Name Prapun Suksompong ID 55555555 Section 3 Seat No R0

Sirindhorn International Institute of Technology
Thammasat University

Midterm Examination: Semester 1 / 2009

Course Title: ECS203 (Basic Electrical Engineering)

Instructor: Asst. Prof. Dr.Prapun Suksompong

Date/Time: December 25, 2009 / 9:00-12:00

Instructions:

- This examination has 11 pages (including this cover page).
- Conditions of Examination:
  ✓ **Closed book**
  (No dictionary, ☐ No calculator ☑ Calculator (e.g. FX-991MS) allowed)
  ....Open book
  ....Semi-Closed book (..............sheet(s) ☐ 1 page ☐ both sides of A4 paper note)
- **Read these instructions and the questions carefully**.
- Students are not allowed to be out of the examination room during examination.
  Going to the restroom may result in score deduction.
- Turn off all communication devices and place them with other personal belongings in the area designated by the proctors or outside the test room.
- (1 pt) Write your name, student ID, section, and seat number clearly in the spaces provided on the top of this sheet. Then, write your **first name and the last three digits of your ID** in the spaces provided on the top of each page of your examination paper, starting from page 2.
- The examination paper is not allowed to be taken out of the examination room. Violation may result in score deduction.
- Unless instructed otherwise, ***write down all the steps*** that you have done to obtain your answers. You may not get any credit even when your final answer is correct without showing how you get your answer.
- When not explicitly stated/defined, all notations and definitions follow ones given in lecture.
- Units are important.
- Some points are reserved for *accuracy* of the answers and also for reducing answers into their *simplest* forms.
- Points marked with * indicate challenging problems.
- Do not cheat. Do not panic. Allocate your time wisely.
- Dr. Prapun will visit each exam room regularly. In general, there is no need to ask the proctor to call for Dr. Prapun.

Name______________________________________ ID________________________

1. (5 pt) Suppose you want to use a 40 Ω resistor but you only have one 20 Ω resistor, one 30 Ω resistor, and one 60 Ω resistor. How would you connect the three resistors to get 40 Ω?
   Draw how the three resistors are connected *and* **show** your calculation of the equivalent resistance.

2. (29 pt) In this question, you **must** use the specified techniques to solve the problem. There will be **no credit** given if you do not follow the instructions. As always, your score depends strongly on your explanation of your answer. If the explanation is incomplete, zero score may be given even when the final answer is correct.

   Let

   $$V_S = 6 \text{ V and } R_1 = R_2 = R_3 = 2\ \Omega.$$

   Use the above values for all parts of this question.

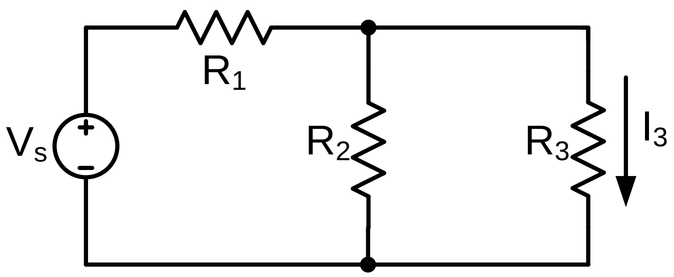


Figure 1

   a. (6 pt) Consider the circuit in Figure 1. Find I_3 by first applying **source transformation** once and then use any method of your choice to find I_3.

Name______________________________________ ID________________________

b. (6 pt) Use **nodal analysis** to obtain V_a in Figure 2. Then, use V_a and the resistance value(s) to **find** I_3.

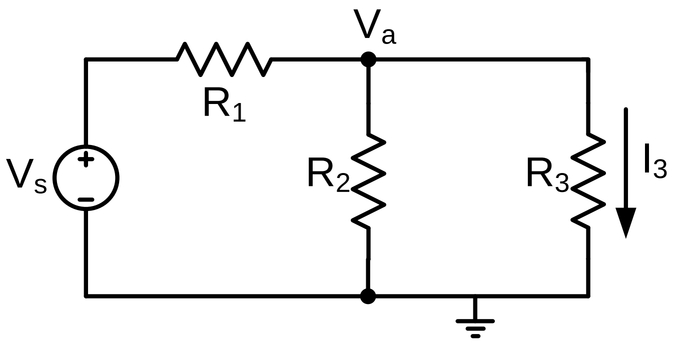


Figure 2

c. (6 pt) Use **mesh analysis** to **find all** mesh currents in Figure 3. Then, use the mesh current(s) to **find** I_3.

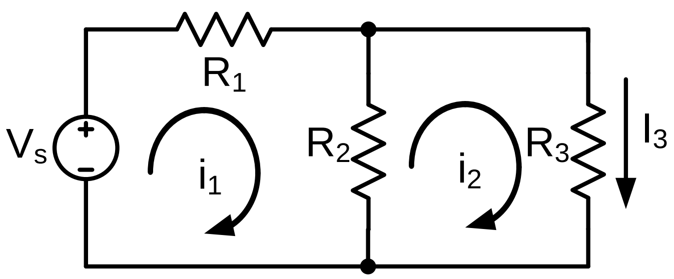


Figure 3

Name_______________________________________ ID________________________

d. (6 pt) In this part, we will find the **Norton equivalent** of the circuit (with respect to terminals a and b) in Figure 4.

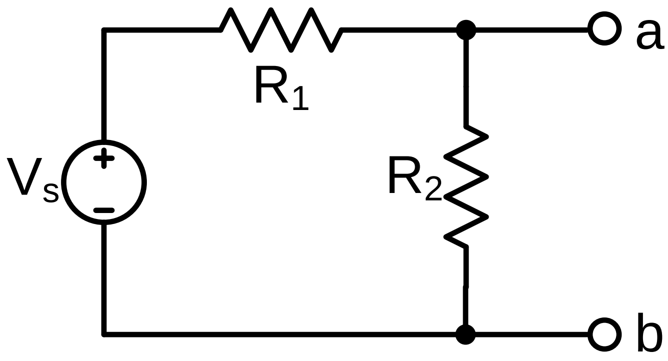


Figure 4

i. Draw the circuit that is used to find I_N and then find I_N.
ii. Draw the circuit that is used to find R_N from Figure 4 and then find R_N.
iii. Draw the **Norton equivalent** of the circuit in Figure 4.

e. (5 pt) Use your answers from part (d) to determine I_3 in Figure 1.

Name____ ID_________________________

3. (33 pt) In this question, you **must** use the specified techniques to solve the problem. There will be **no credit** given if you do not follow the instructions. As always, your score depends strongly on your explanation of your answer. If the explanation is incomplete, **zero** score may be given even when the final answer is correct.

Use the following values for all parts of this question:

$V_S = 24$ V, $I_S = 2$ A, $R_1 = R_2 = 3\ \Omega$, and $R_3 = R_4 = 6\ \Omega$.

Consider the circuit in Figure 5.

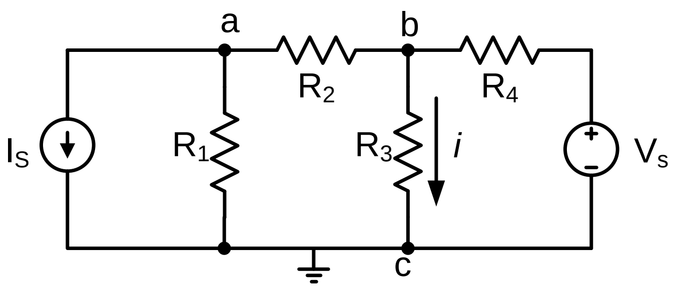


Figure 5

a. (5 pt) Use **source transformation(s)**, resistor combination(s), source combination(s) and one application of the ~~voltage~~ current divider formula to find *i*.

b. (8 pt) We will now use **superposition theorem** to find *i*.
   i. (4 pt) Draw the two sub-circuits resulted from applying superposition theorem.
   ii. (2 pt) Find *i* in each of the sub-circuit in part (i) using any technique(s) of your choice.
   iii. (2 pt) Use the values of *i* from part (ii) to find *i* in Figure 5.

c. (5 pt) Use **nodal analysis** to **find V_a and V_b** in Figure 5 and then find *i* from V_b.

Name____ ID_________________________

d. (5 pt) Determine R_{th} and V_{th} at terminals b-c of the circuit in Figure 6.

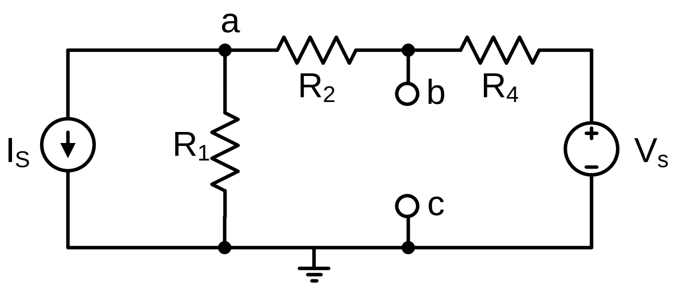


Figure 6

e. (5 pt) Use your answers **from part (d)** to help determine *i* in Figure 5.

f. (3 pt) Determine R_N and I_N at terminals b-c of the circuit in Figure 6.

g. (2 pt) Reconsider the circuit in Figure 5, how long does it take for R_3 to consume 60 J.

Name____ ID_________________________

4. (6 pt) Consider the circuit in Figure 7. Suppose

$$V_S = 24\text{ V},\ I_S = 2\text{ A},\ R_1 = R_2 = 3\ \Omega,\text{ and } R_4 = 6\ \Omega.$$

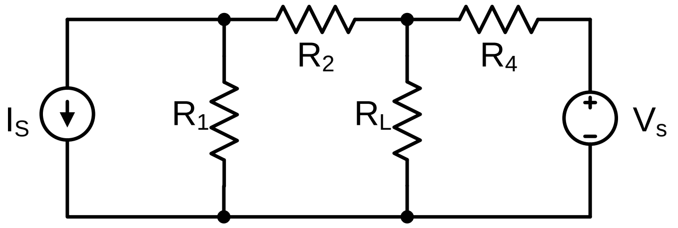


Figure 7

Find the value of the load resistance R_L for maximum power transfer (to the load). Also, find the corresponding amount of maximum power.

5. (15 pt) Consider the ideal op amp circuit shown in Figure 8.

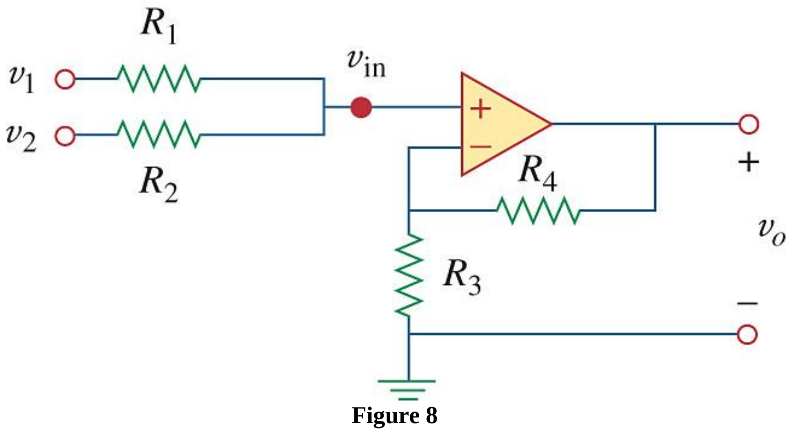


Figure 8

Name Prapun ID 555

a. (5 pt) State two important characteristics of the ideal op amp. (What are the two rules that we can use to analyze op amp circuit?)

① $i_+ = i_- = 0$

② $v_- = v_+$

b. (5 pt) Find v_{in} in terms of v_1, v_2, R_1, and R_2.

c. (5 pt) Find v_o when

$R_1 = 5\ \Omega$, $R_2 = 3\ \Omega$, $R_3 = 7\ \Omega$, $R_4 = 7\ \Omega$,
$V_1 = 20$ V, $V_2 = 12$ V.

Name____ ID_________________________

6. (4 pt) In this question, you **must** use the specified techniques to solve the problem. There will be **no credit** given if you do not follow the instructions. As always, your score depends strongly on your explanation of your answer. If the explanation is incomplete, zero score may be given even when the final answer is correct.

Consider the circuit in Figure 9.

Suppose $R_1 = R_2 = R_3 = R_4 = 5\ \Omega$, and $R_5 = 11\ \Omega$.

Here, we introduce a 1 A current source

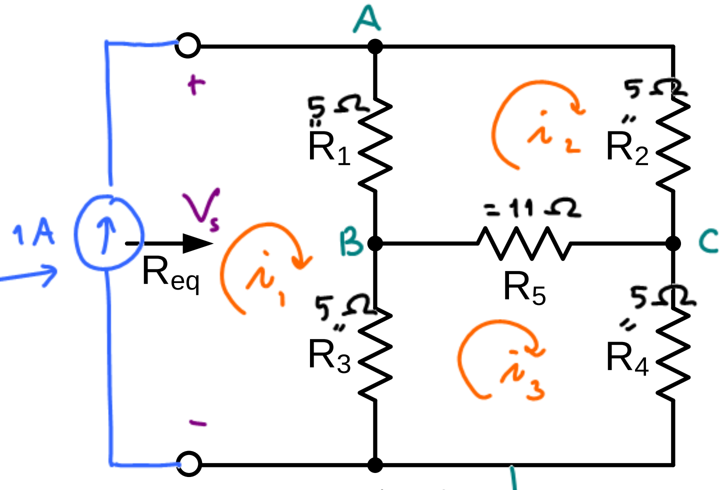
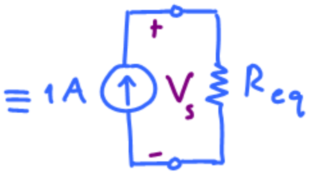


Figure 9



By Ohm's law,

$V_s = (1A) \times R_{eq}$

$R_{eq} = \frac{V_s}{1A}$

a. (2 pt) Find R_{eq} using **nodal analysis**.

KCL @ node A: $-1 + \frac{V_A - V_B}{5} + \frac{V_A - V_C}{5} = 0$

KCL @ node B: $\frac{V_B - V_A}{5} + \frac{V_B - V_C}{11} + \frac{V_B}{5} = 0$

KCL @ node C: $\frac{V_C - V_A}{5} + \frac{V_C - V_B}{11} + \frac{V_C}{5} = 0$

Calculator ⇒ $V_A = 5$, $V_B = \frac{5}{2}$, $V_C = \frac{5}{2}$

Note that $V_s = V_A - 0 = V_A$

Therefore, $R_{eq} = \frac{V_s}{1\Omega} = \frac{V_A}{1\Omega} = 5\ \Omega$

b. (2 pt) Find R_{eq} using **mesh analysis**.

Mesh #1: i_1 directly passes though the "1A" current source:

$i_1 = 1\ A$

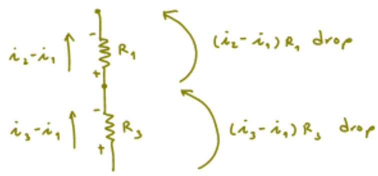
Mesh #2: Apply KVL around mesh #2

$-5 \times (i_2 - i_1) - 5 i_2 - 11(i_2 - i_3) = 0$

Mesh #3 ...

Calculator ⇒ $i_2 = \frac{1}{2}\ A$, $i_3 = \frac{1}{2}\ A$

$V_A = -(i_3 - i_1) R_3 - (i_2 - i_1) R_1 = 5\ V.$



Therefore, $R_{eq} = \frac{V_s}{1\Omega} = \frac{V_A}{1\Omega} = 5\ \Omega$

Name_____________________________________ ID_______________________

7. (2 pt) Suppose you want to use a 70 Ω resistor but you only have two 60 Ω resistors, one 30 Ω resistor, and one 300 Ω resistor. How would you connect the four resistors to get 70 Ω?
   Draw how the four resistors are connected *and* **show** your calculation of the equivalent resistance.

8. (5 pt) Consider the circuit in Figure 10. The resistance values of the resistors are unknown.

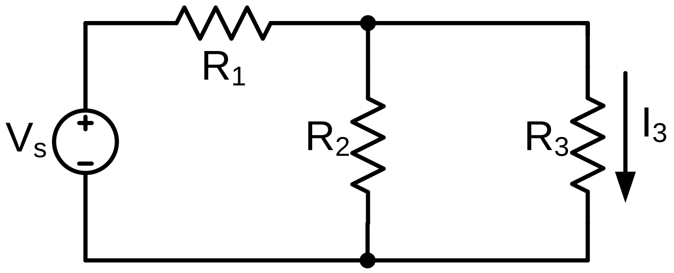


Figure 10

Suppose $I_3 = 1$ A when $V_S = 12$ V. Find I_3 when $V_S = 18$ V. Make sure that you provide enough justification for your answer.