Final Exam
C. DiMarzio, Northeastern University
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Student Name: _____

1 Short–Answer Questions

If two wires are made of the same material and have the same length, the thicker wire will have a higher resistance.

☐ True   ☐ False

Capacitances in parallel add; *e.g.* $C = C_1 + C_2$.

☐ True   ☐ False

The effect called "Jacob's Ladder" is the result of trying to make

☐ an instantaneous change in voltage on a capacitor.
☐ an instantaneous change in current through a capacitor.
☐ an instantaneous change in voltage on an inductor.
☐ an instantaneous change in current through an inductor.

In an ideal inductor, the average power is

☐ $\frac{V^2}{L}$ ☐ $\frac{V^2}{2L}$ ☐ Indeterminate   ☐ 0

To find the steady–state solution of a circuit,

☐ Short the capacitors and inductors
☐ Open the capacitors and short the inductors
☐ Short the voltage sources and open the current sources
☐ Open the voltage sources and shorrt the current sources

If you observed the following signal on an oscilloscope, which of the settings would you change?
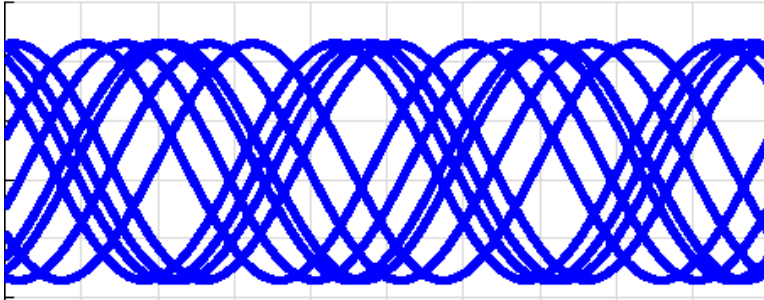
☐ Channel 1 Settings   ☐ Horizontal Sweep Speed
☐ Trigger Settings

On an oscilloscope, I see a sine wave with a voltage, V peak–to–peak. What voltage will I read on a multimeter?

☐ V ☐ $\frac{V}{2}$ ☐ $\frac{V}{\sqrt{2}}$ ☐ $\frac{V}{2\sqrt{2}}$

I have a signal in which I know the highest frequency is $1\,\mathrm{kHz}$. In order to obtain all the information in this signal I need to sample at

☐ $< 1\,\mathrm{Hz}$ ☐ $> 500\,\mathrm{Hz}$ ☐ $> 1\,\mathrm{kHz}$ ☐ $> 2\,\mathrm{kHz}$

A capacitor...

☐ has a positive reactance that increases in magnitude with increasing frequency.

☐ has a positive reactance that decreases in magnitude with increasing frequency.

☐ has a negative reactance that increases in magnitude with increasing frequency.

☐ has a negative reactance that decreases in magnitude with increasing frequency.

The largest voltage that can be output by an op–amp is limited by the power rails.

☐ True   ☐ False

If two signals are multiplied in the time domain, then in the frequency domain, they are...

☐ also multiplied.   ☐ convolved.   ☐ autocorrelated.   ☐ added.

A time domain signal is real valued. In the frequency domain, the voltage is $V(f)$ for positive frequencies. For negative frequencies... (Check All correct answers).

☐ $ReV(-f) = ReV(f)$ ☐ $ReV(-f) = -ReV(f)$
☐ $ImV(-f) = -ImV(f)$ ☐ $ImV(-f) = ImV(f)$

2   Current and Voltage
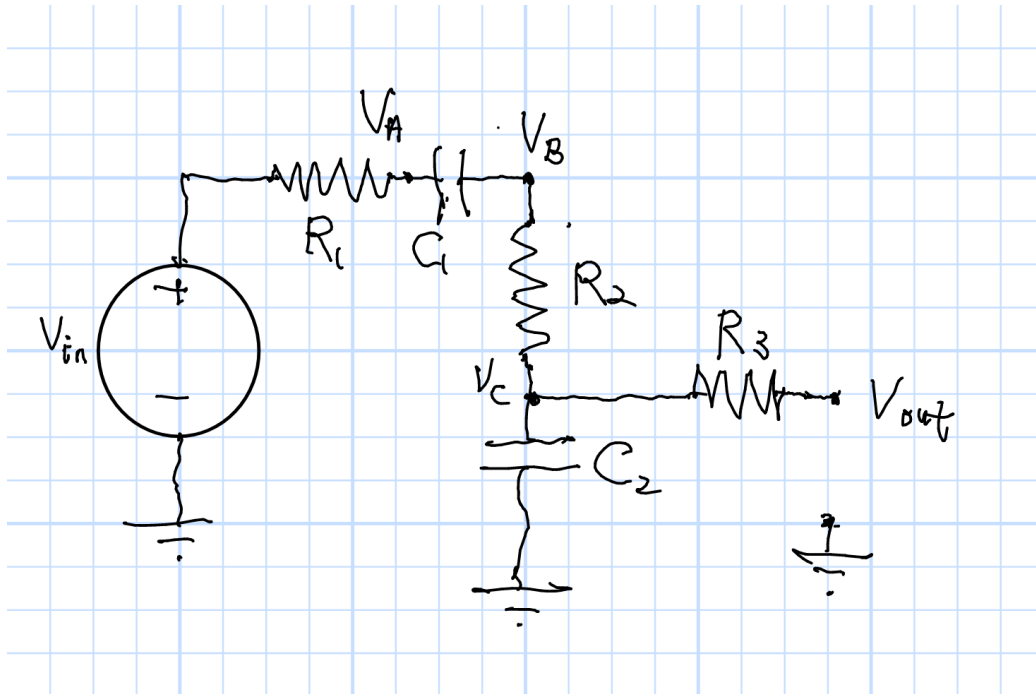
Consider the circuit in the figure. Here $V_{in} = 5$ at $f = 1\,\text{kHz}$, $R_1 = 4\,\text{K}\Omega$, $R_2 = 1\,\text{K}\Omega$, $R_3 = 1\,\text{K}\Omega$, $C_1 = 20\,\mu\text{F}$, and $C_2 = 1\,\mu\text{F}$.
For now the output is not connected to anything. Calculate the voltages and express in rectangular form;

$V_A = $ _____

$V_B = $ _____

$V_C = $ _____

Now, let's calculate the Thévenin equivalent circuit as seen at the output. First, what is the open–circuit voltage?
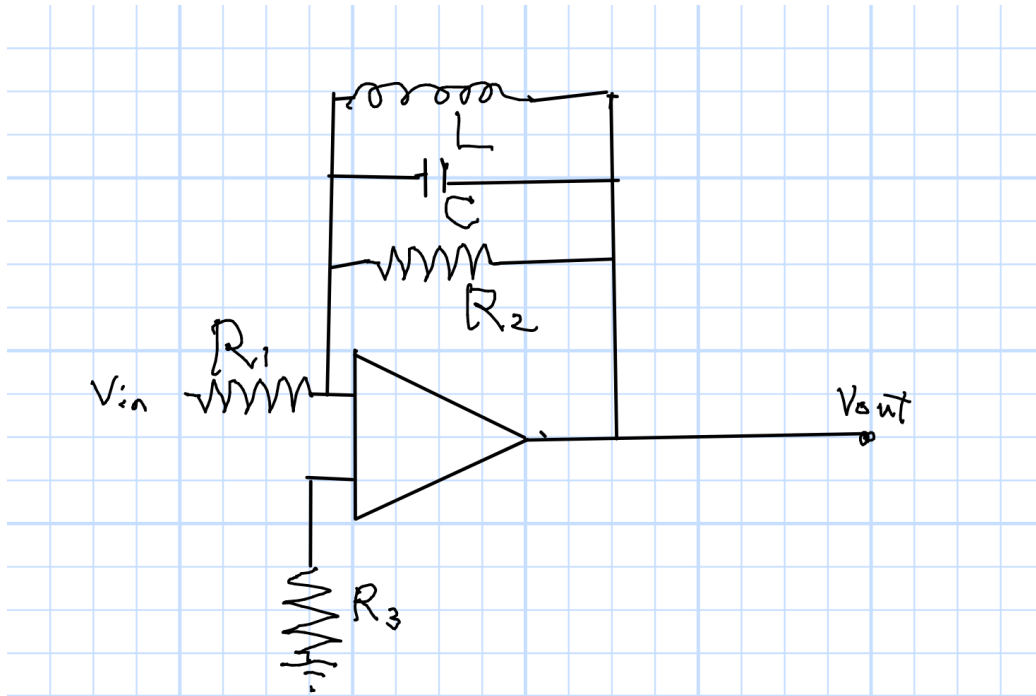
$V_{OC} = $ _____

What is the short–circuit current?

$I_{SC} = $ _____

What is the Thévenin Impedance?

$Z_T =$ _____

3 Filter

Consider the filter in the circuit. Here $R_1 = 940\,\Omega$, $R_2 = 4.7\,\mathrm{k}\Omega$, $R_3 = 4.7\,\mathrm{k}\Omega$, $L = 5\,\mathrm{mH}$, and $C = 225\,\mathrm{pF}$.

What type of filter is this?

☐ Low Pass   ☐ High Pass   ☐ Band Pass   ☐ Band Stop

At what frequency is the gain highest? Hint: The feedback impedance is highest when the reactance is zero.

$f_c = $ _____

What are the reactances of the capacitor and inductor at this frequency?

$X_C = $ _____

$X_L = $ _____

What is the gain in dB at this frequency?

Gain=_____ dB.

What is the phase of the gain in degrees at this frequency?

Phase=_____ Degrees.

What is the input impedance of this amplifier?

$Z_{in} = $_____

Now change the frequency to $250\,\text{kHz}$.
What are the reactances of the capacitor and inductor at this frequency?

$X_C = $_____

$X_L = $_____

What is the gain in dB at this frequency?

Gain=_____ dB.

What is the phase of the gain in degrees at this frequency?

Phase=_____ Degrees.

4   Fourier Transform

Consider two input signals, $5\,\text{Volts}\angle 0\,\text{deg}$ at $f_1 = 1\,\text{kHz}$ and $7\,\text{Volts}\angle 45\,\text{deg}$ at $f_1 = 2.5\,\text{kHz}$.

Draw the spectrum of the sum of these signals. Use frequency axes that cover an appropriate range of positive and negative frequencies. Plot the real part with the symbol "o" and the imaginary part with "x," and the absolute value with a "+". Label the axes and show numbers.

If I want to digitize this result, at what frequency must I sample?

$f_{sample} > $ _____

I have a device, called a mixer, that multiplies two signals. If I use these two signals as inputs, at what frequencies do I expect to see signals in the output?

_____

_____

If I want to digitize this result, at what frequency must I sample?

$f_{sample} >$ _____