Note that impedance (our new complex number notation with resistance + ‘reactance’) is naturally expressed in rectangular form: \( Z = X + jX \). Voltage and current are naturally expressed as sinusoids with a magnitude and phase angle, readily written in polar notation. This leads to problems with mixed complex number notation and why you need to be able to manipulate these numbers in any form.

Note also that some problems are stated in the phasor domain and some in the time domain. For a problem given in the time domain, you must first transform all the circuit elements into the phasor domain. Then solve the problem, and transform it back to the time domain. **Report your final answer as a time domain cosine function, not as a phasor if the problem is given in the time domain. Always report your answer in the form (domain) that the problem is given.**

**Problem 1**
Express the following functions in cosine form, and write them as phasors, and plot them (roughly) in the complex plane. (Note that you **cannot** write them as phasors until they are expressed in cosine form.)

(a) \( 10 \sin (\omega t + 30^\circ) \)
(b) \(-9 \sin (8t)\)
(c) \(-20 \sin (\omega t + 45^\circ)\)

**Problem 2**
Evaluate this complex expression and report your answer in rectangular form, polar form, as a phasor, and plot the phasor (roughly) in the complex plane.
\[
\frac{60\angle45^\circ}{7.5 - j10 + j2}
\]

**Problem 3**
Evaluate this complex expression and report your answer in polar and rectangular form. Be sure to determine which quadrant is the correct quadrant for the angles you find using the tan\(^{-1}\) function on your calculator.
\[
\frac{(10\angle60^\circ)(35\angle-50^\circ)}{(2 + j6) - (5 + j)}
\]
**Problem 4**
Use phasors (i.e., phasor notation) to find:

\[ 20 \sin(400t) + 10 \cos(400t + 60^\circ) - 5 \sin(400t - 20^\circ) \]

*Note:* You can only use phasor notation if the frequency (\( \omega \)) is the same for every sinusoid in a circuit, and in an expression. Be sure you are comfortable with why this is true.

**Problem 5**
Find the equivalent impedance, \( Z_{eq} \), as seen by the source, for the circuit below. Assume \( i_s(t) = I_s \cos(200t) \).

Express the answer in rectangular coordinates and plot \( Z_{eq} \) in the complex plane.

![Circuit Diagram](image1)

**Problem 6**
Use nodal analysis to find \( V \) in the circuit below.

![Circuit Diagram](image2)
**Problem 7**
Use mesh analysis to find $v_o(t)$ in the circuit below. Let $v_{s1}(t) = 240 \cos(100t + 90^\circ)$ and $v_{s2}(t) = 160 \cos(100t)$. Note that with three loops, you will have three equations – this can be readily solved using Mathematica, Matlab or other computer tool.

![Circuit Diagram for Problem 7](image1.png)

**Problem 8**
Use superposition to find $i_x(t)$. Note that the equivalent impedance ‘seen’ by each source (connected across the terminals of the source) is different!

![Circuit Diagram for Problem 8](image2.png)

**Problem 9**
Find the Thevenin equivalent circuit of the circuit below. Draw your Thevenin equivalent circuit and label the Thevenin voltage and impedance.

![Circuit Diagram for Problem 9](image3.png)
Problem 10
Find the equivalent impedance as seen by the source for the circuit below (the circuit use in lab 6). Plot and label the three $Z_{eq}$ for parts (a), (b), and (c) on the same complex plane graph (rectangular coordinates make more intrinsic sense for $Z$ but you can use any form you like):

a) $Z_{eq}$ at a frequency significantly lower than the resonant frequency, $f_0$ (you can select the frequency you want to use. Be sure to express the frequency in radians, $\omega_0$, for the calculations, not in Hz)

b) $Z_{eq}$ at resonant frequency, $f_0$ (again in radians, $\omega_0$, for the calculations)

c) $Z_{eq}$ at a high frequency, significantly larger than $f_0$ (now, and always, in radians, $\omega_0$, for the calculations)

\[ R = 2k\Omega \]
\[ L = 47\text{mH} \]
\[ C = 100\text{pF} \]