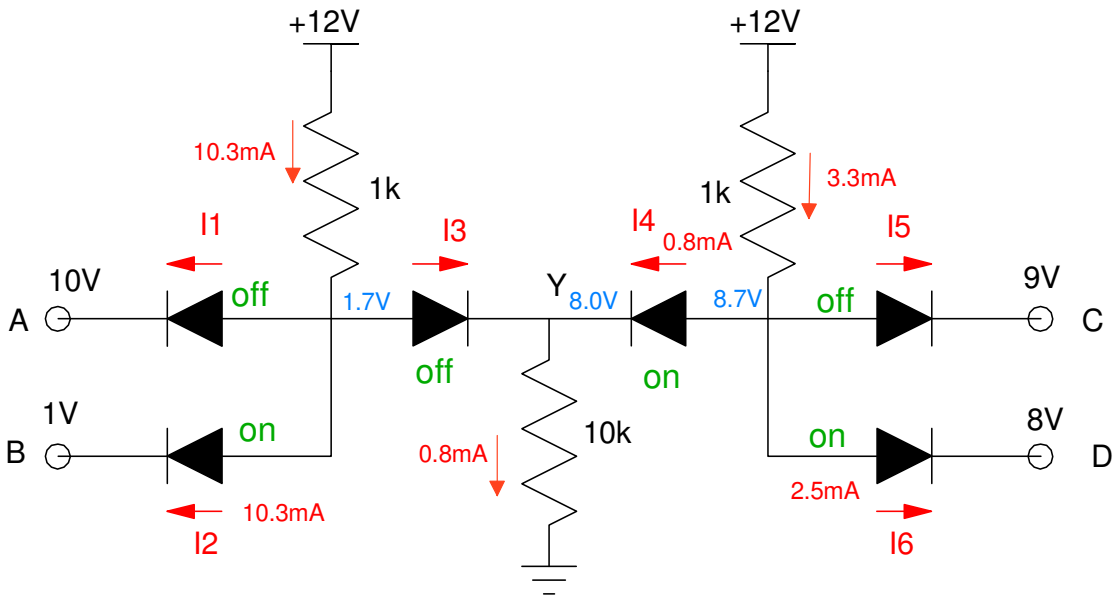
ECE 320 - Homework #4 Solution

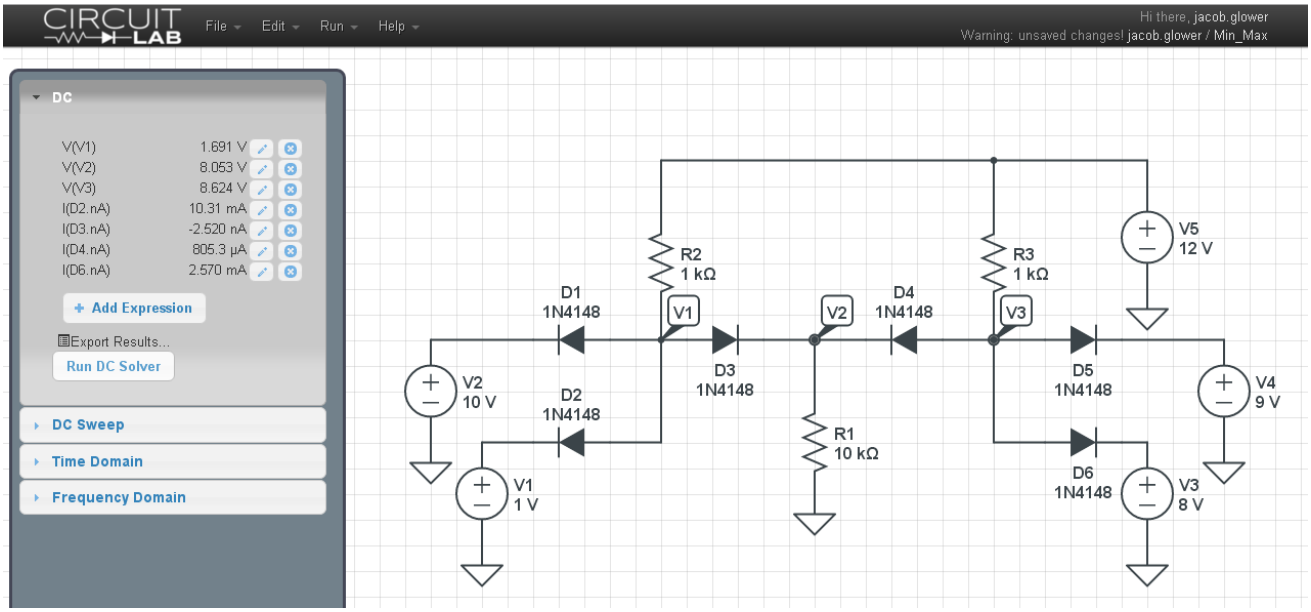
Max/Min Circuits, Clipper Circuits, Transistor Theory. Due Monday, Feb 10th

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)



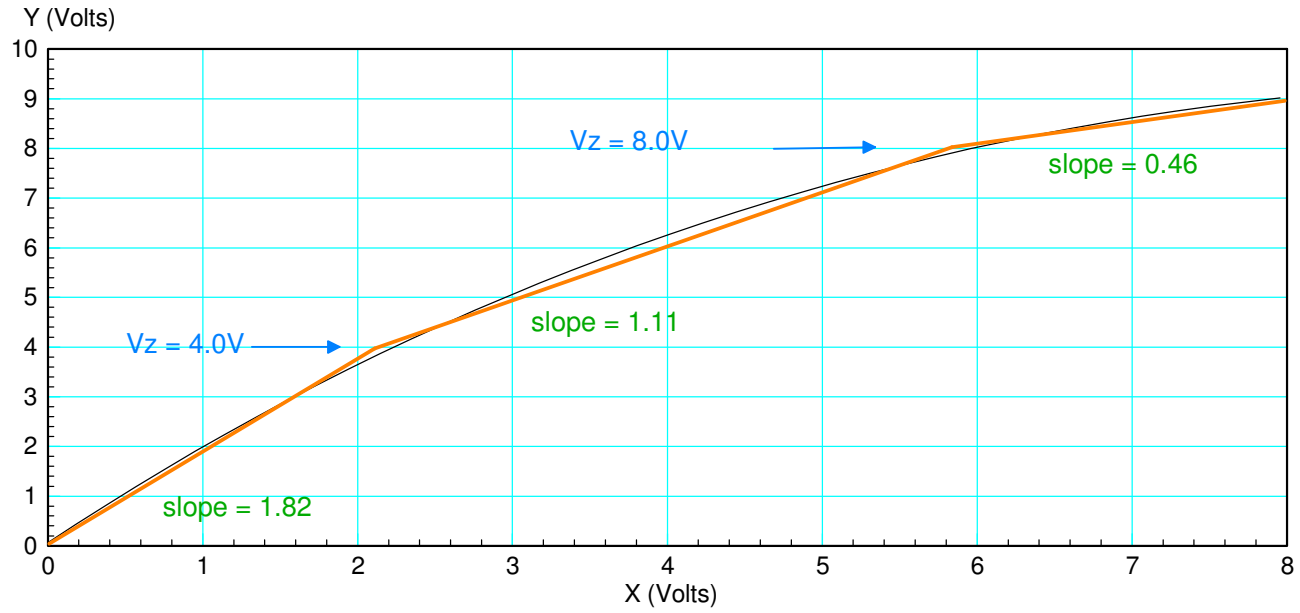
2) Check your results in PartSim (or similar program)



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, +/- 200mV



Op-Amp: To get an intial gain of 1.81, add an op-amp with a gain of 1.81

$$gain = 1 + \frac{R_{16}}{R_{17}}$$

Let R17 = 1k

R16 = 810

Stage 1: Zener voltage = 4.0V

$$gain = \left(\frac{R_{19}}{R_{19+R_{18}}}\right) \cdot 1.81 = 1.11$$

$$\left(\frac{R_{19}}{R_{19}+1k}\right) = \frac{1.11}{1.81} = 0.613$$

$$R_{19} = \left(\frac{0.613}{1-0.613}\right) 1k = 1586\Omega$$

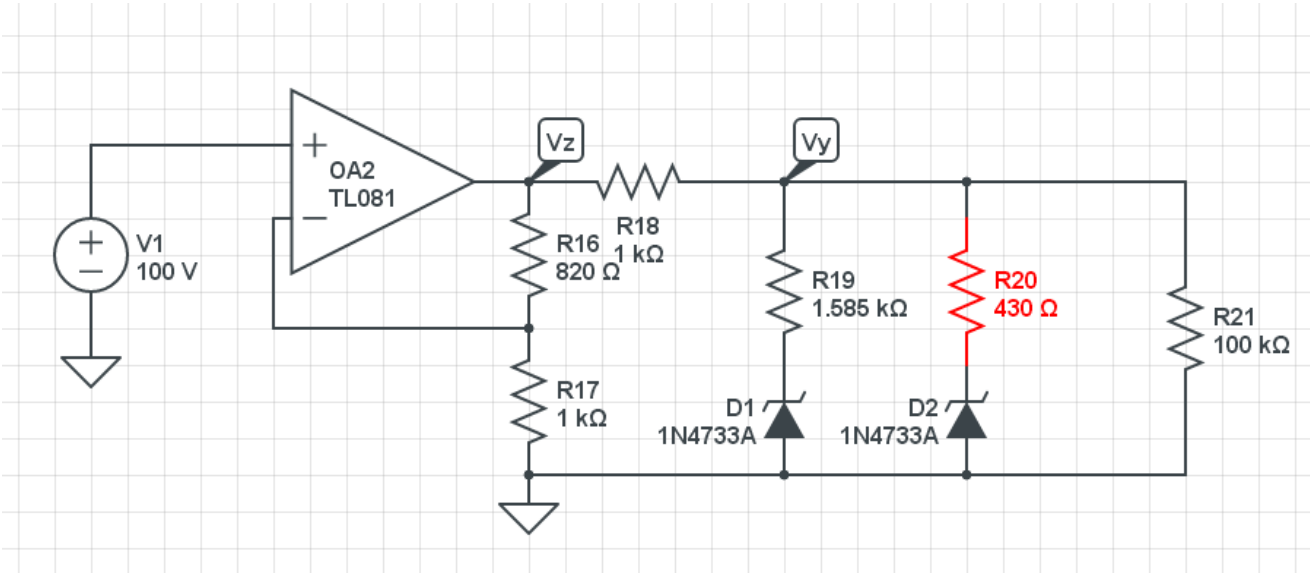
Stage 2: Zener voltage = 8.0V

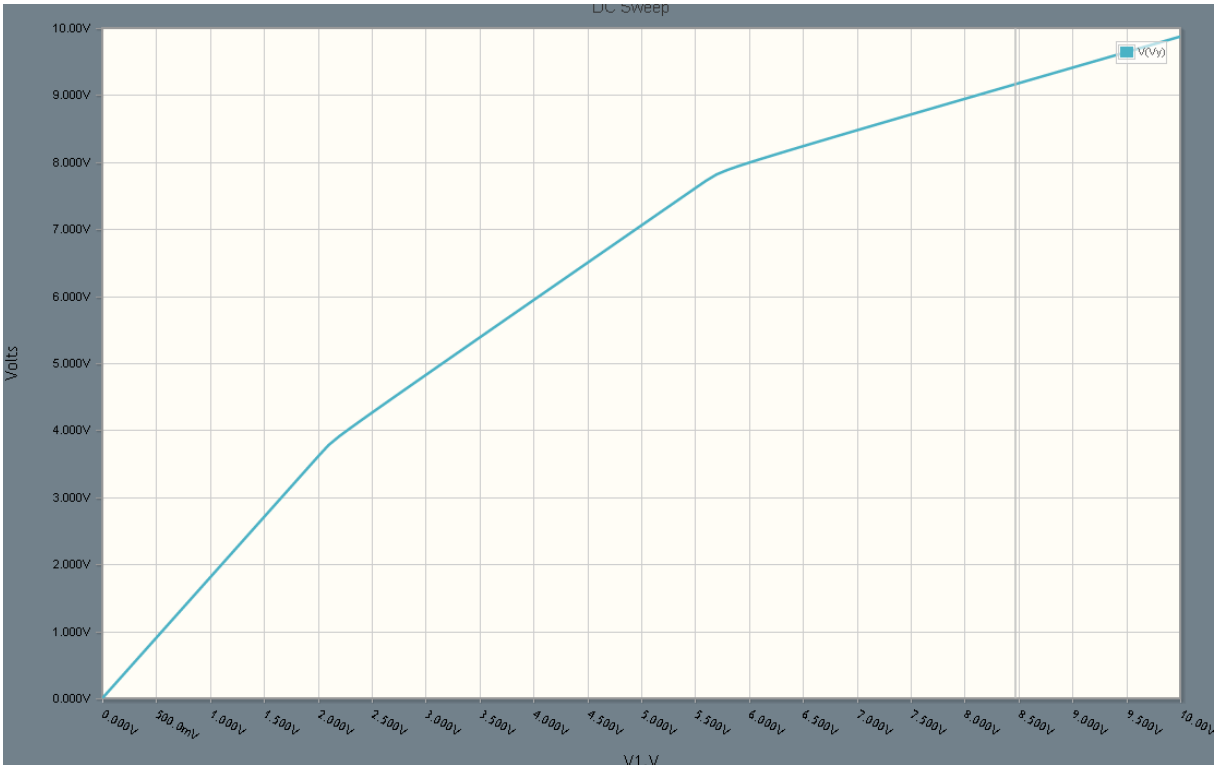
$$gain = \left(\frac{R_{net}}{R_{net}+R_{18}}\right) \cdot 1.81 = 0.46$$

$$R_{net} = 341\Omega = R_{19} || R_{20}$$

$$R_{20} = 430\Omega$$

4) Check your design in PartSim

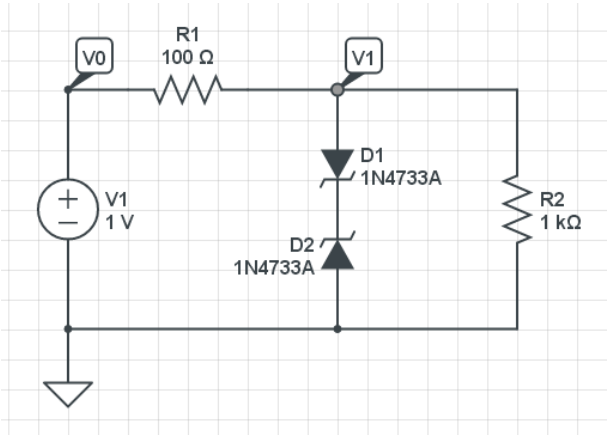




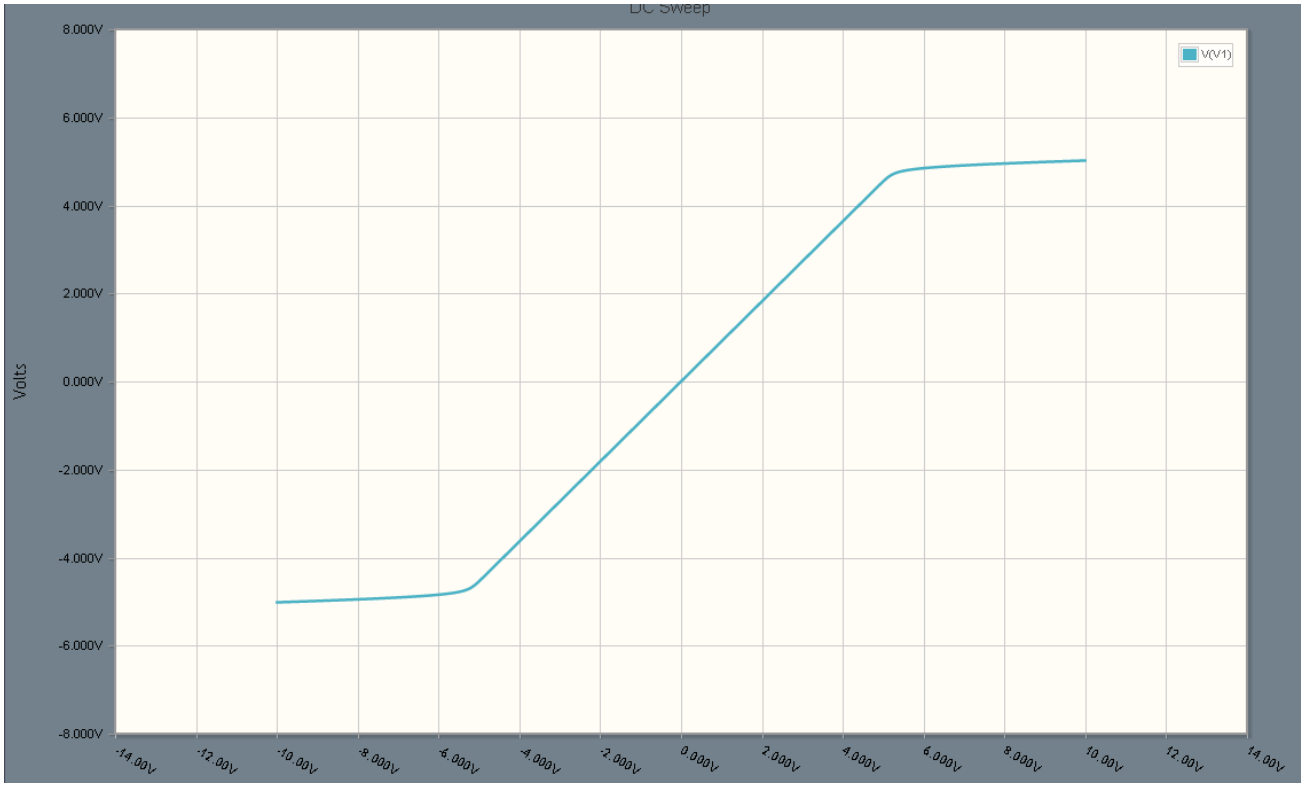
5) Design a circuit which meets the following requirements:

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

$$V_{out} = \begin{cases} +5V & V_{in} > +5V \\ V_{in} & -5V < V_{in} < +5V \\ -5V & V_{in} < -5V \end{cases}$$



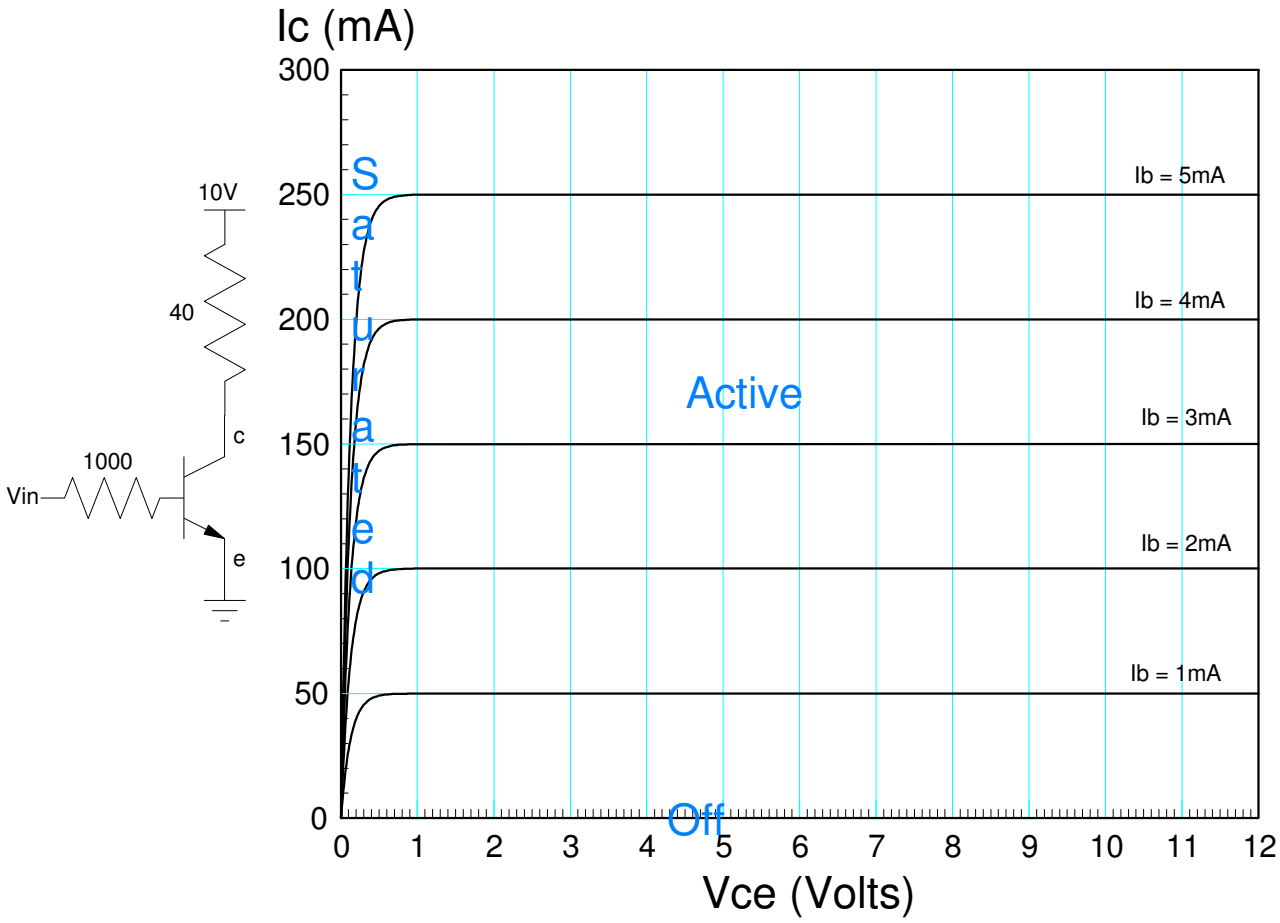
Both diodes are 4.3V zeners



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

- Ib = 0
- Ic = 0
- Q-Point: (10V, 0mA) *off*

Vin = 3V

$$I_b = \left(\frac{5V - 0.7V}{1000\Omega}\right) = 2.3mA$$

$$\beta I_b = 115mA$$

Q-Point: (5.4V, 115mA) *active*

Vin = 6V

$$I_b = \left(\frac{6V - 0.7V}{1000\Omega}\right) = 5.3mA$$

$$\beta I_b = 265mA > \frac{10V - 0.2V}{40\Omega} = 245mA$$

Q-Point: (0.2V, 245mA) *saturated*