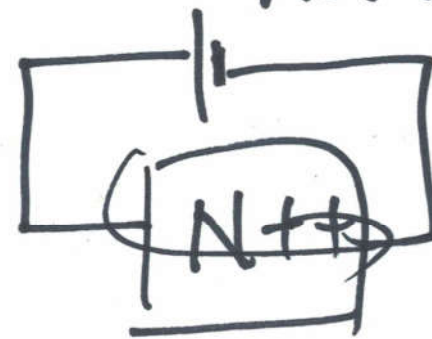
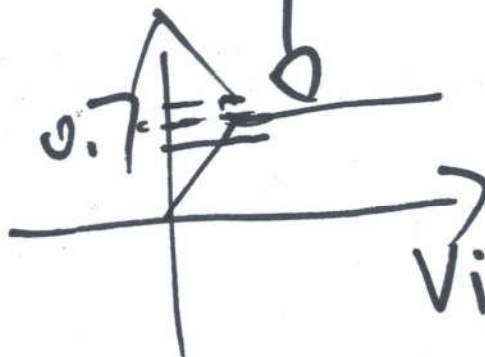
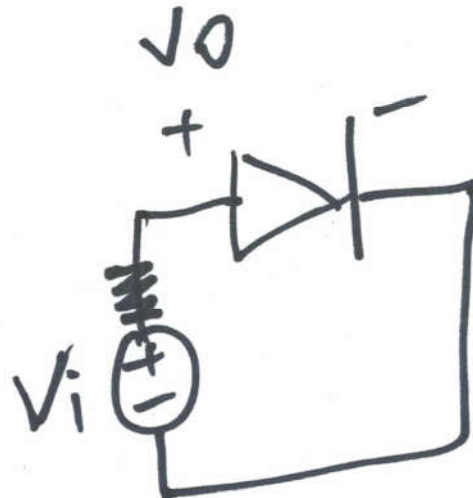
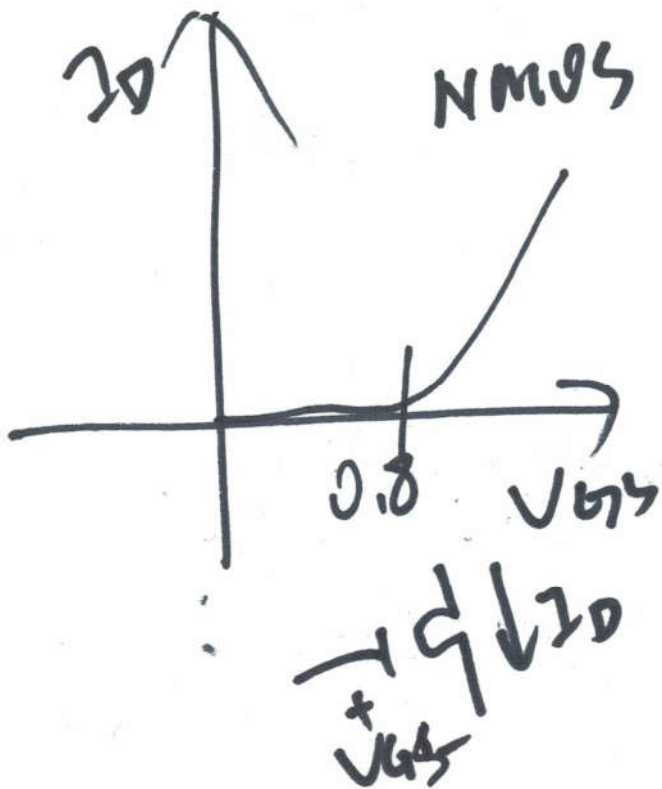
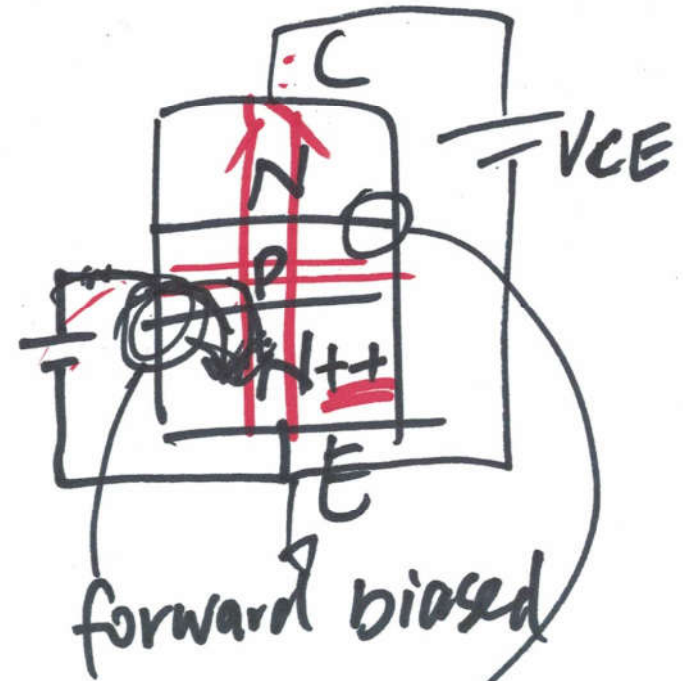
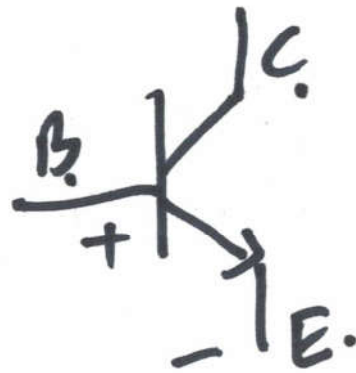
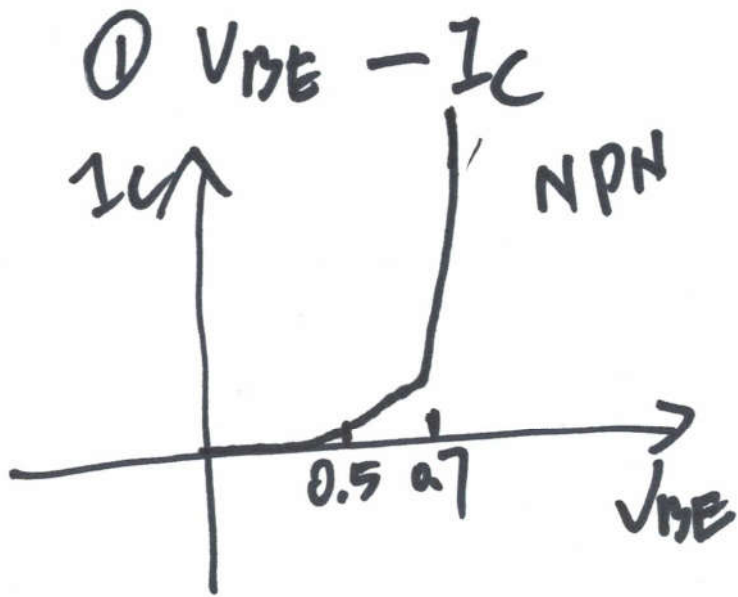


More BJTs



reverse biased

⇓

Active Mode

$$I_c = I_s e^{V_{BE}/V_T}$$

I_s : saturation current / ~~sat~~ scale current $(10^{-12} \sim 10^{-18} \text{ A})$

I_s is proportional to:

- Junction area
- base width
- Temperature

V_{BE} : forward voltage across the base-emitter junction

V_T : The thermal voltage, 25mV at room temp.

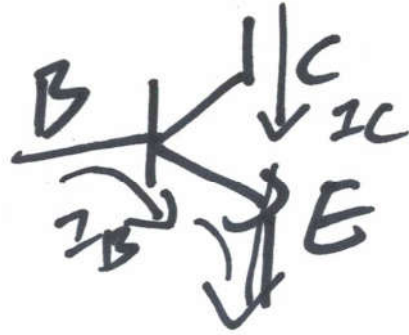
$$I_B = \frac{I_C}{\beta}$$

($\beta \sim 50-200$)

$$I_E = I_B + I_C$$

$$\alpha I_E = I_C$$

$\alpha \approx 0.9$



$$I_E = I_B + I_C$$

$$\frac{1}{\alpha} I_C = \frac{1}{\beta} I_C + I_C$$

$$\frac{1}{\alpha} = \frac{1}{\beta} + 1$$

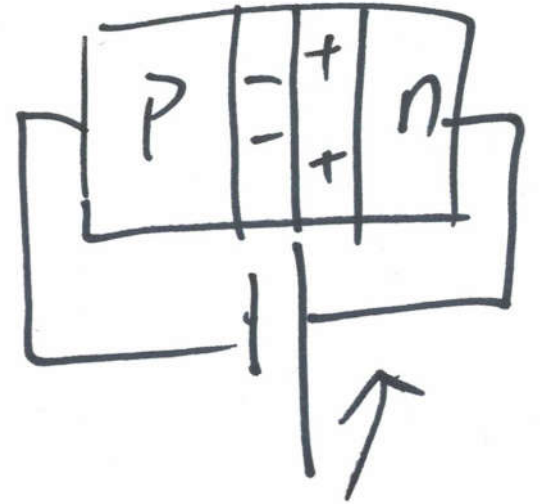
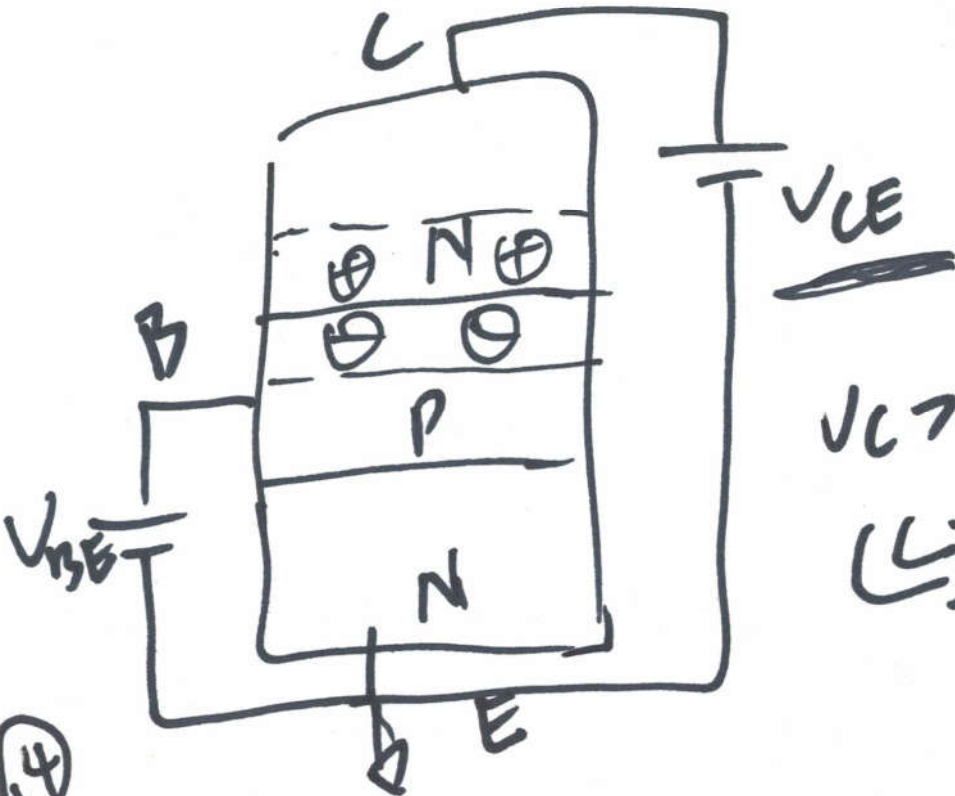
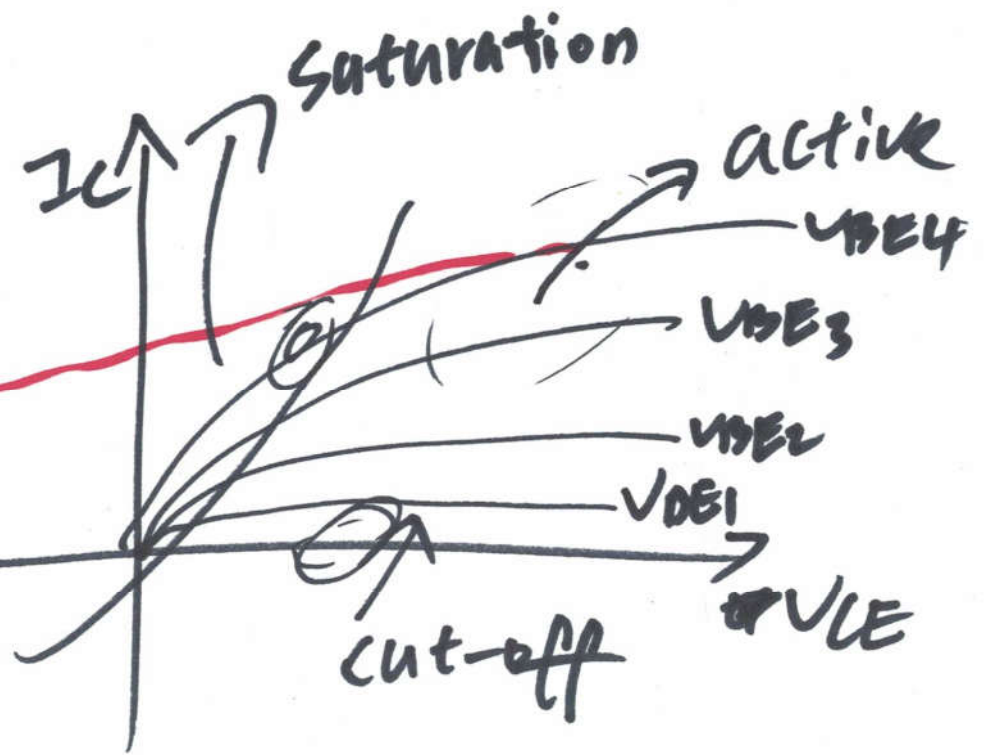
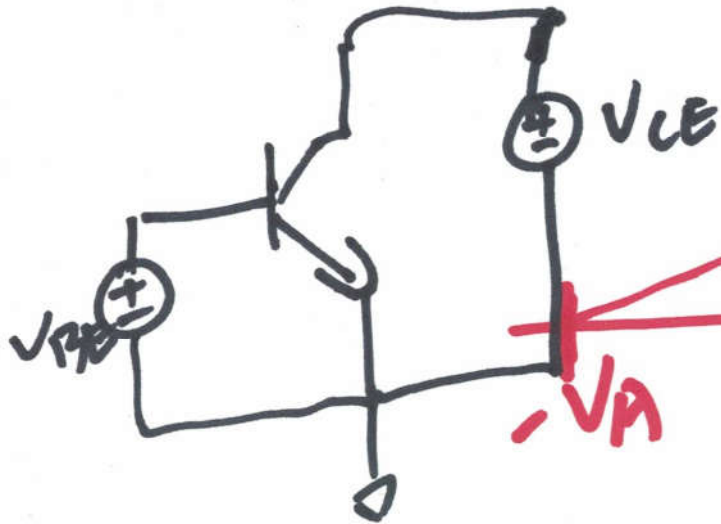
$$\alpha = \frac{1}{\frac{1}{\beta} + 1} = \frac{\beta}{1 + \beta}$$

$$\frac{1}{\beta} = \frac{1}{\alpha} - 1$$

$$\beta = \frac{1}{\frac{1}{\alpha} - 1} = \frac{\alpha}{1 - \alpha}$$

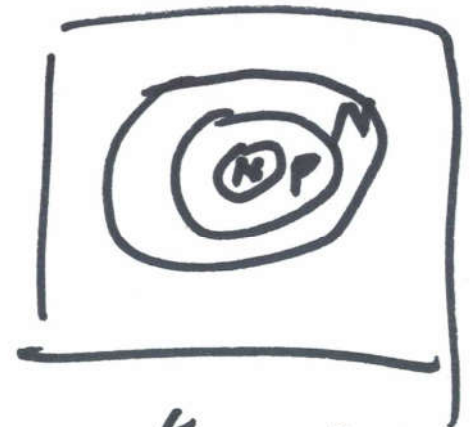
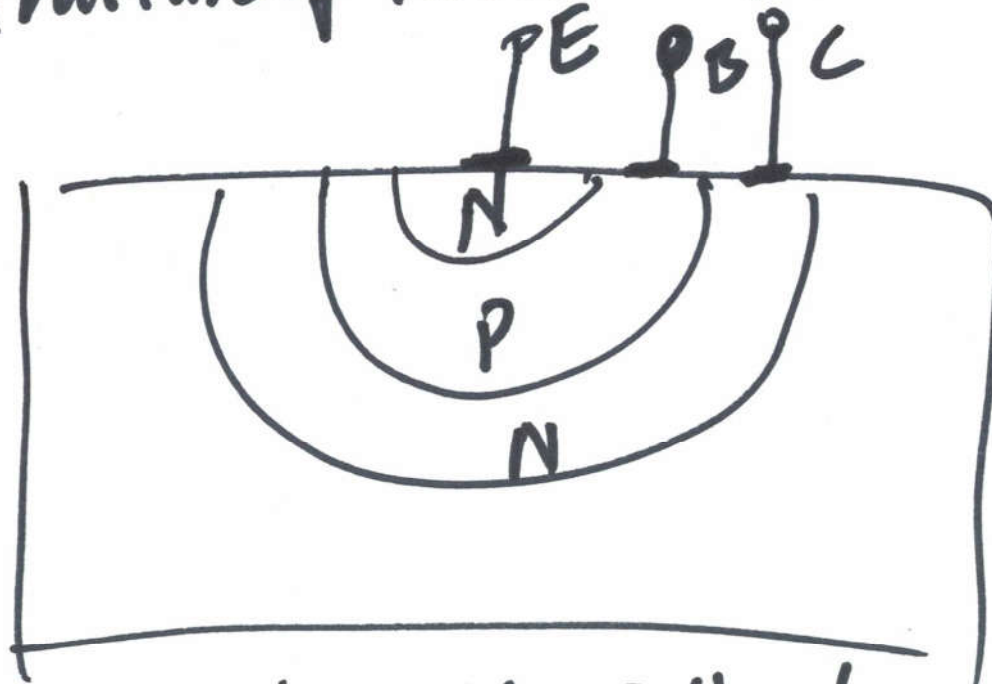
③

② Early Effect



④

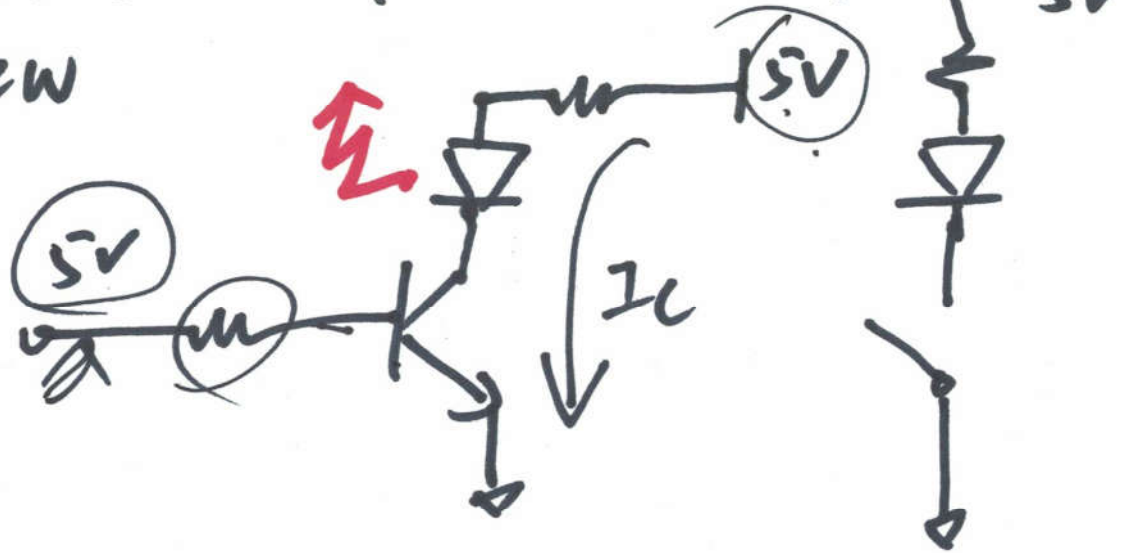
③ Structure of Actual NPN Transistors



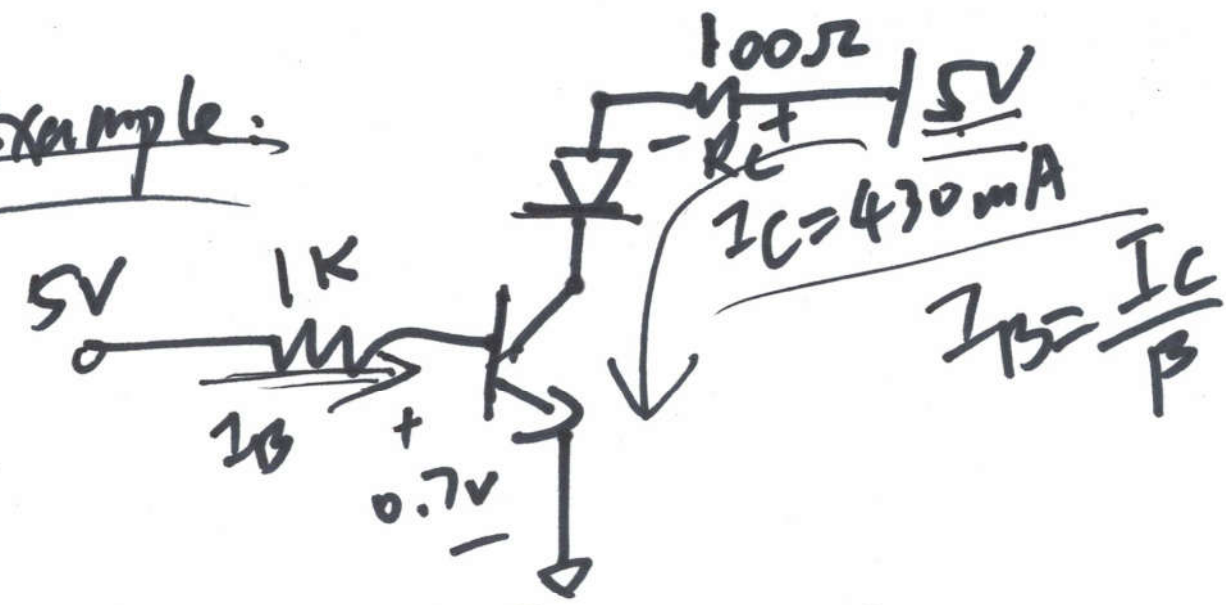
cross-sectional view

top-view

④ Applications



Example:



$$I_B = \frac{5 - 0.7}{1k} = 4.3 \text{ mA}$$

$$I_C = \beta I_B = 100 \cdot 4.3 \text{ mA} = 430 \text{ mA}$$

$$100 \Omega \cdot 430 \text{ mA} = 43000 \text{ mV} = \underline{\underline{43 \text{ V}}}$$



6

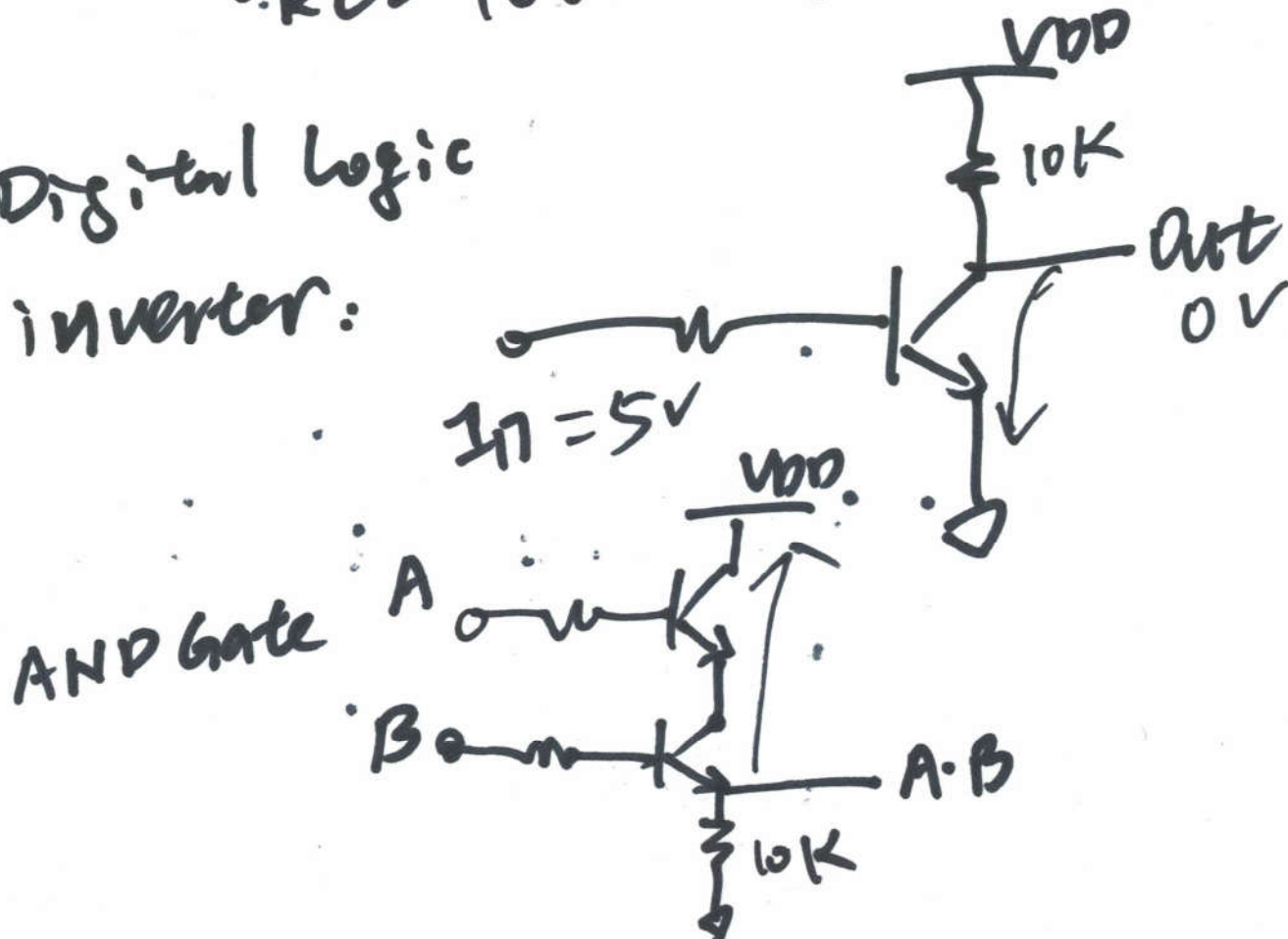
if $R_D = 20K$

$$I_B = \frac{5 - 0.7}{20K} = \frac{4.3V}{20K} = 0.215mA$$

$$I_C = 100 \cdot I_B = 21.5mA$$

$$V_{RC} = 100\Omega \cdot I_C = 2150mV = \underline{2.15V}$$

△ Digital Logic
inverter:



⑦

OR Gate:

