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**Subject : Physics**

**B.SC – Second Year Semester IV**
**Paper – II**

**UNIT - 2**

## Topic : Field Effect Transistor

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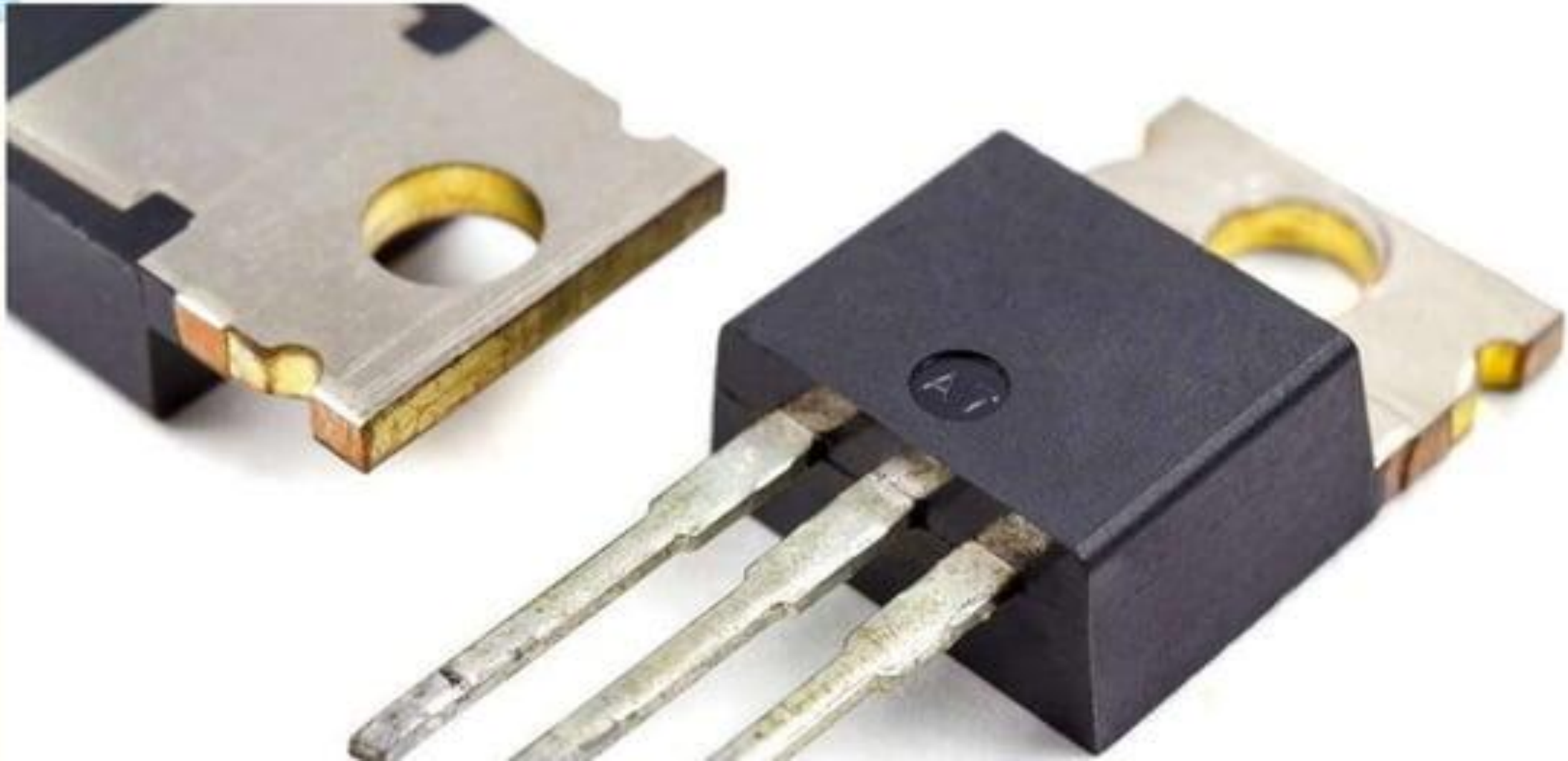
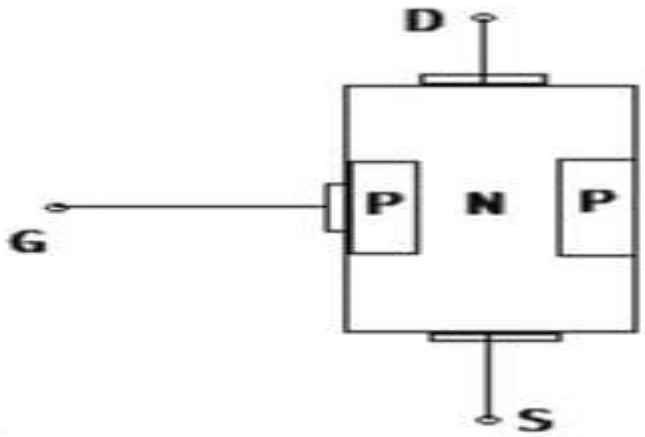
# FET (Field Effect Transistor)



# Introduction

- The three terminals of the FET are known as Gate, Drain, and Source.
- It is a voltage controlled device, where the input voltage controls by the output current.
- In FET current used to flow between the drain and the source terminal. And this current can be controlled by applying the voltage between the gate and the source terminal.
- So this applied voltage generate the electric field within the device and by controlling these electric field we can control the flow of current through the device.




- The bipolar junction transistor has two main disadvantage.
  - It has a low input impedance
  - It has considerable noise level
- To overcome this problem Field effect transistor (FET) is introduced because of its:
  - High input impedance
  - Low noise level than ordinary transistor
- Junction Field Effect Transistor (JFET) is a type of FET.
  - Basically, FETs are available in small sizes and they use low space on a chip.

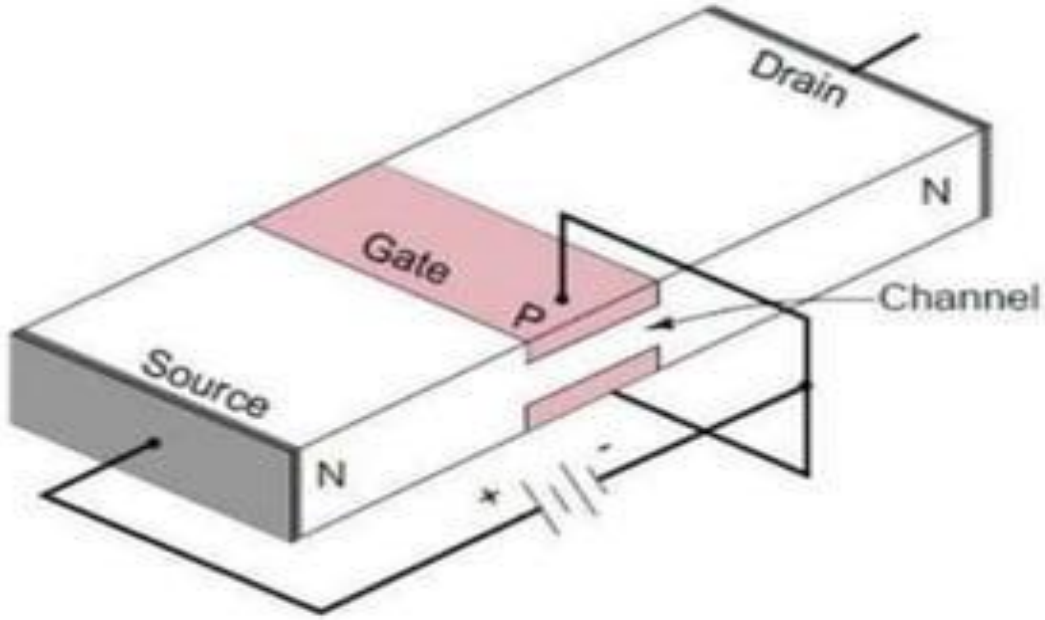
# Types of FET:

There are two types of FET:

- JFET (Junction Field Effect Transistor)
  - n-channel JFET
  - p-channel JFET
- IG-FET (Insulated Gate Field Effect Transistor)
  - MOSFET (Metal Oxide Semiconductor Field Effect Transistor) is the type of IG-FET,
    - where a layer of $SiO_2$ is used as an insulating layer to insulate the gate from the channel.
  - The MOSFET can be further classified into
    - Depletion-type MOSFET (n-channel and p-channel)
    - Enhancement-Type MOSFET (n-channel and p-channel)

# Junction Field Effect Transistor

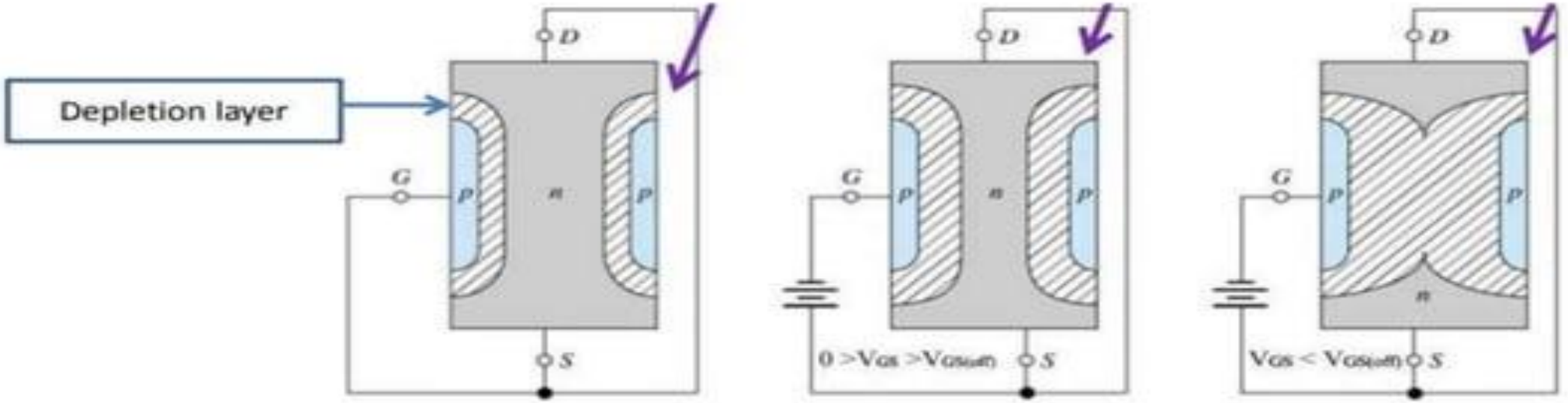
- In JFET this gate terminal is provided using this PN junction. So if you see the n-type JFET, two small p-type regions are fabricated near the channel.
- This channel is made up of n-type semiconductor than it is known as n-channel JFET. And likewise if it is made up of p-type semiconductor than it is known an p-channel JFET.




*Junction field effect transistor*

# Theory of Operation

- When gate-source voltage($V_{GS}$) is applied and drain-source voltage is zero i.e. $V_{DS}$= 0V
  - When $V_{GS}$ = 0V , two depletion layers & channel are formed normally.
  - When $V_{GS}$ increase negatively i.e. 0V > $V_{GS}$ > $V_{GS(off)}$ , depletion layers are also increased and channel will be decrease.
  - When $V_{GS}$=$V_{GS(off)}$, depletion layer will touch each other and channel will totally removed. So no current can flow through the channel.

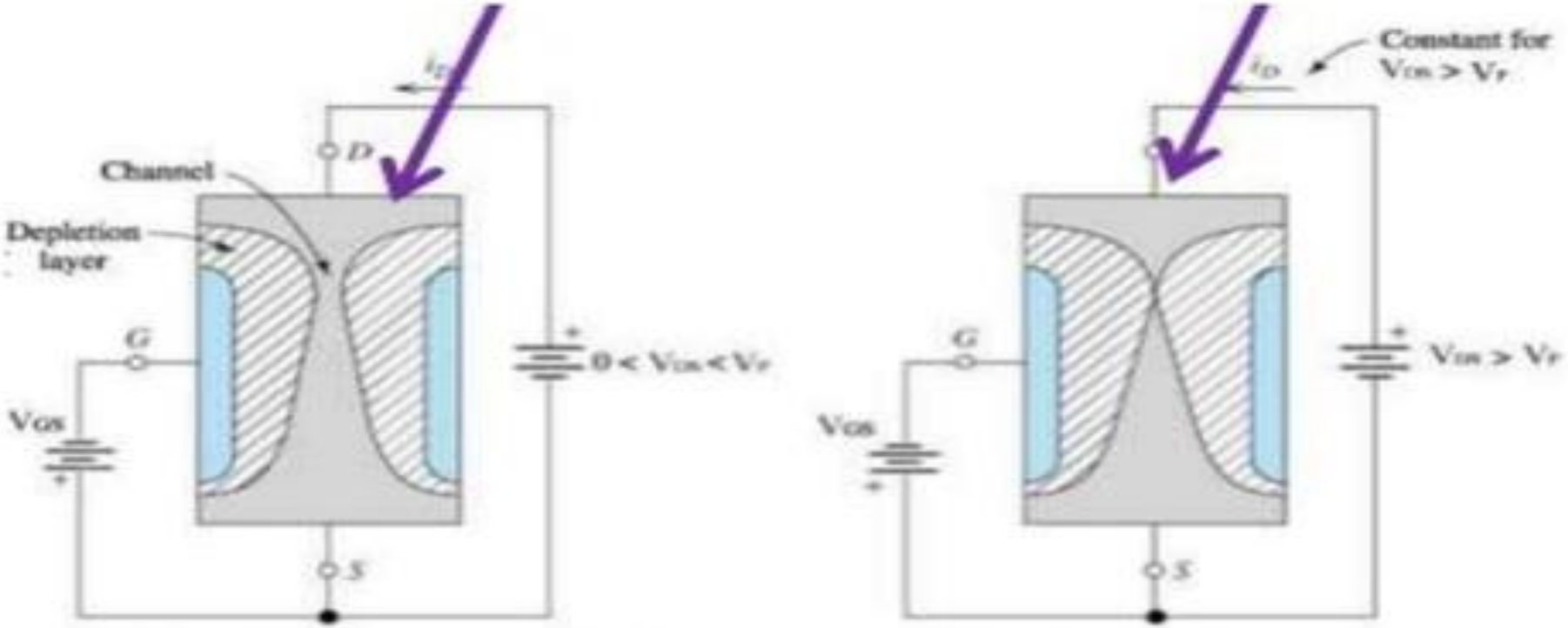



(a) Bias is zero and depletion layer is thin hence channel resistance is low.

(b) $V_{GS}$ is applied hence depletion layer is increased. So less charge can be flow through the channel.

(c) $V_{GS}$ is geater than cut off voltage hence no coductive path exist.

- When drain-source voltage ($V_{DS}$) is applied at constant gate-source voltage ($V_{GS}$) : .
  - When $V_{DS}$ increases i.e. $0V < V_{DS} < V_P$ , depletion layer at drain end is gradually increased and drain current also increased.
  - When $V_{DS} = V_P$ the channel is effectively closed at drain end and it does not allow further increase of drain current. So the drain current will become constant.




(a) Channel becomes narrower as $V_{DS}$ is increased

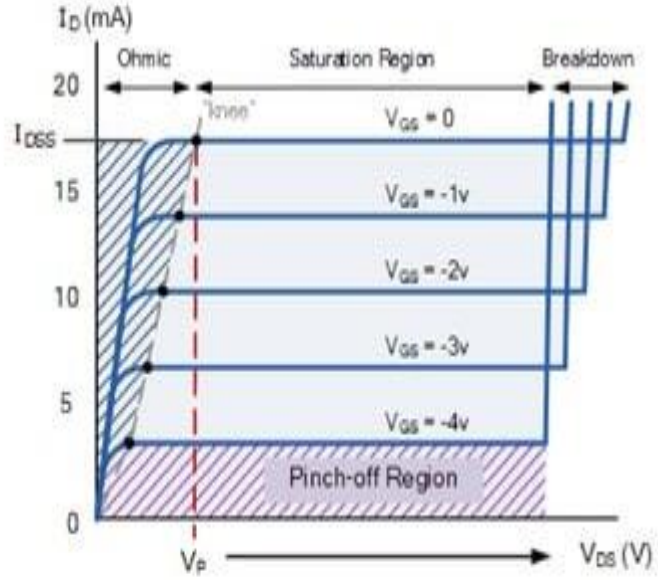
(b) Current is confined to a very narrow strip for $V_{DS} > V_P$

# Features of JFET

- JFET is a voltage controlled device i.e. input voltage ($V_{GS}$) control the output current ($I_D$).
- In JFETs, the width of a junction is used to control the effective cross-sectional area of the channel through which current conducts.
- It is always operated with Gate-Source p-n junction in reverse bias.
- Because of reverse bias it has high input impedance.
- In JFET the gate current is zero i.e. $I_G=0$.

# I-V Characteristics

- It is the curve between drain current ($I_D$)and drain-source voltage ($V_{DS}$)for different gate-source voltage ($V_{GS}$). It can be characterized as:
- For $V_{GS}$=0V the drain current is maximum.
- Then if $V_{GS}$ increases Drain current $I_D$ decreases even though $V_{DS}$ is increased.
- When $V_{GS}$ reaches a certain value, the drain current will be decreased to zero.
- For different $V_{GS}$, the $I_D$ will become constant after pinch off voltage ($V_P$) though $V_{DS}$ is increased.




# Transfer Characteristics

- This curve shows the value of $I_D$ for a given value of $V_{GS}$ .

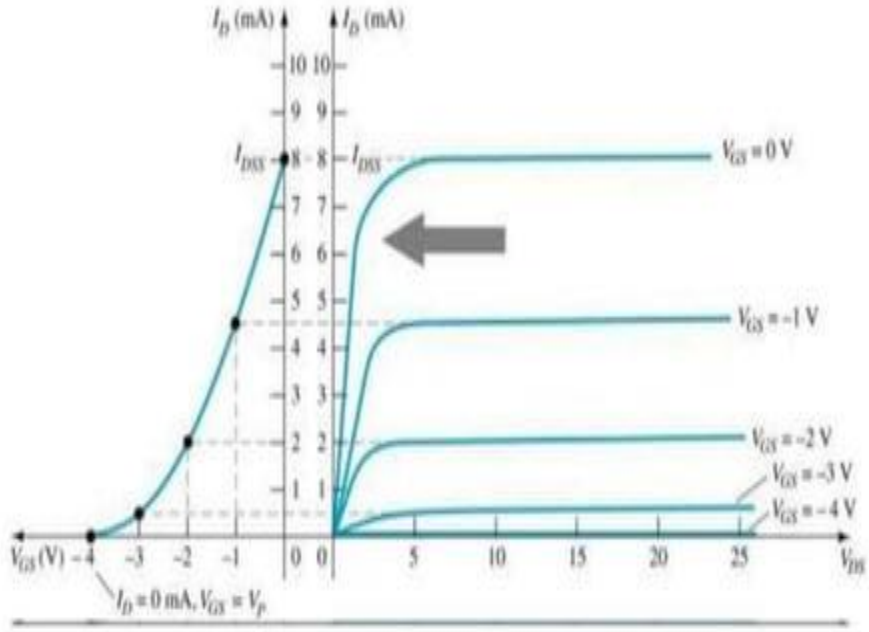
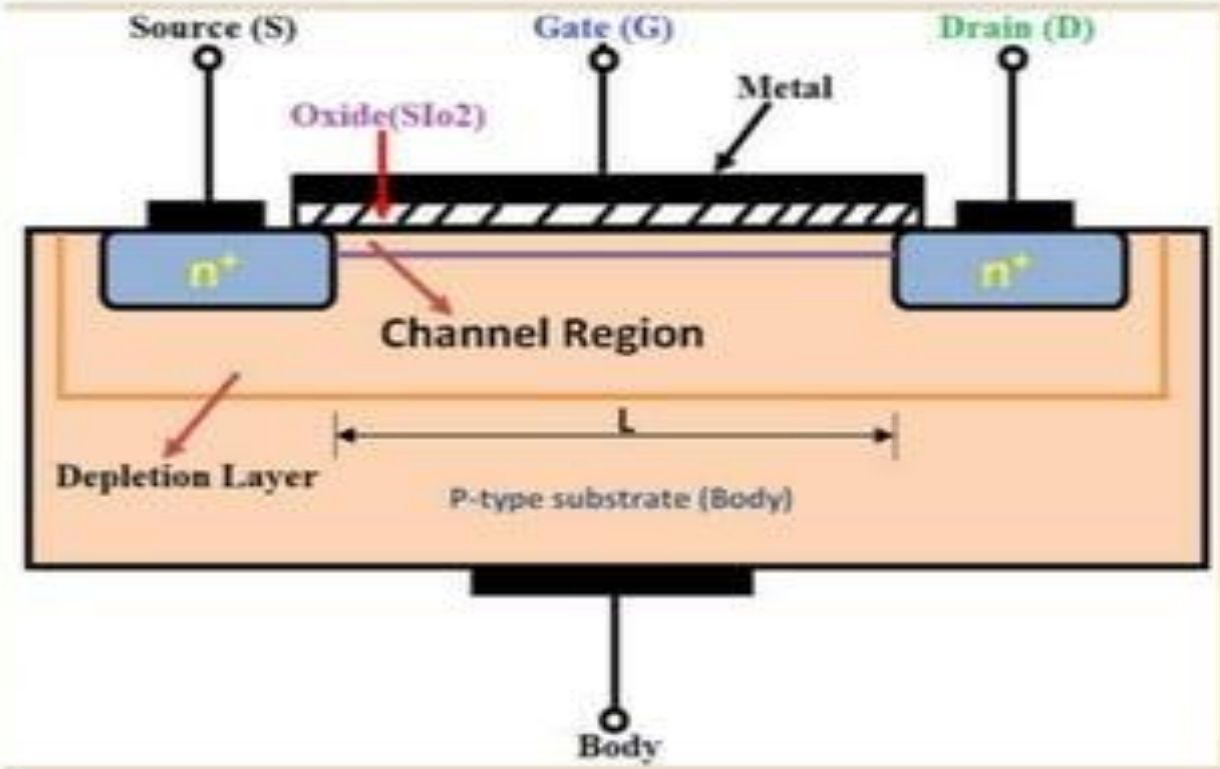



Fig: Transfer Characteristic Curve

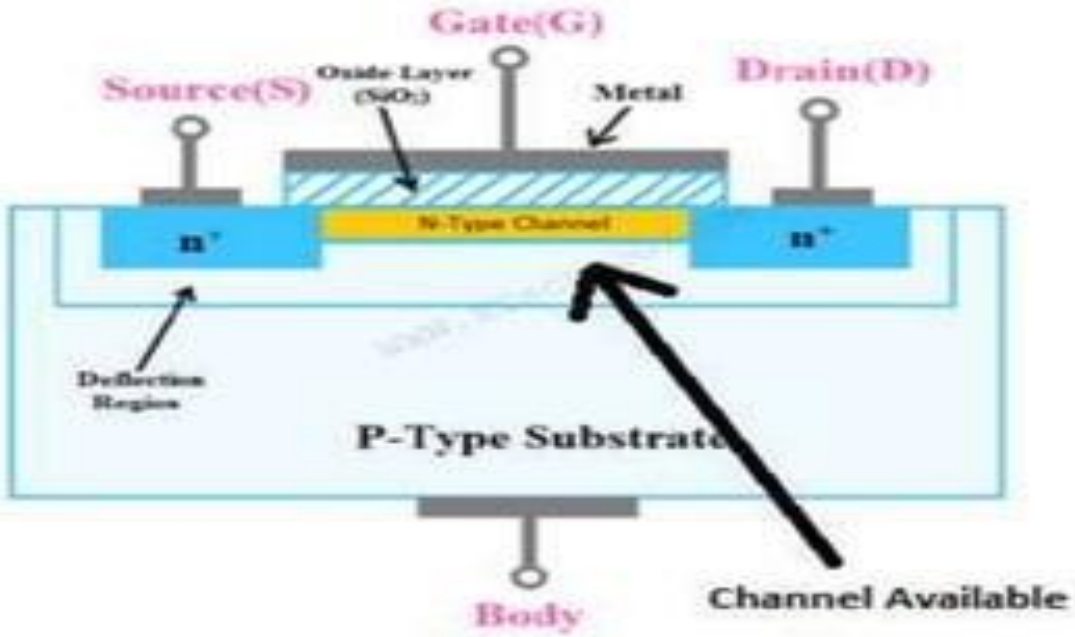
# MOSFET (Metal Oxide Semiconductor Field Effect Transistor)



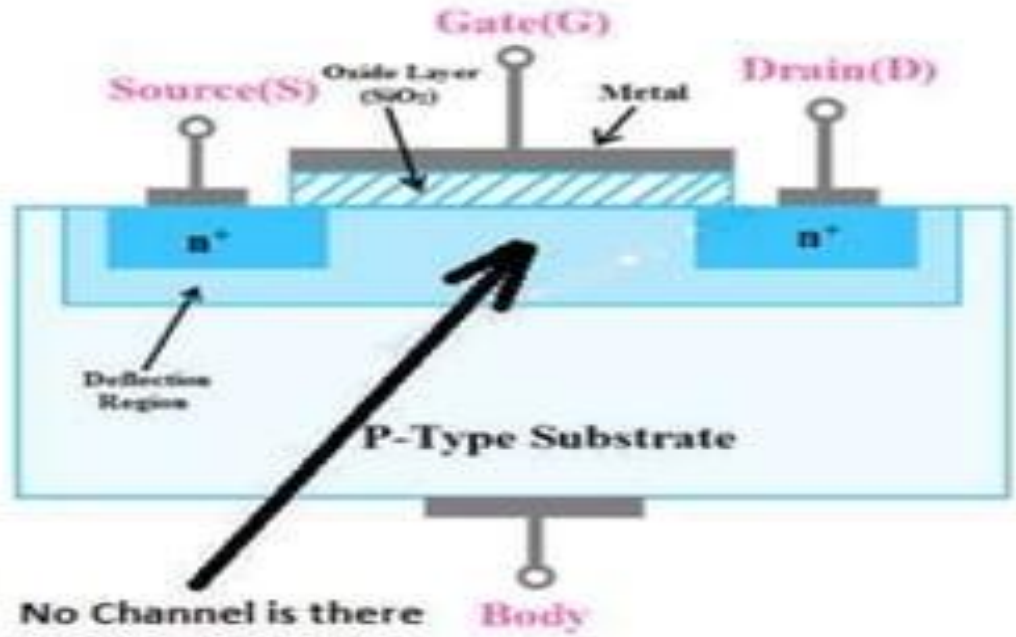

In this MOSFET, the gate is made up of a metal layer and the insulated layer is made up of silicon dioxide.

# Classification of MOSFET

- The MOSFET can be further classified into
  - Depletion-type MOSFET (n-channel and p-channel)
  - Enhancement-Type MOSFET (n-channel and p-channel)



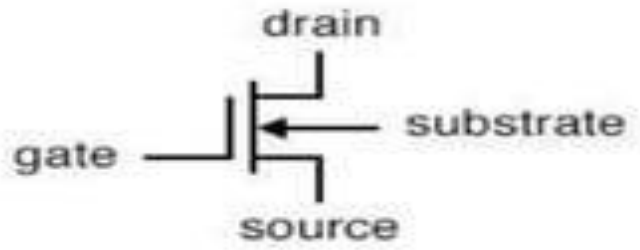

Depletion Type MOSFET



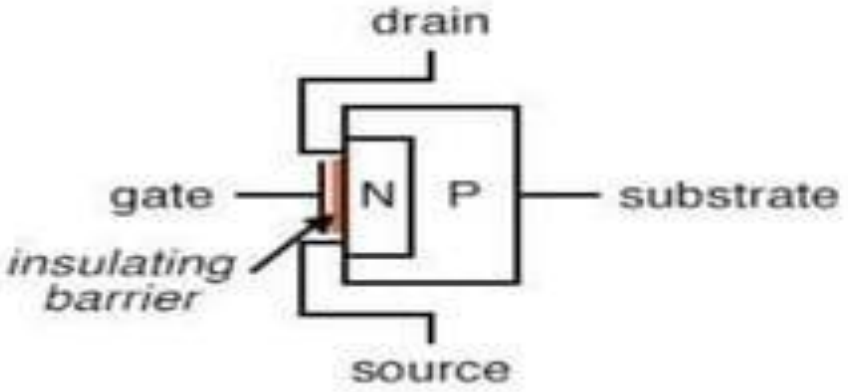

Enhancement Type MOSFET

# IG-FET (Insulated Gate-Field Effect Transistor)

- IGFET uses an insulated layer between the gate terminal and the channel. And typically this insulated layer is formed from the oxide layer of the semiconductor.
- The name IGFET refers to the any type of FET which has an insulated gate. And the most common form of IG-FET is the MOSFET.




schematic symbol




physical diagram

- When we apply the voltage at the gate terminal than due to the electric field it can either deplete or enhance a number of charge carriers in this given channel.
- So by the application of voltage if the number of charge carrier gets depleted in this channel than it is known as the depletion type MOSFET.
- If the number of charge carrier increases than it is known as the enhancement type MOSFET.

# Advantage of FETs

- It is simpler to fabricate, smaller in size.
- It has longer life and higher efficiency.
- It has high input impedance.
- It has negative temperature coefficient of resistance .
- It has high power gain.

# Disadvantage of FETs

- JFET has low voltage gain.
- They are more costly than junction transistor.
- It has lower switching time compare to BJT.
- Special handling is required during installation.

# Applications of FETs

- Amplifier
- Oscillator
- Analog Switch
- Integrated Circuits
- Buffer Amplifiers