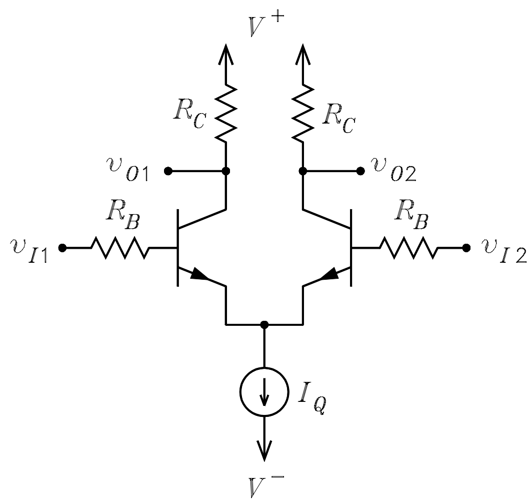
ECE 3040 Quiz 9 – July 20, 2005

Professor Leach Name________________________________

Instructions. Print your name in the space above. The quiz is closed-book and closed-notes. The quiz consists of two problems. Draw a box around all numerical answers. **Honor Code Statement:** *I have neither given nor received help on this quiz.* Initials __________

Formula summary: $\alpha = \beta/(1+\beta)$, $r_\pi = V_T/I_B$, $g_m = I_C/V_T$, $r_e = V_T/I_E$, $r'_e = (1-\alpha)R_{tb} + r_e$, $r_0 = (V_A + V_{CE})/I_C$, $I_{C(npn)} = I_S \exp(V_{BE}/V_T)$, $I_{C(pnp)} = I_S \exp(V_{EB}/V_T)$, $I_C = \alpha I_E = \beta I_B$

1. The figure shows a differential amplifier. It is given that $R_B = 1\,\mathrm{k}\Omega$, $R_C = 10\,\mathrm{k}\Omega$, $I_Q = 1\,\mathrm{mA}$, $V_{CE} = 10\,\mathrm{V}$, $V_A = \infty$, $V_T = 25\,\mathrm{mV}$, and $\beta = 99$.
(a) What are the numerical values of g_m, r_π, r_0, r_e, and r'_e?
(b) Draw the simplified small-signal T model and use it to solve for the numerical values of i'_{e1} and i'_{e2} as functions of v_{i1} and v_{i2}
(c) Use the solution for i'_{e1} and i'_{e2} to solve for the numerical values of v_{o1} and v_{o2} as functions of v_{i1} and v_{i2}.



$R_B := 1000$ $\quad R_C := 10000$ $\quad I_Q := 0.001$ $\quad V_{CE} := 10$ $\quad V_T := 0.025$ $\quad \beta := 99$

$\alpha := \dfrac{\beta}{1+\beta}$ $\quad \alpha = 0.99$

$g_m := \dfrac{\alpha \cdot I_Q}{2 \cdot V_T}$ $\quad g_m^{-1} = 50.505$ $\quad r_e := \dfrac{2 \cdot V_T}{I_Q}$ $\quad r_e = 50$ $\quad r'_e := \dfrac{R_B}{1+\beta} + r_e$ $\quad r'_e = 60$

$i'_{e1} = \dfrac{v_{i1} - v_{i2}}{2 \cdot r'_e}$ $\quad i'_{e1} = \dfrac{v_{i1} - v_{i2}}{120}$ $\quad i'_{e2} = -i'_{e1}$ $\quad A_v := \dfrac{-\alpha \cdot R_C}{2 \cdot r'_e}$ $\quad A_v = -82.5$

$v_{o1} = A_v \cdot (v_{i1} - v_{i2})$ $\quad v_{o1} = -82.5 \cdot (v_{i1} - v_{i2})$ $\quad v_{o2} = -v_{o1}$ $\quad v_{o2} = 82.5 \cdot (v_{i1} - v_{i2})$

2. The figure shows a complementary CC amplifier. Each BJT has the saturation current $I_S = 3 \times 10^{-14}\,\mathrm{A}$. Assume $V_T = 0.025\,\mathrm{V}$.
(a) If cutin is defined as the base-emitter voltage at which the collector current is 0.2 mA, solve for the numerical value of the cutin voltage for the two transistors.

$I_S := 3 \cdot 10^{-14}$ $\quad V_T := 0.025$ $\quad I_C := 0.0002$ $\quad V_{BE1} := V_T \cdot \ln\left(\dfrac{I_C}{I_S}\right)$ $\quad V_{BE} = 0.7$

$V_{EB2} := V_{BE1}$

(b) Sketch and label the graph of v_O versus v_I. See the Class Notes.
(c) If v_I is a sine wave of amplitude $V_1 > V_\gamma$, sketch and label the waveform of v_O versus time. See the Class Notes.