Engr228 **Exam #2** **Spring, 2020**

SCORE KEY /30

Rules of engagement:

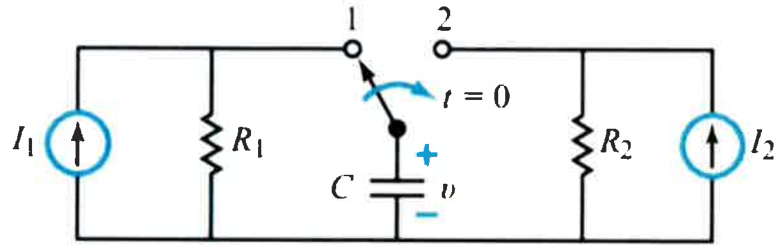
- This exam is open book:
  - You **may** use all materials at your disposal including the internet, Zybooks, textbooks, lecture notes and videos, example problems and your calculator.
  - You **may not** consult anyone other than yourself about anything related to this test until 5pm on Wednesday, May 27.
- You are allocated a total of 3 hours, **in one sitting**, to work on this exam. You must monitor yourself and stay within this time frame. Once you open the test, you must submit the finished product to the D2L drop box **test2** within 3 hours.
- The drop box will close at 5pm on Wednesday, May 27 and late submissions will not be accepted.
- You may email me your test directly, but only if D2L is not available.
- Students with documented disabilities – I am willing to help you in any way I can, but you are responsible for arranging for your allowed accommodations, including appropriate time extensions.
- I will be generally available, by email only, during the hours you can take the exam, except for 8pm – 6am.
- You will be asked to sign your name below. When you do, I will take this to indicate that you abided by these rules. You must sign your name to get a non-zero grade on the exam.

NAME________________________________

8 pts First-Order Circuits

The switch in the figure at the right has been in position 1 for a very long time. It is moved to position 2 at t = 0 seconds. The component values are:

$I_1 = 4$ mA
$I_2 = 6$ mA
$R_1 = 3$ kΩ
$R_2 = 6$ kΩ
$C = 0.2$ mF



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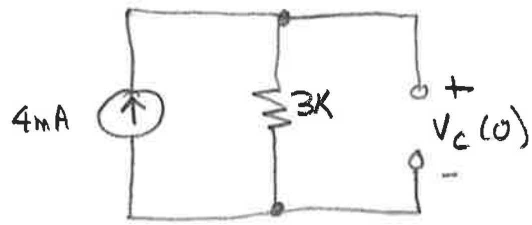
2 pts Find the initial capacitor voltage $V_C(0)$.

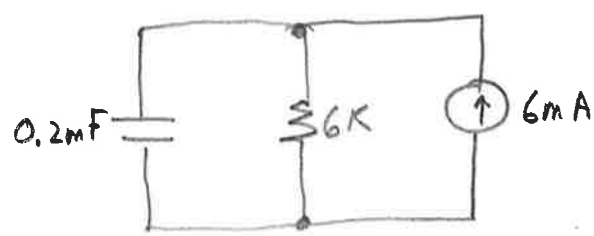
$V_c(0) = (4mA)(3K) = \boxed{12V}$



2 pts Find the time constant (τ) of this circuit for t > 0 seconds.

$\tau = RC = (0.2 \times 10^{-3})(6K)$

$= \boxed{1.2 \text{ seconds}}$



2 pts Find the voltage across the capacitor at time infinity, $V_C(\infty)$.

$V_c(\infty) = (6mA)(6K) = \boxed{36V}$

2 pts Find an expression for $V_C(t)$ for t > 0 seconds.

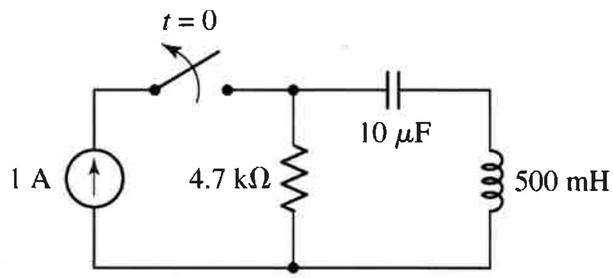
$V_c(t) = V_c(\infty) + [V_c(0) - V_c(\infty)]e^{-t/RC}$

$= 36 + [12 - 36]\, e^{-\frac{5}{6}t}$

$= \boxed{36 - 24e^{-\frac{t}{1.2}} \; V}$

10 pts Second-Order Circuits

The switch in the circuit at the right has been closed since Noah built the ark. It is opened at t = 0 seconds.



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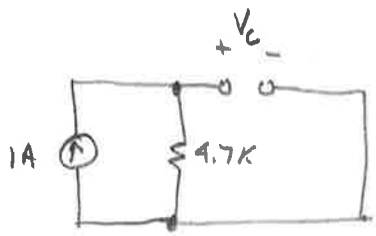
2 pt Find $V_C(0)$

$V_c(0) = (1)(4.7k)$

$= \boxed{4700V}$



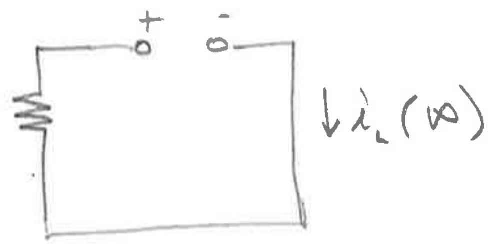
2 pt Find $I_L(0)$

$i_L(0) = \boxed{0A}$

1 pt Find $I_L(\infty)$

Because the capacitor is an open circuit

$i_L(\infty) = \boxed{0A}$



2 pts Find α and ω_0

Series RLC Circuit

$\alpha = \frac{R}{2L} = \boxed{4700 \text{ Rad/sec}}$

$\omega_0 = \frac{1}{\sqrt{LC}} = \boxed{447.2 \text{ Rad/sec}}$

1 pt Is this system overdamped, critically damped, or underdamped?

$\alpha > \omega_0$ so $\boxed{\text{over Damped}}$

2 pts Find s_1 and s_2 (the roots of the characteristic equation)

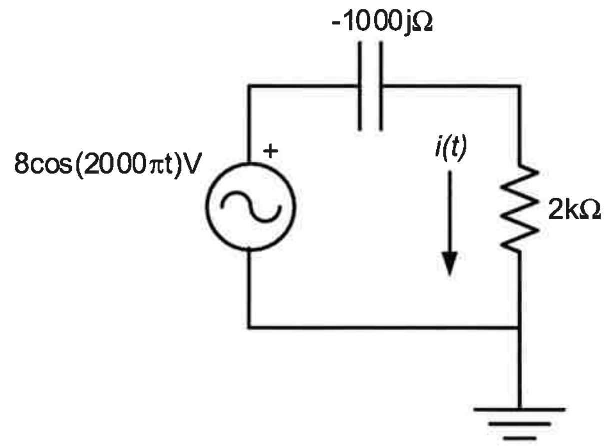
$s_{1,2} = -\alpha \pm \sqrt{\alpha^2 - \omega_0^2}$

$= -4700 \pm \sqrt{4700^2 - 447.2^2}$

$= -4700 \pm 4679$

$\boxed{s_{1,2} = -21.3 \text{ AND } -9379}$

8 pts Phasor Circuits
The following four problems are worth **one point each** and refer to the figure at the right. Circle the best answer.



The DC component of the voltage source is:
- a) 0 V
- b) 8 V
- c) 2000π V
- d) Cannot be determined
- e) None of the above

The frequency of the source in Hz is:
- a) 2000π
- b) 1000
- c) 8
- d) Impossible to tell
- e) None of the above

The value of capacitance is:
- a) 0.159 mF
- b) 0.159 F
- c) 0.159 μF
- d) Impossible to tell
- e) None of the above

The phase difference between the resistor voltage and current ($\theta_V - \theta_I$) is:
- a) 90°
- b) -90°
- c) 180°
- d) 0°
- e) None of the above

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4 pts Calculate the voltage across the capacitor and express your answer in ***polar, rectangular, and sinusoidal*** forms.

using Voltage divider,

$$V_c = \frac{V_s Z_{cap}}{Z_{cap} + R} = \frac{8\angle 0 \, (-1000j)}{-1000j + 2000}$$

$$V_c = 3.578 \angle -63.43^\circ \text{ V}$$
$$= 1.60 - 3.20j \text{ V}$$
$$= 3.578 \cos(2000\pi t - 63.43^\circ) \text{ V}$$

4

pts **Phasor Circuits**

Find the value of ω such that $v_a(t)$ and $i_s(t)$ are in-phase.

Component values are:

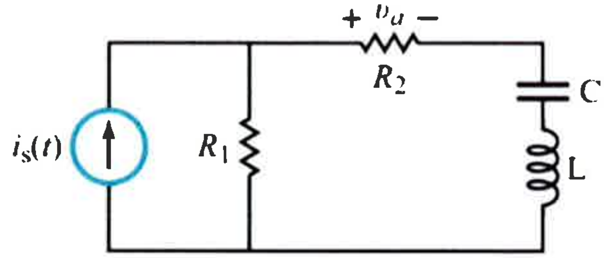
$R_1 = 5\Omega$

$R_2 = 3\Omega$

$L = 35$ mH

$C = 7$ mF

$i_s(t) = 10\cos(100t)$ mA



the Quick:

in order for i_s and v_a to be in phase (say 0°), then the phase of the Capacitor has to cancel the phase of the inductor, or $\frac{1}{j\omega C} = j\omega L$

Solving, $\omega = \frac{1}{\sqrt{LC}} = $ **63.89 Rad/sec**

the long way:

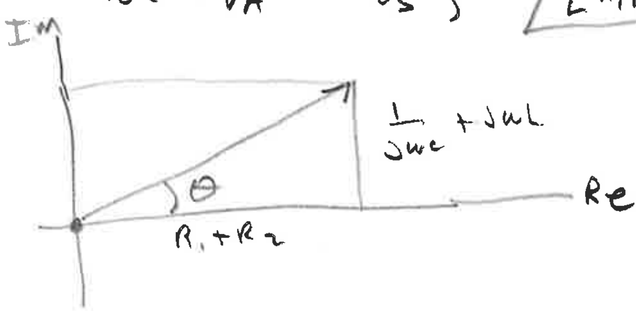
$$v_a = i_{r_2} R_2 = \frac{i_s (R_1)}{R_1 + R_2 + Z_{cap} + Z_{IND}}$$ (using current divider)

$$\left[R_1 + R_2 + Z_{cap} + Z_{IND}\right] v_a = R_1 i_s$$

or

$$\left[R_1 + R_2 + \frac{1}{j\omega C} + j\omega L\right] V_a \angle\theta_{va} = R_1 i_s \angle\theta_{is}$$

for $\theta_{VA} = \theta_{is}$, $\angle\left[R_1 + R_2 + \frac{1}{j\omega C} + j\omega L\right] = 0$



For that ∠ to be 0°,

$$\frac{1}{j\omega C} = -j\omega L$$

OR

$$\omega = \frac{1}{\sqrt{LC}} = $$ **63.89 Rad/sec**