ECE 35, Fall 2022 – Section B
Final

Your sequence number

Grade

/ 31

Last name

First + middle name(s)

PID

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.

▼

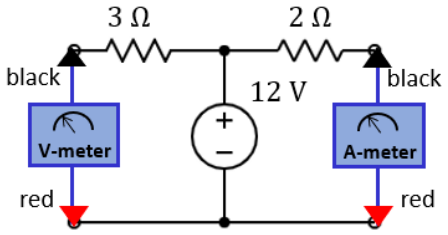
PID

(1) *(7 points)*

(a) The ammeter and voltmeter are ideal.

What is the reading X of the voltmeter?

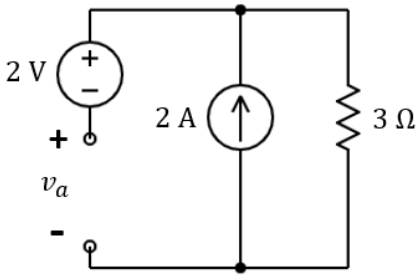
What is the reading Y of the ammeter?



X

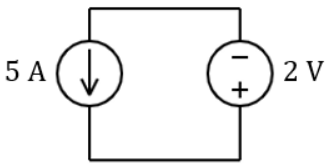
Y

(b) What is the voltage v_a?



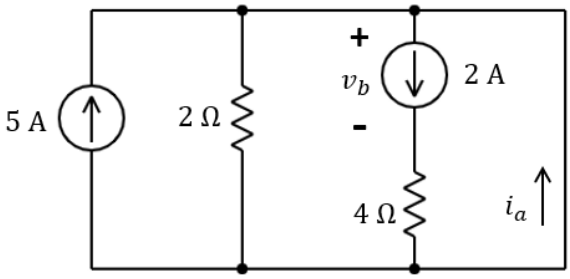
v_a

(c) What is the power P <u>received</u> by the current source ?



P

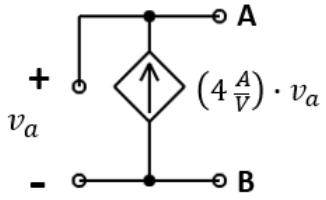
(d) What is the voltage v_b?
What is the current i_a?



v_b

i_a

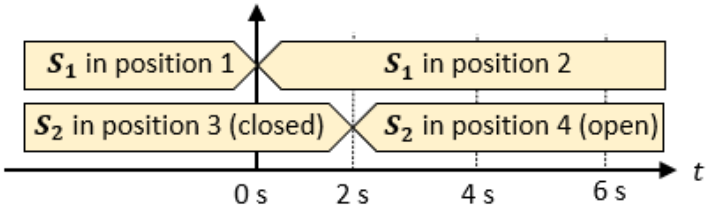
(e) What is the Thevenin resistance R_{th} between A and B ?



R_{th}

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

- For $t < 0$ s, switch S_1 is in position 1, switch S_2 is in position 3, and the system has reached steady state.
- At time $t = 0$ s, switch S_1 moves from position 1 to position 2 (you may assume that i_{S1} turns off at that point). Switch S_2 stays in position 3 (closed).
- At time $t = 2$ s, switch S_2 moves from position 3 to position 4 (open). Switch S_1 stays in position 2.



(a) Find the capacitor voltage v_c at time $t = 0^-$s (i.e., immediately before switch S_1 moves).

Find the node voltage v_a at time $t = 0^+$s (i.e., immediately after switch S_1 moves).

(b) Find the node voltage v_a at time $t = 2^-$s. (i.e., immediately before switch S_2 moves).

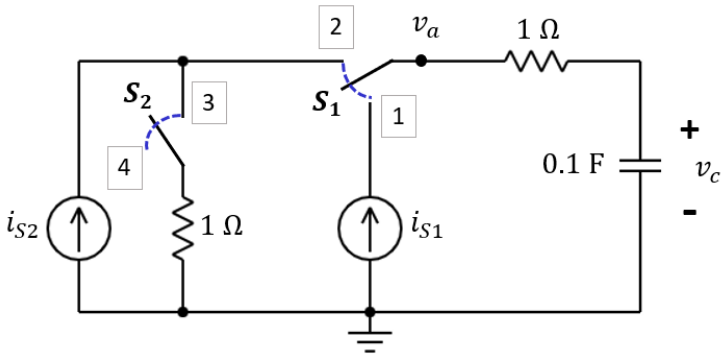
(c) Find the node voltage v_a at time $t = 6$ s.

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

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

$v_a(2^-\text{s})$

$v_a(6\text{ s})$



$i_{S1} = 8\cos\left(10t - \frac{\pi}{2}\right)$ A

$i_{S2} = 5$ A

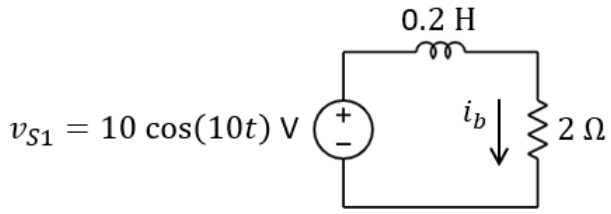
(3) *(6 points)* For all the circuits in this question, you may assume that they are in steady-state.

(a) Find the phasor of $v_x(t) = 8\sin\left(20t + \frac{\pi}{4}\right)$ V. You can write your answer in cartesian or polar coordinates.

$\mathbf{V_x}$ =

(b) Find the current i_b at time $t = \frac{\pi}{10}$ s.

$i_b\left(\frac{\pi}{10}\text{s}\right)$ =



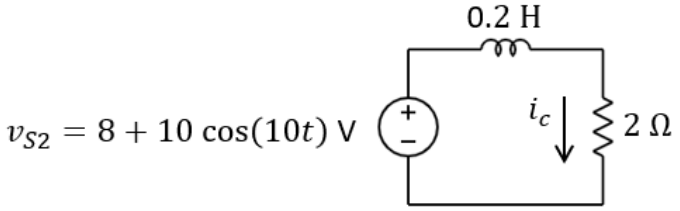
(c) Note the similarity to circuit in part (b).

Find the voltage v_{S2} of the voltage source at time $t = \frac{\pi}{10}$ s.

$v_{S2}\left(\frac{\pi}{10}\text{s}\right)$ =

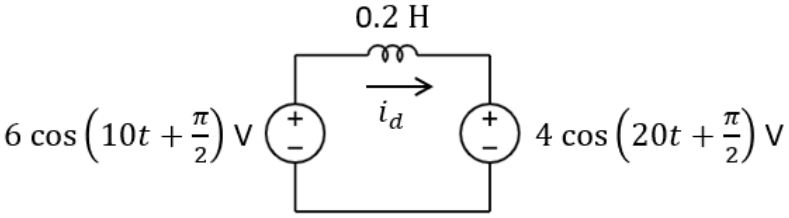
Find the current i_c at time $t = \frac{\pi}{10}$ s.

$i_c\left(\frac{\pi}{10}\text{s}\right)$ =



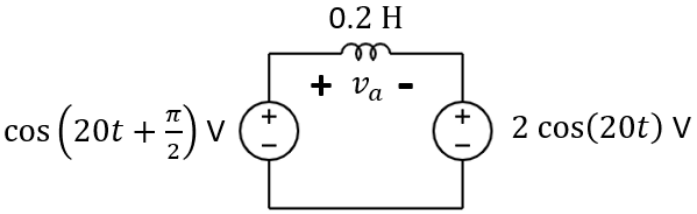
(d) Find the current i_d at time $t = \frac{\pi}{10}$ s.

$i_d\left(\frac{\pi}{10}\text{s}\right)$ =



(e) Find the maximum value of the waveform $v_a(t)$.

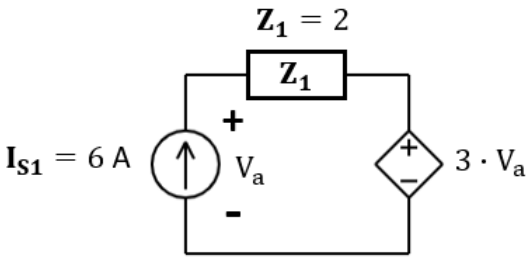
$v_{a\,max}$ =



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

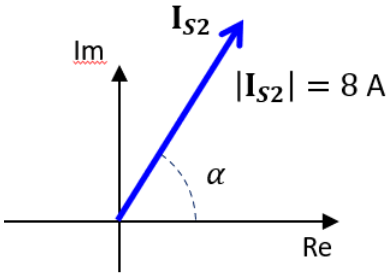
(a) Find the phasor $\mathrm{V_a}$. You can write your answer in cartesian or polar coordinates.

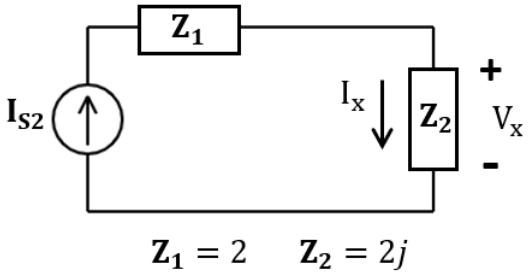
$\mathrm{V_a}$ ____



(b) In the circuit below, we set $\alpha = \frac{\pi}{2}$ (the figure is clearly not drawn to scale). Find the average power P_s supplied by the current source I_{s2}.

P_s ____





(c) For the same circuit as in part (b), we change α to $\alpha = \frac{\pi}{6}$.

Find the average power P_s supplied by the current source I_{s2}. P_s ____

Find the average power P_1 received by the element with impedance $\mathbf{Z_2}$. P_2 ____

Find the magnitude of the phasor $\mathrm{V_x}$. $|\mathrm{V_x}|$ ____

Find the RMS value of i_x. i_{xRMS} ____

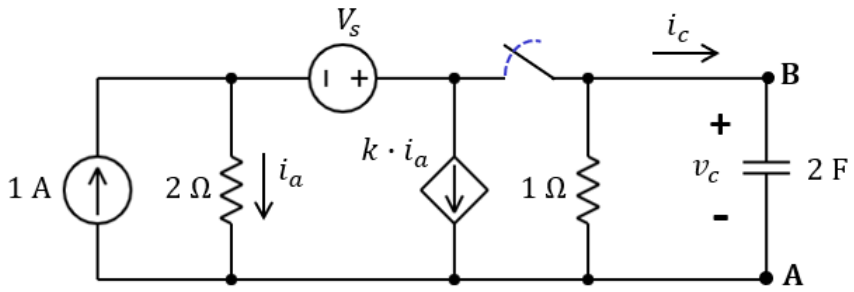
(5) *(5 points)*

(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.

We measure that when the voltage v_c reaches 6 V, the current i_c is 2 A. Similarly, when the voltage v_c becomes 10 V, the current i_c drops to 0 A.

Find the Norton equivalent resistance R_N between A and B when we remove the capacitor from the circuit.

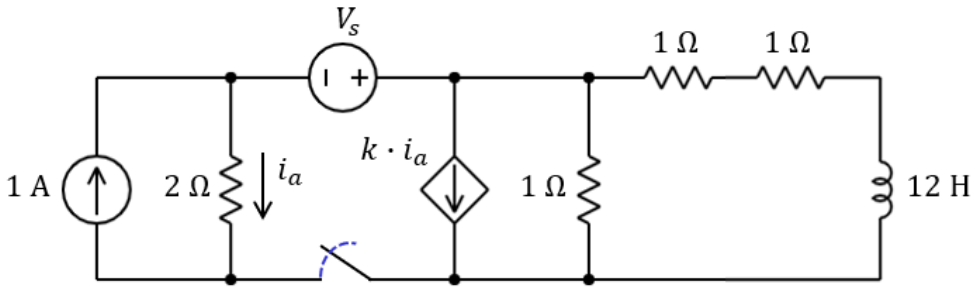
R_N



(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 associated with $i_a(t)$ for $t > 400$ s.

τ



ECE35 Equation Sheet

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

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

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

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	$\sqrt{3}$	∞