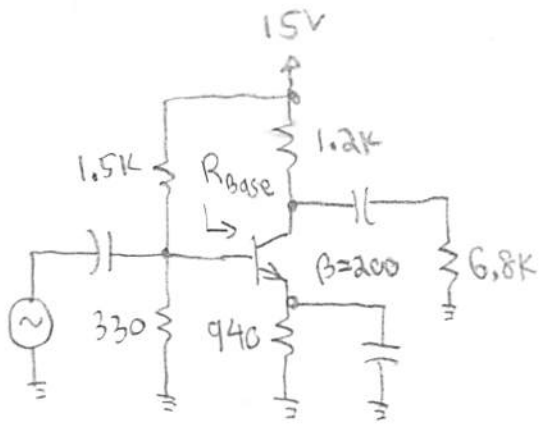
ECE248
HW4 Solns (Total = 100 pts)



8.17 $R_{Base} = (\beta+1) r_e'$

(+8)

Stiff divider?

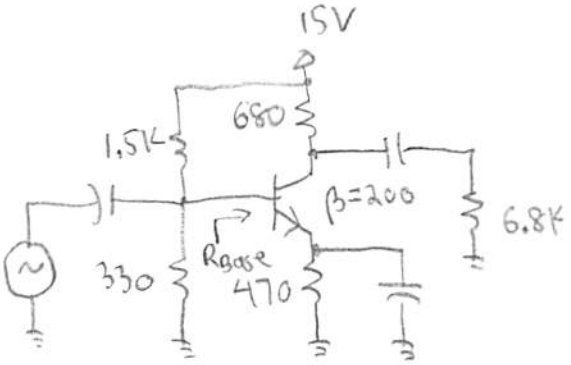
$1.5K \,//\, .33K = 0.27K$
$\frac{201}{100} .94K = 1.89K$ ✓

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

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

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

8.18



(+8) $R_{base} = (\beta+1) r_e'$

Stiff divider?

$1.5K \,//\, .33K = 0.27K$
vs.
$\frac{201}{100} \cdot .47K = 0.94K$ ✓

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

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

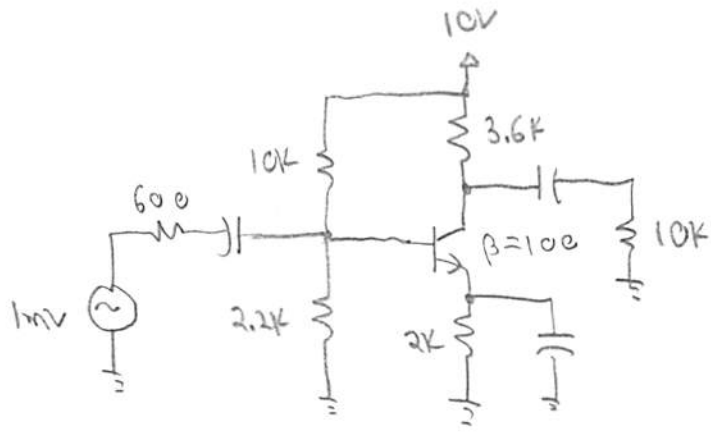
$R_{base} = (201)(6.1) = \boxed{1226\Omega}$

8.27 (+10)

$$\frac{V_{OUT}}{V_S} = \frac{Z_{IN}}{Z_{IN}+R_S}\cdot\frac{V_{OUT}}{V_{IN}}$$

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

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



Need to find r_e'!

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

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

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

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

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

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

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

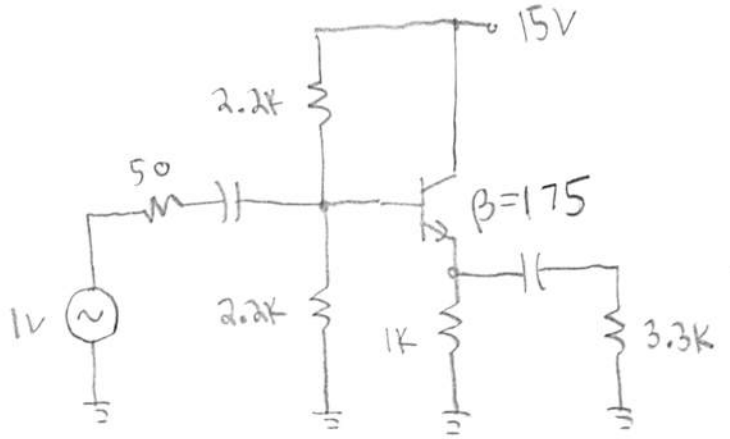
$$\Rightarrow \frac{V_{OUT}}{V_S} = \frac{1.31K}{1.31K+.61K}\times(-55.5) = -38.1$$

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

9.8 (+10)

Emitter follower!

$$\frac{V_{OUT}}{V_S} = \frac{Z_{IN}}{Z_{IN}+R_S} \quad \boxed{\frac{V_{OUT}}{V_{IN}}} \uparrow \frac{r_e}{r_e+r_e'}$$



$r_e = 1000 \,//\, 3300 = \underline{767.4}$

r_e'? Stiff divider? $2.2K \,//\, 2.2K = 1.1K$

$\frac{176}{100} \times 1K = 1.76K$ ✓

$\rightarrow V_{BB} = 15\,\frac{2.2K}{4.4K} = 7.5V$

$I_{EQ} = \frac{7.5-0.7}{1K} = \underline{6.8mA}$

$r_e' = \frac{.026}{6.8\times10^{-3}} = \underline{3.82\Omega}$

$\Rightarrow \frac{V_{OUT}}{V_{IN}} = \frac{767.4}{767.4+3.82} = \underline{0.995}$

$Z_{IN} = \underbrace{(2.2K \,//\, 2.2K)}_{1.1K} \,//\, \underbrace{[176(3.82+767.4)]}_{135.7K} = \underline{1.09K}$

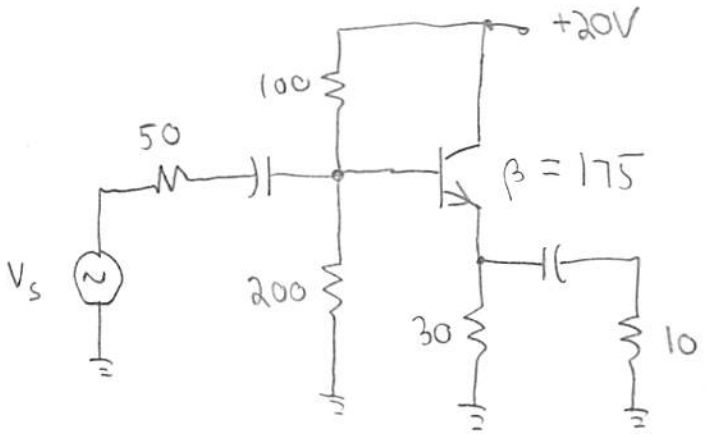
$\Rightarrow \frac{V_{OUT}}{V_S} = \frac{1090}{1090+50} \times .995 = \boxed{0.95}$

9.13 (+12)

$$\frac{V_{OUT}}{V_S} = \frac{Z_{IN}}{Z_{IN}+R_S} \times \frac{r_e}{r_e + r_e'}$$

$r_e = 30 // 10 = \underline{7.5}$

r_e' ?



Stiff divider? $100 // 200 = 67$

$\frac{176}{100}\,30 = 52.8$

NOT stiff, but close enough $\rightarrow V_{BB} = 20\,\frac{200}{300} = \underline{13.33}$

$I_{EQ} = \frac{13.33 - 0.7}{30} = 0.42A$

$r_e' = \frac{.026V}{.42A} = \underline{.062\Omega}$

$Z_{IN} = \underbrace{(100//200)}_{67} // \underbrace{[176(.062+7.5)]}_{1331}$

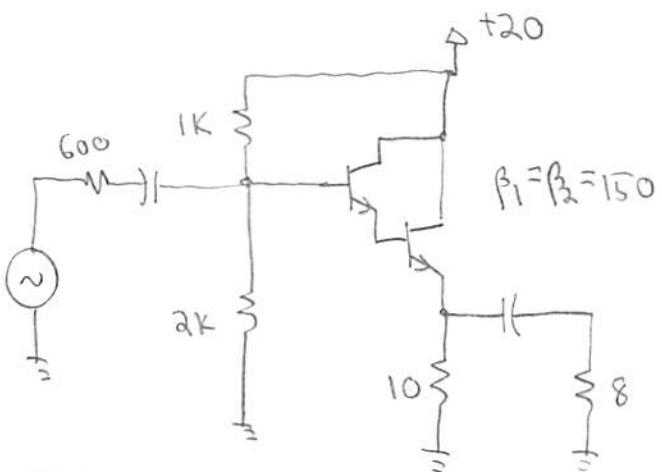
$= \underline{63.8\Omega}$

$\Rightarrow \frac{V_{OUT}}{V_S} = \frac{63.8}{63.8+50} \times \frac{7.5}{7.5+.062} = \boxed{0.556}$

9.X For Darlington.

(+12) $R_{base} = (150 \times 150 + 1)(r_e' + r_e)$

r_e' ? $\quad r_e = 10 // 8 = 4.44$



- Stiff divider? $1K // 2K = 667$

$\frac{(22501)}{100}\,10 = 2250$ ✓

$V_{BB} = 20\,\frac{2K}{3K} = 13.33V$

For Darlington,

$I_{EQ} = \frac{13.33 - 1.4}{10} = 1.19A \Rightarrow r_e' = 2\,\frac{.026}{1.19A}$

$= \underline{.044\Omega}$

$R_{base} = 22501\,(.044 + 4.44)$

$= \boxed{100.4K}$

$\frac{4.44}{4.44 + .044} = 0.99$

$$\frac{V_{OUT}}{V_S} = \frac{Z_{IN}}{Z_{IN} + R_S} \boxed{\frac{r_e}{r_e + r_e'}}$$

$Z_{IN} = (1K // 2K) // R_{base} = 0.663K$

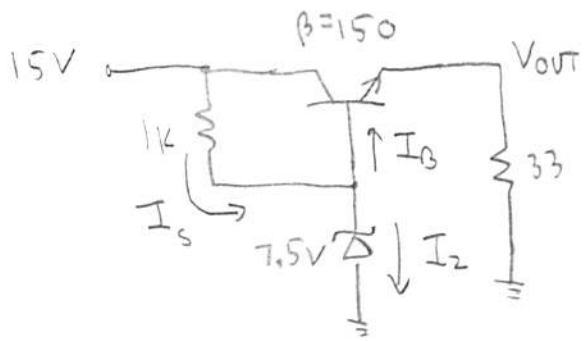
($1K // 2K$ = .667K; R_{base} = 100.4K)

$$= \frac{663}{663 + 600} \times .99 = \boxed{0.52}$$

9.24

(+8) $V_{OUT} = V_Z - 0.7$

$= \boxed{6.8V}$



$I_Z = I_S - I_B$

$= \underbrace{\frac{15 - 7.5}{1K}}_{7.5mA} - \underbrace{\frac{1}{151} \times \frac{6.8V}{.033K}}_{1.36mA}$

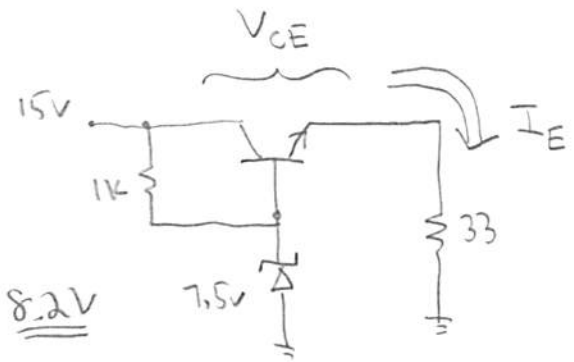
$\alpha = \frac{150}{151} = .993$

$= \boxed{6.14\ mA}$

9.33

(+8) $P = I_B V_{BE} + I_C V_{CE}$

$I_E = \frac{7.5 - 0.7}{33} = 0.21A$



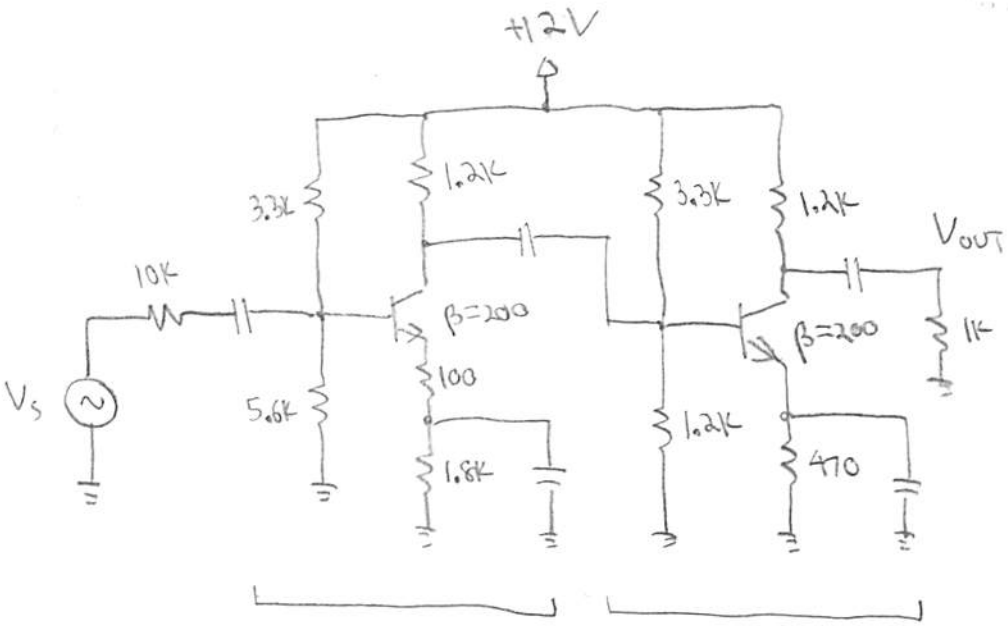
$V_{CE} = V_C - V_E = 15 - (7.5 - 0.7) = 8.2V$

$I_B = \frac{.21A}{151} = .0014A$

$P = (.0014A)(0.7V) + (.21A)(8.2V)$

$= \boxed{1.723W}$

9.4 (+12)



→ start with A_2

- stiff divider?

$3.3K \,//\, 1.2K = 0.88K$

$\frac{201}{100}\, .47K = 0.94K$ ✓

- $V_{BB} = 12\,\frac{1.2K}{1.2K+3.3K} = 3.2V$

$I_{EQ} = \frac{3.2-0.7}{.47K} = 5.32\,mA$

$r_{e2}' = \frac{.026V}{5.32mA} = .0049K$

- $r_c = 1.2K \,//\, 1K = 0.545K$

- $A_2 = -\frac{200}{201}\,\frac{0.545K}{.0049K} = -110.7$

$A_1 = -\alpha\,\frac{R_c // R_{IN2}}{r_{e1}' + R_e}$ $\qquad A_2 = -\alpha\,\frac{R_c // R_L}{r_{e2}'}$

$Z_{IN2} = (3.3K \,//\, 1.2K) \,//\, (201)(.0049K)$

$= 0.465K$

→ Compute A_1

- stiff divider? $3.3K \,//\, 5.6K = 2.08K$

$\frac{201}{100}\, 1.9K = 3.82K$ ✓

- $V_{BB} = 12\,\frac{5.6K}{5.6K+3.3K} = 7.55V \rightarrow I_{EQ} = \frac{7.55-0.7}{1.9K} = 3.61\,mA$

$r_{e1}' = \frac{.026V}{3.61mA} = .0072K$

- $r_c = 1.2K \,//\, 0.465K = 0.335K$

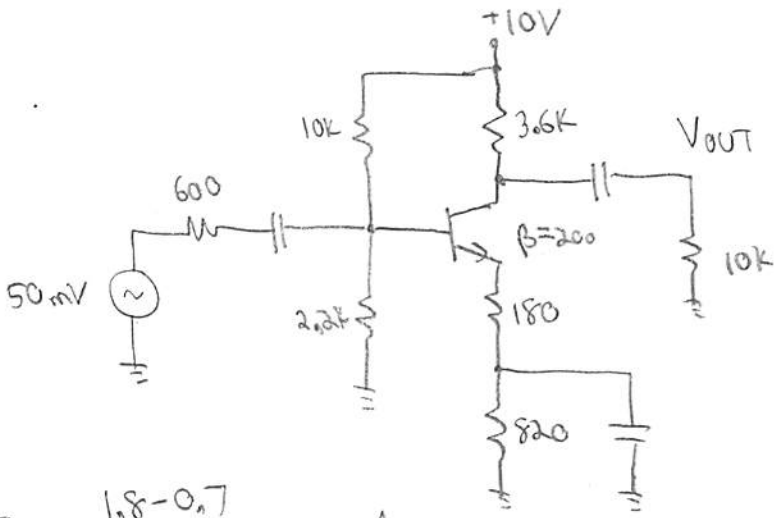
- $A_1 = -\frac{200}{201}\,\frac{0.335K}{.0072K+0.1K} = -3.1$

$Z_{IN} = (3.3K \,//\, 5.6K) \,//\, 201\,(.0072K + .1K)$

$= 1.89K$

$$\Rightarrow \frac{V_{OUT}}{V_S} = \frac{Z_{IN}}{Z_{IN}+R_S} A_1 A_2 = \frac{1.89K}{1.89+10K}(-3.1)(-110.7) = \boxed{54.5}$$

9.2 (+12)



- stiff divider?

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

$\frac{201}{100} \times 1K = 2.01K$ ✓

- $V_{BB} = 10 \frac{2.2K}{2.2K+10K} = 1.8V \Rightarrow I_{EQ} = \frac{1.8-0.7}{1K} = \underline{1.1mA}$

$r_e' = \frac{.026V}{1.1mA} = \underline{.0236K}$

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

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

- $A = -\alpha \frac{r_c}{r_e'+R_e} = -0.995 \frac{2.65K}{(.0236K+.18K)} = \underline{-12.95}$

- $Z_{IN} = (10K \,//\, 2.2K) \,//\, \underbrace{201(.0236K+.18K)}_{40.9K} = \underline{1.73K}$

$$\Rightarrow V_{OUT} = 50mV \frac{1.73K}{1.73K+.6K} \times (-12.95) = \boxed{-481mV}$$