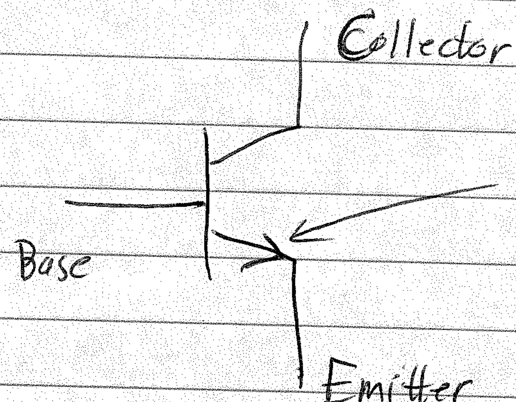
Example 4-11 of the text, on pages 173-176, is a good thing to study. It selects the Bipolar Junction Transistor to examine and analyze, take a look at it.

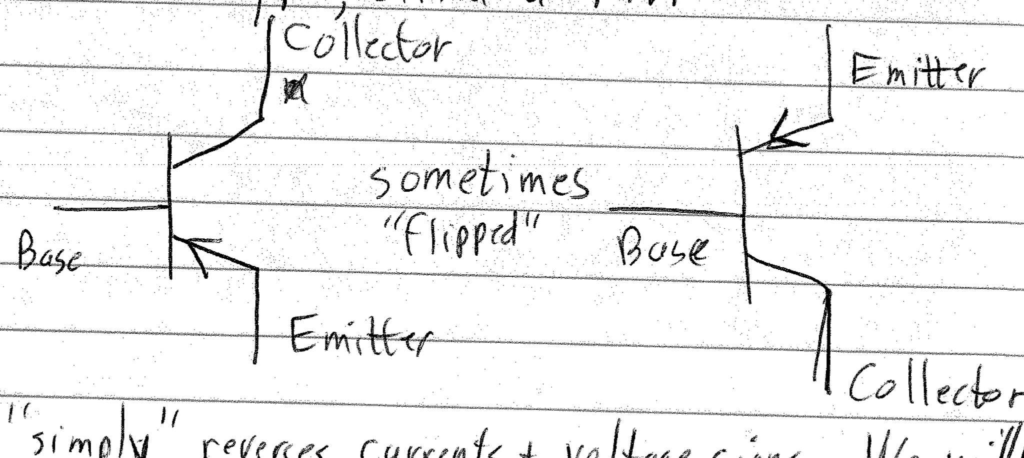
The authors show the ~~connections to~~ symbol + definitions:



shows direction the current will flow. This is an NPN transistor

not pointing in

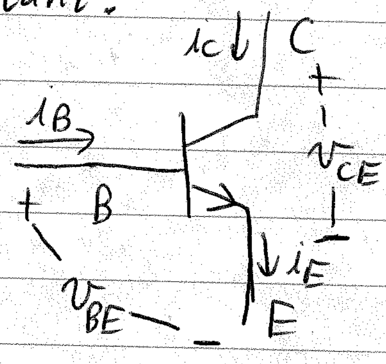
There is another type, called a PNP:



This "simply" reverses currents + voltage signs. We will do things with NPN and revisit PNP's later

There are three main functional regions for a transistor.

Debate continues about which regions are most important.

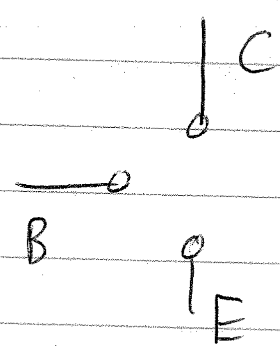


Applying a voltage to the base ($v_{BE} > V_\gamma$) allows a current to flow between the Collector and the Emitter. Effectively it changes the resistance between C+E ~~by as~~ according to the current flowing into the base.

KCL: $i_E = i_C + i_B$

I prefer to ~~talk abo~~ describe it in a different order than the text.

1) When $v_{BE} < V_\gamma$ (the cutoff voltage) it is in the "Cutoff Mode."



$i_B = 0$
$i_C = 0$
$i_E = 0$

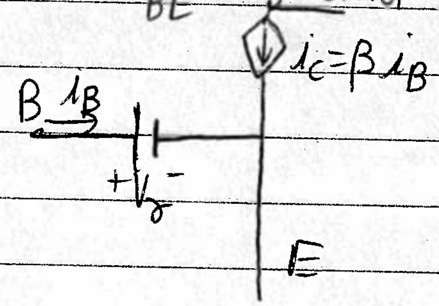
No current flows, an open switch between C+E

2) When $v_{BE} = V_\gamma$ then $i_C = \beta i_B$ (this is the possible current, not the actual current.)

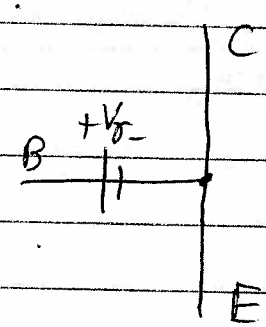
i_C will have some maximum value, depending on the rest of the circuit. This is for $i_C < i_{Cmax}$.

Called the Active Mode

~~3) When $v_{BE} = V_\gamma$ and $i_C = i_{Cmax}$,~~

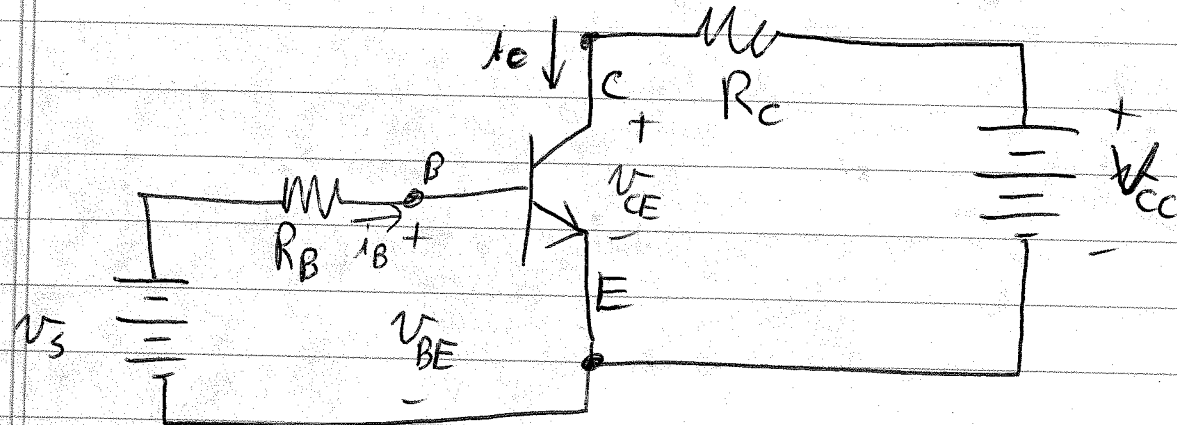


3) When $v_{BE} = V_\gamma$ and $i_C = i_{Cmax}$, then no more current can flow in the collector, even if we increase i_B. This is called the "Saturation Mode":



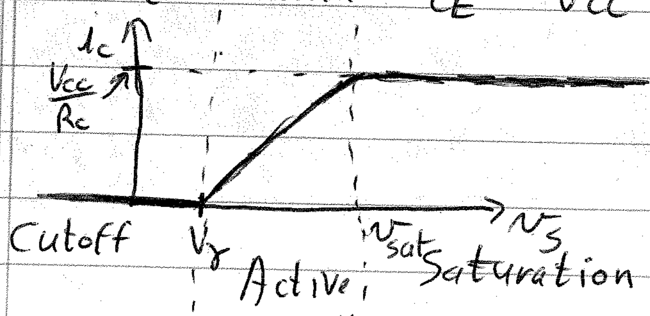
Looks like a switch turned on between C+E

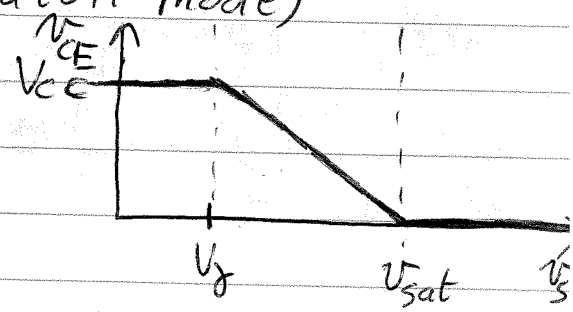
We need to put this in a ckt to see it in operation. The text chose a "Common Emitter" configuration:



Let's turn up v_S from zero to a "large" value and look at v_{CE} and i_C.

1) For $v_S < V_\gamma$, no current flows into the base, so $i_C = 0$ and $v_{CE} = V_{CC}$ (Cutoff Mode)





2) When $v_S > V_\gamma$, we have $v_{BE} = V_\gamma$, so

$$i_B = \frac{v_S - V_\gamma}{R_B} \quad \text{and} \quad i_C = \beta i_B = \frac{\beta}{R_B}(v_S - V_\gamma)$$

as we increase v_s, we increase i_C.

until we get to the point where $i_c = \frac{V_{cc}}{R_C}$, the ~~maximum current the~~ Short ckt current from the V_{cc} and R_c Practical Source, (add to Graph)

~~Effectively we have~~

B.) ~~When v_s~~ This occurs at

$$\frac{V_{cc}}{R_c} = \frac{\beta}{R_B}(v_{sat} - V_\gamma)$$

$$\frac{R_B}{\beta R_c}V_{cc} + V_\gamma = v_{sat} = V_\gamma + \underbrace{\frac{R_B}{\beta R_c}V_{cc}}_{\text{width of the Active Region}}$$

typically $\frac{R_c}{R_B}$ is large, so

$\frac{V_{cc}}{\beta\left(\frac{R_c}{R_B}\right)}$ is small, on the order of millivolts.

3.) $v_s > v_{sat}$: $i_c = \frac{V_{cc}}{R_c}$ (graph)

Saturation Mode

Here is where some debate comes in. Those who study Solid State Electronics and love to study the inner workings of things, and/or who grew up shortly after the invention of the transistor, insist that the active region is the most important. It is where you get <u>gain</u> (more output than input) which is what the transistor was invented to do.

Others point to the fact that the active region is very narrow, that the Cutoff and Saturation modes are much easier to hit and understand, and, most importantly, that the vast majority of all transistors are used in only these two modes, contend that ~~this is good enough~~ knowing how transistors work in these two modes is useful and usually all you need, particularly for computers or digital applications!

Let $v_s < V_\gamma$ denote a "0"

Let $v_s > v_{sat}$ denote a "1"

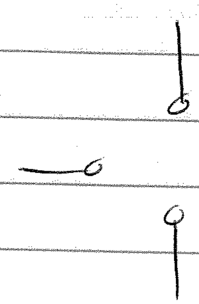
Look at v_{CE}

Then

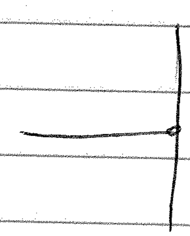
	v_s	v_{CE}
0	$< V_\gamma$	$V_{cc} =$ "1"
1	$> v_{sat}$	$0 =$ "0"

This is an "inverter".

In "0"



In "1"



Be sure to look at the examples in text, especially Design Exercise 4-13 on page 176.