Name: Solutions

EXAM 2: EECS 215
Introduction to Electronic Circuits
Wednesday, March 22, 2017. 6:00pm-8:00pm

Lecture Section (circle 1):	001 Finelli	002 Phillips

This test consists of five problems with points as indicated to total 60 points.

Read through the entire exam before beginning.
Show all work (on the pages provided in this booklet) to earn partial credit.
Briefly explain major steps, include units, and write your final answers in the areas provided.
Do not unstaple the pages.

No credit will be given if no work is shown.

Exam Policies

- No food allowed during exam.
- No books allowed (closed book exam).
- One, 8.5 x 11 inch notes page (TWO SIDED) allowed
    a. ***Note the page of equations at the back of this exam***
- Only scientific calculators allowed (**graphing calculators not permitted**).
- No communication of any kind is allowed. No use of cell phones, computers, or any devices besides calculators. Violation of this will be treated as an honor code violation.
- No credit will be given for this exam without a signed honor pledge.

Write out the honor pledge and sign below.

"I have neither given nor received unauthorized aid on this examination, nor have I concealed any violations of the Honor Code"

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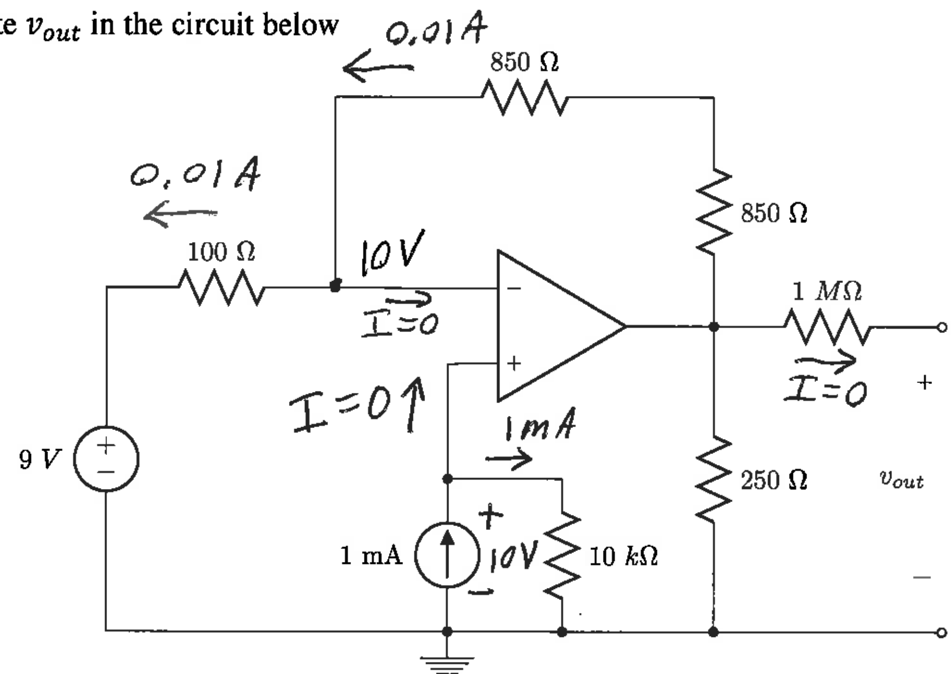
Signature: ______________________________

Do not write in this space

Problem 1: [ ]/12	Problem 4: [ ]/12
Problem 2: [ ]/12	Problem 5: [ ]/12
Problem 3: [ ]/12	

Total score [ ]/60

1. Calculate v_{out} in the circuit below



+ terminal: $(1mA)(10k\Omega) = 10\,V$
(same as − terminal)

current at (−) terminal: $\dfrac{10-9}{100\,\Omega} = 0.01\,A$

current in feedback loop: $\dfrac{V_{out} - 10}{850+850} = 0.01\,A$

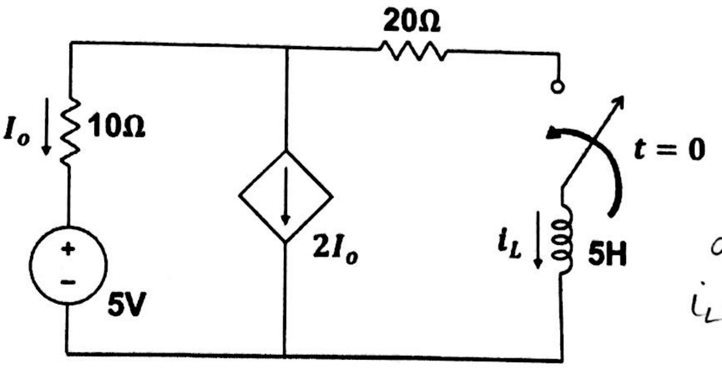
$V_{out} = 27\,V$

Write your answer here:

$v_{out} =$ 27 V

Problem 1 score: [ ]/12

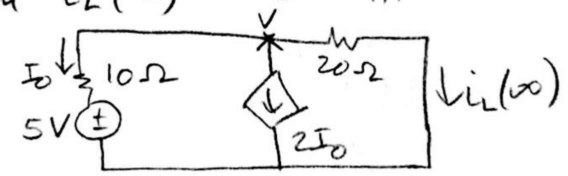
2. The switch in the circuit below has been open for a very long time, and it closes at $t = 0$ seconds. Solve completely for $i_L(t), t \geq 0$.



open switch ⇒
$i_L(0^-) = i_L(0^+) = 0\,A$

need $i_L(\infty)$ and R_{TH}

$t \to \infty$



KCL at top:

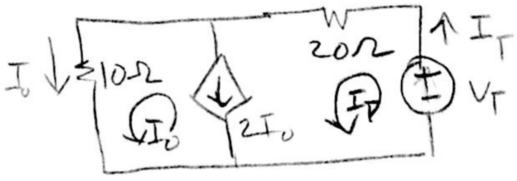
$$\frac{V-5}{10} + 2\left(\frac{V-5}{10}\right) + \frac{V}{20} = 0$$

I_o

$$7V = 30 \Rightarrow V = 30/7$$

$$i_L(\infty) = \frac{V}{20} = \boxed{3/14\ A}$$

R_{TH} use test source method (deactivate 5V source)



mesh analysis w/ supermesh

$$\left.\begin{aligned} -10I_o - 20I_T + V_T &= 0 \\ \text{and} \quad 2I_o &= I_T - I_o \end{aligned}\right\} \quad \frac{V_T}{I_T} = R_{TH} = \frac{70}{3}$$

so... $\tau = L/R = \dfrac{5}{70/3} = 3/14$

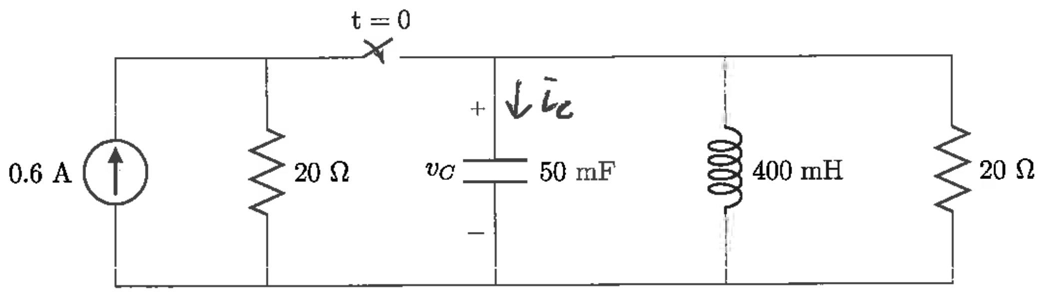
$$i_L(t) = i_L(\infty) + \{i_L(0) - i_L(\infty)\}\, e^{-t/\tau}$$

Write your answer here:

$i_L(t) =$ $\frac{3}{14}\left(1 - e^{-14t/3}\right)$ A $= .214\left(1 - e^{-4.666t}\right)$ A

Problem 2 score: [ ]/12

3. The circuit below had the switch open for a very long time before it is closed at time $t = 0$. Find the voltage across the capacitor $v_C(t)$ for $t \geq 0$.



$t<0$: $\underline{v_c(0) = 0}$, $i_L(0) = 0$

$t = 0^+$: since $v_c(0) = 0$, no current through resistors $(I = V/R = 0)$

also, $i_L(0) = 0$

$i_c(0^+) = 0.6\ A$

$v_c'(0^+) = \frac{i_c(0^+)}{C} = \frac{0.6\,A}{0.05\,F} = \underline{12\ V/s}$

Parallel RLC, $R = 20 // 20 = 10\,\Omega$

$\alpha = \frac{1}{2RC} = \frac{1}{2(10)(0.05)} = 1\ s^{-1}$

$\omega_0 = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{(0.4)(0.05)}} = 7.0711$

$\omega_0 > \alpha$, underdamped

$\omega_d = \sqrt{\omega_0^2 - \alpha^2} = 7\ rad/s$

$v_c(\infty) = 0$, since inductor short as $t \to \infty$

$v_c(t) = e^{-\alpha t}(B_1 \cos \omega_d t + B_2 \sin \omega_d t) + v_c(\infty)$

$= e^{-t}(B_1 \cos 7t + B_2 \sin 7t)$

Write your answer here:

$v_C(t) = \frac{12}{7} e^{-t} \sin 7t = 1.7143 e^{-t} \sin 7t\ V$

Problem 3 score: [ ]/12

$$v_c(0) = B_1 = 0$$

$$v_c(t) = e^{-t}(B_2 \sin 7t)$$

$$v_c'(t) = -e^{-t}(B_2 \sin 7t) + e^{-t}(B_2 \cos 7t)(7)$$

$$v_c'(0) = 7B_2 = 12$$

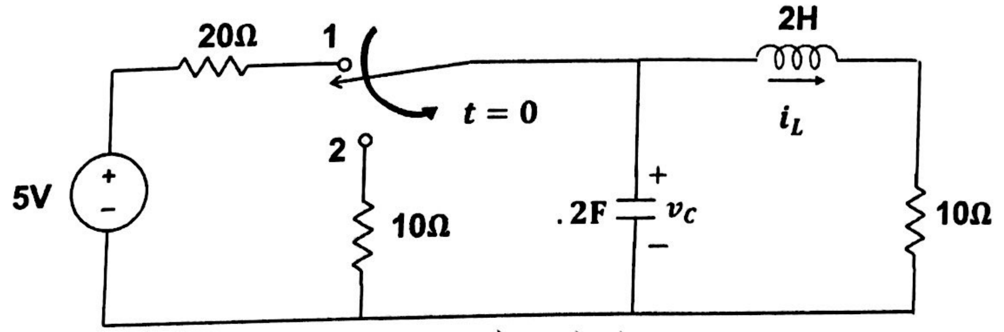
$$B_2 = \frac{12}{7}$$

$$v_c(t) = \frac{12}{7} e^{-t} \sin 7t \quad V$$

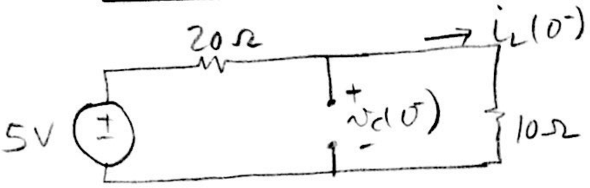
$$= 1.7143\, e^{-t} \sin 7t \quad V$$

4. The switch in in the circuit below has been in position (1) for a very long time. At $t = 0$ seconds, it moves to position (2). Determine:

   a. $i_L(0^+)$ and $v_C(0^+)$
   b. $i_L'(0^+)$ and $v_C'(0^+)$



$t=0^-$

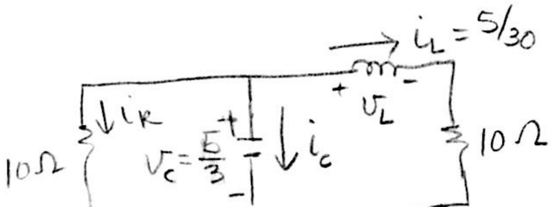


voltage ÷

$v_C(0^-) = v_C(0^+) = \left(\frac{10}{10+20}\right)5 = \frac{5}{3}$ V

$i_L(0^-) = i_L(0^+) = \frac{5/3}{10} = \frac{5}{30}$ A

$t=0^+$



Ohm's Law, 10Ω resistor

$i_R(0^+) = 10v_c = \frac{5v}{3}$

$i_c(0^+) + i_R(0^+) + i_L(0^+) = 0 \Rightarrow i_c(0^+) = -\left(\frac{5/3}{10}\right) - \frac{5}{30} = -\frac{1}{3}$ A

$v_c'(0^+) = \frac{1}{.2}\left(-\frac{1}{3}\right) = -5/3$ V/s

KVL right loop

$-5/3 + v_L(0^+) + 10\left(\frac{5}{30}\right) = 0$

$\Rightarrow v_L(0^+) = 0$

$i_L'(0^+) = \frac{1}{L} v_L(0^+) = 0$

Write your answer here:

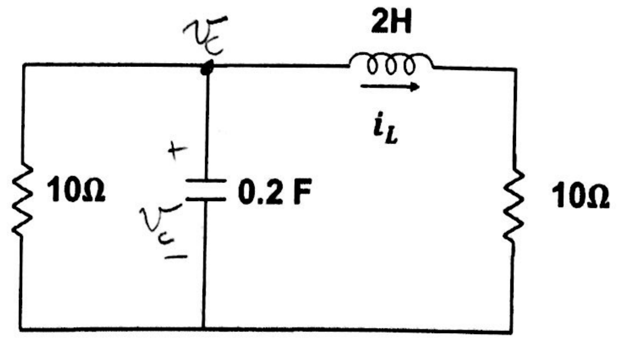
$i_L(0^+) =$ 5/30 A $\qquad v_C(0^+) =$ 5/3 V

$i_L'(0^+) =$ 0 A/s $\qquad v_C'(0^+) =$ −5/3 V/s

Problem 4 score: [ ]/12

5. For the circuit below, determine the second order differential equation for $i_L(t)$. Do not solve the equation. Rather, compute the constants K_1 and K_2 for the equation:

$$\frac{d^2 i_L(t)}{dt^2} + K_1 \frac{di_L(t)}{dt} + K_2 i_L(t) = 0$$



KCL at top: $\frac{v_C}{10} + 0.2\frac{dv_C}{dt} + i_L = 0$ ⊛

KVL right loop: $-v_c + 2\frac{di_L}{dt} + 10 i_L = 0 \Rightarrow v_c = \frac{2di_L}{dt} + 10i_L$

sub into equation *

$$\frac{2\frac{di_L}{dt} + 10i_L}{10} + .2\frac{d}{dt}\left(\frac{2di_L}{dt} + 10i_L\right) + i_L = 0$$

$$\frac{4}{10}\frac{d^2 i_L}{dt^2} + \frac{22}{10}\frac{di_L}{dt} + 2i_L = 0$$

$$\boxed{\frac{d^2 i_L}{dt^2} + 5.5\frac{di_L}{dt} + 5i_L = 0}$$

Write your answer here:

$K_1 =$ 5.5 $K_2 =$ 5

Problem 5 score: [ ]/12