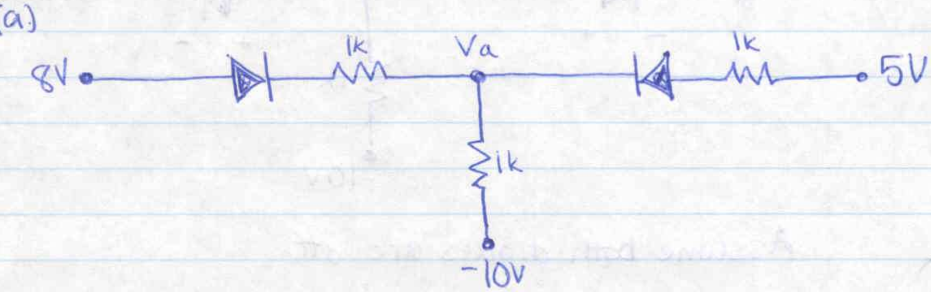
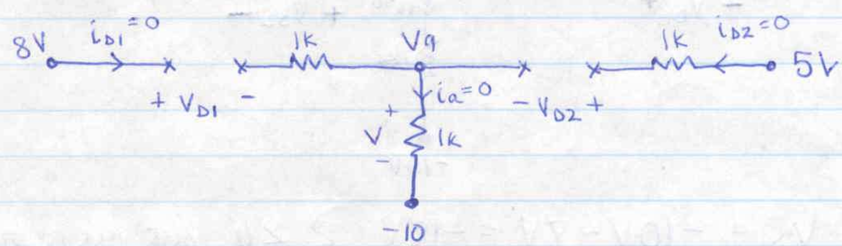
# Practice Midterm Solutions

1.)

(a)

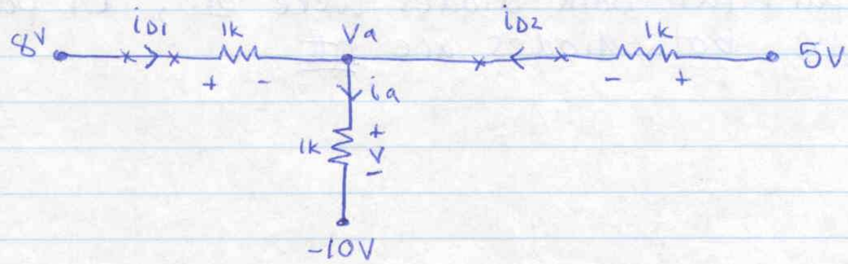



Assume both diodes are off. (Open circuit, $i_D = 0$, $V_D \leq 0$)




$V_{D1} = 8V - (-10V) = 18V$
$V_{D2} = 5V - (-10V) = 15V$ } $> 0$, so our assumption is wrong.

Assume both diodes are on. (Short circuit, $i_D \geq 0$, $V_D = 0$)




KCL @ Va: $i_{D1} + i_{D2} = i_a$

$i_{D1} = \frac{8V - V_a}{1k}$ $\quad i_{D2} = \frac{5V - V_a}{1k}$ $\quad i_a = \frac{V_a - (-10V)}{1k}$

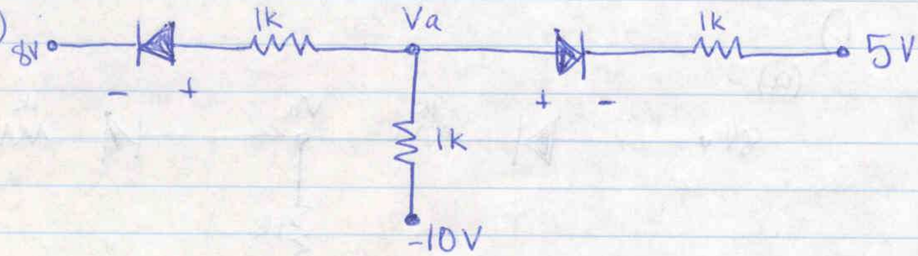
$8V - V_a + 5V - V_a = V_a + 10V$

$= V_a = 1V$

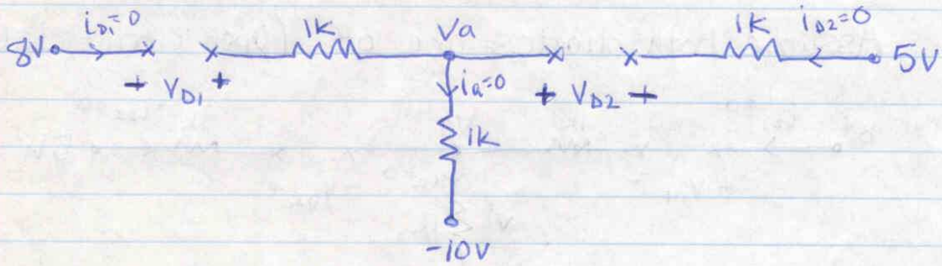
$i_{D1} = 7mA \quad i_{D2} = 4mA$ $\quad > 0$, so our assumption is right.

(a) both diodes are on and $i_{D1} = 7mA$, $i_{D2} = 4mA$

(b.)



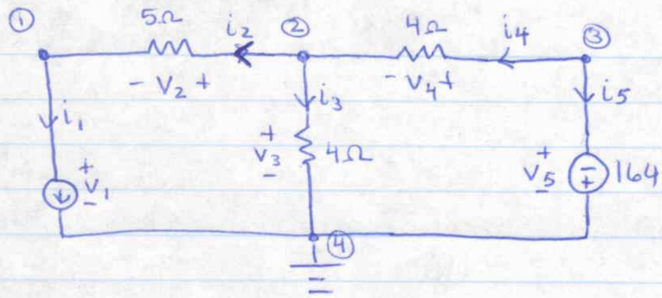

Assume both diodes are off.



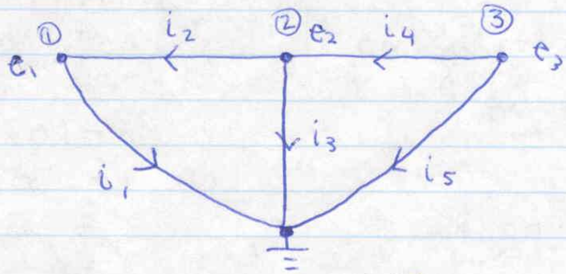

$V_{D1} = -10V - 8V = -18V$
$V_{D2} = -10V - 5V = -15V$
} < 0, our assumption was right.

Intuitively, this makes sense because the numbers are the same and just the direction of the diodes have changed. So where in part (a) both diodes were on, In part (b) both diodes are off

2.)




(a)




$$A = \begin{bmatrix} 1 & -1 & 0 & 0 & 0 \\ 0 & 1 & 1 & -1 & 0 \\ 0 & 0 & 0 & 1 & 1 \end{bmatrix} \begin{matrix} ① \\ ② \\ ③ \end{matrix}$$

nodes

1 2 3 4 5
branches

* convention: current <u>entering</u> a node is <u>negative</u>.

(b.) KCL: $i_1 - i_2 = 0$

$i_2 + i_3 - i_4 = 0$

$i_4 + i_5 = 0$

KVL:

$$A^T \cdot [e] = [v]$$

$$\begin{bmatrix} 1 & 0 & 0 \\ -1 & 1 & 0 \\ 0 & 1 & 0 \\ 0 & -1 & 1 \\ 0 & 0 & 1 \end{bmatrix} \cdot \begin{bmatrix} e_1 \\ e_2 \\ e_3 \end{bmatrix} = \begin{bmatrix} v_1 \\ v_2 \\ v_3 \\ v_4 \\ v_5 \end{bmatrix}$$

① $e_1 = v_1$

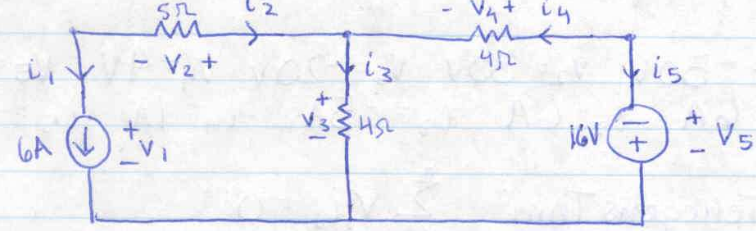
② $-e_1 + e_2 = v_2$

③ $e_2 = v_3$

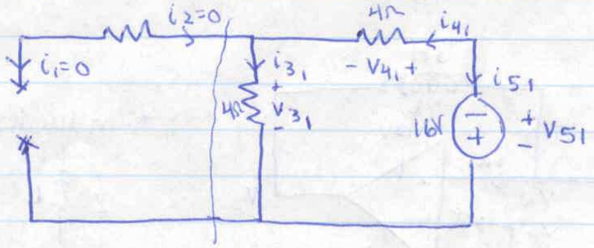
④ $-e_2 + e_3 = v_4$

⑤ $e_3 = v_5$

3.) Superposition: Find $V_3$

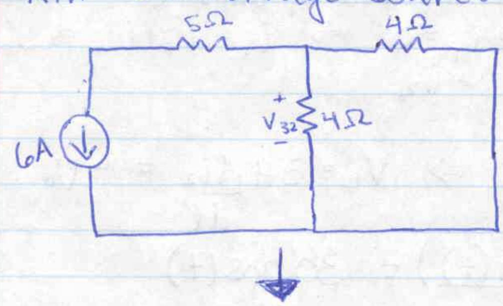



(a) Kill the current source

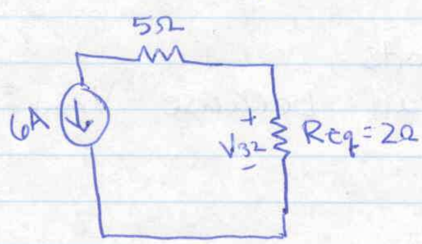



Voltage divider: $V_{3_1} = -\left(\frac{4}{4+4}\right) \cdot 16 = -8V$

Kill the voltage source




· The 4Ω resistors are in parallel, therefore the voltage across them are the same, so we can find Req




Req =

$V_{32} = IR_{eq} = -6A \cdot 2\Omega = -12V$

$V_3 = V_{3_1} + V_{32} = -20V$

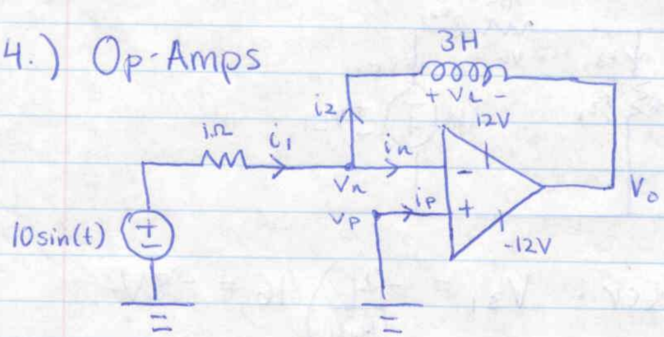
(b) by inspection

$V_1 = -50V \quad V_2 = 30V \quad V_3 = -20V \quad V_4 = 4V \quad V_5 = -16V$
$i_1 = 6A \quad i_2 = 6A \quad i_3 = -5A \quad i_4 = 1A \quad i_5 = -1A$

(c.) Tellegens Thm: $\sum_{i=1}^{n} V_j i_j = 0$

$V_1 i_1 + V_2 i_2 + V_3 i_3 + V_4 i_4 + V_5 i_5 =$
$-300 + 180 + 100 + 4 + 16 = 0$

4.) Op-Amps




* inductors: $V = L\frac{di}{dt}$


Assume linear, current into op-amp = 0

$V_p = V_n \Rightarrow i_n = i_p = 0. \Rightarrow i_1 = i_n + i_2 \Rightarrow i_1 = i_2$

$i_1 = \frac{10\sin(t) - 0}{1\Omega} = i_2$

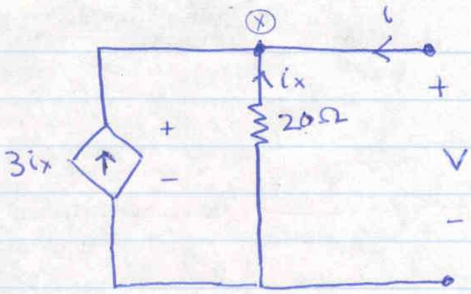
$i_2 = \frac{1}{3}\int V_L \, dt \Rightarrow V_L = 3H\frac{di_2}{dt} = -V_o$

$-V_o = 3\frac{d(10\sin(t))}{dt} = 30\cos(t)$

$V_o(t) = -30\cos(t)$ volts

The op-amp will rail because $V_{max} = 30$ but $V_{supply} = 12V$

5.)

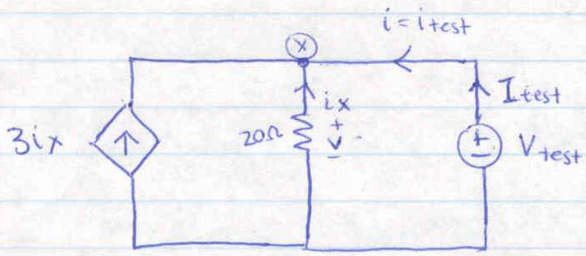



There are <u>no</u> independent sources in this circuit, so we automatically know:

$V_{oc} = 0$

$I_{sc} = 0$

Apply a test voltage to obtain $R_{thev}$.




$$R_{thev} = \frac{V_{test}}{I_{test}}$$

$V = V_{test}$ b/c they are in parallel

$i = I_{test}$

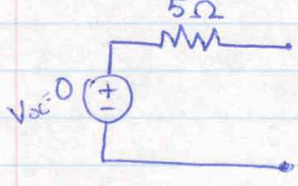
$$i_x = \frac{-V}{20\Omega} = \frac{-V_{test}}{20\Omega}$$

KCL @ ⓧ: $I_{test} + i_x + 3i_x = 0$

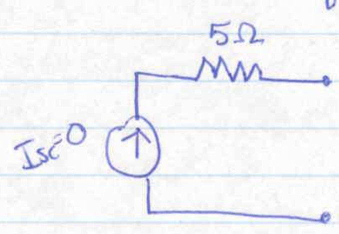
$I_{test} = -4i_x$

$$R_{thev} = \frac{-20i_x}{-4i_x} = 5\Omega$$

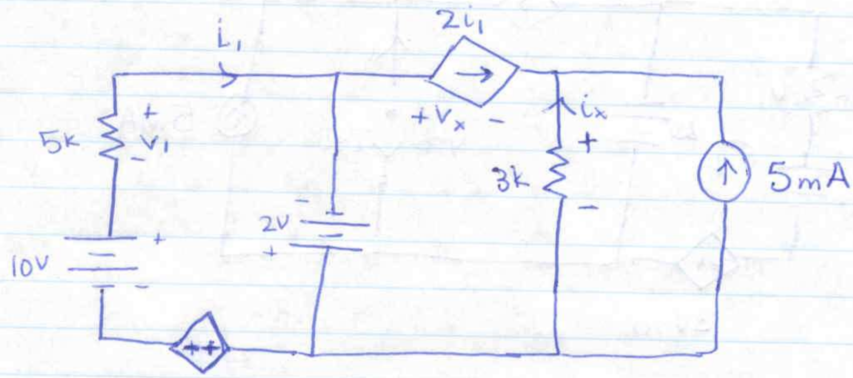
Thevenin Eq.

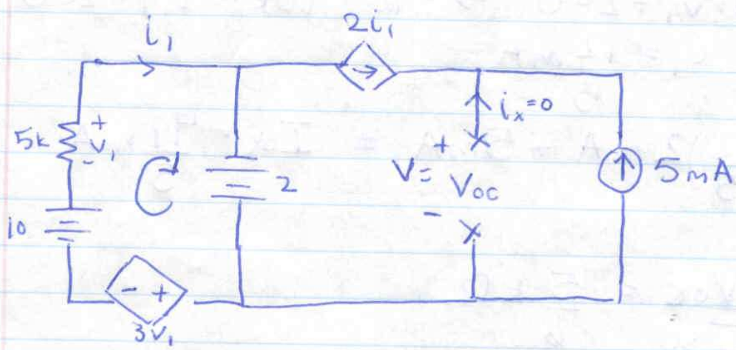



Norton Eq.



6.) To find the Thevenin Equivalent, we must find $V_{oc}$.




KVL: $10 + V_1 + 2 - 3V_1 = 0 \Rightarrow 12 + (5k \cdot i_1) - 3V = 0$

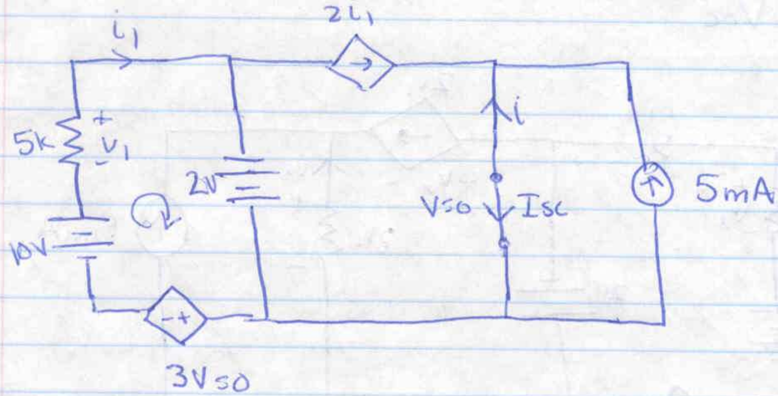
$3V = 12 + \frac{25}{2}$

$2i_1 = -5mA \Rightarrow i_1 = \frac{-5}{2}mA \Rightarrow V_{11} = \frac{25}{2}V$

$V = V_{oc} = \frac{49}{6}V$

Find $R_{thev}$. Kill all independent sources

Find Isc.




$I_{sc} = 2i_1 + 5mA$

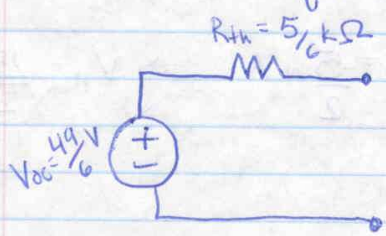
KVL: $10 + v_1 + 2 = 0 \Rightarrow 10 + (5k \cdot -i_1) + 2 = 0$

$\Rightarrow i_1 = \frac{12}{5} mA$

$I_{sc} = \left(\frac{12}{5}\right) 2\,mA + 5mA = I_{sc} = \frac{49}{5} mA$

$R_{thev} = \frac{V_{oc}}{I_{sc}} = \frac{5}{6} k\Omega$

Thevenin Equivalent




Norton Equivalent