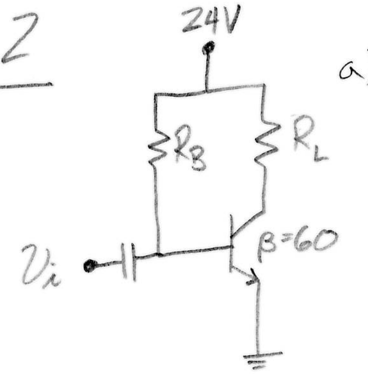
8.2



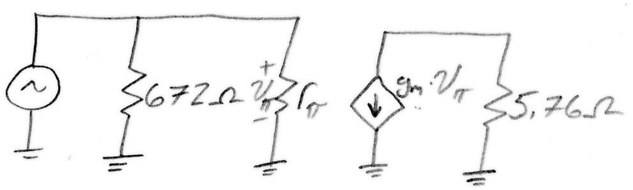
a) $P_{Q,MAX} = 25W$

Max power @ $V_{CE} = 12V \Rightarrow I_C = \frac{25W}{12V} = 2.08A$

$\therefore R_L = \frac{12V}{2.08A} = \underline{5.76\Omega}$

$I_B = \frac{I_C}{60} = \frac{2.08}{60} = 34.7mA \Rightarrow R_B = \frac{23.3V}{34.7mA} = \underline{\underline{672\Omega}}$

b) AC circuit



$r_\pi = \frac{60 \cdot 0.026}{2.08} = \underline{0.750\Omega}$

$g_m = \frac{2.08}{.026} = \underline{80 A/V}$

$V_\pi = V_i = 0.012 \sin \omega_0 t$ $\quad V_o = -g_m \cdot V_i \cdot 5.76 = -461 V_i$

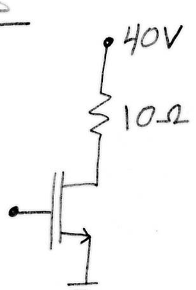
$V_o = -5.53 \sin \omega_0 t = 3.91 V_{RMS}$

$\therefore P_{AC} = \frac{3.91 V_{rms}^2}{5.76\Omega} = 2.66W \leftarrow$ Power dissipated by R_L

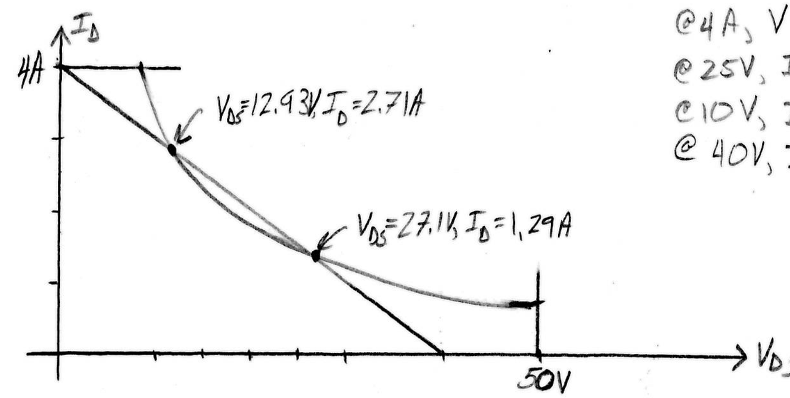
$\therefore P_{TRANSISTOR} = 25W - 2.66W = \underline{\underline{22.3W}}$

$\underline{35W}$
@50V; I=0.7A
@4A, V=8.75
@25V, I=1.4A
@10V, I=3.5A
@40V, I=0.875

8.5



$I_{D,MAX} = 4A$
$V_{DS,MAX} = 50V$
$P_{D,MAX} = 35W$
$K_N = 0.25 A/V^2$
$V_{TN} = 4V$



Load line: $V_{DS} = 40 - 10 I_D$

$I_D = \frac{40 - V_{DS}}{10} = -\frac{1}{10} V_{DS} + 4$

@max power, $V_{DS} = 20V, I_D = 2A$

$P = \underline{40W}$

Max Power Curve: $I_D = \frac{35}{V_{DS}}$

$-\frac{1}{10} V_{DS} + 4 = \frac{35}{V_{DS}} \Rightarrow -V_{DS}^2 + 40 V_{DS} = 350$

$V_{DS} = 12.93, 27.07$

$I_D = 2.71A, 1.29A$

*Anything between $12.93 < V_{DS} < 27.07$ will exceed $\underline{35W}$!

8.5 b) $I_D = 0.25(V_{GG}-4)^2$

$V_{DS} = 40 - 10 I_D$

$P_D = I_D \cdot V_{DS}$

c) @ $V_{GG} = 7V$

$P_D = 39.4W$ which exceeds $P_{D,MAX} = \underline{35W}$

$V_{GG}=5V$: $I_D = 250mA$, $V_{DS} = 37.5V$ $P_D = 9.375W$

$V_{GG}=6V$: $I_D = 1A$, $V_{DS} = 30V$, $P_D = 30W$

$V_{GG}=7V$: $I_D = 2.25A$, $V_{DS} = 17.5V$, $P_D = 39.375W$

$V_{GG}=8V$: $I_D = 4A$, $V_{DS} = 0 \leftarrow$ Not in saturation!

$$I_D = 0.25(2(V_{GG}-4)V_{DS} - V_{DS}^2) = \frac{40-V_{DS}}{10}$$

$$40 - V_{DS} = 2.5(8V_{DS} - V_{DS}^2)$$

$$2.5V_{DS}^2 - 21V_{DS} + 40 = 0$$

$V_{DS} = 2.92V$, $I_D = 3.71A$, $P_D = 10.83W$

$V_{GG} = 9V \leftarrow$ also in triode

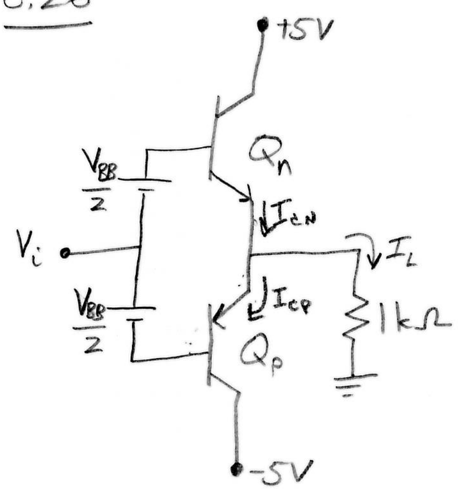
$$I_D = 0.25(2(9-4)V_{DS} - V_{DS}^2) = \frac{40-V_{DS}}{10}$$

$$40 - V_{DS} = 2.5(10V_{DS} - V_{DS}^2)$$

$$2.5V_{DS}^2 - 26V_{DS} + 40 = 0$$

$V_{DS} = 1.88V$, $I_D = 3.81A$, $P_D = 7.17W$

8.26



$I_S = 2\times10^{-15}A$

a) $I_{CnQ} = I_{CpQ} = 1mA \Rightarrow 1mA = 2\times10^{-15}e^{V_{BE}/.026}$

$V_{BE} = 0.7V \Rightarrow V_{BB} = 1.4V$

$P_Q = 1mA \cdot 5V = \underline{5mW}$

b) Assuming $I_C = I_E$, we have four equations:

① $I_{CN} = I_L + I_{CP}$

② $V_{EBP} = V_T \ln(I_{CP}/I_S)$

③ $V_{BEN} = V_T \ln(I_{CN}/I_S)$

④ $V_{EBP} + V_{BEN} = V_{BB}$

We have 4 equations & 4 unknowns (I_{CN}, I_{CP}, V_{EBP} & V_{BEN}), with a mix of linear and exponential relationships - we must iterate through 4 equations!

We can start with assuming Q_N is off & Q_P is on, and $I_L = -3.5mA$

① $I_{CN} = 0 \Rightarrow I_{CP} = I_L = 3.5mA$

② $V_{EBP} = .026 \ln(3.5mA/2fA) = 733mV$

④ $V_{BEN} = 1.4 - V_{EBP} = 1.4 - 0.733 = 667\,mV$

③ $I_{CN} = 2fA\,e^{(0.667/.026)} = 277\,\mu A$

2^{ND} Iteration

① $I_{CP} = 277\,\mu A - (-3.5\,mA) = 3.78\,mA$

② $V_{EBP} = .026 \ln\left(3.78\,mA / 2fA\right) = 735\,mV$

④ $V_{BEN} = 1.4 - 0.735 = 665\,mV$

③ $I_{CN} = 2fA\,e^{(0.665/.026)} = 257\,\mu A$

3^{rd} Iteration

① $I_{CP} = 3.76\,mA$

② $V_{EBP} = 735\,mV$

④ $V_{BEN} = 665\,mV$

③ $I_{CN} = 258\,\mu A$

4^{th} Iteration

① $I_{CP} = \underline{3.76\,mA}$

② $V_{EBP} = \underline{735\,mV}$

④ $V_{BEN} = \underline{665\,mV}$

③ $I_{CN} = \underline{258\,\mu A}$

$V_i = -3.5V + V_{BEN} - V_{BB}/2 = -3.5 + 0.665 - 0.7 = -3.535V$, or

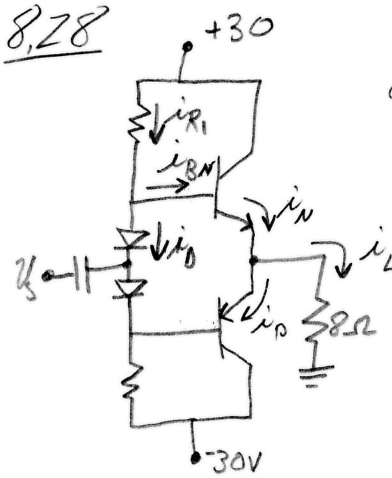
$V_i = -3.5V - V_{EBP} + V_{BB}/2 = -3.5 - 0.735 + 0.7 = -3.535V$

c) $P_{Q_N} = (5+3.5)(258\,\mu A) = \underline{2.19\,mW}$

$P_{Q_P} = (-3.5+5)(3.76\,mA) = \underline{5.64\,mW}$

$P_L = (3.5)(3.5\,mA) = \underline{12.25\,mW}$

8.28



a) $i_L = \dfrac{24V}{8\Omega} = 3A$

$i_N \approx i_L = 3A \Rightarrow i_{BN} = \dfrac{3A}{41} = 73.2\,mA$

for $i_D = 25mA$, $i_{R_1} = 25mA + 73.2\,mA = 98.2\,mA$

Need V_{R_1}: $V_{R_1} = 30 - (24 + V_{BEN})$

$V_{BEN} = .026 \ln\left(\dfrac{3A}{6pA}\right) = 700\,mV \Rightarrow V_{R_1} = 5.3V$

$\therefore R_1 = \dfrac{5.3V}{98.2\,mA} = \underline{54\Omega}$

With $i_D = 25\,mA$ $V_D = 0.026 \ln\left(\dfrac{25\,mA}{6pA}\right) = 576\,mV$

$\therefore V_{EBP} = 2(576\,mV) - 700\,mV = \underline{451.8\,mV}$

$i_P = 6pA\,e^{(452/26)} = \underline{211\,\mu A}$

*Technically we could correct i_N, but this is so small it won't matter.

8.28 b) With $V_O = 0$, $i_N = i_P$ & $V_{EBP} = V_{BEN} = V_D$

$$I_D = I_{R1} - I_{BN} \quad \& \; I_{R1} = \frac{30 - V_{BEN}}{R1}, \quad I_{BN} = \frac{I_S}{\beta+1} e^{V_{BEN}/V_T}$$

$$\therefore I_D = \frac{30 - V_{BEN}}{54} - \frac{6pA}{41} e^{V_{BEN}/.026}$$

We need another equation relating I_D & V_{BEN}

$$\left.\begin{array}{l} V_{BEN} + V_{EBP} = 2V_D \\ V_D = V_T \ln\left(I_D/I_S\right) \end{array}\right\} \begin{array}{l} 2V_{BEN} = 2V_T \ln\left(I_D/6pA\right) \\ \underline{V_{BEN} = V_T \ln\left(I_D/6pA\right)} \end{array}$$

We now iterate to find I_D & V_{BEN}

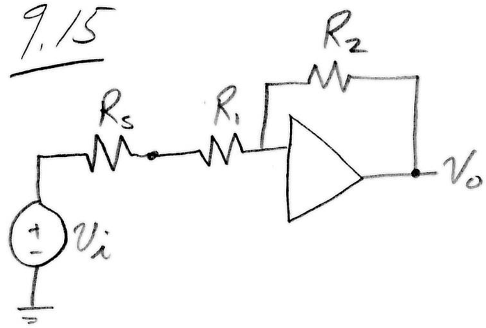
Guess $V_{BEN} = 0.6V$

$$I_D = \frac{30-0.6}{54} - \frac{6p}{41} e^{.6/.026} = 542.9mA$$

$$V_{BEN} = .026 \ln\left(542.9 \times 10^{-3} / 6 \times 10^{-12}\right) = 656mV$$

2ND Iteration	3rd Iteration
$I_D = 530.2mA$	$I_D = \underline{530.5mA} = I_N = I_P$
$V_{BEN} = 655mV$	$V_{BEN} = \underline{655mV} = V_{EBP} = V_D$

9.15



a) $v_o = \frac{-R_2}{R_1+R_s} = 30 \pm 2.5\%$

2.5% of $30 = 0.75 \Rightarrow 29.25 < A_v < 30.75$

Max gain with $R_s = 1k\Omega$, min w/ $R_s = 2k$

$30.75 = \frac{R_2}{1k+R_1}$; $29.25 = \frac{R_2}{2k+R_1}$

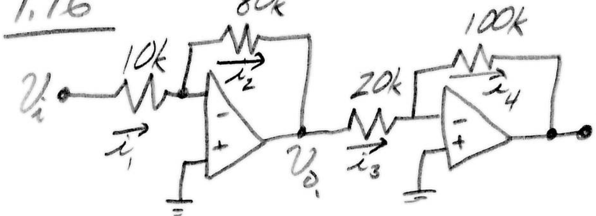
$\frac{30.75}{29.25} = \frac{2k+R_1}{1k+R_1} \Rightarrow \underline{R_1 = 18.5k\Omega}$

$R_2 = 30.75(1+18.5)$
$= \underline{599.6k\Omega}$

b) for $v_i = 25mV$

$\underline{731.25 < -v_o < 768.75mV}$

9.16



$A_{v_1} = -\frac{80}{10} = -8 \Rightarrow v_{o_1} = (-0.15)(8) = \underline{-1.2V}$

$A_{v_2} = \frac{-100}{20} = -5 \Rightarrow v_o = (1.2)(-5) = \underline{-6V}$

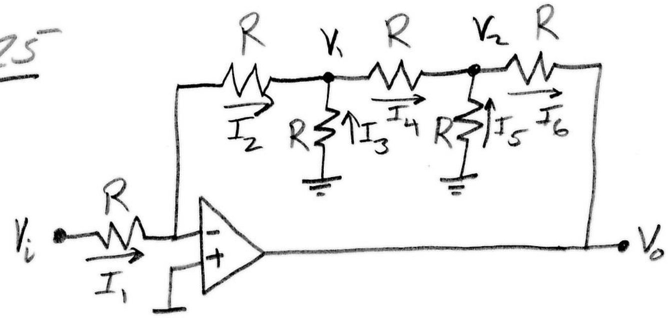
$i_1 = \frac{-0.15}{10k} = \underline{-15\mu A} = i_2$

$i_3 = \frac{1.2}{20k} = \underline{60\mu A} = i_4$

$i_{o_1} = i_3 - i_2 = 60\mu A - (-15\mu A) = \underline{75\mu A}$

$i_{o_2} = -i_4 = \underline{-60\mu A}$

9.25



$\underline{A_v = -8}$

For figure 9.12, $\underline{A_v = -3}$

$I_1 = \frac{v_i}{R}$ $\quad I_2 = I_1$

$V_1 = -I_2 \cdot R = I_1 \cdot R = -v_i$

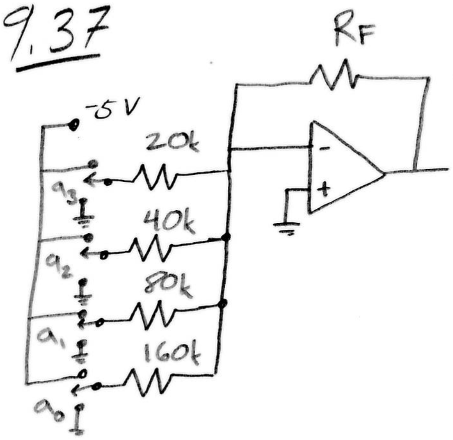
$I_3 = \frac{v_i}{R} = I_1 \Rightarrow I_4 = I_2 + I_3 = 2I_1$

$V_2 = V_1 - I_4 \cdot R = -v_i - 2I_1R = -3v_i$

$I_5 = \frac{3v_i}{R} = 3I_1 \Rightarrow I_6 = I_4 + I_5 = 5I_1$

$V_o = V_2 - I_6R = -3v_i - 5I_1R = -8v_i$

9.37



a) For a summing amplifier, the gain of an input x is given by $-R_F/R_x$

For a_3: $V_o' = (+5)\cdot\frac{+R_F}{20k}$ $\quad$ a_1: $V_o''' = (+5)\cdot\frac{+R_F}{80k}$

a_2: $V_o'' = (+5)\cdot\frac{+R_F}{40k}$ $\quad$ a_0: $V_o'''' = (+5)\cdot\frac{+R_F}{160k}$

$$V_o = 5\left(\frac{a_3\cdot R_F}{20} + \frac{a_2 R_F}{40} + \frac{a_1 R_F}{80} + \frac{a_0 R_F}{160}\right)$$

$$V_o = \frac{5}{10}\cdot R_F\left(\frac{a_3}{2} + \frac{a_2}{4} + \frac{a_1}{8} + \frac{a_0}{16}\right)$$

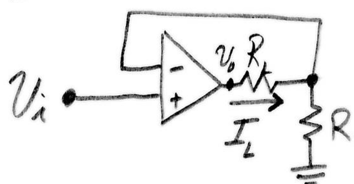
b) $2.5 = \frac{5}{10}\cdot R_F\left(\frac{1}{2}\right)$

$R_F = \underline{10k\,\Omega}$

c) i) $V_o = 5\left(\frac{1}{16}\right) = \underline{0.3125V}$

ii) $V_o = 5\left(\frac{1}{2}+\frac{1}{4}+\frac{1}{8}+\frac{1}{16}\right) = \underline{4.688V}$

9.52



a) $I_{R_1} = \frac{V_i}{R_1}$

$I_L = I_{R_1} = \frac{V_i}{R_1}$

b) $V_{R_L} = I_L\cdot R_L = \frac{V_i}{R_1}\cdot R_L = \frac{R_L}{R_1}\cdot V_i$

$V_o = V_i + V_{R_L} = V_i + \frac{R_L}{R_1}\cdot V_i = \left(1+\frac{R_L}{R_1}\right)V_i$

for $R_L = 1k$ & $R_1 = 9k$

$V_{o,max} = 10V \Rightarrow 10 = \left(1+\frac{1}{9}\right)V_i \Rightarrow V_{i,max} = \underline{9V}$

$I_{L,max} = \frac{9V}{9k\Omega} = \underline{1mA}$