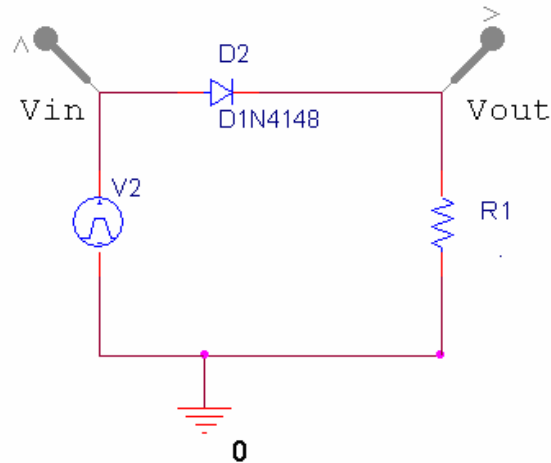Name_____

Section _____

Question 1 – Diodes
Assume that the forward bias threshold voltage for the diode in the circuit is 0.7V.

A. Consider the following circuit

a) What type of diode circuit is the circuit above? (1 pt)

b) What will be the voltage at Vout be when the input voltage is at the following levels:
(1 pt each = 7 pt)

Vin = 0V

Vin = 0.5V

Vin = -0.5V

Vin = 3V

Vin = -3V

Vin = 5V
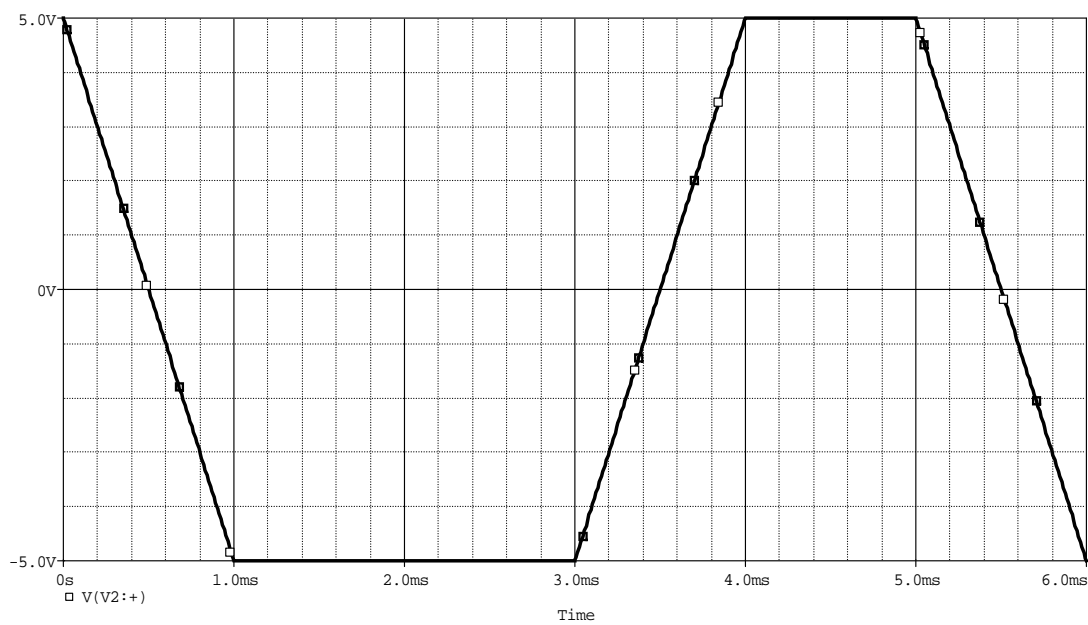
Vin = -5V

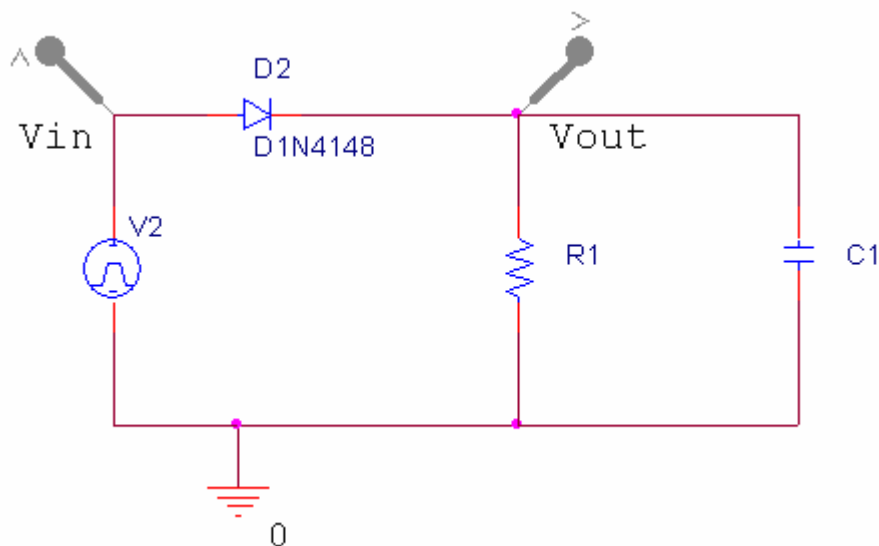c) If R1=900Ω, what will be the current through the circuit when Vin has the following values: (2 pt each = 4 pt)

Vin = 3V

Vin = -0.5V

d) Sketch the output of the above circuit for the following input. (4 pt)

B. Now we add a capacitor in parallel with the load resistor, as shown below:


2

a) If C2 is 10µF and R1=900Ω, what is the time constant, τ, of the RC circuit combination R1-C2? (3 pt)

b) Assume that the capacitor discharges at a linear rate of $3/\tau$ V/s at the beginning of its discharge cycle. (In other words, assume a linear rate of discharge of $3/\tau$.) Plot the output of the circuit with the smoothing capacitor. (Note that this plot does not start at time t=0, so you can assume the signal has already reached steady state.) (6 pt)
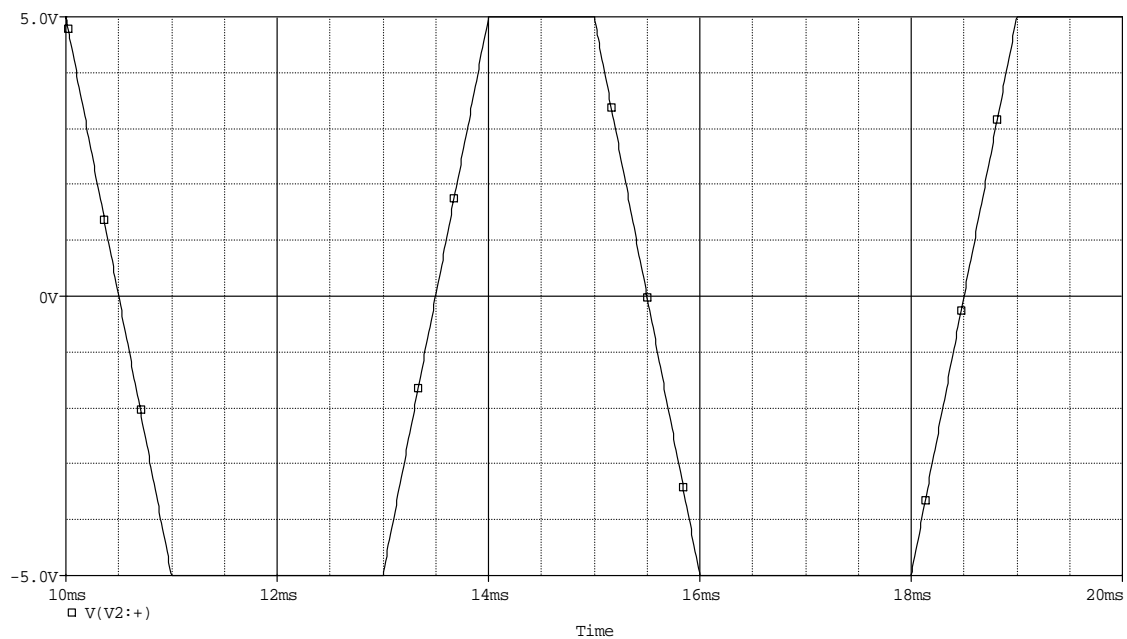
Show work here:

Question 2 – Zener diodes

Part A: Characteristic curve -- The following plot shows the characteristic curve for a Zener diode.
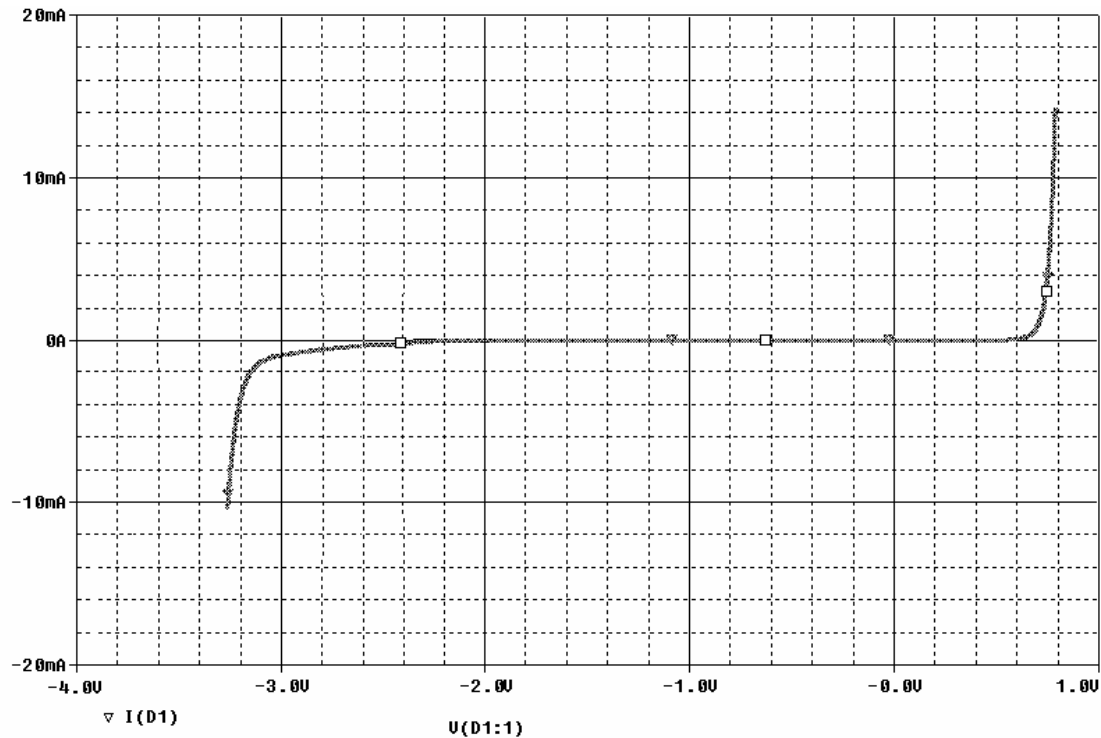
a) Mark the following regions on the plot: (6 pt)

The forward bias region   The reverse bias region   The Zener region

b) Estimate the Zener voltage for this diode to the nearest 0.1 of a volt. (2 pt)

c) If the knee current of this diode is the current at the point where the voltage across the diode is within 0.1V of the Zener voltage, what is the knee current of this diode? (3 pt)
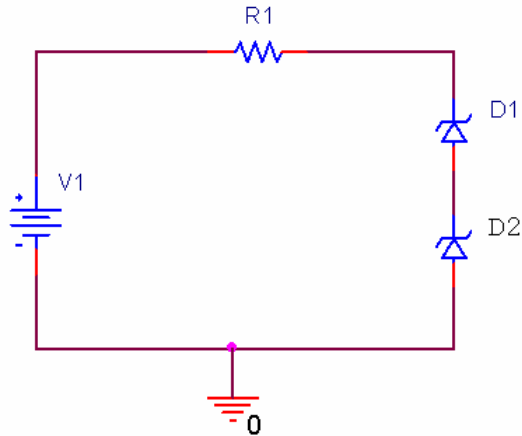
d) Mark the knee current and the Zener voltage on the plot of the characteristic curve. (2 pt)

Part B – Zener diode circuit -- We place two of these Zener diodes in a circuit as shown below.

a) What region will the Zener diodes be in, forward bias (FB), reverse bias (RB), or Zener (Z), when the input voltage at V1 is each of the following? (1 pt each = 6 pt)

      -7.5V   D1:   D2:

      -3.5V   D1:   D2:

      -1.0V   D1:   D2:

       1.0V   D1:   D2:

       3.5V   D1:   D2:

       7.5V   D1:   D2:

b) What will the current through the circuit be if R1=2K and the voltage at the input is each of the following? (2 pt each = 6 pt)
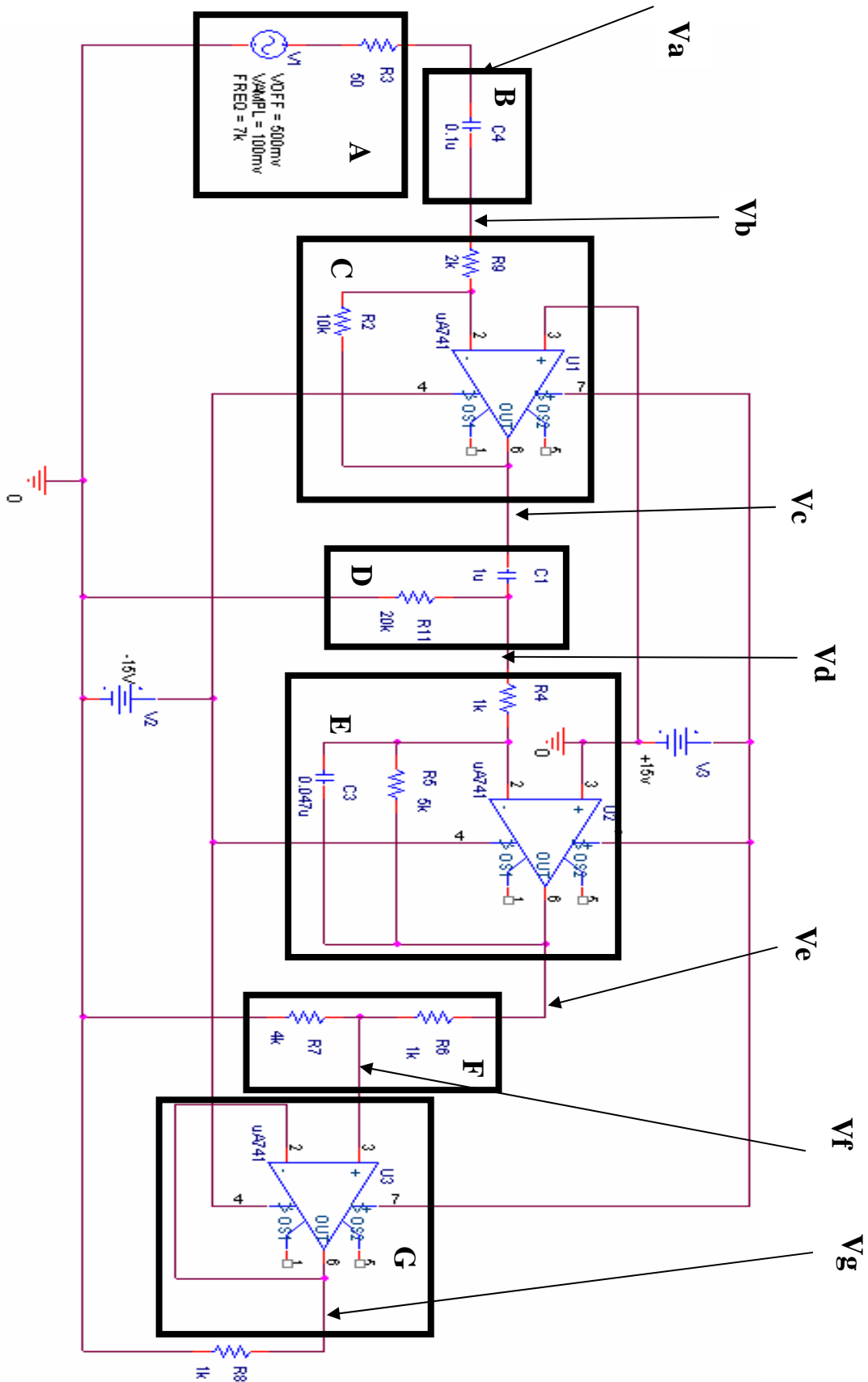
      -7.5V:

      3.5V:

      7.5V:

Question 3 – Circuit Functionality

In the circuit on the previous page, the circuit blocks are identified by capital letters. The voltage levels between the blocks (measured relative to ground) are identified by the notation Vx.

Part A: Identify each of the blocks in the circuit

  A (1 pt):

  B (1 pt):

  C (1 pt):

  D (1 pt):

  E (1 pt):

  F (1 pt):

  G (1 pt):

Part B: Analyze circuit blocks.

a) What does resistor R3 represent? (1 pt)

b) What is the gain of block C (include the sign)? (1 pt)

c) What if the corner frequency in Hertz of block D? (2 pt)

d) What is the corner frequency in Hertz of block E ? (2 pt)

e) What is the gain of block E at frequencies significantly below the corner frequency (include the sign)? (1 pt)

f) What is the gain of block E at frequencies significantly above the corner frequency (include the sign)? (1 pt)

g) If the voltage at Ve is 10V, what will the voltage at Vf be? (1 pt)

h) If the voltage at Vf is 5V, what will the voltage at Vg be? (1 pt)

i) If the voltage at Vg is 3V, what will the current through R8 be? (1 pt)

Part C – Block input and output (6 pt)

The following 6 plots show the input and output to blocks B, C, D, E, F and G when the
input at block A is set to the values shown in the circuit diagram. All show two traces.
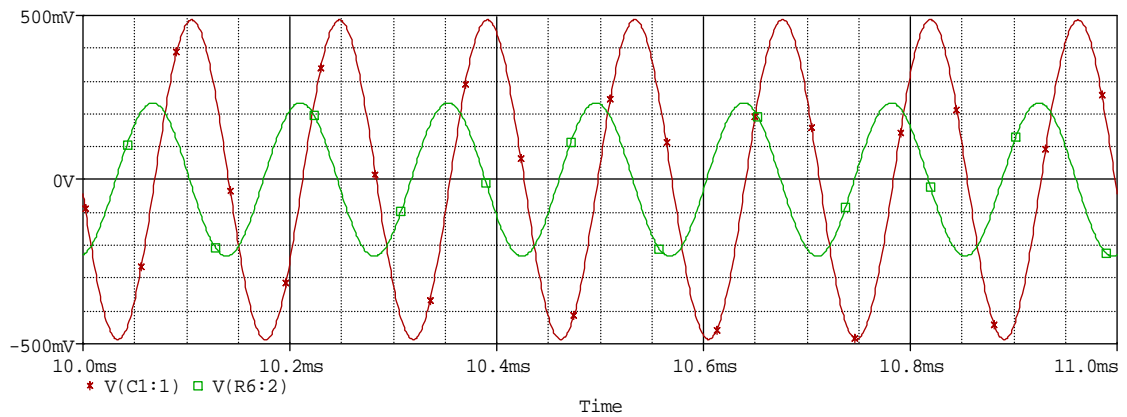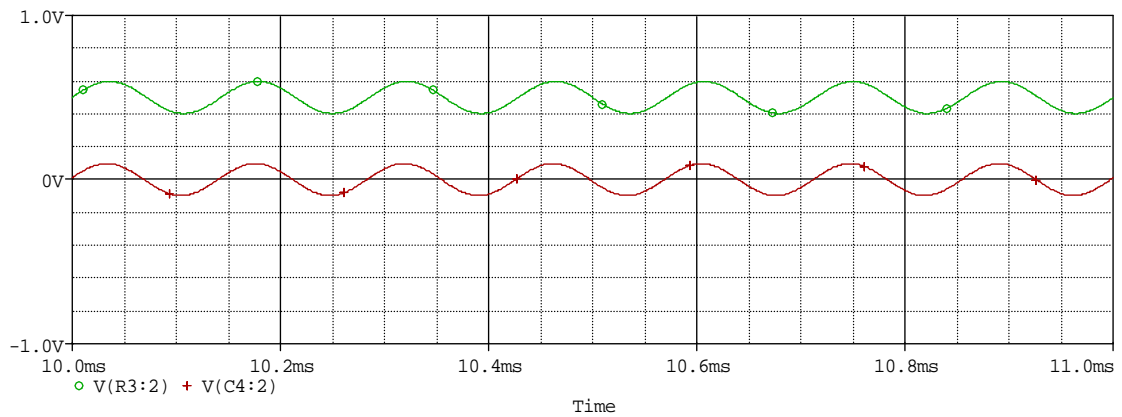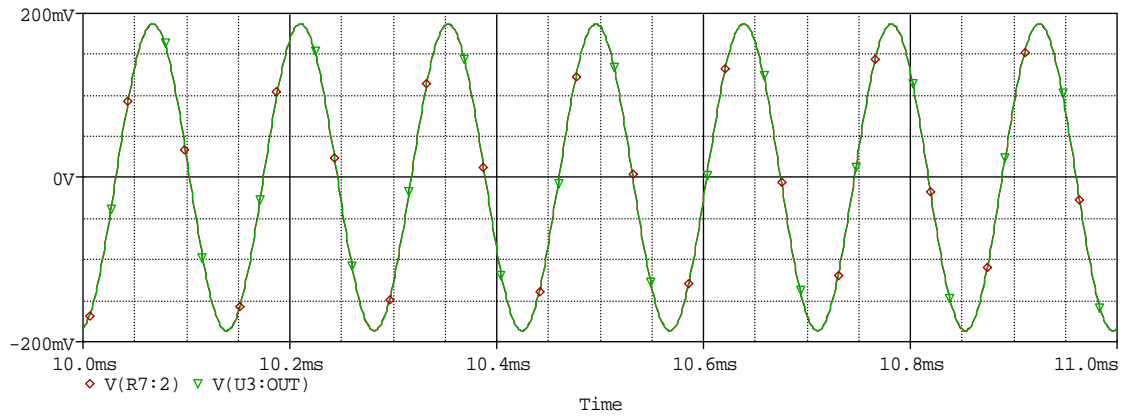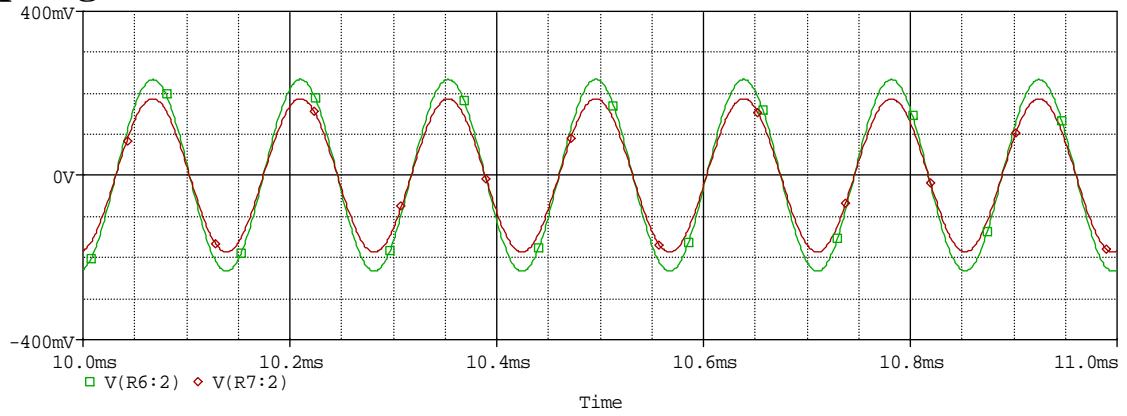Identify which is which.

V(R6:2)   V(R7:2)
Time

V(R7:2)   V(U3:OUT)
Time

V(R3:2)   V(C4:2)
Time

V(C1:1)   V(R6:2)
Time
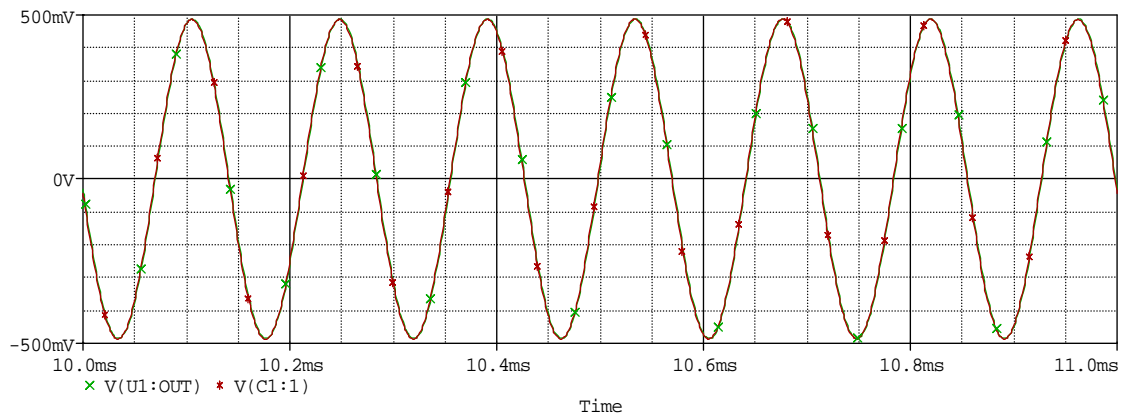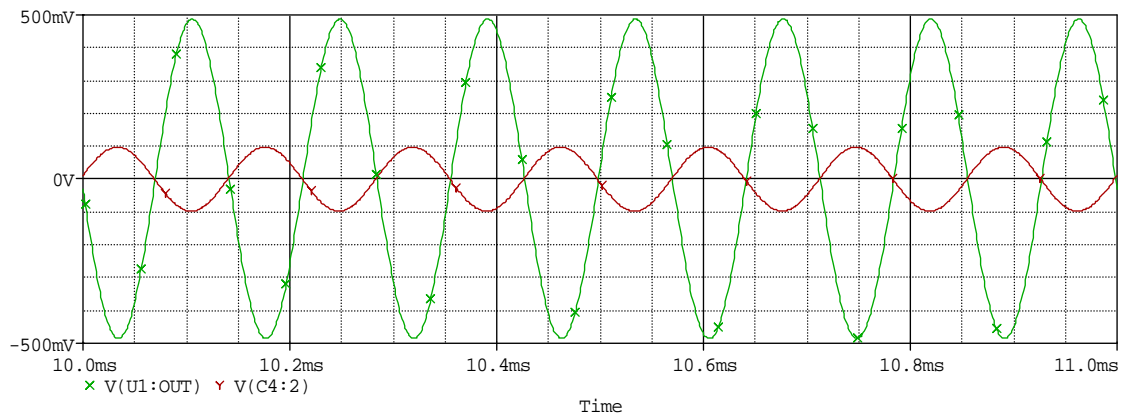
Question 4 – Circuit Functionality

Having just been hired as the only engineer in a new start-up company, your supervisor has provided the following circuit from an applications note that she thinks might work for controlling a motor on your first project. It has some symbols/components you are not familiar with, but you recognize most of the components from your experience in EI.
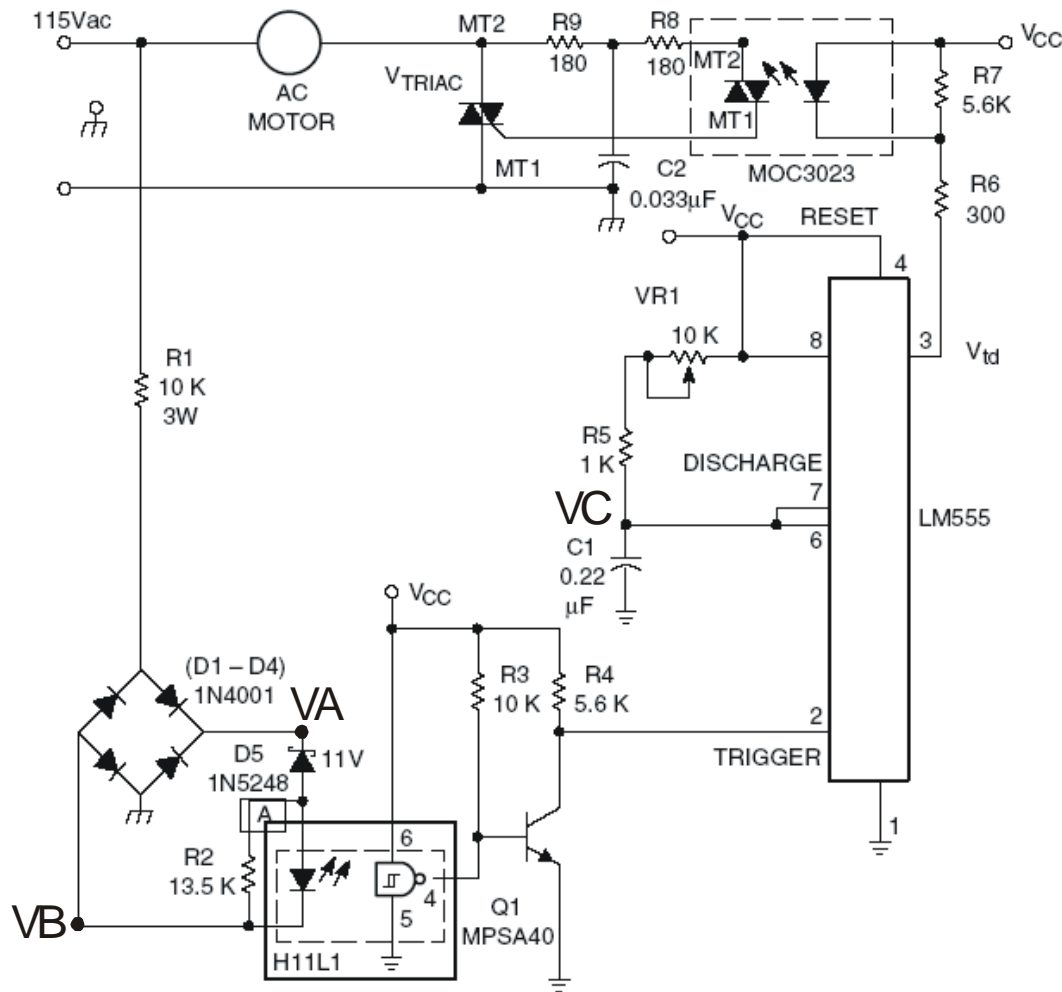
From a quick web search, you learn that an MOC3023 is an optically isolated triac driver, and a triac is a solid state device for controlling AC power. The Triac looks like this

 . The machine will be used in the US, which you know has AC power that is nominally 115V oscillating at 60Hz.

a) Circle and label the following circuit blocks in the diagram. (1 pt each = 7 pts)

1 – 2 LEDs	2 – Full Wave rectifier	3 – Monostable multivibrator
4 – transistor	5 – Schmitt trigger	6 – Zener diode
7 – AC Motor		

b) The Zener diode is used to (select one): (2 pts)

       Thermally protect the circuit   Limit Current

       Rectify the input signal   Limit Voltage

c) The Zener voltage of the Zener diode is: (2 pts)

d) The LED in the H11L1 has a forward bias voltage drop of 1.2V. When the diode is lit, what is the current through R2? (3 pts)

e) What is the maximum voltage between test points VA and VB? (2 pts)

f) After searching the web for the H11L1 data sheet, you confirm that when the LED is on, the Schmitt trigger output is low, and when it's off, the output is high. The 555 timer begins capacitor charging when the trigger signal falls from logic high to logic low. How frequently does this occur? (2 pts)

g) Based on your knowledge of the 555 timer, what is the charging time constant for capacitor C1 when potentiometer VR1 is set in the middle of its range of adjustment? (3 pts)

h) Pin 7 of the 555-timer is the discharge pin, what device is this connected directly to inside the 555 timer based on the model from project 3? (2 pts)

       Flip-Flop   transistor   comparator   NAND gate (or equivalent)

i) Approximately how long will it take for this capacitor to discharge once the threshold has been reached? (1 pt)

j) If you didn't have R1 as specified when you had to build this circuit, which of the following could you most likely safely replace it with (1 pt)

1. A 30k 1/4W carbon film resistor from your EI parts kit

2. A 1k, 30W wire wound resistor

3. A 12k, 4W resistor of unknown construction

4. A zener diode with at least a 115V zener voltage

Extra Credit (1pt): What does the circuit do? The i-v characteristic curve of a triac, shown below, will help you understand what it does.
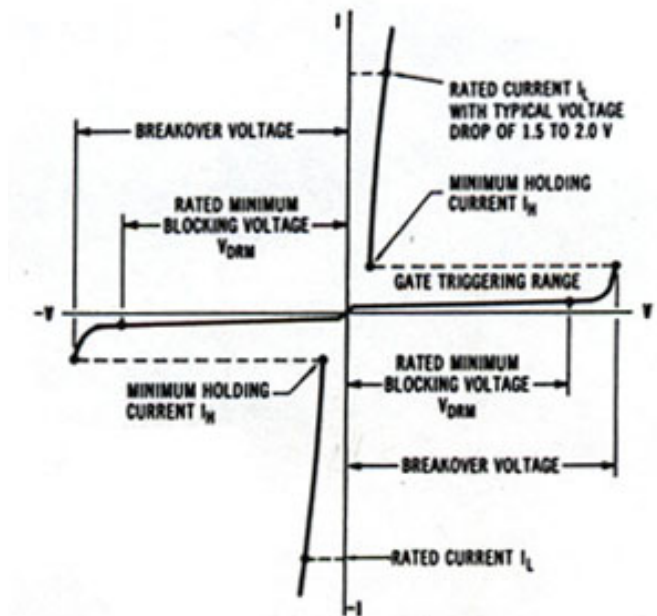
Typical triac VI characteristic curves.