ECSE-200 Electric Circuits 1
Quiz #3 (Feb. 1, 2019)

LAST NAME SOLUTIONS **MCGILL ID#** ____________

FIRST NAME ____________ **SIGNATURE** ____________

- ***Only Faculty standard calculator accepted***
- ***Show all your work***
- ***Clearly indicate your final answer with SI units and SI multiplier***
- ***You have 45 minutes to complete this quiz***
- ***Plagiarism will have important consequences***

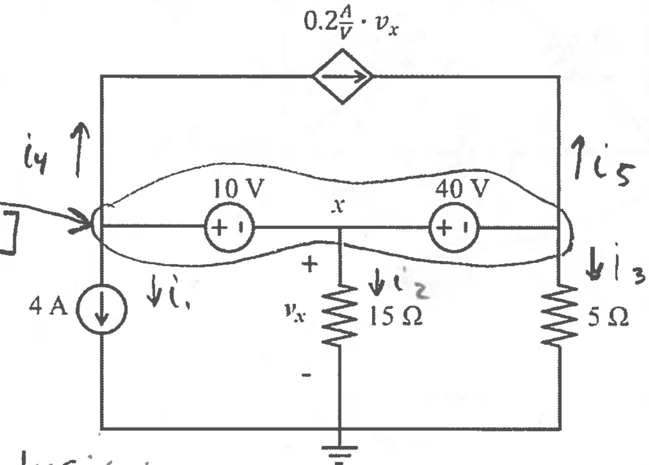
Question 1. Consider the circuit shown. Answer the following questions.

a) How many nodes are there in this circuit? [1 pt] $\boxed{\text{4 nodes}}$ [+1]

b) Identify the super-node in the circuit [1 pt] [+1]

c) What is the current supplied by the dependent current source? [2 pt]

d) What is the total power absorbed by both resistance? [2 pt]



c) $i = 0.2\frac{A}{V}\cdot V_x$ use nodal analysis:

KCL @ supernode $i_1 + i_2 + i_3 + i_4 + i_5 = 0$ [+0.5]

$$-4A + \frac{V_x}{15\Omega} + \frac{(V_x - 40V)}{5\Omega} + \underbrace{0.2\frac{A}{V}\cdot V_x - 0.2\frac{A}{V}\cdot V_x}_{=0} = 0 \quad [+0.5]$$

$\times 15\Omega$ $\quad -60V + V_x + 3V_x - 120V = 0$

$4V_x = 60V \Rightarrow V_x = 45V$ [+0.5]

$i = 0.2\frac{A}{V}\cdot 15V$

$\boxed{i = 3A}$ [+0.5]

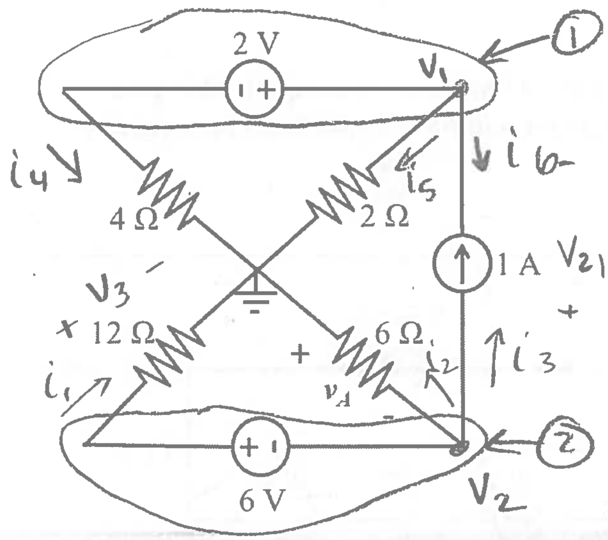
d) $P_{15\Omega} = V_x \cdot i_2 = \frac{V_x^2}{R}$ [+0.5] $= \frac{(45V)^2}{15\Omega} = 15W$ [+0.5]

$P_{5\Omega} = (V_x - 40V)\times i_3 = \frac{(V_x - 40V)^2}{5\Omega} = \frac{(25V)^2}{5\Omega} = 125W$ [+0.5] [+0.5]

$\boxed{P_{tot} = 140W}$

Question 2. Consider the circuit shown below. Answer the following questions.

a) How many super-nodes are there in this circuit? Identify them. [1 pt]
b) Using the node voltage method, find the value of the voltage v_A across the 6 Ω resistor. [2 pt]
c) How much power does the independent current source deliver or absorb? [1 pt]
d) How much power is absorbed by the 12 Ω resistor? [1 pt]



a) There are two super-nodes [+0.5]
identified [+0.5]

b) KCL @ super-node 2

$i_1 + i_2 + i_3 = 0$ [+0.5]

$$\frac{(V_2 + 6V)}{12\,\Omega} + \frac{V_2}{6\,\Omega} + 1A = 0 \quad [+0.5]$$

$(\times 12) \Rightarrow V_2 + 6V + 2V_2 + 12V = 0$ [+0.5]

$3V_2 = -18V \quad V_2 = -6V$

$V_A = -V_2 = 6V \quad \boxed{V_A = 6V}$ [+0.5]

c) To get V_{21} (voltage across source)
find V_1 KCL @ 1 $i_4 + i_5 + i_6 = 0$

$$\frac{(V_1 - 2V)}{4\,\Omega} + \frac{V_1}{2\,\Omega} - 1A = 0$$

$(\times 4) \quad V_1 - 2V + 2V_1 - 4A = 0$

$3V_1 = 6V \quad V_1 = 2V$ [+0.5]

$V_{21} = V_2 - V_1 = -6V - 2V = -8V \rightarrow P = 1V = -8W$

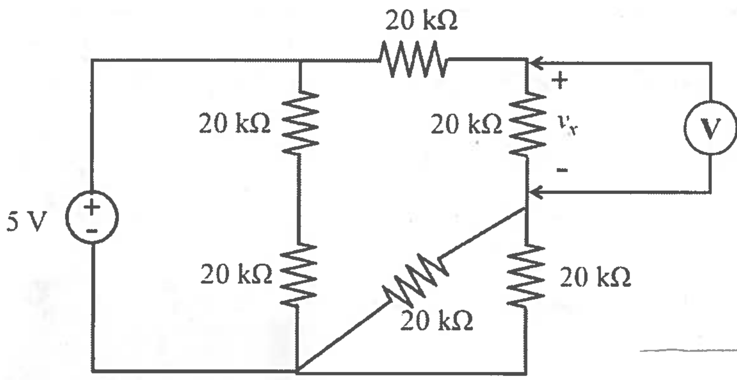
$\boxed{\text{Power delivered: } 8W}$ [+0.5]

d) V_3 (voltage accross 12 Ω) $V_3 = (V_2 + 6V) - 0V = (-6V + 6V) = 0$

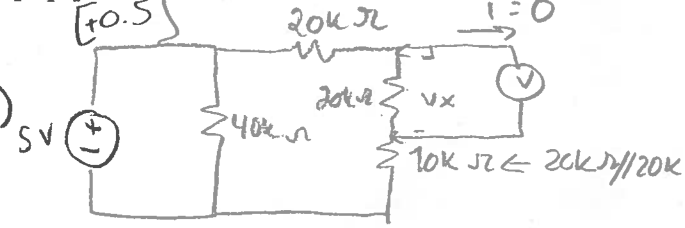
$\boxed{\text{There is 0W power absorbed (no power absorbed)}}$

Question 3. The practical voltmeter used to measure v_x in the circuit shown below is a D'Arsonval galvanometer with a full-scale current (i_{FS}) of 1 mA ($i_{FS} = 1mA$), an internal resistance R_M of 25 Ω (due to the wire loop resistance), and a series resistance R_s chosen such that the full-scale meter current (i_{FS}) is reached with 100 V at the voltmeter terminals. Answer the following questions.

1) What is the value of v_x if an ideal voltmeter was used to make the measurement? [1 pt]
2) What is the value of the series resistance R_s in the practical voltmeter used to measure v_x? [2 pt]
3) What is the measured voltage v_x by the practical voltmeter? [1 pt]
4) To decrease the measurement error on the voltage v_x, should a larger series resistance R_s be used or a smaller series resistance R_s be used? Justify your answer. [1 pt]



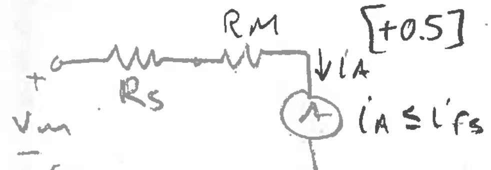
1) [+0.5]



$V_x = 5V \cdot \frac{20k\Omega}{20k\Omega + 20k\Omega + 10k\Omega} = 2V$ [+0.5]

$\boxed{V_x = 2V}$

2) Practical voltmeter



[+0.5] $i_A \leq i_{FS}$

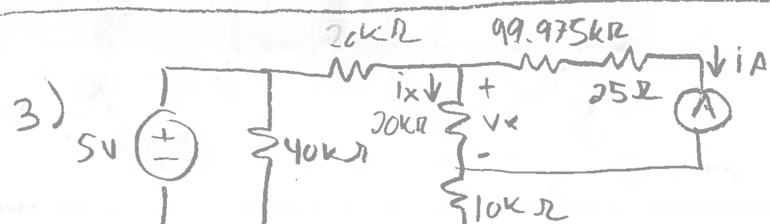
[+0.5] $R_M = 25\Omega$, $i_A = i_{FS}$: 1mA when $V_m = 100V$

$V_M = i_A(R_s + R_m)$

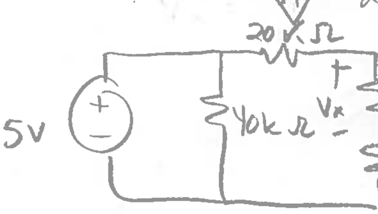
$100V = 1mA(R_s + 25\Omega)$ [+0.5]

$\boxed{R_s = 99.975k\Omega}$ or $R_s \approx 100k\Omega$ accepted. [+0.5]

3)



⇓ 20kΩ is in parallel with (99.975kΩ+25Ω)



$20k\Omega // (99.975k\Omega + 25\Omega) = 20k\Omega // 100k\Omega = 16.67k\Omega$ [+0.5]

[+0.5]

$V_x = 5V \cdot \frac{16.67k\Omega}{16.67k\Omega + 10k\Omega + 20k\Omega} = 1.786V$

$\boxed{V_x = 1.786V}$

4) A larger [+0.5] resistance R_s will reduce the current "leaking" through the voltmeter. [+0.5]

Extra working space.