ECE 3050 Analog Electronics Quiz 6
February 18, 2009

Professor Leach Name______________________________

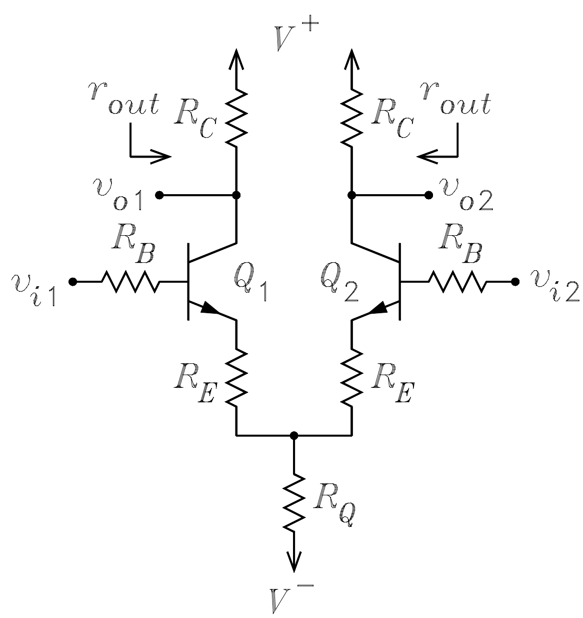
Instructions. Print your name in the space above. **Honor Code:** *I have neither given nor received help on this quiz.* Initials ____________

1. The figure shows a BJT diff amp. It is given that $V^+ = +24\,\text{V}$, $V^- = -24\,\text{V}$, $R_B = 150\,\Omega$, $R_E = 75\,\Omega$, $R_C = 24\,\text{k}\Omega$, $R_Q = 23\,\text{k}\Omega$, $V_T = 0.025\,\text{V}$, $V_A = \infty$, $V_{BE} = 0.65\,\text{V}$, $\beta = 74$, $I_E = 0.5\,\text{mA}$, $r_e = 50\,\Omega$, $r_x = 30\,\Omega$, and $r'_e = 52.4\,\Omega$.

$$r_e = \frac{V_T}{I_E} = 50\,\Omega \qquad r'_e = \frac{R_B + r_x}{1+\beta} + r_e = 52.4\,\Omega \qquad g_m = \frac{I_C}{V_T} = 0.01973\,\text{S} \qquad r_\pi = \frac{V_T}{I_B} = 3.75\,\text{k}\Omega$$

$$r'_\pi = r_x + r_\pi + (1+\beta)\,R_{te} \qquad r_0 = \frac{V_A + V_{CE}}{I_C} = \infty \qquad r_{ic} = \frac{r_0 + r'_e \| R_{te}}{1 - \alpha \dfrac{R_{te}}{r'_e + R_{te}}} = \infty$$

Before starting the problem, note that the answers for some of the numerical calculations are given with the above formulas.
(a) For $v_{i2} = 0$, solve for the small-signal Thévenin resistance R_{te1} looking out of the emitter of Q_1.
(b) For $v_{i2} = 0$, solve for the small-signal voltage gain v_{o1}/v_{i1}.
(c) For $v_{i1} = 0$, solve for the small-signal voltage gain v_{o1}/v_{i2}. If you are clever, it is possible to make use of the solution for v_{o1}/v_{i1} to simplify the numerical calculations.
(d) Make use of the solutions from the parts above to write the solutions for the small-signal gains v_{o2}/v_{i2} and v_{o2}/v_{i1}.



$V_T := 0.025 \quad r_x := 30 \quad V_p := 24 \quad R_C := 24000 \quad \beta := 74 \quad \alpha := \frac{\beta}{1+\beta} \quad \alpha = 0.987$

$V_n := -24 \quad R_B := 150 \quad R_E := 75 \quad R_Q := 23000 \quad V_{BE} := 0.65$

$$I_E := \frac{0 - V_{BE} - (V_n)}{\frac{R_B}{\beta} + \frac{(R_E + 2 \cdot R_Q)}{\alpha}} \qquad I_E = 5 \cdot 10^{-4} \qquad V_C := V_p - \alpha \cdot I_E \cdot R_C \qquad V_C = 12.16$$

$$r_e := \frac{V_T}{I_E} \qquad r_e = 50 \qquad r'_e := \frac{R_B + r_x}{1+\beta} + r_e \qquad r'_e = 52.4$$

$$I_B := \frac{\alpha \cdot I_E}{\beta} \qquad r_\pi := \frac{V_T}{I_B} \qquad r_\pi = 3.75 \cdot 10^3 \qquad I_C := \alpha \cdot I_E \qquad g_m := \frac{I_C}{V_T} \qquad g_m = 1.973 \cdot 10^{-2}$$

$$g_m^{-1} = 50.675 \qquad R_{te} := R_E + R_{p2}(R_Q, R_E + r'_e) \qquad R_{te} = 2.017 \cdot 10^2$$

$$A_{v11} := \frac{\alpha}{r'_e + R_{te}} \cdot (-R_C) \qquad A_{v11} = -93.193$$

$$A_{v12} := -A_{v11} \cdot \frac{R_Q}{R_Q + r'_e + R_E} \qquad A_{v12} = 92.679$$

$$A_{v22} := A_{v11} \qquad A_{v22} = -93.193 \qquad A_{v21} := A_{v12} \qquad A_{v21} = 92.679$$