1. Assume the transistors at the right have a finite $\beta$ and an infinite Early voltage. Write an expression for the input resistance $R_{in}$ in the circuit shown below. Your expression should include only real resistances ($R_1$, $R_2$, $R_3$, $R_4$, or a subset of these) and possibly $\beta$, $r_{e1}$ or $r_{e2}$, and $r_{e2}$ or $r_{e1}$. (Assume all transistors have the same $\beta$.) Circle your answer.

$$R_{in} = \frac{r_{in}}{\beta_n + r_{on}}$$

2. The transistors below are identical, use $V_{BE}=0.7$, $\beta=100$, $g_m=80m$ A/V, $r_n=1250\Omega$, $C_1=C_2=100\mu F$.

(a) Find the complete frequency response for $V_o/V_{sig}$, ignore $r_o$ and the parasitic capacitors.

(b) Find the low frequency pole values.

$$V_o = \frac{g_m2V_{IT1}}{(2k\|r_{IT1})+100}$$

$$V_{IT1} = \frac{V_{sig}(22k\|r_{IT1})}{V_{sig}}$$

$$\frac{V_o}{V_{sig}} = \frac{6420}{(s+808)(s+368)}$$
3. Use the following circuit for both problems #3 and #4: \( \beta = 100, |V_{BE}| = 0.7 \) Find \( V_{E1}, V_{C1}, V_{C2}, V_{E2}, V_{E3}, V_{C3}, I_{E1}, I_{E2}, \) and \( I_{E3}. \)

4. Analyze the circuit to find the midband gain \( \frac{V_o}{V_{sig}}, \) \( R_{in}\) (ignore input source, \( V_{sig}\)), and \( R_{out}\) (ignore \( RL = 1k\)).

\[
I_{B2} = \frac{I_{E2}}{(\beta + 1)} = 19.6uA \\
I_{E2} = -0.7 + (1.98m)(5.1k) = 1.98m \\
I_{E2} = \frac{1.98m}{(4.7k)} + 0.4V
\]

\[
I_{C1} = \alpha I_{E1} = 1.98m \left( \frac{1.9k}{\beta + 1} \right) = 0.6
\]

\[
I_{E2} = 0.7 + I_{E2} \left( \frac{1.98m}{(4.7k)} + 5.1k \right) = 1.98m
\]

\[
I_{C1} = \frac{I_{E1}}{(\beta + 1)} = 0.6
\]

\[
V_{C1} = 1.96V = V_{RB2}
\]

\[
I_{2} = I_{C2} - I_{E3} = 1.96m - 3\mu = 1.92m
\]

\[
I_{C2} = \frac{I_{E3}}{(\beta + 1)} = 1.92m
\]

\[
V_{E3} = +\frac{I_{E3}}{(1.3k)} - 10 = -4.93V
\]

\[
V_{C3} = \frac{\alpha I_{E3}}{3k} + 1.3k = 2.28V
\]

\[
10 - I_{C3} = V_{C3} = 2.28V
\]

Check: \( Q1: 0.196 > 0 > -0.9V \) \\
\( Q2: -4.2 < 0.196 < 0.9V \)

\[ Q3: 
2 \leq 4.2 \leq 4.93 \]
5. The input and output curves vs time are are shown below. Explain in detail why this circuit is not amplifying the signal and is instead 0V. $V_{CE,SAT}=0.2V$, $V_{BE}=0.7V$, and $\beta=100$.

![Diagram](image)

$4V - I_B(1k) - 0.7 = 0$

$I_B = \frac{4-0.7}{1k} = 3.3mA$

$V_B = 4V - 3.3V = 0.7V$

$V_c = 10 - 1k(I_c) = 10 - 1k(\beta I_B) = 10 - 1k(33)$

$=> V_c = 10 - 330V$ : Not possible.

Is it cutoff? No -> $V_{BE} > 0.7$ since input = 4V

- must be saturated $=>$

$I_c = \frac{10-0.2}{1k} = 9.8mA$

$V_c = 0.2V$, $< V_B = 0.7$, $> V_E = 0$

$\beta_{sat} \Rightarrow$

$\beta_{forward} = \frac{I_c}{I_B} = \frac{9.8mA}{3.3mA} \approx 3 < \beta_{forward}=100$

Can not amplify when in saturation operation!
6. $\beta$ can range from 40 to 200. For the two extreme values of $\beta(\beta=40$ and $\beta=200)$ find $I_E$, $V_E$, $V_B$, Rin (ignore the source resistance 10k), and the midband voltage gain $\text{Vout}/V_{\text{sig}}$.

\begin{align*}
\beta = 40: \\
&I_E = 2.41 \text{mA} \\
&V_E = 1K(I_E) = 2.41 \text{V} \\
&V_B = V_E + 0.7 = 3.11 \text{V} \\
\beta = 200: \\
&I_E = 5.54 \text{mA} \\
&V_E = 5.54 \text{V} \\
&V_B = 6.24 \text{V}
\end{align*}

\begin{align*}
\text{Voltage at } \text{a when circuit is disconnected or open:} \\
&V_{\text{th}} = \frac{V_{\text{sig}}(100k)}{10k} \text{ (VT has no current through it)} \\
R_{\text{th}} &= R_T + 100k || 10k
\end{align*}

\begin{align*}
\beta = 40: \\
R_T = \frac{\text{Vout}}{\text{Vsig}} = \frac{25m(41)}{500(41)} = 2.425 \Omega \\
9m = \beta r_T = 0.094 \\
R_{\text{in}} &= \frac{100k}{10k} = 10k \\
R_{\text{in}} &= \frac{0.91(500)(41)}{500(41) + 425 + 100k || 10k} = 0.622 \frac{V}{V} \\
\text{Vout} &= \frac{0.91(500)(41)}{500(41) + 9.07 + 9.07} = 0.83 \frac{V}{V}
\end{align*}