ECE 214 — Exam #2

Estimated time for completion: $\leq$ 1.25 hour
26 April 2016

Rules of the Exam

Rule 1: The examination period begins at 8:00am on Tuesday 26 April 2016 and ends at 9:15am on Tuesday 26 April 2016.

Rule 2: The exam is worth 15% of your grade.

Rule 3: To receive credit for the answer make sure to include the units along with the numerical answer and show all work.

Rule 4: There is minimal partial credit.

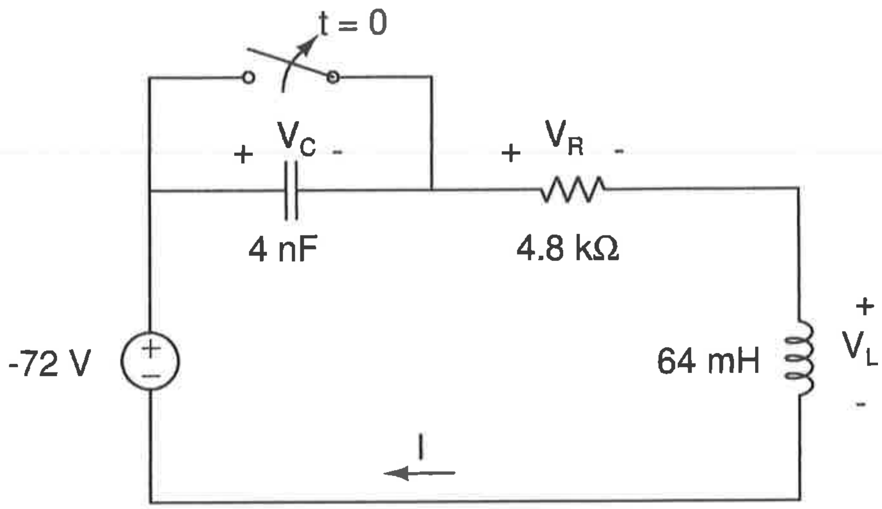
Rule 5: The exam is closed book and closed notes. You may use your ECE 214 Laboratory Notebook and a calculator.

Rule 6: Do not discuss this exam with anyone until after 1:00pm on Tuesday 26 April 2016.

Answer Key

Name

Problem: Step response for a series RLC circuit. The switch in the circuit below has been closed for 37,321 years and opens at time $t = 0$. Complete the table for the circuit:



	$t = -50\mu s$	$t = 0^+$ s	$t = 50\mu s$	$t = \infty$
V_C	0 V	0 V	-82.77 V	-72 V
V_R	-72V	-72V	3.89V.	0 V
V_L	0 V	0 V	6.88 V	0 V
I	-15 mA	-15 mA	-810.4 μA	0 A

Extra Credit:
At what time after the switch opens is the voltage across the inductor a maximum? 18.55μs

$\alpha = \frac{R}{2L} = \frac{4800}{2\times 64\times10^{-3}} = 37{,}500$ rad/s

$w_0 = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{64\times10^{-3}\times 4\times10^{-9}}} = 62{,}500$ rad/s

$W_d = (w_0^2 - \alpha^2)^{\frac{1}{2}} = 50{,}000$ rad/s

$i(t) = A_1 e^{-\alpha t}\cos(50{,}000t) + A_2 e^{-\alpha t}\sin(50{,}000t) + i(\infty)$, with $i(\infty) = 0$

$i(0) = -0.015 = A_1$ $\boxed{A_1 = -0.015\ A}$

$L\left.\frac{di(t)}{dt}\right|_{t=0^+} = v_L(0^+) = 0$

$\left.\frac{di(t)}{dt}\right|_{t=0^+} = 0$

$\left.\frac{di}{dt}\right|_{t=0^+} = A_1(-\alpha) + A_2(50{,}000) = 0$

$A_2 = A_1 \frac{\alpha}{50{,}000} = 0.75A_1$ $\boxed{A_2 = 0.75A_1}$

$i(t) = -0.015e^{-37500t}\cos(50{,}000t) - (0.75)(0.015)e^{-37500}\sin(50{,}000t)$

$.001843 - .001033$

$i(50\mu s) = 810.4\ \mu A$

$v_r = 4800 \times i(50\mu s) = 3.89V$

$V_L = L\frac{di}{dt} = 64\times10^{-3}\frac{di}{dt}$

$$i(t) = -0.015\, e^{-37{,}500t}\left[\cos(50{,}000t) + \frac{3}{4}\sin(50{,}000t)\right]$$

$$\frac{di}{dt} = -0.015\, e^{-37{,}500t}\left[-50{,}000\sin(50{,}000t) + \frac{3}{4}\,50{,}000\cos(50{,}000t)\right]$$

$$+ (0.015)(37{,}500)\, e^{-37{,}500}\left[\cos(50{,}000t) + \frac{3}{4}\sin(50{,}000t)\right]$$

$$\frac{di}{dt} = e^{-37{,}500t}\Big[750\sin(50{,}000t) - \cancel{562.5\cos(50{,}000t)}$$

$$+ \cancel{562.5\cos(50{,}000t)} + 421.875\sin(50{,}000t)\Big]$$

$$= e^{-37{,}500t}\left[1171.88\sin(50{,}000t)\right]$$

$$v_L = L\frac{di}{dt} = 64\times10^{-3}\frac{di}{dt}$$

$$v_L(50\mu s) = 64\times10^{-3}\, e^{-37{,}500\times50\times10^{-6}}\left[1171.88\sin(50{,}000\times50\times10^{-6})\right]$$

$$= 6.8834\,V$$

$$V_C + V_R + V_L + 72 = 0$$

$$V_C = -72 - V_R - V_L = -72 - 3.89 - 6.88 = -82.77$$

Extra Credit

$$v_L(t) = 75\, e^{-37{,}500t}\sin(50{,}000t)$$

$$\frac{dv_L}{dt} = \cancel{75}\,\cancel{e^{-37{,}500t}}\cos(50{,}000t)\times 50{,}000 - \cancel{75}(37{,}500)\,\cancel{e^{-37{,}500t}}\sin(50{,}000t) = 0$$

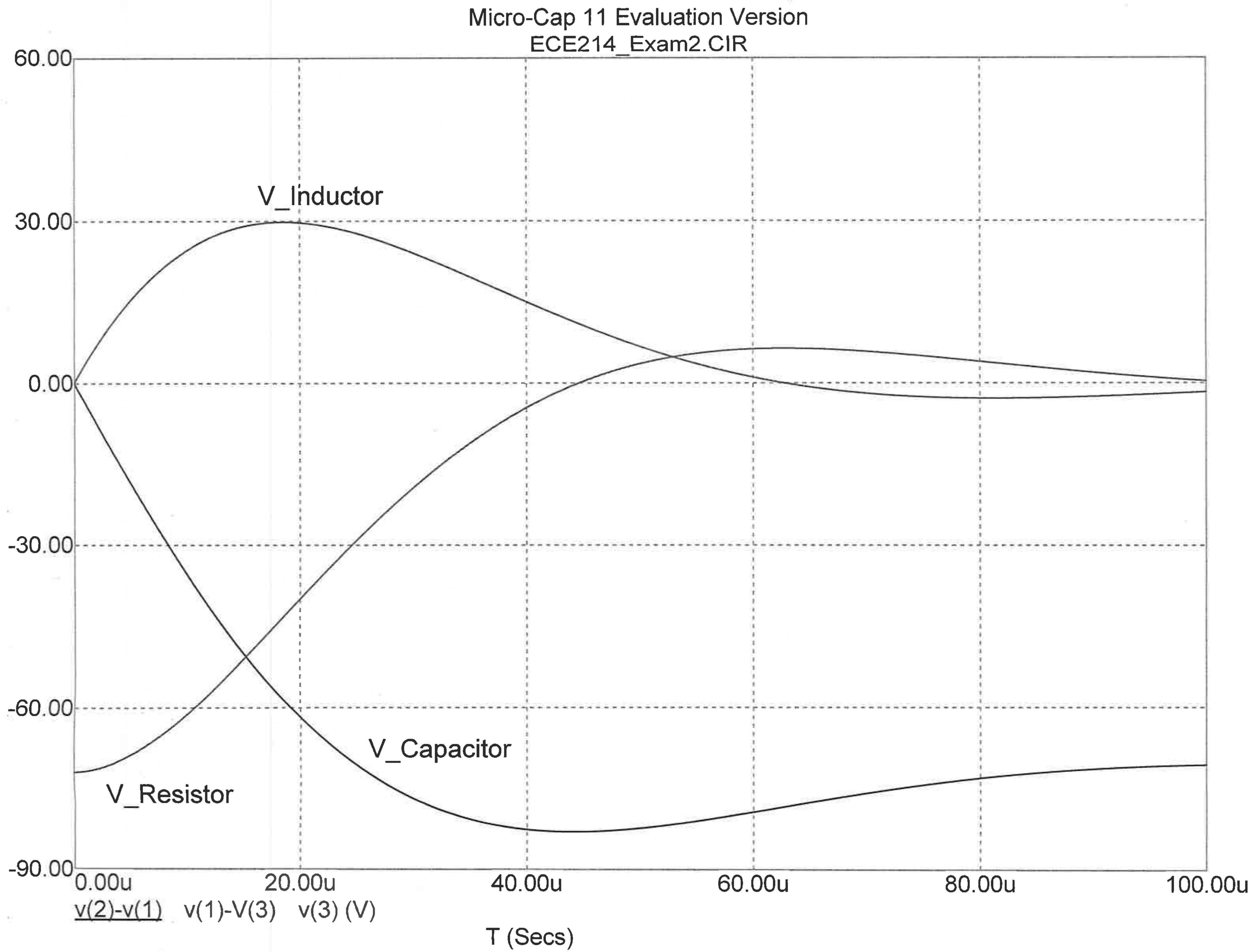
$$50{,}000\cos(50{,}000t) = 37{,}500\sin(50{,}000t)$$

$$\cos(50{,}000t) = 0.75\sin(50{,}000t)$$

$$50{,}000\cos(50{,}000t) = 37{,}500\sin(50{,}000t)$$

$$\frac{4}{3} = \frac{\sin(50{,}000t)}{\cos(50{,}000t)} = \tan(50{,}000t)$$

$$\boxed{t = 18.55\,\mu s}$$


Micro-Cap 11 Evaluation Version
ECE214_Exam2.CIR
60.00
30.00
0.00
-30.00
-60.00
-90.00
V_Inductor
V_Capacitor
V_Resistor
0.00u
20.00u
40.00u
60.00u
80.00u
100.00u
v(2)-v(1)   v(1)-V(3)   v(3) (V)
T (Secs)