EE 40
Homework #4
Solutions and Grading

Problem 1: 10 Points

Design constraint #1: Power supplied to resistors is 60 W.

R_1, R_2, R_3 in series $\Rightarrow$ have same current I (goes from top to bottom since 24 V is + at top...)

$$P_{total} = 60 = I^2R_1 + I^2R_2 + I^2R_3 = I^2(R_1 + R_2 + R_3)$$

$$I = \frac{24\ V}{R_1 + R_2 + R_3}$$

$$P_{total} = 60 = \frac{24^2}{(R_1+R_2+R_3)^2}(R_1 + R_2 + R_3) = \frac{576}{R_1 + R_2 + R_3}$$

$$\Rightarrow R_1 + R_2 + R_3 = \frac{576}{60} = 9.6\ \Omega$$

Design constraint 2:

$$V_2 - \text{Common} = 5\ V = 24 \cdot \frac{R_2}{R_1 + R_2 + R_3} = \frac{24 R_2}{9.6}$$

$$\Rightarrow \boxed{R_2 = 2\ \Omega}$$

$$\text{Common} - V_3 = 12\ V = 24 \cdot \frac{R_3}{R_1 + R_2 + R_3} = \frac{24 R_3}{9.6}$$

$$\boxed{R_3 = 4.8\ \Omega}$$

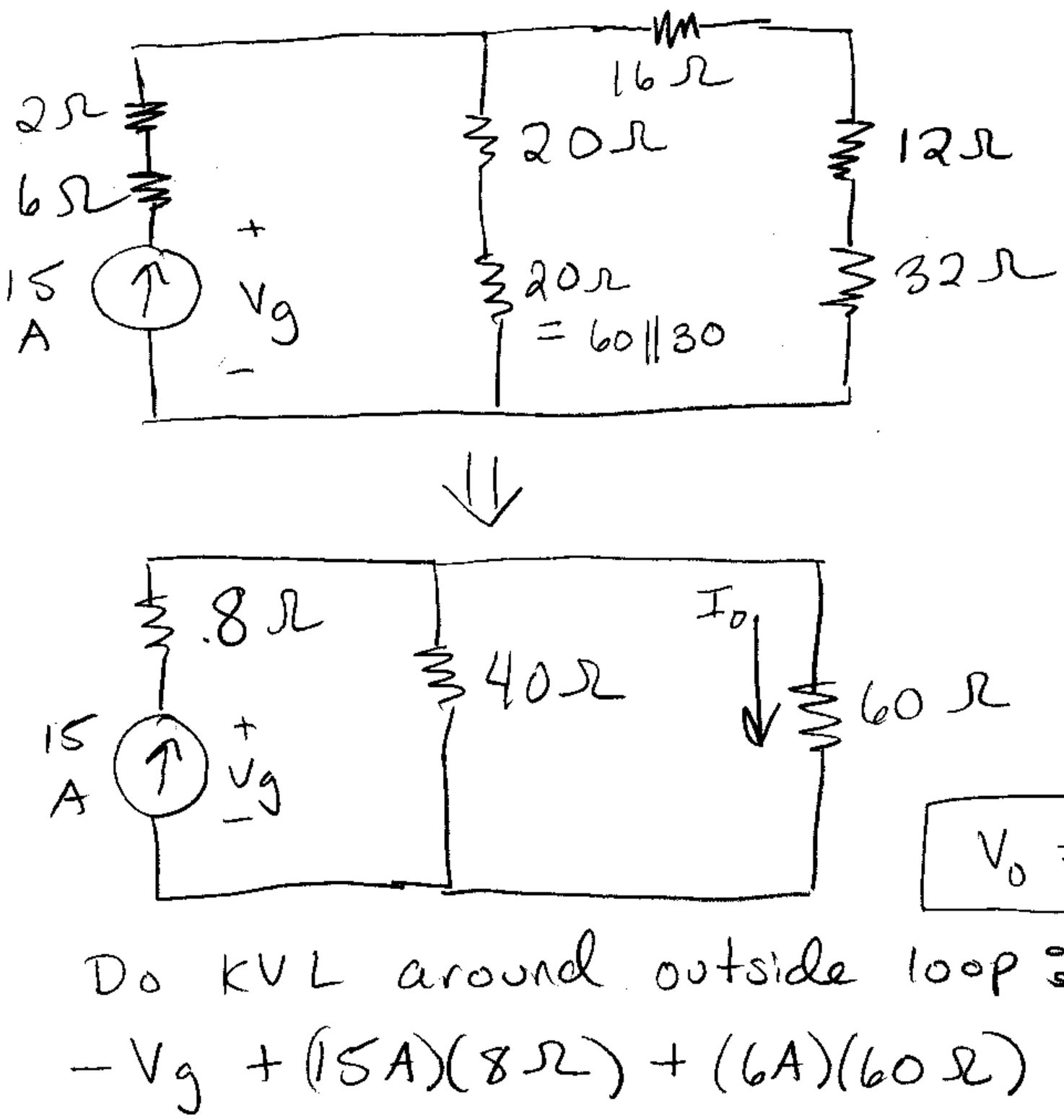
$$V_1 - \text{Common} = 12 = 24\,\frac{R_1 + R_2}{R_1 + R_2 + R_3} = \frac{24(R_1 + 2)}{9.6}$$

$$\boxed{R_1 = 2.8\,\Omega}$$

10 Points for correct answers
8 Points for minor & math errors
5 Points for a significant error (or multiple math errors)
0 Points for multiple significant errors

Problem 2° 10 Points

There are many ways to solve this!
I used current division - first simplifying R's



$$I_o = 15A \cdot \frac{40\,\Omega}{40 + 60\,\Omega}$$

$$= 6A$$

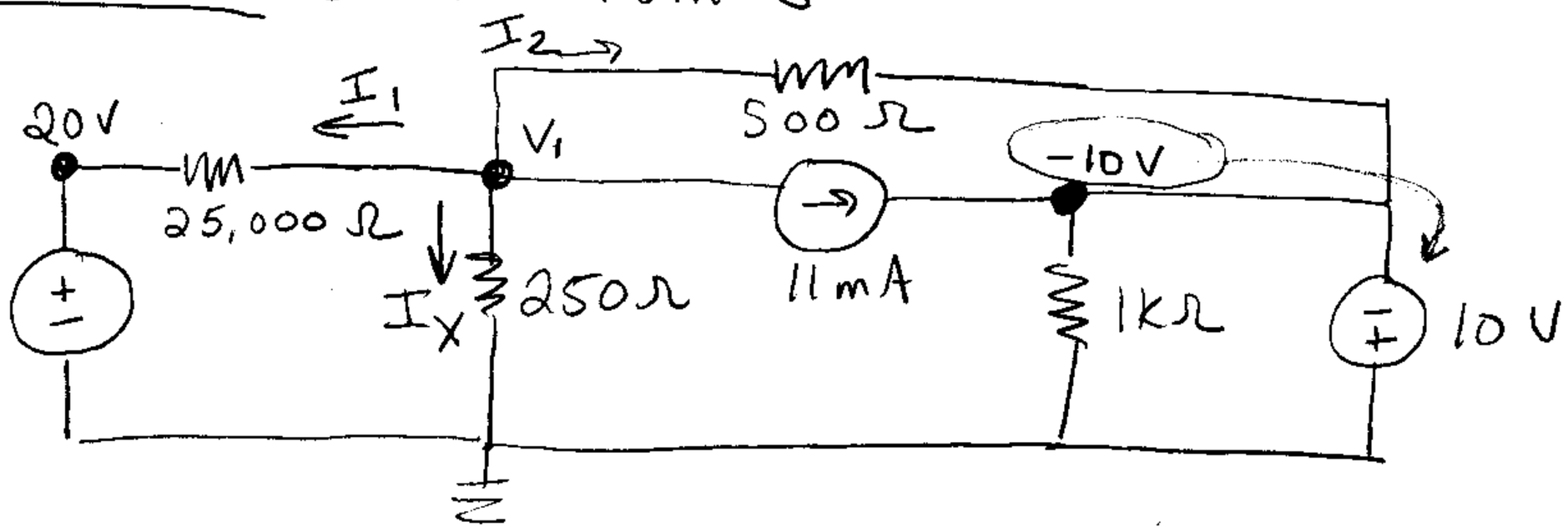
$$\boxed{V_o = 32\,\Omega \cdot 6A = 192\,V}$$

Do KVL around outside loop: (clockwise)

$$-V_g + (15A)(8\,\Omega) + (6A)(60\,\Omega) = 0 \qquad \boxed{V_g = 480\,V}$$

10 Points for both answers correct
8 Points for math, sign, small error
6 points for a significant error (or multiple math errors)
4 points for 2 significant errors
2 " " 3 " "
0 " " 4 or more "

Problem 3: 20 Points



Above, I have labeled the reference node, the other nodes, voltage values for other nodes if known, and the only unknown node voltage V_1.

KCL @ V_1:

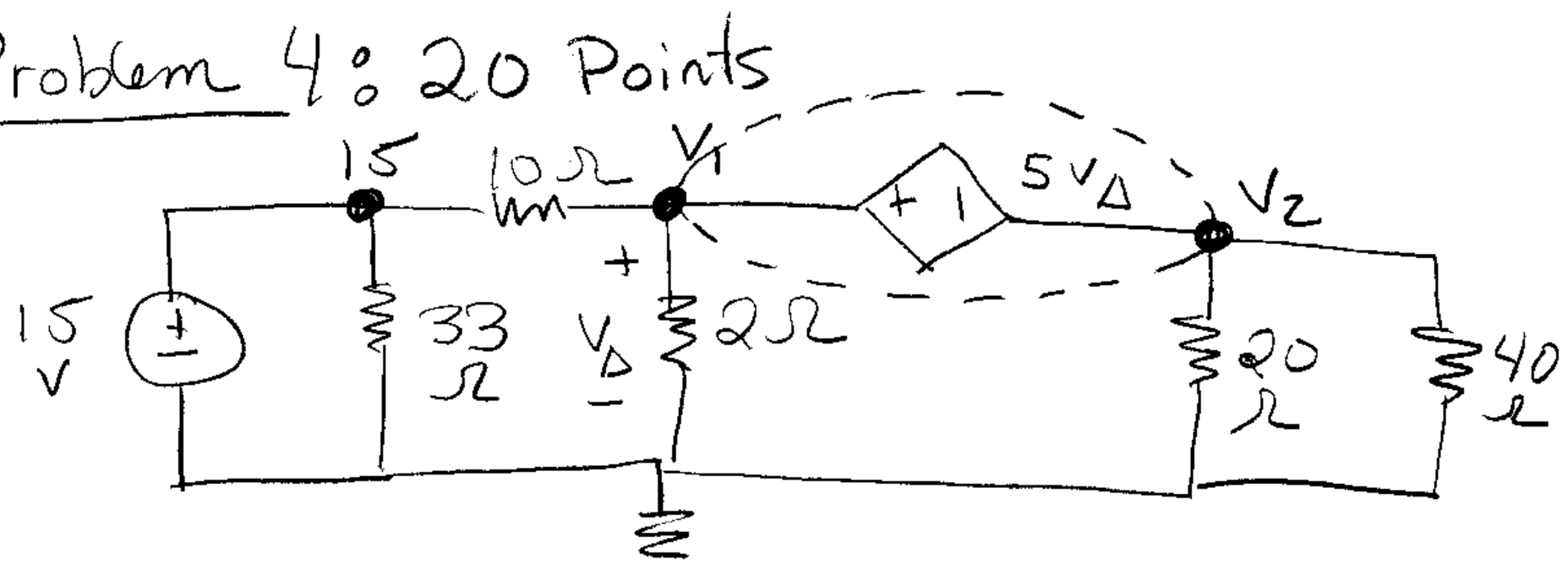
$$\underbrace{\frac{V_1 - 20}{25000}}_{I_1} + \underbrace{\frac{V_1}{250}}_{I_X} + \underbrace{\frac{V_1 - -10}{500}}_{I_2} + 11 \times 10^{-3} = 0$$

Solve to find $V_1 = -5\,V$

$$I_X = \frac{V_1}{250} = -20\,mA$$

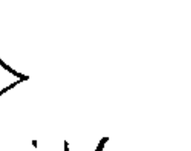
20 Points for correct answer
18 Points for math + minor error
16 Points for multiple math + minor errors
20-5n points for n significant errors
10 points if right answer, but not node voltage method (must at least have KCL @ V_1)
0 points for "I_x not shown" lame excuse

Problem 4: 20 Points



I have labeled the reference node, nodes with known voltages, and the two unknown node voltages V_1 and V_2.

KCL @ V_1
KCL @ V_2
> Can't be done! the voltage source (having unknown current) prevents it!



Make a supernode (as shown) around source

KCL @ supernode:

$$\frac{V_1-15}{10}+\frac{V_1}{2}+\frac{V_2}{20}+\frac{V_2}{40}=0$$

Inside supernode:

$$V_1-V_2=5V_\Delta$$

Extra equation defining controlling current in terms of node voltages:

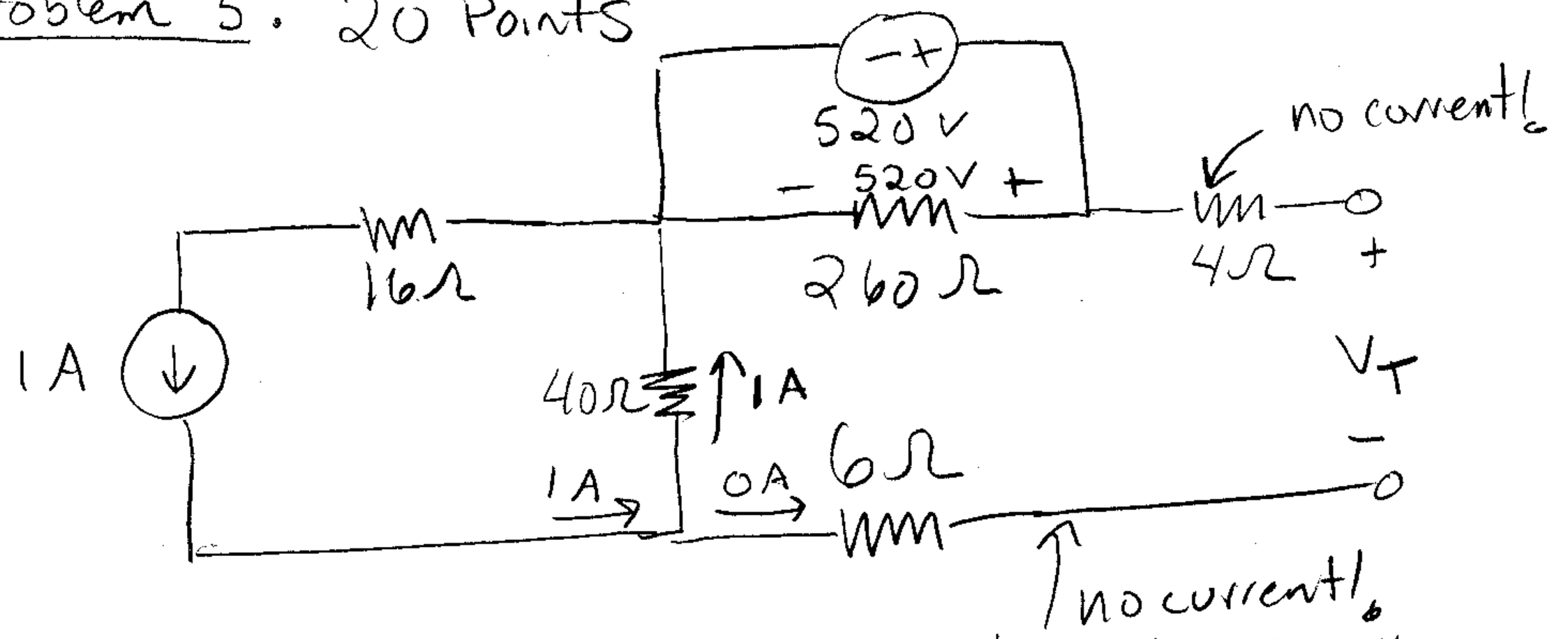
$$V_\Delta = V_1$$

Solve these 3 equations in 3 unknowns to get:

$$\boxed{V_\Delta = 5\,V}$$

Same grading as Problem 4. It's ok if simplifications were made before doing node voltage analysis.

Problem 5: 20 Points



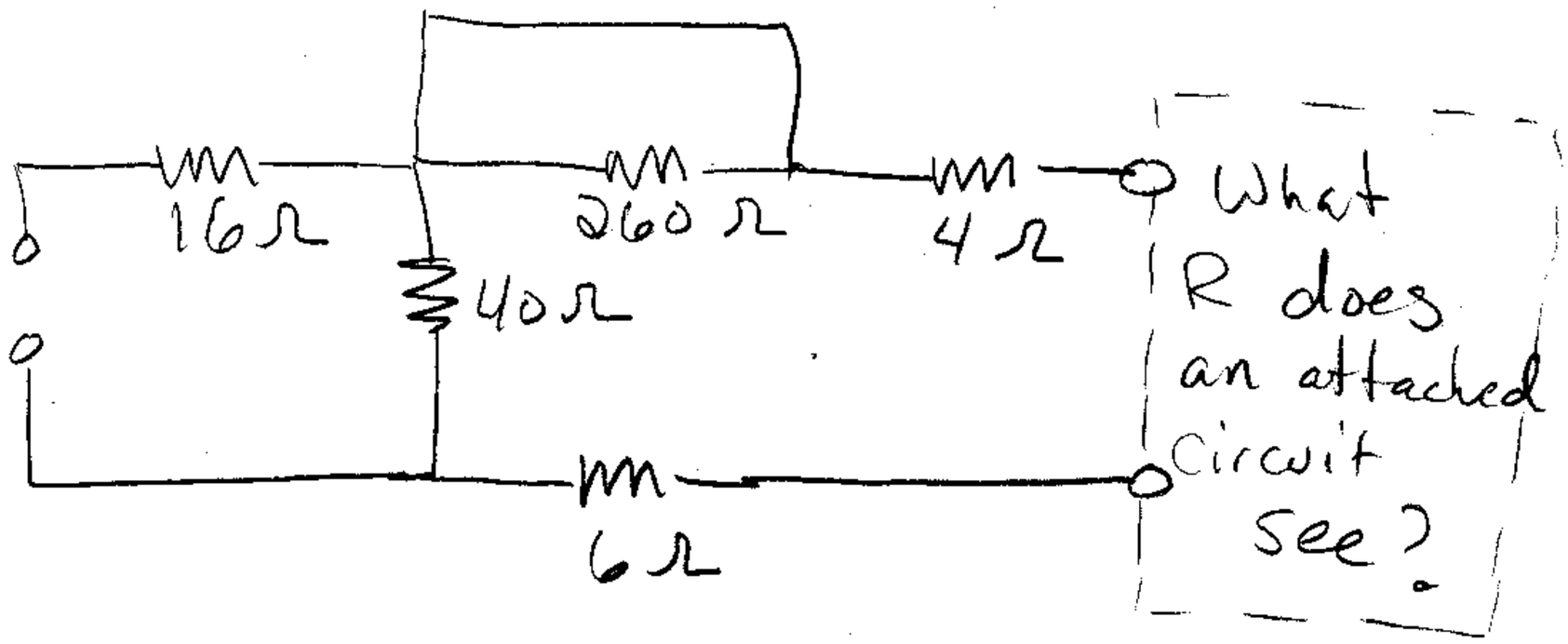
I first observe the above about the circuit.

Doing KVL involving V_T and the 40Ω resistor (clockwise starting at V_T)

$$V_T + (40\,\Omega)(1\,A) - 520\,V - (4\,\Omega)(0\,A) = 0$$

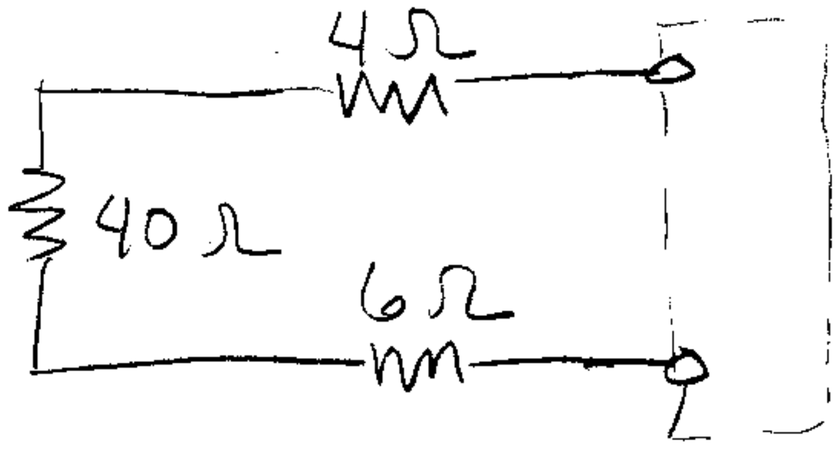
$$\boxed{V_T = 480\,V}$$

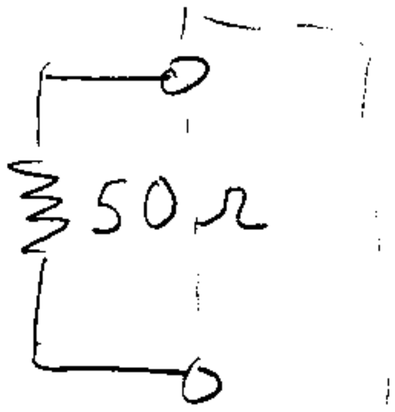
Turn off sources to find R_T:



16Ω Cannot carry current - has no effect

260Ω is in parallel with wire - becomes wire





$R_T = 50\Omega$

20 Points for both answers correct
(10 points for each V_T and R_T)

V_T: 8 points for minor/math error
5 points for 1-2 major or multiple math error
0 points for more than 2 major errors

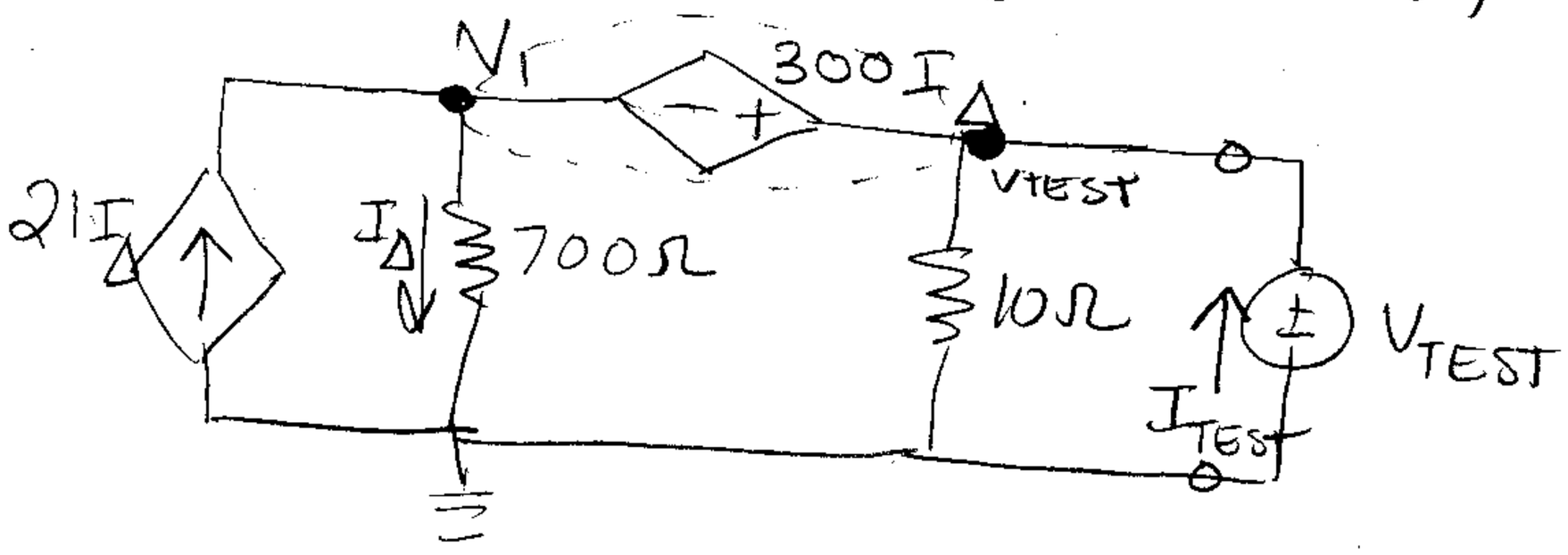
R_T: Same grading
Turning off sources wrong is a major error

Problem 6: 20 Points

Since no independent sources are present,

$$\boxed{V_T = 0}$$

Find R_T by applying test voltage, $R_T = \frac{V_{TEST}}{I_{TEST}}$



Do node-voltage analysis with indicated ground node:

KCL@ V_1

KCL@ V_{TEST} > Voltage source ◇ disallows

KCL@ Supernode around source:

$$-21I_\Delta + I_\Delta + \frac{V_{TEST}}{10} - I_{TEST} = 0$$

Inside supernode:

$$V_{TEST} - V_1 = 300\, I_\Delta$$

Definition of controlling current I_Δ:

$$I_\Delta = V_1 / 700\,\Omega$$

subs above in 2nd above

$$V_{TEST} - 700 I_\Delta = 300 I_\Delta \Rightarrow I_\Delta = V_{TEST}/1000$$

Subs in KCL:

$$-20\left(\frac{V_{TEST}}{1000}\right) + \frac{V_{TEST}}{10} = I_{TEST}$$

$$-20\,V_{TEST} + 100\,V_{TEST} = I_{TEST} \cdot 1000$$

$$80\,V_{TEST} = 1000\,I_{TEST}$$

$$\frac{V_{TEST}}{I_{TEST}} = R_T = \frac{1000}{80} = 12.5\,\Omega$$

20 Points for correct answer
18 for minor/math error
20-5n for each major error
15 for multiple math errors