Due Wednesday, Apr. 2, 2025 by 11:59 p.m.

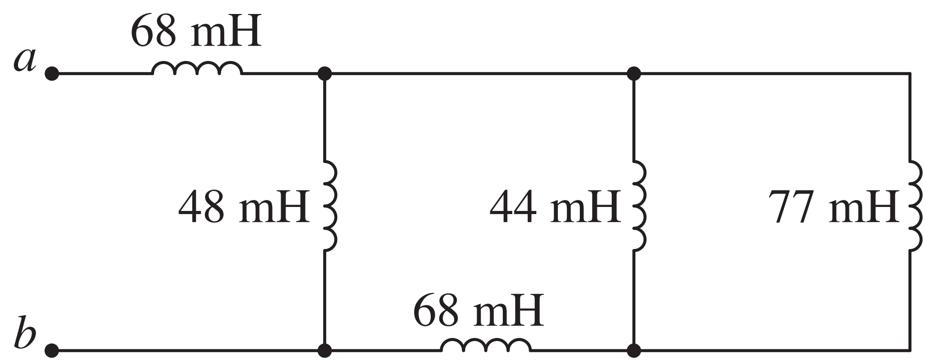
NOTE: This is only the "handwritten" portion of Homework 10. There are also problems you must do online via the Mastering site. For this handwritten portion, you must submit a PDF scan of your work at Canvas. Please ensure your work is contained in a single file and is legible.

You must complete the problems on the following pages which made up the first exam in this course from a previous semester. You may print this file and show your work on these pages as you would for the exam, or you may provide your solution on separate paper (or via some other document-capture technique that shows your work). The hardcopy of the exam is printed double-sided. To ensure a circuit and the questions about that circuit are on facing pages, some pages are blank (and are identified as being intentionally blank).

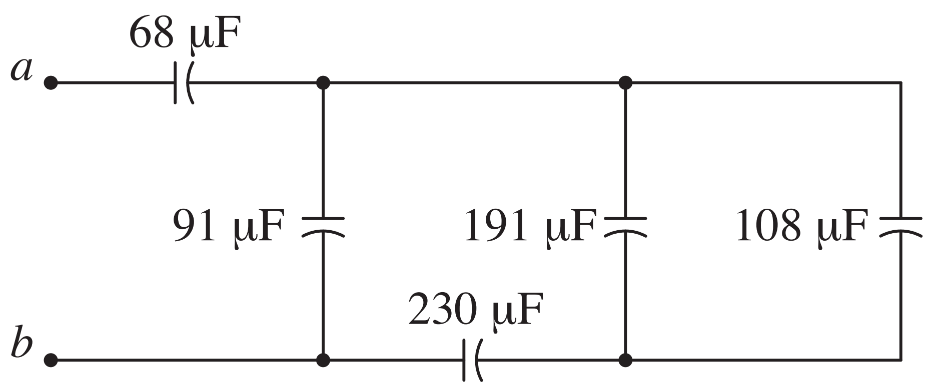
Shown below are the rules that pertained to this exam, but you are free to treat this assignment like any other homework assignment. These rules are provided merely so that you can become familiar with them as the rules for your exam on Apr. 4th will be similar or the same.

The rules:

- Relax!
- Closed book.
- Closed notes except you are allowed three sheets (front and back) of notes (whether handwritten or typeset or some combination thereof).
- All work must be your own. Merely *looking* at the work of others is cheating and may carry all the consequences associated with cheating. Focus on doing your best while completely ignoring your classmates.
- **No work, no credit.** Show your work.
- **Neatness counts.** If I can't easily read it, you won't get credit.
- You may use the "standard" scientific functions of a calculator. Programmed calculations are not permitted. (A programmable calculator is allowed, but you are not allowed to program it or use pre-installed programs.)
- No cell phones or other electronic devices (other than a calculator).
- If you submit your test before 50 minutes from the start of the exam, the number of incorrect points will be multiplied by three. Take your time and check your work!
- The value of each question is indicated within brackets, e.g., [10]. (Questions with equal value are not necessarily of equal difficulty.)
- Unless told otherwise, you are free to use any suitable approach to obtain the answer. Just be sure to properly document your work so it is clear how you arrived at the answer.
- **Note**: The answers to all the questions can be obtained without significant work. If you find yourself doing a lot of work, you may want to pause and rethink what you're doing.
- The last page provides Table 8.2 from Nilsson and Riedel concerning the natural response of parallel RLC circuits.



(a)

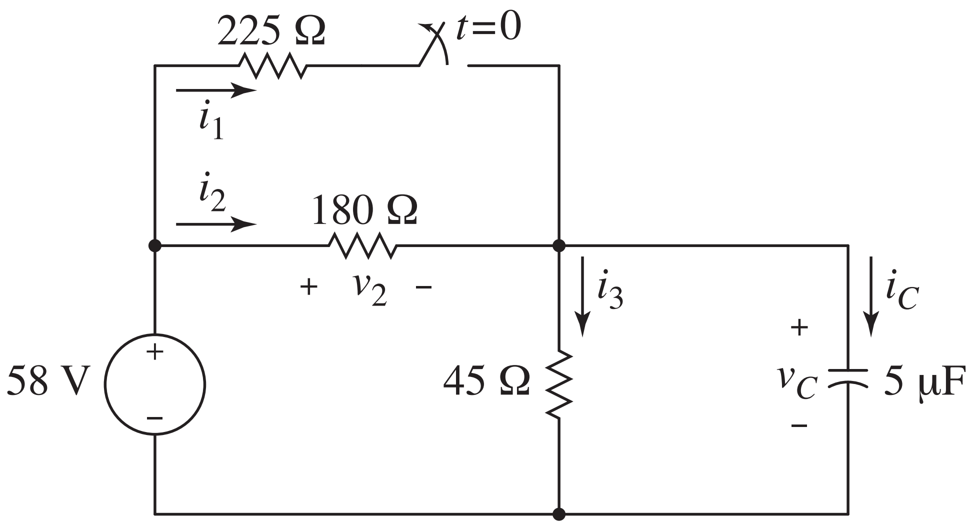


(b)

1. The following questions pertain to the circuits shown on the previous page.

   (a) **[9]** What is the equivalent inductance of the inductors shown in (a)?

   (b) **[9]** What is the equivalent capacitance of the capacitors shown in (b)?



2. The questions below and on the following page pertain to the circuit shown above which is in steady state prior to the switch opening at $t = 0$. (**Hint:** Keeping in mind what can and cannot change instantaneously, for the most part these questions merely involve Ohm's law, voltage division, KVL, or KCL.)

   (a) **[4]** What is $v_C(0^-)$?

   (b) **[4]** What is $v_C(\infty)$?

   (c) **[4]** What is $v_2(0^-)$?

   (d) **[4]** What is $v_2(0^+)$?

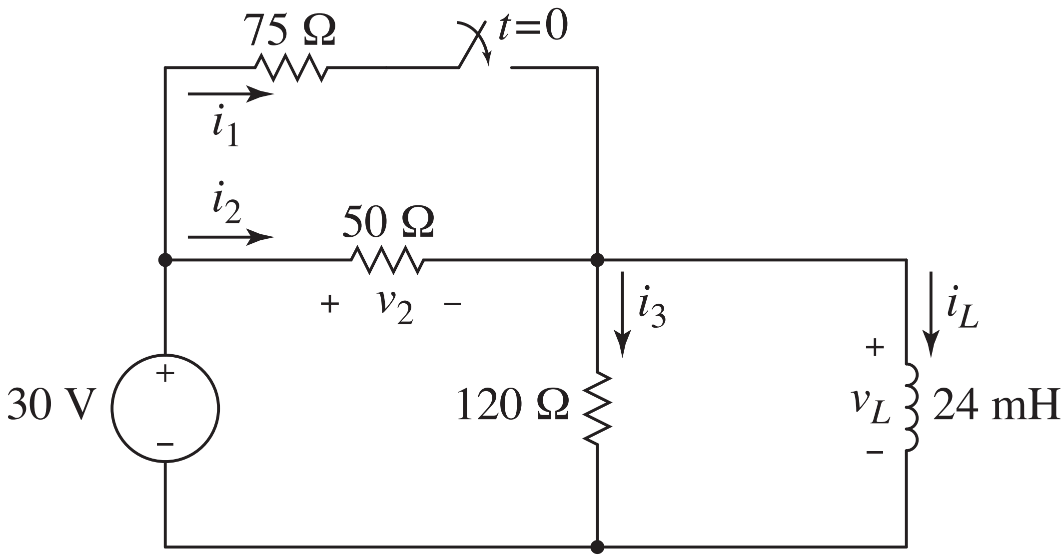
(e) **[4]** What is $i_1(0^-)$?

(f) **[4]** What is $i_1(0^+)$?

(g) **[4]** What is $i_C(0^-)$?

(h) **[4]** What is $i_3(0^+)$?

(i) **[5]** What is the time constant τ that pertains for $t > 0$.


75 Ω
t=0
i1
i2
50 Ω
+ v2 −
iL
i3
+
30 V
+
−
120 Ω
vL
24 mH
−

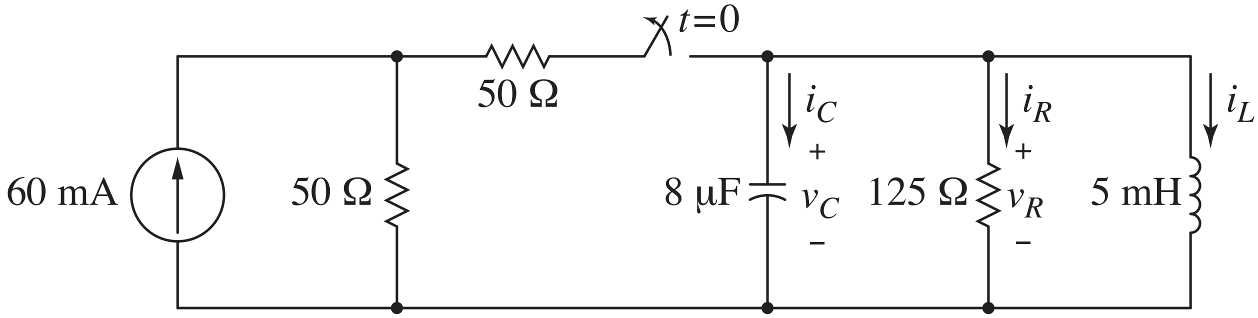
3. The following questions pertain to the circuit shown on the previous page which is in steady state prior to the switch closing at $t = 0$.

   (a) **[4]** What is $i_L(0^-)$?

   (b) **[4]** What is $i_L(\infty)$?

   (c) **[4]** What is the time constant τ that pertains for $t > 0$?

   (d) **[5]** What is $i_L(t)$ for $t > 0$? (You do not need to derive the differential equation. You merely need to provide the function with all appropriate constants.)


t=0
50 Ω
60 mA
50 Ω
8 μF
iC
vC
125 Ω
iR
vR
5 mH
iL

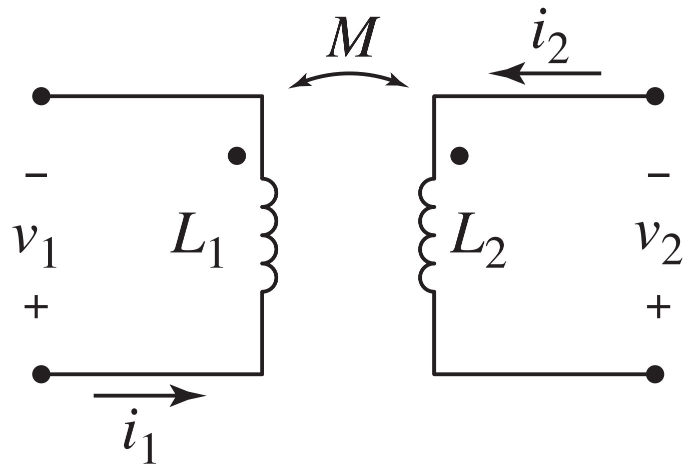
4. The following questions pertain to the circuit on the previous page which is in steady state prior to the switch opening at $t = 0$.

   (a) **[5]** What is $i_L(0^-)$?

   (b) **[5]** What is $v_R(0^+)$?

   (c) **[5]** What is $i_C(0^+)$?

   (d) **[5]** For $t > 0$, do the currents and voltages behave in an overdamped, critically damped, or underdamped manner? (Justify your answer.)


M
i2
v1
L1
L2
v2
i1

5. **[8]** In general, the voltage across mutually coupled inductors can be expressed as

$$v_1 = \pm L_1 \frac{di_1}{dt} \pm M \frac{di_2}{dt}$$
$$v_2 = \pm L_2 \frac{di_2}{dt} \pm M \frac{di_1}{dt}$$

where the signs are dictated by voltage polarities, the direction of current flows, the passive sign convention, and the dot convention. What are v_1 and v_2 for the circuit on the previous page?

Table 8.2 from Nilsson and Riedel concerning the natural response of parallel RLC circuits. ($V_0 = v_C(0)$; $I_0 = i_L(0)$)

Characteristic equation	$s^2 + \frac{1}{RC}s + \frac{1}{LC} = 0$
Neper, resonant, and damped frequencies	$\alpha = \frac{1}{2RC} \quad \omega_0 = \sqrt{\frac{1}{LC}} \quad \omega_d = \sqrt{\omega_0^2 - \alpha^2}$
Roots of the characteristic equation	$s_1 = -\alpha + \sqrt{\alpha^2 - \omega_0^2}, \quad s_2 = -\alpha - \sqrt{\alpha^2 - \omega_0^2}$
$\alpha^2 > \omega_0^2$: overdamped	$v(t) = A_1 e^{s_1 t} + A_2 e^{s_2 t}$, t ≥ 0 $v(0^+) = A_1 + A_2 = V_0$ $\frac{dv(0^+)}{dt} = s_1 A_1 + s_2 A_2 = \frac{1}{C}\left(\frac{-V_0}{R} - I_0\right)$
$\alpha^2 < \omega_0^2$: underdamped	$v(t) = B_1 e^{-\alpha t}\cos\omega_d t + B_2 e^{-\alpha t}\sin\omega_d t$, t ≥ 0 $v(0^+) = B_1 = V_0$ $\frac{dv(0^+)}{dt} = -\alpha B_1 + \omega_d B_2 = \frac{1}{C}\left(\frac{-V_0}{R} - I_0\right)$
$\alpha^2 = \omega_0^2$: critically damped	$v(t) = D_1 t e^{-\alpha t} + D_2 e^{-\alpha t}$, t ≥ 0 $v(0^+) = D_2 = V_0$ $\frac{dv(0^+)}{dt} = D_1 - \alpha D_2 = \frac{1}{C}\left(\frac{-V_0}{R} - I_0\right)$