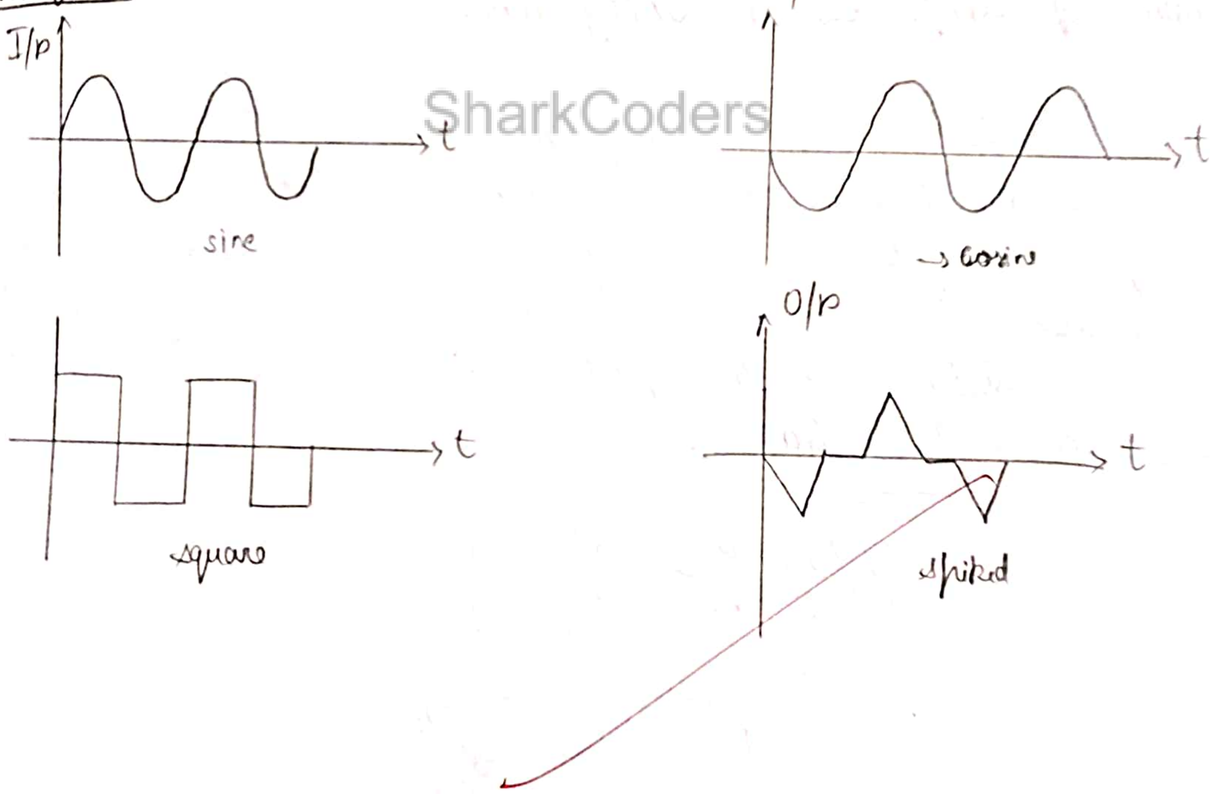
$$\frac{V_s - 0}{R} = C_F \frac{dV}{dt}$$

g) (g.1) Differentiator.



Waveforms

(g.1)



$$\frac{V_s - V_0}{R} = C_F \frac{d(0 - V_0)}{dt}$$

$$\boxed{\frac{V_s}{R_1} = \frac{C_F\, d(-V_0)}{dt}}$$

Integrating both sides:-

$$\int_0^t \frac{V_{in}}{R_1} dt = \int_0^t C_F \frac{d}{dt}(-V_0)\, dt$$

$$\int_0^t \frac{V_{in}\, dt}{R_1} = C_F\,(-V_0) + V_0$$

$$V_0 = \frac{-1}{R_1 C_F} \int_0^t V_{in} dt + C$$

Where, C is constant.

g) Explain op-am as differentiator.

Op-amp can be used as a differentiator to produce an output voltage that's proportional to the rate of change of the input voltage.

Applying KCL at node A:-

$$I = I_1 + I_F$$

$$\frac{dQ}{dt} = 0 + \frac{V_2 - V_0}{R_F}$$

$$\frac{d(CV)}{dt} = 0 + \frac{V_2 - V_0}{R_F}$$

$$\frac{C\, d(V_s - V_2)}{dt} = \frac{V_2 - V_0}{R_F}$$

Acc. to Voc, $V_1 = V_2 = 0V$

$$\frac{C\,d(V_s)}{dt} = \frac{-V_o}{R_F}$$

$$\boxed{\frac{V_o}{R_F} = -C\frac{d(V_s)}{dt}}$$

Q4. Application of Op-amp.

- Amplifier – Inverting & non-inverting amplifier: used to work to amplify weak signals in audio, instruments & communication system.
- Filter – Active filter used in audio processing and signals ~~conditionaling~~ conditioning to filter out unwanted frequencies.
- Comparators – Voltage comparators are used to compare two voltage and provide a digital output indically which is larger, useful in level detection and threshold applications.
- Integrator & Diffrentiator – Integrator & diffrentiator circuit i[s] used in analog compilers and cont[rol] system for mathematical operation on signals.
- Oscillator – waveforms for various applications including sign[al] generation and testing.

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- Instrumental Amplifiers - Precision amplification: used in medical devices and sensor to amplify small diffrential signals while rejecting noise and common mode signals.

- Summing Amplifiers - Audio mixing: used to sum multiply audio signals is into one output. Common in mixture and sound processing equipmental.

- Voltage Regulator - Linear Regulation: Op-amp are used in voltage regulation circuit to maintain stable output voltages.

Assinment IV

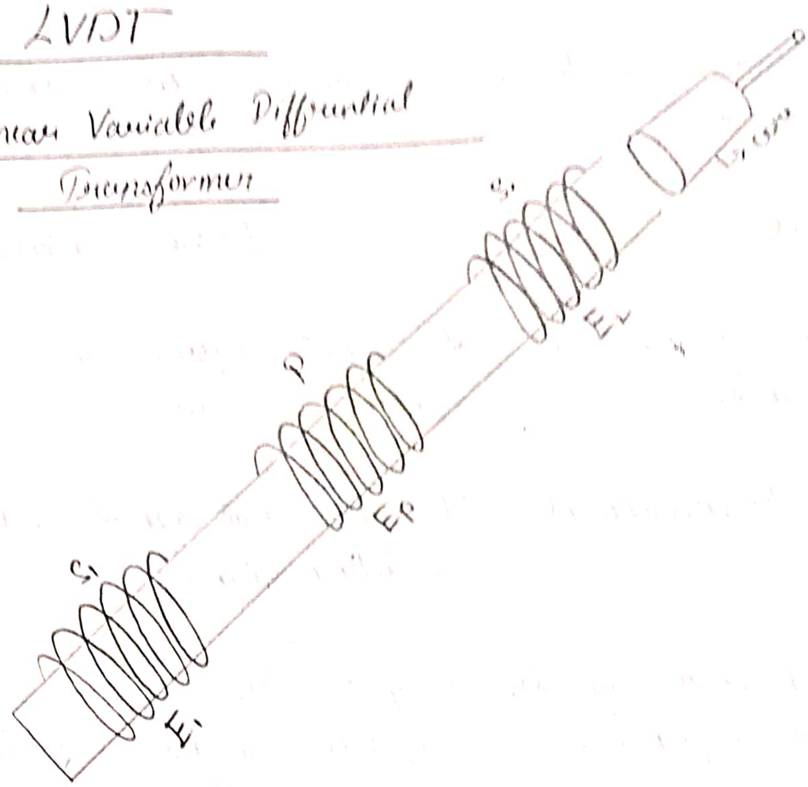
PCET's Pimpri Chinchwad University

Q1. What is the difference between active / passive sensors. ~~Wh~~ With Examples

	Active Sensors	Passive Sensors
1	Requires an external source for active components.	Does not require an external energy source.
2.	Emits signal into the environment.	Does not emit signal; detect existing signals.
3.	Actively generate / emit signals, then analyze the response or reflection.	Rely on ambient energy or signals / measures variations without emitting signals.
4.	Can have a longer range due to actively emitted signals.	May have limited range based on ambient signals.
5.	Used in applications where ~~controls or~~ over emitted signals is ~~nessa~~ necessary.	Commonly used when detecting existing signals is sufficient.
6.	Examples:- Radar system, LiDAR, active SONAR	Examples:- Infrared sensors, cameras, microphones.

Q2 LVDT

Linear Variable Differential Transformer



Case 1: When core is at primary coil

$E_T = E_1 - E_2 = 0$ (Null EMF)

Case 2: When core is at S_1

$E_T = E_1 > E_2 = E\ +ve$

Case 3: When core is at S_2

$E_T = E_1 < E_2 = E\ -ve$

Q2. How does LVDT (Linear Variable Differential Transformer) work, and where is it commonly used?

Working Principle:

An LVDT is an electromechanical sensor that converts linear motion into an electrical signal. It comprises three coils wound around a cylindrical former: a primary coil & two secondary coils. A movable ferromagnetic core is placed inside the former.

How it works:

1. AC Excitation - An AC voltage is applied to the primary coil including an alternating magnetic flux in the core.

2. Magnetic Flux Couplinging - The magnetic flux from the primary coils couples with the secondary coils including voltages in them.

3. Core Position & Voltage - The magnitude & phase of the voltage induced in the secondary coils depends on the position of the core.

- When the core is centered, the voltages in the secondary coils are equal & opposite, resulting in a zero output voltage.

- As the core moves away from the center, the voltage in one secondary coil increases while the other decreases, leading to a differential output voltage.

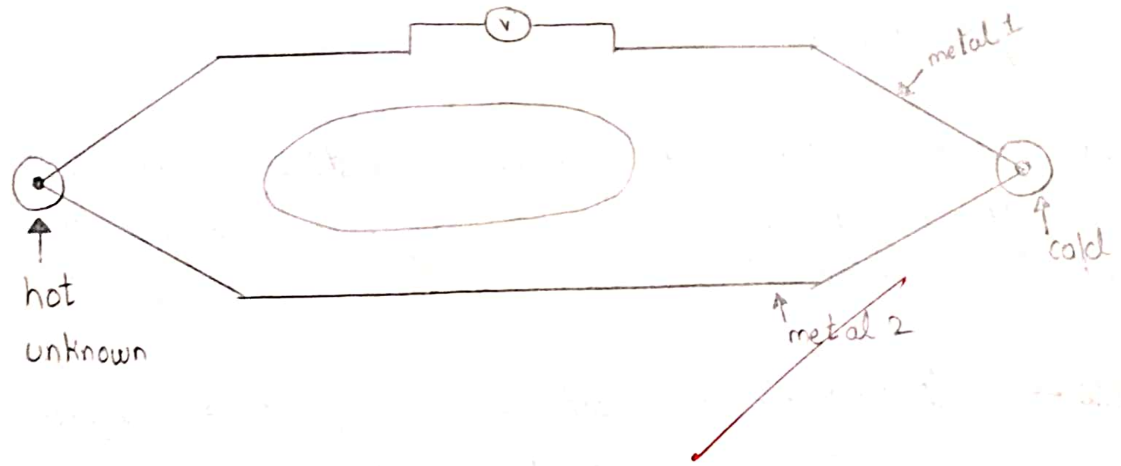
4. Output Signal – The differential output voltage is proportional to the displacement of the core from the center point.

Common Applications:

LVDTs are widely used in various industries due to their high accuracy, reliability, & durability. Some common applications include:

- Aerospace – Measuring aircraft wing deflection, engine vibration, and control surface position.
- Automotive – Monitoring ~~engine~~ engine valve movement, brake pad wear, and suspension system performance.
- Manufacturing – Precision machining, quality control, and robot control.
- Civil Engineering – Structural health monitoring, bridge deflection measurement, and dam monitoring.
- Medical Equipment – Position sensing in medical devices like surgical robots & prosthetic limbs.
- Test & Measurements – Calibration of measuring instruments, force & pressure measurement.

Q3. Thermocouple



Q3. How does a thermocouple measure temperature?

A thermocouple is a temprature sensor that works based on the Seeback effect. It consists of two dissimilar metal wires joined at one end, forming a junction. When this junction is exposed to a temprature differece, a small voltage is generated, which is proportional to the temprature difference.

How it works:

1. Seeback Effect :- When two different metals are joined at one end and a temprature difference is applied across the junction, a voltage (called the seeback voltage) is generated. This voltage is proportional to the temprature difference.

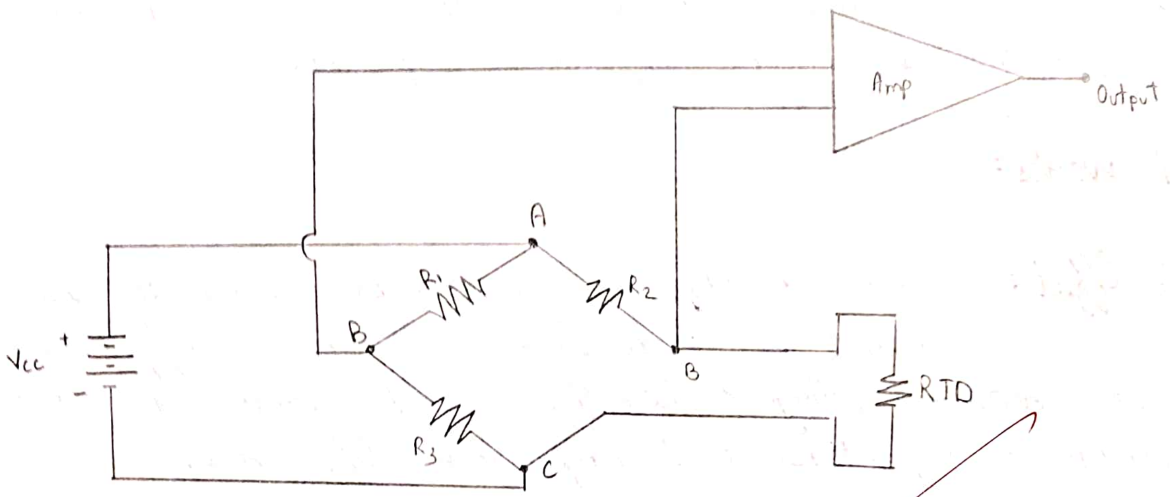
2. Thermocouple Junction – The junction of the two dissimilar metals is the sensing element. When this junction is exposed to a temprature, the seeback voltage is generated.

3. Voltage Measurement – The generated voltage is measured by a device called a thermocouple meter or a data acquisition system.

4. Temprature Calculation – The measured voltage is then converted into a temprature reading using a calibration curve specific to the type of thermocouple used.

Application: Thermocouples are relaiable, durable, & can measure a wide range of tempratures, making them a popular choice for temprature measurement in various applications such as Industrial equipments, Automative Industry, HVAC systems etc.

Q4 * Resistance Temprature Detector; (RTD)



Q4. How is an RTD (Resistance Temperature Detector) used in temperature sensing?

An RTD (Resistance Temperature Detector) works on the principle that the electrical resistance of a metal changes with temperature. As the temperature increases, the resistance of the metal also increases.

Usage of RTD in temperature sensing:

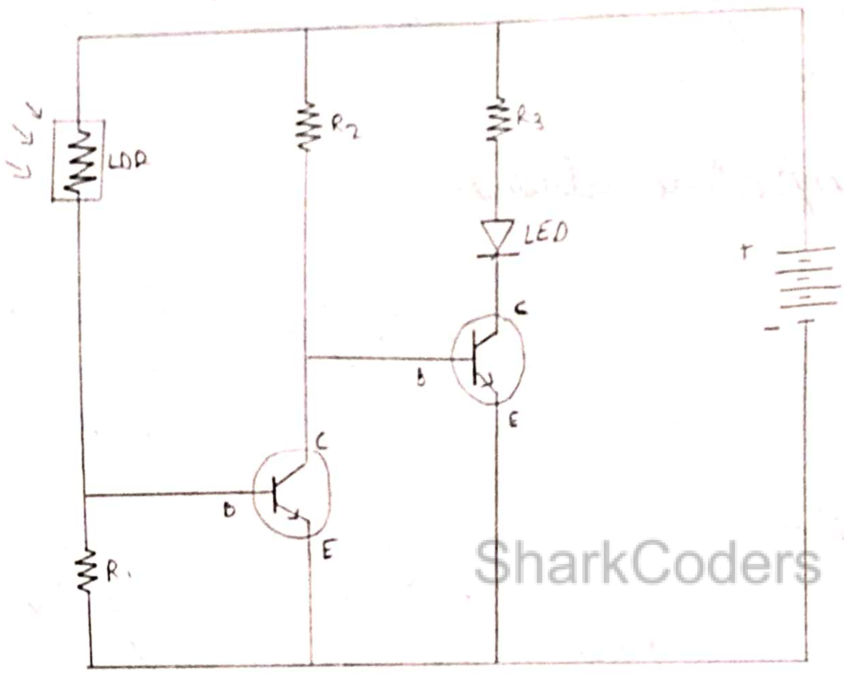
1. RTD Element – The core of an RTD is a metal element, typically made of platinium, nickel or copper, which exhibits a predictable change in resistance with temperature.

2. Measurement Circuit – The RTD is connected to a measurement circuit, often a wheatstone bridge or a similar configuration. This circuit applies a small current to the RTD & measures the resulting voltage drop across it.

3. Resistance Measurement – The voltage drop across the RTD is directly proportional to its resistance. By measuring this voltage, the circuit can determine the RTD's resistance.

4. Temperature Calculation – The measured resistance is then compared to a calibrated resistance-temperature curve for the specific RTD material. This curve relates resistance to temp., allowing the circuit to calculate the temperature corresponding to the measured resistance.

Q5. LDR (Light Dependent Resistor)



Automatic street light control system using LDR

Q5. How does an LDR (Light Dependent Resistor) work? Given an example of where an LDR might be used.

An LDR is a type of resistor whose resistance changes depending on the amount of light falling on it. It's made of a semiconductor material that has a high resistance in darkness but a low resistance when exposed to light.

Working:

1. In Darkness – When no light falls on LDR, its resistance is very high. This is because there are few free electrons to conduct electricity.

2. In Light – When light falls on the LDR, photons from the light strike like the semiconductor material. This energy excites ~~atom~~ electrons, freeing ~~atom~~ them from their bonds & allowing them to conduct electricity. ~~As~~ As more light falls on the LDR more electrons are freed, reducing its resistance.

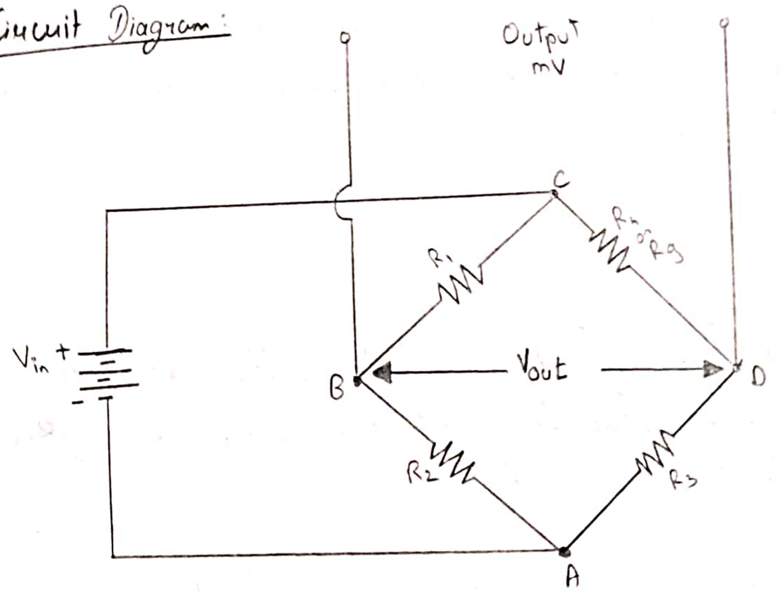
Example Application: Automatic Street Lights

• Working:

- An LDR is connected to a circuit that controls the street light.
- During the daytime, sunlight falls on the LDR, reducing its resistance. This low resistance signals the circuit to keep the street light off.
- As darkness falls, the LDR's resistance increases. This high resistance triggers the circuit to turn on the street light.

Q6 Strain Gauge

Circuit Diagram:



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Q6. Explain how a strain gauge measures mechanical stress. Where would you commonly find a strain gauge in use?

A strain gauge is a device used to measure strain, which is the deformation of a material under stress. It works on the principle that the electrical resistance of a conductor changes with its length & cross-sectional area.

Working:

1. Construction - A strain gauge consists of a metal foil, which in-turn pattern bounded to a flexible backing material.

2. Strain Application - When a force is applied to the material, it deforms, causing the strain gauge to also deform.

3. Resistance Change - This deformation changes the length & cross-sectional area of the metal foil, which in turn changes its electrical resistance.

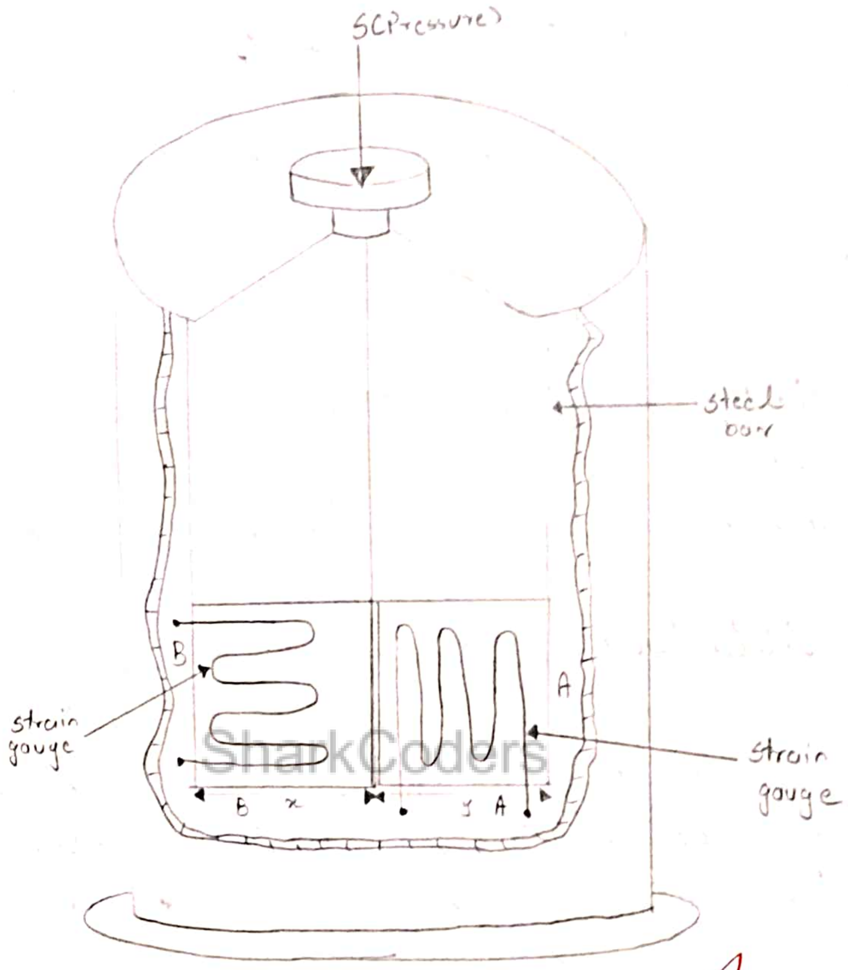
4. Measurement - This change in resistance is measured using a wheatstone bridge circuit, which converts the resistance change into a measurable voltage.

5. ~~Strain~~ Strain Calculation - The measured voltage is then used to calculate the strain experienced by the material.

Common Application of Strain Gauges:

- Civil Engineering:
  - Monitoring the structural health of bridges, building & dams.
  - Measuring soil pressure & load distribution on foundations.
- Aerospace:
  - Monitoring the stress & strain on aircraft components during flights
  - Testing the strength & durability of aerospace materials.
- Automotive Industry:
  - Measuring the stress & strain on vechicle components during testing & use.
  - Developing & testing new vehicle designs.
- Manufacturing:
  - Quality control & testing of manufactured products.
  - Monitoring the performance of machinery & equipment.

Q7 Strain Gauge Load Cell



Strain Gauge Load Cell

Q7. Describe the principle behind load cells as pressure sensors.

A load cell is a type of transducer that converts a force (such as weight or pressure) into a measurable electrical output. The most common type of load cell utilizes strain gauges to achieve this conversation.

Working:

1. Strain Gauge Integration – Strain gauges, which are small, thin, foil resisters, are bonded to a load-bearing element within the load cell.

2. Force Application – When a force applied to the load cell, it deforms the load bearing element. This deformation, in turn, struches or compresses the strain gauges.

3. Resistance ~~Chage~~ Change – As the strain gauge deform, their electrical resistance changes. This changes in resistance is directly proportional to the applied force.

4. Wheatstone Bridge Circuit – The strain gauges are typically connected in a wheatstone bridge configurations. This circuit amplifies the small resistance changes caused by the applied force.

5. Electrical Output – The wheatstone bridge produces an electrical output voltage that is proportional to the applied force. This voltage can be measured & converted into a force reading.

Applications:

- Industrial Weighing of matrials.
- Presice measurements in scientific research.
- Vehicle weighing system.
- Force measurement.
- Pressure management.

Assignment - 5

Q1. Convert:

1. Binary to decimal:-

• $(10101)_2 = (?)_{10}$

$\Rightarrow 1\times2^4 + 0\times2^3 + 1\times2^2 + 0\times2^1 + 1\times2^0$

$16 + 4 + 1 \Rightarrow (21)_{10}$

• $(11110)_2 = (?)_{10}$

$1\times2^4 + 1\times2^3 + 1\times2^2 + 1\times2^1 \times 0\times2^0$

$\Rightarrow 16 + 8 + 4 + 2 + 0$

$\Rightarrow (30)_{10}$

2. Decimal to Binary:

• $(25)_{10} = (?)_2$

2	25	
2	17	1
2	8	1
2	4	0
2	2	0
	1	0
		1

$\Rightarrow (100011)_2$

• $(47)_{10} = (?)_2$

2	47	
2	23	1
2	11	1
2	5	1
2	2	1
	1	0
		1

$(47)_{10} \Rightarrow (101111)_2$

- $(19)_{10} = (?)_2$

2	19	
2	9	1
2	4	1
2	2	0
	1	0
		1

$(19)_{10} = (10011)_2$

3. Hexadecimal to Decimal

- $(1F)_{16} = (?)_{10}$

$\Rightarrow 1 \times 16^1 + 15 \times 6^0 = 16 + 15 = (31)_{10}$

- $(A5)_{16} = (?)_{10}$

$10 \times 16^1 + 5 \times 16^0 = 160 + 5$
$= (165)_{10}$

- $(3C)_{16} = (?)_{10}$

$\Rightarrow 3 \times 16^1 + 12 \times 16^0 = (60)_{10}$

- $(EF.B1)_{16} = (?)_{10}$

$14 \times 16^1 + 15 \times 16^0 = 239$
$11 \times 16^{-1} + 1 \times 16^{-2} = 0.711$
$\Rightarrow (239.711)_{10}$

4. Octal to Binary

- $(17)_8 = (?)_2$

8	17	
8	2	1
		2

~~2~~	17	
2	~~8~~	
	4	

7;

2	7	
2	3	1
	1	1

1;

(1;1) 1

$(17)_8 = (1111)_2$

- $(25)_8 = (?)_2$

2

2 = 10

5;

2	5	
2	2	1
	1	0
		1

$(25)_8 = (10101)_2$

- $(34)_8 = (?)_2$

3 = 11

4 =

2	4	
2	2	0
	1	0
		1

$(34)_8 = (11100)_2$

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5. **Binary to Hexadecimal**

- $(10\,1101\,1011)_2 = (?)_{16}$

  $= (2DB)_{16}$

- $(1111\,1001)_2 = (?)_{16}$

  $= (F9)_{16}$

- $(0101\,1111 \cdot 0111\,11)_2 = (?)_{16}$

  $= (5F.7C)_{16}$

6. **Decimal to Octal**

- $(1792.589)_{10} = (?)_8$

8	1792	
8	224	0
8	25	0
	3	4
		3

$0.589 \times 8 = 4.712 = 4$
$0.712 \times 8 = 5.696 = 5$
$0.696 \times 8 = 5.568 = 5$

$\Rightarrow (3400.455)_8$

- $(378.93)_{10} = (?)_8$

8	378	
8	47	2
	5	7
		5

$0.93 \times 8 = 7.44 = 7$
$0.44 \times 8 = 3.52 = 3$
$0.52 \times 8 = 4.16 = 4$

$\Rightarrow (572.734)_8$

Q2. Binary Arithmetic:

1) Binary Addition:-

a)
```
  (1)(1)
   1010
 + 0110
 ------
  10000
```

b)
```
  (1)(1)(1)
   1111
 + 0101
 ------
  10100
```

c)
```
   1001
 + 1011
 ------
  10100
```

2) Subtraction:-

a) 1001 − 0110

↓ 1's c

```
   1001
 + 1001
 ------
 [1]0010
  ↓
 carry
```

```
   0010
 +    1
 ------
   0011
```


b) 1110 − 1010

↓ 1's c

```
   0101
 + 1110
 ------
 [1]0011
  ↓
 carry
```

```
   0011
 +    1
 ------
   0100
```

Q3. Truth table of —

• NOT Gate:

• ~~AND Gate~~

A	$\bar{Y}$
0	1
1	0

- AND Gate

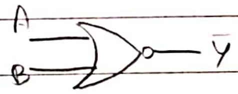
A	B	Y
0	0	0
0	1	0
1	0	0
1	1	1

- NAND Gate

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

A	B	$\overline{Y}$
0	0	1
0	1	1
1	0	1
1	1	0

- NOR Gate

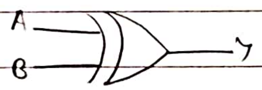


A	B	Y
0	0	1
0	1	0
1	0	0
1	1	0

- OR Gate

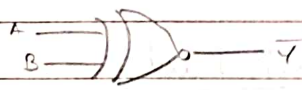
A	B	Y
0	0	0
0	1	1
1	0	1
1	1	1

- XOR Gate



A	B	Y
0	0	0
0	1	1
1	0	1
1	1	0

- XNOR Gate



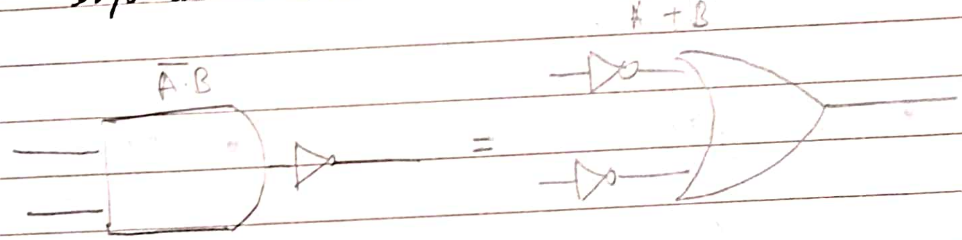
A	B	$\overline{Y}$
0	0	1
0	1	0
1	0	0
1	1	1

Q4. De-Morgan's Law:

- De morgon consists of two theorems.

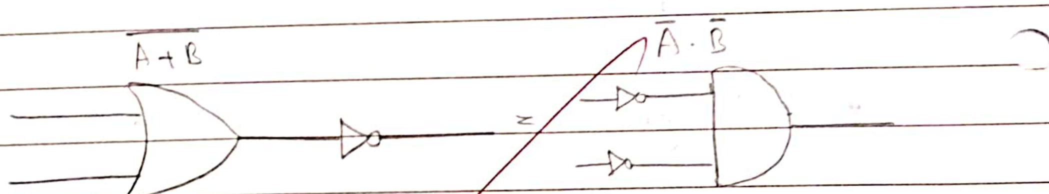
1. The compliment of a product of two variables is equal to the sum of the compliment of each variable.

expression: $\overline{A \cdot B} = \bar{A} + \bar{B}$



2. The compliment of the sum of two variables is equal to the product of compliment of each variable.

expression: $\overline{A + B} = \bar{A} \cdot \bar{B}$



Truth Table:

A	B	$\bar{A}$	$\bar{B}$	$A \cdot B$	$\overline{A \cdot B}$	$A + B$	$\overline{A + B}$	$\bar{A} + \bar{B}$
0	0	1	1	0	1	0	1	1
0	1	1	0	0	1	1	0	1
1	0	0	1	0	1	1	0	1
1	1	0	0	1	0	1	0	0

Q5. A) Half Adder

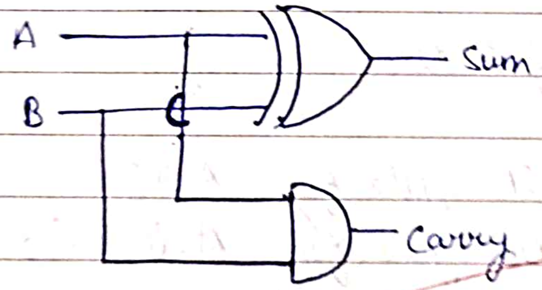
Half adder adds two single bit binary numbers & outputs is a sum and carry.

- Truth Table

A	B	Sum	Carry
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

- As sum is implemented using XOR gate.
- As carry is implemented using AND gate.

- Circuit Diagram



B) Full Adder:

- Full Adder adds three binary bits.

  2 I/P (A,B) & 1 Carry In (C_{in})

  and produces a sum & a carry out.

<u>Truth Table</u>

A	B	Cin	Sum	Carry
0	0	0	0	0
0	0	1	1	0
0	1	0	1	0
0	1	1	0	1
1	0	0	1	0
1	0	1	0	1
1	1	0	0	1
1	1	1	1	1

- In 1st half adder;
  - XOR Gate for $A \oplus B$
  - AND Gate for $A \land B$ (C_1)

- In 2nd half adder;
  - XOR Gate for $S_1 \oplus C_i$
  - AND Gate for $S_1 \land C_{in}$ (C_2)

- OR Gate;
  Combines C_1 & C_2 (C_{out})