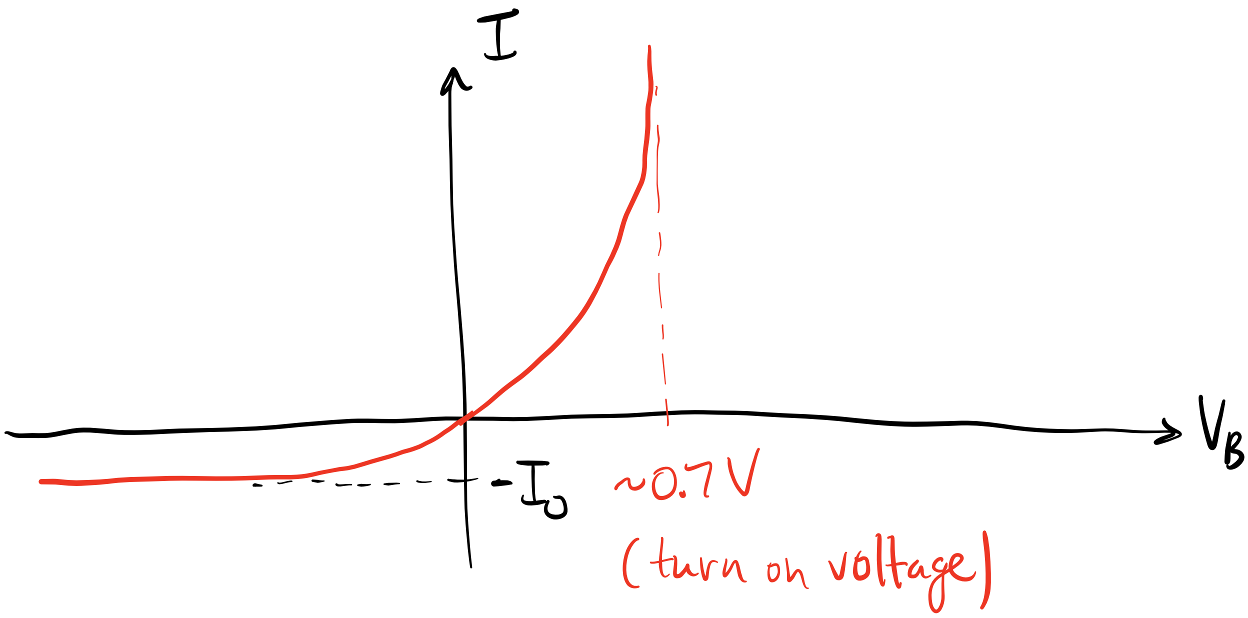
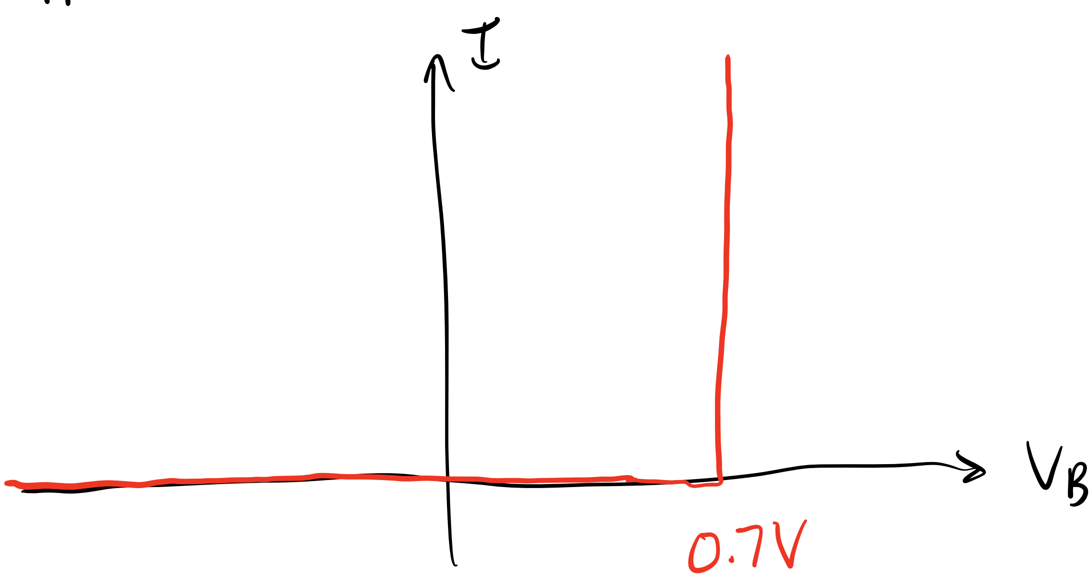
PHYS 231 — Nov. 29, 2023

Last Time: Diode current.

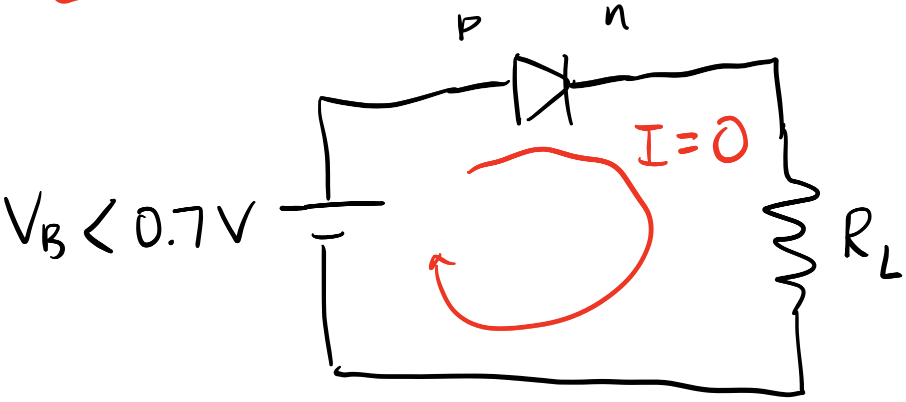
$$I = I_0 \left(e^{eV_B/k_BT} - 1 \right)$$



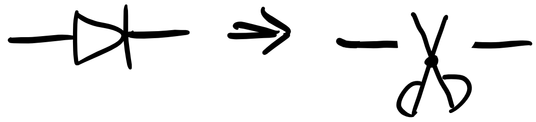
Approximate I-V characteristic as:

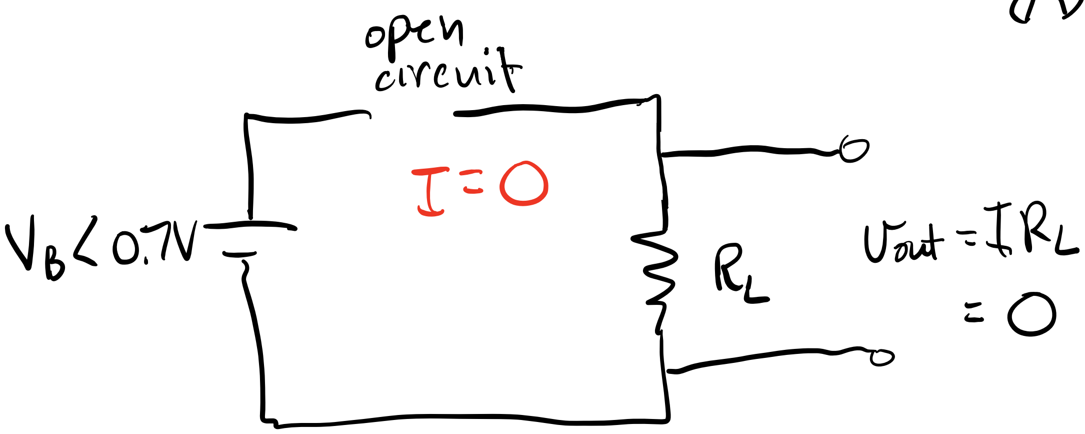


Reverse biased diode: diode "off", no current

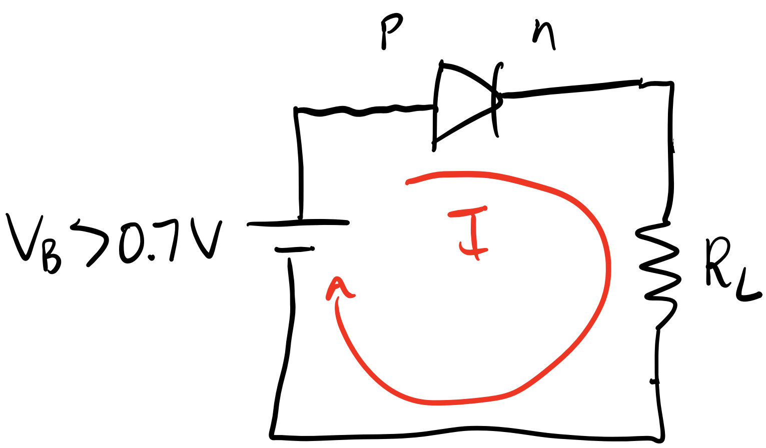


Equiv. Circuit:



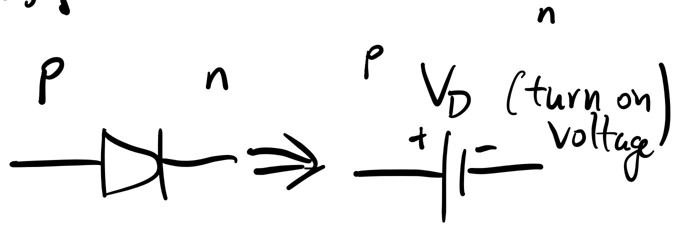


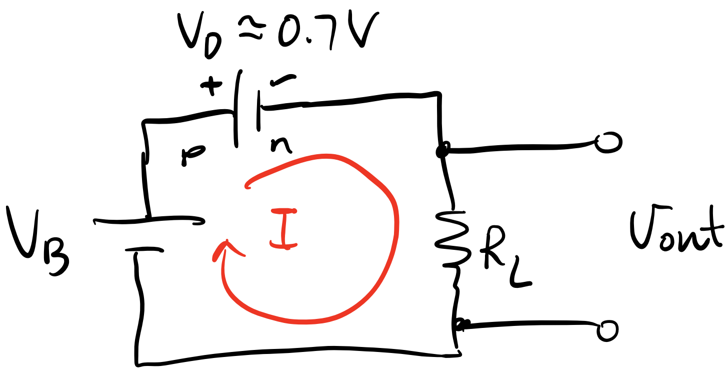
Forward Biased Diode: diode "on", $I \neq 0$.



Must overcome the 0.7 V turn on voltage before current flows.

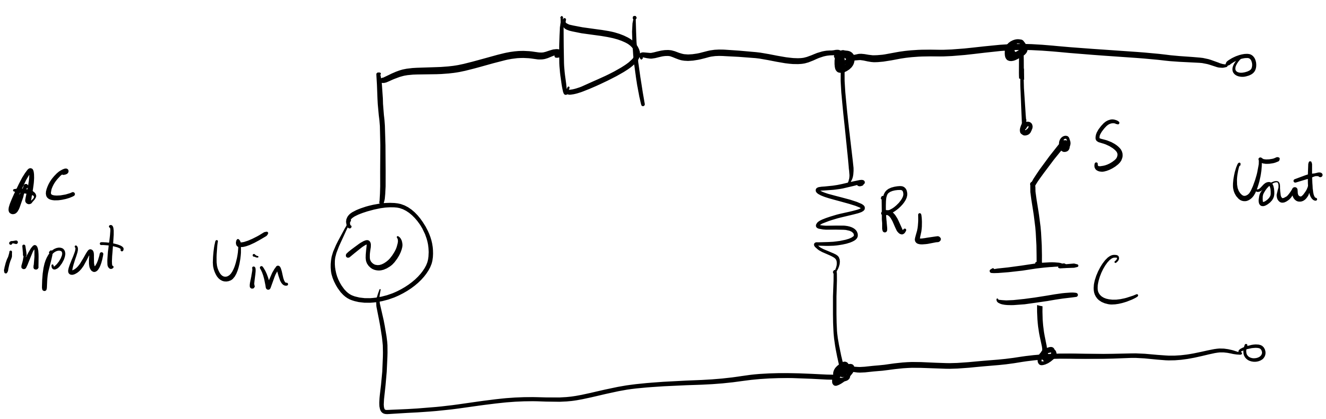
Equivalent circuit



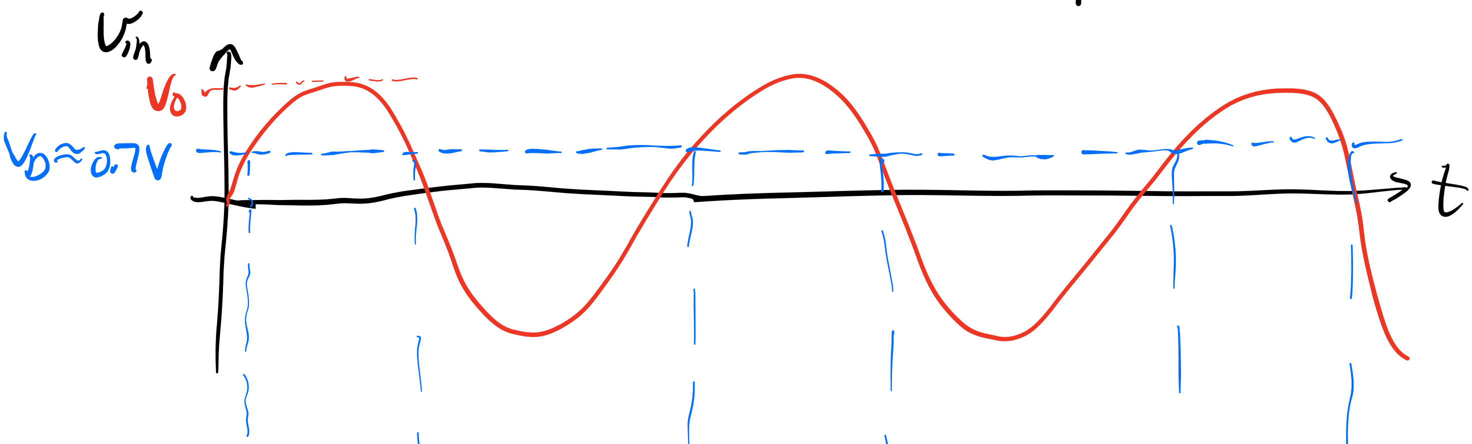


$$I = \frac{V_B - V_D}{R_L} \qquad V_{out} = IR_L = V_B - V_D$$

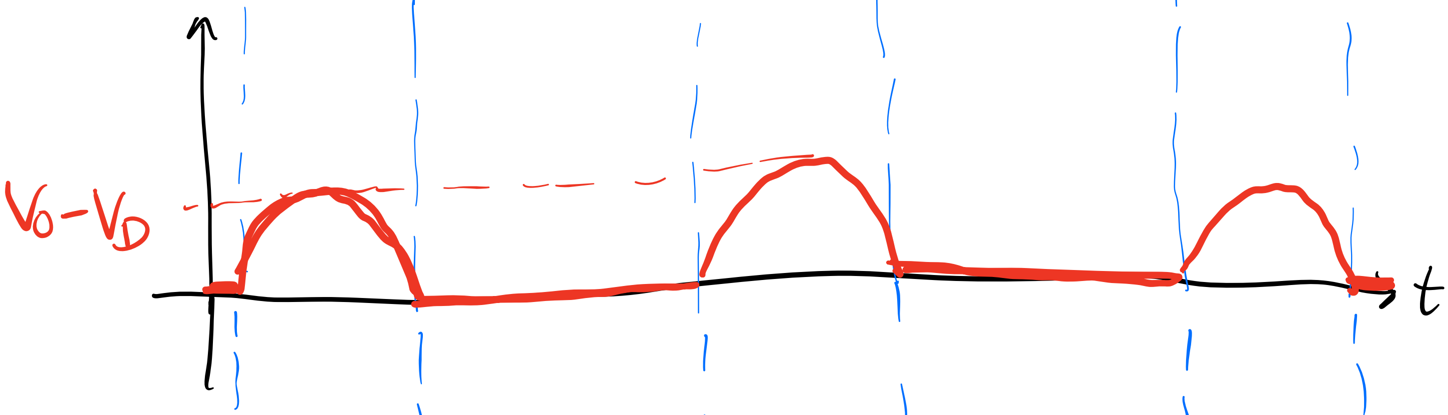
Rectifier Circuit (AC-to-DC conversion)



Plot v_{in} & v_{out} w/ switch open & the closed.



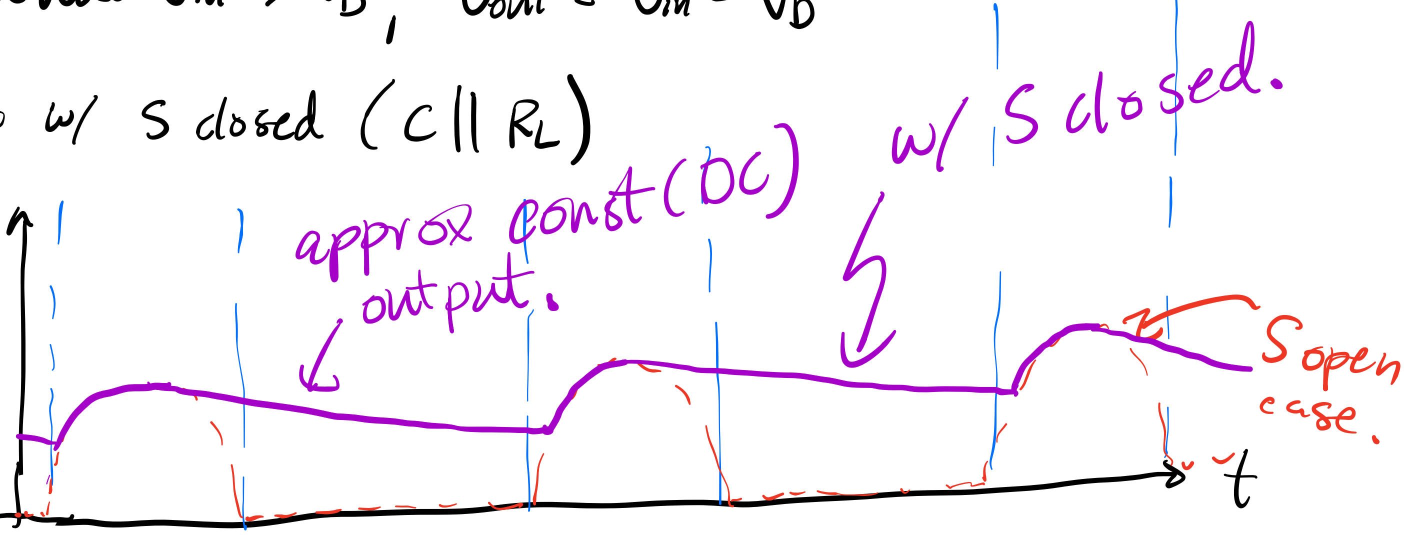
v_{out} w/ S open. (no cap.)



when $v_{in} < V_D \approx 0.7V$, no current & $v_{out} = 0$.

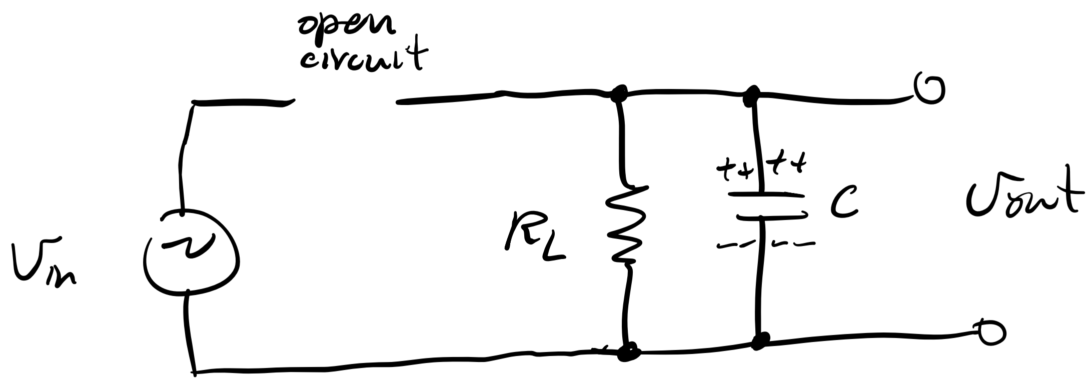
When $v_{in} > V_D$, $v_{out} = v_{in} - V_D$

v_{out} w/ S closed ($C \parallel R_L$)



No change when diode is forward biased.
Still expect $v_{out} = v_{in} - V_D$ when cap is in place.

When $v_{in} < V_D$ & diode is reverse biased, equiv. circuit becomes:

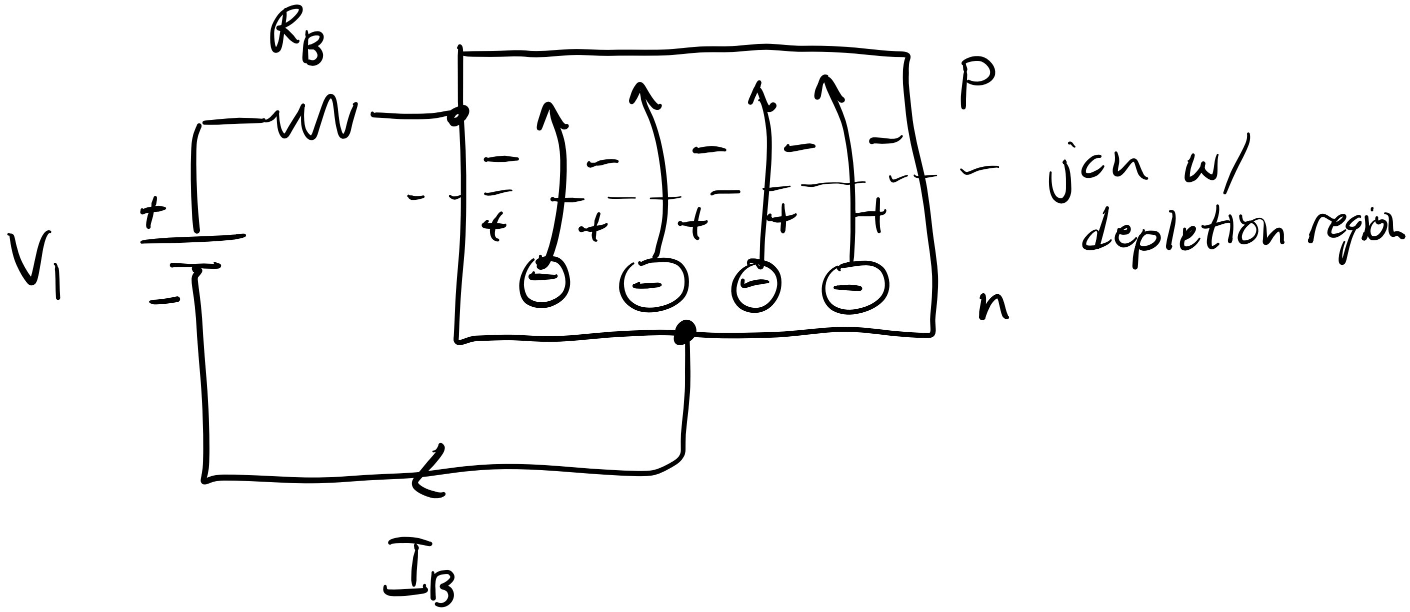


Cap charges when diode is forward biased.

Cap discharges through R_L when diode is reverse biased. Make the time const. $R_L C$ long so discharge is slow.

Bipolar Junction Transistor (BJT)

Start w/ a forward biased diode

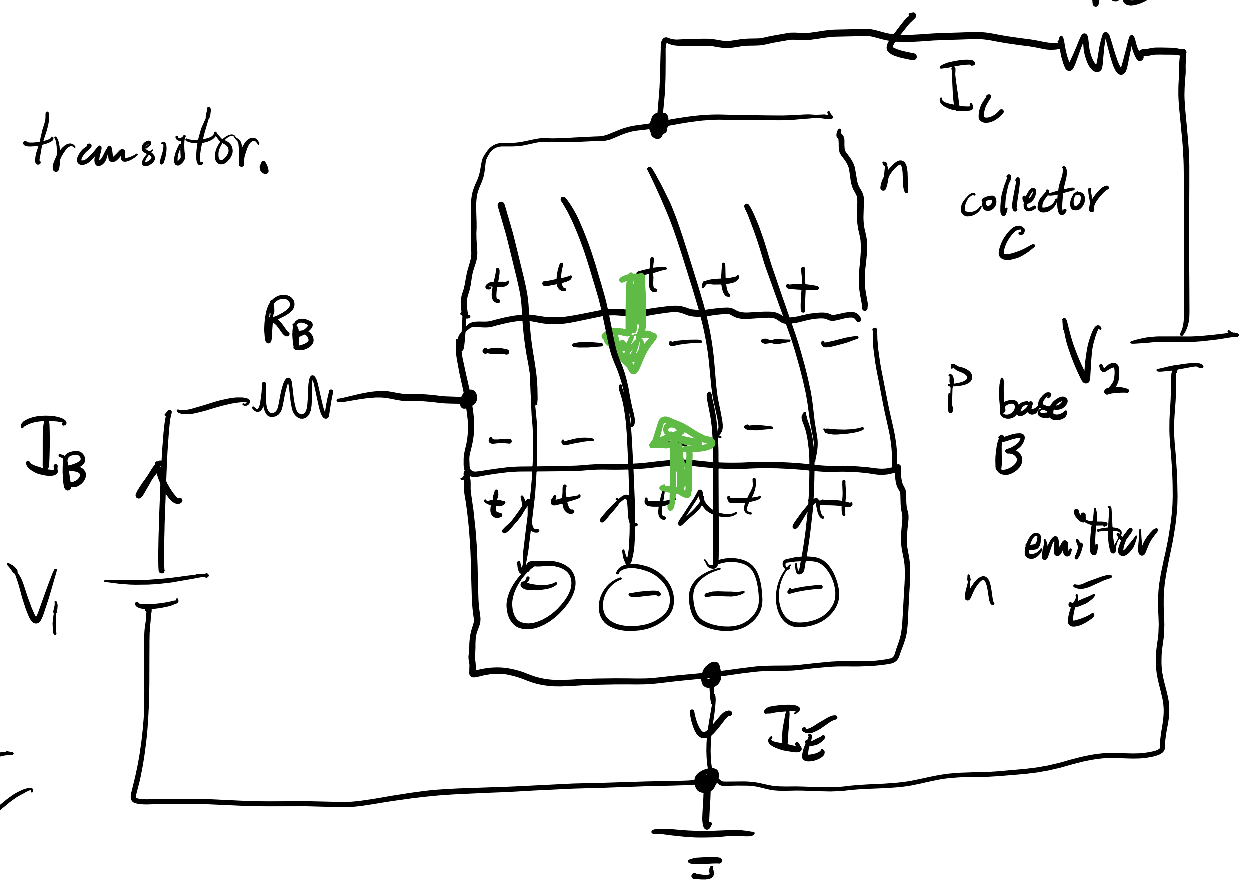


If $V_1 \gtrsim V_D \approx 0.7V$, get large conduction across jcn.

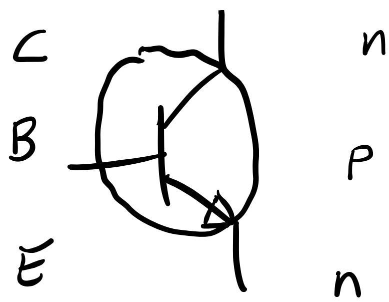
When making a transistor, n-region is much more heavily doped than p-region. ⇒ most of current is due to flow of e^-.

To complete the BJT, a second p-n jcn is created on opp. side of p region.

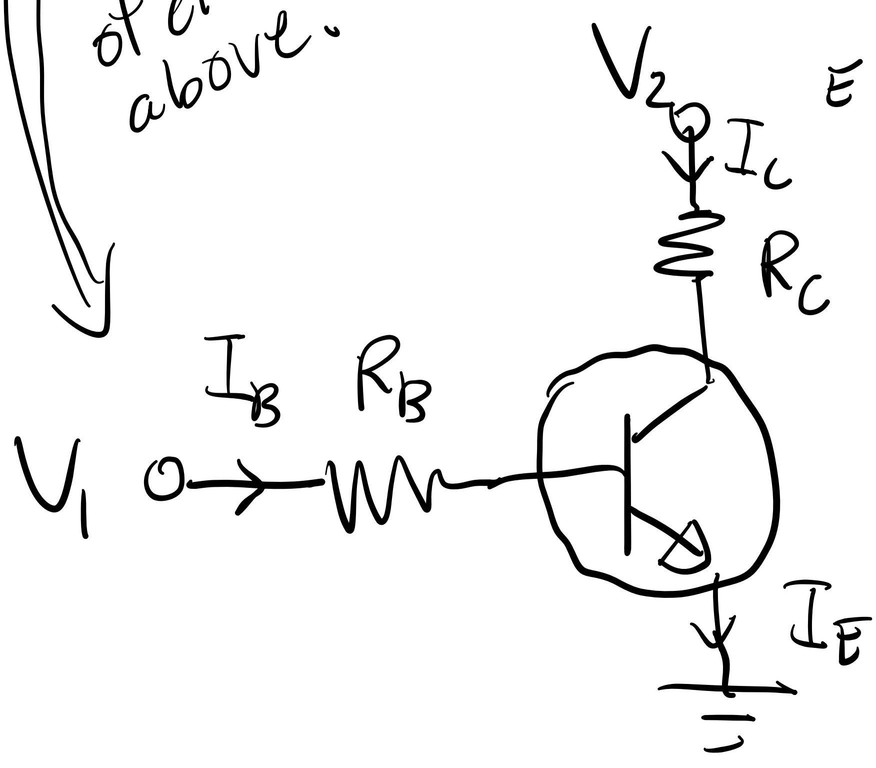
npn transistor.



Circuit symbol for npn transistor is



schematic of circuit above.



Base of a BJT is made very thin.

$\therefore$ most of e^- from emitter cross the base region & a swept into the collector

$\Rightarrow$ I_B is, therefore, always v. small.

By jcn rule : $I_B + I_C = I_E$

Since I_B is small, $I_C \approx I_E$

$$I_C = \alpha I_E \quad \text{typically } \alpha \approx 0.99$$

$$I_B = I_E - I_C$$
$$= I_E(1-\alpha)$$

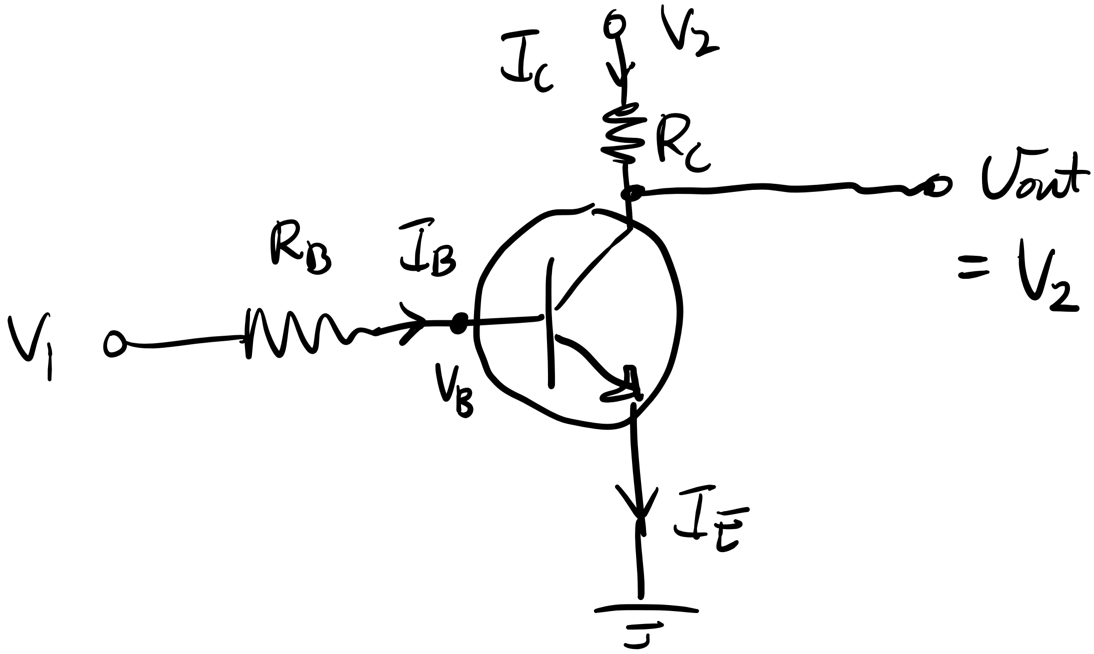
$$\therefore \frac{I_C}{I_B} = \frac{\alpha I_E}{(1-\alpha) I_E} = \frac{\alpha}{1-\alpha} \approx 99$$

$$\boxed{\therefore \ I_C \approx 99 I_B}$$

large current gain.

$\rightarrow$ current amplifier.

Transistor as a Switch.



$= V_2 - I_C R_C$

Since I_B is always small

$$V_1 - \cancel{I_B R_B}^{\to 0} = V_B \quad \therefore \quad V_1 \approx V_B$$

① $V_1 < 0.7\,V$, B-E jcn is reverse biased

& $I_E = I_C = 0$.

$$V_{out} = V_2 - \cancel{I_C R_C}^{\to 0} \qquad V_{out} = V_2.$$

For example, if $V_1 = 0$ & $V_2 = 5V$

V_1	V_{out}
0	5 V

$\Rightarrow$

V_1	V_{out}
LO	HI

② $V_1 > 0.7V$, B-E is forward biased

$I_C \neq 0$.

$$V_{out} = V_2 - I_C R_C \approx 0$$

If $V_1 = 5V$ (HI), $V_{out} \approx 0V$ (LO)

Truth Table

V_1	V_{out}
LO	HI
HI	LO

Inverter.