Name...ID...........................Section........1........Seat No............

Sirindhorn International Institute of Technology
Thammasat University

Final Examination: Semester 2 / 2015

Course Title: ECS203 (Basic Electrical Engineering)

Instructor: Asst. Prof. Dr.Prapun Suksompong

Date/Time (for the real exam): May 19, 2016 / 13:30 - 16:30

Instructions:

- This practice for the final examination has....10....pages (including this cover page).
- Conditions of Examination:
  ....Closed book
  (No dictionary, ☐ No calculator ☑ Calculator (e.g. FX-991) allowed)
  ....Open book
  .....✓.....**Semi-Closed book** (.......1........sheet(s) ☐ 1 page ☑ both sides of A4 paper note)
  This sheet must be hand-written.
  Do not modify (,e.g., add/underline/highlight) content on the sheet inside the exam room.
  It should be **submitted with the exam**. (1 pt)
  |Other requirements are discussed in class and on the course web site.
- **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.
- 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 back of each page will not be graded; it can be used for calculations of problems that do not require explanation.
- The examination paper is not allowed to be taken out of the examination room. Also, do not remove the staple. Violation may result in score deduction.
- Unless instructed otherwise, ***write down all the steps*** that you have done to obtain your answers.
  - When applying formula(s), state clearly which formula(s) you are applying before plugging-in numerical values.
  - You may not get any credit even when your final answer is correct without showing how you get your answer.
  - Formula(s) not discussed in class can be used. However, derivation must also be provided.
- When not explicitly stated/defined, all notations and definitions follow ones given in lecture.
- For the calculation of absorbed power, if the power is actually supplied by the element, then your corresponding answer will be negative.
- Units are important.
- Some points are reserved for *accuracy* of the answers and also for reducing answers into their *simplest* forms.
- All sinusoid should be answered in the standard time-dependent cosine form where the amplitude is positive and the phase is between $-180°$ and $180°$.
- All phasor should be answered in standard polar form where the magnitude is positive and the phase is between $-180°$ and $180°$.
- All impedance should be answered in rectangular form.
- Dr. Prapun will visit each exam room regularly. In general, there is no need to ask the proctor to call for Dr. Prapun.
- Do not cheat. Do not panic. Allocate your time wisely.

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1. (10 pt) Consider the ideal op amp circuit shown in Figure 1.

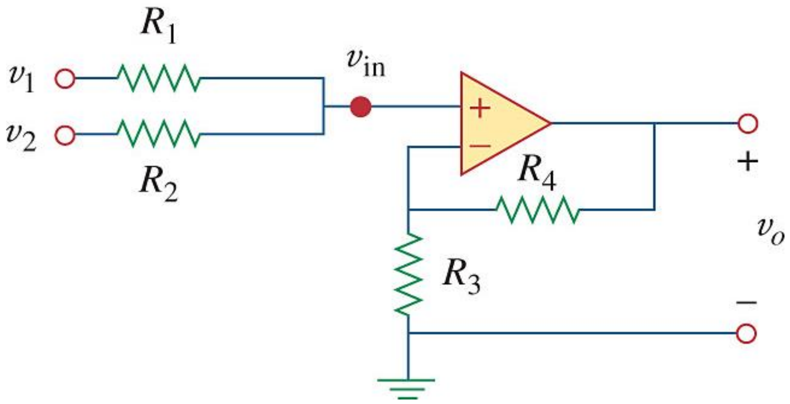

Figure 1

a. (2 pt) State two important characteristics of the ideal op amp. (What are the two rules that we can use to analyze op amp circuit?)

b. (4 pt) Find v_{in} in terms of v_1, v_2, R_1, and R_2.

c. (4 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.

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2. (11 pt) Consider the circuit in Figure 2 below. **Assume** the switch has been **<u>at position 1 for a long time</u>** and moves to position 2 at t = 0 sec.

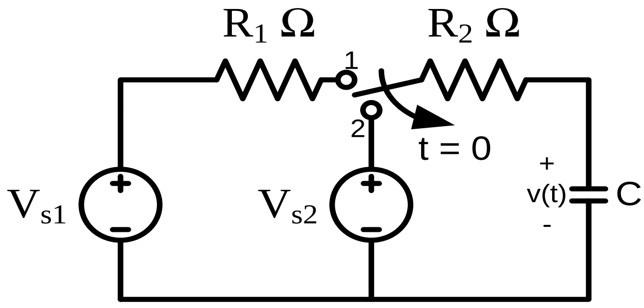

Figure 2

Let

V_{s1} = 5 V, V_{s2} = 0 V, R_1 = 6 Ω, R_2 = 3 Ω, and C = 10 F.

a. (3 pt) Find $v(\mathbf{0}^-)$. Do not forget to justify your answer.

b. (1 pt) Find $v(0)$. Do not forget to justify your answer.

c. (4 pt) Find $v(t)$ for $t > 0$.

d. (3 pt) Find $v(t)$ for $t > 0$ if V_{s2} = **10 V** instead of 0 V.

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3. (10 pt) Consider the circuit in Figure 3 below. Assume the switch has been at position 1 for a long time and moves to position 2 **at t = 5 sec.**

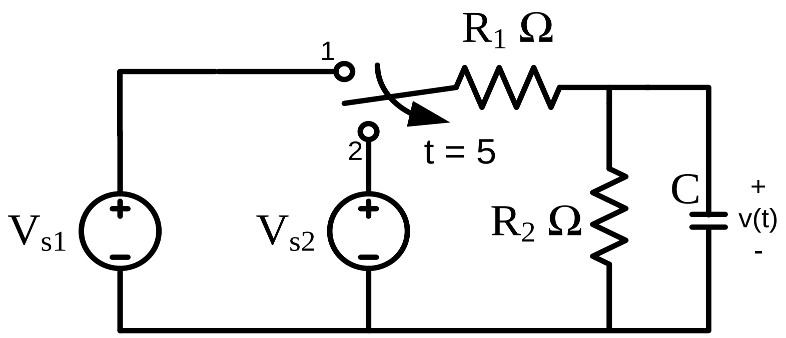

Figure 3

Let

V_{s1} = 16 V, V_{s2} = 8 V, R_1 = 3 Ω, R_2 = 5 Ω, and C = 8 F.

a. (3 pt) Find $v(0)$.

b. (2 pt) Find $v(5)$.

c. (4 pt) Find $v(t)$.

d. (1 pt) Evaluate $v(t)$ at t = 7.

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4. (4 pt) Simplify $x(t)=7\cos(t-777^\circ)-7\sin(t-77^\circ)$. (Your answer should be a time-dependent sinusoid in standard form.)

5. (4 pt) Find the sinusoid $x(t)$ which is represented by a phasor $\mathbf{X} = -7+7j$. Assume $\omega=100$ rad/s. (Your answer should be a time-dependent sinusoid in standard form.)

6. (38 pt) In this question, you **must** use the specified techniques to solve the problem. There will be **<u>no credit</u>** 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 below.

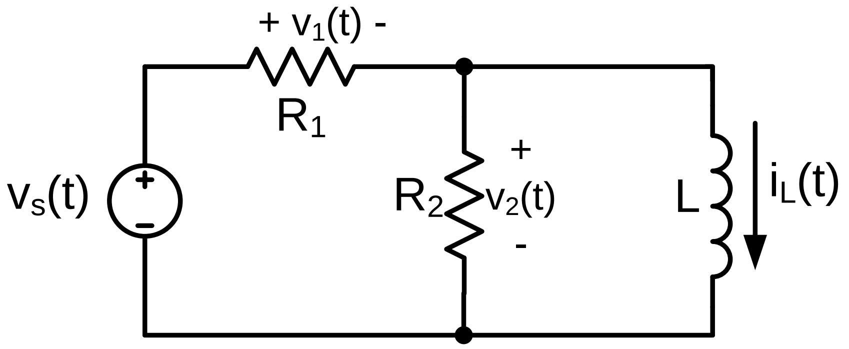

Figure 4

Suppose

$$v_s(t)=7\cos(200t+30^\circ)\ \text{V},$$

$R_1 = 6\ \Omega$, $R_2 = 4\ \Omega$, and $L = 5$ mH.

a. (1 pt) Find $\mathbf{V_s}$ (which is the phasor representation of $v_s(t)$).

b. (2 pt) Find the impedance of the inductor.

c. (8 pt) Use mesh analysis to **<u>find all mesh currents</u>** (in the clockwise direction) in phasor form.

d. (2 pt) Use the mesh current(s) to find the current $i_L(t)$ through the inductor.

e. (6 pt) Use **<u>nodal analysis</u>** to find the voltage $v_2(t)$ across the resistor R_2.

f. (4 pt) Find the voltage $v_1(t)$ across the resistor R_1.

g. (5 pt) Use source transformation(s) and/or impedance combination(s) to transform

the part of the circuit to the left of the inductor

into

a phasor voltage source $\mathbf{V_A}$ in series with an impedance $\mathbf{Z_A}$.

h. (3 pt) Use $\mathbf{V_A}$, $\mathbf{Z_A}$, and the impedance of the inductor to find $i_L(t)$.

i. (1 pt) Find the instantaneous power absorbed by R_1

j. (1 pt) Find the average power absorbed by R_1

k. (2 pt) Find the average power absorbed by L

l. (3 pt) Find the average power **absorbed** by the voltage source.

7. (9 pt) Consider the circuit in Figure 5 below.

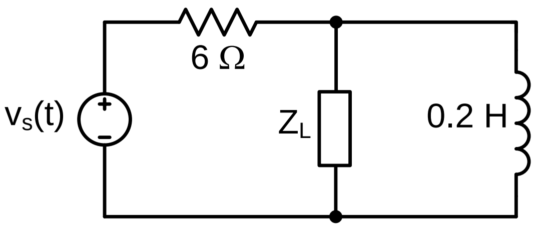

Figure 5

Suppose

$$v_s(t) = 7\cos\left(200t + 30^\circ\right) \text{ V},$$

a. (4 pt) Determine the **load impedance** Z_L for maximum power transfer (to Z_L).

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b. (3 pt) In the lab, how can you build the optimal Z_L which you got in part (a) from a combination of resistor/inductor/capacitor? **Draw and explain** your answer. Indicate the values of each component (in Ω/H/F).

c. (2 pt) Calculate the **maximum power** absorbed by the load Z_L.

8. (3 pt) What is seriously wrong with Figure 6 below. Justify your answer.

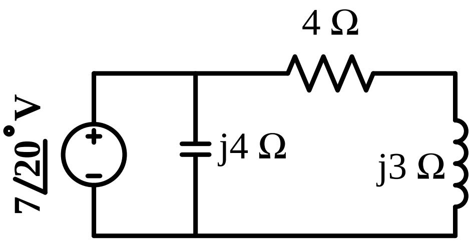

Figure 6

9. (4 pt) Consider the circuit in Figure 7.

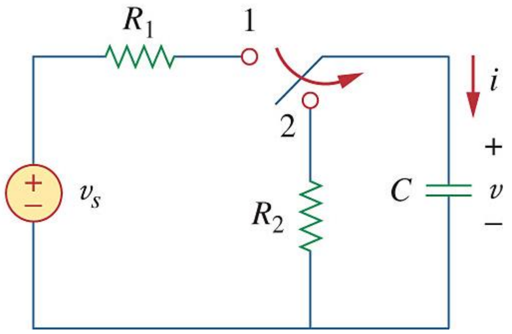

Figure 7

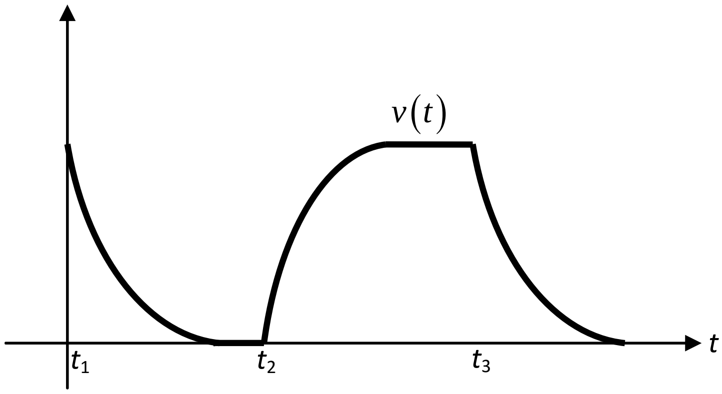

Figure 8

Assume that the switch has been in position 1 during time $t < 0$. Then, during time $t \geq 0$ the switch changes its position three times: at t_1, t_2, t_3.
(At time t_1, the switch changes to position 2. At time t_2, the switch changes back to position 1. At time t_3, the switch changes again to position 2.)

Figure 8 shows the voltage $v(t)$ for time $t > 0$.

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If the capacitance value C is **decreased** by 10%, how would the plot in Figure 8 change? **Provide some explanation and sketch** the plot of the new $v(t)$ directly in Figure 8. Assume the same initial voltage at time t_1.

10. (6 pt) Consider the op-amp circuit in Figure 9 below. All voltages are represented by their phasors.

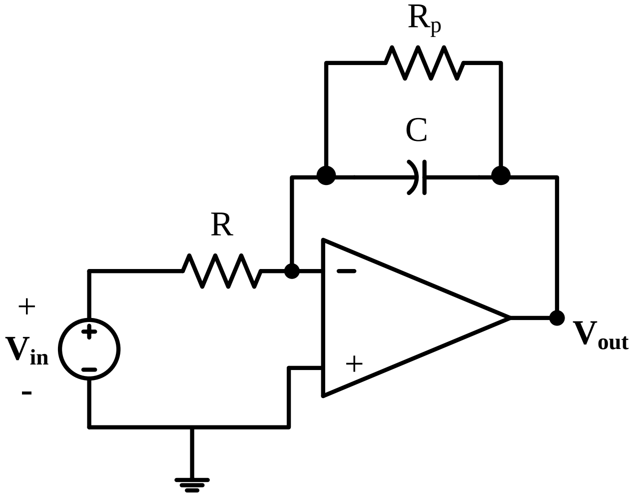

Figure 9

d. (5 pt) Find the gain $\left|\frac{\mathbf{V_{out}}}{\mathbf{V_{in}}}\right|$ in terms of ω, R, C, R_p.

e. (1 pt) Find the gain $\left|\frac{\mathbf{V_{out}}}{\mathbf{V_{in}}}\right|$ when ω = 0 rad/s.

11. (1 pt) Do not forget to **submit your formula sheet with your final exam**.