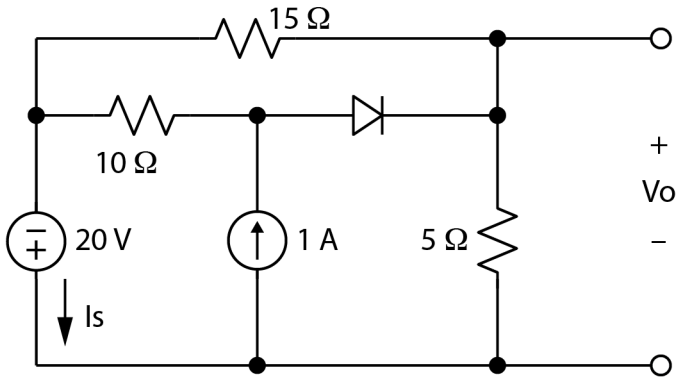
Homework 3

To receive full credits, you must describe the reasoning behind each step, e.g. KVL on L1, or using Ohm's law on R1, etc. Problems without reasoning receive 0 points regardless of providing correct or incorrect result. Problems with clear reasoning and correct result receives full points. Solutions with clear reasoning and incorrect results receive 3/4 of the total points.

Use the branch current method (BCM) or node voltage method (NVM) to solve the following problems. Explain why you selected such a method.

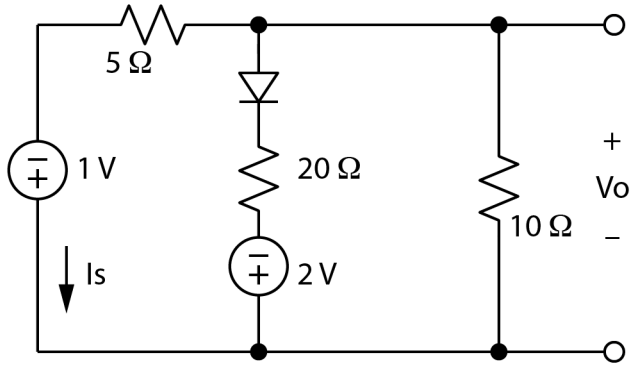
Problem 1: (*10 points*)

a) Determine whether the diode is in the ON of OFF state. $V\gamma$ = 0.7 V.
b) Solve for Vo and Is.

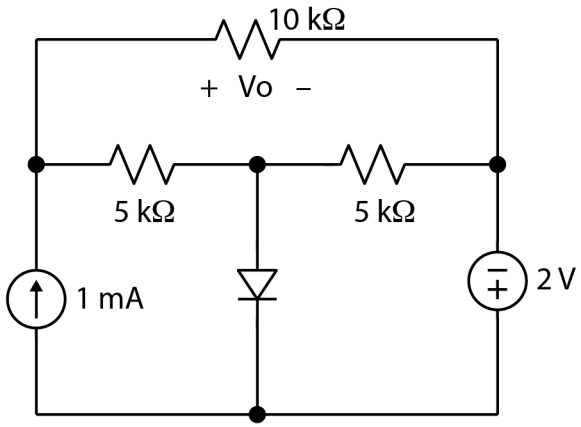


Problem 2: (*10 points*)

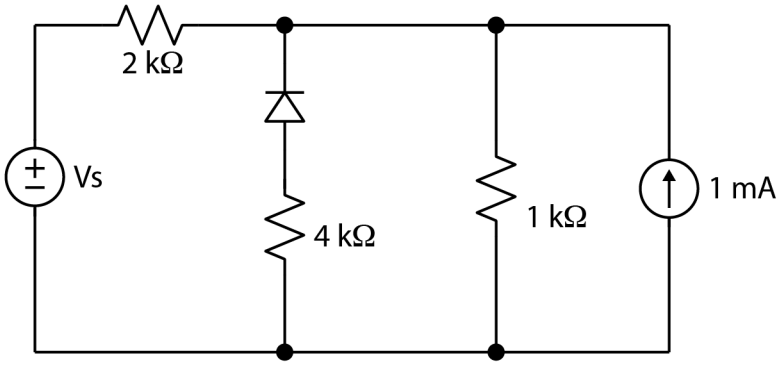
a) Determine whether the diode is in the ON of OFF state. $V\gamma$ = 0.7 V.
b) Solve for Vo and Is.



Problem 3: (*20 points*)
Solve for Vo. Vγ = 0.7 V.

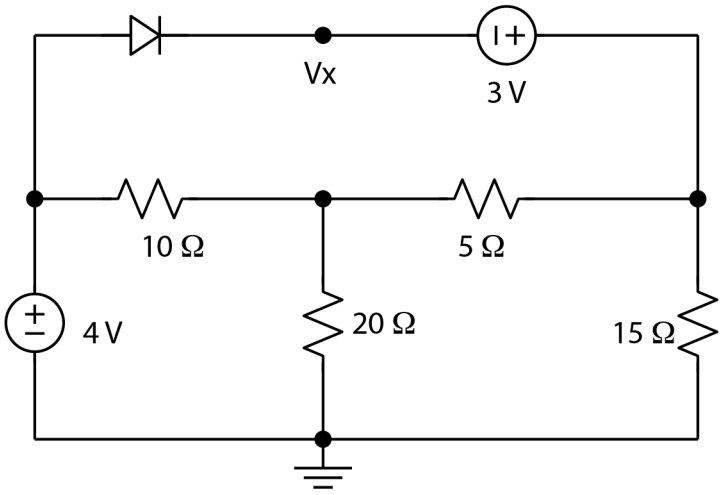


Problem 4: (*30 points*)
Determine the range of Vs such that the diode would be in the ON state. Vγ = 0.7 V



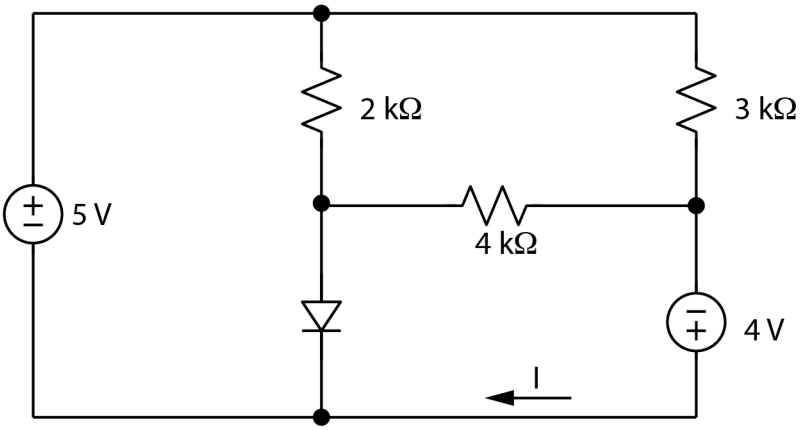
Problem 5: (*20 points*)

a) Determine whether the diode is in the ON or OFF state. V_γ = 2 V.
b) Solve for the node voltage Vx.

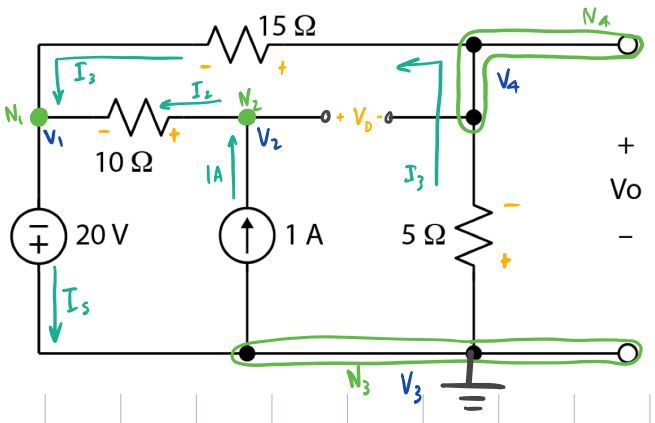


Problem 6: (*10 points*)

a) Determine whether the diode is in the ON or OFF state. V_γ = 1 V.
b) Solve for I.



Problem 1a



4 nodes - 1 ref - 1 voltage source
= 2 unknown

Write easily found voltages

$V_3 = 0v$

$V_1 + 20 = V_3 \rightarrow V_1 = -20v$

$V_4 = V_o$

KCL equations

KCL at N_2: $I_2 = 1$

$$\frac{V_2 - V_1}{10} = 1$$

$$V_2 + 20 = 10$$

$$V_2 = -10v$$

KCL at N_4: $I_3 = I_3$

$$\frac{V_3 - V_4}{5} = \frac{V_4 - V_1}{15}$$

$$3(-V_4) = V_4 + 20$$

$$-3V_4 = V_4 + 20$$

$$-V_4 = 20$$

$$V_4 = -5$$

$V_D = V_2 - V_4$

$= -10 + 5$

$= -5V$

Diode is OFF

Part B

$V_o = V_4$

$= -5V$

KCL at N_3: $I_5 = I_2 + I_3$

$I_2 = 1A$

$$I_s = 1 + I_3$$

Solve for I_3 at 5Ω resister

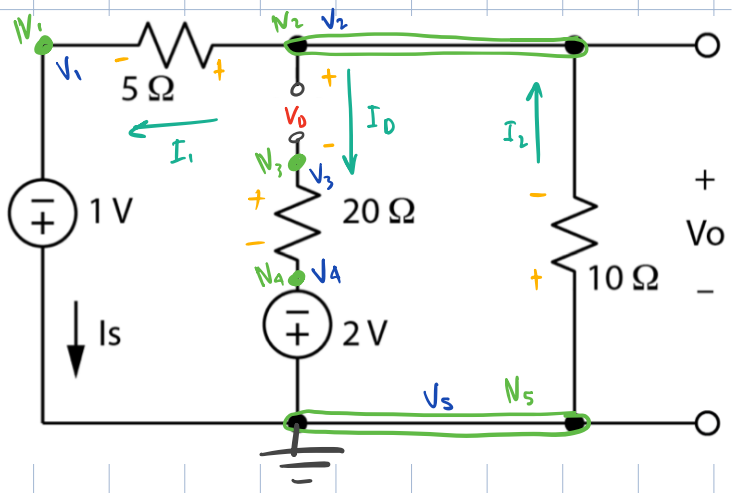
$$I_3 = \frac{V_3 - V_4}{5}$$

$$= \frac{0 + 5}{5}$$

$$= 1\,A$$

$$I_s = 2\,A$$

Problem 2a



Start with diode in OFF

5 nodes - 1 ref - 2 voltage sources
= 2 unknown voltages

Known Voltages

$V_5 = 0\,v$ $\quad I_D = 0\,A$ because diode is off

$V_4 = -2v$

$V_1 = -1v$

Solve for unknown voltages

KCL at N_2: $I_1 = I_2$

$$\frac{V_2 - V_1}{5} = \frac{V_5 - V_2}{10}$$

$$\frac{V_2 + 1}{5} = \frac{-V_2}{10}$$

$$2V_2 + 2 = -V_2$$

$$3V_2 = -2$$

$$V_2 = -\frac{2}{3} V$$

KCL at N_3: $0 = \frac{V_3 - V_4}{20}$

$$0 = V_3 + 2$$

$$V_3 = -2V$$

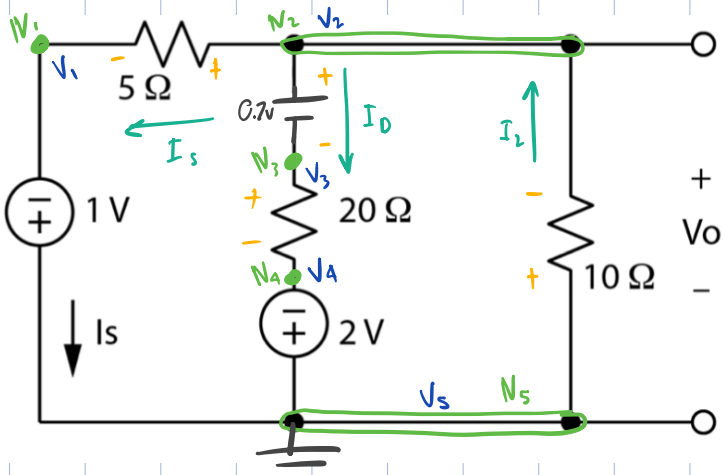
$$V_D = V_2 - V_3$$

$$= -\frac{2}{3} + 2$$

$$= \frac{4}{3} V$$

Dicde is ON

5 nodes - 1 ref - 3 voltage sources
= 1 unknown



Known Voltages

$$V_5 = 0V$$

$$V_4 = -2V$$

$$V_1 = -1V$$

$$V_2 = V_3 + 0.7$$

Solve for I_D at the 20Ω resistor

$$I = \frac{V}{R}$$

$$I_D = \frac{V_3 - V_4}{20}$$

KCL at V_2: $I_2 = I_5 + I_D$

$$\frac{0 - V_2}{10} = \frac{V_2 - V_1}{5} + \frac{V_3 - V_4}{20}$$

$$\frac{0 - (V_3 + 0.7)}{10} = \frac{(V_3 + 0.7) + 1}{5} + \frac{V_3 + 2}{20}$$

$$-2(V_3 + 0.7) = 4(V_3 + 1.7) + V_3 + 2$$

$$-2V_3 - 1.4 = 4V_3 + 6.8 + V_3 + 2$$

$$-7V_3 = 10.2$$

$$V_3 = -1.457V$$

$$V_2 = -0.757V$$

$$V_o = V_2 - 0$$

$$= -0.757V$$

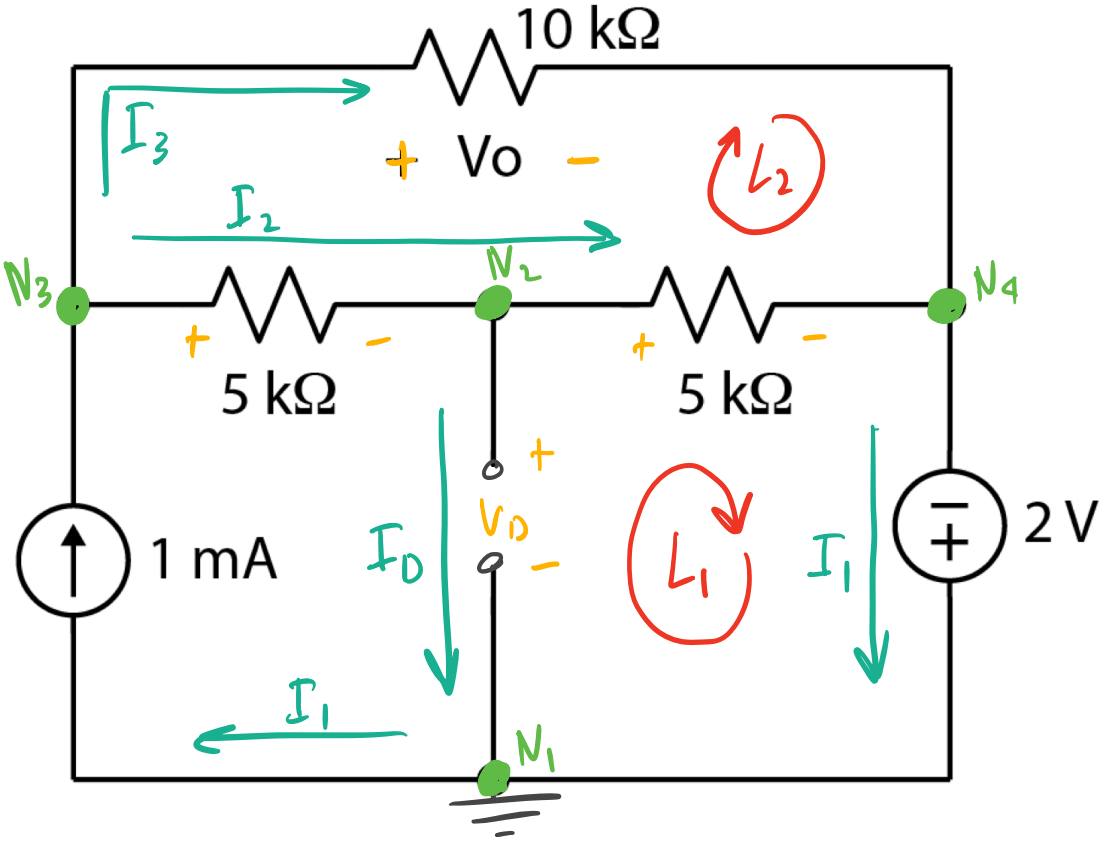
Solve for I_s at the 5 Ω resistor

$$I_s = \frac{V_2 - V_1}{5}$$

$$= 0.0486 A$$

Problem 3a

Solve with diode initially OFF



2 backyards - 1 current source = 1 unknown

4 nodes - 1 ref - 1 voltage source = 2 unknowns

Use branch current method

known currents

$I_D = 0$

$I_1 = 0.001\ mA$

$$I_2 = 0.001 - I_3 \quad (1)$$

KVL on L_2: $5000 I_2 - 10{,}000 I_3 + 5000 I_2 = 0$

$10{,}000 I_2 - 10{,}000 I_3 = 0$

$I_2 - I_3 = 0$

$$I_2 = I_3 \quad (2)$$

Sub (2) into (1)

$I_2 = 0.001 - I_2$

$2I_2 = 0.001$

$I_2 = 0.0005\ A$

$I_3 = 0.0005\ A$

KVL on L_1: $V_0 - 5000 I_2 + 2 = 0$

$V_0 = 5000 I_2 - 2$

$= 0.5\ V$

Diode is OFF

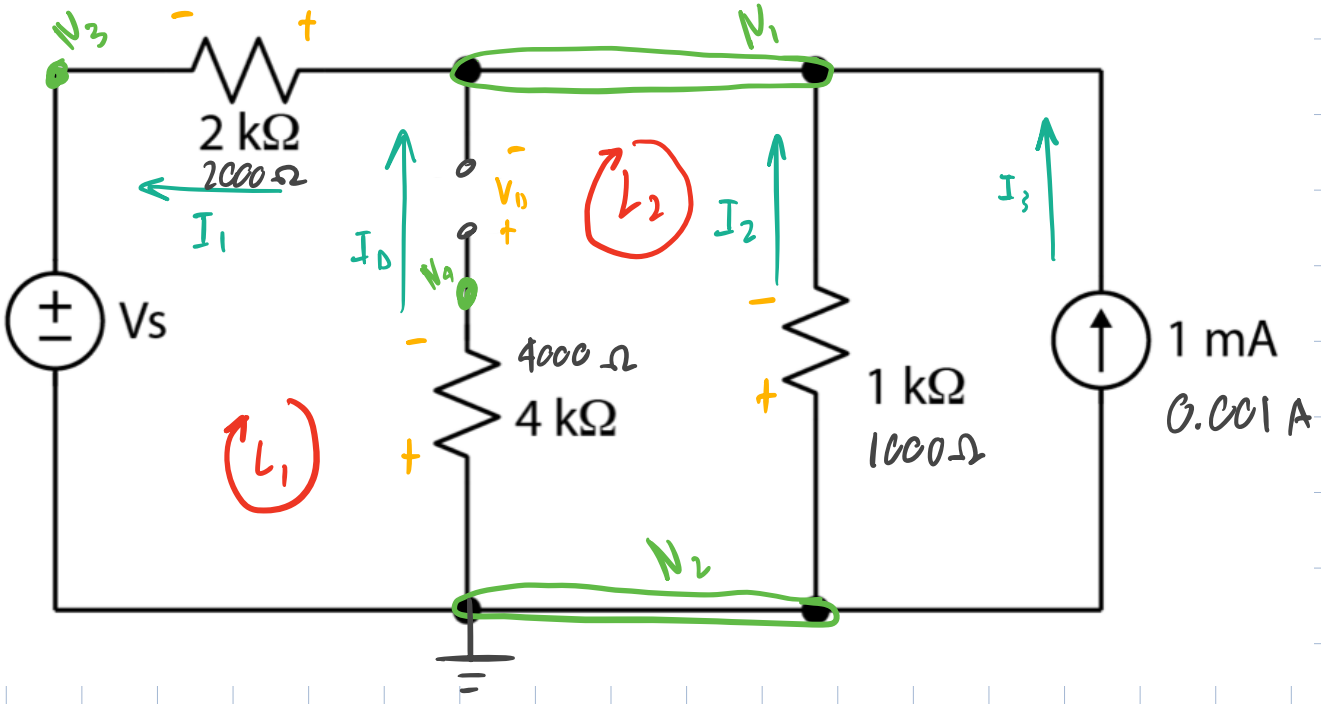
Solve for V_o

$V_o = 10,000\, I_3$

$= 5\,V$

Problem 4a

Start with Diode OFF



4 nodes - ref - 1 voltage source = 2 unknown

2 backwards - 1 current source = 1 unknown

Known Currents

$I_3 = 0.001\,A$

$I_D = 0\,A$

$I_1 = I_2 + I_3$

$= I_2 + 0.001$

KVL on L_1: $V_S + 2000 I_1 + V_D + 4000 I_D = 0$

$V_S + 2000(I_2 + 0.001) + V_D = 0$ (1)

KVL on L_2: $1000 I_2 - 4000 I_D - V_D = 0$

$1000 I_2 = 4000 I_D + V_D$

$I_2 = 4I_D + \frac{V_D}{1000}$

$= \frac{V_D}{1000}$ (2)

Sub (2) into (1)

$V_S + 2000\left(\frac{V_D}{1000} + 0.001\right) + V_D = 0$

$V_S + 2V_D + 2 + V_D = 0$

$-3V_D = V_S + 2$

$V_D = \frac{V_S + 2}{-3}$

For the diode to be on $V_D \geq V_\gamma$

$V_\gamma \leq \frac{V_S + 2}{-3}$

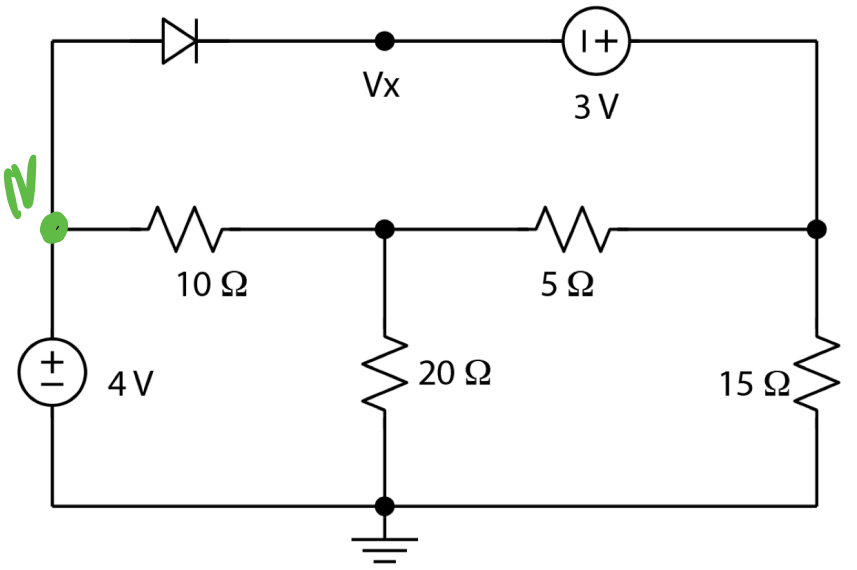
$-3V_\gamma \geq V_S + 2$

$V_s \leq -3V_y - 2$

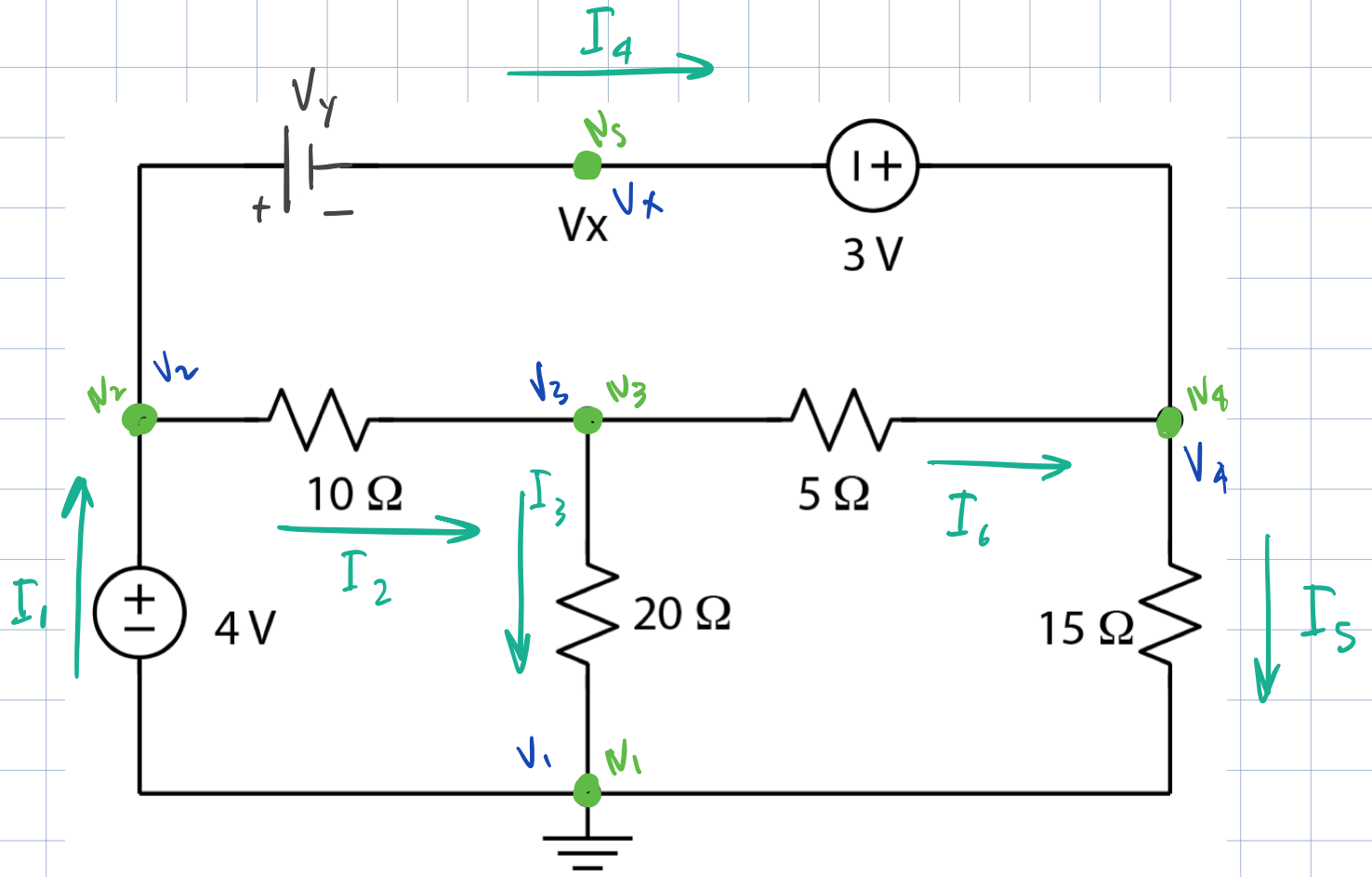
$V_s \leq -4.1V$

Problem 5a

Diode is ON because N is at 4 volts



Problem 5b



5 nodes - 1 ref - 3 voltage sources = 1 unknown

3 backwards - 0 current sources = 3 unknowns

Use node voltage method

known voltages

$V_1 = 0V$

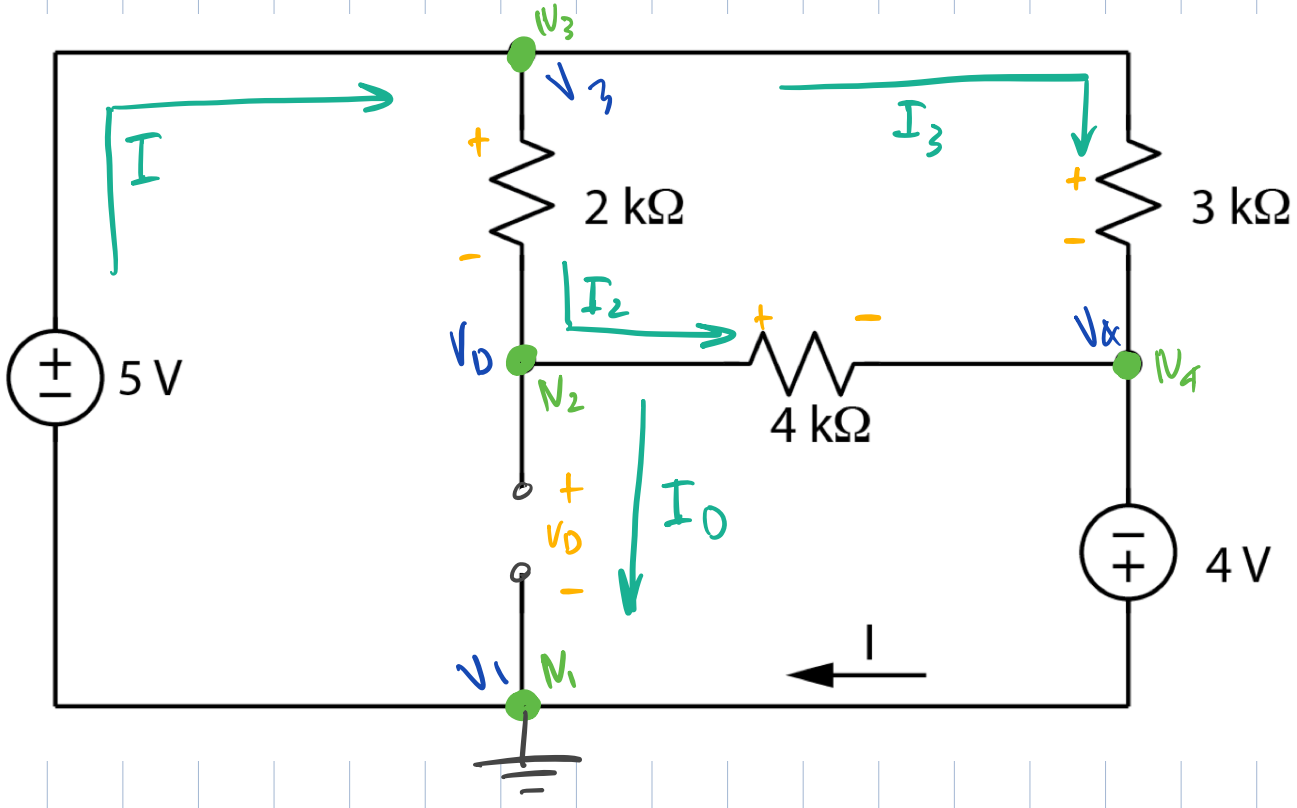
$V_2 = 4V$

$V_x = V_2 - V_y$

$= 2V$

Problem 6a

Start with the diode OFF



4 Nodes - 1 ref - 2 voltage sources = 1 unknown

2 loops - 0 current sources = 2 unknowns

Use node voltage analysis

Known Voltages

$V_1 = 0\ V$

$V_3 = 5V$

$V_4 = -4V$

Kcl at V_2: $I_2 = I_2$

$$\frac{V_3 - V_D}{2000} = \frac{V_D - V_4}{4000}$$

$$2V_3 - 2V_D = V_D - V_4$$

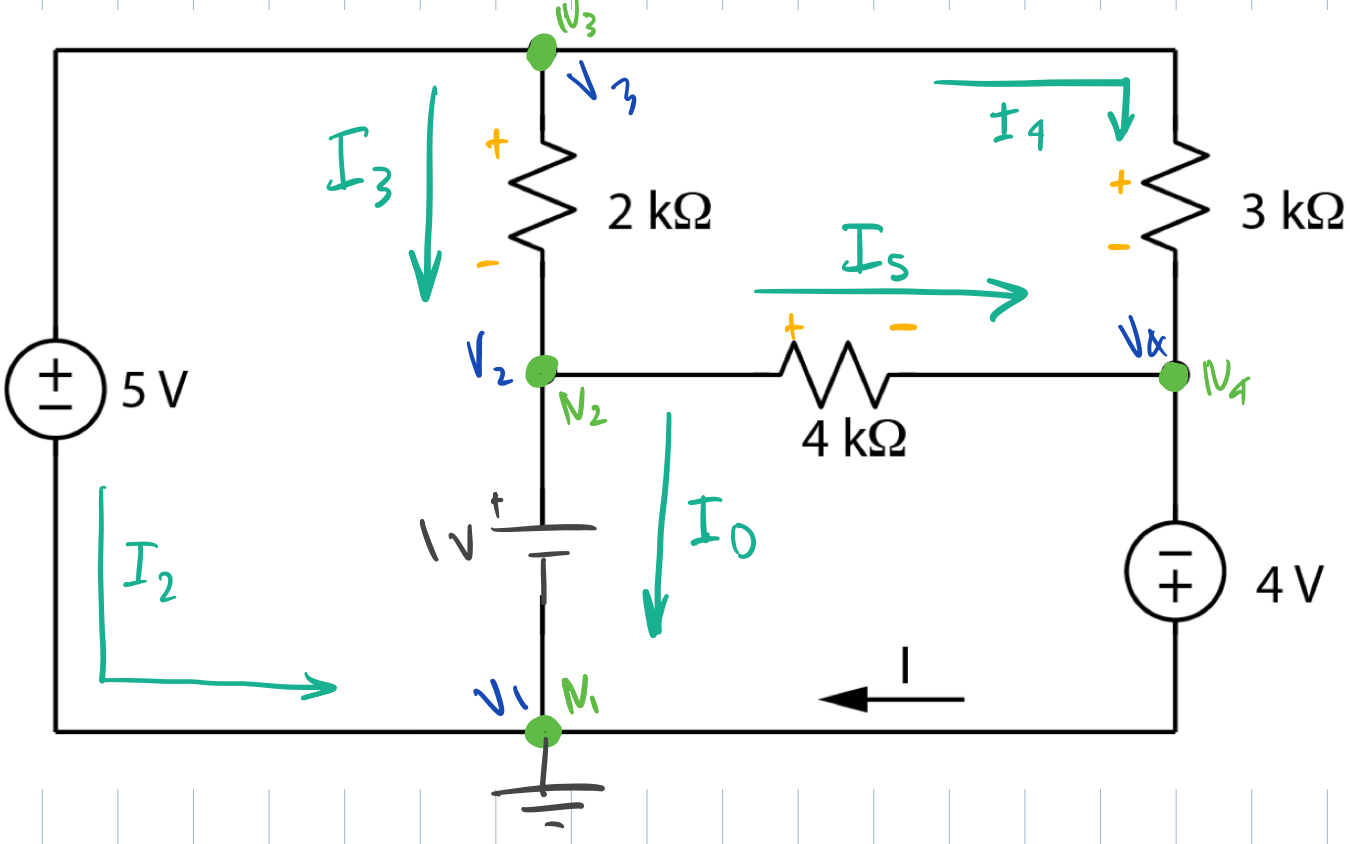
$$10 - 2V_D = V_D + 4$$

$$3V_D = 6$$

$$V_D = 2\ V$$

Dicde is ON

Problem 6b



4 nodes - 1 ref - 3 voltage sources = 0 unknowns

Known voltages

$V_1 = 0\ V$

$V_2 = 1\ V$

$V_3 = 5\ V$

$V_4 = -4\ V$

KCL at V_4: $I_4 + I_5 = I$

$$\frac{V_3 - V_4}{3000} + \frac{V_2 - V_4}{4000} = I$$

$$I = \frac{5 + 4}{3000} + \frac{1 + 4}{4000}$$

$$= 0.00425\ A$$