Homework 1

Use a separate piece of paper for each problem. Solutions with clear reasoning and correct results receive full points. Solutions with clear reasoning and incorrect results receive 3/4 of the total points. Solutions with current results but no rationale receive no points.

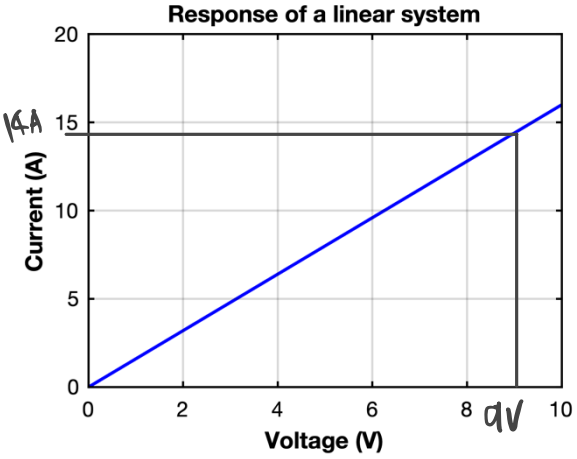
Problem 1: A piece of iron is cut into a rectangular shape with dimensions of 1 m long, 10 cm wide and 50 mm tall.

a) What is the resistance? (5 points)
b) If the materials is changed to copper and using the same dimensions what is the resistance? (*10 points*)
c) What would be the dimensions of a rectangular shape piece of copper such as the resistance value is same as in "a)"? (5 points)

$\rho_{fe} = 1x10^{-7}\ \Omega$ m, $\rho_{cu} = 1.68x10^{-8}\ \Omega$ m.

Problem 2: Analyze the following IV curve and:

a) Find the slope. (3 points)
b) If this is a single resistor connected to a 9 V ideal battery, what is the current that flows across the resistor? (2 points)



Problem 3: A thermistor is a temperature dependent resistor whose resistance is modeled via the modified Steinhart Hart equation:

$$\frac{1}{T} = \frac{1}{T_0} + \frac{1}{B} ln\left(\frac{R}{R_0}\right)$$

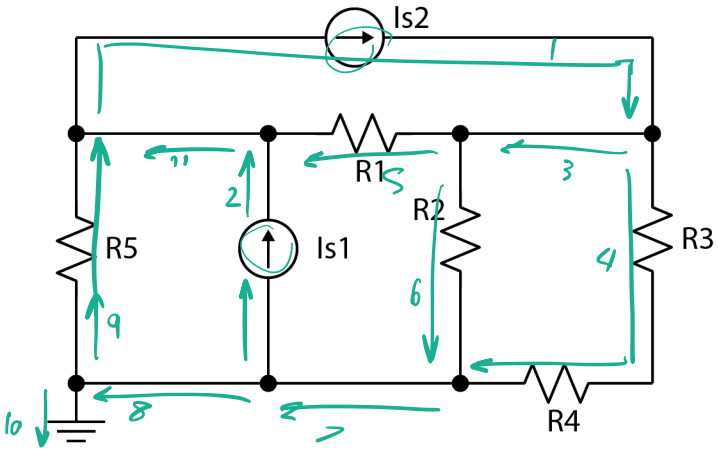
where R_0 is the resistance value at a reference temperature T_0, and B is the thermistor parameter given by the vendor in units of Kelvin [K]. Consider a thermistor sold by Murata (NCP03WF104) whose R_0 = 100 kΩ at T_0 = 25 ºC and B = 4250 K.

a) Calculate the Resistance value at 15 ºC. (5 points)
b) Calculate the Resistance value at 35 ºC. (5 points)
c) What is the change in resistance between those to temperatures. (5 points)

Problem 4: In a circular gold conductor 100 m long and 1mm in diameter flows a 5A current. What is the voltage across that conductor? (10 points)

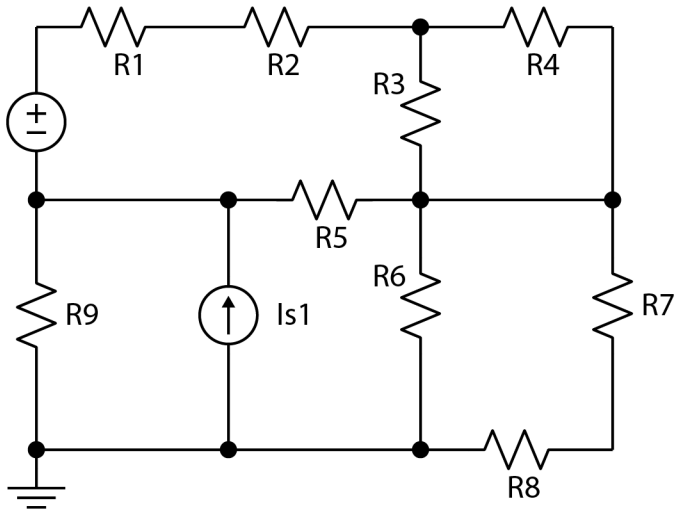
Problem 5: Consider the following electrical circuit.

a) Identify the number of nodes, branches, and loops. (10 points)
b) Write the KVL equation on all the loops. (15 points)

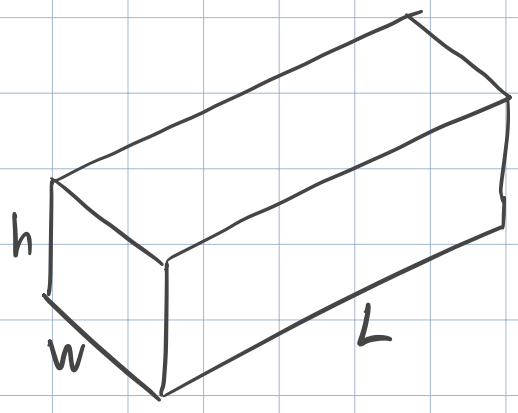


Problem 6: Consider the following electrical circuit.

a) Identify the number of nodes, branches, and loops. (10 points)
b) Write the KCL equation at each node. Define your current. (15 points)



Problem 1a



$$R = \rho_{rc} \frac{L}{A}$$

$$A = wh$$

$$R = \rho_{rc} \frac{L}{wh}$$

$$L = 1\,m$$

$$w = 10\,cm = 0.1\,m$$

$$h = 50\,mm = 0.05\,m$$

$$R = 2e{-}5\ \Omega$$

Problem 1b

$$R = \rho_{cu} \frac{L}{wh}$$

$$L = 1\,m$$
$$w = 0.1\,m$$
$$h = 0.05\,m$$

$$R = 3.36e{-}6\,\Omega$$

Problem 1c

$$R = \rho_{cu} \frac{L}{wh}$$

Let only L change to change resistance

$$\frac{R}{\rho_{cu}} = \frac{L}{wh}$$

$$L = \frac{Rwh}{\rho_{cu}}$$

$R = 2e\text{-}5\ \Omega$
$w = 0.1\,m$
$h = 0.05\,m$

$$L = 5.95\,m$$

Problem 2a

$P_1 = (0,0)$
$P_2 = (6,9)$

$$m = \frac{y_2 - y_1}{x_2 - x_1}$$

$$= \frac{9}{6}$$

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

Problem 2b

14 A, see graph above for work

Problem 3a

$$\frac{1}{T} = \frac{1}{T_0} + \frac{1}{B}\ln\left(\frac{R}{R_0}\right)$$

$$B\left(\frac{1}{T} - \frac{1}{T_0}\right) = \ln\left(\frac{R}{R_0}\right)$$

$$\frac{R}{R_0} = e^{B\left(\frac{1}{T} - \frac{1}{T_0}\right)}$$

$$R(T) = R_0 e^{B\left(\frac{1}{T} - \frac{1}{T_0}\right)}$$

$100\ k\Omega \cdot \frac{1000\ \Omega}{1\ k\Omega}$

$R_0 = 100\ k\Omega$
$= 100{,}000\ \Omega$

$T_0 = 25^\circ C$
$= 298.15\ K$

$B = 4250\ K$

$$R(13^\circ C) = R(288.15K) = 164{,}000\ \Omega$$

Problem 3b

$$R(35^\circ C) = R(308.15K) = 62{,}965\ \Omega$$

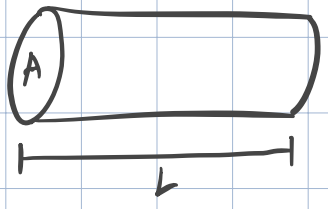
Problem 3c

$$R(15^\circ C) - R(35^\circ C) = 101035\ \Omega$$

Problem 4

$$R = \rho\frac{L}{A}$$

$A = \pi r^2$



Ohm's Law : $R = \frac{V}{I}$

$\frac{V}{I} = \rho \frac{L}{A}$

$V = \frac{\rho L I}{A}$

$L = 100\,m$

$I = 5\,A$

$d = 1mm$
$= 0.001m$

$V = \frac{\rho L I}{\pi r^2}$

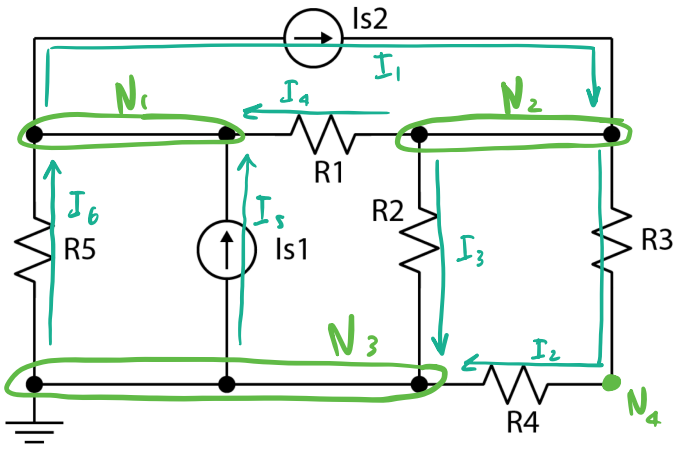
$2r = d \rightarrow r = \frac{d}{2}$

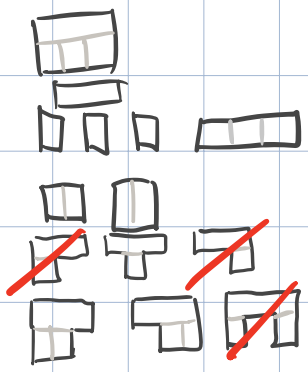
$V = \frac{\rho L I}{\pi (\frac{d}{2})^2}$

$= 15.534\,V$

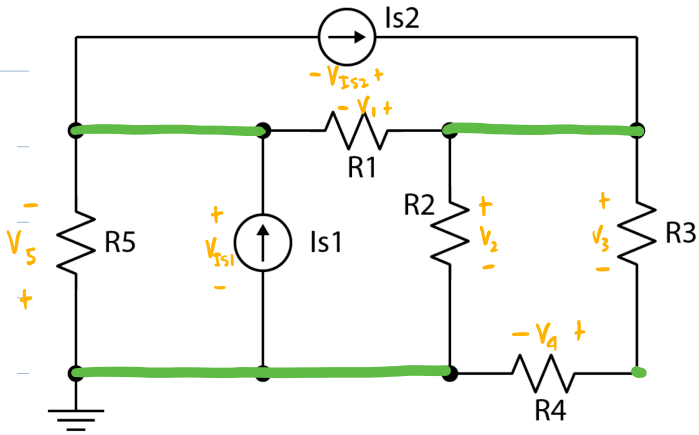
Problem 5a

Nodes : 4
Branches : 6
Loops : 11





Problem 5b



KVL on Loop: $R5 - IS1 \rightarrow V_5 + V_{SI1} = 0$

KVL on loop: $I_{S1} - R1 - R2 \rightarrow -V_{S1} - V_1 + V_2 = 0$

KVL on loop: $R2 - R3 - R4 \rightarrow -V2 + V3 + V4 = 0$

KVL on loop: $Is2 - R1 \rightarrow V_1 - V_{IS2} = 0$

KVL on loop: $R5 - R1 - R2 \rightarrow V_5 - V_1 + V_2 = 0$

KVL on loop: $I_{S1} - R_1 - R3 - R4 \rightarrow -V_{IS1} - V_1 + V_3 + V_4 = 0$

KVL on loop: $I_{S1} - I_{S2} - R2 \rightarrow -V_{S1} - V_{IS2} + V_2 = 0$

KVL on loop: $R5 - R1 - R3 - R4 \rightarrow V_5 - V_1 + V_3 + V_4 = 0$

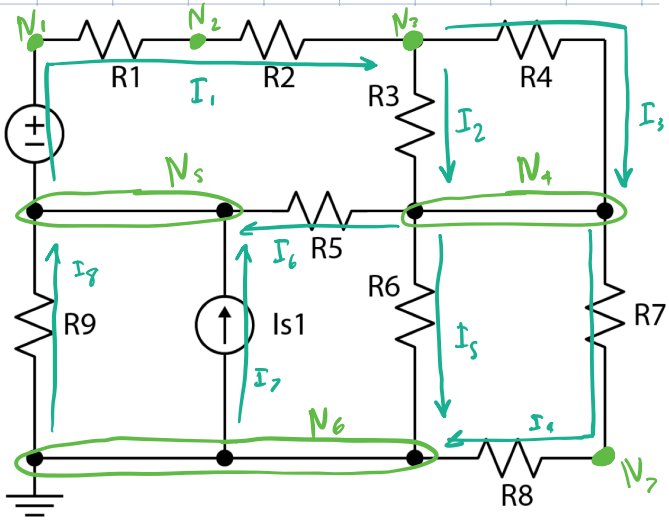
KVL on loop: $R5 - I_{S2} - R2 \rightarrow V_5 - V_{IS2} + V_2 = 0$

KVL on loop: $I_{S1} - I_{S2} - R3 - R4 \rightarrow -V_{IS1} - V_{IS2} + V_3 + V_4 = 0$

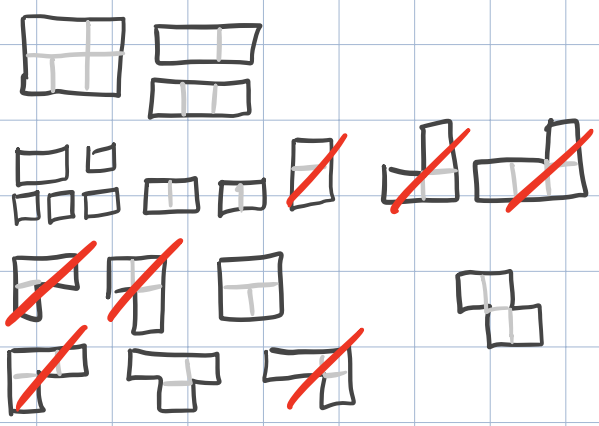
KVL on loop: $R5 - IS2 - R3 - R4 \rightarrow V5 - V_{IS2} + V_3 + V_4 = 0$

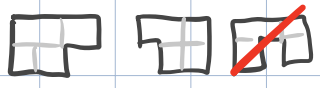
← From the key

Problem 6a



Nodes: 7
Branches: 8
Loops: 15

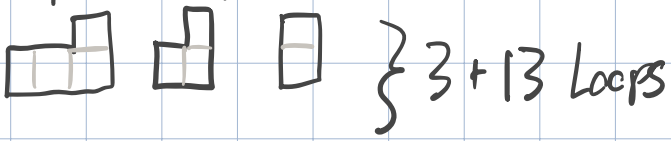




Problem 6a

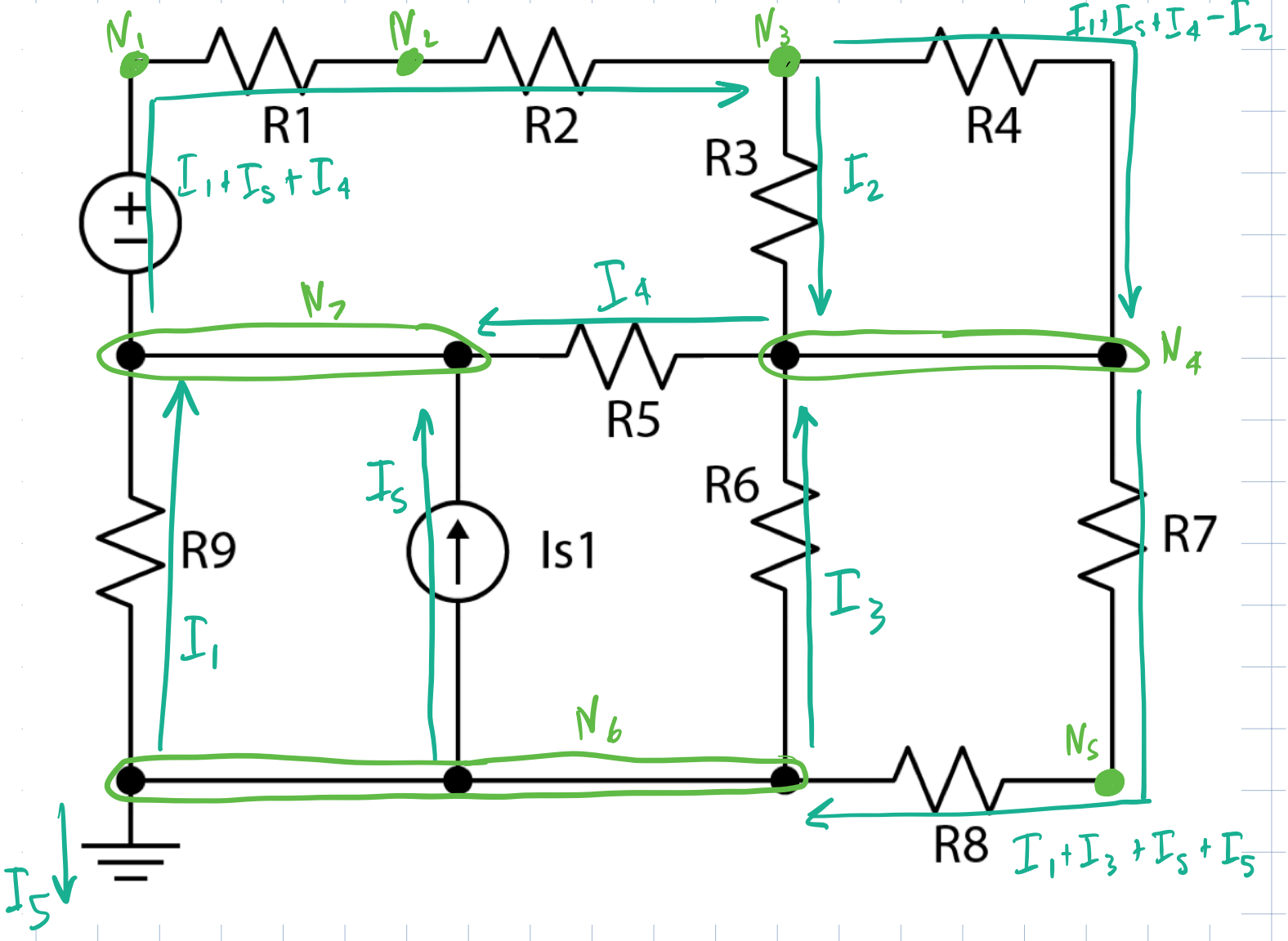
Nodes: 7
Branches: 9
Loops: 16

All previous loops in Q5 and



Problem 6b

5 backyards - 1 current source = 4 unknowns



$$N_1: I_1 + I_s + I_4 - (I_1 + I_s + I_4) = 0$$

$$N_2: I_1 + I_s + I_4 - (I_1 + I_s + I_4) = 0$$

$$N_3: -(I_1 + I_s + I_4) + I_2 + (I_1 + I_s + I_4 - I_2) = 0$$

$$N_4: \cancel{-(I_1 + I_s + I_4 - I_2)} - I_2 - I_3 \cancel{+ (I_1 + I_3 + I_s + I_5)} + I_4 = 0$$

$$-I_2 - I_3 + I_4 = 0$$

$$N_5: -(I_1 + I_3 + I_s + I_5) + (I_1 + I_3 + I_s + I_5)$$

N_6: $-(I_1 + I_3 + I_5 + I_5) + I_3 + I_5 + I_1 + I_6 = 0$

$-I_5 + I_6 = 0$

N_5: $-I_4 - I_5 - I_1 + (I_1 + I_5 + I_4) = 0$