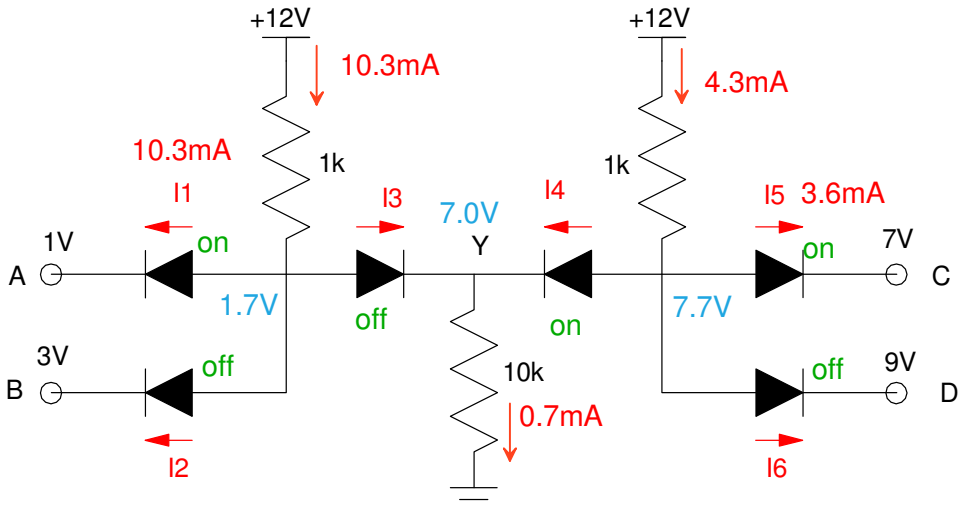
ECE 320 - Homework #4

Max/Min Circuits, Clipper Circuits, Transistor Theory. Due Monday, February 7th

Max/Min:

1) Determine the voltages and currents for the following max/min circuit. What function does this circuit implement? Y = f(A, B, C, D)



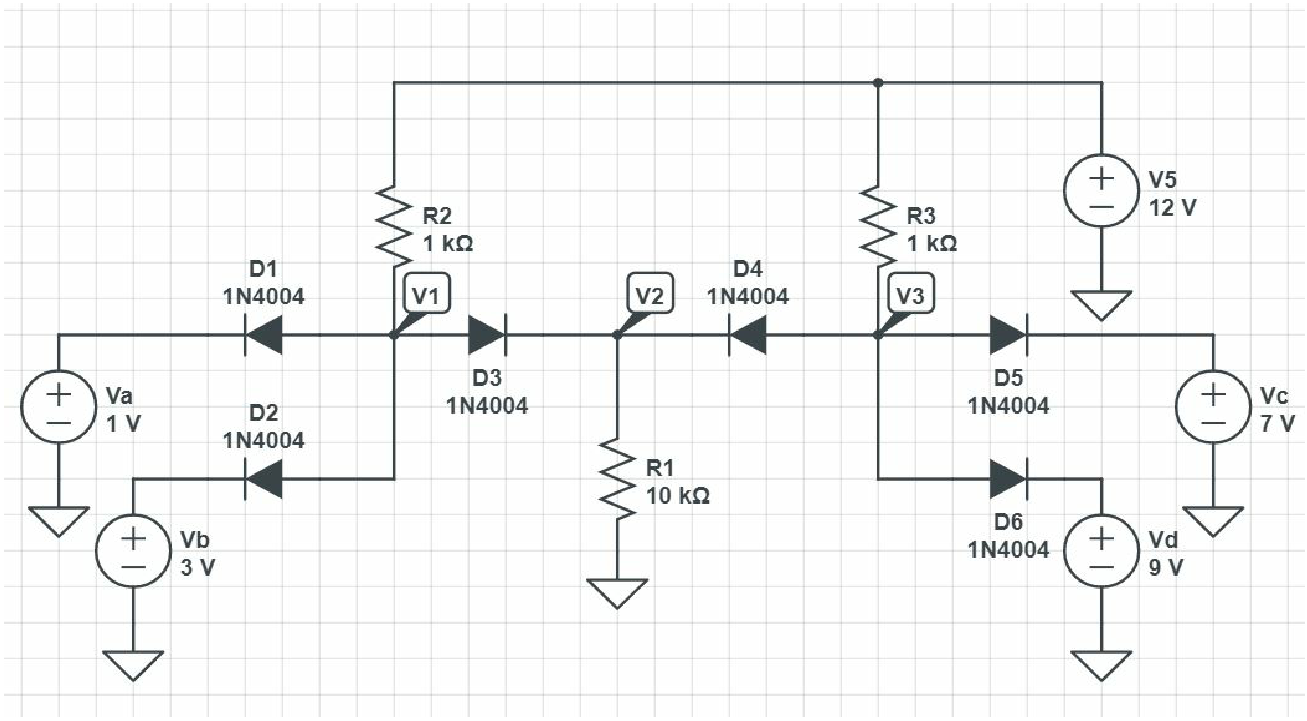
Problem 1-2.

2) Check your results in CircuitLab (or similar program) using 1N4004 diodes

	I1	I2	I3	I4	I5	I6
Calculated	10.3mA	0	0	0.7mA	3.6mA	0
Simulated	10.30mA	-76.9pA	-76.9pA	0.7061mA	3.635mA	-76.9pA

Note that CircuitLab answers are slightly different than calculated answers.

- Calculations assumed ideal diodes
- Actual diodes are not ideal (answers are different), but
- The ideal diode model is close (answers are close but slightly different)



DC

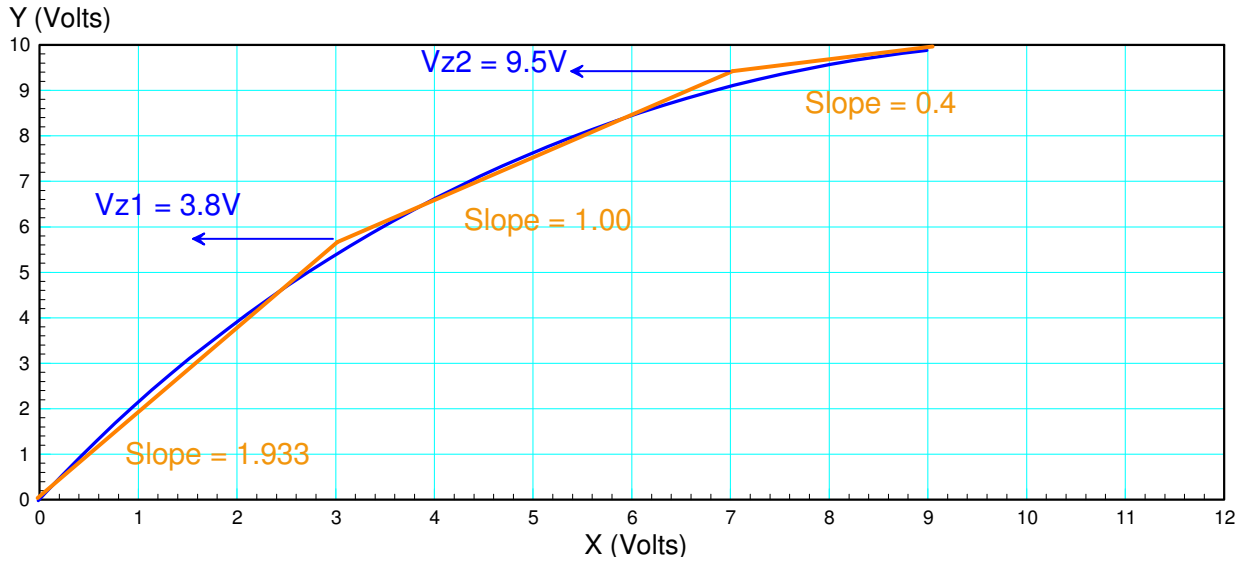
V(V1)	1.698 V
V(V2)	7.061 V
V(V3)	7.658 V
I(D2.nA)	-76.90 pA
I(D3.nA)	-76.90 pA
I(D4.nA)	706.1 µA
I(D6.nA)	-76.90 pA
I(D1.nA)	10.30 mA

+ Add Expression

Clipper Circuits:

3) Design a circuit to approximate the following function subject to the following requirements:

- Input: 0 .. 10V, capable of 100mA
- Output: 100k resistor
- Relationship: Graph below, +/- 500mV



Stage 1: Gain = 1.933

$$gain = 1 + \frac{R_0}{1k}$$

$$R_0 = 933\Omega$$

Stage 2: Gain = 1.000

$$gain = 1.000 = \left(\frac{R_1}{R_1 + 1k}\right)(1.933)$$

$$R_1 = \left(\frac{1.000}{1.933 - 1.000}\right)1k\Omega = 1072\Omega$$

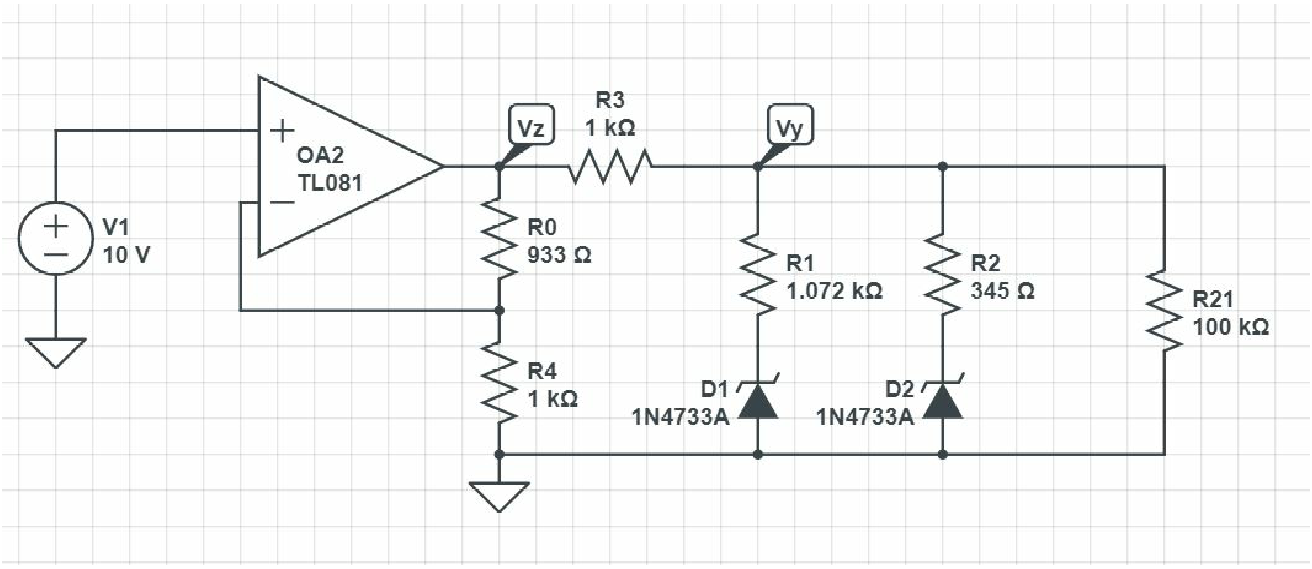
Stage 3: Gain = 0.4

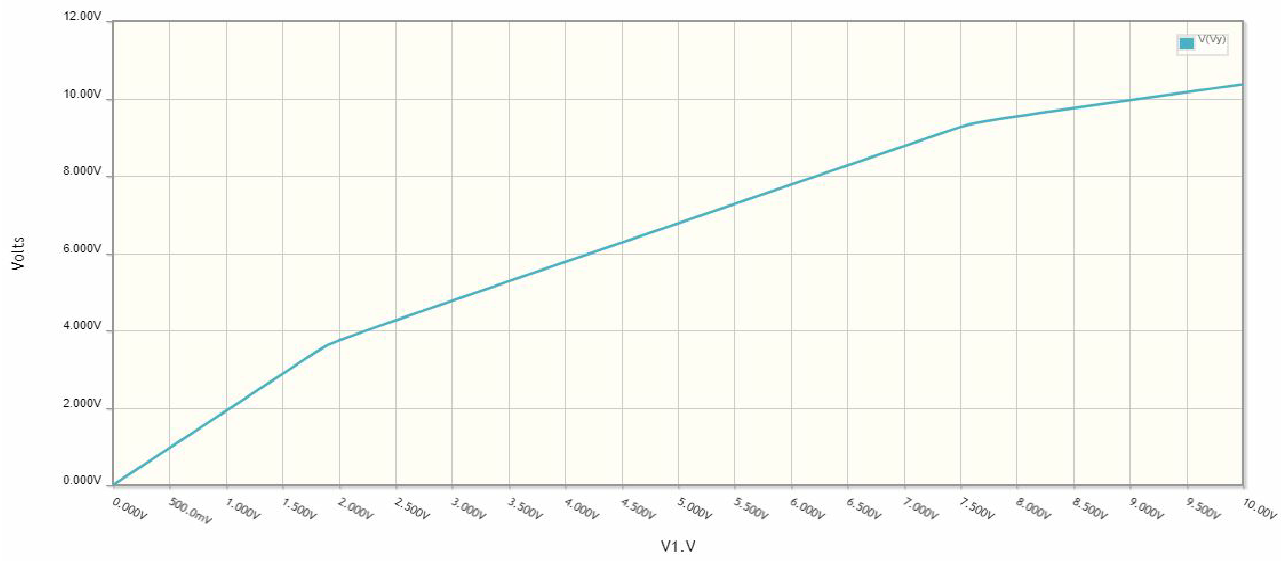
$$gain = 0.4 = \left(\frac{R_{12}}{R_{12} + 1k}\right)(1.933)$$

$$R_{12} = R_1 || R_2 = \left(\frac{0.4}{1.933 - 0.4}\right)1k\Omega = 261\Omega$$

$$R_2 = 345\Omega$$

4) Check your design in CircuitLab

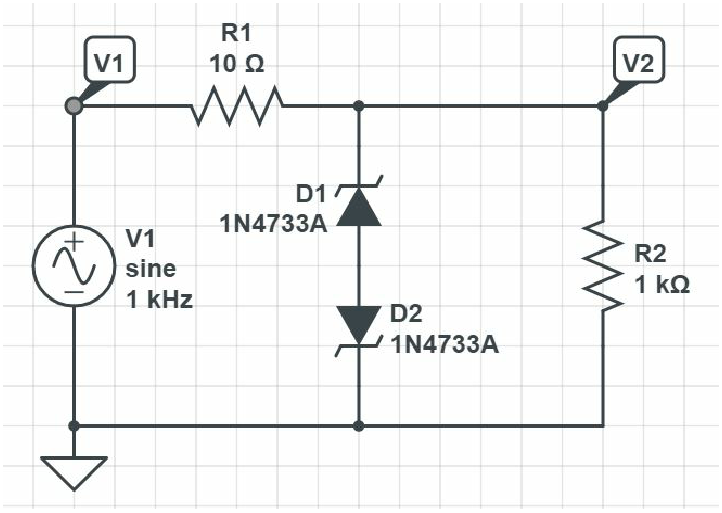




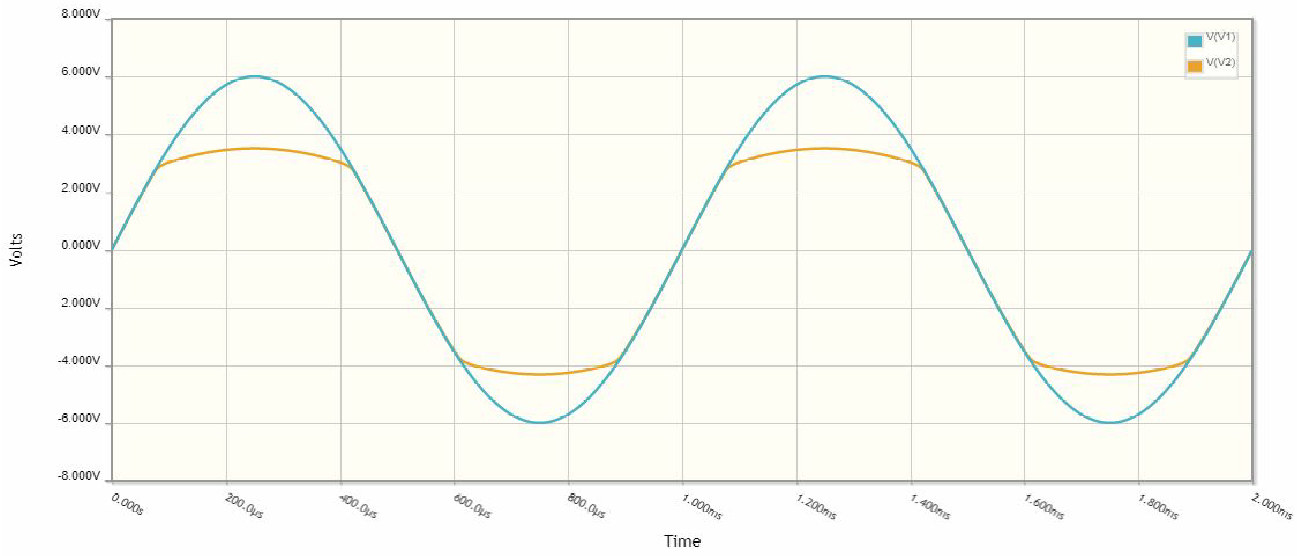
5) Design a circuit which meets the following requirements:

- Input: -10 .. +10V, capable of 100mA
- Output: 1k resistor
- Relationship:

$$V_{out} = \begin{cases} +3V & V_{in} > +3V \\ V_{in} & -4V < V_{in} < +3V \\ -4V & V_{in} < -4V \end{cases}$$



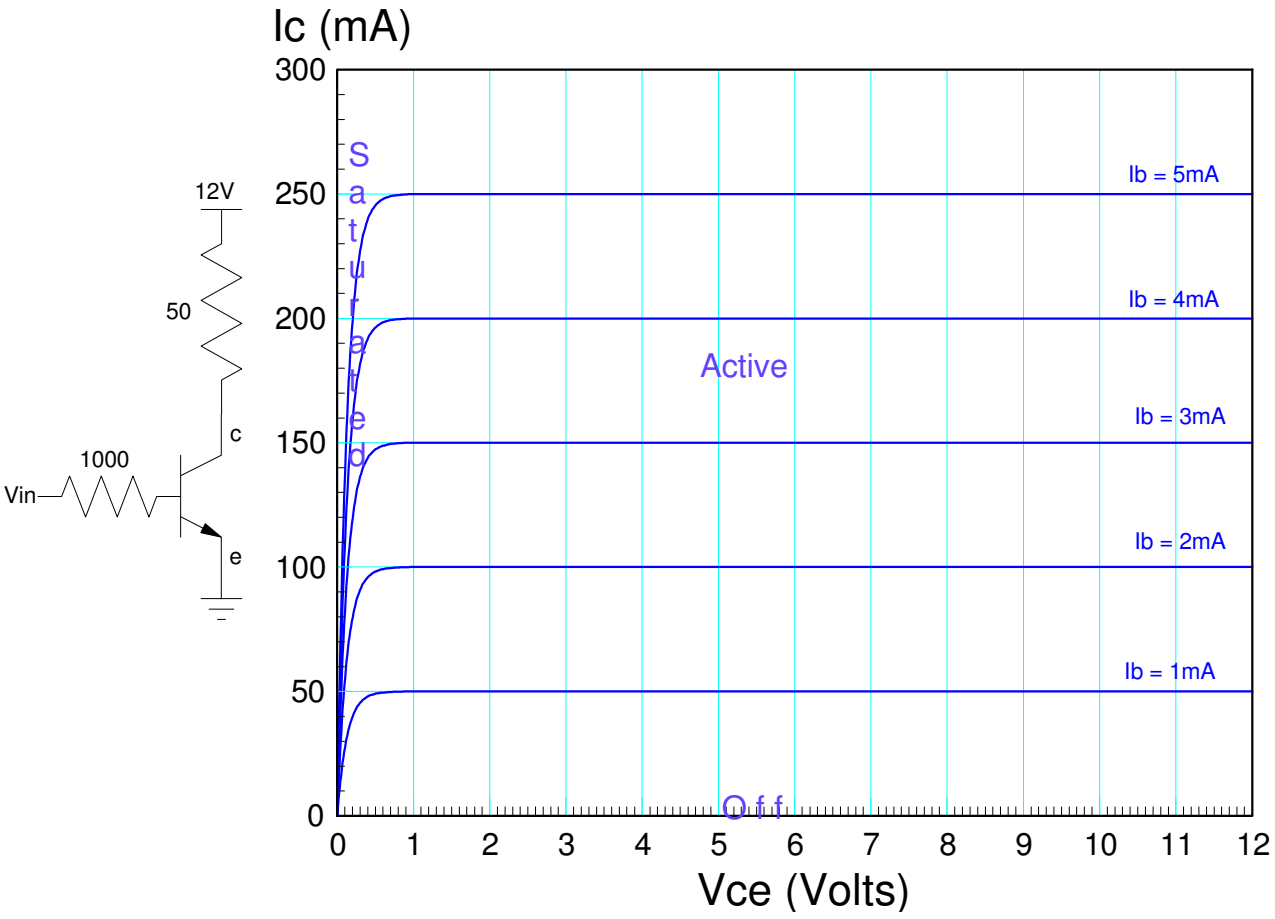
D1 is a 2.3V Zener diode, D2 is a 3.3V Zener diode



Transistors

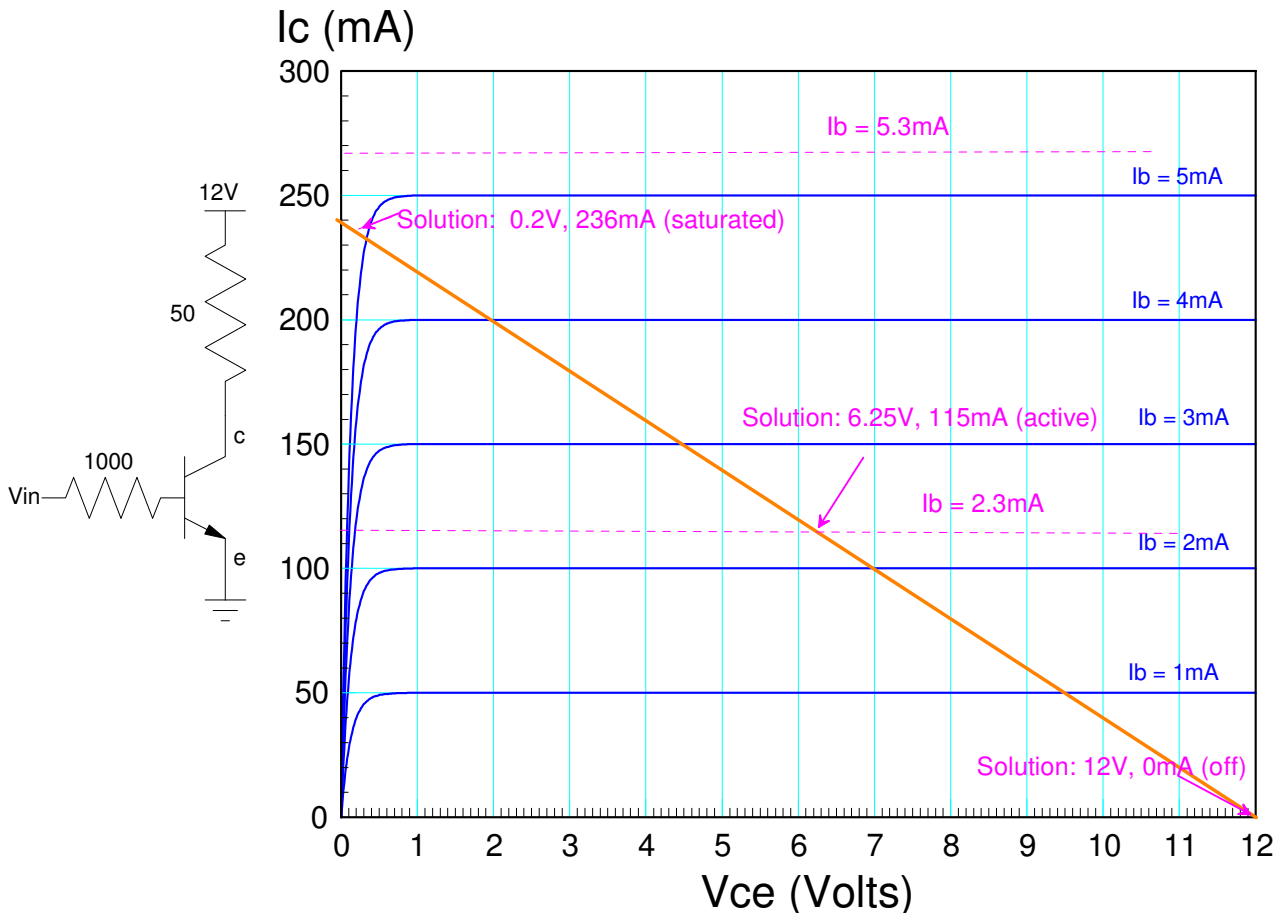
6) Determine the current gain, β, for the transistor show below. Also label the off, active, and saturated regions.

$$\beta = \left(\frac{250mA}{5mA}\right) = 50$$



7) Draw the load-line and determine the Q-point for

- Vin = 0V
- Vin = 3V
- Vin = 6V

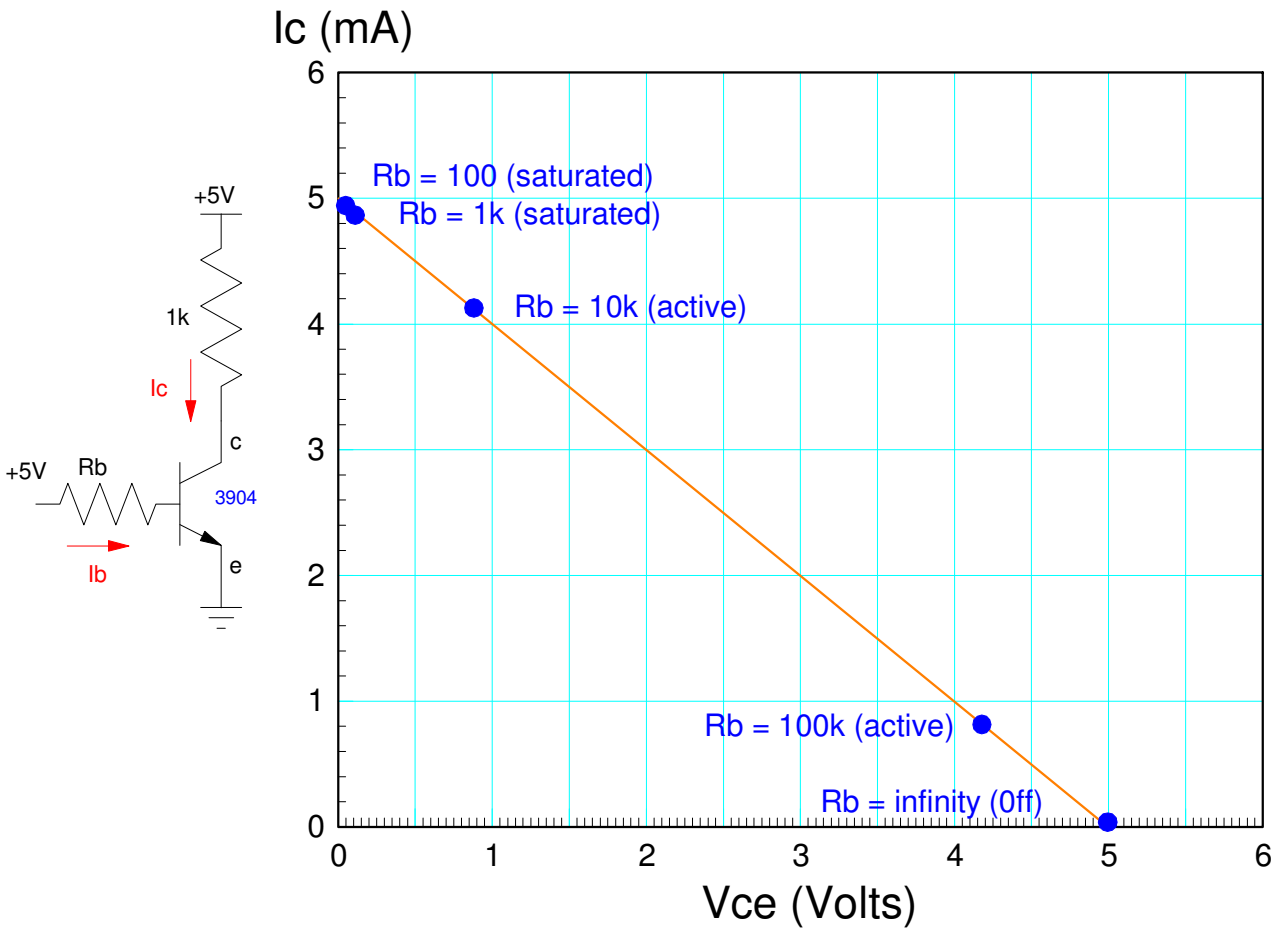


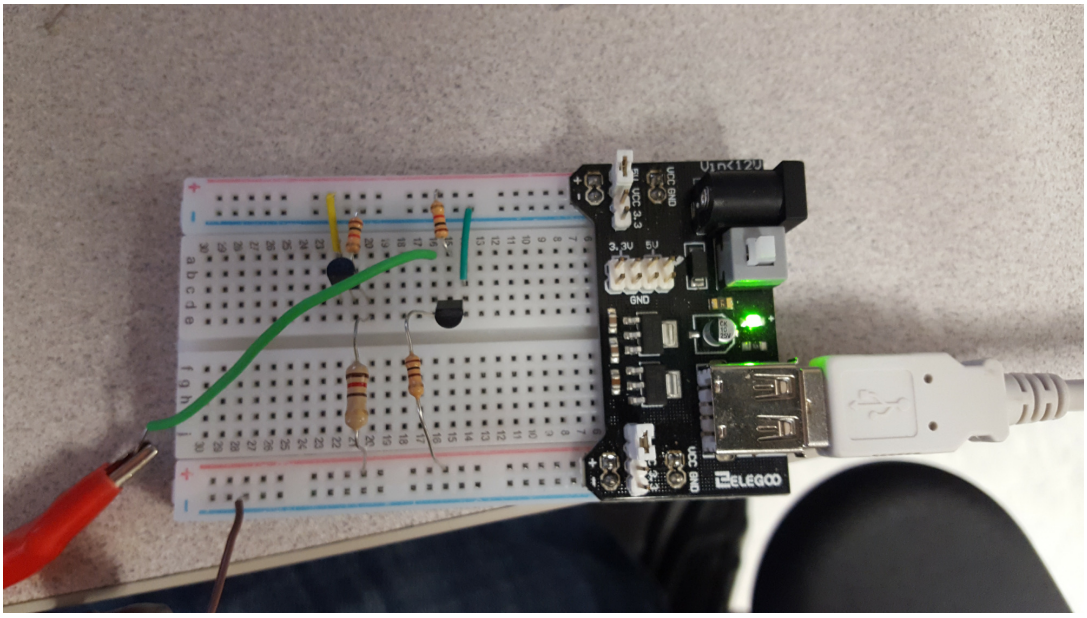
Lab: Please include a photo of your circuit to receive credit for problems 8-10

8-10) Build the following circuit with your electronics kit.

- Measure Vce and Ic for 100 < Rb < infinity.
- Determine the operating point for each conidition and the current gain for your 3904 transistor
- Draw the load line on the graph below and mark each point you measured

Rb	Vb	Vc	Ib	Ic	Current Gain (Ic/Ib)	Operating Region (off / active / saturated)
100 br - bl - br	0.936	0.130	40.64mA	48.70mA	1.198	saturated
1k br - bl - re	0.856	0.157	4.144mA	48.43mA	11.69	saturated
10k br - bl - or	0.819	0.879	418uA	41.21mA	98.56	active
100k br - bl - ye	0.736	4.230	67.9uA	7.70mA	113.3	active
infinity	0	5.03	0	0	n/a	off




VCC GND
VCC 3.3
3.3V 5V
GND
VCC GND
ELEGOO