ECE 209 — Exam # 3

Estimated time for completion: <1.25 hour
26 November 2019

Rules of the Exam

Rule 1: The examination begins at 9:30am on Tuesday, 26 November 2019, and ends at 10:45pm on Tuesday, 26 November 2019.

Rule 2: There are three problems plus one extra credit problem.

Rule 3: The exam is closed book and closed notes. You may use an 8.5" x 11" sheet of paper with notes, a ruler, and a calculator.

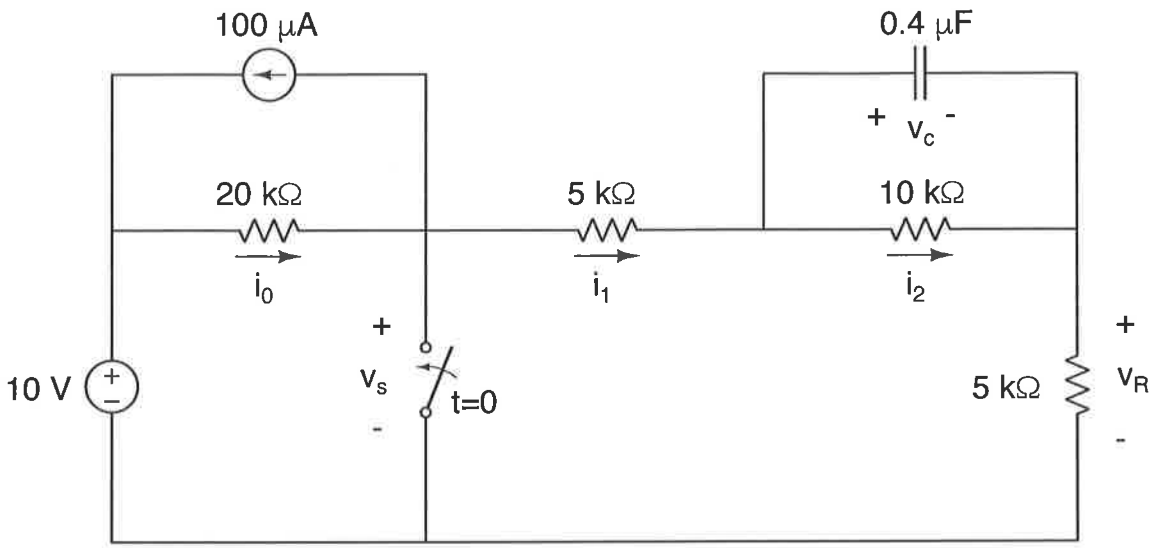
Rule 4: Do not leave the room until you have completed the exam.

Rule 5: To receive full credit for an answer include the units along with the numerical answer.

Rule 6: Show all work - answers without supporting work will not receive credit.

Answer Key
Name

Problem 1 (30 points). In the circuit below, the switch has been open for a very long time, and closes at $t = 0$.



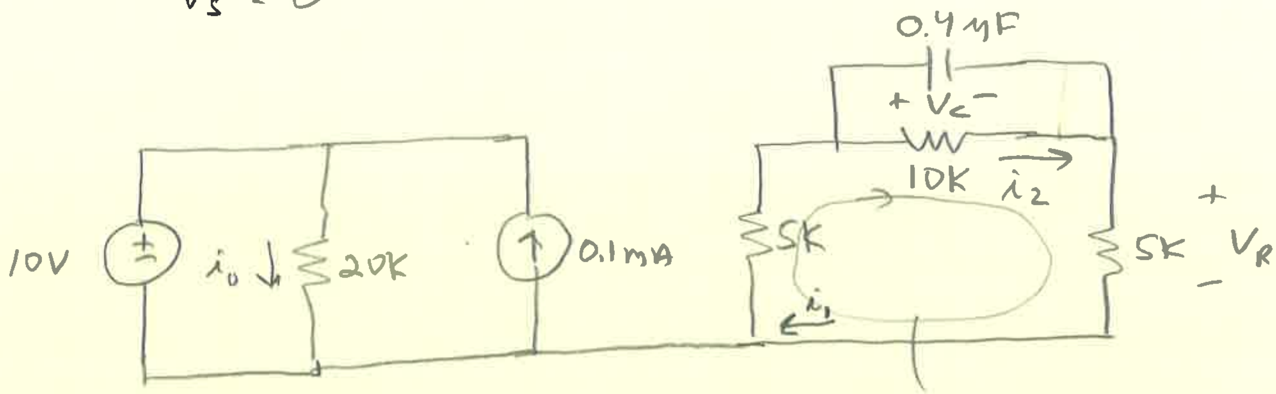
Complete the table below:

	t = 0⁻	t = 0⁺	t = ∞
i_0	0.3 mA	0.5 mA	0.5 mA
i_1	0.2 mA	-0.2 mA	0 V
i_2	0.2 mA	0.2 mA	0 V
v_s	4 V	0 V	0 V
v_c	2 V →	2 V	0 V
v_R	1 V	-1 V	0 V

What is the time constant of the circuit for $t > 0$? 2 ms

For $t \geq 0^+$

$V_s = 0$



@ $t=0^+$: KVL: $10K \cdot i_2 + 10K \cdot i_1 = 0$

$\therefore\ i_1(0^+) = -i_2(0^+)$

$V_c(0^+) = V_c(0^-) = 2V$

$i_2(0^+) = V_c(0^+)/10K = 2mA$

$i_1(0^+) = -2mA$

$V_R(0^+) = -2mA \cdot 5K = -1V$

$i_0(0^+) = 10V/20K = .5\ mA$

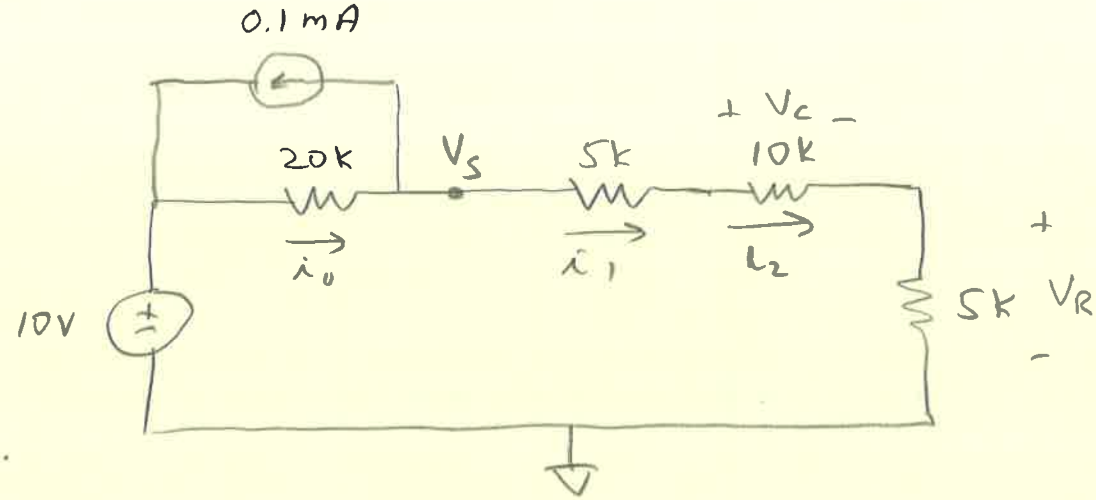
@ $t=\infty$ $\quad i_1 = i_2 = V_R = V_c = V_s = 0$

$i_0 = 10V/20K = 0.5\ mA$

$\tau = RC = [10K \| (5K+5K)] \cdot 0.4\mu$

$= 5K \cdot 0.4\mu = 2\times 10^{-3} = 2ms$

For $t \le 0^-$



KCL @ V_s : $\frac{V_s - 10}{20K} + 0.1m + \frac{V_s}{20K} = 0$

$V_s = 4\,V$

$i_0 = \frac{10 - V_s}{20K} = \frac{10-4}{20k} = \frac{6}{20K} = 0.3\,mA$

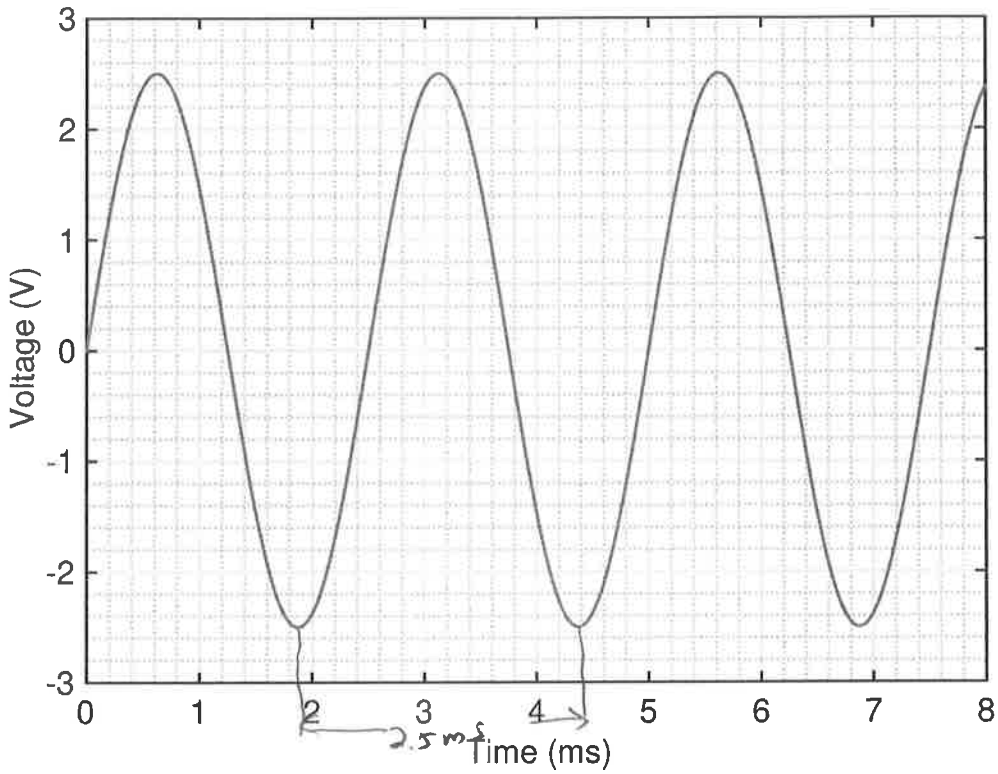
$i_1 = i_2 = \frac{V_s}{20K} = \frac{4}{20K} = 0.2\,mA$

$V_R = i_2 \times 5K = 1V$

$V_c = i_2 \times 10K = 2V$

Problem 2 (35 points). The voltage waveform shown below can be described by the equation:

$$V(t) = V_m \cos(\omega t + \phi)$$



T = 2.5 ms

f = 400 Hz

What is V_m? 2.5 V

What is ω? $800\pi = 2513.3$ rad/s

What is ϕ? -90° or $-\frac{\pi}{2}$ radians

What is the peak-to-peak voltage? 5 V

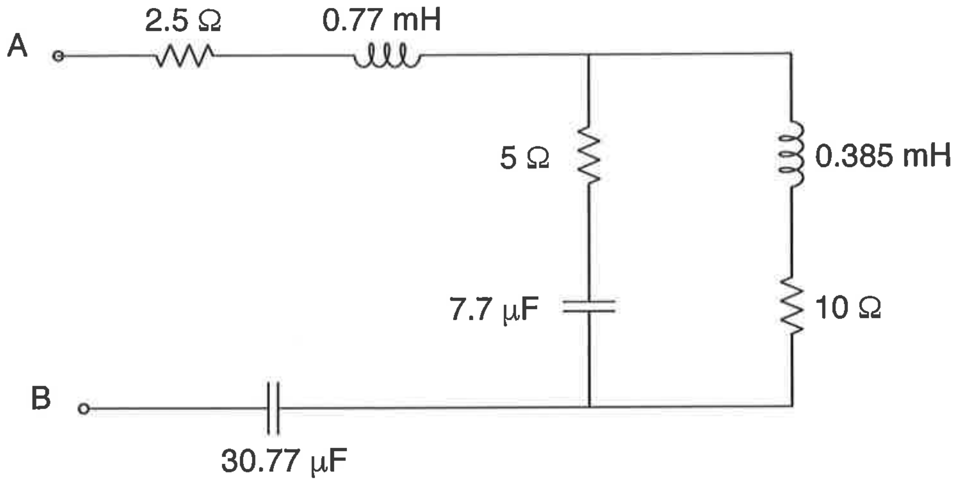
What is V_{RMS}? $\frac{2.5}{\sqrt{2}} = 1.77$ V

What is **V**, the Phasor representation of $v(t)$? $2.5\angle{-90^\circ}$

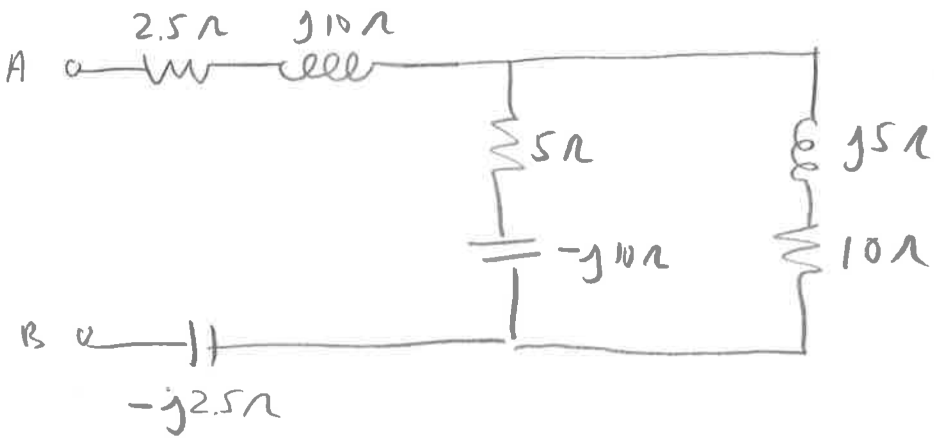
Problem 3 (35 points). Consider the circuit below operating at a frequency of 2,069 Hz.

$\omega = 2\pi f$

$= 13{,}000$ rad/s



Draw the frequency domain representation of this circuit.



$Z = 2.5 + j10 - j2.5 + \underbrace{(5 - j10) \| (10 + j5)}_{7.5 - j2.5}$

$= 10 + j5$

Calculate the equivalent impedance between terminals **A** and **B** $10+j5\ \Omega$

Calculate the equivalent admittance between terminals **A** and **B** $Y=\frac{1}{Z}=0.08-j0.04\ \Omega^{-1}$

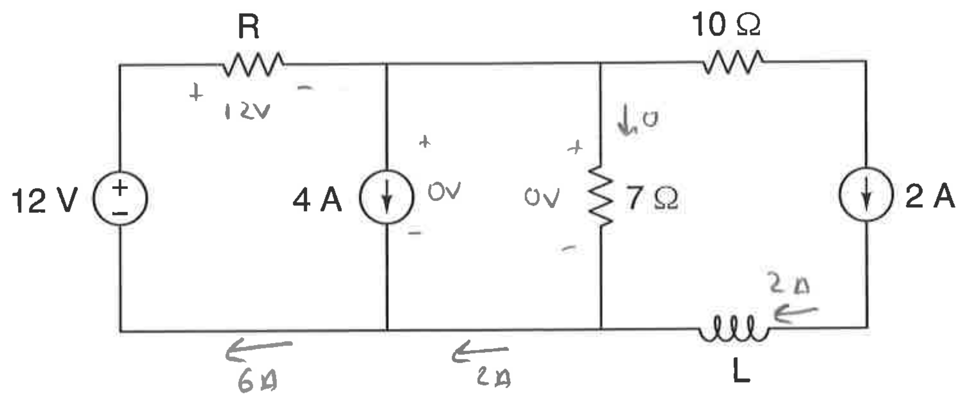
What is the equivalent resistance between terminals **A** and **B**? $10\ \Omega$

What is the equivalent reactance between terminals **A** and **B**? $5\ \Omega$

What is the equivalent conductance between terminals **A** and **B**? $0.08\ \Omega^{-1}$

What is the equivalent susceptance between terminals **A** and **B**? $-0.04\ \Omega^{-1}$

Bonus Problem (6 points). In the circuit below, the 4A source delivers no power and absorbs no power. There is 10 mJ of energy stored in the inductor. Determine the values of R and L.



R = 2Ω

L = 5mH

$$\text{Energy} = \frac{1}{2} L i^2$$

$$= \frac{1}{2} L 4 = 10^{-2}$$

$$L = 10^{-2}/2 = 5 \times 10^{-3}\ H$$

$$L = 5\ mH$$