APPC, E & M: Unit C HW 8

Name: ______________________

Hr: ___ Due at beg of hr on: __________

UC, HW8, P1

Reference Videos: (1) "Time Constants for RL Circuits"
(2) "An Example of an Inductance Problem"
YouTube, lasseviren1, INDUCTANCE playlist

A. Earlier in this course, we covered RC circuits, i.e., circuits having resistors and capacitors. To review, write the equation for the time constant τ of an RC circuit.

B. Recently, we've been studying LR circuits, i.e., circuits having an inductor and a resistor in (for us) series. Write the equation for the time constant τ of an LR circuit.

C. This is NOT in the video, but… What electrical components, do you suppose, are MOST CERTAINLY a part of any **<u>RLC circuit</u>**?

D. We have established (in several videos, and also derived by you in HW7, P4 and P5) that the exponential parts of the time-dependent-behavior-equations for LR circuits can be written:

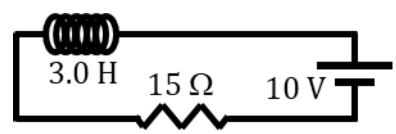
$$1 - e^{\frac{-Rt}{L}} \qquad \text{AND} \qquad e^{\frac{-Rt}{L}}$$

Below the appropriate expression, write either **decaying** or **climbing**.

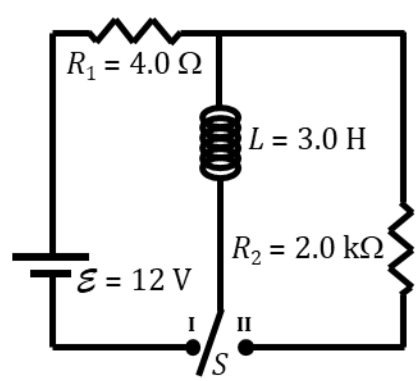
E. Combine your Part B answer with each equation in Part D to yield two new equations that DON'T contain either R or L. (Just write the exponents.) $1 - e$ AND e

F. Below your Part E expressions… When the time $t = \tau$, write the value of each expression, to two decimal places.

G. Determine the time constant of the circuit shown directly to the right. Include proper units on your answer.



Consider now the more-complicated circuit shown. Note, in particular, the value of R_2. The analysis begins when the switch is thrown to Point I. Find magnitudes of each of the following. Include proper units.



H. At time $t = 0$, determine the:

i. current I in the left half of the circuit

ii. voltage drop V_{R1} across resistor R_1

iii. emf $\mathcal{E}_L$ in the inductor L

I. At time $t = \infty$, determine the:

i. current I in the left half of the circuit

ii. voltage drop V_{R1} across resistor R_1

iii. emf $\mathcal{E}_L$ in the inductor L

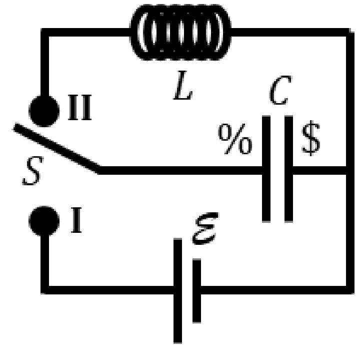
J. Now S is flipped to Point II. At time $t = 0$, find the:

i. current I in the right half of the circuit

ii. voltage drop V_{R2} across resistor R_2

iii. emf $\mathcal{E}_L$ in the inductor L

UC, HW8, P2
Reference Video: "LC Circuit"
YouTube, lasseviren1, INDUCTANCE playlist



A. An LC circuit always has which two circuit elements present?

B. Here, we will assume that the resistance of the circuit is equal to __________.

The figure shows a circuit with a capacitor C, a battery $\mathcal{E}$, and an inductor L. The capacitor is initially uncharged. The following scenario begins when the switch is thrown to Point I.

C. In the bottom half of the circuit, current will flow in which direction? (circle) CW CCW

D. Given that there are NO resistors in the bottom part of the circuit,
FOR HOW LONG will the current referenced in Part C continue flowing?

E. At this point, which plate will have the higher potential? (circle) % $

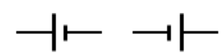
F. Which plate will be positively charged? (circle) % $

Now the switch is thrown to Point II.

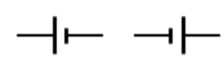
G. What is value of the initial current that subsequently flows in the top half of the circuit?

H. When current does flow in the top half, in which direction will it start to flow? (circle) CW CCW

I. The current will build to some maximum magnitude, and it does so by: (circle)
- i. increasing linearly
- ii. increasing rapidly at first, and then tapering off
- iii. increasing slowly at first, then at a greater rate

J. Up to this point in the process, the inductor has had an induced emf that points: (circle) 

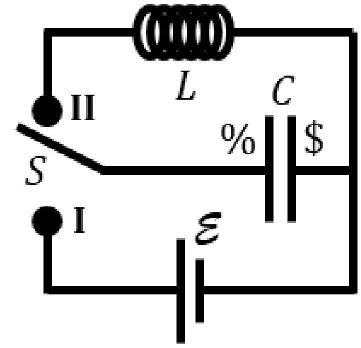
K. Up to this point in the process, the magnitude of the inductor's emf has been: (circle)
- i. increasing linearly
- ii. increasing rapidly at first, and then tapering off
- iii. increasing slowly at first, then at a greater rate
- iv. decreasing linearly
- v. decreasing rapidly at first, and then tapering off
- vi. decreasing slowly at first, then at a greater rate

L. Just after the current reaches a maximum, the inductor's induced emf will point: (circle) 

M. In the following moments, the magnitude of the inductor's emf will be: (circle)
- i. increasing linearly
- ii. increasing rapidly at first, and then tapering off
- iii. increasing slowly at first, then at a greater rate
- iv. decreasing linearly
- v. decreasing rapidly at first, and then tapering off
- vi. decreasing slowly at first, then at a greater rate

N. When the current next has a value of zero, which plate will be positively charged? (circle) % $

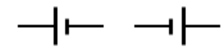
UC, HW8, P3
Reference Videos: (1) “LC Circuit”
(2) “LC Circuit (Part II)”
YouTube, lasseviren1, INDUCTANCE playlist



This problem begins as a continuation of the previous one, so you might need to refer back to your work there to pick up the thread of the narrative. The figure has been reproduced for your convenience.

When we left off in P2, the switch had been thrown to Point II and we had reached the point at which the current had momentarily ceased flowing in the top half of the circuit. We now continue…

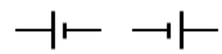
O. When current resumes in the top half, in which direction will it flow? (circle) CW CCW

P. At the instant of Part O, in which direction will the inductor’s induced emf point? (circle) 

Q. At the instant of Part O, the induced emf in the inductor will be: (circle) basically zero a maximum magnitude

R. In the subsequent moments, the magnitude of the inductor’s emf will be: (circle)

i. increasing linearly
ii. increasing rapidly at first, and then tapering off
iii. increasing slowly at first, then at a greater rate
iv. decreasing linearly
v. decreasing rapidly at first, and then tapering off
vi. decreasing slowly at first, then at a greater rate

S. Once again, the current will build to a maximum magnitude. Just after the current reaches this maximum, the inductor’s induced emf will point: (circle) 

T. In the following moments, the inductor’s emf will be: (circle)

i. increasing linearly
ii. increasing rapidly at first, and then tapering off
iii. increasing slowly at first, then at a greater rate
iv. decreasing linearly
v. decreasing rapidly at first, and then tapering off
vi. decreasing slowly at first, then at a greater rate

U. When the current next has a value of zero, which plate will be positively charged? (circle) % $

V. Your Part U answer agrees *precisely* with WHICH lettered Part from the previous problem, P2? ______

And round and round we go, with charge sloshing back and forth until it subsides due to friction losses. ☺

W. The narrator mentions, in the “LC Circuit” video, that the frequency of the sloshing that was just mentioned conforms to the following equation: $f = \frac{1}{2\pi}\sqrt{\frac{1}{LC}}$

He then states that, when you tune a radio to a particular frequency, you are changing…WHAT?

X. In “LC Circuit (Part II)”, it is stated that, when the maximum charge Q resides on the plates of the capacitor C, the total energy of the system can be represented by WHAT equation?

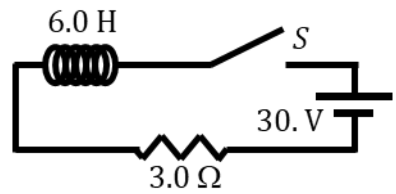
E_{tot} =

Y. Then, for any combination of charge-on-the-plates q AND current-i-through-the-inductor L, this same total energy can be represented by WHAT equation?

E_{tot} =

UC, HW8, P4

Reference Video: "Review of Unit on Inductance (Part I)"
YouTube, lasseviren1, INDUCTANCE playlist



Answer questions based on the figure in the upper right.

A. Determine the value of this circuit's time constant τ.
Show the original equation, your work and units.

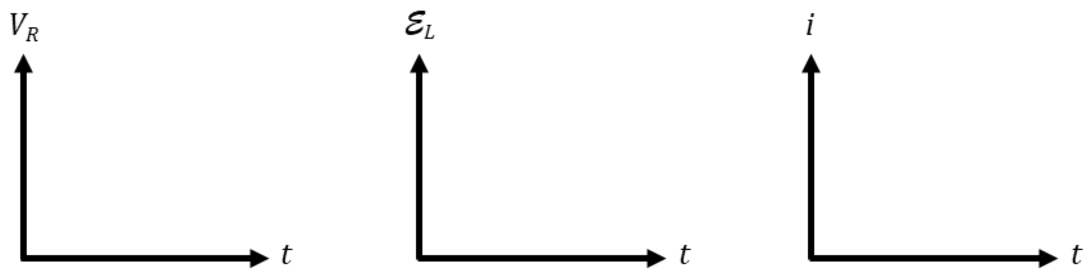
B. When the switch is first closed, i.e., at $t = 0$, what is the current in the circuit?

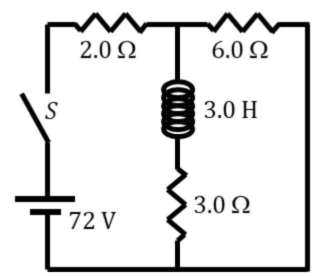
C. Give an extremely brief and simple reason for your Part B answer.

D. At $t = \infty$, what is the current in the circuit?

E. Give an extremely brief and simple reason for your Part D answer.

F. Below, draw approximate graphs on the axes provided. Label (with the correct number and unit) any nonzero asymptotic value. Also, on each graph, indicate where ONE time constant τ comes into play, and specify BOTH the x- and y-values at that location.





Answer the following questions based on the figure at right. NOTE: The narrator makes a mistake in the "Switch Opened" part of this video, so be sure to THINK when you are completing Part I below. If you understand the key principles involved in LR circuits, you will have no trouble navigating this obstacle. ☺

Determine numerical answers to the following quantities.

G. At the instant the switch is thrown:

i. $I_{2\,\Omega}$ = _________

ii. $I_{3\,\Omega}$ = _________

iii. $I_{6\,\Omega}$ = _________

iv. $V_{2\,\Omega}$ = _________

v. $V_{3\,\Omega}$ = _________

vi. $V_{6\,\Omega}$ = _________

vii. $\mathcal{E}_L$ = _________

viii. dir. of $\mathcal{E}_L$ (circle) NEITHER

H. A long time after the switch is thrown:

i. $I_{2\,\Omega}$ = _________

ii. $I_{3\,\Omega}$ = _________

iii. $I_{6\,\Omega}$ = _________

iv. $V_{2\,\Omega}$ = _________

v. $V_{3\,\Omega}$ = _________

vi. $V_{6\,\Omega}$ = _________

vii. $\mathcal{E}_L$ = _________

viii. dir. of $\mathcal{E}_L$ (circle) NEITHER

I. The instant the switch is opened:

i. $I_{2\,\Omega}$ = _________

ii. $I_{3\,\Omega}$ = _________

iii. $I_{6\,\Omega}$ = _________

iv. $V_{2\,\Omega}$ = _________

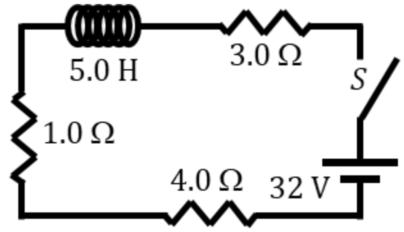
v. $V_{3\,\Omega}$ = _________

vi. $V_{6\,\Omega}$ = _________

vii. $\mathcal{E}_L$ = _________

viii. dir. of $\mathcal{E}_L$ (circle) NEITHER

UC, HW8, P5
Reference Video: "Review of Unit on Inductance (Part II)"
YouTube, lasseviren1, INDUCTANCE playlist



With reference to the figure at right, determine numerical answers for the quantities listed. Include proper units.

A. At the instant the switch is thrown ($t = 0$):

i. $I_{1\,\Omega}$ = __________

ii. $I_{3\,\Omega}$ = __________

iii. $I_{4\,\Omega}$ = __________

iv. $V_{1\,\Omega}$ = __________

v. $V_{3\,\Omega}$ = __________

vi. $V_{4\,\Omega}$ = __________

vii. $\mathcal{E}_L$ = __________

viii. dir. of $\mathcal{E}_L$ ⊣⊢ ⊣⊢ NEITHER (circle)

B. A long time after the switch is thrown ($t = \infty$):

i. $I_{1\,\Omega}$ = __________

ii. $I_{3\,\Omega}$ = __________

iii. $I_{4\,\Omega}$ = __________

iv. $V_{1\,\Omega}$ = __________

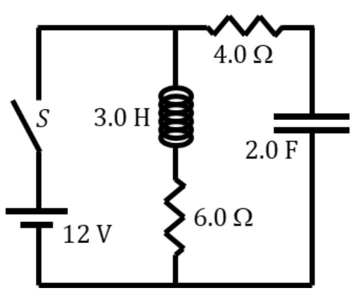
v. $V_{3\,\Omega}$ = __________

vi. $V_{4\,\Omega}$ = __________

vii. $\mathcal{E}_L$ = __________

viii. dir. of $\mathcal{E}_L$ ⊣⊢ ⊣⊢ NEITHER (circle)

Now, let's try our hand at partially analyzing an RLC circuit. ☺ With reference to the figure below, determine numerical answers for the quantities listed. Include proper units.



C. At the instant the switch is thrown:

i. $I_{4\,\Omega}$ = __________

ii. $I_{6\,\Omega}$ = __________

iii. $V_{4\,\Omega}$ = __________

iv. $V_{6\,\Omega}$ = __________

v. V_C = __________

vi. $\mathcal{E}_L$ = __________

vii. dir. of $\mathcal{E}_L$ ⊥ ⊥ NEITHER (circle)

D. A long time after the switch is thrown:

i. $I_{4\,\Omega}$ = __________

ii. $I_{6\,\Omega}$ = __________

iii. $V_{4\,\Omega}$ = __________

iv. $V_{6\,\Omega}$ = __________

v. V_C = __________

vi. $\mathcal{E}_L$ = __________

vii. dir. of $\mathcal{E}_L$ ⊥ ⊥ NEITHER (circle)

E. The behavior of LC circuits is very similar to that of mass-spring systems, i.e., both conform to the equations of ______________ ____________________ _____________. These equations are oscillatory, with values going up and down and periodically repeating; that is, they have trig functions in them and are said to be ____________________________ (even though they sometimes have cosine functions – hint, hint…).

F. As we saw in HW8, P3, the frequency of an LC circuit is given by: $f = \frac{1}{2\pi}\sqrt{\frac{1}{LC}}$

Based on this information, write the equation for the period T of the changes in an LC circuit.

G. Suppose your car radio has an inductor with an inductance of 1.20 nH. If you wish to tune the radio to 99.5 FM (i.e., f = 99.5 MHz), you should adjust the radio's circuit to have a capacitance of what value?