NAME: key STUDENT NO.:

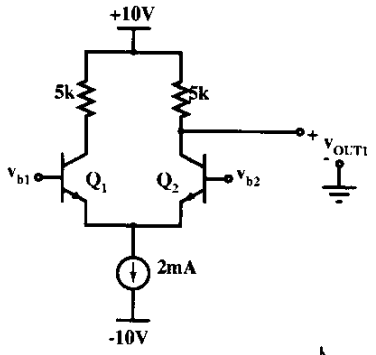
University of Puerto Rico
Electrical and Computer Engineering Department
INEL 4202 - Electronics II - Spring 2001 - Exam 3a - Prof. M. Toledo
THERE ARE FOUR PROBLEMS - BE CLEAR OR LOOSE POINTS
Use $\beta = 100$ when needed.

1. For the differential amplifier shown below, find

   (a) the voltage gain $A_v = v_{out1}/v_{b1}$ when the base of Q_2 is grounded. (15 points)

   (b) the quescient point collector-to-emitter voltages for Q_1 and Q_2. (15 points) (HINT: this should be calculated with both bases grounded)

   (c) the input resistance. (15 points)



(a) $A_V = +\frac{1}{2} g_m R_C$; $g_m = \frac{I_C}{V_T} = \frac{1mA}{25mV} = \frac{1}{25}$ Ω

$A_V = \frac{1}{2}\left(\frac{1}{25}\right)(5000) = \boxed{100}$

(b) $V_E = -0.7V$

$V_C = 10V - 1mA(5K) = 5V$ } $\boxed{V_{CE} = 5.7V}$

(c) $R_{in} = 2r_\pi = 2\beta/g_m = 2(100)/\frac{1}{25}\Omega = \boxed{5K\Omega}$

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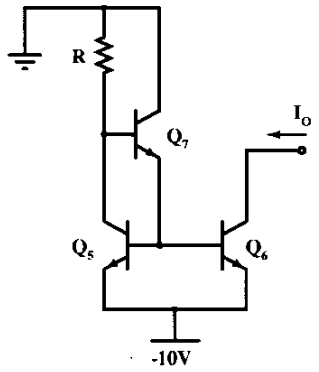
2. The circuit shown below will implement the constant current source for the diagram shown in problem 1. Find R such that $I_O = 2mA$. Assume all transistors have equal areas and very large β. (15 points)



$$I_{ref} = \frac{10V - 1.4V}{R} = \frac{8.6V}{R} = 2mA$$

$$R = \frac{8.6V}{2mA} = \boxed{4.3K\Omega}$$

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3. The circuit shown in problem 1 uses the current mirror shown in problem 2 to implement the constant current source. Find the gain $A_{CM} = v_{out1}/v_{CM}$, obtained when a common voltage v_{CM} is appied to both v_{b1} and v_{b2}, if all transistors exhibit an early voltage of 100V. (10 points)

$$A_{CM} \simeq \frac{1}{2} \frac{R_C}{R_{TAIL}}$$

$$R_{TAIL} \simeq r_{DQ6} = \frac{V_A}{I_{C_6}} = \frac{100V}{2mA} = 50 \text{ K}\Omega$$

$$A_{CM} = \frac{1}{2} \frac{5K}{50} = \boxed{.05}$$

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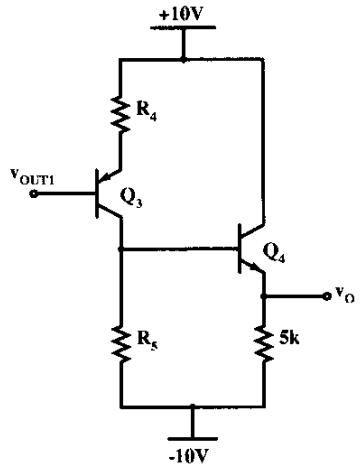
4. The circuit shown below will be connected to the output of the differential stage shown in problem 1. Find

   (a) R_4 and R_5 such that transistor Q_3 is biased at approximately $5mA$ and the quescient output voltage (when both inputs are grounded) is zero. (10 points)

   (b) the overall gain of the amplifier. (10 points)

   (c) the approximate output resistance of the amplifier. (10 points)



(a) $V_{B3} = V_{C2} = 5V$, $V_{E3} = 5.7V$ $\Big\}$ $V_{R4} = 4.3V \Rightarrow R_4 = \frac{4.3V}{5mA} = \boxed{860\Omega}$ 660

$V_{E4} = 0V \Rightarrow V_{B4} = V_{C3} = +0.7V \Rightarrow V_{R5} = 10.7V$

$R_5 = \frac{10.7}{5mA} = \boxed{2.14K\Omega}$

(b) $A_{VQ3} \cong -\frac{2.14K\Omega}{860\Omega} = -2.5$

stage 2 loading on stg. 1 $= \frac{101(860)}{5K + 101(860)} = \boxed{0.95}$

$A_{VQ4} \simeq 1$

$\therefore A_{V\,total} = 100(.95)(-2.5)(1) = \boxed{-238}$

(c) $R_{out} = 5K \,||\, \frac{r_{\pi 4} + R_5}{\beta + 1}$

$I_{C4} \cong \frac{10V}{5K} = 2mA \Rightarrow r_{\pi 4} = \frac{100(25mV)}{2mA} = 1.25K$

$R_{out} = 5K \,||\, \frac{1.25K + 2.14K}{101} = 5K \,||\, 34 \cong \boxed{34\Omega}$