Name: ______________________________ (please print)

Signature: ___________________________

ECE 3455
Quiz #5
April 22, 2009

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.

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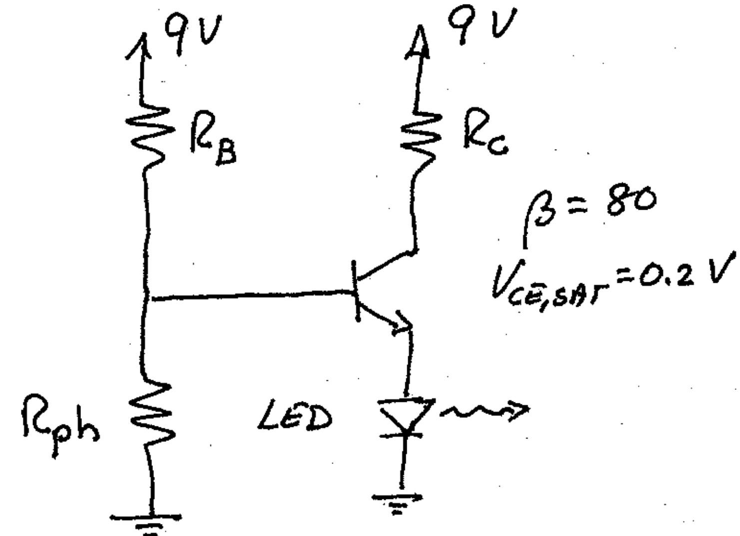
The circuit shown below is intended to operate as a "night light". The photo resistor R_{ph} has a resistance of 200 kΩ in the dark, and 10 kΩ in daylight. The BJT has $\beta = 80$ and $V_{CE,SAT} = 0.2$ V. It is intended to operate in saturation to turn the LED on at night, and in cutoff to turn the LED off during the day. The LED can be modeled as a diode with a constant forward voltage drop of 0.7 V. The table summarizes the specifications.

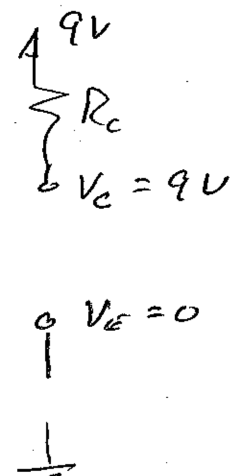
Choose R_B and R_C so that the LED is on (LED in forward bias, BJT in saturation) in the dark, and off (LED off, BJT cutoff) in daylight. Assume the LED light does not affect the operation of the photo resistor.

Summary of Specifications			
	LED	BJT	R_{ph}
day	off	cutoff	10 kΩ
night	on	saturation	200 kΩ

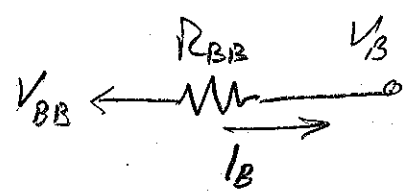


We consider day time first: the BJT is in cutoff so R_c does not matter and we can focus on R_B.

$$V_{BB} = 9 \cdot \frac{R_{ph}}{R_{ph} + R_B} \qquad R_{BB} = R_B \,//\, R_{ph}$$



$I_B = 0 \Rightarrow V_B = V_{BB}$



We have $R_{ph} = 10$ kΩ and we require $V_B = V_{BB} < 1.4$ V so that the BE junction and the LED will be OFF.

Room for Extra Work

So: $V_B = 9 \cdot \frac{R_{ph}}{R_{ph}+R_B} < 1.4\ V$ $\quad R_{ph} = 10\ k\Omega$

clearly $\boxed{R_B = 100\ k\Omega}$ will suffice. Then

$V_B = 9 \cdot \frac{10}{10+100} = 0.818\ V < 1.4$

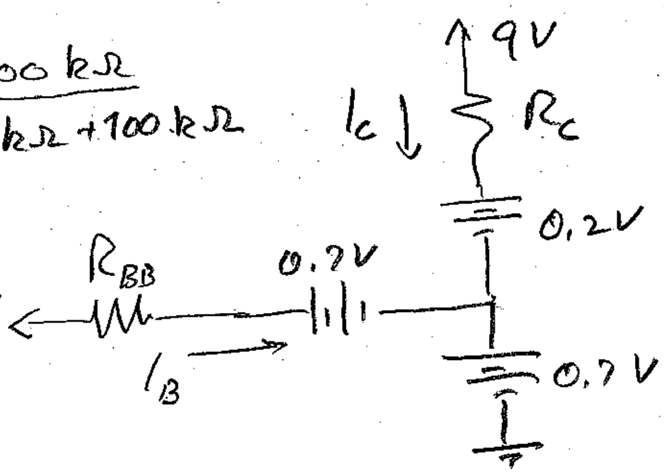
so $I_B = 0$. Also $V_{BE} = 0$ and $V_{BC} = -8.2\ V$

so both junctions are OFF.

With this choice of R_B we go to night time conditions:

$V_{BB} = 9 \cdot \frac{R_{ph}}{R_{ph}+R_B} = 9 \cdot \frac{200\ k\Omega}{200\ k\Omega + 100\ k\Omega}$

$= 6\ V.$



$R_{BB} = 200k \| 100k$

$= 67\ k\Omega$

So now $I_B = \frac{V_{BB} - 1.4}{R_{BB}} = 69\ \mu A$ $\quad \beta I_B > I_c$

We also have $I_c = \frac{9 - 0.2 - 0.7}{R_c}$ and this needs to be less than $\beta I_B = 5.52\ mA$ for saturation. Choosing

$\boxed{R_c = 2.2\ k\Omega}$ $\Rightarrow$ $I_c = 3.68\ mA$ which is OK.