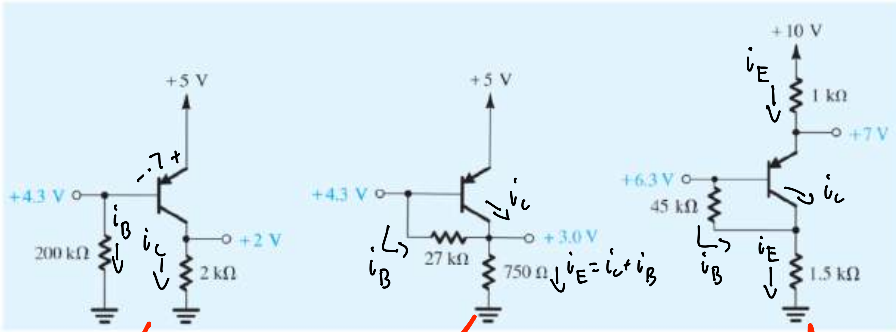
1. Measurements on the circuits below produce labeled voltages as indicated. Find the value of β for each transistor.



$i_B = \frac{i_C}{\beta}$

$\beta = \frac{i_C}{i_B} = \frac{\left(\frac{2}{2K}\right)}{\left(\frac{4.3}{200K}\right)}$

$\boxed{\beta = 46.512}$

$i_B = \frac{i_E}{\beta+1}$

$\beta = \frac{i_E}{i_B} - 1$

$\beta = \frac{\left(\frac{3}{750}\right)}{\left(\frac{4.3-3}{27K}\right)} - 1$

$\boxed{\beta = 82.08}$

$i_E = \frac{10-7}{1K} = 3mA$

$6.3 = i_B 45K + i_E 1.5K$

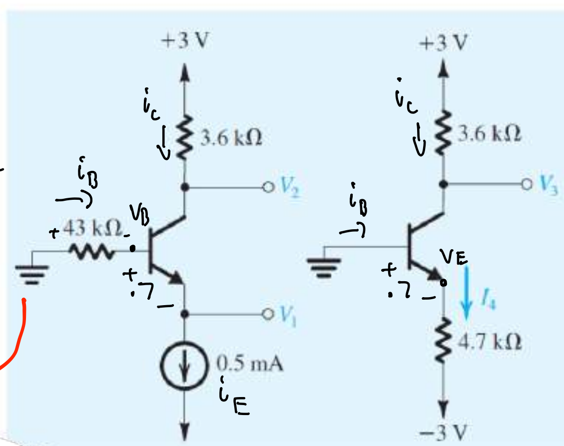
$\frac{6.3 - i_E 1.5K}{45K} = i_B$

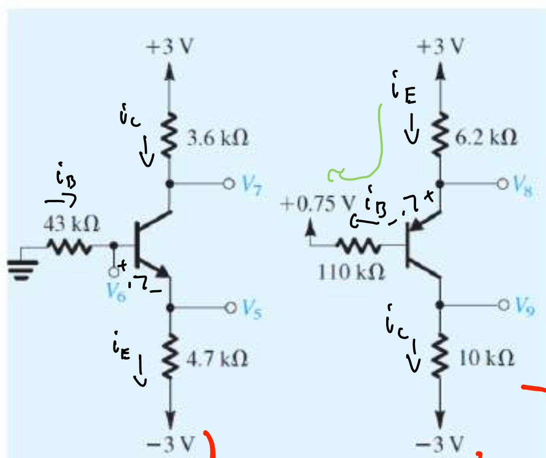
$i_B = .04 mA$

$i_C = i_E - i_B$
$= 3 - .04$
$i_C = 2.96 \ mA$

$\boxed{\beta = \frac{i_C}{i_B} = \frac{2.96}{.04} = 74}$

2. For the circuits in below, find values for the labeled node voltages and branch currents. Assume β=100 to be very high.





$i_B = \frac{i_E}{\beta+1} = \frac{.5mA}{100+1}$

$i_B \approx 4.95 \ \mu A$

$i_C = \beta i_B \approx .495 mA$

$\frac{3-V_2}{3.6K} = i_C$

$3 - i_C 3.6K = V_2$

$\boxed{V_2 \approx 1.218 [V]}$

$V_B = -i_B 43K$

$V_B = -0.213$

$\boxed{V_1 = V_B - .7 \approx -.913 [V]}$

$V_E = -0.7$

$\boxed{I_4 = \frac{-.7-(-3)}{4.7K} = .489mA}$

$i_B = \frac{I_4}{\beta+1} = 4.85 \mu A$

$i_C = \beta i_B = .485 \ mA$

$3 - V_3 = i_C 3.6K$

$V_3 = 3 - (.485m)(3.6K)$

$\boxed{V_3 \approx 1.26V}$

$0 - (-3) = i_B 43K + .7 + i_E(4.7K)$

$3 - .7 = i_B(43K + (\beta+1)(4.7K))$

$i_B = \frac{2.3}{(43K + (\beta+1)(4.7K))}$

$i_B \approx 4.44 \mu A$

$i_C = \beta i_B \approx 0.444 \ mA$

$0 - V_6 = i_B 43K$

$\boxed{V_6 = -0.191 [V]}$

$V_6 - .7 = V_5$

$\boxed{V_5 = -0.891 [V]}$

$3 - V_7 = i_C 3.6k$

$V_7 = 3 - i_C 3.6k$

$\boxed{V_7 \approx 1.4 [V]}$

$3 - .75 = i_E 6.2K + .7 + i_B 110K$

$2.25 - .7 = i_B(110K + (\beta+1)6.2K)$

$i_B = \frac{1.55}{(110K + (\beta+1)6.2K)}$

$i_B \approx 2.11 \mu A$

$i_E = (\beta+1) i_B = 0.213 \ mA$

$3 - V_8 = i_E 6.2K \Rightarrow 3 - i_E 6.2K$

$\boxed{V_8 \approx 1.682 [V]}$

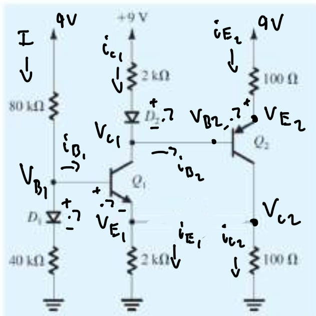
$i_C = \beta i_B = .211 mA$

$V_9 - (-3) = i_C 10K$

$\boxed{V_9 = i_C 10K - 3 \approx -0.895 [V]}$

3. Consider the circuit shown in figure below. Using $|V_{BE}|$ and V_D= 0.7 V independent of current, and β=∞, find the voltages V_{B1}, V_{E1}, V_{C1}, V_{B2}, V_{E2}, and V_{C2}, initially with R open-circuited and then with R connected. Repeat for β=100, with R open-circuited initially, then connected.

$\beta = \infty$



$\frac{9-.7}{120k} = I \approx 69.2\mu A$

$9 - V_{B_1} = I\, 80k$

$V_{B_1} = 9 - 80k \cdot I$

$\boxed{V_{B_1} \approx 3.467\ [V]}$

$\boxed{V_{E_1} = V_{B_1} - .7 \approx 2.767[V]}$

$i_B = \frac{i_C}{\beta} = \frac{i_C}{\infty} = 0 \Rightarrow i_{C_1} = i_{E_1} \Rightarrow i_{E_2} = i_{C_2}$

$V_{E_1} = i_{E_1} 2K$

$i_{E_1} = \frac{V_{E_1}}{2K} \Rightarrow i_{E_1} = i_{C_1} = 1.38\,mA$

$9 - .7 - V_{C_1} = i_{C_1} 2k$

$8.3 - i_{C_1} 2K = V_{C_1}$

$\boxed{V_{C_1} \approx 5.533\ [V] = V_{B_2}}$

$V_{E_2} - .7 = V_{B2}$

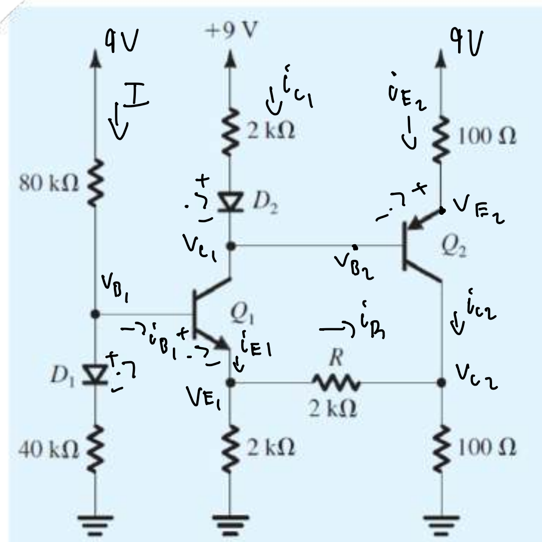
$\boxed{V_{E_2} = V_{B2} + .7 = 6.23\ [V]}$

$i_{E_2} = \frac{9 - V_{E_2}}{100} = 27.67\,mA = i_{C2}$

$V_{C2} = i_{C2} 100$

$\boxed{V_{C2} = 2.767\ [V]}$

$\beta = \infty$



$V_{E_1} = 2.767[V]$

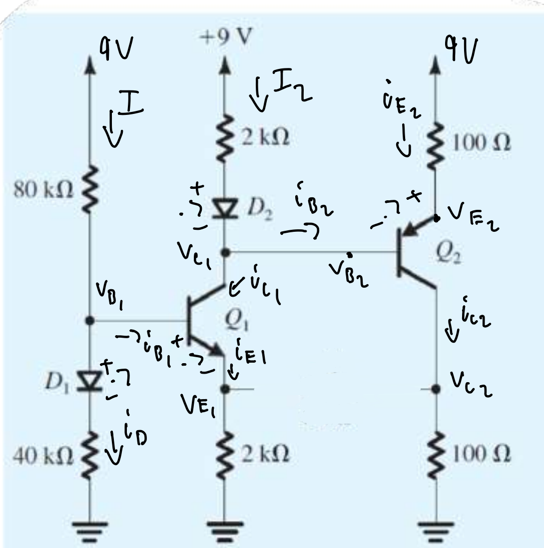
$V_{C2} = 2.767[V]$

$i_R = \frac{V_{E_1} - V_{C2}}{R}$

$i_R = 0$

$\boxed{\text{Voltages same whether R is connected or not } (\beta \to \infty)}$

$\beta = 100$



$\boxed{V_{E_2} = V_{B2} + .7 = 5.982\ [V]}$

$i_{E_2} = \frac{9 - V_{E_2}}{100} = 30.18\,mA$

$i_{C_2} = \frac{\beta}{\beta+1} i_{E_2} = 29.88\,mA$

$\boxed{V_{C2} = i_{C2} \cdot 100 = 2.98\ [V]}$

$\boxed{V_{E_1} = 2K(i_{B_1}(101)) = 2.444\ [V]}$

KCL @ V_{B_1}: $I = i_{B_1} + i_D$

$\frac{9 - V_{B_1}}{80K} = \frac{V_{B_1} - .7}{2K(101)} + \frac{V_{B_1} - .7}{40K}$

$\frac{9}{80K} + \frac{.7}{2K(101)} + \frac{.7}{40K} = V_{B_1}\left(\frac{1}{80K} + \frac{1}{2K(101)} + \frac{1}{40K}\right)$

$V_{B_1} = \left(\frac{9}{80K} + \frac{.7}{2K(101)} + \frac{.7}{40K}\right)\left(\frac{1}{80K} + \frac{1}{2K(101)} + \frac{1}{40K}\right)^{-1}$

$\boxed{V_{B_1} = 3.144}$

$i_{E_1} = i_B(\beta+1) = \frac{V_{E_1}}{2k} = \frac{V_{B_1} - .7}{2K}$

$i_{B_1} = \frac{V_{B_1} - .7}{2K(101)} = 12.1\mu A \Rightarrow i_{C_1} = 1.21\,mA$

KCL @ V_{C_1}: $I_2 = i_{C_1} + i_{B2}$ $\quad i_{B2} = \frac{i_{E_2}}{\beta+1} = \frac{9 - .7 - V_{C_1}}{100\,(101)}$

$\frac{9 - .7 - V_{C_1}}{2K} = i_{C_1} + i_{B2}$

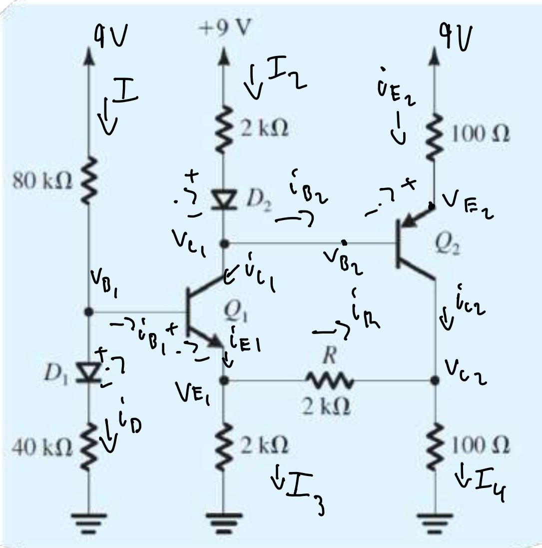
$i_{C_1} = \frac{8.3 - V_{C_1}}{2K} - \frac{8.3 - V_{C_1}}{100(101)}$

$i_{C_1} - \frac{8.3}{2K} + \frac{8.3}{100(101)} = V_{C_1}\left(-\frac{1}{2K} + \frac{1}{100(101)}\right) \Rightarrow$

$V_{C_1} = \left(1.21m - \frac{8.3}{2K} + \frac{8.3}{100(101)}\right)\left(-\frac{1}{2K} + \frac{1}{100(101)}\right)^{-1}$

$\boxed{V_{C_1} = 5.282\ [V] = V_{B_2}}$

$\beta = 100$



KCL @ V_{C_1}: $\dfrac{9-.7-V_{C_1}}{2K} = i_{C_1} + i_{B_2}$

$i_{C_1} = \dfrac{\beta}{\beta+1} i_{E_1} = \dfrac{100}{101}\left(\dfrac{V_{B_1}-.7}{2K} + \dfrac{(V_{B_1}-.7)-V_{C_2}}{2K}\right)$

$i_{B_2} = \dfrac{i_{E_2}}{\beta+1} = \dfrac{9-.7-V_{C_1}}{100\,(101)}$

$$\frac{V_{C_1}-8.3}{2K} + \frac{100}{101}\left(\frac{V_{B_1}-.7}{2K} + \frac{(V_{B_1}-.7)-V_{C_2}}{2K}\right) + \frac{8.3-V_{C_1}}{100\,(101)} = 0$$

$$V_{C_1}\left(\frac{1}{2K} - \frac{1}{100(101)}\right) + V_{B_1}\left(\frac{100}{2K(101)} + \frac{100}{2K(101)}\right) - V_{C_2}\left(\frac{100}{2K(101)}\right) = \frac{1.4\cdot 100}{2K(101)} - \frac{8.3}{100(101)} + \frac{8.3}{2K}$$

$$V_{C_1}(400.99\mu) + V_{B_1}(990.099\mu) - V_{C_2}(495.05\mu) = 4m$$

KCL V_{C_2}: $\dfrac{V_{C_2}}{100} = \dfrac{V_{E_1}-V_{C_2}}{2K} + i_{C_2}$

$i_{C_2} = \dfrac{\beta}{\beta+1} i_{E_2} = \dfrac{8.3-V_{C_1}}{101}$

$$\frac{V_{C_2}}{100} + \frac{V_{C_2}-(V_{B_1}-.7)}{2K} + \frac{V_{C_1}-8.3}{101} = 0$$

$$V_{C_2}\left(\frac{1}{100} + \frac{1}{2K}\right) - V_{B_1}\left(\frac{1}{2K}\right) + V_{C_1}\left(\frac{1}{101}\right) = \frac{8.3}{101} - \frac{.7}{2K}$$

$$-.5m V_{B_1} + 9.9m V_{C_1} + 10.5m V_{C_2} = 81.8m$$

KCL @ V_{B_1}: $\dfrac{9-V_{B1}}{80K} = \dfrac{V_{B_1}-.7}{40K} + i_B$

$$i_{B_1} = \frac{i_{E_1}}{\beta+1} = \Bigg(\underbrace{\frac{V_{E1}}{2K}}_{I_3} + \underbrace{\frac{V_{E_1}-V_{C_2}}{2K}}_{i_R}\Bigg)\frac{1}{\beta+1} = \frac{1}{101}\left(\frac{V_{B_1}-.7}{2K} + \frac{(V_{B_1}-.7)-V_{C_2}}{2K}\right)$$

$$\frac{V_{B_1}-9}{80K} + \frac{V_{B_1}-.7}{40K} + \frac{1}{101}\left[\frac{V_{B_1}-.7}{2K} + \frac{V_{B_1}-.7-V_{C_2}}{2K}\right] = 0$$

$$V_{B_1}\left(\frac{1}{80K} + \frac{1}{40K} + \frac{1}{2K(101)} + \frac{1}{2K(101)}\right) - V_{C_2}\left(\frac{1}{2K(101)}\right) = \frac{9}{80K} + \frac{.7}{40K} + \frac{.7}{2K(101)} + \frac{.7}{2K(101)}$$

$$V_{B_1}(47.401\mu) - V_{C_2}(4.95\mu) = 136.931\mu$$

$$\begin{bmatrix} 47.401\mu & 0 & -4.95\mu \\ 990.099\mu & 400.99\mu & -495.05\mu \\ -.5m & 9.9m & 10.5m \end{bmatrix}^{-1} \begin{bmatrix} 136.931\mu \\ 4m \\ 81.8m \end{bmatrix} = \begin{bmatrix} V_{B_1} \\ V_{C_1} \\ V_{C_2} \end{bmatrix} \Rightarrow$$

$V_{E_1} = V_{B_1} - .7 \approx 2.47$ [V]

$V_{B_1} \approx 3.17$ [V]

$V_{C_1} \approx 5.55$ [V] $= V_{B_2}$

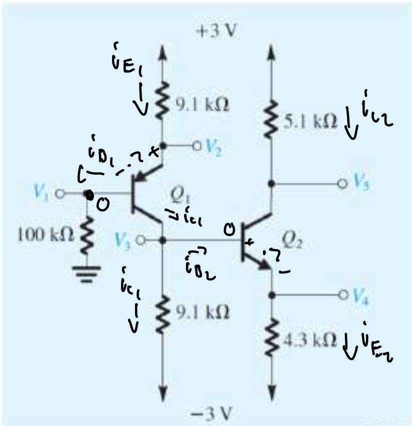
$V_{C_2} \approx 2.71$ [V]

$V_{E_2} = V_{B_2} + .7 = 6.25$ [V]

4. For the circuit shown below, find the labeled node voltages for:

a. β=∞

$i_B = 0, \quad i_C = i_E$



$V_1 = 0 \ [V]$

$V_2 = 0.7 \ [V]$

$$\frac{V_3-(-3)}{9.1K} = i_{C_1} = i_{E_1} = \frac{3-.7}{9.1K}$$

$V_3 + 3 = 2.3$

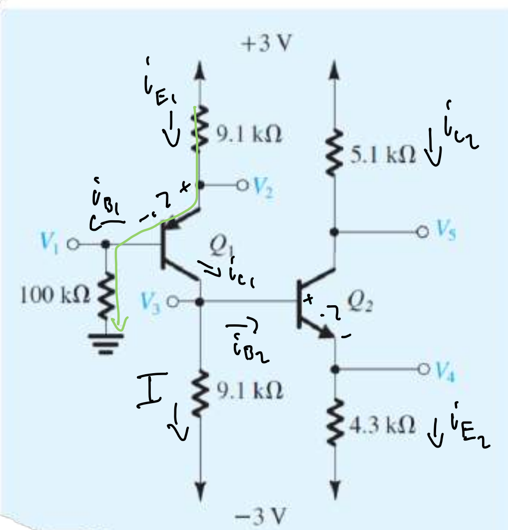
$V_3 = -0.7 \ [V]$

$V_4 = V_3 - .7 = -1.4 \ [V]$

$$\frac{3-V_5}{5.1K} = i_{C_2} = i_{E_2} = \frac{V_4+3}{4.3K}$$

$$V_5 = 3 - \left(\frac{5.1}{4.3}\right)(-1.4+3) = 1.1 \ [V]$$

b. β=100



KVL: $3 - 0 = i_{E_1} 9.1K + .7 + i_{B_1} 100K$

$2.3 = i_{B_1}\left((\beta+1) 9.1K + 100K\right)$

$$i_{B_1} = \frac{2.3}{(101)\,9.1K + 100K} = 2.257 \ \mu A \Rightarrow i_{E_1} = i_B(\beta+1) = 0.228 \ mA$$

$i_{C_1} = \beta i_B = .2257 \ mA$

$3 - V_2 = i_{E_1} \cdot 9.1K$

$V_2 = 3 - 2.07 = 0.926 \ [V]$

$V_1 = V_2 - .7 = 0.226 \ [V]$

$i_{C_1} = I + i_{B_2}$ $\qquad i_{B_2} = \frac{i_{E_2}}{\beta+1}$

$$i_{C_1} = \frac{V_3-(-3)}{9.1K} + \frac{V_3+2.3}{4.3K(101)} \qquad = \frac{V_3 - .7 - (-3)}{4.3K\,(101)}$$

$$i_{C_1} = V_3\left(\frac{1}{9.1K} + \frac{1}{4.3K(101)}\right) + \frac{3}{9.1K} + \frac{2.3}{4.3K(101)}$$

$$V_3 = \frac{\left(i_{C_1} - \frac{3}{9.1K} - \frac{2.3}{4.3K(101)}\right)}{\frac{1}{9.1K} + \frac{1}{4.3K(101)}} = -0.974 \ [V]$$

$V_4 = V_3 - .7 = -1.674 \ [V]$

$3 - V_5 = i_{C_2} \cdot 5.1K$

$$V_5 = 3 - \frac{\beta}{\beta+1}\left(\frac{V_4-(-3)}{4.3K}\right) \cdot 5.1K$$

$V_5 = 1.443 \ [V]$

5. Given the expression

$$H(j\omega) = \frac{\overset{z_1, z_2}{-\left(\frac{\omega}{100}\right)^2}}{\underset{P_1}{\left(1+j\frac{\omega}{100}\right)}\underset{P_2}{\left(1+j\frac{\omega}{1{,}000}\right)}\underset{P_3}{\left(1+j\frac{\omega}{10{,}000}\right)}} \qquad = \left(\frac{j\omega}{100}\right)^2 \qquad j^2\left(\frac{\omega}{100}\right) = -\left(\frac{\omega}{100}\right)$$

(a) Find the starting slope of the Bode plot,
(b) Find the mid-band or pass-band gain,
(c) Determine the total phase shift,
(d) Plot the straight-line approximation for the magnitude and phase, and
(e) Plot the complete transfer function using your favorite software (phase and magnitude).
(f) What happened to the *j* in the numerator?

a) $|H(j10)| \approx \left(\frac{1}{10}\right)^2$

$20 \log\left(\frac{1}{10}\right)^2 = 40\log(1) - 40\log(10)$

$\boxed{40 \text{ dB/dec}}$

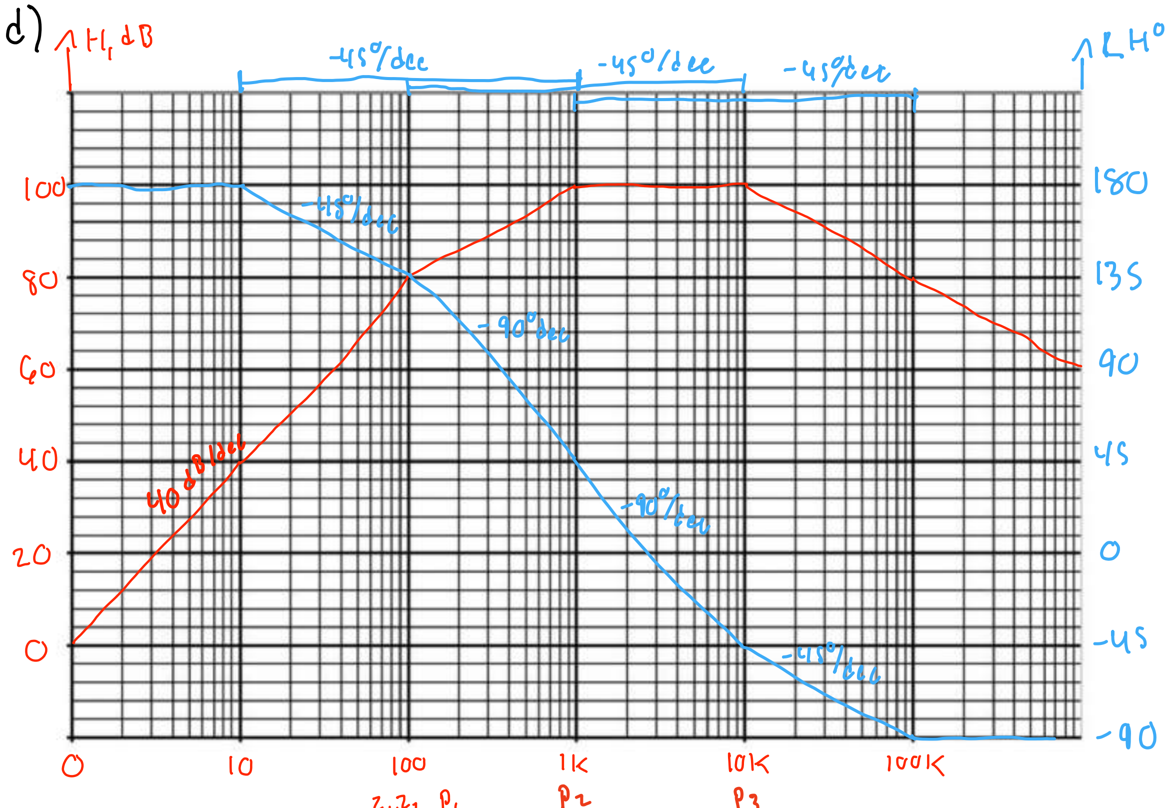
b) $1K < \omega < 10K$

$$H \approx \frac{-\left(\frac{j\omega}{100}\right)^2}{\left(\frac{j\omega}{100}\right)\left(\frac{j\omega}{1000}\right)(1)} = \frac{-\frac{\omega^2}{10K}}{-\frac{\omega^2}{100K}} = \frac{100K}{10K} = 10$$

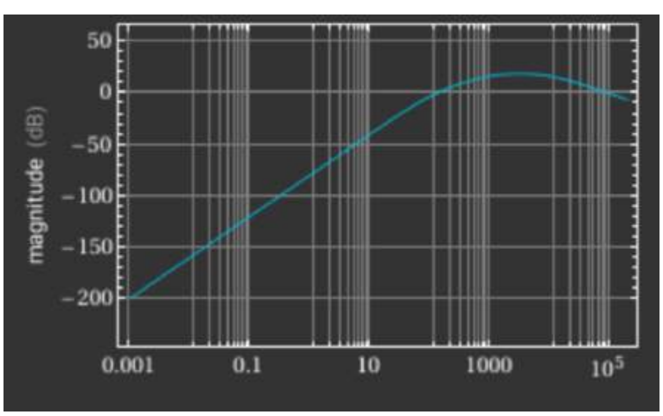
$\boxed{20\log(10) = 20 \text{ dB}}$

c) $\underset{z_1, z_2}{+\cancel{180}} \underset{P_1}{-\cancel{90}} \underset{P_2}{-\cancel{90}} \underset{P_3}{-90} = \boxed{-90^\circ}$

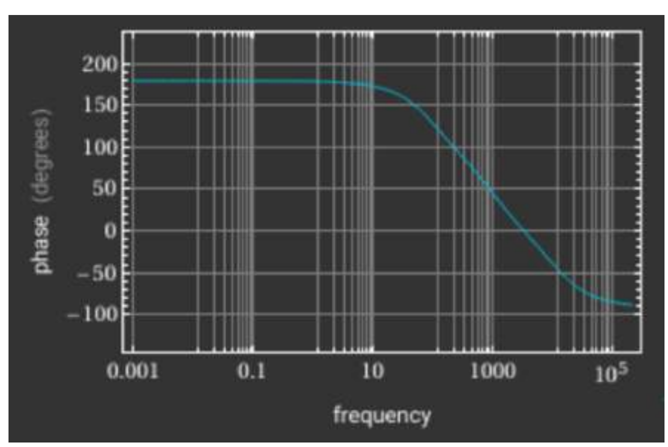
d)



f) the j in numerator got squared giving the -1 out front

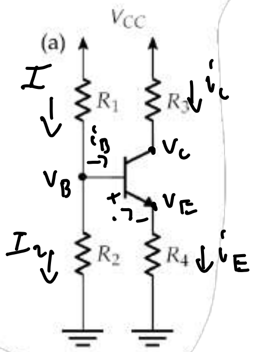


e)



6. For the following circuits, find the base, emitter, and collector voltages and currents. Use

$R_1 = 4.7\ \text{K}\Omega$, $R_2 = 1\ \text{K}\Omega$, $R_3 = 1\ \text{K}\Omega$, $R_4 = 500\ \Omega$, $R_5 = 10\ \text{K}\Omega$, $R_6 = 100\ \text{K}\Omega$, $R_7 = 2.2\ \text{K}\Omega$, $R_8 = 2.7\ \text{K}\Omega$, $C_1 = 1\ \mu\text{F}$, $I_1 = 10$ mA, $V_{CC} = +12$ V, $-V_{EE} = -12$ V, and $\beta = 300$.



$$\frac{V_{CC}-V_B}{R_1} = \frac{V_B}{R_2} + \frac{V_B-.7}{R_4(\beta+1)} \Rightarrow V_B = \left(\frac{V_{CC}}{R_1} + \frac{.7}{R_4(\beta+1)}\right)\left(\frac{1}{R_2} + \frac{1}{R_4(\beta+1)} + \frac{1}{R_1}\right)^{-1}$$

$$\boxed{V_B = 2.098\ [V]}$$

$$V_E = V_B - .7 = 1.398\ [V]$$

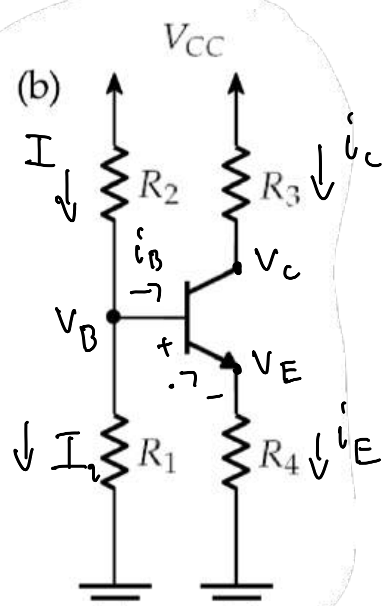
$$i_E = \frac{V_E}{R_4} = \frac{V_B-.7}{R_4} = 2.795\ [mA]$$

$$i_B = \frac{i_E}{\beta+1} = \frac{V_B-.7}{R_4(\beta+1)} = 9.286\ [\mu A]$$

$$i_C = \beta i_B = 2.785\ [mA]$$

$$V_{CC} - V_C = i_C R_3 \Rightarrow V_C = V_{CC} - i_C R_3$$

$$V_C = 9.214\ [V]$$



$$\frac{V_{CC}-V_B}{R_2} = \frac{V_B-.7}{R_4(\beta+1)} + \frac{V_B}{R_1}$$

$$V_B = \left(\frac{1}{R_4(\beta+1)} + \frac{1}{R_1} + \frac{1}{R_2}\right)^{-1}\left(\frac{V_{CC}}{R_2} + \frac{.7}{R_4(\beta+1)}\right)$$

$$V_B = 9.845\ [V] \qquad i_E = \frac{V_E}{R_4} = 18.29\ mA$$

$$V_E = V_B - .7 = 9.14\ [V] \qquad i_B = \frac{i_E}{\beta+1} = 60.76\ \mu A$$

$$V_C = V_{CC} - i_C R_3 = -6.23\ [V] \qquad i_C = \frac{\beta}{\beta+1} i_E = 18.23\ mA$$

$V_C - V_E < .2$ ∴ saturated

$$V_C - V_E = 0.2\ [V]$$

$$V_E = V_B - .7$$

$$i_E = i_C + i_B$$

$$i_E = \frac{V_E}{R_4} = \frac{V_B-.7}{R_4}$$

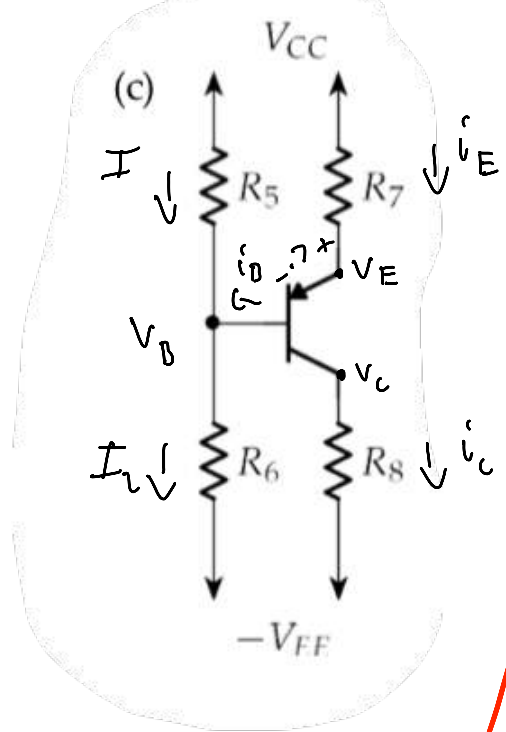
$$i_C = \frac{V_{CC}-V_C}{R_3}$$

$$\underbrace{\frac{V_B-.7}{R_4}}_{i_E} = \underbrace{\frac{V_{CC} - \overbrace{(.2 + (V_B-.7))}^{V_B-.5}}{R_3}}_{i_C} + \underbrace{\left(\frac{V_{CC}-V_B}{R_2} - \frac{V_B}{R_1}\right)}_{i_B}$$

$$V_B\left(\frac{1}{R_4} + \frac{1}{R_3} + \frac{1}{R_2} + \frac{1}{R_1}\right) = V_{CC}\left(\frac{1}{R_3} + \frac{1}{R_2}\right) + \frac{.7}{R_4} + \frac{.5}{R_3}$$

$$V_B = \left(\frac{1}{R_4} + \frac{1}{R_3} + \frac{1}{R_2} + \frac{1}{R_1}\right)^{-1} V_{CC}\left(\frac{1}{R_3} + \frac{1}{R_2}\right) + \frac{.7}{R_4} + \frac{.5}{R_3}$$

$\boxed{V_B = 6.148\ [V] \quad V_E = 5.448 \quad V_C = 5.648 \quad i_E = 10.9\ mA \quad i_C = 6.35\ mA \quad i_B = 4.54\ mA}$



$$\frac{V_{cc}-V_B}{R_5}+i_B=\frac{V_B-V_{EE}}{R_6}$$

$$i_B=\frac{i_E}{\beta+1}=\frac{V_{cc}-V_E}{R_7(\beta+1)}=\frac{V_{cc}-(V_B+.7)}{R_7(\beta+1)}$$

$$\frac{V_{cc}-V_B}{R_5}+\frac{V_{cc}-(V_B+.7)}{R_7(\beta+1)}=\frac{V_B-V_{EE}}{R_6}$$

$$V_B\left(\frac{1}{R_6}+\frac{1}{R_7(\beta+1)}+\frac{1}{R_5}\right)=V_{cc}\left(\frac{1}{R_5}+\frac{1}{R_7(\beta+1)}\right)-\frac{.7}{R_7(\beta+1)}+\frac{V_{EE}}{R_6}$$

$V_B=9.84\,[V]$

$i_B=\frac{i_E}{\beta+1}=2.21\,\mu A$

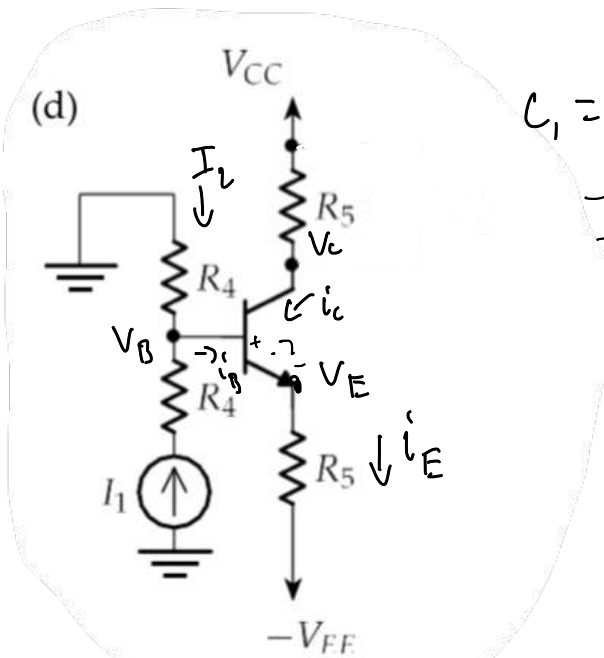
$V_E=V_B+.7=10.54\,[V]$

$i_E=\frac{V_{cc}-V_E}{R_7}=664.4\,\mu A$

$V_c=V_{EE}+i_cR_8$

$i_c=\frac{\beta}{\beta+1}i_E=662.23\,\mu A$

$V_c=-10.21\,[V]$



C_1 = open in dc

$$-\frac{V_B}{R_4}+I_1=i_B$$

$$i_B=\frac{i_E}{\beta+1}=\frac{V_E-V_{EE}}{R_5(\beta+1)}=\frac{(V_B-.7)-V_{EE}}{R_5(\beta+1)}$$

$$\frac{(V_B-.7)-V_{EE}}{R_5(\beta+1)}+\frac{V_B}{R_4}=I_1$$

$$V_B\left(\frac{1}{R_5(\beta+1)}+\frac{1}{R_4}\right)=I_1+\frac{V_{EE}}{R_5(\beta+1)}+\frac{.7}{R_5(\beta+1)}$$

$$V_B=\left(\frac{1}{R_5(\beta+1)}+\frac{1}{R_4}\right)^{-1}\left(I_1+\frac{V_{EE}}{R_5(\beta+1)}+\frac{.7}{R_5(\beta+1)}\right)$$

$V_B=4.997\,[V]$

$V_E=V_B-.7=4.297\,[V]$

$i_E=\frac{V_E-V_{EE}}{R_5}=1.63\,mA$

$V_c=V_{cc}-i_cR_5=-4.24\,[V]$

$i_c=\frac{\beta}{\beta+1}i_E=1.62\,mA$

$V_c-V_E<.2\ \therefore$ saturated

$i_E=i_c+i_B$ $\qquad V_c-V_E=.2$

$i_E=\frac{V_E-V_{EE}}{R_5}=\frac{V_B-.7-V_{EE}}{R_5}$ $\qquad V_B-V_E=.7$

$i_B=\frac{-V_B}{R_4}+I_1$

$$i_c=\frac{V_{cc}-V_c}{R_5}=\frac{V_{cc}-(.2+V_E)}{R_5}=\frac{V_{cc}-(.2+(V_B-.7))}{R_5}$$

$$\frac{V_B-.7-V_{EE}}{R_5}=\frac{V_{cc}-(.2+(V_B-.7))}{R_5}+\frac{-V_B}{R_4}+I_1$$

$$V_B\left(\frac{1}{R_5}+\frac{1}{R_5}+\frac{1}{R_4}\right)=\frac{V_{cc}}{R_5}+\frac{.5}{R_5}+\frac{.7}{R_5}+\frac{V_{EE}}{R_5}+I_1$$

$V_B=4.6\,[V]$ $\qquad V_E=3.9\,[V]$ $\qquad V_c=4.7\,[V]$

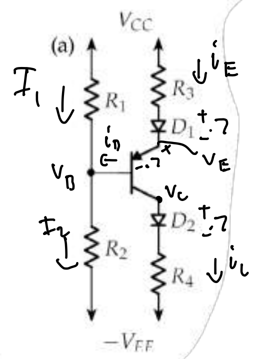
$i_B=0.782\,mA$

$i_E=1.59\,mA$

$i_c=0.799\,mA$

7. For the following circuits, find the base, emitter, and collector voltages and currents. Use

$R_1 = 1\ K\Omega$, $R_2 = 1\ K\Omega$, $R_3 = 3.3\ K\Omega$, $R_4 = 5\ K\Omega$, $R_5 = 10\ K\Omega$, $R_6 = 1\ K\Omega$, $I_1 = 1$ mA, $V_{CC} = +10$ V, $-V_{EE} = -10$ V, and $\beta = 150$. Use a constant voltage drop model for the diodes with a forward bias potential of 0.7 V.



$V_{cc} - V_B = i_E R_3 + .7 + .7$

$V_B = V_{cc} - i_E R_3 - .7 - .7$

$V_B = 8.6 - i_E R_3$

$V_B = 8.6 - (\beta+1) i_B R_3$

$V_B = 8.8$ [mV]

$V_E = V_B + .7 = 0.709$ [V]

$V_c - V_{EE} = .7 + i_c R_4$

$V_c = V_{EE} + .7 + i_c R_4$

$V_c = 3.631$ [V]

$$i_B = \frac{V_B - V_{EE}}{R_2} - \frac{V_{cc} - V_B}{R_1}$$

$$\left(i_B = V_B\left(\frac{1}{R_2} + \frac{1}{R_1}\right) - \frac{V_{cc}}{R_1} - \frac{V_{EE}}{R_2}\right) 1k$$

$1k\, i_B = 2V_B - 10 - (-10)$

$1K\, i_B = 2(8.6 - 498300\, i_B)$

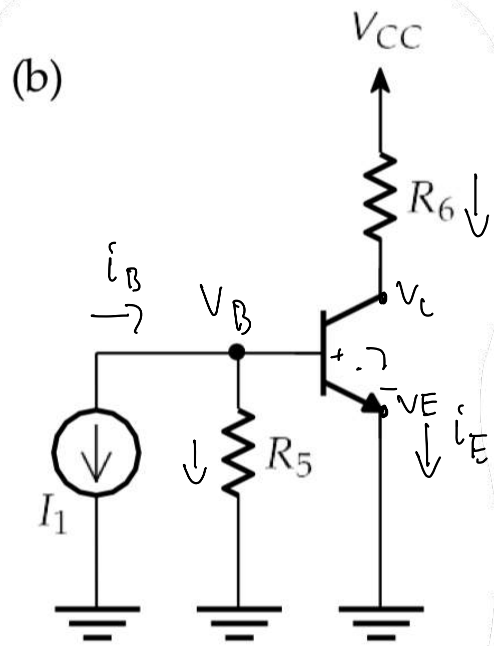
$1K\, i_B + 996600\, i_B = 17.2$

$997600\, i_B = 17.2$

$i_B = 17.24\ \mu A$

$i_E = (\beta+1) i_B = 2.603$ mA

$i_c = \beta i_B = 2.586$ mA



$V_E = 0$

$V_B = V_E + .7 = 0.7$ [V]

$$i_B = -I - \frac{V_B}{R_5}$$

$i_B = -1.07$ mA < 0 ∴ cutoff

so $i_B = i_c = i_E = 0$

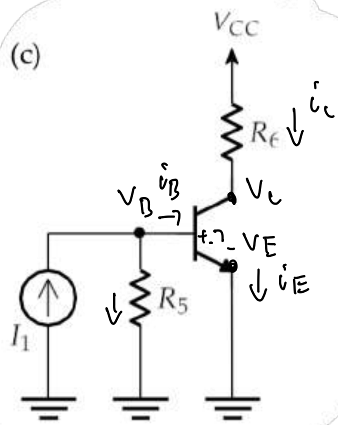
$V_B + I_1 R_5 = 0$

$V_B = -I_1 R_5$

$V_B = -10$ [V]

$V_E = 0$

$V_c = V_{cc} - \cancel{i_c R_4} \Rightarrow V_c = 10$ [V]



$V_E = 0$

$V_B = V_E + 0.7 = 0.7$ [V]

$V_c = V_{cc} - R_4 i_c = -129.5$ [V]

$V_c - V_E < .2$ ∴ saturated

$i_E = i_c + i_B$

$$i_E = \frac{V_{cc} - V_c}{R_4} + I_1 - \frac{V_B}{R_5}$$

$V_c - V_E = 0.2$

$V_B - V_E = 0.7$

$V_E = 0$

$\Downarrow$

$V_c = 0.2$

$V_B = 0.7$

$i_E = 10.73$ mA

$$i_c = \frac{V_{cc} - V_c}{R_4} = 9.8\ mA$$

$i_B = 0.93$ mA

$$-I_1 + \frac{V_B}{R_5} + i_B = 0$$

$$i_B = I_1 - \frac{V_B}{R_5}$$

$i_B = 930\ \mu A$

$i_E = i_B(\beta+1)$

$i_E = 140.43$ mA

$i_c = \beta i_B$

$i_c = 139.5$ mA