ECE 35, Fall 2022 – Section A Final

Your sequence number

Last name	
First + middle name(s)	
PID	

Grade

/ 31

Instructions:

- Do not look at the questions or start writing until it is announced that you can do so.
- You must follow the Final Exam Procedures that were posted on Canvas. If you are unsure of anything, ask. As a reminder:
    - Your phone should be turned off and put inside your bag
    - Calculators are not allowed.
    - This is a closed book exam.
    - Follow the Academic Integrity standards
- These pages contain the exam questions.
    - Do not write any of your work here except for scratch work. It will not be graded.
    - You need to write your final answer in the answer boxes here. Make sure you list units.
    - Keep these question pages stapled together. The last page is the equation sheet; you may detach this if you want.
    - Make sure you write your PID on EACH page.
    - Read each problem completely and thoroughly before beginning.

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(1) *(7 points)*

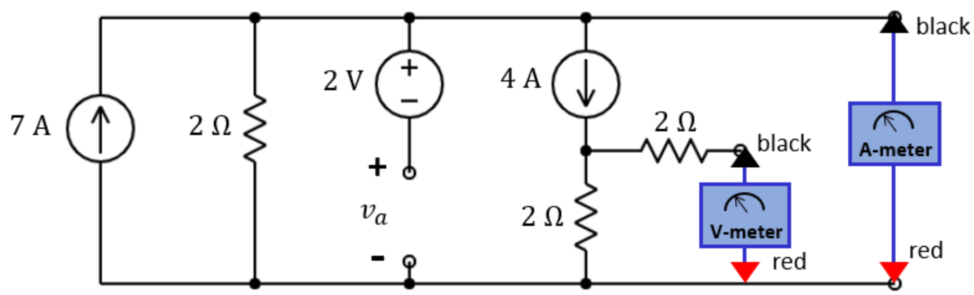
(a) In the circuit below, the ammeter and voltmeter are ideal.

What is the reading X of the voltmeter? X

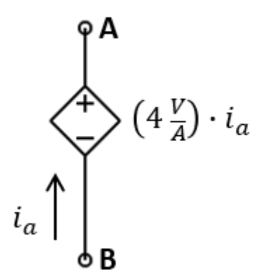
What is the reading Y of the ammeter? Y

What is the voltage v_a? v_a

What is the power P received by the 4 A current source ? P



(b) What is the Thevenin resistance R_{th} between A and B ? R_{th}



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(2) *(7 points)* For this question, you should make reasonable numerical approximations if needed.

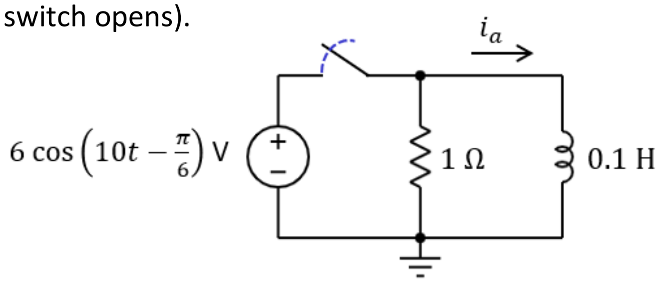
(a) Consider the circuit below. For $t < 0$ s, the switch is closed, and the system has reached steady state. At time $t = 0$ s, the switch opens.

Find the current i_a at time $t = 0^-$s (i.e., immediately before the switch opens).

Find the current i_a at time $t = 0^+$s (i.e., immediately after the switch opens).

$i_a(0^- \text{s})$

$i_a(0^+ \text{s})$



(b) Consider the circuit below. For $t < 0$ s, the switch is in position 1, and the system has reached steady state. At time $t = 0$ s, the switch moves to position 2 (and stays there). Just before the switch moves, i_x is 4 A.

Find the current i_b at time $t = 0^+$s (i.e., immediately after the switch moves to position 2).

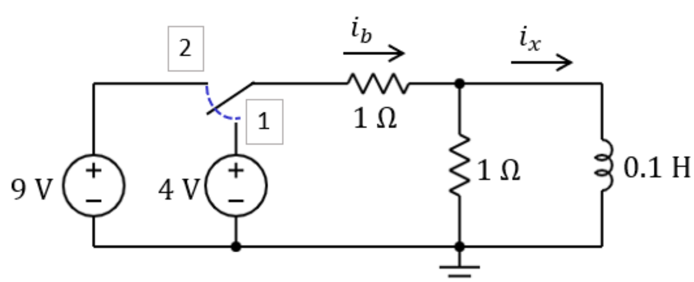
Find the current i_b at time $t = 2$ s.

Find the current i_b at time $t = \infty$.

$i_b(0^+ \text{s})$

$i_b(2 \text{ s})$

$i_b(\infty)$



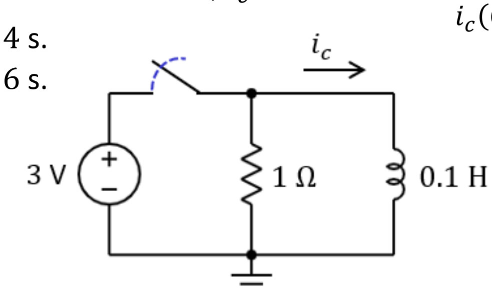
(c) Consider the circuit below. For $t < 2$ s, the switch is open, and the system may not have reached steady state. At time $t = 2$ s, the switch closes. Just after the switch closes, i_c is 5 A.

Find the current i_c at time $t = 4$ s.

Find the current i_c at time $t = 6$ s.

$i_c(4 \text{ s})$

$i_c(6 \text{ s})$



(3) *(6 points)* Consider the circuit below. You may assume it is in steady-state.

(a) Find the current of current source i_{S1} at time $t = \frac{\pi}{20}$ s.

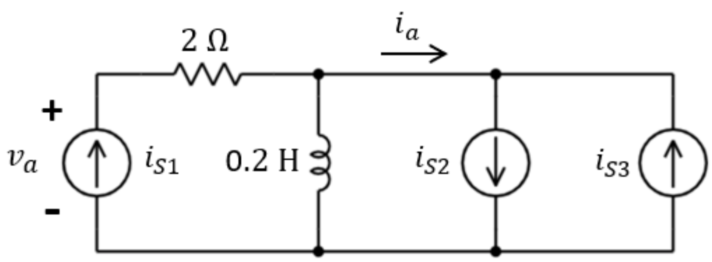
$i_{S1}\left(\frac{\pi}{20}\text{ s}\right)$

(b) Find the voltage v_a at time $t = \frac{\pi}{20}$ s.

$v_a\left(\frac{\pi}{20}\text{ s}\right)$

(c) Find the maximum value of the waveform $i_a(t)$.

$i_{a\,max}$



$i_{S1} = 3 + 5\cos(10t)$ A

$i_{S2} = 6\sin\left(20t + \frac{\pi}{4}\right)$ A

$i_{S3} = 3\sqrt{2}\cos(20t)$ A

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(4) *(6 points)* The circuit below represents an AC circuit in steady-state in the phasor domain (for the complex numbers, you may assume units are V, A, Ω, etc. as appropriate). The voltage source v_S is an AC source with $\omega = 5$ rad/s. Each box represents the impedance of a single circuit element (a resistor, capacitor or inductor).

(a) Find the average power P_s supplied by the voltage source.

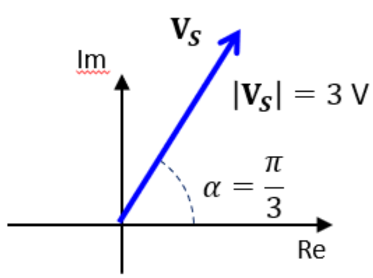
P_s

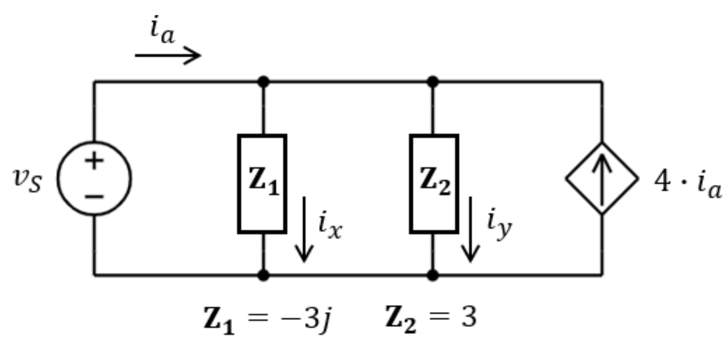
(b) Find the average power P_1 received by the element with impedance $\mathbf{Z_1}$.

P_1

(c) Find the RMS value of i_x.

i_{xRMS}





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(5) *(5 points)*

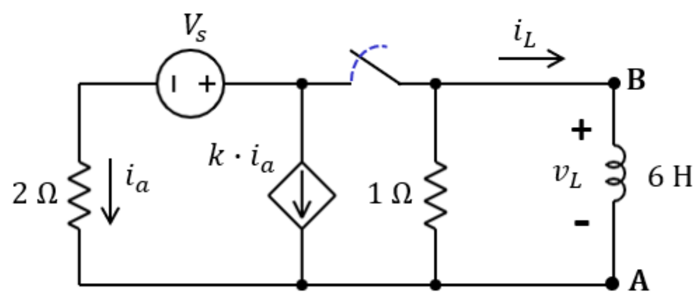
(a) Consider the circuit below. You are not given the values of k and V_s (but you are told that all sources are DC sources). We are considering the circuit after the switch closes.

- The time constant τ associated with $i_L(t)$ during this transition is τ = 2 s.
- You also measure that when current i_L reaches 4 A, the voltage v_L drops to 0 V.

What is the current i_L when the system reaches steady state? i_L

Find the Norton equivalent resistance R_N between A and B if we were to remove the inductor from the circuit. R_N

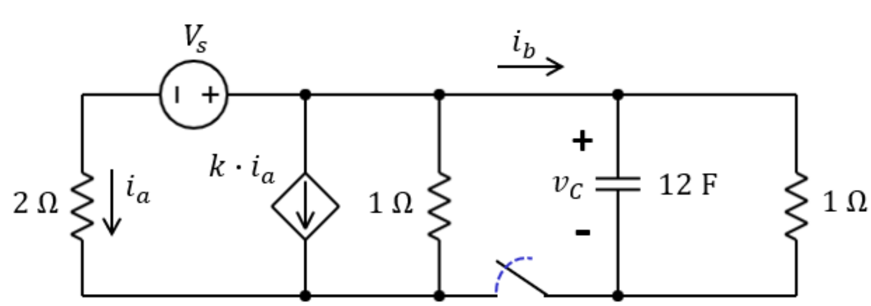
During the transition (in our original circuit with the inductor in there), when the current i_L has a value of 1 A, what is the value of the voltage v_L? v_L



(b) Consider the circuit below. The unknown values of k and V_s are the same as in the circuit above. The switch closes at time t = 400 s (you do not know if the system has reached steady state before the switch closes).

Find the time constant τ_1 associated with $v_c(t)$ for t > 400 s. τ_1

Find the time constant τ_2 associated with $i_a(t)$ for t > 400 s. τ_2



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ECE35 Equation Sheet

Basics: $i \triangleq \frac{dq}{dt}$ $v_{ab} \triangleq \frac{dw}{dq}$ $R = \rho \frac{l}{A}$

Capacitors: $C = \epsilon \cdot \frac{A}{d}$ $Q = C \cdot v$ $w_C = \frac{1}{2} C v^2$

Inductors: $L = \mu \cdot \frac{N^2 A}{l}$ $B \sim i$ $w_L = \frac{1}{2} L i^2$

AC power: $p(t) = \frac{1}{2} V_m I_m \cdot \cos(\theta_v - \theta_i) + \frac{1}{2} V_m I_m \cdot \cos(2\omega t + \theta_v + \theta_i)$

$P = \frac{1}{2} V_m I_m \cos(\theta_v - \theta_i)$ $Q = \frac{1}{2} V_m I_m \sin(\theta_v - \theta_i)$ $X_{rms} = \sqrt{\frac{1}{T} \int_0^T x(t)^2 dt}$

Trigonometry:

$\sin(-\alpha) = -\sin(\alpha)$ $\cos(-\alpha) = \cos(\alpha)$

$\sin(\pi - \alpha) = \sin(\alpha)$ $\cos(\pi - \alpha) = -\cos(\alpha)$

$\sin\left(\frac{\pi}{2} - \alpha\right) = \cos(\alpha)$ $\cos\left(\frac{\pi}{2} - \alpha\right) = \sin(\alpha)$

$\sin\left(\alpha - \frac{\pi}{2}\right) = -\cos(\alpha)$ $\cos\left(\alpha - \frac{\pi}{2}\right) = \sin(\alpha)$

$\sin(2\alpha) = 2\sin(\alpha)\cos(\alpha)$ $\cos(2\alpha) = \cos^2(\alpha) - \sin^2(\alpha)$

$\sin(\alpha \pm \beta) = \sin(\alpha)\cos(\beta) \pm \cos(\alpha)\sin(\beta)$

$\cos(\alpha \pm \beta) = \cos(\alpha)\cos(\beta) \mp \sin(\alpha)\sin(\beta)$

$\sin(\alpha)\sin(\beta) = 0.5 \cdot (\cos(\alpha - \beta) - \cos(\alpha + \beta))$

$\cos(\alpha)\cos(\beta) = 0.5 \cdot (\cos(\alpha - \beta) + \cos(\alpha + \beta))$

$\sin(\alpha)\cos(\beta) = 0.5 \cdot (\sin(\alpha - \beta) + \sin(\alpha + \beta))$

α:	0	$\frac{\pi}{6}$	$\frac{\pi}{4}$	$\frac{\pi}{3}$	$\frac{\pi}{2}$
sin(α):	0	$\frac{1}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{\sqrt{3}}{2}$	1
tan(α):	0	$\frac{\sqrt{3}}{3}$	1	$\sqrt{3}$	∞