B EE-215 Fundamentals of Electrical Engineering

Instructor: Tai-Chang Chen

Midterm

3:30-5:35 pm Friday 05/07

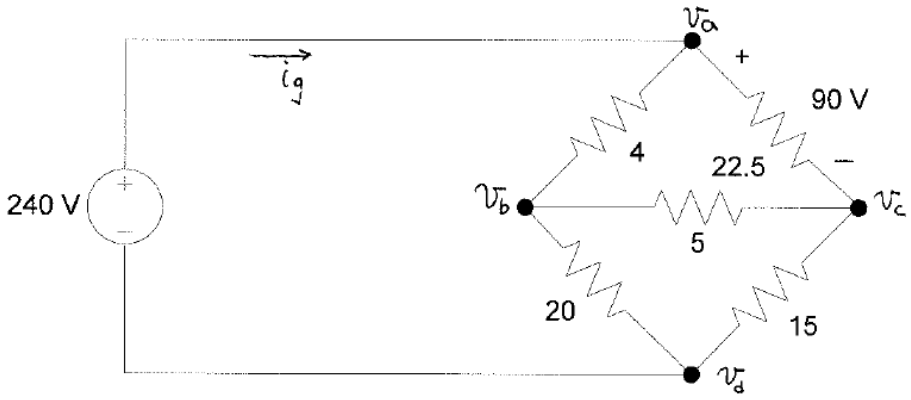
Name: _____

Student Number: _____

Problem #1: Circuit theories applications: [25 points]

The voltage across the 22.5 Ω resistor in the circuit is 90 V, positive at upper terminal.

(a) Find the power dissipated in each resistor.
(b) Find the power supply by the 240 V voltage source
(c) Verify that the power supplied equals the total power dissipated.



$i_{22.5}$ (ohm's law) $= \frac{90V}{22.5} = 4$ A

$v_{15\Omega} = 240 - 90 = 150$ V (KVL) $= v_c$.

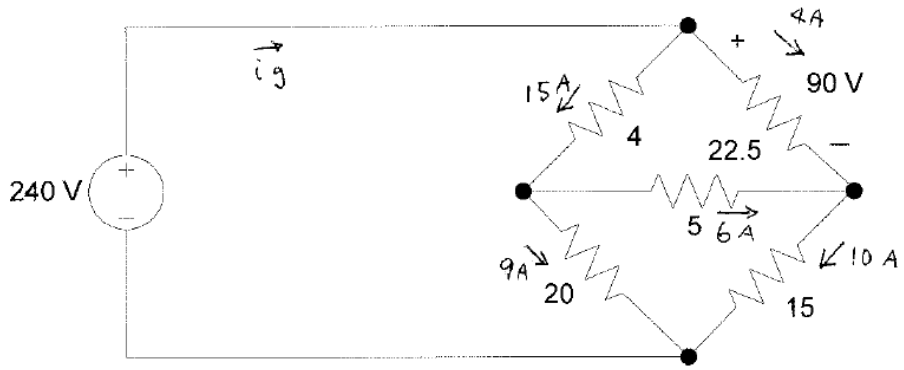
$i_{15} = \frac{150}{15} = 10$ A.

$i_{5\Omega} = 10 - 4 = 6$ A (KCL)

$v_b = v_c + 5 \times 6A = 180$ V.

$i_{4\Omega} = \frac{240-180}{4} = 15$ A

$i_{20\Omega} = \frac{180}{20} = 9$ A



$i_g = 15\,A + 4\,A = 19\,A.$

calculate POWER dissipated:

$P_{4\Omega} = 4 \times 15^2 = 900\,W$

$P_{5\Omega} = 5 \times 6^2 = 180\,W$

$P_{15\Omega} = 15 \times 10^2 = 1500\,W$

$P_{20\Omega} = 20 \times 9^2 = 1620\,W$

$P_{22.5\,\Omega} = 22.5 \times 9^2 = 360\,W$

b)

$P = -240 \times 19 = -4560\,W.$

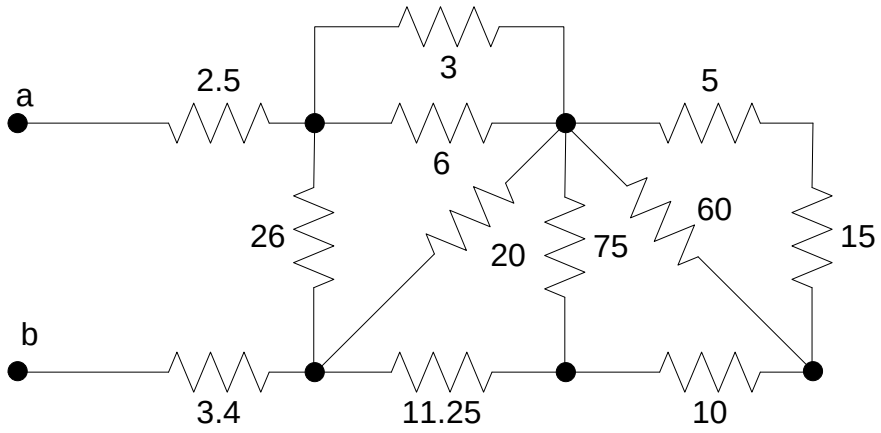
c)

$\Sigma P_{abs} = 900 + 1620 + 180 + 360 + 1500 = 4560\,W$

$\Sigma P_{supp} = \Sigma P_{dis}$

Problem #2: Simplification of circuit: [25 points]

Find the equivalent resistance Rab.



$5 + 15 = 20\ \Omega$

$20 \parallel 60 = 15\ \Omega$

$15 + 10 = 25\ \Omega$

$25 \parallel 75 = 18.75$

$18.75 + 11.25 = 30$

$30 \parallel 20 = 12\ \Omega$

$3 \parallel 6 = 2\ \Omega$

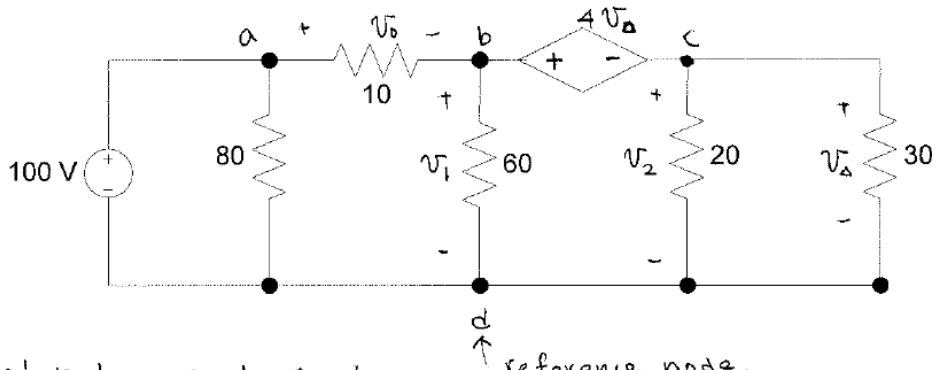
$2 + 12 = 14\ \Omega$

$26 \parallel 14 = 9.1\ \Omega$

$R_{ab} = 9.1 + 2.5 + 3.4 = 15\ \Omega$

Problem #3: Node-Voltage Analysis: [25 points]

Use the node-voltage method to find vo:



Essential nodes: a. b. c. d. ↑ reference node.

Super node : bc

$$\frac{v_1-100}{10}+\frac{v_1}{60}+\frac{v_1-4v_\Delta}{20}+\frac{v_1-4v_\Delta}{30}=0, \quad (v_2=v_1-4v_\Delta)$$

also:

KVL: $v_1 = 4v_\Delta + v_\Delta = 5v_\Delta$

Solve:

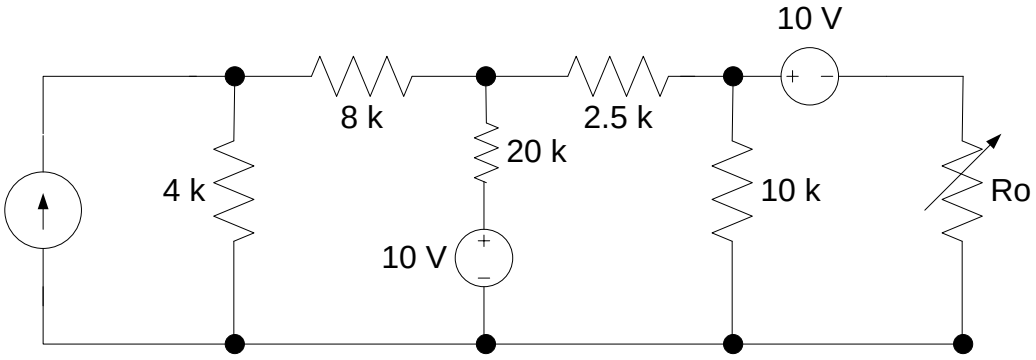
$v_1 = 75\ V. \quad v_\Delta = 15\ V$

Thus $v_o = 100 - v_1 = \boxed{25\ V}$

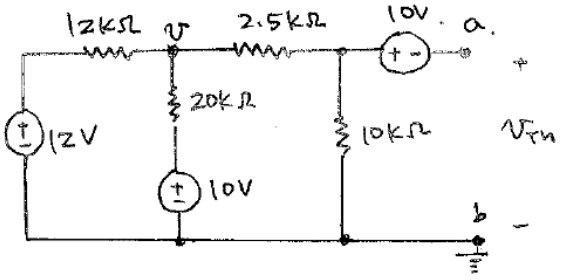
Problem#4: Thevenin Equivalent and Power Calculation [25 points]

The variable resistor in the circuit below is adjusted for maximum power transfer to Ro.

(a) Find the Thevenin equivalent and draw the equivalent circuit:
(b) Find the value of Ro
(c) Find the maximum power that can be delivered to Ro



(a) Source transform: Find open circuit voltage:



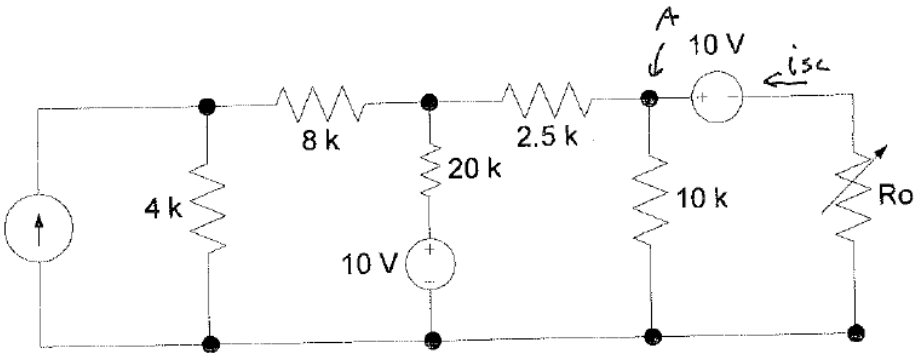
Node-Voltage:

$$\frac{v-12}{12K} + \frac{v-10}{20K} + \frac{v}{10K+2.5K} = 0.$$

Solving: $v = 7.03125\ V.$

$$v_{10K} = \frac{10000}{12500} \times 7.03125 = 5.625\ V.$$

$$\therefore \boxed{V_{Th} = v - 10 = -4.375\ V.}$$



Find short circuit current:

Node voltage: $\frac{v-12}{12k} + \frac{v-10}{20k} + \frac{v-10}{2.5k} = 0$.

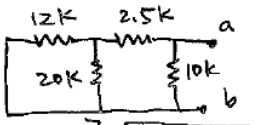
Solving: $v = 10.3125$ V.

KCL: at A:

$$\frac{-(10.3125-10)}{2.5k} + \frac{10}{10k} - i_{sc} = 0$$

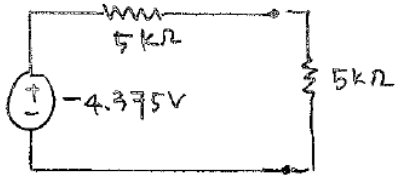
$i_{sc} = 0.875$ mA

R_{Th}: ~~At~~ Dead Network resistance:



$R_{Th} = 10k \,||\, [2.5k + (12k \,||\, 20k)] = 5\,k\Omega$.

(b) $R_o = R_{Th} = 5\,k\Omega$



(c) $P_{max} = i^2 R = \left(\frac{-4.375}{10k}\right)^2 \cdot 5k = 957.03\ \mu W$