Name: _____ (please print)

Signature: _____

ECE 3455
Quiz 4
November 18, 2010

Quiz duration: 30 minutes

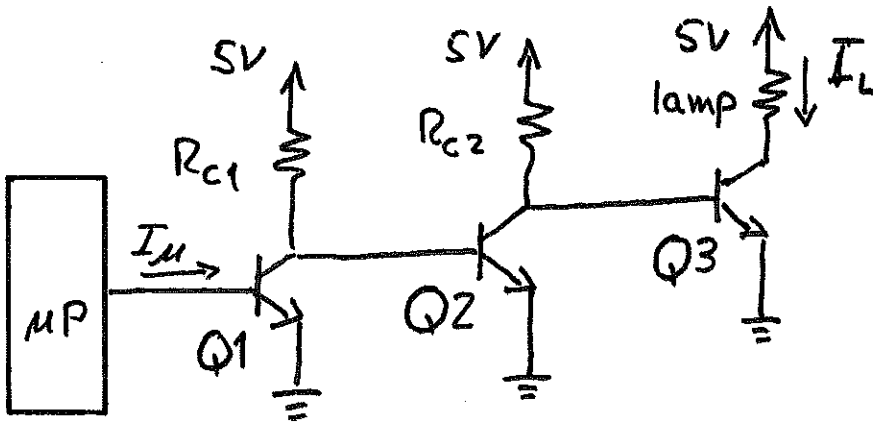
1. You may have one 8 ½ x 11 in. "crib" sheet, written on both sides, during the quiz. You may have any calculator you choose, but no computers. No other notes or materials will be allowed.
2. Show all work necessary to complete the problem on these pages. A solution without the work shown will receive no credit.
3. Show units in intermediate and final results, and in figures.
4. If your work is sloppy or difficult to follow, points will be subtracted.

_____/20

The circuit below contains a microprocessor, three BJTs, and a lamp. The BJTs have $\beta = 50$ and $V_{CE,sat} = 0.3$ V. When the lamp is on, it draws 20 mA of current (I_L in the circuit) and can be modeled by a resistance of 100 Ω. The microprocessor provides a current I_μ which is either 0 or 100 μA.

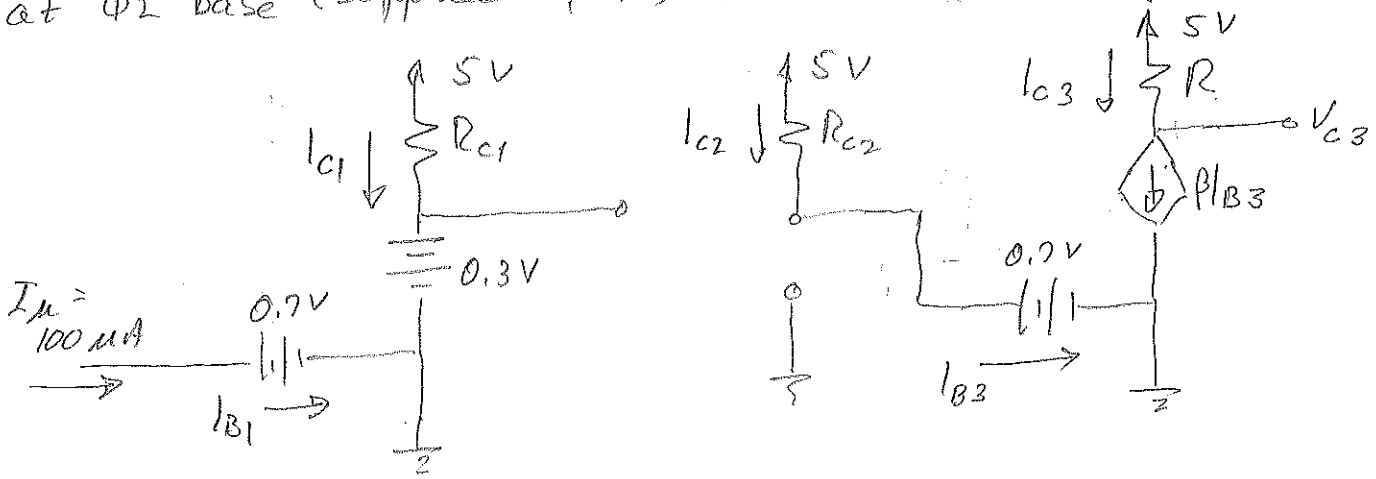
The circuit is intended to work as follows. If $I_{\mu P}$ is 100 μA, Q1 goes into saturation, Q3 goes into active mode, and the lamp goes on. If $I_{\mu P}$ is 0, Q1 is in cutoff, and the lamp goes off.

Choose resistor values (R_{C1}, R_{C2}) so that the circuit functions as stated above. To receive full credit, you must clearly show that your design works for both lamp-on and lamp-off conditions.



LAMP ON:

Q3 active; Q1 saturation ⇒ Q2 cut-off because 0.3V at Q2 base (supplied by Q1) is not sufficient for ON conduction.



$I_{C1} = \dfrac{5 - 0.3}{R_{C1}}$

$I_{B1} = 100\,\mu A$

$\beta I_{B1} > I_{C1}$

$I_{C3} = 20$ mA $R = 100\,\Omega$ ✓

$\Rightarrow V_{C3} = V_{CE3} = 5 - 2 = 3$ V

$I_{B3} = I_{C2} = I_{C3}/\beta$

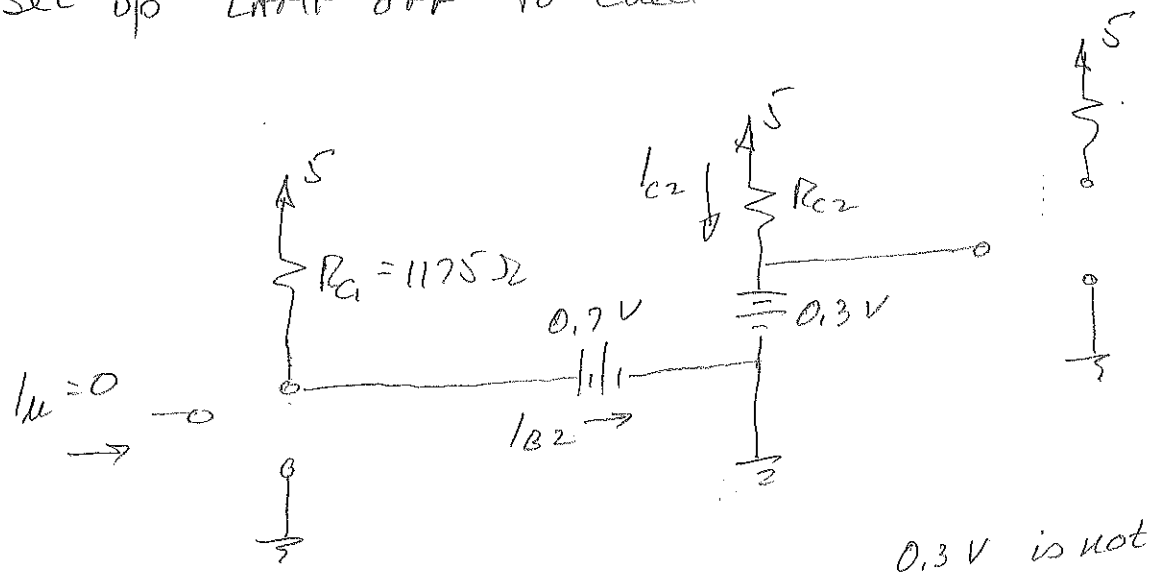
Room for Extra Work

$$R_{C2} = \frac{5 - 0.7}{0.4\ mA} = 10.75\ k\Omega$$

$\beta I_{B1} = 50 \times 100\ \mu A = 5\ mA > I_{C1} = \frac{5 - 0.3}{R_{C1}}$

$R_{C1} > \frac{5 - 0.3}{0.005} = 940\ \Omega$ $\quad R_{C1} = 1\ k\Omega$

Set up LAMP OFF to check:



0.3 V is not sufficient to turn Q3 on, so cut-off.

$\beta I_{B2} = 50 \cdot \frac{5 - 0.7}{1175} = 183.4\ \mu A$

$I_{C2} = \frac{5 - 0.3}{10.75\ k} = 0.437\ mA$

so $\beta I_{B2} > I_{C2}$ ✓