ECE 100 (Spring 2021) - Midterm

(Format: 5 questions, 1hr 45m)

Name: ______________________________

Student ID: __________________________

Score: _______ out of 100

Instructions:

1. Register for the quiz (if you are seeing this, you should have already registered)
2. Once you register for the midterm, you will have 1hr 45m to complete the midterm.
3. After the midterm, you have 15 minutes to submit and upload your quiz to CCLE (under "Week 5 → Midterm").
4. Please fill out this 'End-of-Midterm' survey to acknowledge that you have completed the quiz and submitted your answer sheet to CCLE: https://forms.gle/ZjJAsvxhrNA5jD8fA

Rules:

- Midterm is closed book. No computers, cell phones, etc.
- 1-page cheat sheet
- Scientific calculator allowed.
- Box all of your answers & show your work.
- **If you have questions on the exam, please DO NOT post on Piazza. Email instructor(s) directly.**

Quiz Start Time:

Wednesday, April 28th @ 6:00pm PDT

Note: Once you register for the quiz, you will have 2hr to complete & upload your results. (1hr 45m to take the exam, 15 minutes to upload).

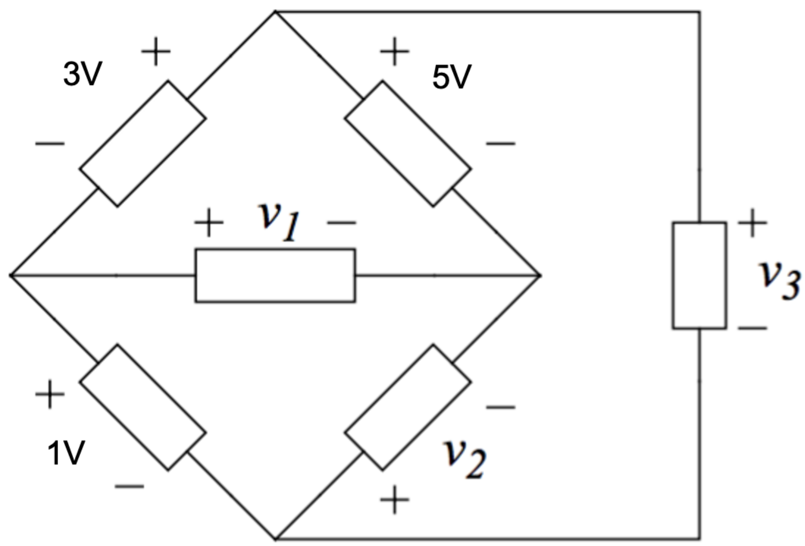
End Time:

Thursday, April 29th @ 5:59pm PDT (answer sheet must be submitted by this time)

No late submissions

Problem 1: KVL & KCL (20 points)

(a) In the following circuits, determine the values of v_1, v_2, &, v_3 given the specified voltage drops across the other other circuit elements.
(8 points)

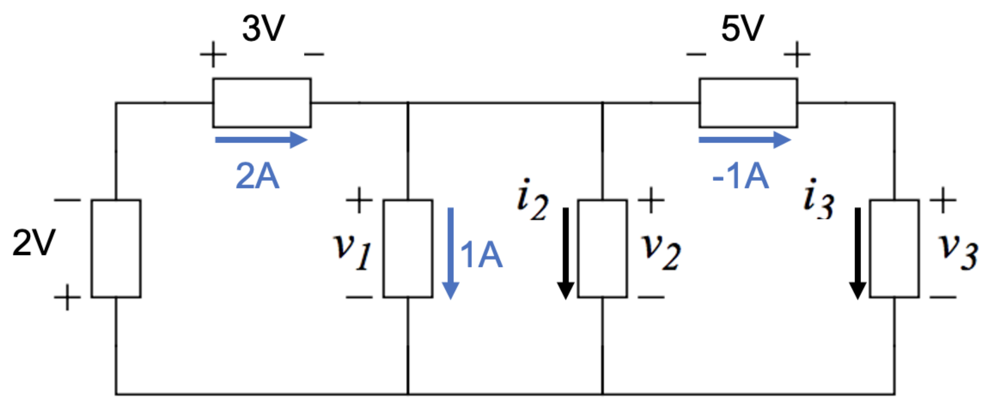


V_1= ---------------

V_2= ---------------

V_3= ---------------

(b) In the following circuits, determine the values of i_2, i_3, v_1, v_2, &, v_3 **given the specified voltage drops across the other other circuit elements.** (12 points)



V_1= ---------------

i_2= ----------------

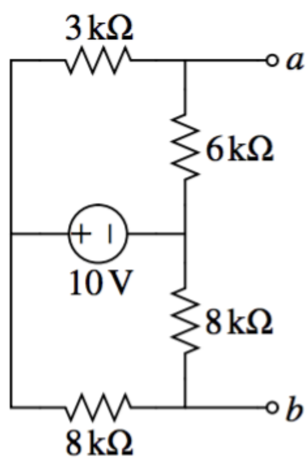
V_2= ---------------

i_3= ----------------

V_3= ---------------

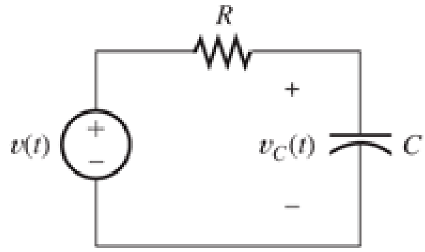
Problem 2: Thevenin & Norton Equivalent Circuits (15 points)

Derive the Thevenin and Norton equivalent circuits at terminals a, b for the circuit below. Be sure to specify units and polarities.

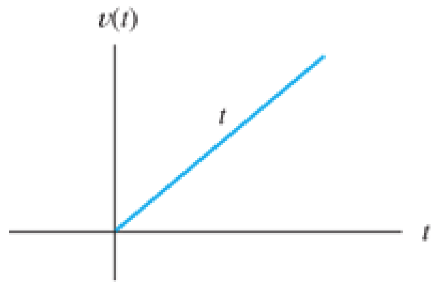


Problem 3: 1st-Order Differential Equations (25 points)

Consider the RC circuit given below: (R=1KΩ and C=1mF)



(a)



(b)

The voltage source has the form of a ramp function:

$t < 0: v(t) = 0$

$t \geq 0: v(t) = t$

(a) Write an expression for $v_c(t)$. (5 points)

Hint: Start by writing the differential equation then solve for $v_c(t)$. The solution has a particular solution (defined by the forcing function) and a complementary solution (defined by the forcing function being set to 0): $v_c(t) = v_{cp}(t) + v_{cc}(t)$ where you may consider $v_{cp}(t) = A + Bt$**.**

(b) Sketch this function (2 points)

(c) We often use the term "at long enough times" at which asymptotic solutions are useful approximations. What is the capacitor voltage at "long enough times"? (2 points)

(d) What is the current flowing through the battery,$i(t)$**?** (3 points)

(e) What is the power being delivered by the battery, $P_{battery}(t)$**?** (3 points)

(f) Explain where the power delivered by the battery is going. (2 points)

(g) If after a sufficiently long time (as defined in (c)), The battery runs out of power, and is not rechargeable, how would you represent this battery after it has run out of juice? (3 points)

(h) Let's assume that the battery runs out of power at $t_1 = 10s$. What would the capacitor voltage, $v_c(t)$, be for $t \geq 10s$? (3 points)

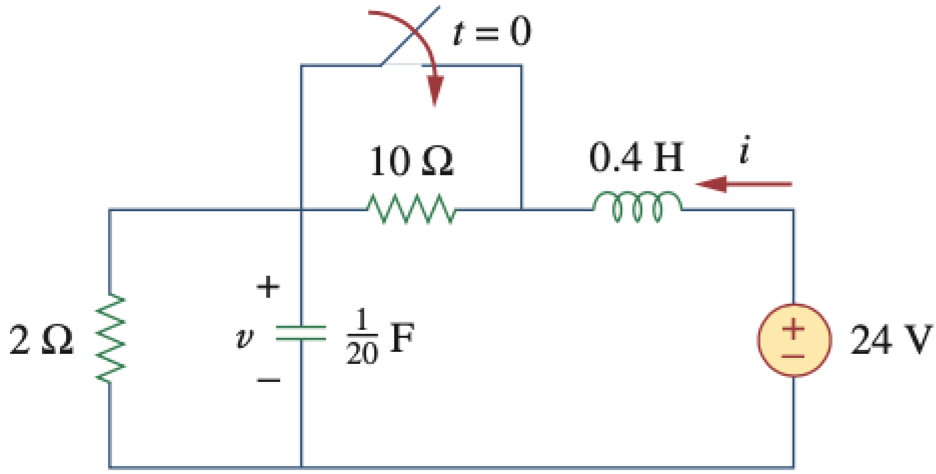
Note: If you were not able to solve for $v_c(t)$ in parts (a-b), you may assume some initial condition before t=10s, e.g. $v_c(t = 10^{-} seconds) = V_\alpha$.

(i) Sketch the complete diagram for $v_c(t)$ including the information for both $0 \leq t \prec 10s$(obtained in part (b) & $t > 10s$. (2 points)

Note: If you were not able to solve for $v_c(t)$ in parts (a-b), please plot $v_c(t)$ for at least $t > 10s$.

Problem 4: Steady-State Analysis (15 points)

The switch in the circuit below was open for a long time but closed at t=0.



(a) At t=0$^-$ (right before the switch is closed), is any energy stored in the inductor or capacitor? Why? (3 points)

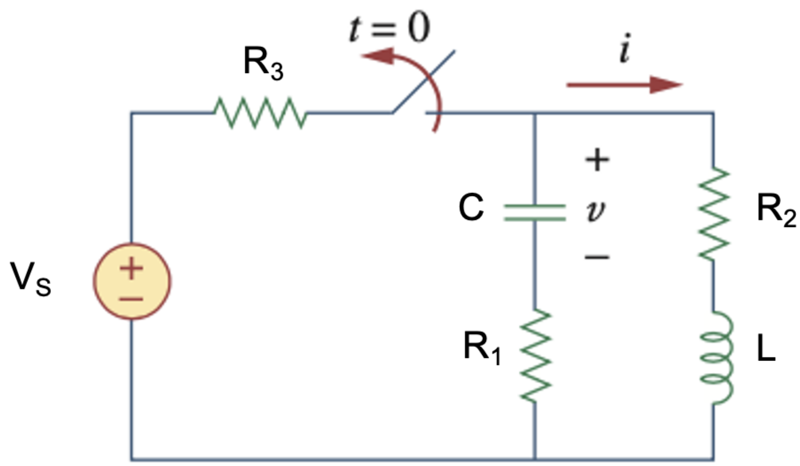
(b) What happens to the resistor (10Ω) after the switch is closed? (2 points)

(c) Solve for the initial conditions: $i(0^{+})$,$v(0^{+})$, $\frac{di(0^{+})}{dt}$,$\frac{dv(0^{+})}{dt}$ (6 points)

(Note: $t = 0^{+}$ means right after the switch is closed).

(d) Solve for the final conditions: $i(\infty)$,$v(\infty)$ (4 points)

Problem 5: 2nd-Order Differential Equations (25 points)



$V_S = 10V,\ R_1 = 3\Omega,\ R_2 = 6\Omega,\ R_3 = 4\Omega,\ C = 0.02F,\ L = 0.5H$

To maximize partial credit, please solve in terms of provided variables and then compute the answer numerically for each step.

(a) Derive a differential equation in terms of $v(t)$ that characterizes circuit behavior for t ≥ 0. (3 points)
Hint: You may choose to utilize KVL.

(b) Solve for $v(t)$ just after the switch changes state at $t = 0$ (e.g. $v(0^+)$). (2 points)

(c) Solve for $\frac{dv(t)}{dt}$ just after the switch changes state at $t = 0$(e.g. $\frac{dv(0^+)}{dt}$). What are the units of this quantity? (3 points)
Hint: Consider how current is defined across a capacitor.

(d) What is the final condition for $v(t)$? (e.g. $v(\infty)$) (2 points)

(e) What is the damping coefficient (ζ)? Is this system overdamped, critically damped, or underdamped? (2 points)

(f) What is the resonant frequency (ω_o)? If applicable, what is the 'natural frequency' (ω_n)? (2 points)

(g) What are the roots of the characteristic equation? (3 points)

(h) What is the general solution given ($v_g(t)$) given the integration constants K_1, K_2, & K_3? (3 points)

Note: You may use K_1, K_2, & K_3 in any order.

(i) Given the initial & final conditions from parts (b)-(d), find the integration constants (K_1, K_2, & K_3) as you had defined in (h). Re-write the final solution for $v(t)$ given these values. (3 points)

(j) Sketch the output waveform, $v(t)$, starting from $t = 0$. (2 points)