Addition and Subtraction

- You can only add or subtract voltages with voltages, currents with currents, impedances with impedances, and admittances with admittances.
Addition with Rectangular Coordinates

- If \( Z = X + Y \) and \( X = a + jb \) and \( Y = c + jd \)
  - Add the real component of the rectangular coordinate \((a + c)\).
  - Add the imaginary component of the rectangular coordinate \((b + d)\).
  - Combine the results into rectangular coordinates.

\[
Z = (a + c) + j(b + d)
\]

- \( \text{Re} (Z) = (a + c) \) and \( \text{Im}(Z) = (b + d) \)
Subtraction with Rectangular Coordinates

- If \( Z = X - Y \) and \( X = a + jb \) and \( Y = c + jd \)
  - Subtract the real component of the rectangular coordinate \((a - c)\).
  - Subtract the imaginary component of the rectangular coordinate \((b - d)\).
  - Combine the results into rectangular coordinates.

\[ Z = (a - c) + j(b - d) \]

- \( \text{Re} \,(Z) = (a - c) \) and \( \text{Im}(Z) = (b - d) \)
Multiplication with Rectangular Coordinates

- If \( Z = XY \) and \( X = a + jb \) and \( Y = c + jd \)
  - Multiply the coefficients of the real components of the two numbers together \((a \cdot c)\).
  - Multiply the coefficients of the imaginary components of the two numbers together \((b \cdot d)\).
  - Multiply the coefficient of the real component of \( X \) with the imaginary component of the \( Y \) \((a \cdot d)\).
  - Multiply the coefficient of the real component of \( Y \) with the imaginary component of the \( X \) \((c \cdot b)\).

- The product \( Z = [(a \cdot c)-(b \cdot d)] + j[(a \cdot d)+(c \cdot b)] \)
  - \( \text{Re}(Z) = [(a \cdot c)-(b \cdot d)] \) and \( \text{Im}(Z) = [(a \cdot d)+(c \cdot b)] \)
Division with Rectangular Coordinates

- If $Z = X/Y$ and $X = a + jb$ and $Y = c + jd$
  - Square the real component of $Y$ ($c^2$).
  - Square the imaginary component of $Y$ ($d^2$).
  - Multiple the coefficient of the real component of $X$ with the real component of the $Y$ ($a\cdot c$).
  - Multiple the coefficient of the imaginary component of $X$ the imaginary component of the $Y$ ($b\cdot d$).
  - Multiple the coefficient of the real component of $X$ with the imaginary component of the $Y$ ($a\cdot d$).
  - Multiple the coefficient of the real component of $Y$ with the imaginary component of the $X$ ($c\cdot b$).

- The quotient $Z =$ \[
\frac{[(a\cdot c)-(b\cdot d)]}{[a^2+c^2]} + j\frac{[(c\cdot b)-(a\cdot d)]}{[a^2+c^2]}\]
  - $\text{Re}(Z) = \frac{[(a\cdot c)-(b\cdot d)]}{[a^2+c^2]}$ and $\text{Im}(Z) = \frac{[(c\cdot b)-(a\cdot d)]}{[a^2+c^2]}$
Addition and Subtraction with Phasors

- To add or subtract voltages, currents, impedances, or admittances that are expressed in phasor notation, you must convert the phasor into rectangular coordinates.
  - Add or subtract the real component of the rectangular coordinate.
  - Add or subtract the imaginary component of the rectangular coordinate.
  - Combine the results into rectangular coordinates.
  - Convert rectangular coordinates to phasor notation.
Multiplication and Division with Phasors

- If $V = v \angle \phi$ and $I = i \angle \theta$
  - To multiple or divide voltages, currents, impedances, or admittances that are expressed in phasor notation,
  - Multiply or divide the magnitudes of the phasors.
  - The resulting phase angle is obtained by:
    - Add the phase angles together if the mathematical function is multiplication
    - Subtract the phase angle associated with the divisor (denominator) from the phase angle associated with the dividend (numerator) if the mathematical function is division.

- $P = VI = vi \angle (\phi + \theta)$ and $Z = V/I = v/i \angle (\phi - \theta)$
Summary

- Addition and subtraction of numbers expressed in rectangular coordinates is straightforward.
- Multiplication and division of numbers expressed in rectangular coordinates is more complex.
  - Some students prefer to convert the number into phasor notation, perform the multiplication or division, and then convert back to rectangular coordinates.
- Multiplication and division with phasors is straightforward.
- Addition and subtraction requires that the phasor be rewritten in rectangular coordinates.