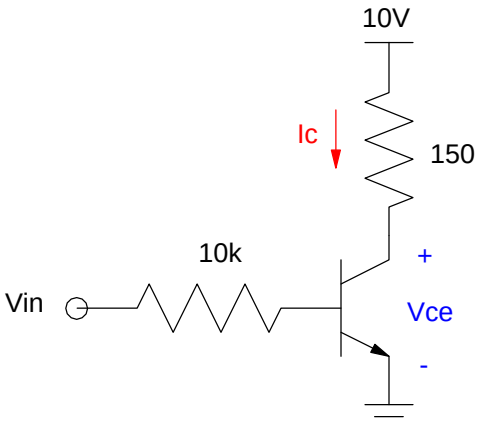
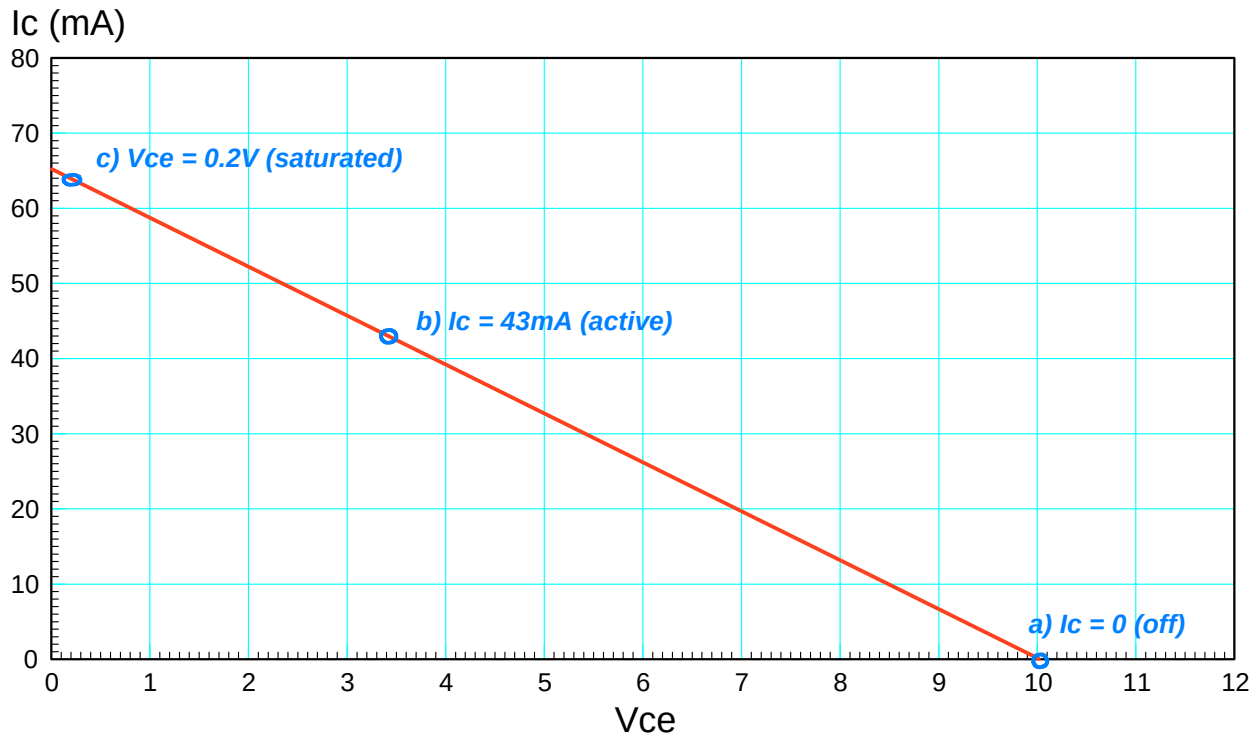
ECE 320: Final Name _____

Part 2: Digital Circutis with Transistors and Op-Amps - March 24, 2017

1) Assume an ideal silicon transistor with Vbe = 0.7V and $\beta = 100$. Draw the load-line for the following circuit and show the operating point for Vin = { 0.5V, 5V, 10V }

Load Line	Q-Point for Vin = 0.5V	Q-Point for Vin = 5V	Q-Point for Vin = 10V
Show on graph	Mark on load line	Mark on load line	Mark on load line





2) Design a circuit so that the output of an op-amp can turn on and off a 1W LED at 300mA.

Input: 0V / 10V binary signal capable of 20mA

Output: 1W LED, Vf = 3.3V @ 100mA

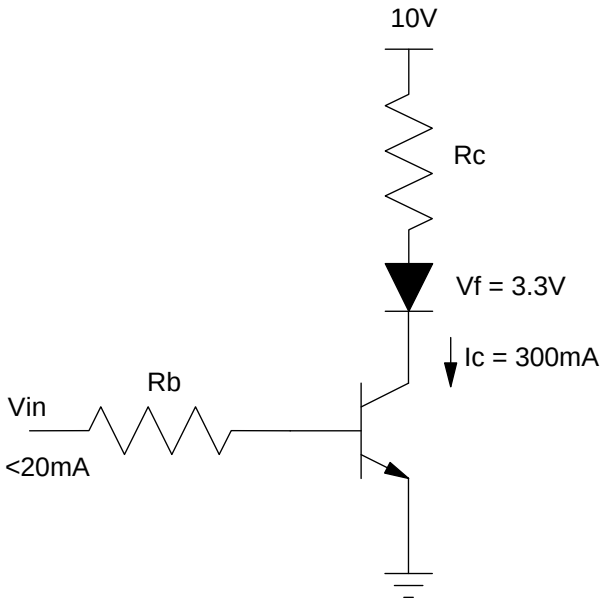
Relatioship:

- When the input is 0V, the LED is off (0mA)
- When the input is 10V, the LED is on (100mA)

Assume a transistor with

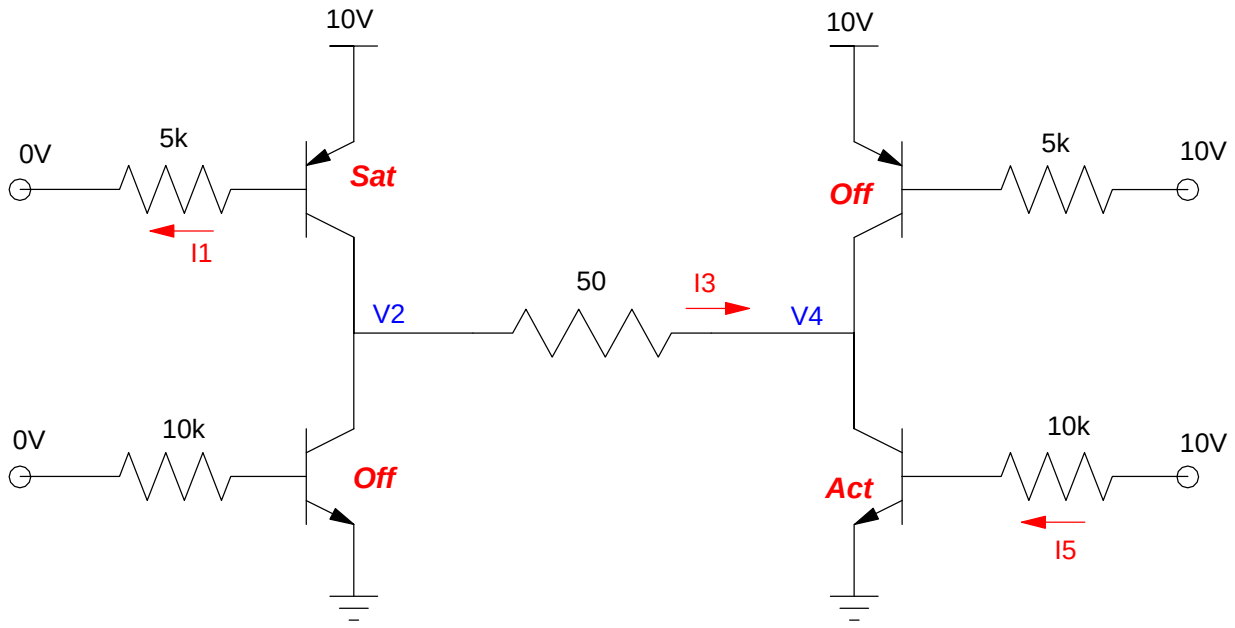
- Vbe = 0.7V
- Vce(sat) = 0.2V
- $\beta = 100$

Rb	Rc	For your design, how low Vin gan go and still saturate the transistor
1000 465 < Rb < 3100	**21.67** (10 - 0.2 - 3.3V) / 300mA	**3.7V (varies)** 3mA * 1000 Ohms + 0.7V



3) Assume ideal transistors with $|V_{be}| = 0.7V$ and $\beta = 100$. Determine the voltages and currents.

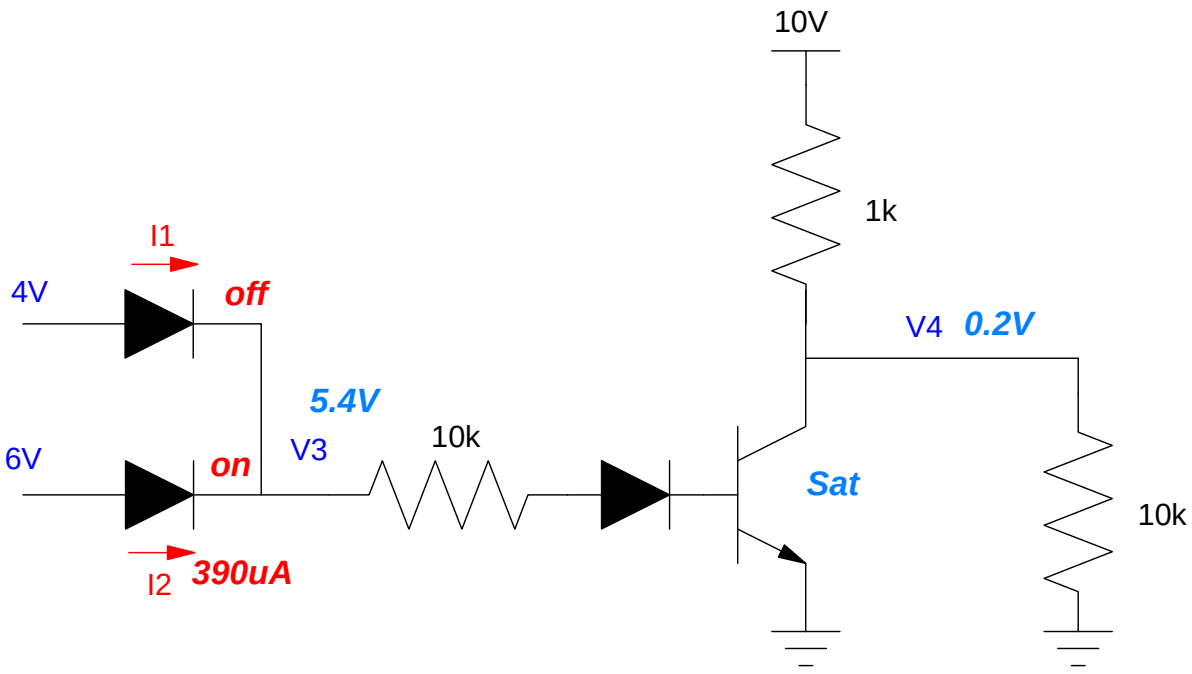
I1	V2	I3	V4	I5
1.86mA 9.3V / 5k	**9.8V** saturated	**93mA** min(186mA, 192mA, 93mA)	**5.15V** 9.8V - 93mA * 50 Ohms	**0.93mA** 9.3V / 10k



4) The following is a DTL NOR gate. Determine the currents and voltages. Assume ideal silicon transistors and didoes with

- Vf = 0.7V
- Vce(sat) = 0.2V, and
- β = 100

I1	I2	V3	V4
0mA	**390uA** (6V - 2.1V) / 10k	**5.4V**	**0.2V** Beta Ib = 39mA max(Ic) = 10mA Beta * Ib > Ic (saturated)

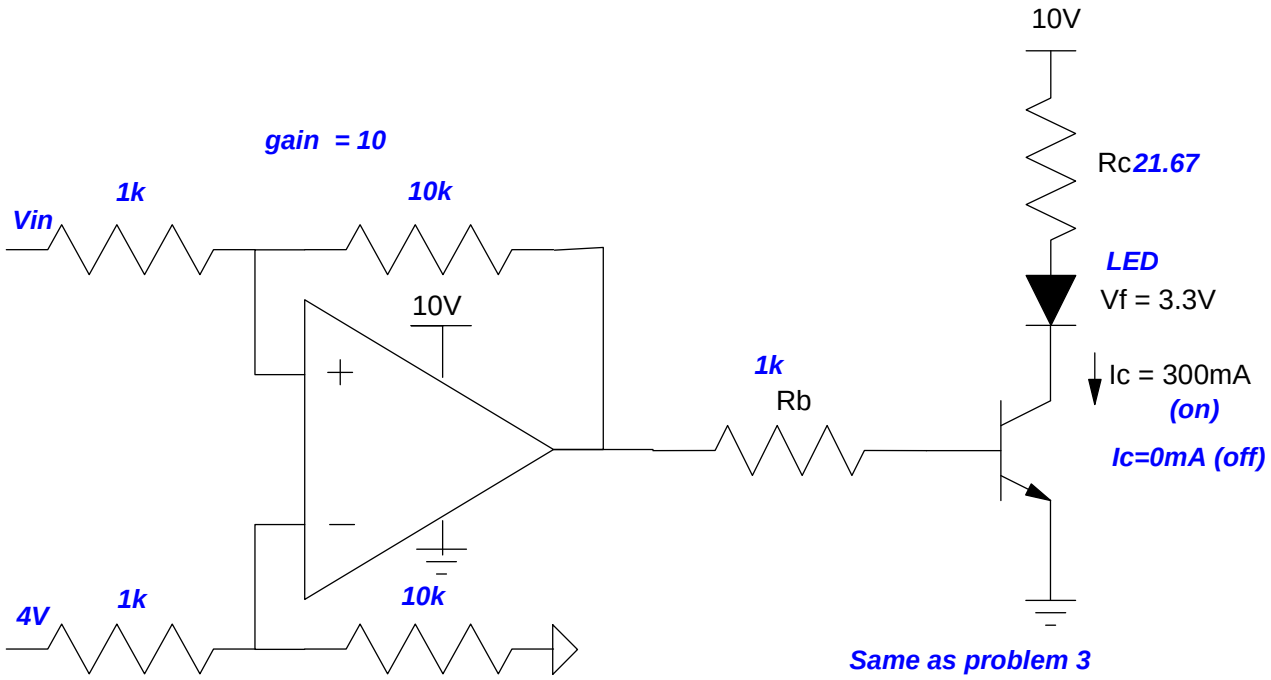


5) Design a Schmitt Trigger to turn a 1W LED on and off:

- Off (Ic = 0mA) when Vin < 3V
- On (Ic = 300mA) when Vin > 4V
- No change (on or off) for 3V < Vin < 4V

Assume an ideal silicon diode, capable of 300mA, with β = `100`

Assume the op-amp outputs 0V / 10V, capable of up to 20mA



Bonus! The wall between the U.S. and Mexico is estimated to cost $2 trillion to build. For comparison, how much would it cost to build enough wind turbines to completely power the U.S. with wind energy?

400,000 1MW wind turbines would provide 4 trillion kWh assuming 100% utilization. This would cost $400 billion.

You'll need more since the wind doesn't always blow and demand isn't constant. Maybe make that $1 trillion (1/2 of the cost of a wall)