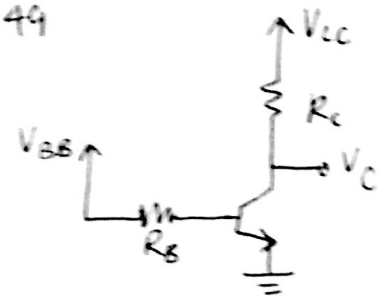
HOMEWORK #6

6.49



$V_{CC} = 5V \quad R_C = 1K\Omega \quad R_B = 20k\Omega \quad \beta = 50$

(a) Active mode with $V_C = 1V$

$I_C = \frac{V_{CC} - V_C}{R_C} = \frac{5-1}{1} = 4mA$

$V_{BE(ON)} = 0.7 \Rightarrow V_B = 0.7V$ & $V_E = 0V$

$I_B = \frac{I_C}{\beta} = \frac{4}{50} mA = 80\mu A = \frac{V_{BB} - V_B}{R_B} \Rightarrow V_{BB} = V_B + 20k\Omega \, 80\mu A$

$= 0.7 + 1600m = 2.3V$ //

(b) at the Edge of Saturation

$V_C = V_E + V_{CEsat} = 0V + 0.2V = 0.2V$

$\Rightarrow I_C = \frac{V_{CC} - V_C}{R_C} = 4.8mA$, $I_B = \frac{I_C}{\beta} = 4.8/50 = 96\mu A$ ~~last~~ valid since we are at the edge of FA & sat^n and not in sat^n region

$\Rightarrow V_{BB} = V_B + I_B R_B = 0.7 + 20k\Omega \, 96\mu A$

$= 0.7 + 1920m = 2.62V$

(c) deep in Saturation $\beta_{forced} = 10$

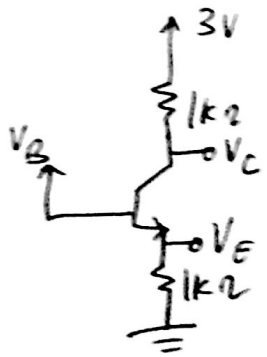
$V_{BB} = V_B + I_B R_B = V_B + \frac{I_C}{\beta_f} R_B \Rightarrow$ 2 unknowns $V_{BB}, V_C \Rightarrow$ assume $V_{CEsat} = 0.2 \Rightarrow V_C = 0.2V$

$\frac{V_{CC} - V_C}{R_C} = \frac{5 - 0.2}{1K\Omega} = 4.8mA$

$= 0.7 + \frac{4.8m}{10} \times 20K$

$= 9.6 + 0.7 = 10.3V$

6.52



β is very high $\Rightarrow I_B = 0 \Rightarrow I_C = I_E$

V_B (a) 1.5V

$V_{BE\,on} = 0.7 \Rightarrow V_C = 0.8V$ Assume FA

$\Rightarrow I_C = 0.8mA = I_E$

$\frac{3 - V_C}{1K\Omega} = I_C = 0.8mA \Rightarrow 3 - V_C = 0.8$

$\Rightarrow V_C = 2.2V$

$V_{CE} = 2.2 - 0.8 = 1.4V \Rightarrow FA$ ✓

(b) 1V

$V_{BE\,on} = 0.7V \Rightarrow V_E = 0.3V \Rightarrow I_C = I_E = 0.3mA$ Assume FA

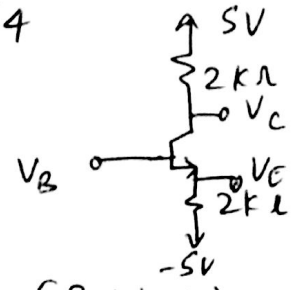
$3 - 0.3 = V_C = 2.7V \Rightarrow V_{CE} = 2.4V \Rightarrow FA$ ✓

(c) $V_B = 0V$

Assume FA $\Rightarrow V_{BE} = 0.7V \Rightarrow V_E = -0.7V \Rightarrow I_E$ is $-ve \Rightarrow$ B-E is off

$\Rightarrow I_E = 0 = I_C \Rightarrow V_E = 0V$, $V_C = 3V$ Cut-off region

6.54



(β is high)

$V_B = -1V \Rightarrow V_{BE} = 0.7 \Rightarrow V_E = -1.7$ V Assume FA

$I_E = I_C = \frac{V_E + 5}{2k} = \frac{-1.7+5}{2k} = \frac{3.3}{2k} = 1.65mA$

$\frac{5 - V_C}{2k} = 1.65mA \Rightarrow 5 - 3.3 = V_C = 1.7V$, $V_{CE} = 3.4V \Rightarrow FA$

$V_B = 0V \Rightarrow V_E = -0.7V$

$I_E = \frac{-0.7+5}{2} = \frac{4.3}{2k} = 2.15mA = I_C = \frac{5 - V_C}{2k}$

$V_E = 0.3V \Rightarrow V_C = 0.5V$ ($V_{CE} = 0.2V$) $\Rightarrow V_C = 5 - 4.3 = 0.7V \Rightarrow V_{CE} = 1.4V \Rightarrow FA$

$I_C = \frac{5-0.5}{2K} = 2.25mA$

$I_E = \frac{0.3+5}{2K} = 2.65mA$

$\alpha = 0.85$

$V_B = +1V \Rightarrow V_E = 0.3V$

$I_E = I_C = \frac{0.3+5}{2K} = \frac{5 - V_C}{2k} \Rightarrow V_C = -0.3V$

$V_{CE} = -0.6V \Rightarrow$ not FA, in Saturation (assume)

I_E at $V_B = 0V \Rightarrow I_E = 0.215mA = I_C \Rightarrow V_C = 5 - 0.43 = 4.57V \Rightarrow V_{CE} = 9.14V \Rightarrow FA$

$\frac{V_E + 5}{2k} = I_E = 0.215mA \Rightarrow V_E = -5 + 0.43 = -4.57V \Rightarrow V_B = -3.87V$

Edge of conduction $\Rightarrow I_E = 0A \Rightarrow V_E = -5V \Rightarrow V_B = -4.3V$ //, $V_C = 5V$

Edge of Saturation $V_{CE\,sat} = V_{CE} = 0.2V \Rightarrow 10 - 0.2 = I_E\,4K\Omega \Rightarrow I_E = \frac{9.8}{4k} = 2.45mA$

$V_E + 5V = 2.45m \times 2k = 4.9V \Rightarrow V_E = -.1V \Rightarrow V_B = 0.6V$, $V_C = 0.1V$

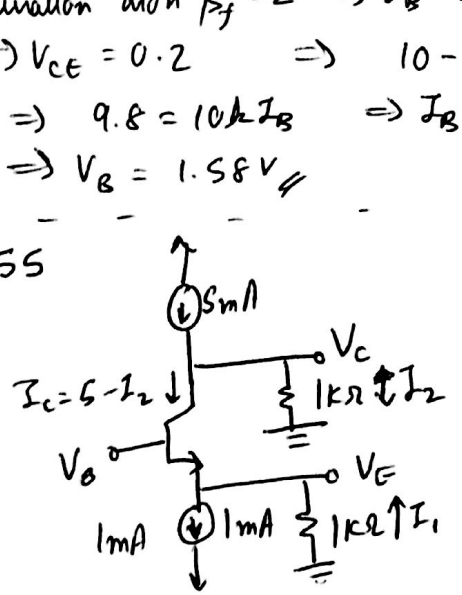
Saturation with $\beta_f = 2 \Rightarrow I_B = I_C/2 \Rightarrow I_C = 2I_B$, $I_E = 3I_B$

$\Rightarrow V_{CE} = 0.2 \Rightarrow 10 - 0.2 = 2k(I_E + I_C) = 2k(5I_B)$

$\Rightarrow 9.8 = 10k I_B \Rightarrow I_B = 0.98mA \Rightarrow I_E = 2.94mA \Rightarrow V_E = -5 + 5.88 = 0.88V$

$\Rightarrow V_B = 1.58V$ //

6.55



$V_B = 0V$

$V_{BE\,on} = 0.5V$

$\Rightarrow V_E = -0.5V$

$\Rightarrow I_E = 0.5mA = I_C$ as $\alpha \simeq 1$

$\Rightarrow \frac{-0 + V_C}{1K\Omega} = 4.5mA = I_2 \Rightarrow V_C = +4.5V$ //

Transistor cut off for $I_E = 0$

$\Rightarrow V_E = -1V$ as $I_1 = 1mA \Rightarrow V_B = -0.5V$ //, $V_C = 5V$

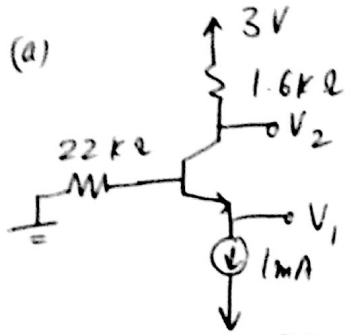
Transistor in Saturation for $V_{CE} = 0.2V$

$I_C = 5 - I_2 = I_E = 1 - I_1 \Rightarrow 5 - I_2 = 1 - I_1 \Rightarrow 4 = I_2 - I_1 = \frac{V_C + V_E}{1K} \frac{}{1k}$

$\Rightarrow V_C - V_E = 0.2$ & $V_C + V_E = 4 \Rightarrow V_C = 2.1V$, $V_E = 1.9V \Rightarrow V_B = 2.4V$ //

6.62

(a)



(β is high)

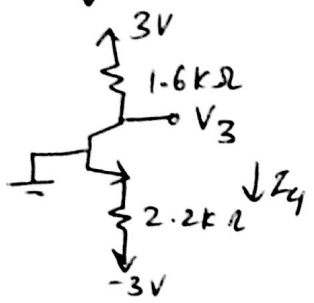
$V_B = 0V$

Assume FA $\Rightarrow V_1 = -0.7V$

$\frac{3 - V_2}{1.6k} = 1m \Rightarrow V_2 = 1.4V$

$V_{CE} = 2.1V \Rightarrow$ FA ✓

(b)



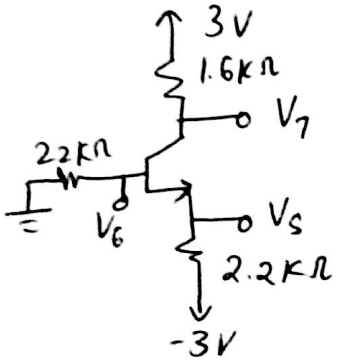
$V_B = 0V \Rightarrow V_E = -0.7V$

$\Rightarrow I_4 = \frac{-0.7 + 3}{2.2k} = \frac{2.3}{2.2k} \simeq 1mA$

$V_3 = 3 - 1.6 \simeq 1.4V$

$V_{CE} = 2.1V \Rightarrow$ FA ✓

(c)

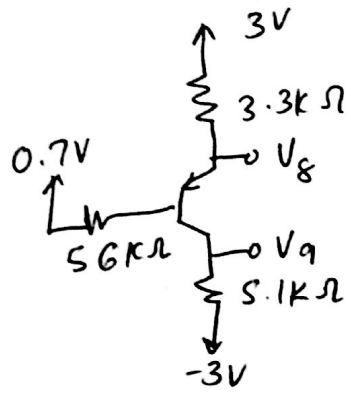


$V_6 = V_B = 0V$) same for high β

$V_S = -0.7V$

$\Rightarrow I_E \simeq 1mA \Rightarrow V_7 = 1.4V$

(d)



$V_B = 0V$ ~~0.7V~~

$V_{EB} = 0.7V$

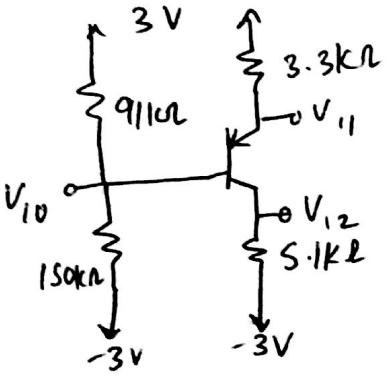
$\Rightarrow V_E = 1.4V$

$\Rightarrow I_E = \frac{3 - 1.4}{3.3} = \frac{1.6}{3.3} \simeq 0.5mA = I_C$

$\Rightarrow V_9 + 3 = 5.1 \times 0.5 \Rightarrow V_9 \simeq -0.5V$ //

$V_{EC} = 1.4 + 0.5 = 1.9V > 0.2V \Rightarrow$ FA ✓

(e)



~~$(3.3 + 5.1) I_E$~~

$V_{10} = -\left(\frac{91}{241} \times \beta\right) + 3 \simeq 3 - 2.3 = 0.7V$

$\Rightarrow V_{11} = 1.4V$

$\Rightarrow I_E = I_C = \frac{1.6}{3.3} \simeq 0.5mA$

$V_{12} + 3 = 5.1 \times 0.5 \Rightarrow V_{12} \simeq -0.5V$

$V_{EC} = 1.9V > 0.2V \Rightarrow$ FA ✓