Problem Set 05: Phasors & RCL Circuits

BME253L - Fall 2025

2025-10-06

Please complete the following problems and tasks, and upload your solutions to Gradescope, using the formatting guidelines below.

Time-Dependent Signal Sources
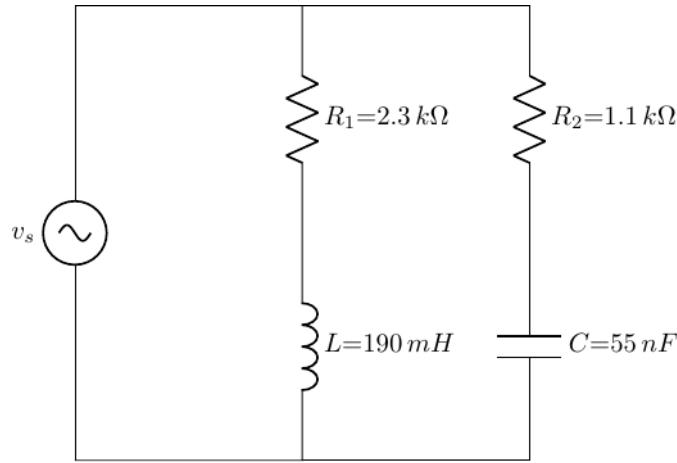
1. Find the average and RMS values of $x(t) = 2\cos(\omega t) + 2.5$.

Phasors and Complex Numbers
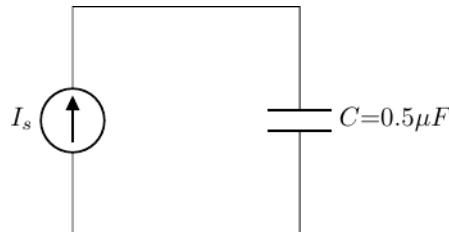
2. Find the phasor form of the following functions:

    a. $v(t) = 155\cos(377t - 25°)$ V

    b. $v(t) = 5\sin(1,000t - 40°)$ V

    c. $i(t) = 10\cos(10t + 630°) + 15\cos(10t - 420°)$ A

    d. $i(t) = 460\cos(500\pi t - 250°) - 220\sin(500\pi t + 15°)$ A

3. Convert the following complex numbers to polar form:

    a. $4 + j4$

    b. $-3 + j4$

    c. $j + 2 - j4 - 3$

4. Given $v_1(t) = 10\cos(\omega t + 30°)$ V and $v_2(t) = 20\cos(\omega t + 60°)$ V, find $v(t) = v_1(t) + v_2(t)$ using:

   a. Time-domain analysis / trigonometric identities

    b. Phasor-domain analysis

Phasor Circuit Analysis

5. If the current and voltage across a component are given by $i(t) = 17 \cos(\omega t - \pi/12)$ A and $v(t) = 3.5 \cos(\omega t + 1.309)$ V, where $\omega = 628.3$ rad/s, determine:

   a. Is the component a resistor, inductor, or capacitor?

   b. The value of the component in its appropriate units.

6. Determine the equivalent impedance of the circuit shown below, where $v_s(t) = 636(3,000t + \pi/12)$ V.
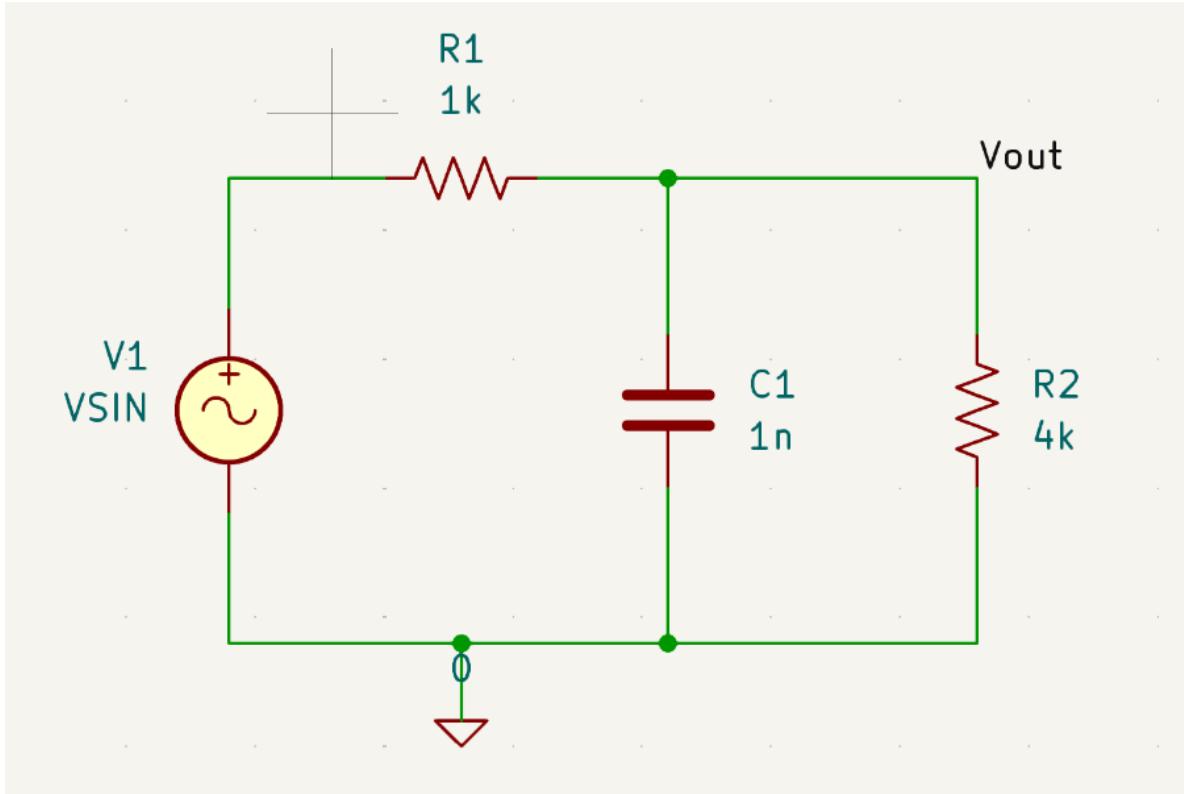
7. In the circuit below, $i_s(t) = I_o \cos(\omega t + \pi/6)$, where $\omega = 1,000$ rad/s and $I_o = 13$ mA.

   a. State, using phasor notation, the source current.

   b. Determine the impedance of the capacitor.

   c. Using only phasor notation, determine the voltage across the capacitor, including its polarity.

KiCad/SPICE

8. Simulate the circuit shown below.

a. AC Frequency Analysis

- Use `VSIN` for the voltage source.
- Be sure to define the SPICE-specific `0` ground (reference) node, and add the V_{out} net label.
- Set all of the component values as shown in the schematic.
- Run the `Simulator` to perform a `Small-signal Analysis (AC)` using the following parameters:
  - Points per decade: 100
  - Start frequency: 10 Hz

> **i** AC Frequency Analysis
>
> Plot the magnitude and phase of the output voltage V_{out}.

b. Transient Analysis

Use the `Transient Analysis` to show the sinusoidal waveforms of both voltage and current through time through the capacitor.

- Set the `VSIN` source to have an amplitude of 12 V and a frequency of 120 kHz.

- Run the `Simulator` to perform a `Transient Analysis` using the following parameters:

  - Time Step: 1 μs

  - Start Time: 0 s

  - Stop Time: 50 μs

> **i** Transient Analysis
>
> Plot the voltage across the capacitor V_{out} and the current through the capacitor I_{C_1}.

Problem Set Format Guidelines

Please follow these guidelines when completing your problem sets to insure accurate grading and to reduce time to troubleshoot problem solving.

- Each problem should be on dedicated pages that will be able to be uniquely selected on Gradescope to associate with specific questions (i.e., do not have multiple problems on the same page).

- For problems that involve circuit analysis, make sure that you clearly present an annotated circuit to show what variables correspond to what quantities in the analysis.

    - Label all circuit elements with symbols.

    - Solve problems symbolically before substituting in numerical values.

- Please write legibly and include all relevant steps in arriving at your solution.

- Please place a box around all final solutions.

> **❗ Important**
>
> All answers must have units!! No units = no credit!

- Attach any computer code (e.g., Python code) used to solve problems and generate plots.

    - This should be done with a Jupyter notebook.

    - Ideally your code should "self described" your thought process, but if unclear, add comments in the code where appropriate to indicate your thought process.

- All plots must be appropriately labeled with units.

- Problem sets must be scanned and converted to PDFs, uploaded to Gradescope, and have each problem associated with the specific question in Gradescope.

> **⚠ Warning**
>
> Failure to associated pages of your PDF with specific problems in Gradescope will result in loss of credit for that question.