AC Circuits (quoting from E. M. Purcell, Electricity and Magnetism, 2nd. Ed, Sect. 8.3)

1. An alternating current or voltage can be represented by a complex number.
2. Any one branch or element of the circuit can be characterized, at a given frequency, by the relation between the voltage and the current in that branch.

Adopt the following rule for the representation:
1. An alternating current $I_o \cos(\omega t + \phi)$ is to be represented by the complex number $I_o e^{i\phi}$, that is, the number whose real part is $I_o \cos \phi$ and whose imaginary part is $I_o \sin \phi$.
2. Going the other way, if the complex number $iy$ represents a current $I$, then the current as a function of time is given by the real part of the product $(x+iy)e^{\ii \omega t}$.

<table>
<thead>
<tr>
<th>Circuit Element</th>
<th>$I=VY$</th>
<th>$V=IZ$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resistors</td>
<td>$\frac{1}{R}$</td>
<td>$R$</td>
</tr>
<tr>
<td>Inductors</td>
<td>$\frac{1}{i\omega L} = -\ii \omega L$</td>
<td>$i\omega L$</td>
</tr>
<tr>
<td>Capacitors</td>
<td>$i\omega C$</td>
<td>$\frac{1}{i\omega C} = -\ii \omega C$</td>
</tr>
</tbody>
</table>

Note that impedances add for elements in series, since voltages add for elements in series.
Note that admittances add for elements in parallel, since currents add for elements in parallel.

**REVIEW OF COMPLEX NUMBERS**

$i = \sqrt{-1}$, $\frac{1}{i} = -i$, $e^{\ii \theta} = \cos \theta + i \sin \theta$

$z = x + iy$, $z^* = x - iy$, $|z| = \sqrt{zz^*} = \sqrt{x^2 + y^2}$

$z = |z|e^{\ii \theta}$, $\tan \theta = \frac{y}{x}$

$z = \frac{A + iB}{C + iD}$, $z^* = \frac{A - iB}{C - iD}$