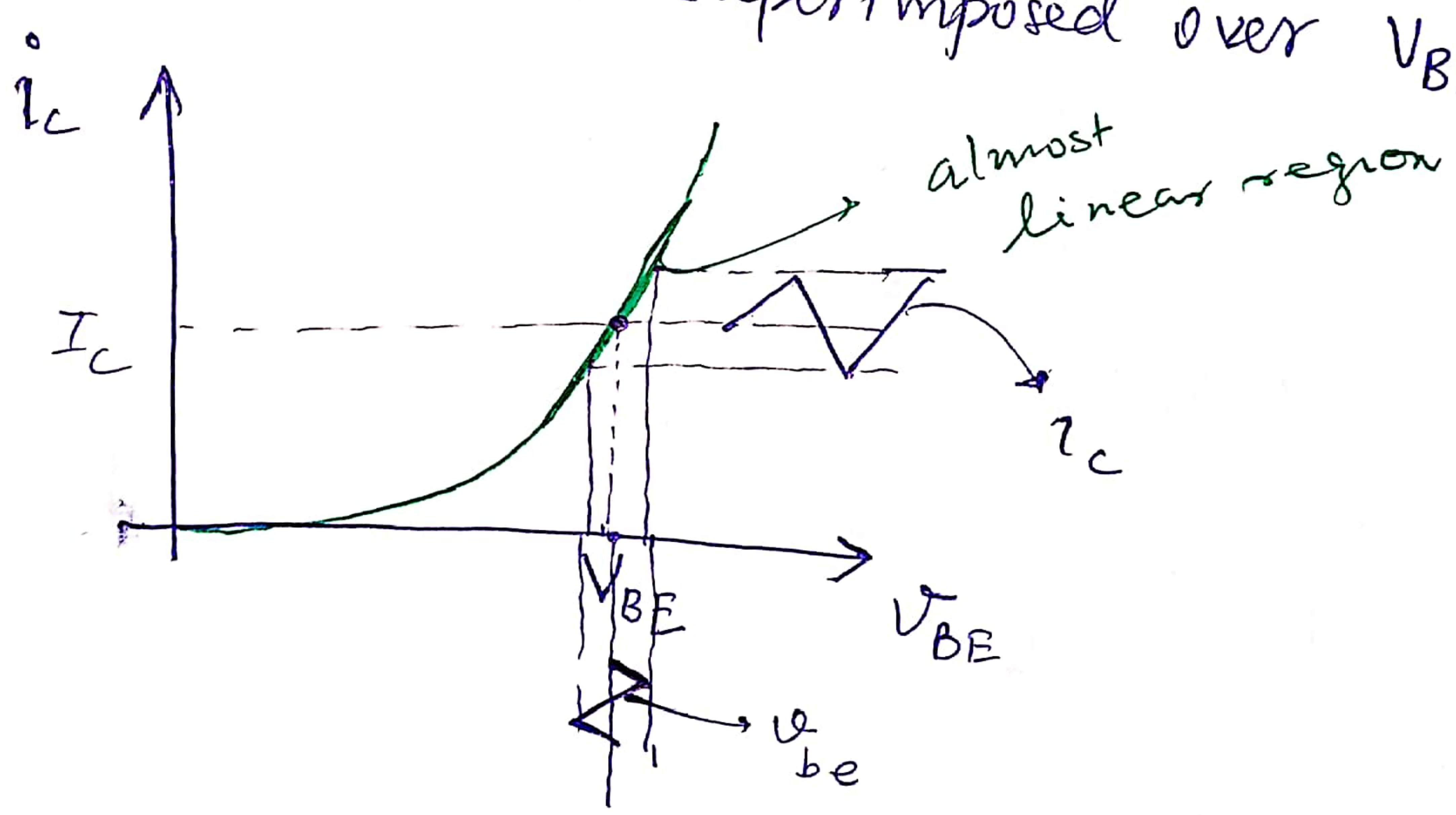
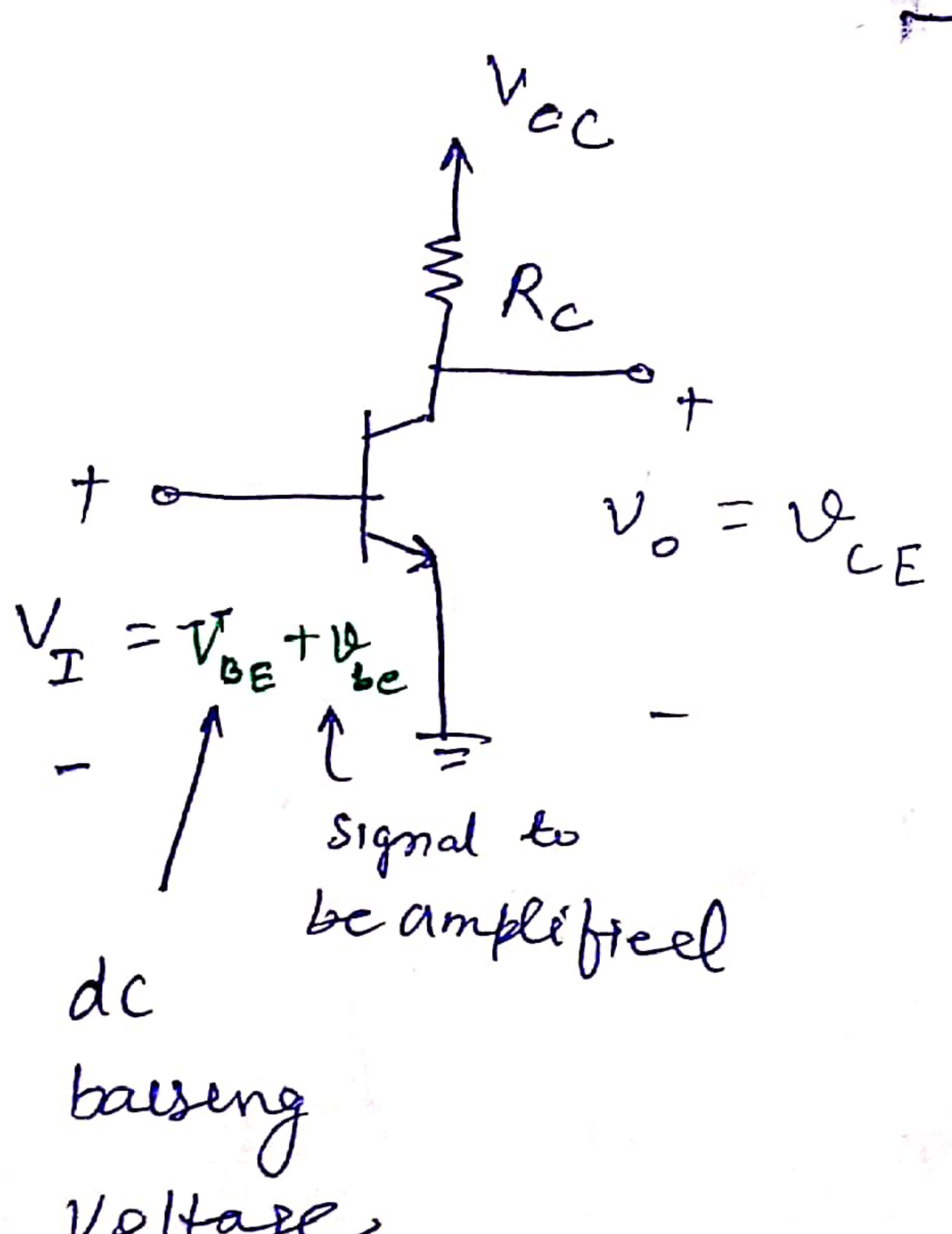
BJT as an Amplifier :-

We know that BJT in active mode acts as a voltage controlled current source. i.e. the change in V_{BE} gives rise to change in collector current, I_C. If we allow to pass the I_C through a resistor R_C then we will be able to obtain an output voltage $I_C R_C$ that can be used as voltage amplification.

However, since BJT is a highly non-linear device $\because$ since $I_C = I_S e^{V_{BE}/V_T}$ $\Rightarrow$ I_C depends exponentially with V_{BE}; the transistor must be baised at a dc base-emitter voltage V_{BE} and then the signal, v_{be} to be amplified will be superimposed over V_{BE}.





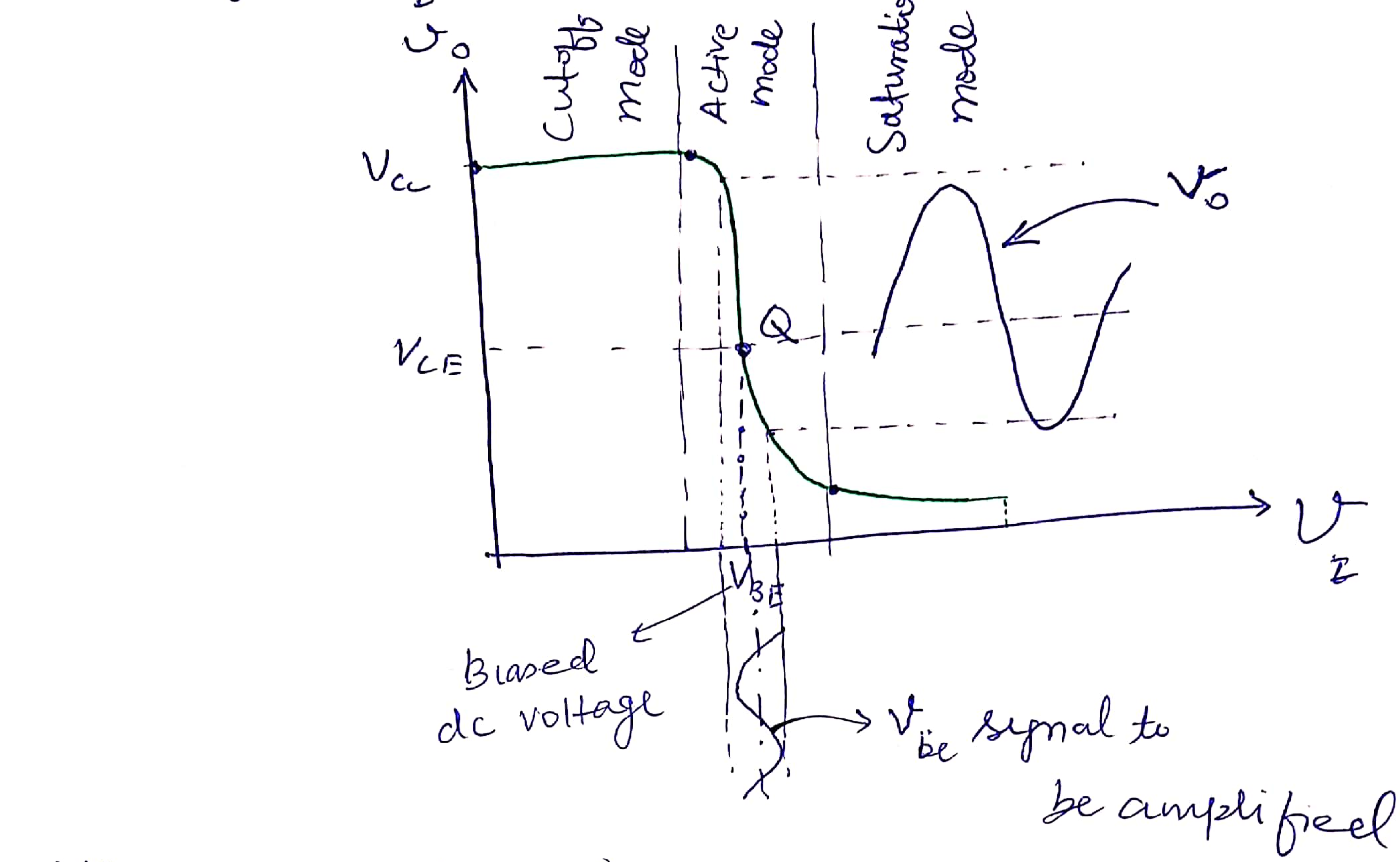
$\Leftarrow$ Basic structure of commonly used CE common-emitter BJT amplifier

The output v_o can be written as

$$v_o = v_{CE} = V_{CC} - R_C i_C$$

$$= V_{CC} - R_C I_S e^{V_I/V_T}$$

The V_o vs V_I is known as transfer characteristics



We can see here in the transfer Characteristics that by baising input voltage at V_{BE}, the transistor operation can be ensured in active region, where we can have a desired linear amplification as shown in figure.

Amplifier Gain (v_o/v_i)

The Amplifier gain A_v, defined by $A_v = \frac{v_o}{v_i}$ ~~can be~~ is the slope of the transfer curve at bais point-Q.

$$A_v \equiv \left.\frac{dv_o}{dv_I}\right|_{v_I = V_{BE}}$$

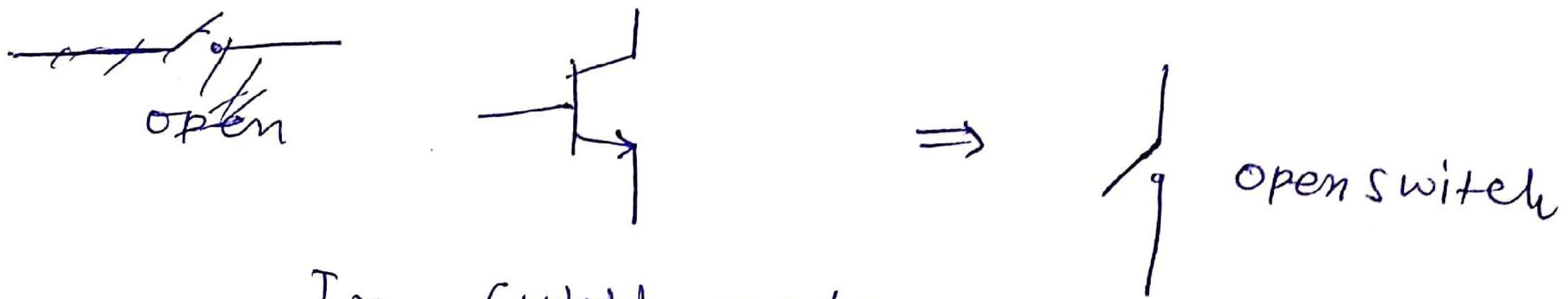
$$= \left.\frac{d}{dv_I}\left[V_{cc} - R_C I_S e^{v_I/V_T}\right]\right|_{v_I = V_{BE}}$$

$$= -\frac{1}{V_T} I_s e^{V_{BE}/V_T} R_C$$

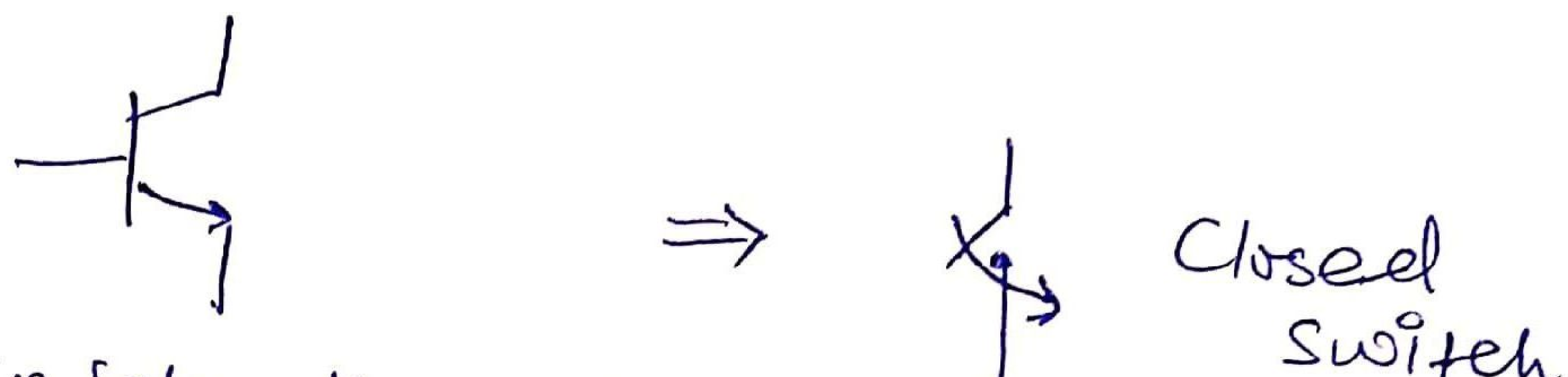
$$\boxed{A_v = \frac{-I_C R_C}{V_T} = -\frac{V_{R_C}}{V_T}}$$

$V_{R_C} \equiv$ Voltage across R_C

BJT as a switch

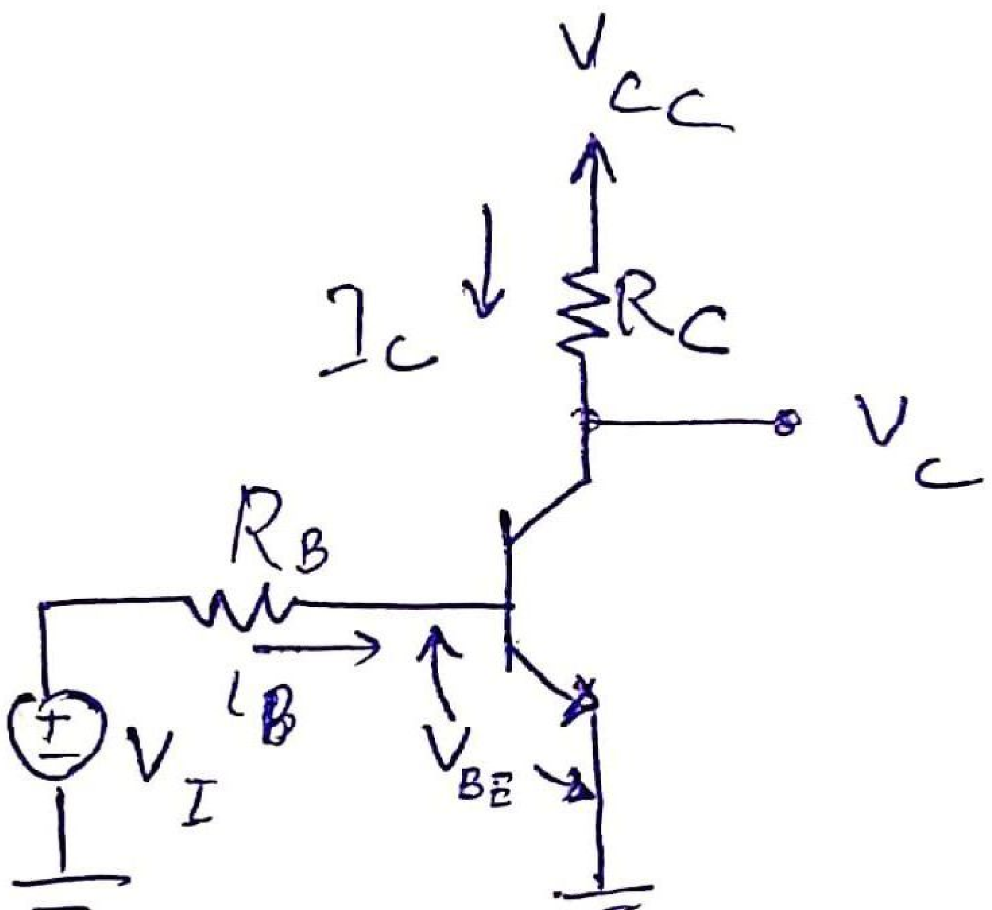


In cutoff mode



In Saturation mode

Consider the common-emitter circuit as shown below



For $V_I < 0.5$ V

The transistor is in cutoff region.

ie $I_B = 0$, $I_C = 0$, $V_C = V_{CC}$

The node C is disconnected from the ground and the switch is in open position.

For $V_I > 0.5$ V

As V_I increases, $V_{BE} \uparrow$ and when V_{BE} reaches 0.7 V, EBJ is frd. bias, ~~the~~ I_B starts flowing into base

$$I_B = \frac{V_I - V_{BE}}{R_B}$$

& $I_C = \beta I_B$

& $V_C = V_{CC} - I_C R_C$

As V_I increases, I_B (and hence I_C) increases therefore V_C decreases.

when V_c becomes lower than V_B by 0.4 V, CBJ becomes forward ~~bais~~ bias and transistor leaves active region and enters the saturation region.

As V_I is increased further transistor goes deeper into the saturation region. The V_{CE} decreases only slightly. when $V_{CE} \simeq V_{CEsat}$ ($\simeq 0.2V$), the Collector current, I_c then remains nearly constant at I_{Csat} given by

$$I_{Csat} = \frac{V_{CC} - V_{CEsat}}{R_C}$$

In this state, the switch is closed with a closure resistane R_{CEsat}.