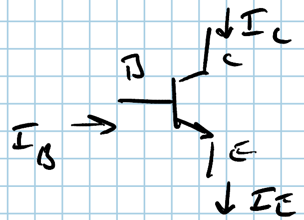
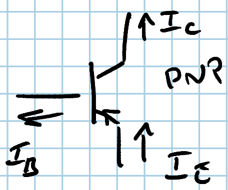
MORE BJT THEORY



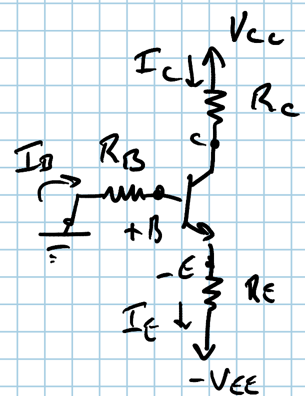


KCL $\quad I_E = I_B + I_C \qquad\qquad I_E = I_B + I_C$

$$\frac{I_C}{I_B} = \beta \qquad\qquad \frac{\beta}{\beta+1} = \alpha = \frac{I_C}{I_E}$$

$\beta \equiv 100 - 300 \qquad\qquad \alpha \to 1.0$ AS $\beta \to \infty$

IF 2 POWER SUPPLIES ARE AVAILABLE:



KVL @ BASE: $\qquad V_{BE} \approx 0.7\,V$

$$I_B R_B + V_{BE} + I_E R_E - V_{EE} = 0$$

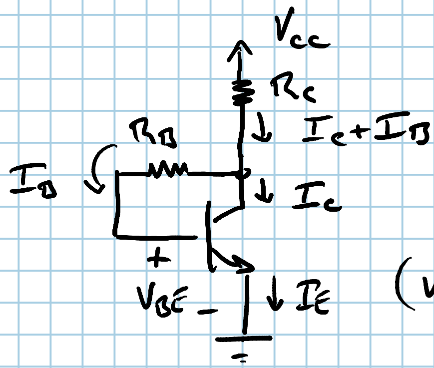
$$\left(I_B = \frac{I_C}{\beta} = \frac{\alpha I_E}{\beta} = \frac{\left(\frac{\beta}{\beta+1}\right) I_E}{\beta} \qquad I_B = \frac{I_E}{\beta+1} \right)$$

$$\left(\frac{I_E}{\beta+1}\right) R_B + V_{BE} + I_E R_E = V_{EE}$$

$$I_E \left(\frac{R_B}{\beta+1} + R_E\right) + V_{BE} = V_{EE}$$

$$I_E = \frac{V_{EE} - V_{BE}}{\frac{R_B}{\beta+1} + R_E}$$

COLLECTOR-TO-BASE FEED-BACK BIASING



$(V_E = 0)$

KVL:

$$V_{cc} - R_c\,(\underbrace{\cancel{I_B + I_c}}_{I_E}) - I_B R_B - V_{BE} = 0$$

FROM BJT THEORY:

$$I_B + I_c = I_E$$

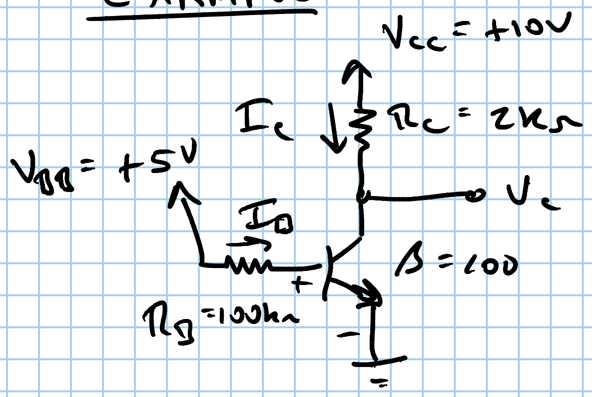
$$R_c I_E + I_B R_B + V_{BE} = V_{cc}$$

$$I_B = \frac{I_E}{\beta + 1}$$

$$\therefore \; I_E \left(R_c + \frac{R_B}{\beta+1} \right) = V_{cc} - V_{BE}$$

$$\boxed{I_E = \frac{V_{cc} - V_{BE}}{R_c + \frac{R_B}{\beta+1}}}$$

EXAMPLE



FIND NODE VOLTAGES + BRANCH CURRENTS

$$\boxed{V_E = 0}$$

KVL @ BASE

$$I_B R_B + \cancel{V_{BE}}^{\,0.7} - 5 = 0$$

$$100\, I_B = 4.3$$

$$\boxed{I_B = 43\,\mu A}$$

$$I_C = \beta I_B = 100\,(43\times10^{-6}A) = \boxed{4.3mA}$$

$$I_E = I_C + I_B = 4.3mA + 0.043\,mA$$

$$\boxed{I_E = 4.343mA}$$

$$I_C = \frac{V_{CC} - V_C}{R_C} \Rightarrow V_C = V_{CC} - I_C R_C$$

$$V_C = 10 - (4.3mA)(2k\Omega)$$

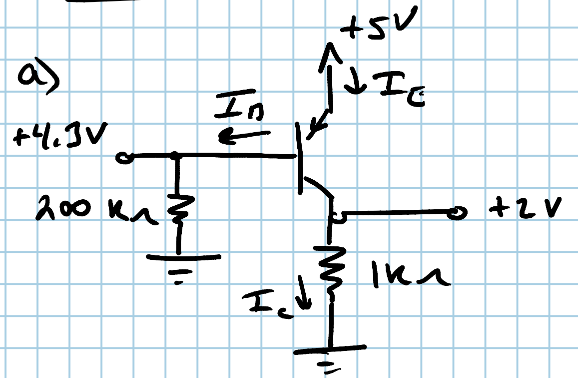
$$\boxed{V_C = 1.4V}$$

$$V_{BE} = V_B - \cancel{V_E}^{\,0} = 0.7\,V$$

$$\boxed{V_B = 0.7\,V}$$

EXAMPLE

a)



FIND β

$$I_C = \frac{2V}{1k\Omega} = 2mA$$

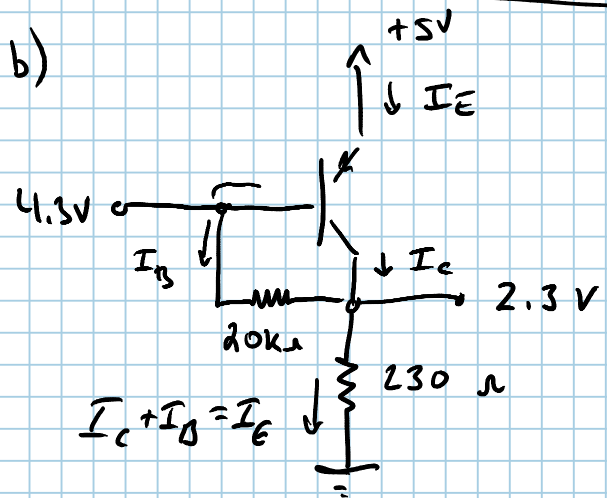
$$I_C = \beta I_B$$

$$I_C = \alpha I_E$$

$$I_B = \frac{4.3V}{200k\Omega} = 21.5\,\mu A$$

$$\beta = \frac{I_C}{I_B} = \frac{2mA}{0.0215mA} = \boxed{93 = \beta}$$

b)



$$I_B = \frac{4.3 - 2.3\ V}{20k\Omega} = \underline{100\,\mu A}$$

$$I_E = I_B + I_C = \frac{2.3V}{0.230k\Omega} = \underline{10\ mA}$$

$$I_C = I_E - I_B = 10 - 0.1 = 9.9mA$$

$$\beta = \frac{I_C}{I_B} = \frac{9.9\,mA}{0.1\,mA} = \boxed{99}$$

REVIEW

- **Op Amps**
    - Inv. Amps
    - Non-Inv. Amps
    - Unity-Gain Amp (Voltage-Follower)
    - Summing Amp (Inv)
    - Multi-Stage Amp.
    - Differential Amp
    - Integrators & Differentiators

- **Diodes**
    - Rectifiers (Half-wave, Full-wave)
    - Zener diodes

- MOSFETs
    - Biasing
    - $\underbrace{\text{N-channel}}_{V_t,\ V_{DS},\ V_{GS} > 0}$, $\underbrace{\text{P-channel}}_{V_t,\ V_{DS},\ V_{GS} < 0}$

	NMOS	PMOS
Triode:	$V_{GS} \geq V_t$	$V_{GS} \leq V_t$
	$V_{DS} < V_{GS} - V_t$	$V_{DS} > V_{GS} - V_t$
Saturation:	$V_{GS} \geq V_t$	$V_{GS} \leq V_t$
	$V_{DS} \geq V_{GS} - V_t$	$V_{DS} \leq V_{GS} - V_t$

	NMOS	PMOS
Triode:	$I_D = k_n'\left(\frac{W}{L}\right)\left[(V_{GS}-V_t)V_{DS} - \frac{1}{2}V_{DS}^2\right]$	$I_D = k_p'\left(\frac{W}{L}\right)\left[(V_{GS}-V_t)V_{DS} - \frac{1}{2}V_{DS}^2\right]$
Saturation:	$I_D = \frac{1}{2}k_n'\left(\frac{W}{L}\right)(V_{GS}-V_t)^2$	$I_D = \frac{1}{2}k_p'\left(\frac{W}{L}\right)(V_{GS}-V_t)^2$

- BJTs

SEE NOTE FROM 21 & 23 JULY

FINAL EXAM: 30 JULY 2015

6:30 – 9:00

CALCULATOR

1 2 SIDED NOTE SHEET

2 1 SIDED " "

$\boxed{\text{JEFF'S CELL\# } 256\text{-}738\text{-}1450}$