1) You find yourself stuck in ECE111 lab at the end of the semester and, before leaving on winter break, you must build the circuit shown below.

\[
\begin{array}{c}
\text{250 } \Omega \\
\text{2 nF}
\end{array}
\]

Going through the component bins, you discover that the only resistors remaining are 100 $\Omega$ ($\pm 5\%$) and the only capacitors are 1 nF ($\pm 10\%$). (Note: 1 nF = $10^{-9}$ F)

(a) Design the simplest possible network that achieves the specified resistance and capacitance values using only the components available. Sketch your network.

(b) What are the $\pm$ uncertainties for the effective values of resistance (in $\Omega$) and capacitance (in nF), and for the time constant $\tau$ (in seconds)?

2) Use nodal analysis for the circuit below to find a set of two linear equations in the frequency domain for appropriately chosen unknown nodal voltage phasors. Write out but do not try to solve these equations.

\[v_1(t) = V_1 \cos(\omega t), \quad v_2(t) = V_2 \cos(\omega t - \pi/2), \quad \text{and} \quad v_3(t) = V_3 \cos(\omega t + \pi/2)\]
3) Using DC and phasor analysis along with and the superposition principle, solve the equation below for the steady-state voltage \( v(t) \), including the DC and AC components (but with no transients). Express your answer in the time domain.

\[
\frac{d^2v}{dt^2} + 2\frac{dv}{dt} + 3v = \cos(t) + 3
\]

4) A time-varying voltage \( v_s(t) \) is applied to the circuit shown below.

(a) Copy the table below into your exam booklet and then determine expressions for all voltages and currents in this table.

(b) What knowledge did you use about the transient behavior of R's, L's, and C's to fill in the table?

(c) Verify that your results satisfy KCL and KVL at \( t = 0^- \), \( 0^+ \), and \( \infty \).

<table>
<thead>
<tr>
<th></th>
<th>( t = 0^- )</th>
<th>( t = 0^+ )</th>
<th>( t \rightarrow \infty )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( v_1(t) )</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( v_2(t) )</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( v_3(t) )</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( i_{L_1}(t) )</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( i_C(t) )</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( i(t) )</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
5) Consider the RLC circuit below.
   (a) Find an expression for the complex impedance $Z(\omega)$.
   (b) What happens to $Z(\omega)$ at resonance? Why?

![RLC Circuit Diagram]

6) Find the Thevenin and Norton source equivalents for the AC circuit shown below.

![AC Circuit Diagram]

(HINT: Delay doing complex algebra till the end.)

7) At $t = 0$, a step voltage $V_o$ is applied to the RC circuit shown below.
   (a) What is the circuit time constant?
   (b) Find a time-dependent expression for the electric current $i(t)$.
   (c) Carefully sketch $i(t)$ versus time, indicating all critical values and times for the waveform.

![RC Circuit Diagram]
8) Consider the inverting amplifier circuit shown below.

Assuming the op-amp to be ideal, find the integro-differential equation that relates $v_{out}(t)$ to $v_{in}(t)$ in the time-domain.

(HINT: One way to do this problem is to use phasors.)