→ Diffusion length = finite life time for excess charge carrier before they recombine.

$$L = \sqrt{D.\tau}$$

it is travelled before diffusing

→ Conduction in Intrinsic Semiconductor:-

$\sigma_p = q n \upsilon_p$

$\sigma_n = q n \upsilon_n$

$\left(\frac{V}{I} = R = \frac{1}{\sigma} \cdot \frac{l}{A} \text{ or } \frac{l}{A} \cdot \frac{V}{I} = \frac{1}{\sigma} \right)$

$$\therefore \sigma = q n_i (\upsilon_p + \upsilon_n)$$

→ Mass Action Law:-

- Prod. of no of holes & no of e^- is const., even if a doping is independent of amount of donor & acceptor impurity doping

$$n_i p = n_i^2$$

→ Carrier conc^n in Intrinsic Semi-Conductor:-

- To calc conductivity, conc^n of free e^- (n) & conc^n of free holes (p)

Fermi-dirac

So, $dn = N(E) f(E) . dE$

↓ density of state

no. of e^-/m^3 b/w E & (E+dE).

$$N(E) = \gamma (E - E_c)^{1/2}$$

$$f(E) = \frac{1}{1 + e^{(E-E_F)/kT}} \approx e^{-(E-E_F)/kT}$$

$$n = \int_{E_c}^{\infty} \gamma (E - E_c)^{1/2} e^{-(E-E_F)/kT} dE$$

$$n = N_c e^{-(E_c - E_F)/kT}$$

→ Diode = (-|>|-) → 2 electrode device, unilateral, ...

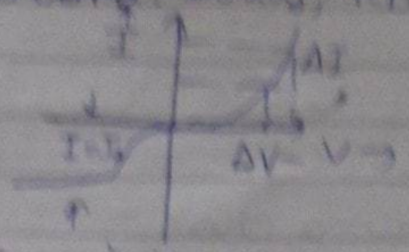
→ Diode Current eqⁿ → $I = I_0 (e^{V/\eta V_T} - 1)$ V_T = thermal voltage, I = diode current, I_0 = reverse saturation current

$V_T = \frac{kT}{q} = \frac{T}{11600}$ (T = 300K)

for Ge: $I = I_0(e^{40V} - 1)$ ($\eta = 1$), Si: $I = I_0(e^{20V} - 1)$ ($\eta = 2$)

→ Diode Resistance = FB cond. only, RB resistance

① DC Resis (Static) =



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

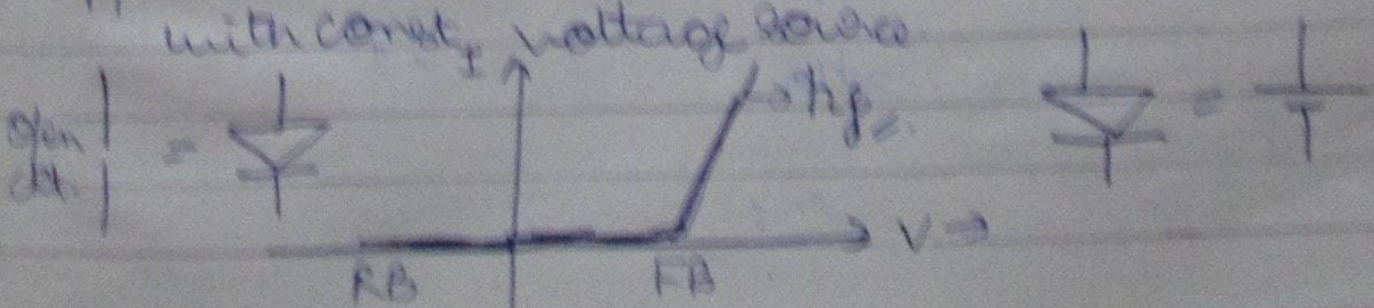
② AC Resis (Dynamic): $r = \frac{\Delta V}{\Delta I}$ = small chg in V / small chg in I

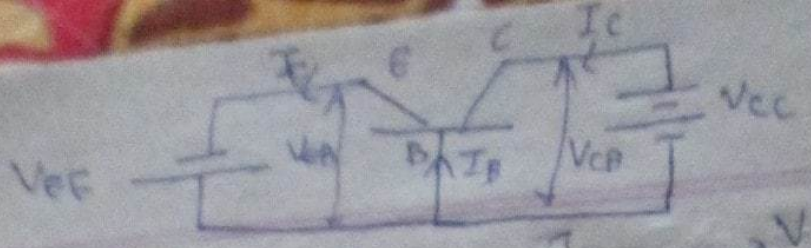
→ Reverse Resistance = in several mega Ω

→ Transition Capacitance = (like in Varactor Diode)
- $C_T = \frac{\epsilon A}{W}$, ‖ layer of ... (as 2 sides of jⁿ form transitⁿ cap)
- in R.B only ... ‖ plate cap (depletⁿ layer = plate)
- appears in Varactor diode.

→ Diffusion Capacitance = (C_D)
- in FB junctⁿ, where $C_D >> C_T$ = Rate of injected charge with applied voltage $C_D = \frac{dQ}{dV}$; $C_D \propto I_f$ → forward current

→ Piecewise Linear Diode Model =
- to get solⁿ of qes, as VI char is not linear
- particular regⁿ of opⁿ of VI diode are broken
- Approx the actual VI char. by straight line • Resis in series with const. voltage source





Comp to CB, V_1 I_1 V_2

$V_{EB} = h_i I_E + h_r V_{CB}$

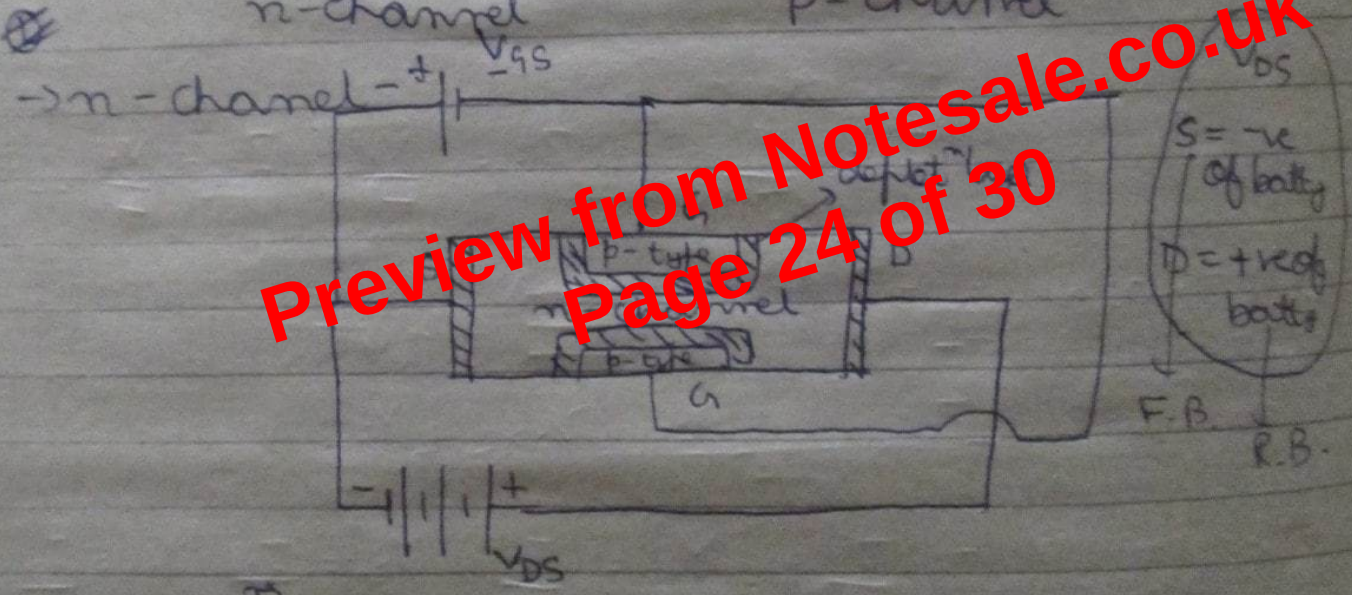
$I_C = h_f I_E + h_o V_{CB}$

$\downarrow I_2$ $\hookrightarrow I_1$ $\hookrightarrow V_2$

→ FET (Field Effect Transistor) -

- flow of current in conduct^n region is controlled by elec. field.
- cond^n only by majority carriers.
- Emitter ↔ Source; Collector ↔ Drain; Base ↔ Gate
  (S) (D) (G)

n-channel p-channel



• Operat^n -

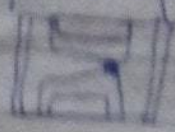
I. $V_{GS} = V_{DS} = 0$ → thickness of j^n = uniform

II. $V_{DS} = 0$, (V_{GS} ↓ from 0) (R.B ↑)
↳ (↑ off to V_{OS})
↳ PN j^n ↑, Thickness ↑ until two deplet^n layers make contact - cutoff V_o

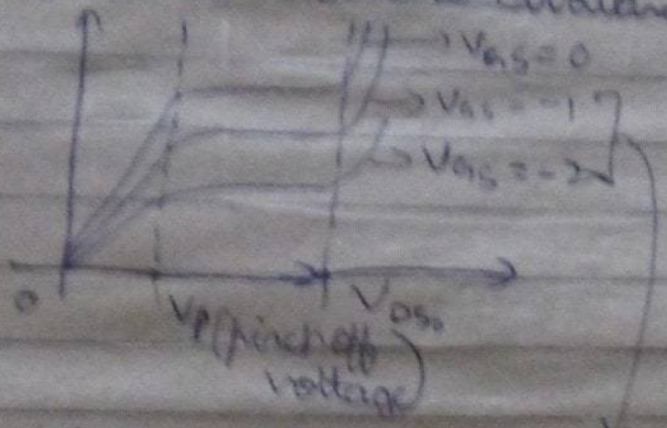
III. $V_{GS} = 0$, V_{DS} ↑ (F.B ↑)

- I_D flow from S to D. $R = \frac{\rho l}{A}$ ∴ $I_D = \frac{V_{DS}}{R}$
  ↳ depend ① ② A ③ V_{DS} $= \frac{V_{DS} \times A}{\rho \times l}$
  ④ majority carriers (P).

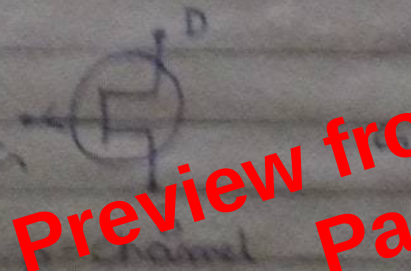
- Reverse voltage across PN junction ↑ → thickness ↑ (wedge shape)
- as V_{DS} ↑, at certain V_p (pinch off voltage), cross section area → 0



- Characteristics: - as V_{DS} ↑, I_D ↑ • $V_{DS} = V_p$ (pinch off)
- At V_{DSS}, I_D ↑ sudden due to avalanche breakdown



II. V_{GS} = -ve (1), V_{DS} ↑ → similar to I.



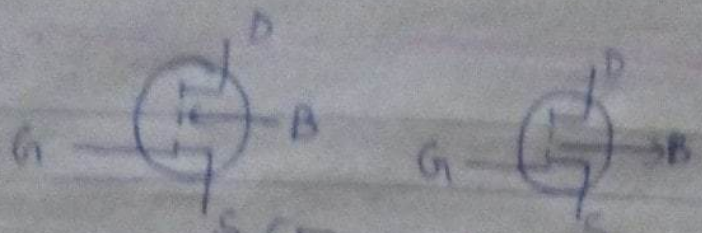
n-channel p-channel

→ Parameters JFET:

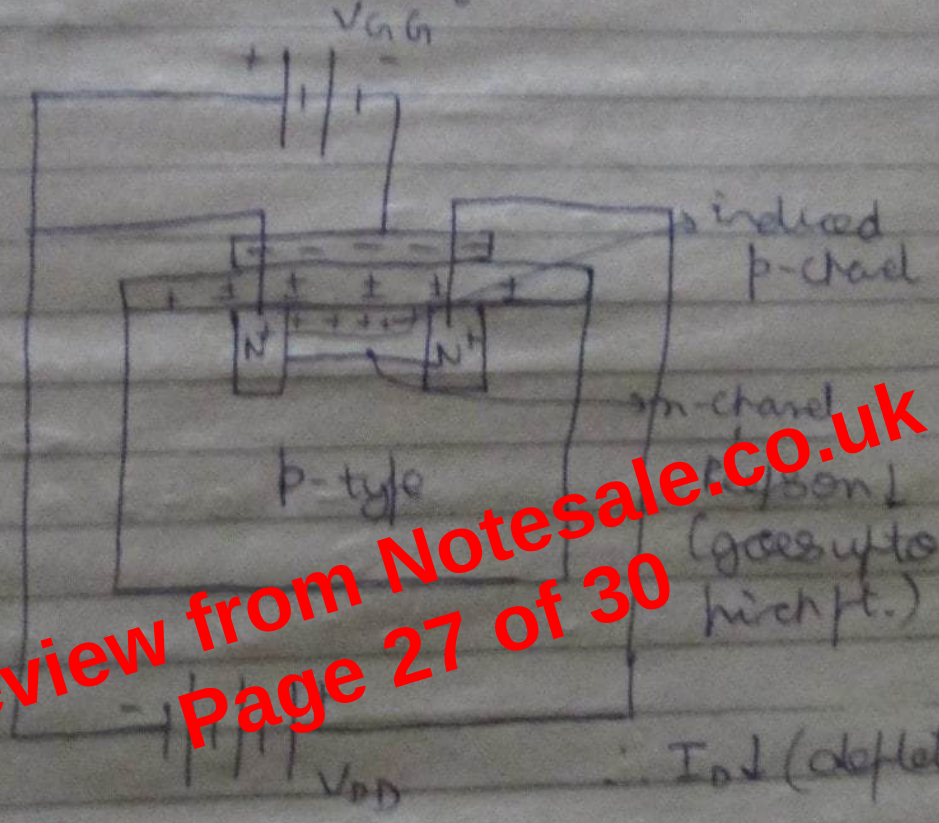
- Drain Resis = $r_d = \frac{\Delta V_{DS}}{\Delta I_D}$, V_{GS} const
- Transconductance = $\frac{\Delta I_D}{\Delta V_{GS}}$, V_{DS} const
- $\mu = \frac{\Delta V_{DS}}{\Delta V_{GS}}$, I_D const $\mu = g_m \times r_d$

→ MOSFET (Metal Oxide Semicond field effect Transistor)

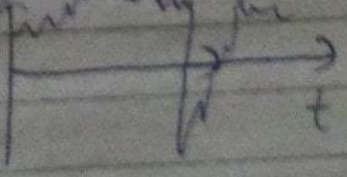
↳ as gate terminal is insulated from channel & so called insulated gate FET.



② De-Mosfet - (polarity of V_{GS} reverse)



→ Analog Signal - varies with time.
Eg - sine, Eg - temp etc



→ Digital Signal -
rep by sequence of no's, each no rep by a signal magnitude at a particular time generally binary (0 & 1)