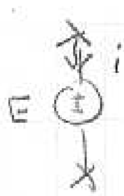
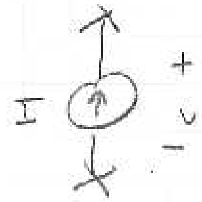
Final Review

Review Notes:

1.)  → is $i = 0$ **NO!**

 is $v = 0$? **NO!**

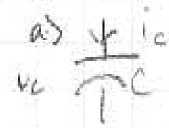
2.) Final is 4 Problems

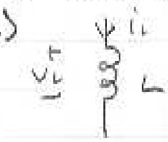
(1) Nodal Analysis → Set up, don't solve
→ Review Problem 4 of Midterm 1

Undecided Yet {
(2) Op-Amp or RC/RL circuit (not sure yet)
→ Review HW Problems
(3) Diodes or another Op-Amp (not sure yet)
→ If diode → just review HW
→ If op-amp → review Problems 1 & 4 from Midterm 2
}

(4) Graphical Method & Load Line Method
→ Review my lecture notes & last HW
→ Know how to Thevenize Circuits

3.) For RC/RL circuits, remember

a.)  $i_C = C \frac{dv_C}{dt}$

b.)  $v_L = L \frac{di_L}{dt}$

c.) $x(t) = x_\infty + (x_0 - x_\infty) \exp[-(t - t_0)/\tau]$

d.) $\tau = RC$ or L/R

4.) All diodes will be ideal. Not necessarily true of op-amps.

5.) Make sure to go over all of Chapter 7 for RC/RL circuits.
" " " " " " " Chapter 5 for op-amps.

6.) All circuits to be thevenized do not require "Test Source Method"
i.e. Just find V_{OC} & I_{SC} → $R_{TH} = \frac{V_{OC}}{I_{SC}}$

7.) When / how to assume if a diode is on.

if $i \to$ &  Assume on
if $i \to$ & Assume off

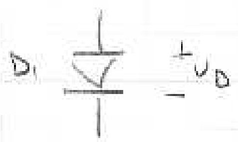
8.) For multiple switches in RC/RL circuits.

τ could change after each switch.

9.) Op-Amps. Can't assume ideal?

Then $v_{out} = A(v^+ - v^-)$ ALWAYS TRUE

10.) Remember for diodes,

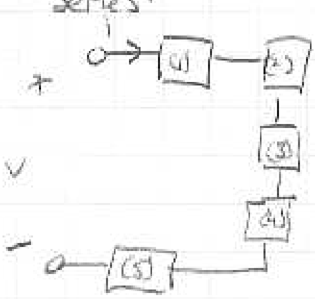


If you assume D_1 is off & you calculate $v_D > 0$, ASSUMPTION IS WRONG.

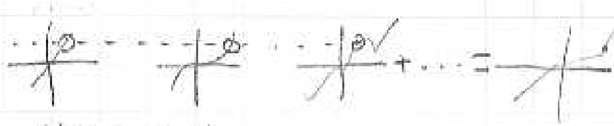
$v_D < 0$ for diode off & $v_D > 0$ for diode on

11) Graphical Method

Series:

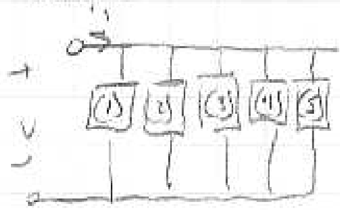


i is same, but $v_1 + v_2 + v_3 + \ldots = v$
For a given i, add all v's.



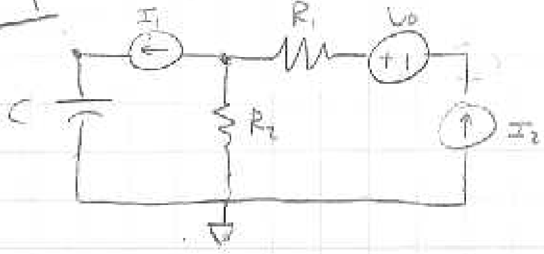
Horizontally

Parallel



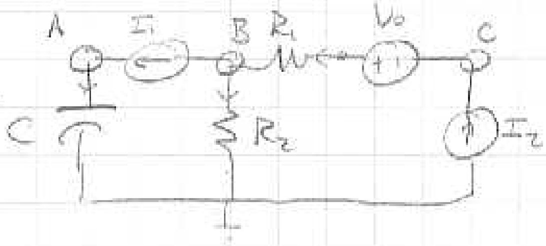
v is same for all, but $i = i_1 + i_2 + i_3 + \ldots$
For a given v, add all i's

Example 1



Write 3 nodal Equations

Soln



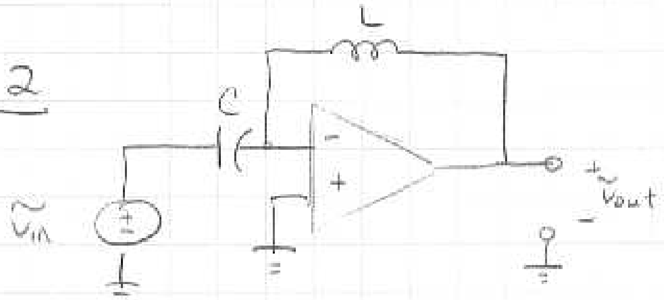
(A) $I_1 = C \frac{dv_A}{dt}$ ✓

(B) In = Out

$I_2 = \frac{V_B}{R_2} + I_1$ ✓

(C) $\frac{V_C + V_0 - V_B}{R_1} = I_2$ ✓

Example 2



$\tilde{V}_{in} = \sin(\omega t)$

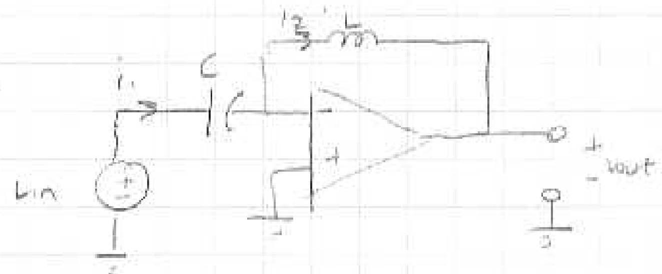
$\omega = 1000$ rad/sec

$L = 1mH$

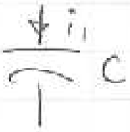
$C = 1mF$

Find v_{out}/v_{in}

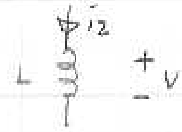
Soln



$i_1 = i_2$



$i_1 = C \frac{dv_{in}}{dt}$



$V = 0 - v_{out} = L \frac{di_2}{dt} = L \frac{di_1}{dt}$

So: $i = C \frac{dv_{in}}{dt}$ $\quad v_{out} = -L \frac{di}{dt}$

$v_{out} = -L \frac{d}{dt}\left[C \frac{dv_{in}}{dt}\right] = -LC \frac{d^2 v_{in}}{dt^2}$

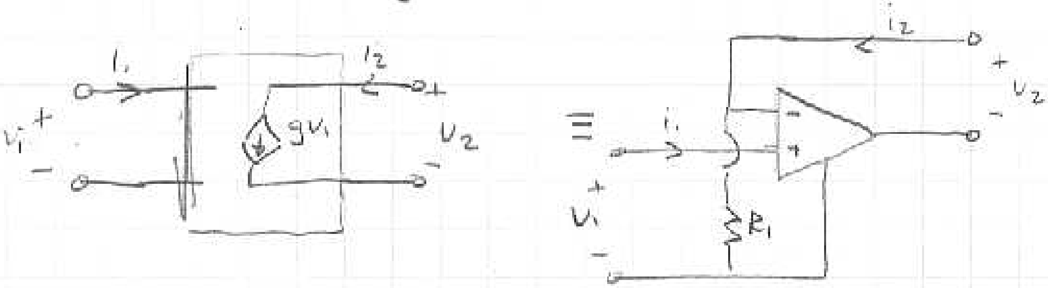
$\frac{d^2 v_{in}}{dt^2} = \frac{d}{dt}\left[\frac{d}{dt}(\sin \omega t)\right] = \frac{d}{dt}\left[\omega \cos \omega t\right] = -\omega^2 \sin \omega t = -\omega^2 v_{in}$

$v_{out} = -LC(-\omega^2 v_{in}) \Rightarrow \boxed{\frac{v_{out}}{v_{in}} = LC\omega^2}$

$\frac{v_{out}}{v_{in}} = (.001H)(.001F)(1000\ sec^{-1})^2 \rightarrow \boxed{\frac{v_{out}}{v_{in}} = 1}$

Example 3 Controlled Sources modeled by Amplifiers:

① VCCS: Voltage Controlled Current Source



$i_2 = g\, v_1$

What is "g"?

$v^+ = v^- = v_1$

$i_1 = 0$

$\frac{v_1 - 0}{R_1} = i_2 \rightarrow i_2 = \frac{v_1}{R_1} = g v_1 \rightarrow \boxed{g = \frac{1}{R_1}}$

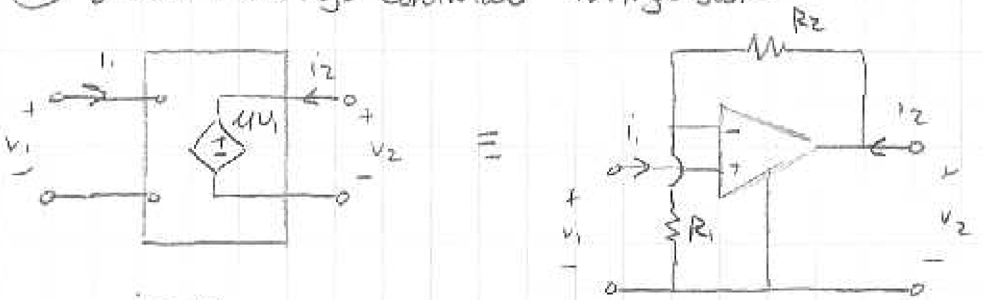
② CCVS: Current Controlled Voltage Source

$v_2 = r\, i_1$

What is "r"?

$v_1 = v^- = v^+ = 0$ $\quad i_1 = \frac{0 - v_2}{R} \rightarrow v_2 = -R i_1 = r i_1 \rightarrow \boxed{r = -R}$

③ VCVS: Voltage Controlled Voltage Source



$v_2 = \mu\, v_1$

What is "μ"?

$i_1 = 0$

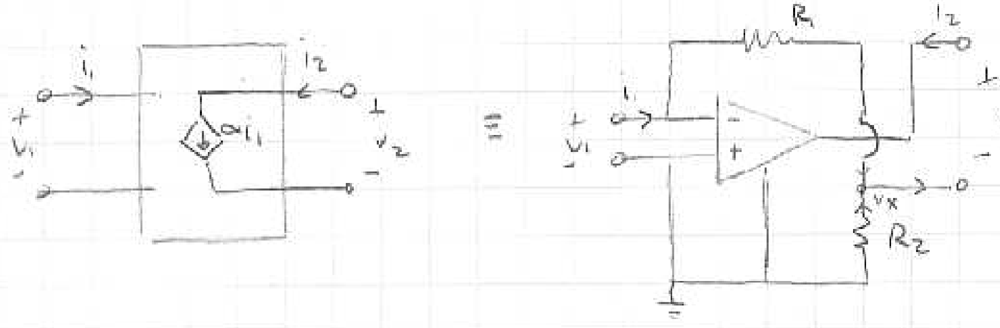
$v_1 = v^- = v^+$

$\frac{v_2 - v_1}{R_2} = \frac{v_1 - 0}{R_1} \rightarrow v_2 = R_2 v_1 \left[\frac{1}{R_1} + \frac{1}{R_2}\right]$

$v_2 = v_1 \left[1 + \frac{R_2}{R_1}\right] = \mu v_1 \rightarrow \boxed{\mu = 1 + \frac{R_2}{R_1}}$

Example 3 Continued

④ CCCS : Current Controlled Current Source



$i_2 = \alpha i_1$

What is "α"?

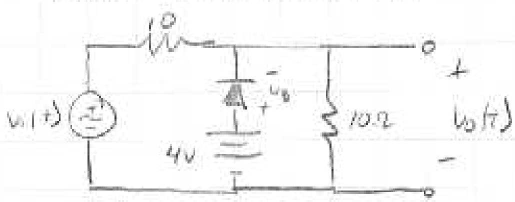
$v_1 = 0 \qquad V^- = V^+ = 0 \qquad v_x = 0 - i_1 R_1$

$$\frac{0 - v_x}{R_2} + i_1 = i_2 = i_1 \frac{-(-i_1 R_1)}{R_2} = i_1\left[1 + \frac{R_1}{R_2}\right] = \alpha i_1$$

$$\boxed{\alpha = 1 + \frac{R_1}{R_2}}$$

Example 4

$v_s(t) = 10\sin(2000\pi t)$



a.) Find $v_o(t)$ vs. t

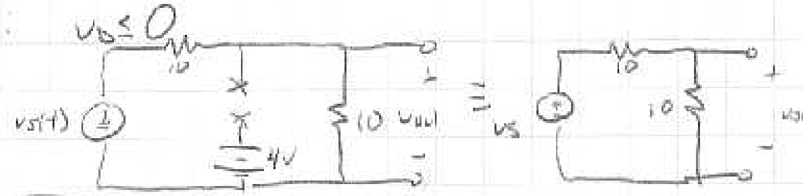
b.) Find Transfer Characteristic: $v_o(t)$ vs $v_s(t)$

Case 1: Diode 1 is on: $v_D \geq 0$

$v_D = 0$

$\underline{V_{out} = 4V}$

Case 2: Diode 1 is off: $v_D \leq 0$



Voltage Divider:

$V_{out} = \left(\frac{10}{10+10}\right) v_s \rightarrow \boxed{V_{out} = \frac{V_s}{2}}$

When valid:

$4 - v_D = V_{out}$

$4 - v_{out} = v_D$

Diode off $\Rightarrow 4 - v_{out} \leq 0$

$v_{out} \geq 4 \rightarrow \frac{v_s}{2} \geq 4 \rightarrow v_s \geq 8$

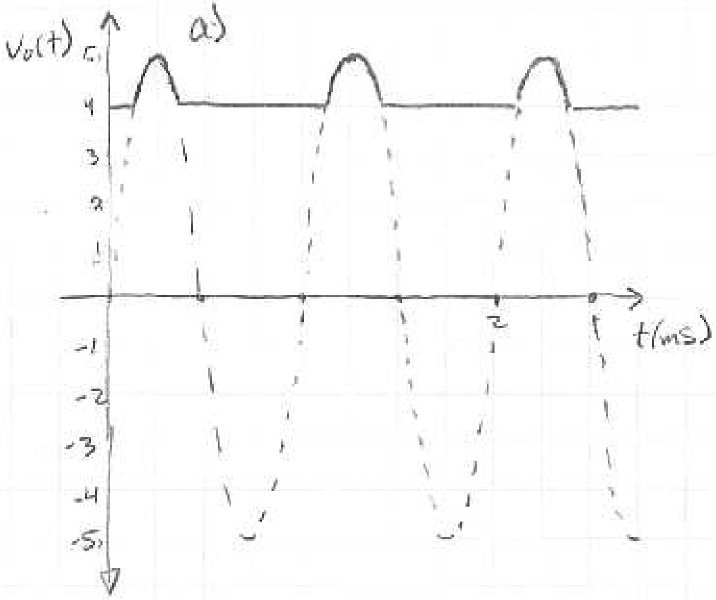
Diode on $\Rightarrow 4 - v_{out} \geq 0$

$v_{out} \leq 4 \rightarrow \frac{v_s}{2} \leq 4 \rightarrow v_s \leq 8$

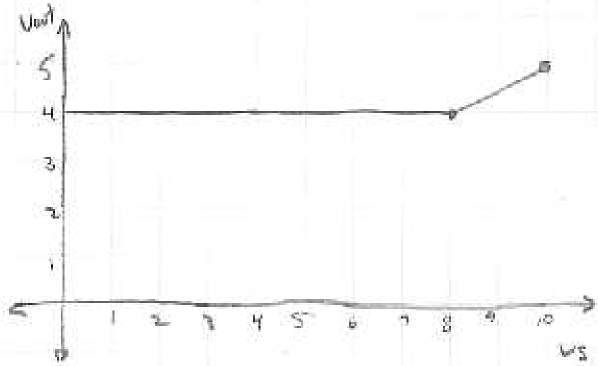
$$V_o(t) = \begin{cases} 4V, & \text{if } V_s \leq 8V \\ \frac{V_s}{2}, & \text{if } V_s \geq 8V \end{cases}$$

Ex 4 Cont

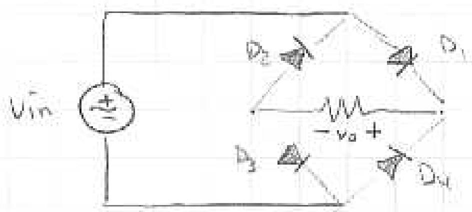
a)



b)



Example 5 Bridge Rectifier



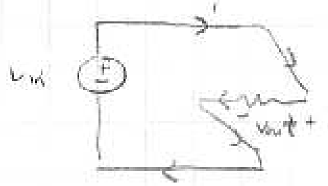
$v_{in} = 10\sin(2000\pi t)$

All diodes ideal

Plot $v_o(t)$

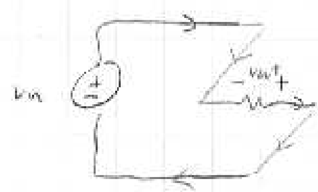
→ Analyze path of current for varying v_{in}.

$v_{in} > 0 \rightarrow D_1$ & D_3 on. D_2 & D_4 off



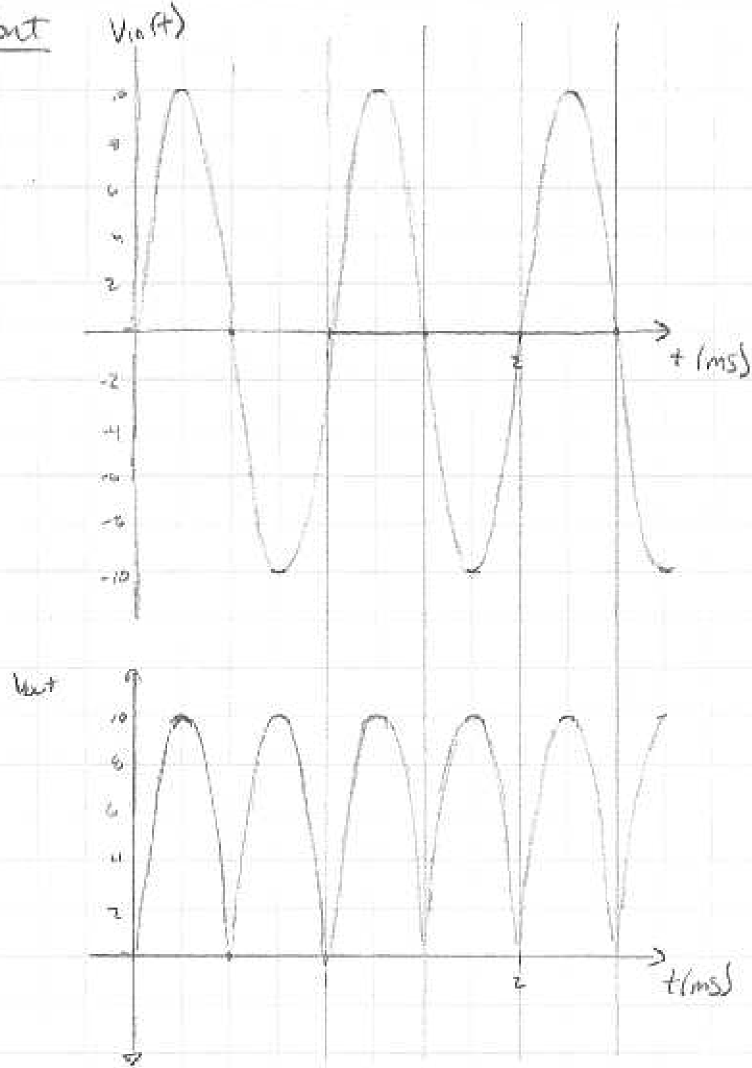
$v_{in} = v_{out}$

$v_{in} < 0 \Rightarrow D_1$ & D_3 off, D_2 & D_4 on

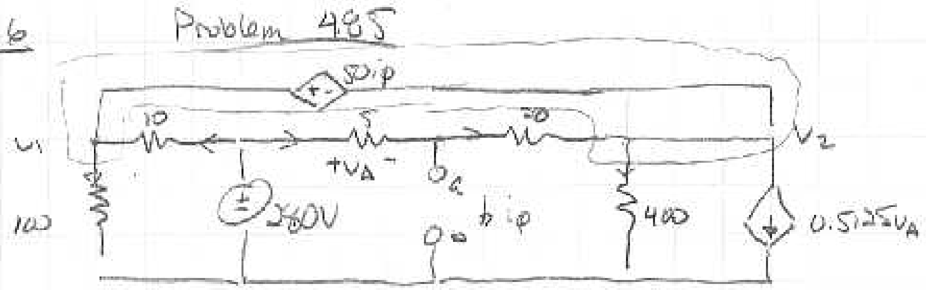


$v_{in} = -v_{out}$

Ex.5 Cont



Ex. 6 Problem 4.85



Find Thevenin Equivalent

V_{oc}: $i_\phi = 0$ $\quad 50 i_\phi = 0$ $\quad v_1 = v_2$

(1) $\frac{280 - v_1}{10} + \frac{280 - v_1}{25} = \frac{v_1}{100} + \frac{v_1}{400} + 0.5125 v_\Delta$

(2) Voltage Divider: $v_\Delta = \frac{5}{25}(280 - v_1) = 56 - 0.2 v_1$

Solve: $v_1 = 210V \quad v_\Delta = 14$

$V_{TH} = 280 - v_\Delta = 266\,V$

I_{sc}: $v_\Delta = 280 \qquad v_1 - v_2 = 50 i_\phi$

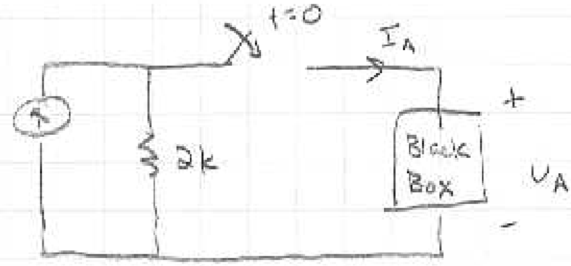
$\frac{280 - v_1}{10} + \frac{0 - v_2}{20} = \frac{v_1}{100} + \frac{v_2}{400} + 0.5125 v_\Delta$

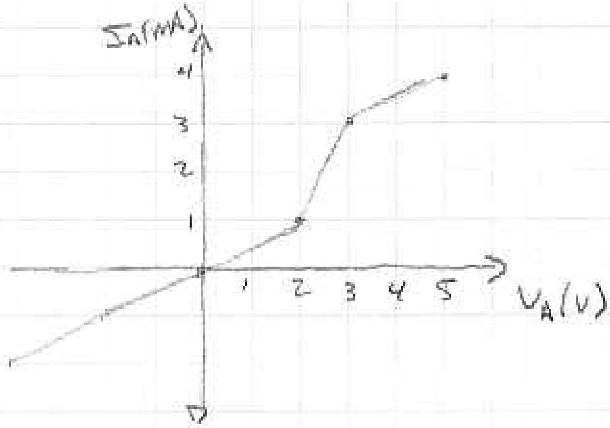
$i_\phi = \frac{280 - 0}{5} - \left[\frac{0 - v_2}{20}\right] \Rightarrow i_\phi = 56 + 0.05 v_2$

Solve: $i_\phi = I_{sc} = 7.6A$

R_{TH}: $\frac{V_{TH}}{I_{sc}} = \frac{266\,V}{7.6\,A} = 35\,\Omega$

Example 7

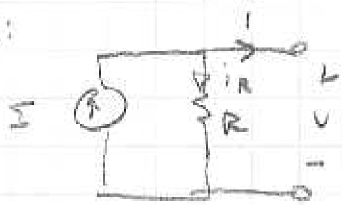




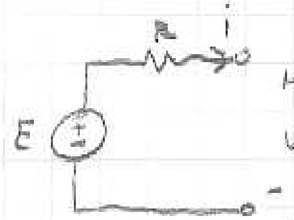
What is the operating pt. of this circuit?

Load-Line Method!

Side-Note:



or



KVL:

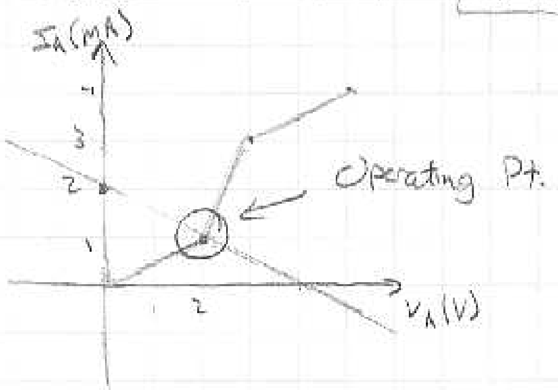
$E - iR = v$

$$\boxed{i = f(v) = \frac{1}{R}\left[E - v\right]}$$

KCL: $I = i + i_R$, $i_R = v/R$

$$\rightarrow \boxed{i = f(v) = I - \frac{v}{R}}$$

Back to circuit: $i = I - v/R \Rightarrow \boxed{i\,(mA) = 2 - v/2}$



$$\boxed{\begin{aligned} V_A &= 2V \\ I_A &= 2mA \end{aligned}}$$