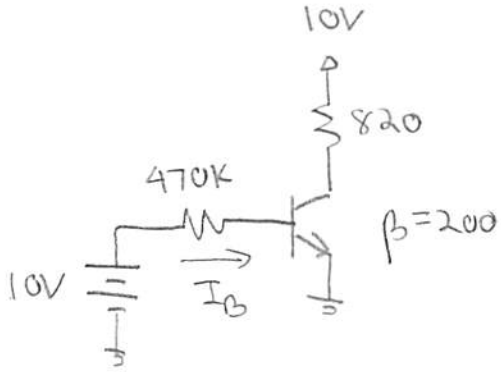
ECE 248
HW 3 Solutions

Total = 100 pts

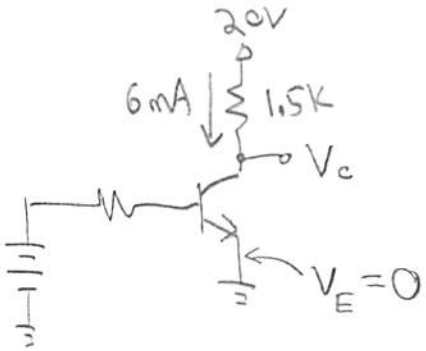
6.5 (+5)

$$I_B = \frac{10 - 0.7}{470K} = \boxed{0.02\ mA}$$



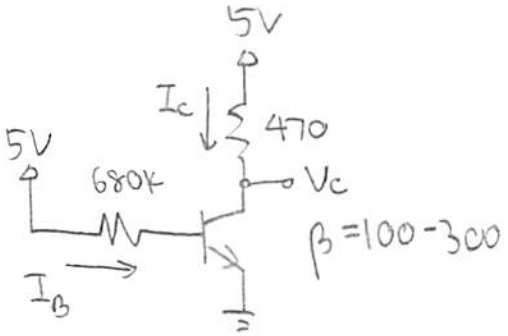
6.8 (+5)

$$V_{CE} = V_C - \cancel{V_E}^{\,0}$$
$$= V_C$$
$$= V_{CC} - I_C R_C$$
$$= 20 - (6mA)(1.5K) = \boxed{11V}$$



7.14 (+8)

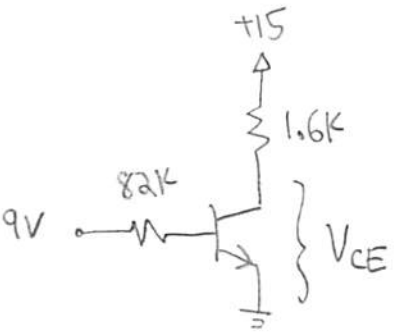
$$V_{CE} = V_C - \cancel{V_E}^{\,0}$$
$$= V_{CC} - I_C R_C$$
$$= V_{CC} - \beta I_B R_C$$
$$I_B = \frac{5 - 0.7}{680K} = .0063\ mA$$



$\beta = 100$: $V_{CE} = 5 - 100 \times .0063mA \times .47K = \boxed{4.7V}$

$\beta = 300$: $V_{CE} = 5 - 300 \times .0063mA \times .47K = \boxed{4.11V}$

7.XX Need to find V_{CE}



(+5) $V_{CE} = V_C - V_E$ (E → 0)

$= V_{CC} - I_C R_C$

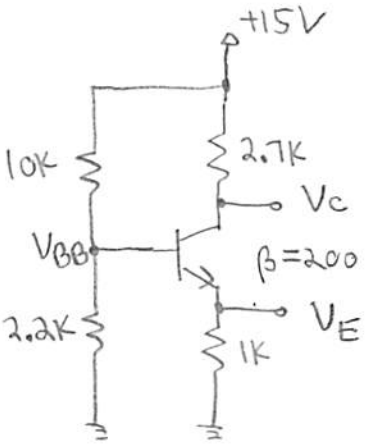
$= V_{CC} - \beta I_B R_C$

I_B: $\frac{9-0.7}{82K} = 0.101mA$

$= 15 - 100 \times .1mA \times 1.6K = \underline{\underline{-1.2V}} < 0$

NOT in active mode!

8.XX



(+8) (a) stiff divider?

$10K // 2.2K = 1.8K$

$\frac{200+1}{100} \times 1K = 2.01K$ ✓ YES

(b) $V_{BB} = 15 \frac{2.2K}{2.2K + 10K} = \boxed{2.7V}$

$\alpha = \frac{200}{201} = .995$

(c) $V_{CQ} = V_{CC} - I_{CQ} R_C = V_{CC} - \alpha I_{EQ} R_C$

I_{EQ}: $\frac{2.7-0.7}{1K} = 2mA$

$= 15 - .995 \times 2mA \times 2.7K$

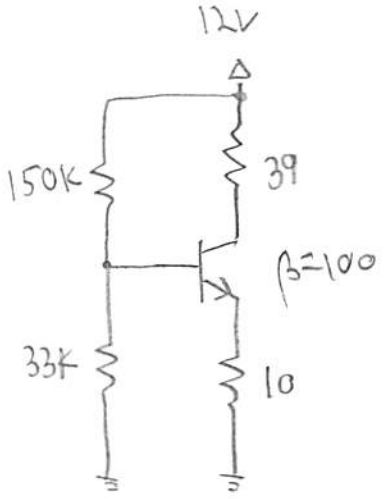
$= \boxed{9.63V}$

(d) $V_{CEQ} = V_{CQ} - V_{EQ} = 9.63 - 2 = \boxed{7.63V}$

V_{EQ}: $2.7 - 0.7 = 2V$

8.44

(+8)



(a) Thevenize the divider!

$$V_{TH} = 12 \cdot \frac{33K}{33K + 150K} = \boxed{2.16V}$$

(b) $R_{TH} = 150K \,//\, 33K = \underline{\underline{27K}}$

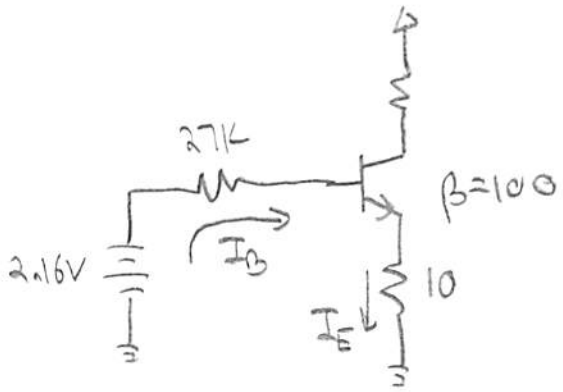
$$\frac{\beta+1}{100} \times .010K = \frac{201}{100} \times .010K = \underline{\underline{.02K}}$$

$27K > .02K$! Divider is no where close to being stiff!

(c) KVL:

$$2.16 - I_B \cdot 27K - 0.7 - I_E \cdot 10 = 0$$

$I_E = (\beta+1) I_B$

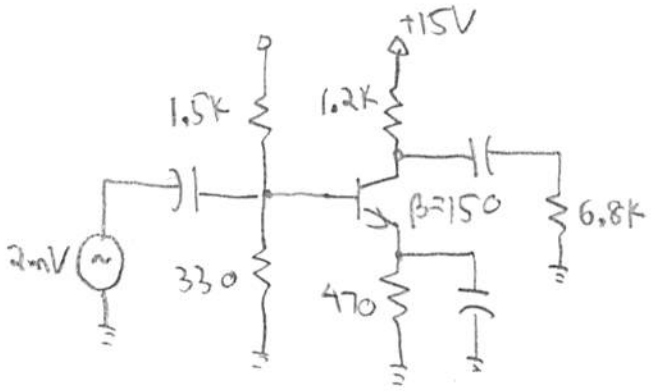


$$I_B = \frac{2.16 - 0.7}{27K + 101 \cdot .010K} = .052mA$$

$$V_{BB} = 2.16 - I_B \cdot 27K = 2.16 - .052mA \cdot 27K$$

$$= \boxed{0.75V}$$

(+8) 9.19



For AC equivalent circuit:

① All DC voltages become AC grounds

② $R_c // R_L = r_c = 1.2K // 6.8K = \underline{\underline{1.02K}}$

$R_1 // R_2 = 1.5K // .33K = \underline{\underline{.271K}}$

③ Use T-model ⇐ need r_e'

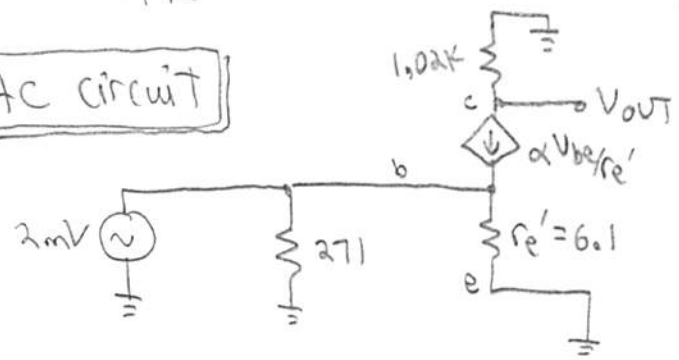
Stiff divider? $1.5K // .33K = .271K$

$\frac{150+1}{100} \times .47K = .71K$ ✓

$\Rightarrow V_{BB} = 15 \frac{330}{330+1500} = 2.71V$

$\Rightarrow I_{EQ} = \frac{2.71 - 0.7}{470} = .0043\,A \Rightarrow r_e' = \frac{.026}{.0043A} = \underline{\underline{6.1\,\Omega}}$

AC circuit



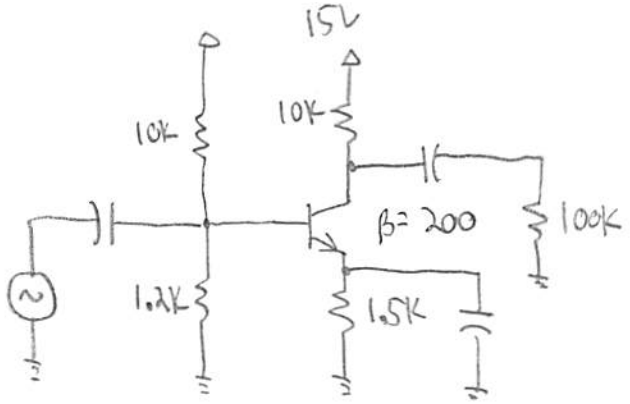
9.XX

(+5)

$\frac{V_{OUT}}{V_{IN}} = -\alpha \frac{r_c}{r_e'} = -.995 \frac{1020}{6.1} = \boxed{-166.4}$

$\alpha = \frac{200}{201} = .995$

9.44 (+8)



(a) • $r_c = R_c // R_L$

$= 10K // 100K = \underline{9.1K}$

• $R_1 // R_2 = 10K // 1.2K = \underline{1.07K}$

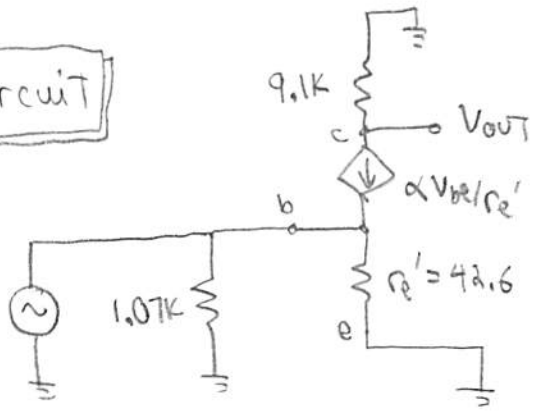
• Stiff divider? $10K // 1.2K = 1.07K$ ✓

$\frac{201}{100} \cdot 1.5K = 3K$

$\rightarrow V_{BB} = 15 \frac{1.2K}{1.2K + 10K} = 1.61V$

$\Rightarrow I_{EQ} = \frac{1.61 - 0.7}{1.5K} = 0.61mA \Rightarrow r_e' = \frac{.026}{.61 \times 10^{-3} A} = \underline{42.6\Omega}$

AC circuit

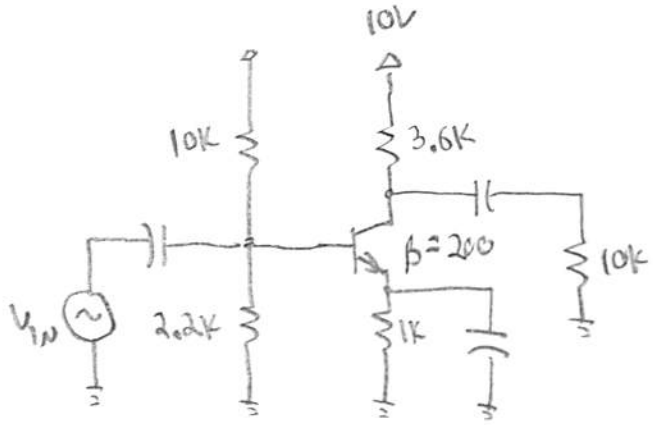


(b) $\frac{V_{OUT}}{V_{IN}} = -\alpha \frac{r_c}{r_e'} = -.995 \frac{9.1K}{.0426K} = \boxed{-212.6}$

(c) $r_c = 10K // 1K = \underline{0.91K}$

$\Rightarrow \frac{V_{OUT}}{V_{IN}} = -.995 \frac{.91K}{.0426K} = \boxed{-21.3}$

10.XX (+8)



(a) Stiff divider?

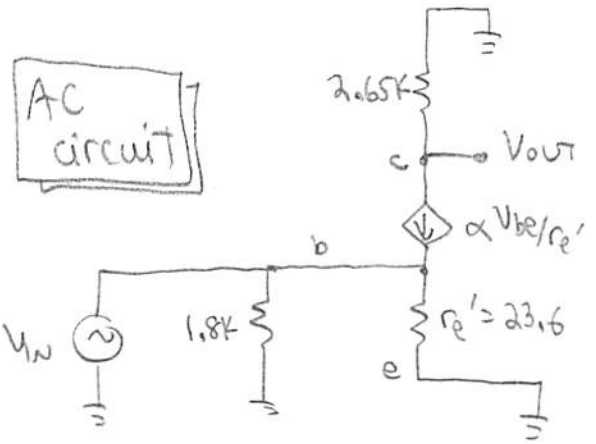
$10K \,//\, 2.2K = 1.8K$

$\frac{101}{100} \cdot 1K = 2.01K$ ✓

$\Rightarrow V_{BB} = 10 \frac{2.2K}{2.2K + 10K} = 1.8V$

$\Rightarrow I_{EQ} = \frac{1.8 - 0.7}{1K} = 1.1mA \Rightarrow r_e' = \frac{.026}{.0011} = \boxed{23.6\Omega}$

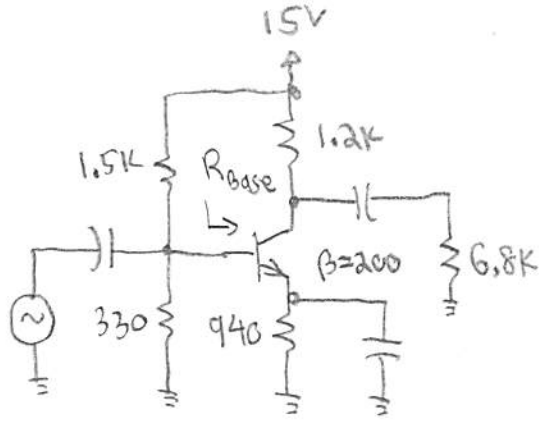
(b) $r_c = 3.6K \,//\, 10K = 2.65K$



(c) $V_{out} = \left(\frac{V_{out}}{V_{in}}\right) \cdot 2mV = \left(-\alpha \frac{r_c}{r_e'}\right) 2mV = \left(-.995 \frac{2.65K}{.0236K}\right) \cdot 2mV$

$= \boxed{-223.5\,mV}$

9.17 (+8)



$R_{Base} = (\beta+1) r_e'$

Stiff divider?

$1.5K \,//\, .33K = 0.27K$

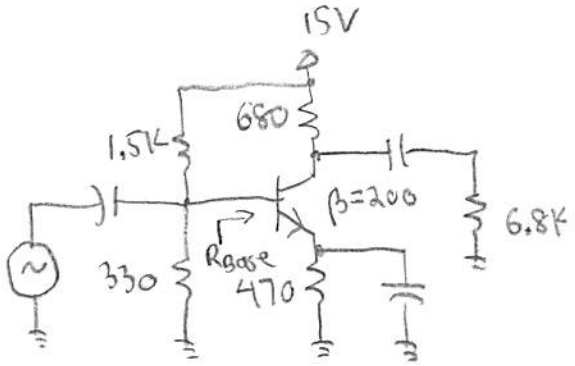
$\frac{201}{100} .94K = 1.89K$ ✓

$\rightarrow V_{BB} = 15 \frac{.33K}{.33K + 1.5K} = 2.7V$

$\Rightarrow I_{EQ} = \frac{2.7 - 0.7}{.94K} = 2.1mA \Rightarrow r_e' = \frac{.026}{.0021A} = \underline{12.4\Omega}$

$R_{Base} = (201)(12.4\Omega) = \boxed{2492\Omega}$

9.18 (+8)



$R_{base} = (\beta+1) r_e'$

Stiff divider?

$1.5K \,//\, .33K = 0.27K$

vs.

$\frac{201}{100} \cdot .47K = 0.94K$ ✓

$\rightarrow V_{BB} = 15 \frac{.33K}{.33K + 1.5K} = 2.7V$

$\Rightarrow I_{EQ} = \frac{2.7 - 0.7}{470} = 4.26 \times 10^{-3} A \Rightarrow r_e' = \frac{.026}{.00426} = \underline{6.1\Omega}$

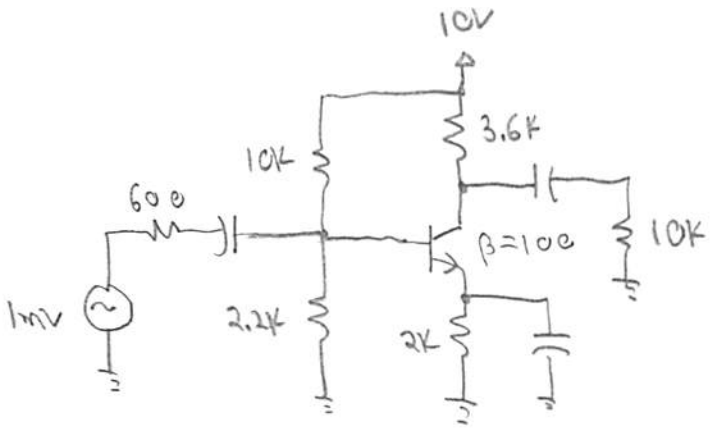
$R_{base} = (201)(6.1) = \boxed{1226\Omega}$

10.5 (+8)

$$\frac{V_{OUT}}{V_S} = \frac{R_{IN}}{R_{IN}+R_S} \qquad \frac{V_{OUT}}{V_{IN}}$$

$R_{IN} = (10K \,//\, 2.2K) \,//\, (\beta+1)r_e'$

$\frac{V_{OUT}}{V_{IN}} = -\alpha \frac{r_c}{r_e'}$



Need to find r_e'!

- Stiff divider? $10K \,//\, 2.2K = 1.8K$ vs. $\frac{101}{100} 2K = 2.02K$ ✓

$$\Rightarrow V_{BB} = 10 \frac{2.2K}{10K+2.2K} = 1.8V$$

$$\Rightarrow I_{EQ} = \frac{1.8-0.7}{2K} = 0.55mA \Rightarrow r_e' = \frac{.026}{.55\times10^{-3}A} = \underline{47.3\Omega}$$

- $r_c = R_C \,//\, R_L = 3.6K \,//\, 10K = 2.65K$

$\alpha = \frac{100}{101} = 0.99$

$$\frac{V_{OUT}}{V_{IN}} = -0.99 \frac{2.65K}{.0473K} = \underline{-55.5}$$

$$R_{IN} = (10K \,//\, 2.2K) \,//\, 101(.0473K) = \underline{1.31K}$$

$$\Rightarrow \frac{V_{OUT}}{V_S} = \frac{1.31K}{1.31K+.6K} \times (-55.5) = -38.1$$

$$V_{OUT} = \left(\frac{V_{OUT}}{V_S}\right) \times V_S = (-38.1)(1mV) = \boxed{-38.1\,mV}$$

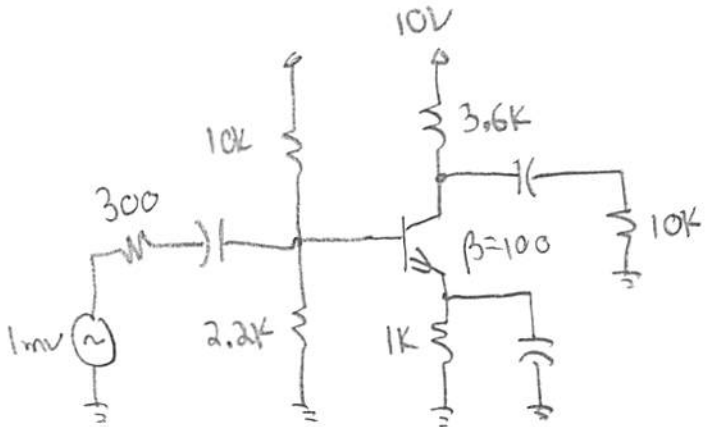
10.6 (+8)

$$V_{OUT} = \left(\frac{V_{OUT}}{V_S}\right) \times V_S$$

$$= \frac{R_{IN}}{R_{IN}+R_S}\left(\frac{V_{OUT}}{V_{IN}}\right) \times V_S$$

$$\uparrow$$

$$-\alpha \frac{r_c}{r_e'}$$



Find r_e'!

- Stiff divider? $10K \,//\, 2.2K = 1.8K$ vs. $\frac{101}{100} \times 1K = 1.01K$ — Oops! Not stiff, but OK to ignore for this problem. (sorry about that...)

$$V_{BB} = 10\,\frac{2.2K}{2.2K+10K} = 1.8V$$

$$\rightarrow I_{EQ} = \frac{1.8V - 0.7}{1K} = \underline{1.1mA} \Rightarrow r_e' = \frac{.026}{1.1\times10^{-3}A} = \underline{23.6\Omega}$$

- $r_c = 3.6K \,//\, 10K = 2.65K$

$$\frac{V_{OUT}}{V_{IN}} = -\alpha\,\frac{r_c}{r_e'} = -0.99\,\frac{2.65K}{.0236K} = \underline{-111.2}$$

$$R_{IN} = (10K \,//\, 2.2K) \,//\, 101(.0236K) = \underline{1.026K}$$

$$\frac{V_{OUT}}{V_S} = \frac{1.026K}{1.026K + .3K}(-111.2) = \underline{-86}$$

$$V_{OUT} = (-86)\times 1mV = \boxed{-86mV}$$