The general form of Ohm's law is

$$V = Z \times I$$

where Z is called the complex impedance.

- The impedance of a resistor is R.

- The impedance of a capacitor is $\frac{1}{j\omega C}$.

- The impedance of an inductor is $j\omega L$.

The units of impedance are Ohms.

For a resistor the voltage and the current are in phase.
For a capacitor or for an inductor the current and voltage are out of phase by 90^o or $\frac{\pi}{2}$.

Representation by trigonometric functions is cumbersome
A more elegant approach is to use complex numbers
Use the relationship

$$e^{j\theta} = \cos\theta + j\sin\theta$$

where $j = \sqrt{-1}$.
Note that in electronics we use j rather than i to represent $\sqrt{-1}$ because of the possibility of confusion with i when it is used to represent a current.

A sinusoidally varying voltage can then be represented by the imaginary part of:–

$$\begin{aligned}
V &= V_o e^{j\omega t} \\
\text{and then} \quad \frac{dV}{dt} &= V_o j\omega e^{j\omega t} \\
&= j\omega V \\
\text{So for capacitors} \quad I &= C\frac{dV}{dt} \\
&= j\omega C V \\
\text{giving} \quad V &= \frac{1}{j\omega C} I \\
\text{For inductances} \quad L\frac{dI}{dt} &= V \\
\text{By integration} \quad LI &= \int V dt \\
&= \frac{1}{j\omega} V \\
\text{Giving} \quad V &= j\omega L I
\end{aligned}$$

Generalise Ohm's Law to get:—

$$
\begin{aligned}
V &= ZI \\
\text{where} \quad Z &= \text{Complex Impedance} \\
\text{and} \quad Z_R &= R \quad \text{for a resistance} \\
Z_C &= \frac{1}{j\omega C} \quad \text{for a capacitor} \\
\text{and} \quad Z_L &= j\omega L \quad \text{for an inductor}
\end{aligned}
$$

Calculate the impedance of a $0.1\mu F$ capacitor at a frequency of 19kHz.

The impedance of a capacitor is:—

$$
\begin{aligned}
Z_C &= \frac{1}{j\omega C} \\
&= \frac{1}{j2\pi f C} \\
&= \frac{-j}{2\pi f C} \\
&= \frac{-j}{2\pi 19 \times 10^3 \times 0.1 \times 10^{-6}} \\
&= \frac{-j}{0.01193} \\
&= -83.8j \text{ Ohms}
\end{aligned}
$$

In the equation

$$Z_C = -83.8j \text{ Ohms}$$

The 83.8 gives the numerical relationship between the magnitude or amplitude of the voltage and current waveforms.
The j indicates that the voltage and current sinusoidal waveforms are 90^o out of phase with each other
The $-$ sign indicates that the current waveform leads the voltage waveform.