

UNIVERSITY OF CALIFORNIA, BERKELEY
Department of Electrical Engineering and Computer Sciences

EE100/EE42
Intro. To Electronics Engineering

Fall 2008
Prof. Leon O. Chua

MIDTERM
October 14th 2008
Time Allotted: 1.5 hours

NAME: Solutions _____ , _____
(print) Last First

STUDENT ID#: _____ CIRCLE ONE: EE100 EE42

I WILL NOT CHEAT ON THIS EXAM. Signature: _____

Note(s):

1. MAKE SURE THE EXAM HAS 15 NUMBERED PAGES.
2. This is a CLOSED BOOK exam. However, you may use ONE 8.5 x 11" of notes (both sides) and a calculator.
3. SHOW YOUR WORK on this exam. MAKE YOUR METHODS CLEAR TO THE GRADER so you can receive partial credit.
4. WRITE ANSWERS CLEARLY IN THE SPACES (lines, boxes or table) PROVIDED.
5. Remember to specify units on answers whenever appropriate.
6. IF YOU ARE WRITING TOO MUCH, YOU ARE PROBABLY MAKING A MISTAKE!

SCORE: 1: _____ / 25

2: _____ / 10

3: _____ / 15

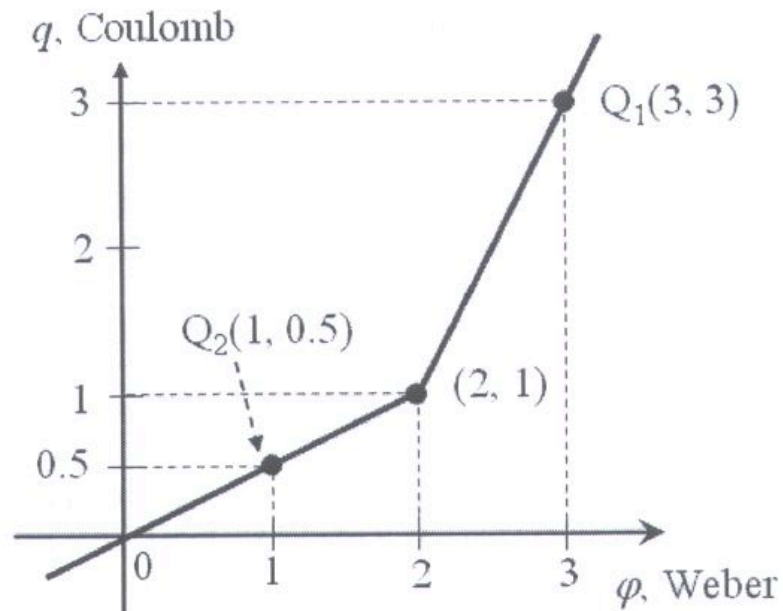
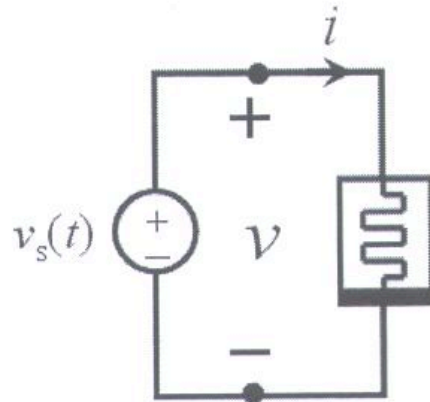
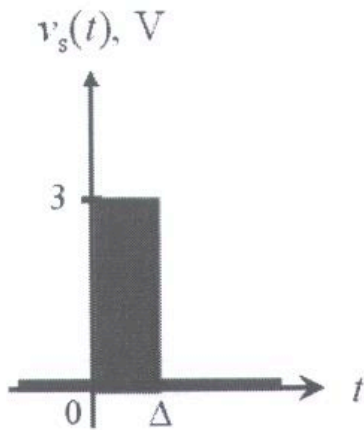
4: _____ / 15

5: _____ / 25

6: _____ / 10

TOTAL: _____ / 100

PROBLEM 1 [25 points]



Consider the same memristor circuit from homework #5 (refer to figure above). Assuming $\phi(0) = q(0) = 0$ at time $t = 0$, find the pulse width Δ for the memristor to be biased at the operating points $Q_1(3, 3)$, and $Q_2(1, 0.5)$, respectively.

Δ for $Q_1(3, 3)$: 1 sec

Δ for $Q_2(1, 0.5)$: $\frac{1}{3}$ sec

EXTRA WORKSPACE FOR PROBLEM 1

Work

- Since we have voltage source across the memristor, we can find the flux across it as a function of time

$$\begin{aligned} \phi(t) &= \int_{-\infty}^t v_s(\tau) d\tau \\ &= \int_{-\infty}^0 v_s(\tau) d\tau + \int_0^t v_s(\tau) d\tau \end{aligned}$$

I.C.: $\phi(0) = 0$

For any $t > \Delta$, the integral reduces to

$$\phi(t) = \underset{\downarrow}{3} \underset{\downarrow}{\Delta} \text{ for } t > \Delta$$

- Now, let's bias the memristor at $Q_1(3,3)$

$$Q(\Delta) = 3\Delta = 3 \Rightarrow \boxed{\Delta = 1 \text{ sec}}$$

Similarly, let's bias the memristor at $Q_2(1,0.5)$

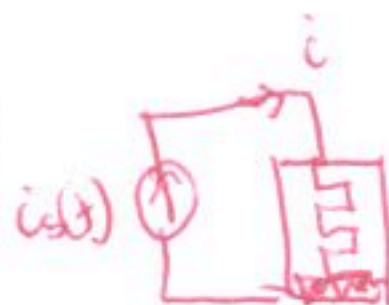
$$Q(\Delta) = 3\Delta = 1 \Rightarrow \boxed{\Delta = \frac{1}{3} \text{ sec}}$$

↳ don't forget units!

Note

- we were using a current source, then we could find the charge as a function of time

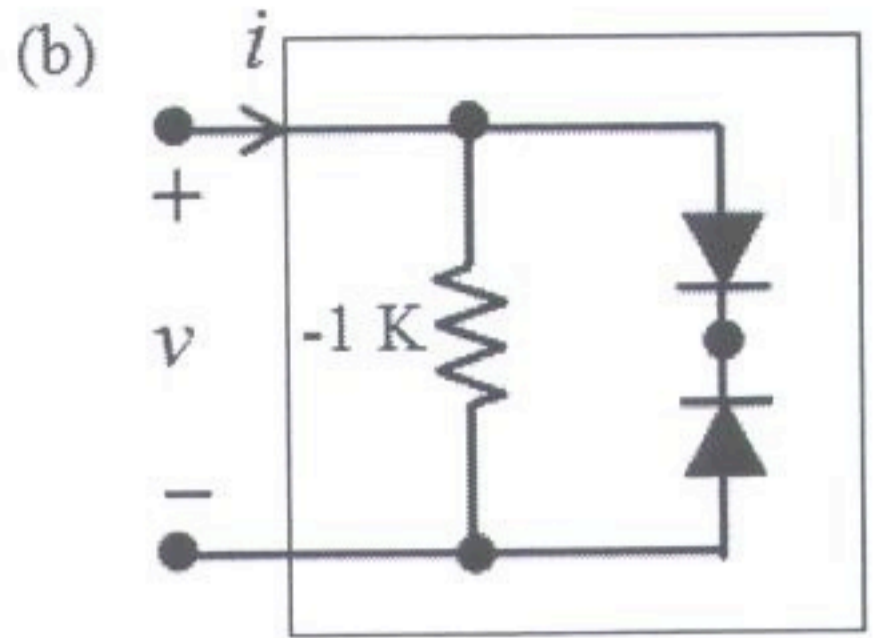
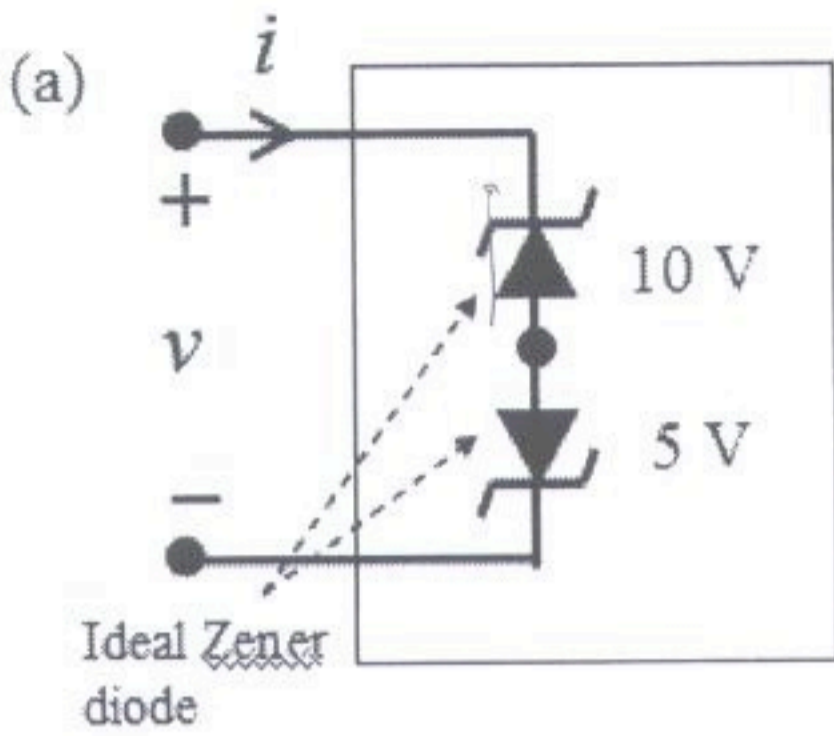
$$q(t) = \int_{-\infty}^t i_s(\tau) d\tau$$



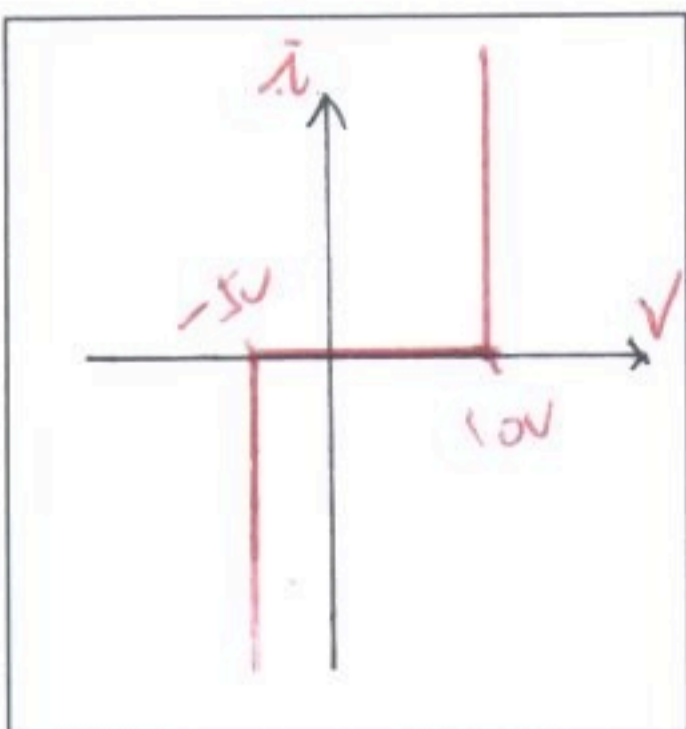
To bias the memristor, look at the charge necessary.

PROBLEM 2 [10 points]

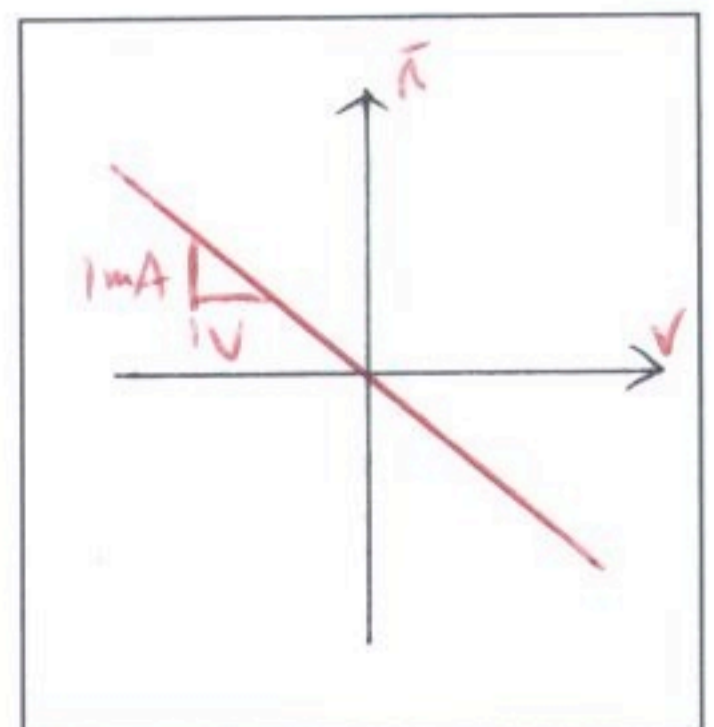
Find and sketch the DP plot of the following one-ports:



Sketch DP plot in the correct boxes below. Please label axes with correct units.



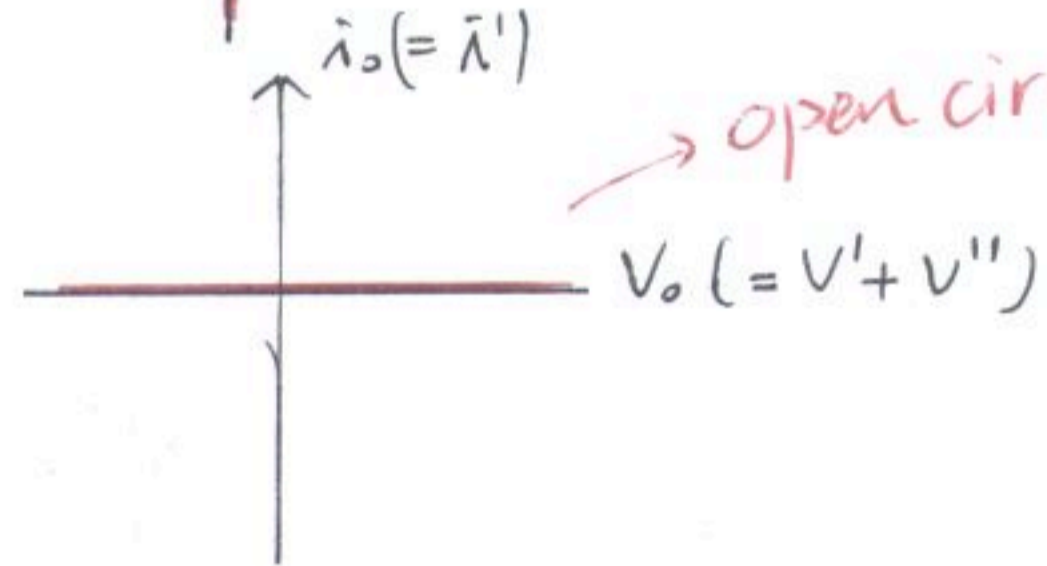
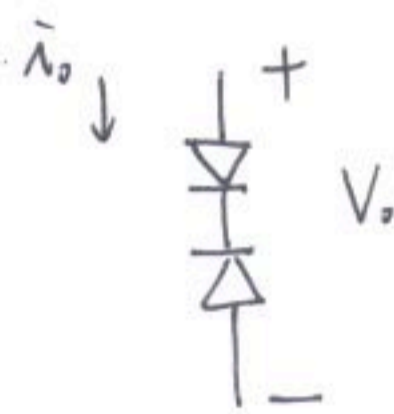
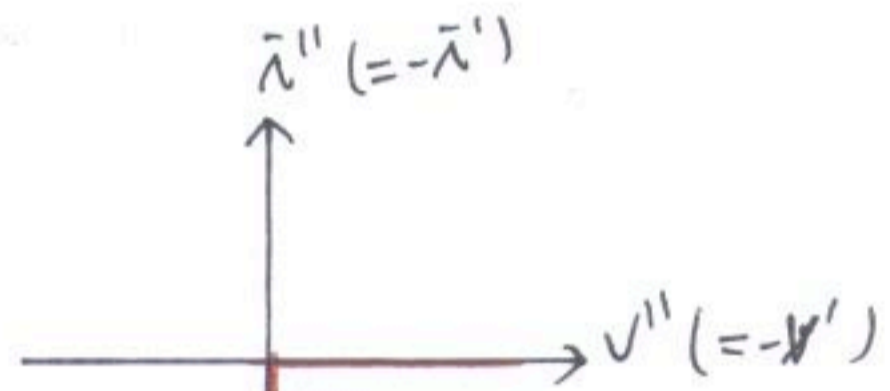
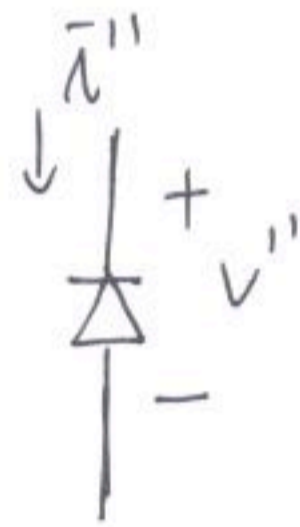
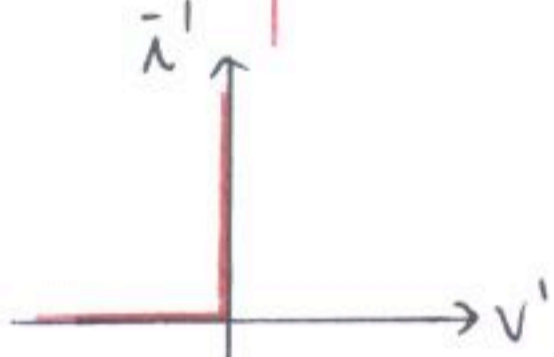
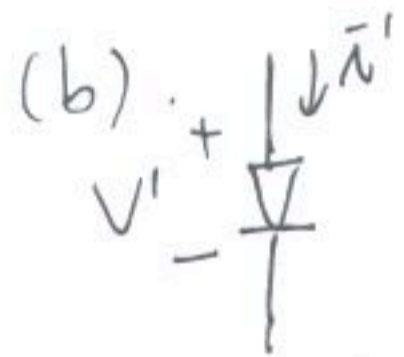
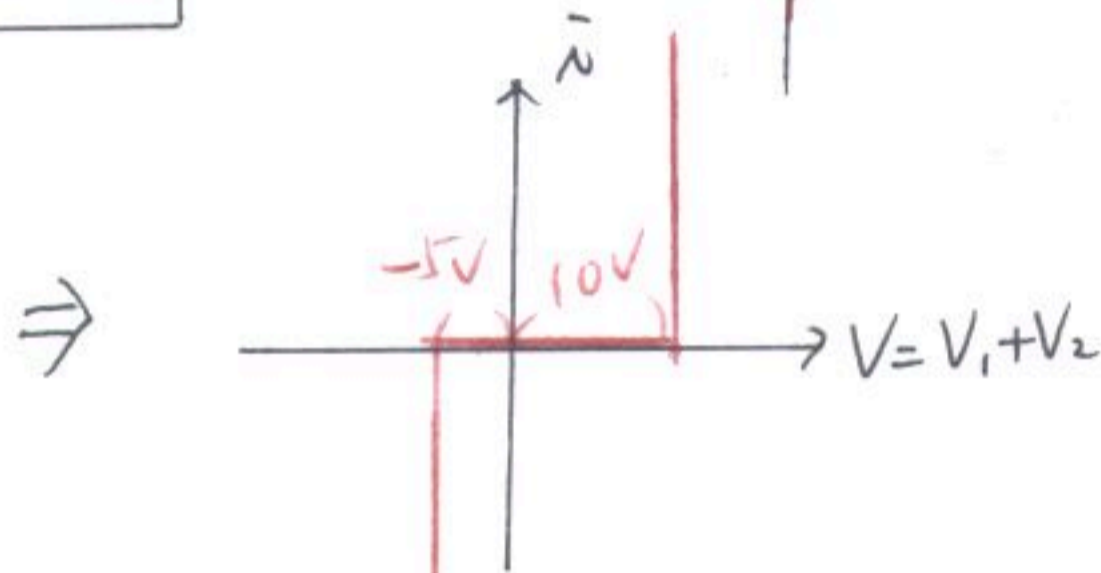
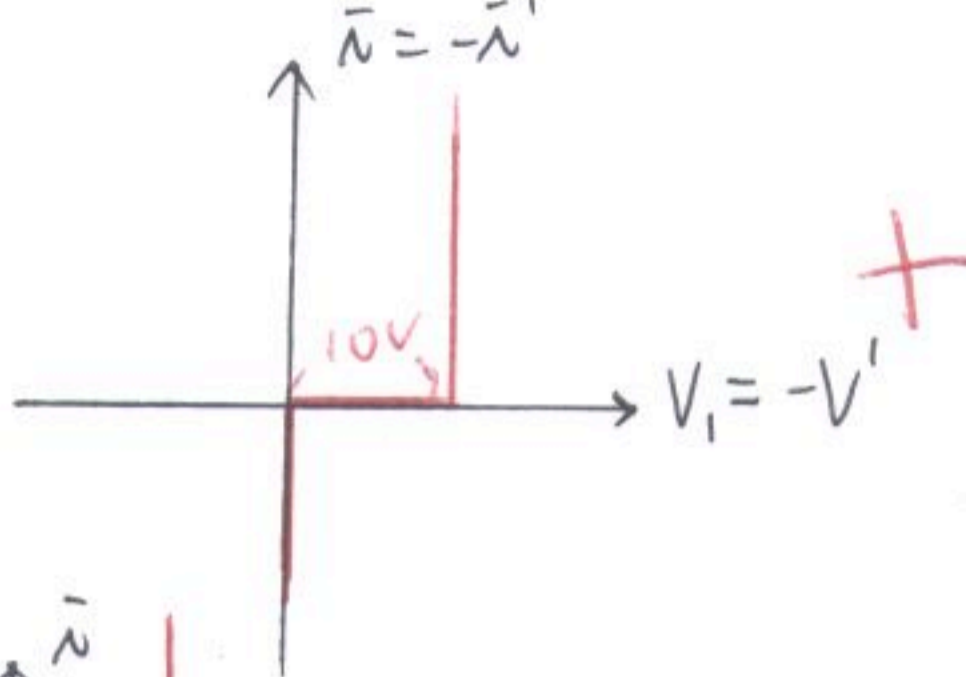
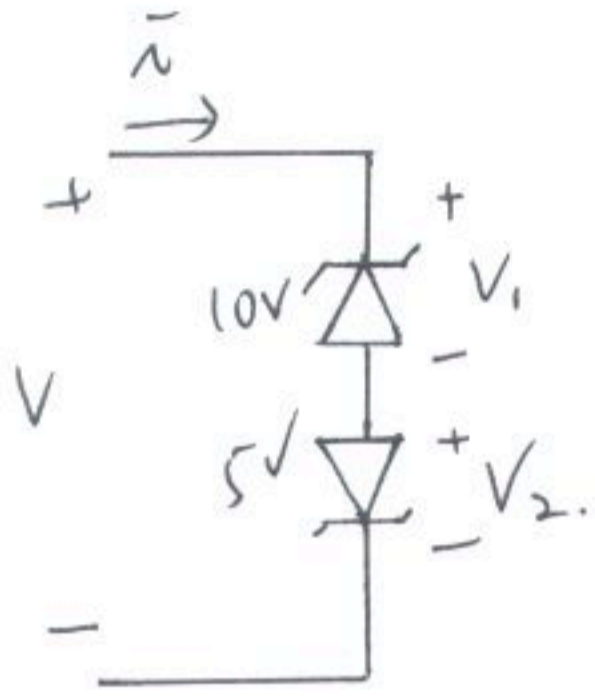
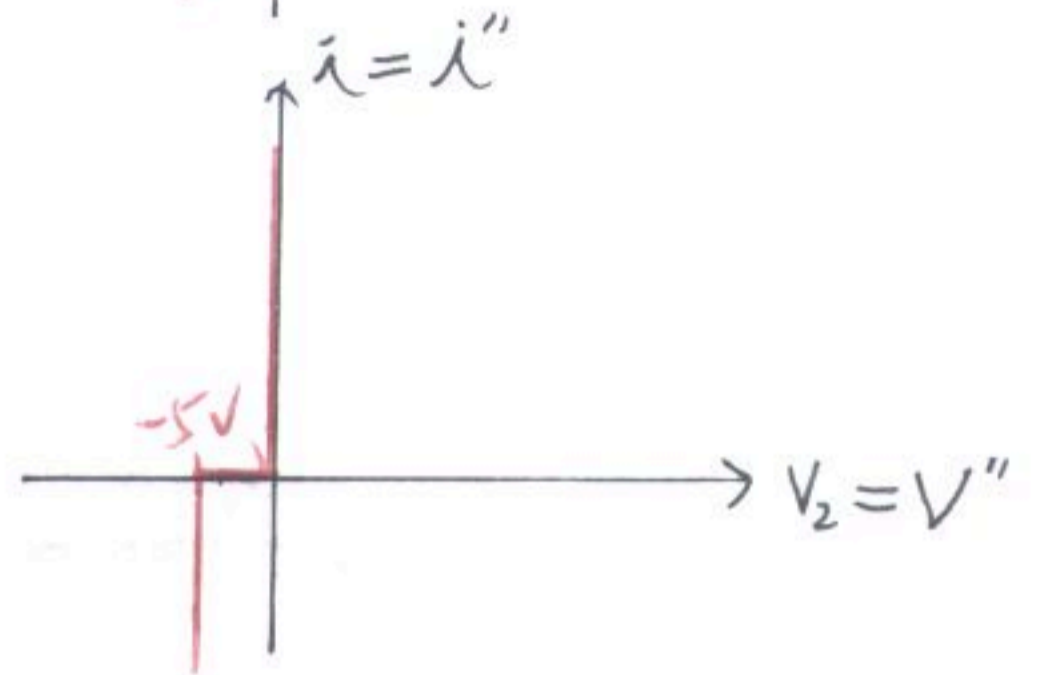
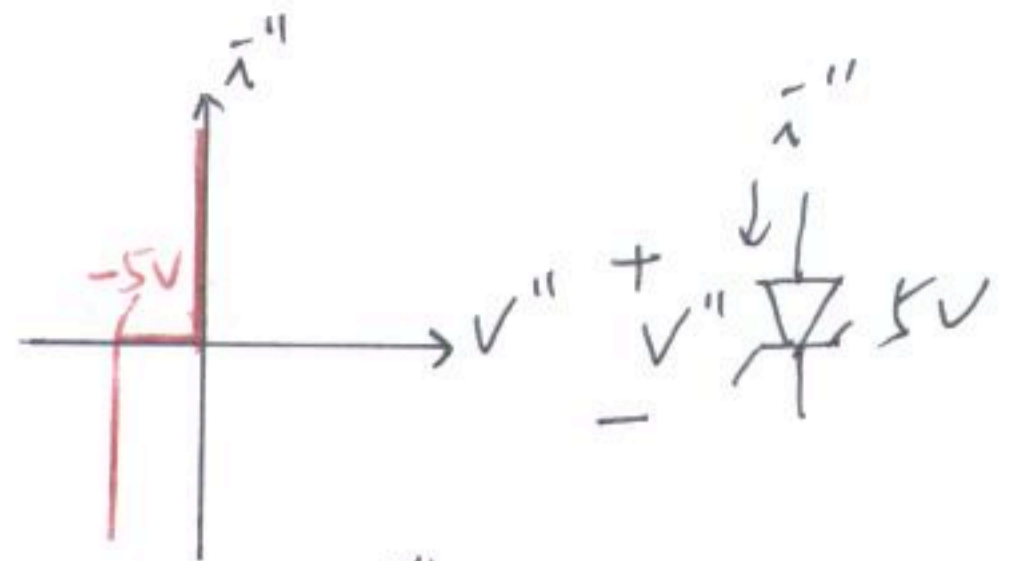
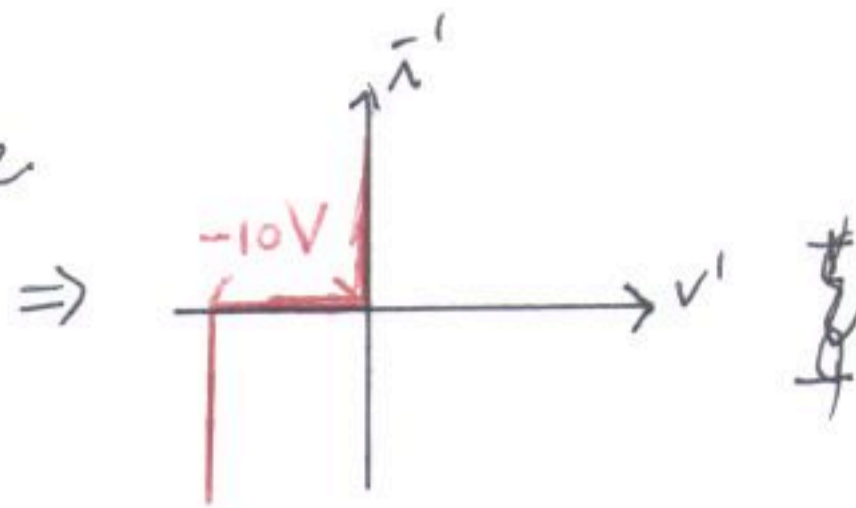
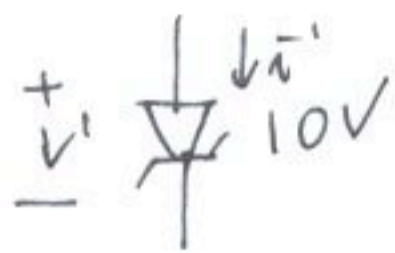
Part (a)



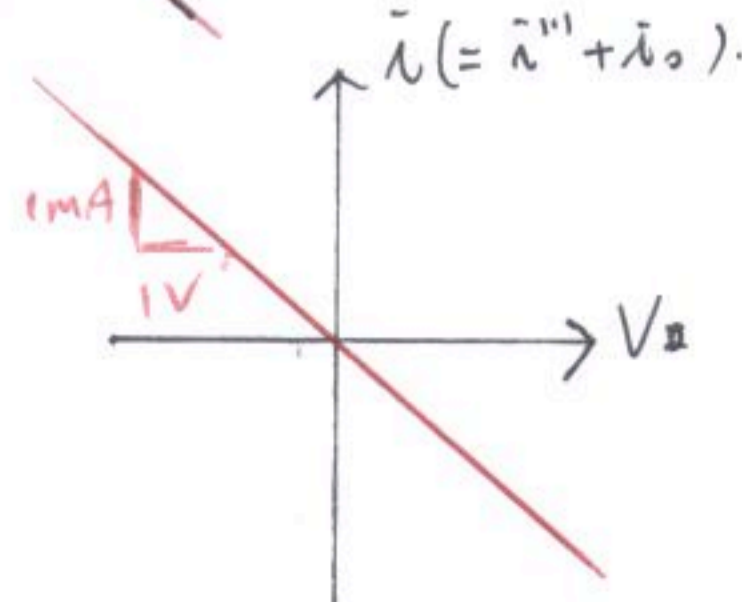
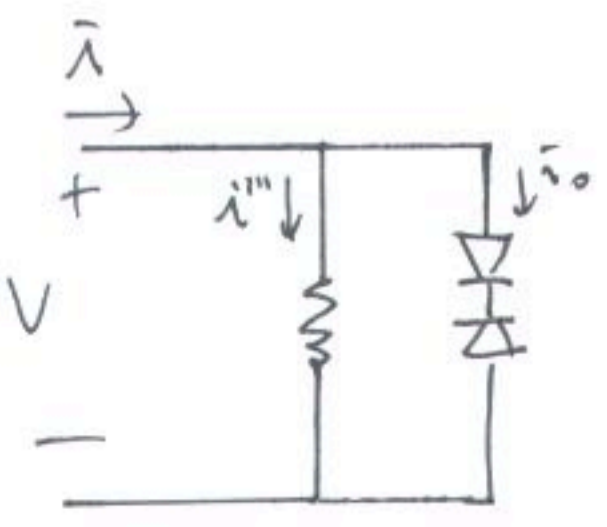
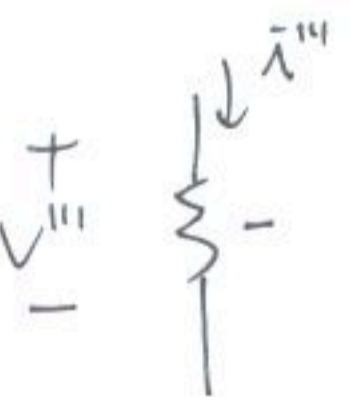
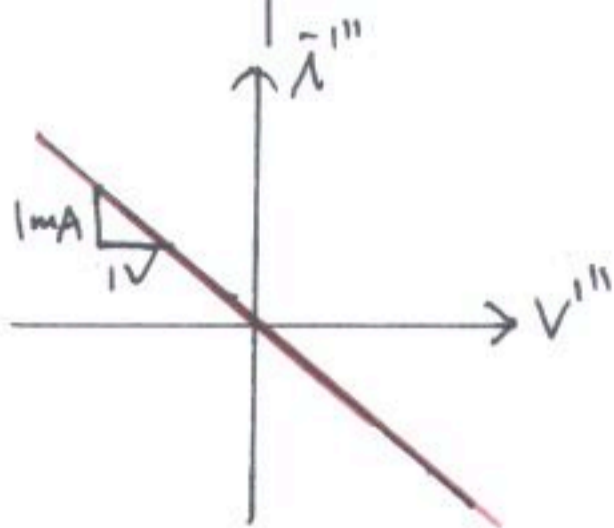
Part (b)

EXTRA WORKSPACE FOR PROBLEM 2

(a) - for a zener diode

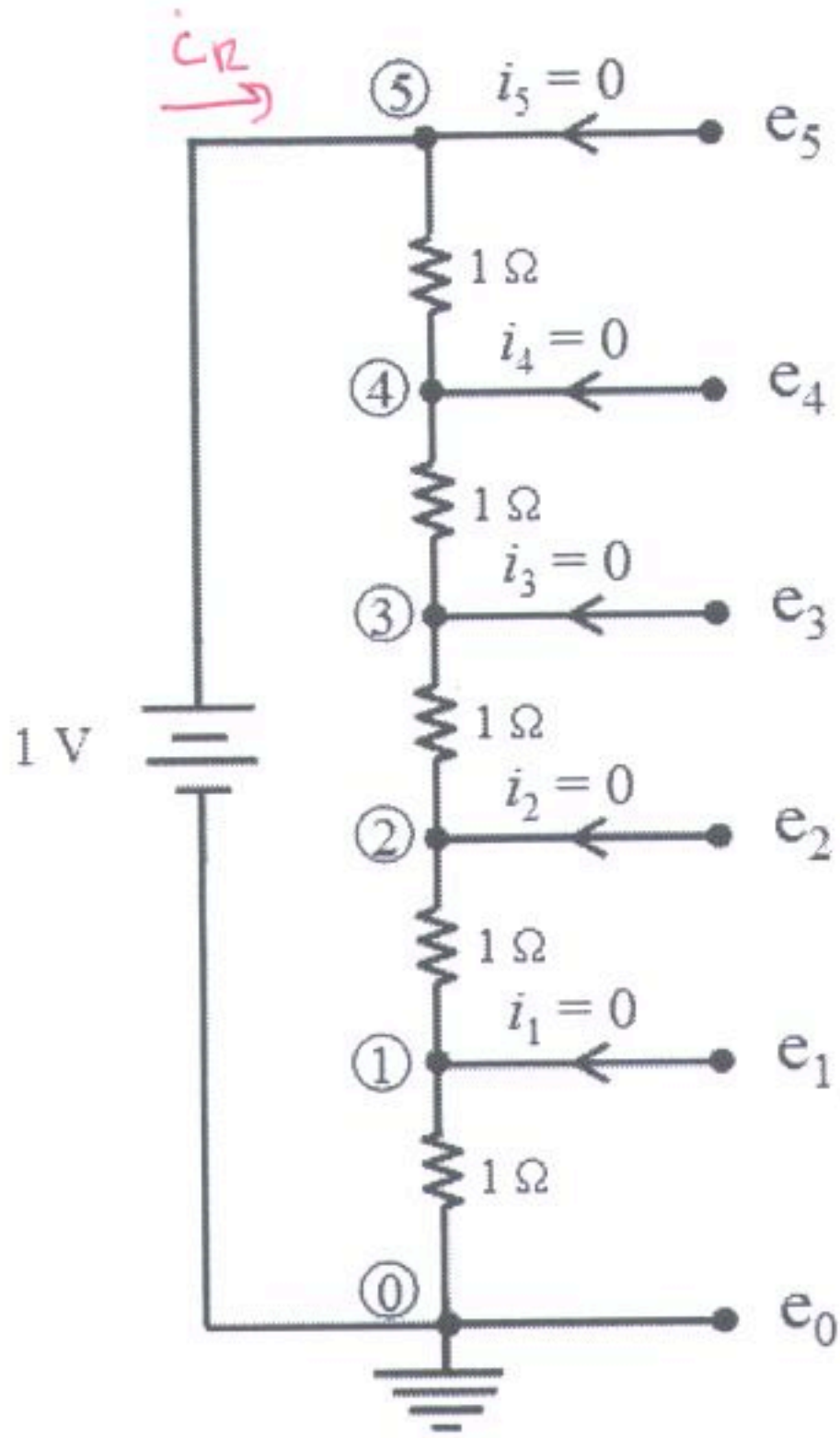


open circuit.



PROBLEM 3 [15 points]

(a) Find the node-to-datum voltages e_0, e_1, e_2, e_3, e_4 and e_5 of the following circuit:



Method 1: Voltage Divider

- you can see that the resistors divide up the voltage into multiple taps.

- For ex to find e_3

from $V = V_{\text{tot}} \frac{R_2}{R_1 + R_2}$



$$e_3 = 1V \cdot \frac{3\Omega}{2\Omega + 3\Omega} = \frac{3}{5} V = .600 V$$

Method 2: KCL+KVL

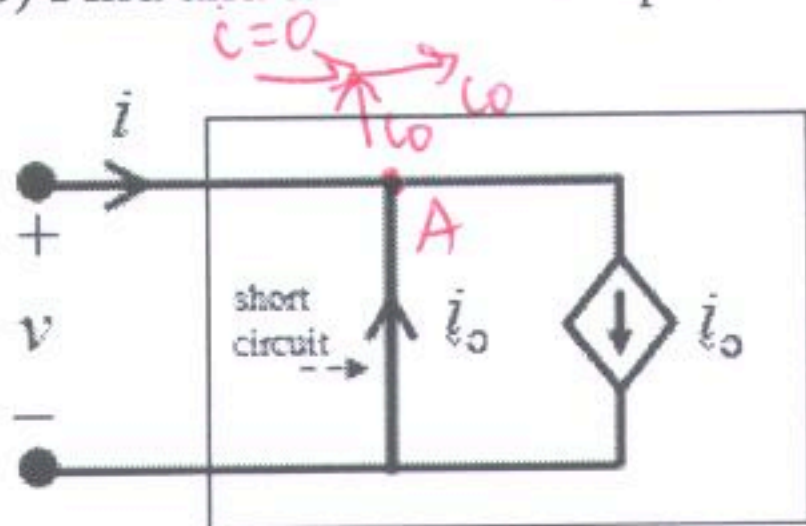
use KCL+KVL to see that

$$C_R = 1V / 5\Omega = 200 \text{ mA}$$

to find e_3

$$e_3 = 3\Omega \cdot 200 \text{ mA} = .6 V$$

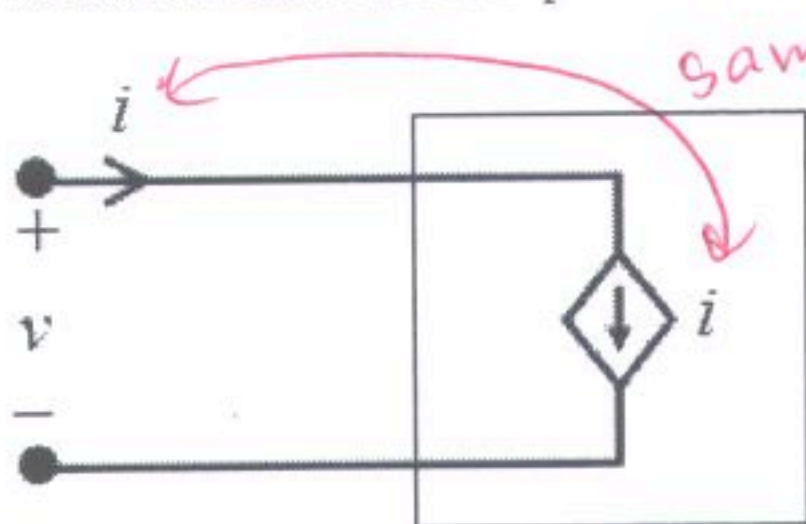
(b) Find and sketch the DP plot of the following one-port



KVL \rightarrow short circuit across ports forces $V=0$

KCL @ A shows that $C=0$ since the same current flows through the branch

(c) Find and sketch the DP plot of the following one port



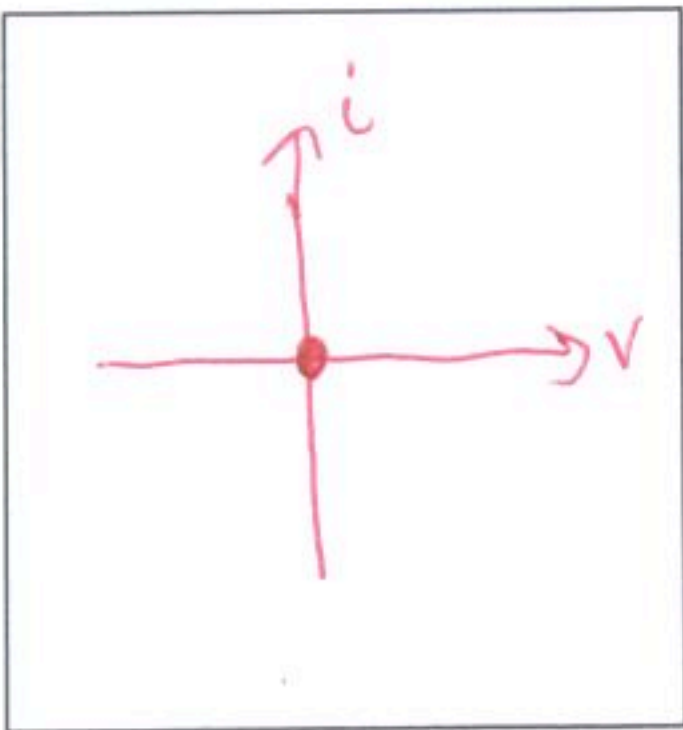
- ideal current source supports any voltage range $V = \text{anything}$

\rightarrow current i is mirrored by current source

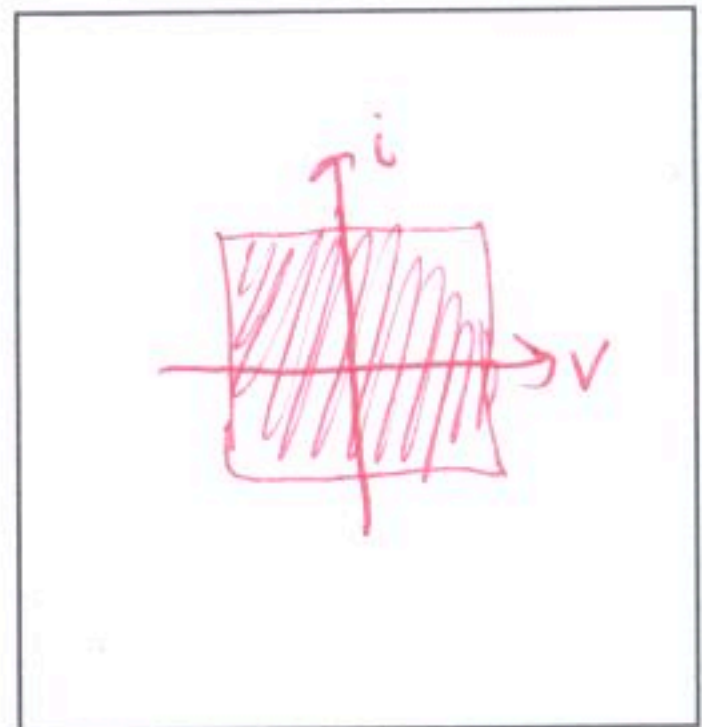
$i = \text{anything}$

e_0 : 0V e_1 : .2V e_2 : .4V e_3 : .6V e_4 : .8V e_5 : 1V

Sketch DP plot in the correct boxes below. Please label axes with correct units.



Part (b)

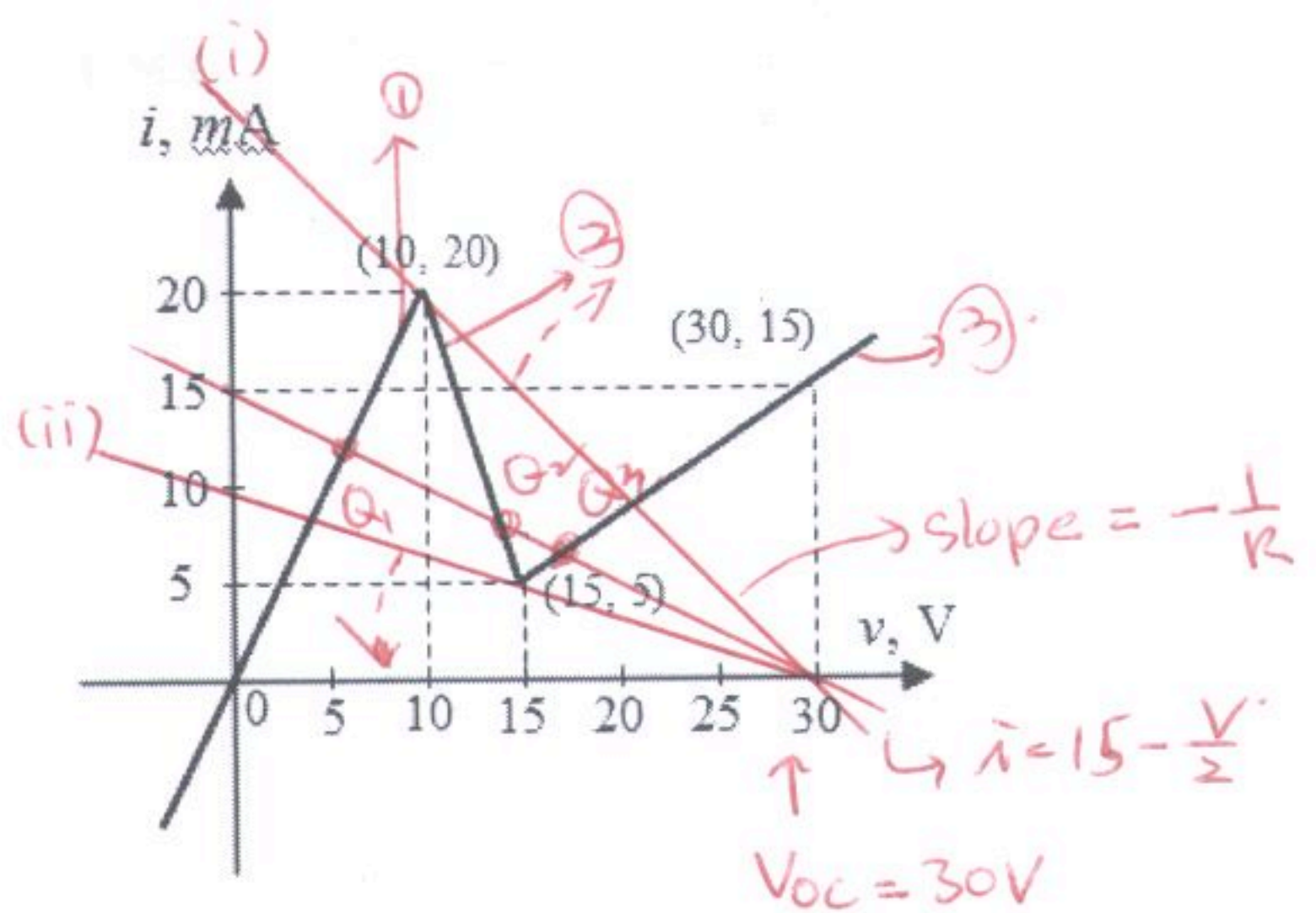
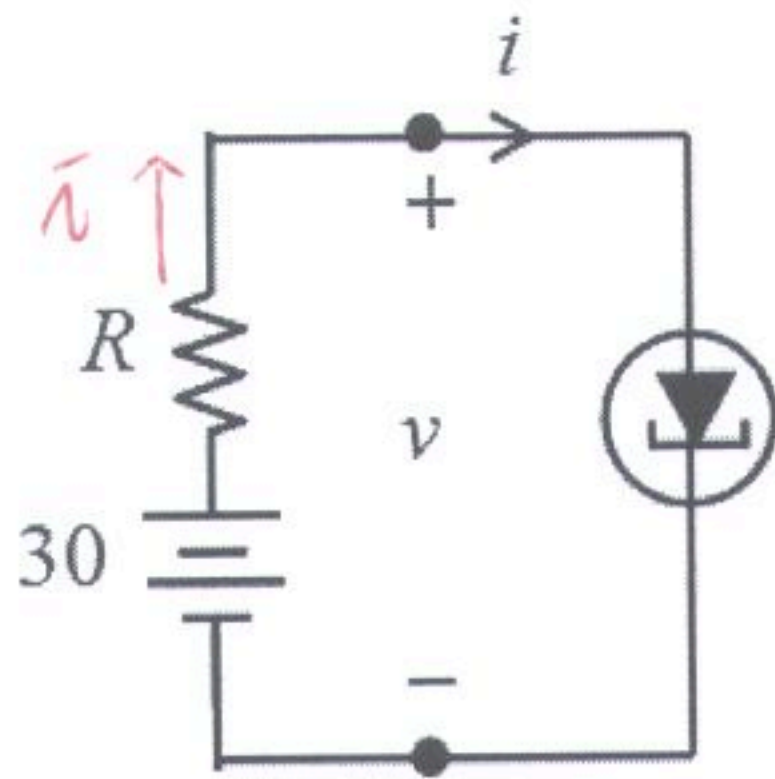


Part (c)

Note

Label your axis!

PROBLEM 4 [15 points]



(a) Find all operating point(s) of the tunnel diode with $R = 2K$.

(b) Find all values of R for which the circuit has only one operating point.

(a)

from KVL.

$$V = 30 - \bar{i}R$$

$$\Rightarrow \bar{i} = 15 - \frac{V}{2}$$

load line

have 3 intersections which means 3 operating points. you can estimate by watching at it or. Write out equations for line segments and find the solutions. for load line and segment ①, segment ②, segment ③

$$\left. \begin{aligned} \text{equation for ①. } x &= \frac{y}{2} \\ \text{equation for ②. } (y-20) &= -3(x-10) \\ \text{equation for ③. } (y-5) &= \frac{2}{3}(x-15) \end{aligned} \right\} x=v, y=i$$

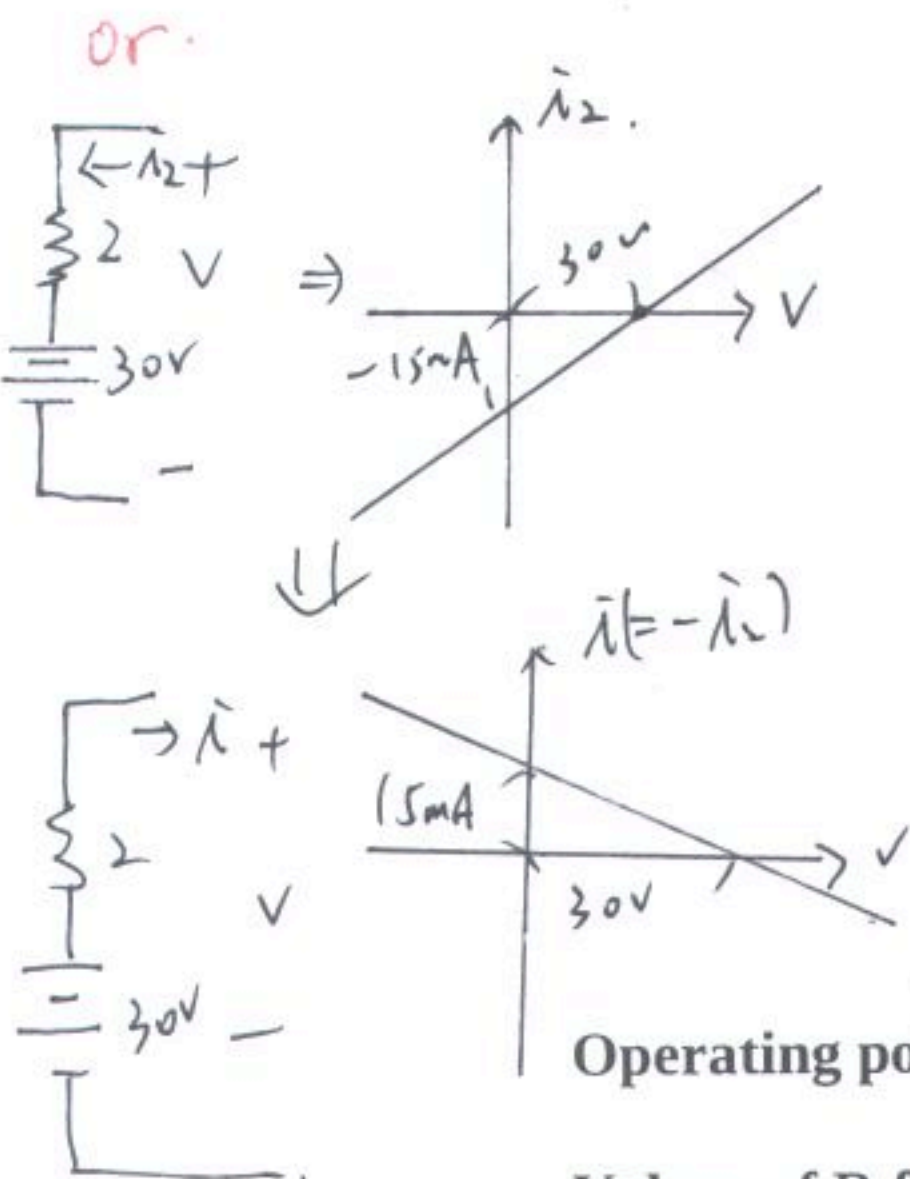
Solve equations for ① and load line $\Rightarrow (v, i) = (6, 12)$
 " for ② and load line $\Rightarrow (14, 8)$
 " for ③ and load line $\Rightarrow (\frac{120}{7}, \frac{45}{7})$

(b). only have solution when load line have slope larger than (ii), and slope smaller than (i)

$$\Rightarrow \text{slope} = \frac{-1}{R} > \frac{-1}{3K} \quad R > 3K, \quad \text{slope} = \frac{-1}{R} < \frac{-1}{1K} \quad R < 1K$$

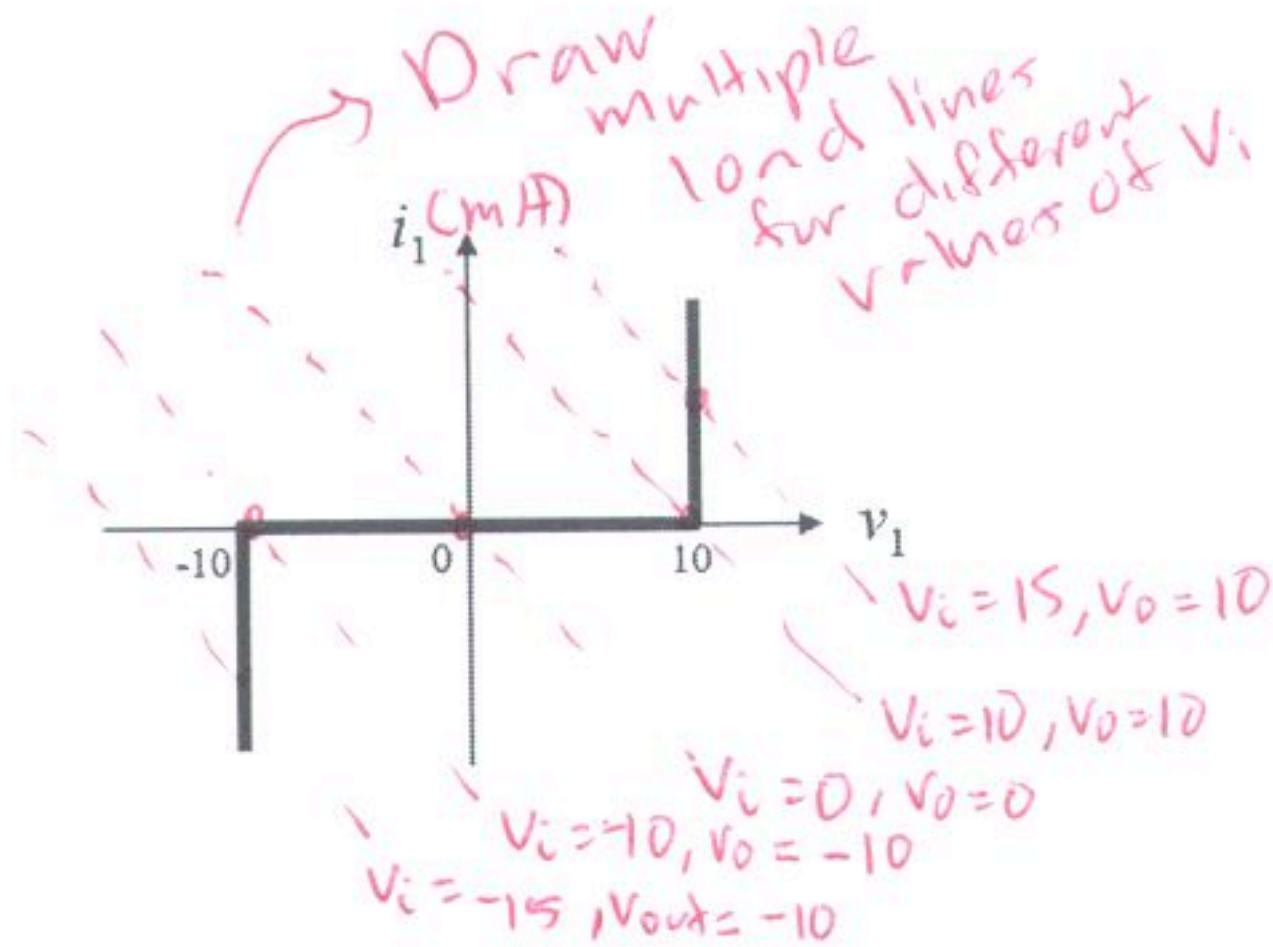
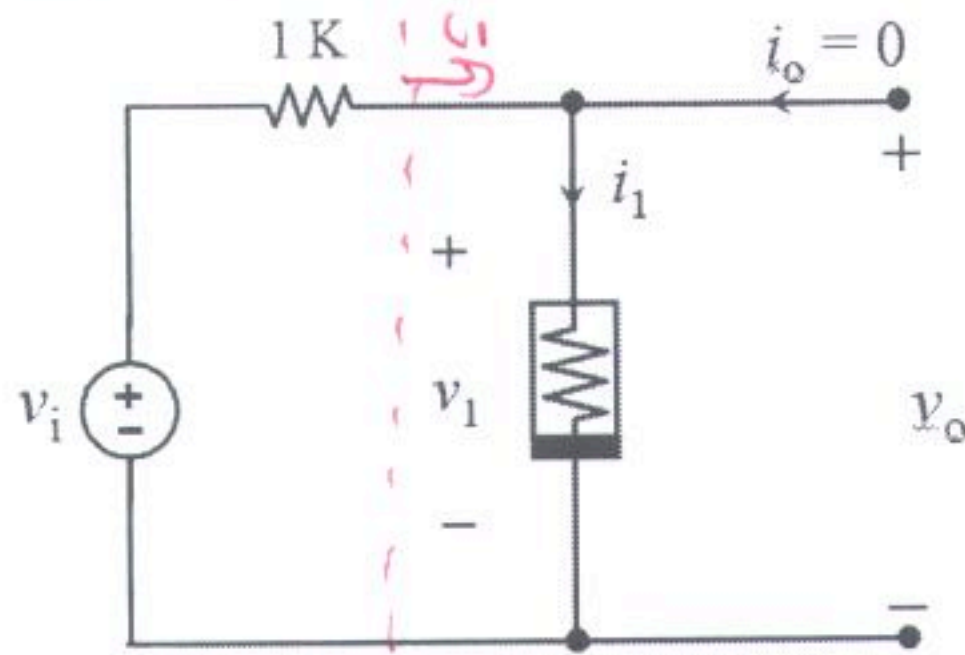
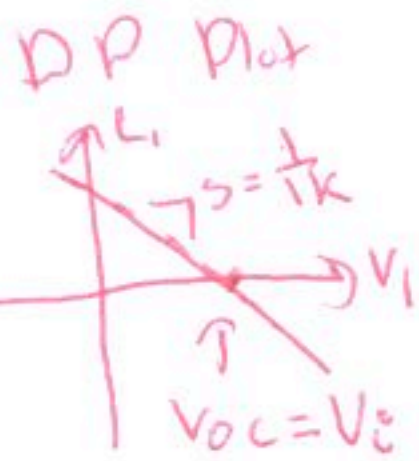
Operating point(s) of the tunnel diode ($R = 2K$): $(6V, 12mA), (14V, 8mA), (\frac{120}{7}V, \frac{45}{7}mA)$

Values of R for only one operating point: $R > 3K \quad R < 1K$

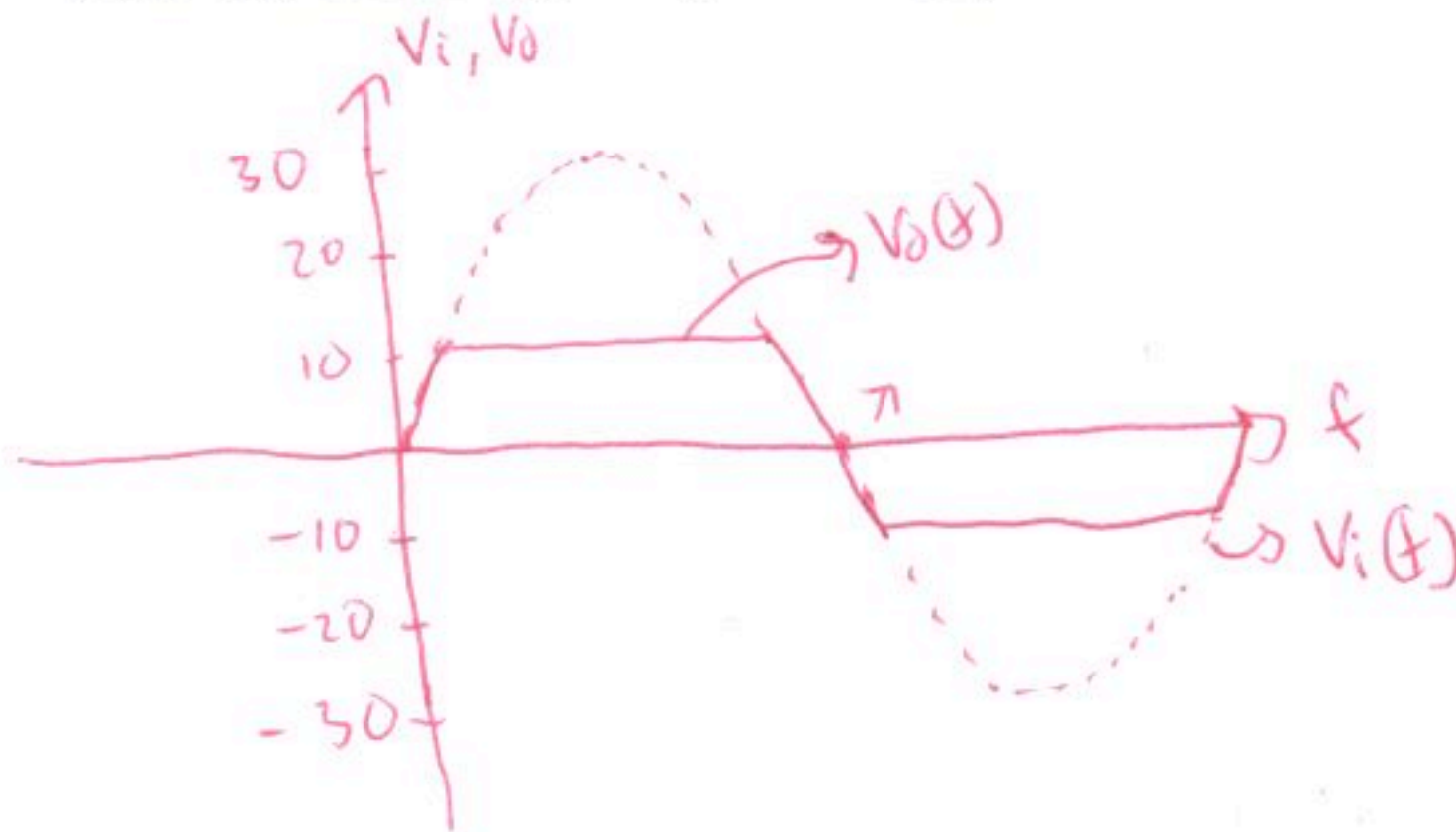


PROBLEM 5 [25 points]

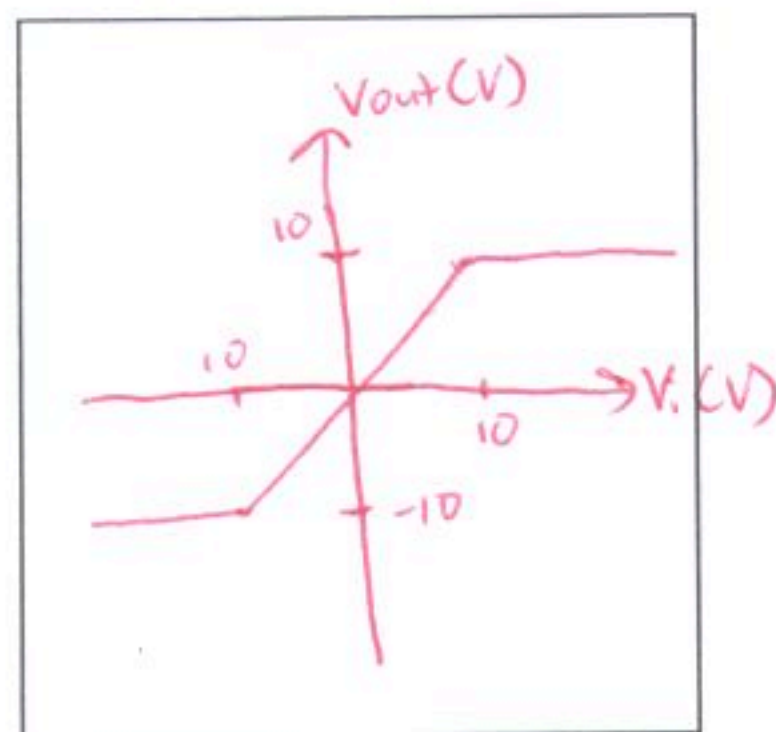
(a) Apply load line analysis to find and sketch the $v_o - v_s - v_i$ transfer characteristic (TC) plot of the following clipping circuit. The $v_1 - i_1$ characteristic of the nonlinear resistor is given.



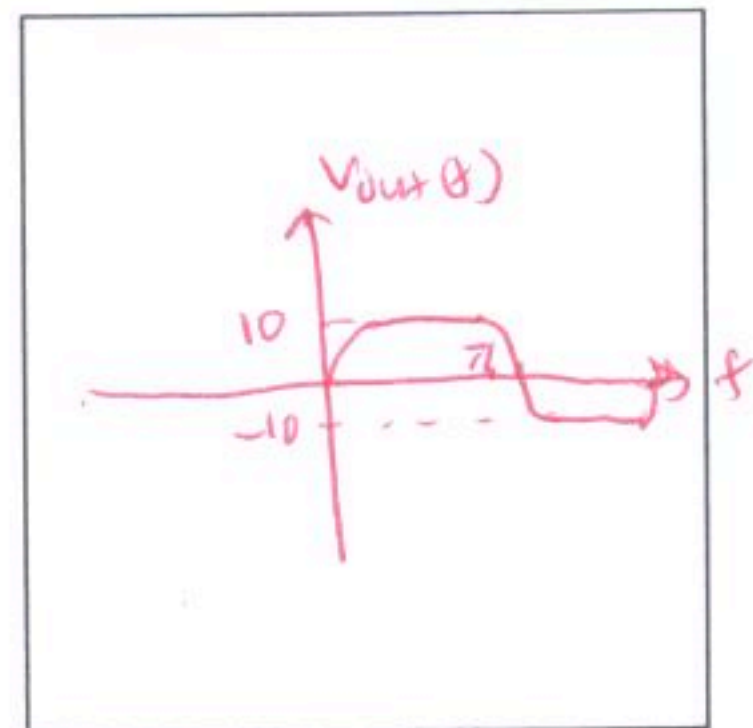
(b) If $v_i(t)$ is $30\sin(t)$ volts, sketch $v_o(t)$.



Sketch plots in the boxes below. Please label axes with correct units.



(a)



(b)

output clips in this region

For $V_i < -10, V_{out} = -10$
For $-10 \leq V_i \leq 10, V_{out} = V_i$
For $V_i > 10, V_{out} = 10$

PROBLEM 6 [10 points]

Consider the Shannon circuit game driven by a current source I (refer to next page for the figure).

Circle the following subsets of branch currents which form a cut set.

$$S_1 = \{i_1, i_2, i_4, i_5, i_6, i_9, i_{11}, i_{13}\}$$

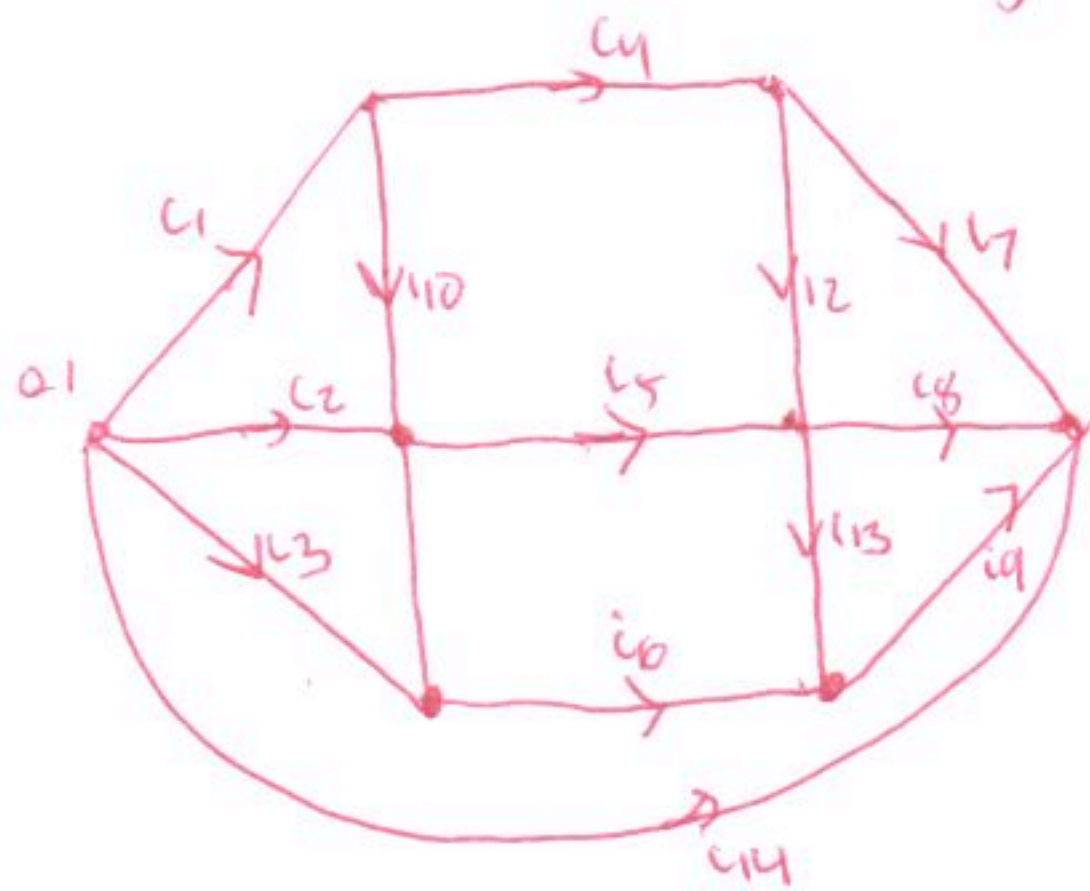
$$S_2 = \{i_4, i_5, i_9, i_{13}, i_{14}\}$$

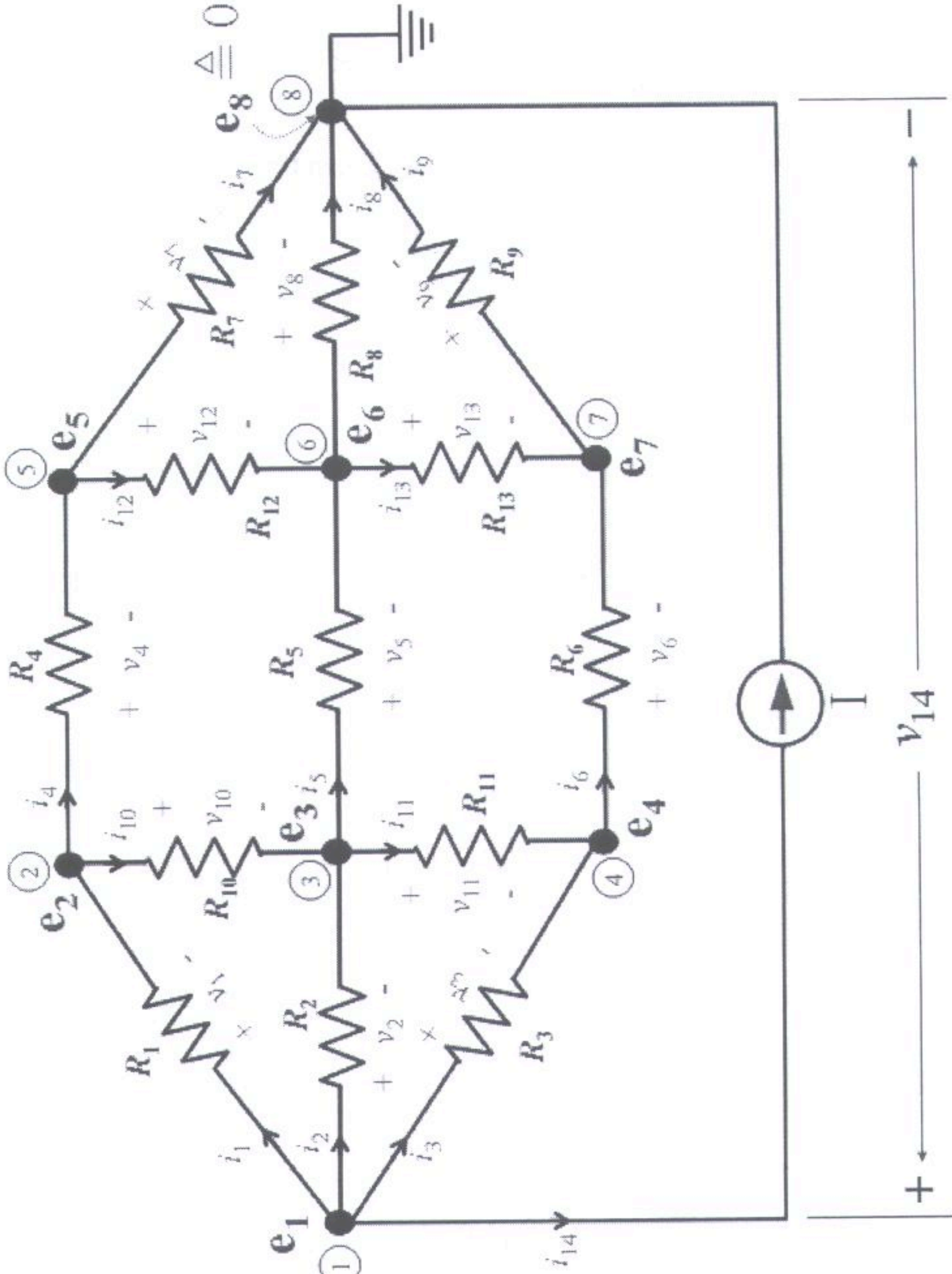
$$S_3 = \{i_1, i_4, i_7, i_{10}, i_{12}\}$$

$$S_4 = \{i_2, i_8, i_{10}, i_{11}, i_{12}, i_{13}\}$$

- The conditions for a set of branches to be a cut-set are:
- removal of all the branches of the cut set results in an unconnected digraph, which means the resulting digraph is no longer connected
 - removal of all but any one branch of the subset leaves the digraph connected. This implies that if any branch in the subset is left intact, the digraph remains connected.

First, turn the circuit diagram into a digraph.



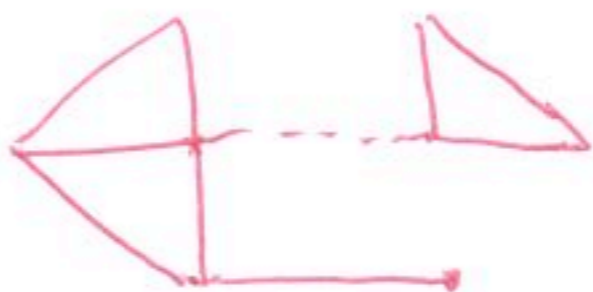
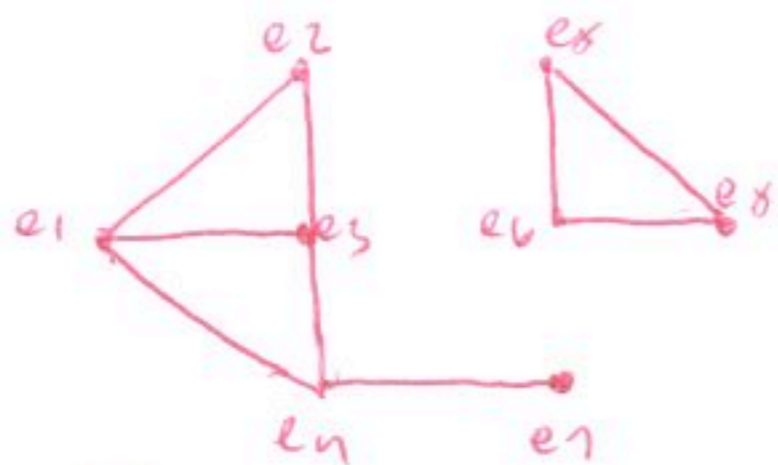


EXTRA WORKSPACE FOR PROBLEM 6

Let's try $S_2 = \{e_4, e_5, e_6, e_7, e_8\}$

- remove all the branches from the subset

↳ Then try putting one of the branches back



↳ digraph is disconnected ✓

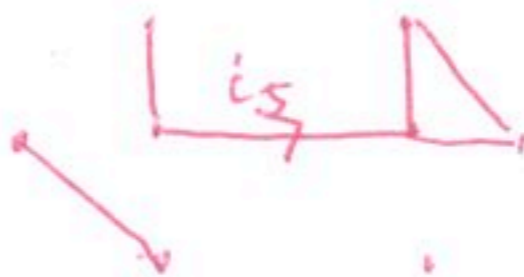
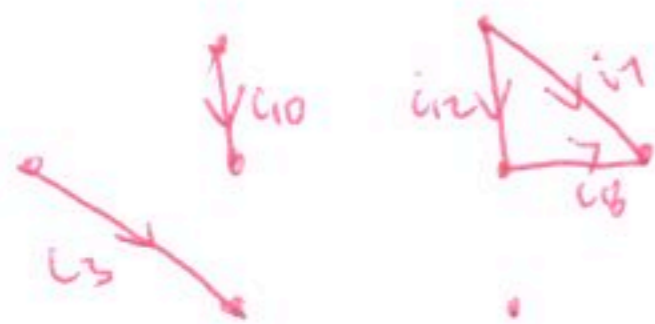
digraph is connected ✓

Note: you have to check to see that placing any of the other branches also connects the graph.

S_2 is a cutset.

Let's try $S_1 = \{i_1, i_2, i_4, i_5, i_6, i_8, i_{11}, i_{13}\}$

They putting some back in



digraph is disconnected ✓

digraph is still disconnected ✗

S_1 ~~is~~ is NOT a cutset.

- Follow a similar approach for S_3 & S_4