University of Toronto
Faculty of Applied Science and Engineering

Term Test I

Feb. 12, 2015
Duration: 90 minutes

ECE159 - Electric Circuit Fundamentals
Examiners: Ali Sheikholeslami and Li Qian

ANSWER QUESTIONS ON THESE SHEETS, USING THE BACKS IF NECESSARY.

WRITE IN PEN ONLY (NO PENCIL)!

1. Calculator type is restricted (no programmable calculators).
2. Weight for each question is indicated in []. Attempt all questions, since a blank sheet will certainly get a zero.

maximum grade = 30

Last Name: Solutions

First Name: ______

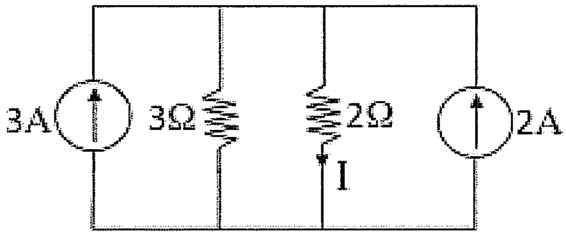
Student Number: ______

Tutorial Section: ______

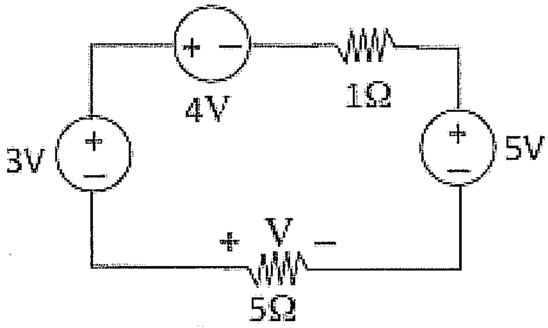
Question	Mark
1	........../8
2	........../4
3	........../6
4	........../6
5	........../6
Total	........../30

Q1. [8 marks]

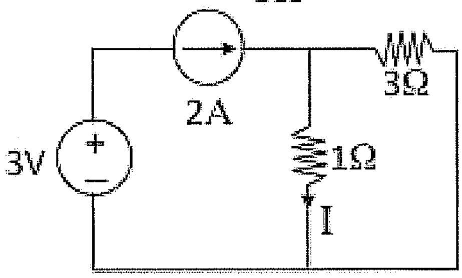
(a) [4 marks] Fill out the values in the boxes below:



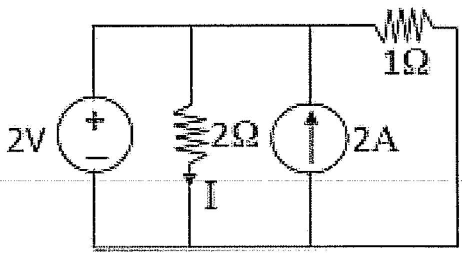
I= 3 A



V= 5 V

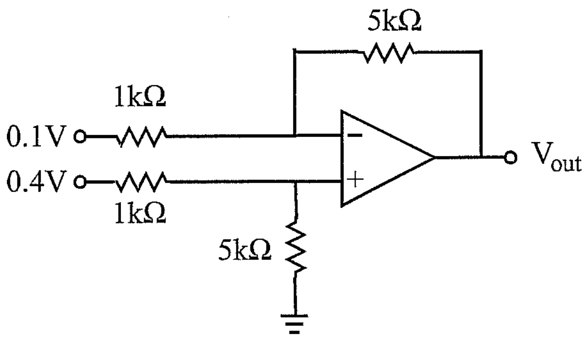


I= 1.5 A



I= 1 A

Q1(b) [4 marks] In the circuits shown below, assume the op-amps are ideal and operate in the linear region (i.e. not saturated). Fill out the output voltage values in the boxes provided.

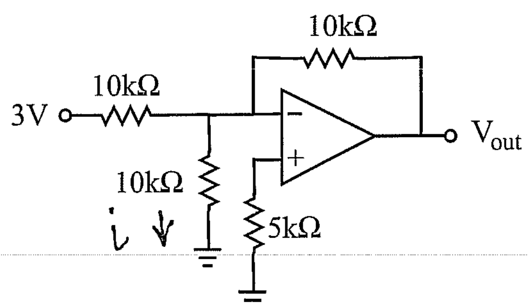


$V_{out} =$ 1.5 V

Use superposition

$0.1V \rightarrow -0.5V$ $\Rightarrow V_{out} = 2 - 0.5 = 1.5V$

$0.4V \rightarrow 0.4 \times \frac{5}{6}(1+5) = 2V$

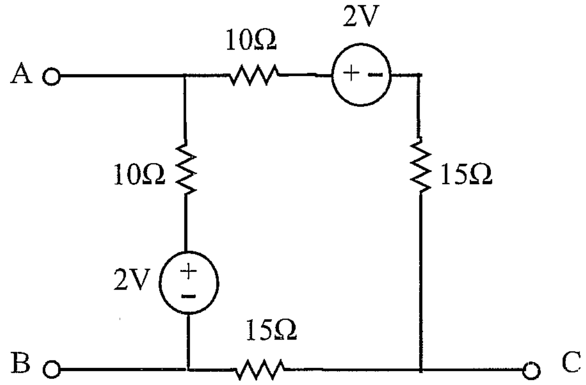


$V_{out} =$ −3 V

$V_{out} = \frac{-10}{10} \times 3V = -3V$

Note $i = 0$ due to virtual ground at the inverting terminal.

Q2 [4 marks] Find the Thevenin equivalent circuit for:

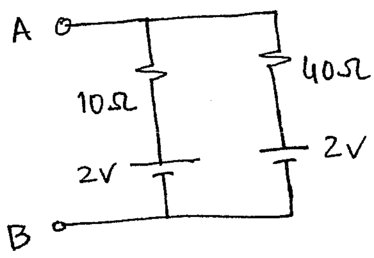


(a) [2 marks] the circuit between terminals A and B while terminal C is open.

Use superposition :

$$V_T = 2V \frac{40}{50} + 2V \frac{10}{50} = \boxed{2V}$$

$$R_{eq} = 10 \parallel 40 = \frac{10 \times 40}{50} = \boxed{8\Omega}$$

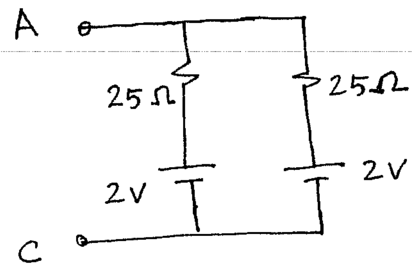


(b) [2 marks] the circuit between terminals A and C while terminal B is open.

Use superposition

$$V_T = 2 \frac{25}{50} + 2 \frac{25}{50} = \boxed{2V}$$

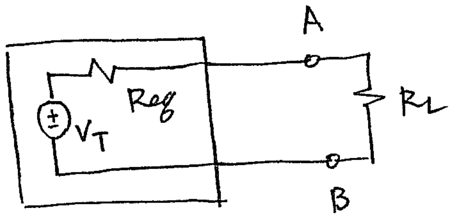
$$R_{eq} = 25 \parallel 25 = \boxed{12.5\Omega}$$



Q3 [6 marks] An unknown linear DC circuit has accessible terminals A and B. If one places a load resistor R_L between A and B and measures the voltage across it, one obtains the following results:

R_L	V_{AB}
12Ω	3V
2.4Ω	1.5V

(a) [4 marks] What should R_L be in order to draw the maximum power from the unknown circuit?



$$V_{AB} = V_T \frac{R_L}{R_L + R_{eq}}$$

$$\Rightarrow \begin{cases} 3 = V_T \dfrac{12}{12 + R_{eq}} \\ 1.5 = V_T \dfrac{2.4}{2.4 + R_{eq}} \end{cases}$$

Solve the 2 equations for V_T & R_{eq}

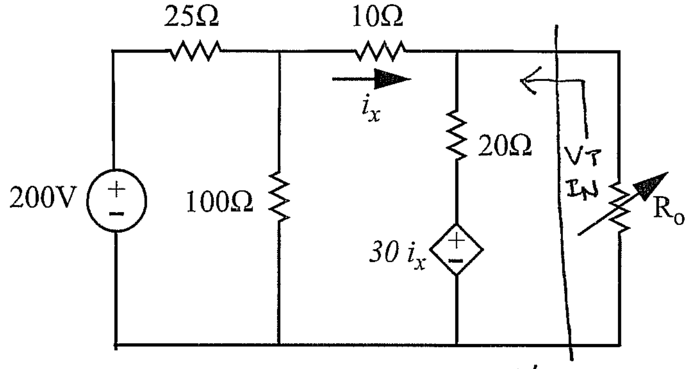
$$\Rightarrow \boxed{V_T = 4\,V}, \quad \boxed{R_{eq} = 4\,\Omega}$$

For maximum power : $\boxed{R_L = R_{eq} = 4\,\Omega}$

(b) [2 marks] Find the maximum power that can be delivered to the load resistor.

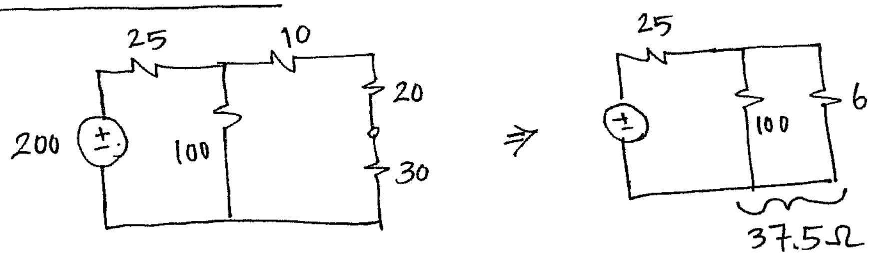
$$P_{max} = \frac{V_T}{2} \frac{V_T}{2R_L} = \frac{16}{4 \times 4} = \boxed{1\,W}$$

Q4 [6 marks] The variable resistor (R_o) in the circuit shown below is adjusted until the power it dissipates reaches 250W. Find the two values of R_o that satisfy this condition.



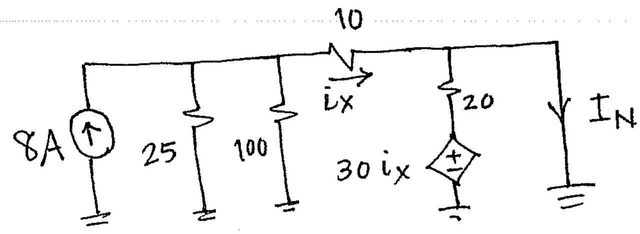
First, find V_T & I_N, then $R_{eq} = \frac{V_T}{I_N}$

V_T Calculations



$$\Rightarrow V_T = 200 \frac{37.5}{37.5+25} \times \frac{50}{50+10} = \boxed{100V}$$

I_N Calculations



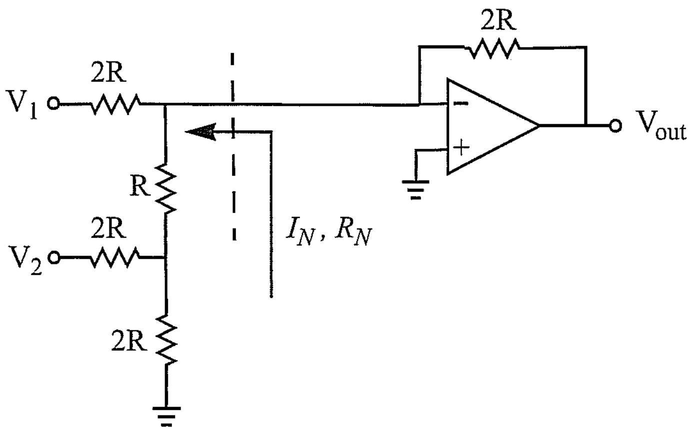
$$i_x = 8 \frac{0.1}{0.1+0.04+0.01} = 5.33A$$

$$I_N = i_x + \frac{30 i_x}{20} = 2.5 i_x = \boxed{13.33 A}$$

$$\Rightarrow R_{eq} = \frac{V_T}{I_N} = \frac{100}{13.33} = \boxed{7.5\Omega}$$

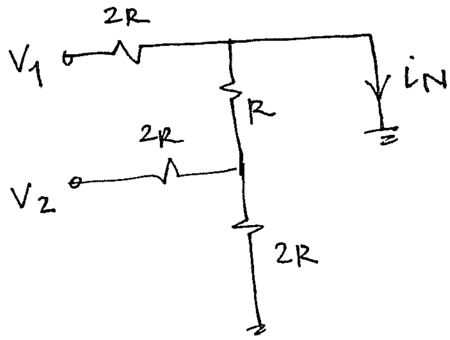
See Extra blank page for the rest.

Q5. [6 marks] In the circuit shown below:



(a) [4 marks] Find the Norton equivalent for the circuit to the left of the dashed line as indicated.

Use superposition to find i_N



$V_1 \Rightarrow \frac{V_1}{2R}$

$V_2 \Rightarrow \frac{V_2}{4R}$

$\Rightarrow \boxed{i_N = \frac{V_1}{2R} + \frac{V_2}{4R}}$

$R_{eq} = 2R \parallel [R + 2R \parallel 2R] = \boxed{R}$

(b) [2 marks] Write an expression for V_{out} in terms of V_1 and V_2.

$\Rightarrow V_{out} = -2R \times i_N = -2R\left(\frac{V_1}{2R} + \frac{V_2}{4R}\right) = \boxed{-\left(V_1 + \frac{V_2}{2}\right)}$

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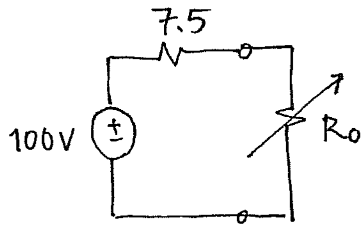

$$P_0 = 100 \frac{R_0}{R_0+7.5} \times 100 \frac{1}{7.5+R_0} = \frac{10^4 R_0}{(7.5+R_0)^2} = 250$$

$$\Rightarrow 40 R_0 = (56.25 + R_0^2 + 15 R_0)$$

$$\Rightarrow R_0^2 - 25 R_0 + 56.25 = 0$$

$$\Rightarrow R_0 = \frac{25 \pm \sqrt{625-225}}{2} = \frac{25 \pm 20}{2}$$

$$\Rightarrow \boxed{R_0 = 22.5\,\Omega \text{ OR } R_0 = 2.5\,\Omega}$$