

IS-10-Fun with Vectors

K6SQN

Understanding some aspects of electronics requires mathematics and especially some trigonometric functions. Not many of us like math. Fortunately there is an easy but less accurate substitute. Sort of like adding and subtracting using your fingers. We can solve simple AC circuits from power line to radio frequencies with this method. It's working with "vectors".

We'll start with the definitions:

Horizontal line is the "x" axis.

Vertical line is the "y" axis.

Positive values are above the "x" axis, negative are below.

We will only use "Quadrants" I and IV. Just "I" on this page.

The angle "Theta" indicates Phase or degrees.

The "x" axis can represent circuit R, E, I or P

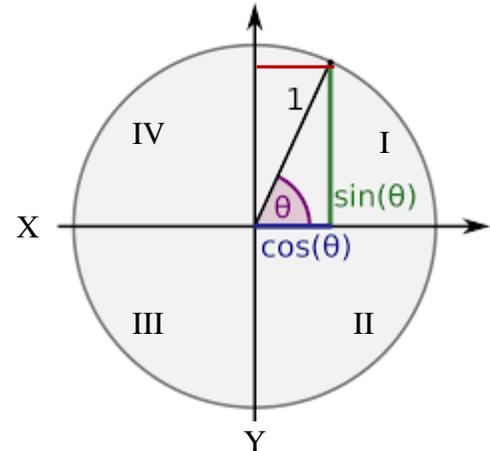
The "y" axis represents circuit X, E, I or P

The "1" line represents circuit Z, Et or Pt.

R = Resistance, X = Reactance, Z = Impedance P = Power

I = Current, E = Force in Volts, Θ = (Theta) = Phase angle

$Z = \sqrt{\text{axis X}^2 + \text{axis Y}^2}$. = Total opposition to current flow.



You can solve most problems with a pencil, a circle on a piece of paper, a ruler and a protractor.

Here is your handy dandy mechanical calculator:

Redraw the above circle image on a piece of paper omitting the sin, cos and "1" lines.

Make pencil marks equal distance between each on the right side of the "x" axis.

Cut a strip of paper the length of the x axis. Duplicate the x axis marks on to it.

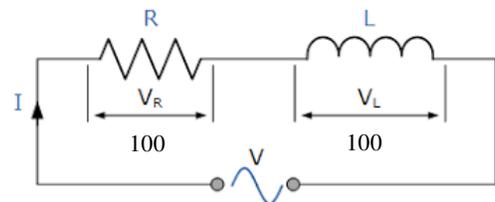
Place the strip on the upper Y axis and copy the marks on to it.

Assign a value to the marks to make a ruler, 1, 5, and 10, each, whatever.

Example: A series circuit has an inductor whose reactance is 100 Ohms and a resistance whose value is 100 Ohms.

What is the impedance and phase angle?

(Not the same angle as above, your lines will be equal)



Solution: Mark a point for 100 Ohms on the "x" axis.

Make a mark on the "y" axis that represents 100 ohms. Draw a vertical line upward from that point on the x axis like the green line above. Draw a horizontal line like the red line above from that point to the "y" axis. With the paper strip (your ruler) measure the distance from the center of the circle to the point where the "x" and "y" lines meet like the black line (1) above.

(1) Read that length on your ruler. You should read 141 Ohms. This is the impedance (Z) of the circuit.

(2) A circle consists of 360 degrees. This quarter circle (quadrant) consists of 90 degrees.

The "Z" line bisects this 90 degrees so the phase angle is $\frac{1}{2}$ of 90, or 45 degrees.

(3) If we apply 141 Volts to this 141 Ohm impedance, Ohms law says we'd have 1 Ampere of current.

(4) That 1 Ampere of current is flowing through both the resistor and the inductor in series.

(5) One Ampere flowing through the 100 Ohm resistor says it has 100 Volts (V_R) across it.

The same for the inductor (V_L). That totals 200 Volts but we only have a supply of 141 Volts.

How can that be? This bit of electronics magic will be revealed in future information sheets.