

# Sinusoidal waveforms

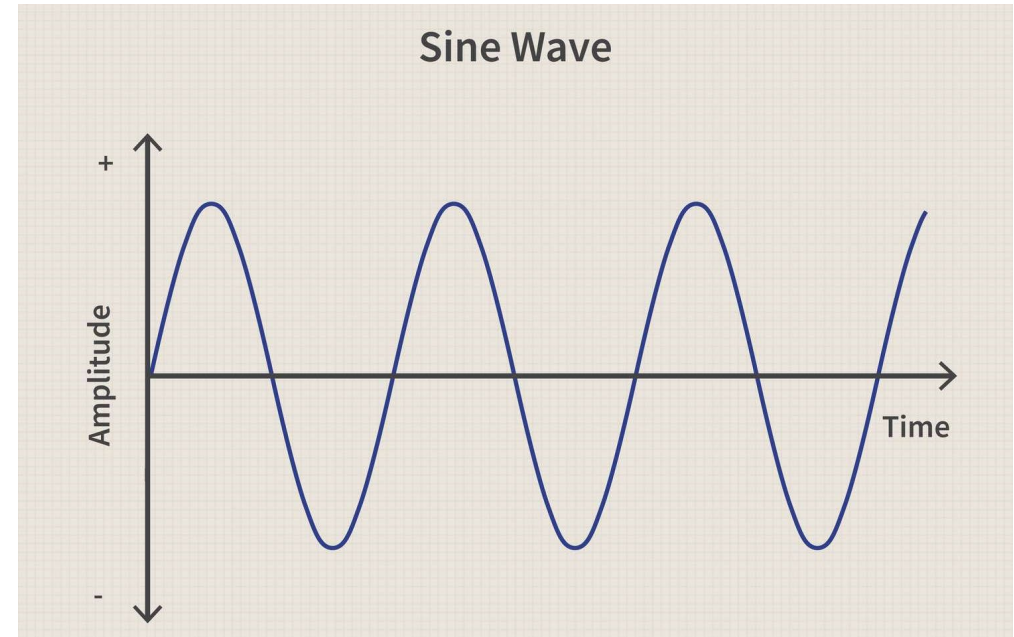
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# Sinusoidal Waveform

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- A sinusoidal waveform oscillates smoothly between positive and negative values
- These sinusoidal waves are most used to display both amplitude and voltage
- Understanding Sinusoidal waveforms is very important for understanding AC power



# Equation for a sinusoidal waveform

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- The equation for a sinusoidal is:
  - $y(t) = A\sin(\omega t + \Phi)$
  - $A$  = Amplitude of the wave
  - $\omega$  = Angular frequency, related to the wave's frequency/period
  - $t$  = Time
  - $\theta$  = Phase angle, which determines the wave's horizontal displacement.

# Converting between values

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- Period/Wavelength:

- We can convert between period and angular frequency using the equation:

$$\omega = \frac{2\pi}{T}$$

T = Period

$\omega$  = Angular Frequency

- Wave Speed:

- We can work out the speed of a wave using frequency and wavelength:

$$v = f\lambda$$

f = Frequency

$\lambda$  = Wavelength

- Frequency:

- We can work out frequency from angular frequency using

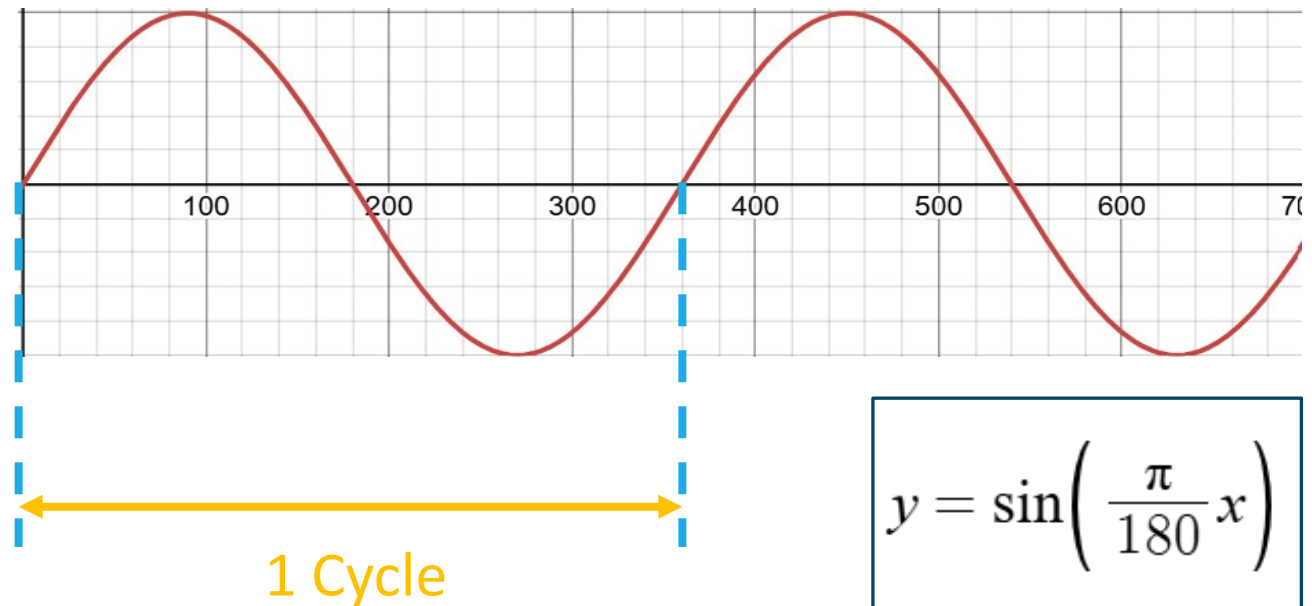
$$\omega = 2\pi f$$

f = Frequency

$\omega$  = Angular Frequency

# Understanding Sinusoidal waveforms

- A cycle is the section of the waveform from where the waveform starts to when it repeats itself
- The length of a cycle is affected by the **frequency** of the wave and thus affected by Angular frequency
- The length of a cycle will often be in radians rather than degrees, so you must convert it using  $\pi/180$
- 1 **Period/Wavelength** = the horizontal distance over which one complete cycle of the sine graph is completed

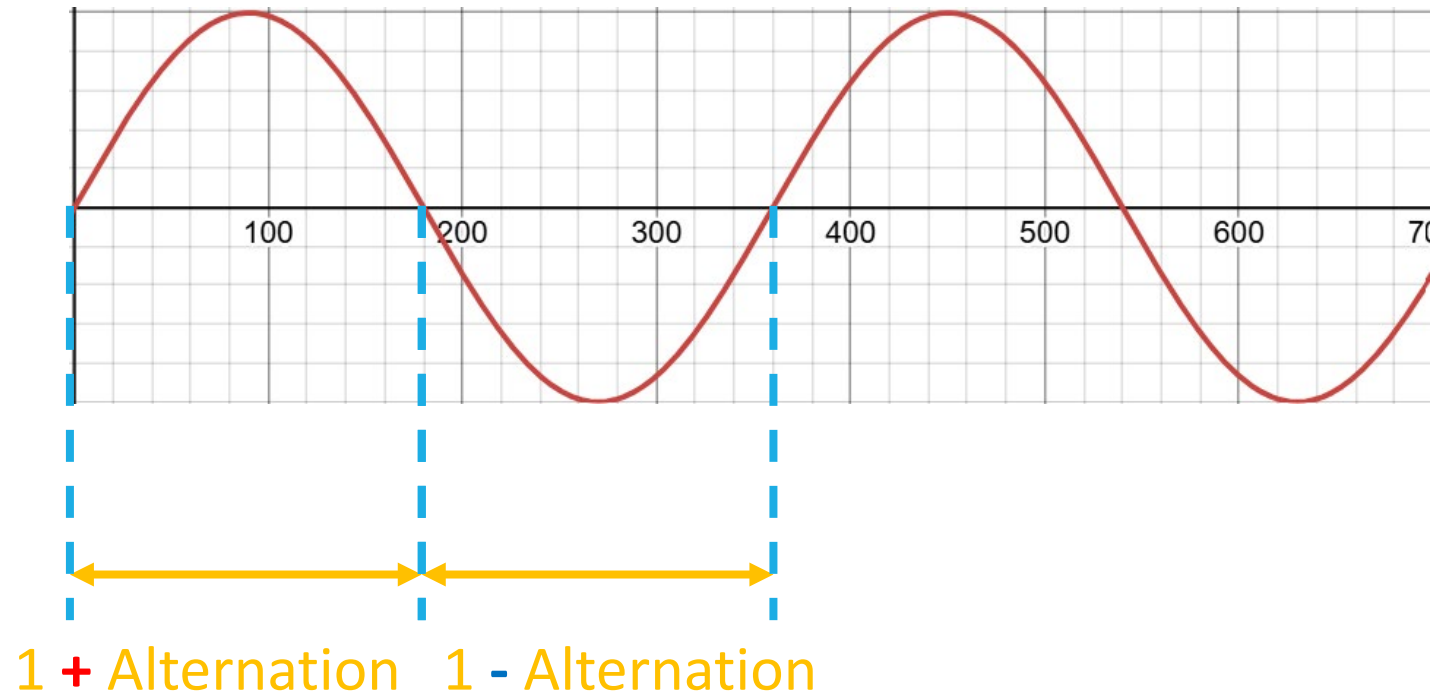


$$y = \sin\left(\frac{\pi}{180}x\right)$$

Equation to get this sine wave using degrees instead of radians

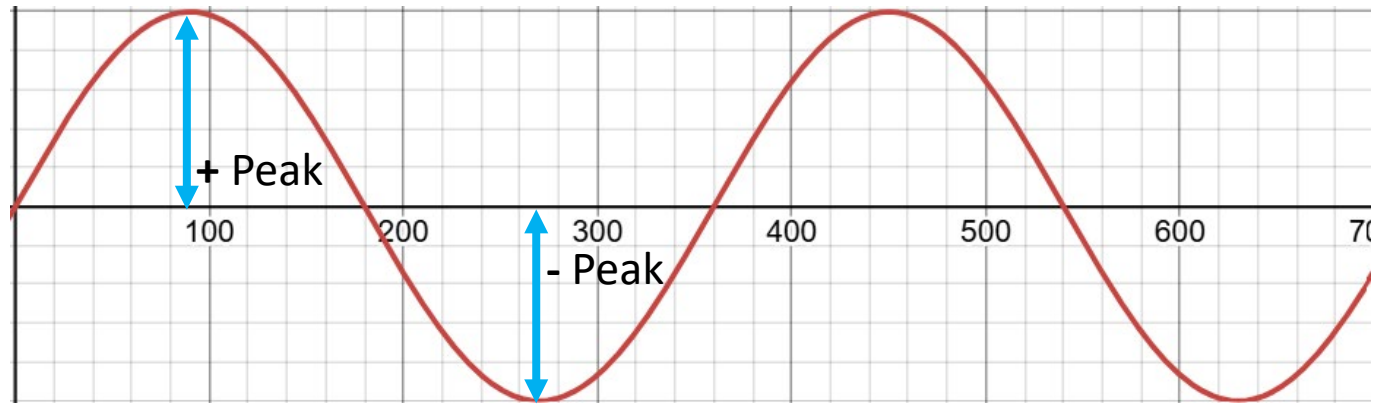
# Understanding Sinusoidal waveforms

- An alternation is half of the cycle
- Alternations can be either positive or negative
- Both the length and height of an alternation are equal to all the other alternations



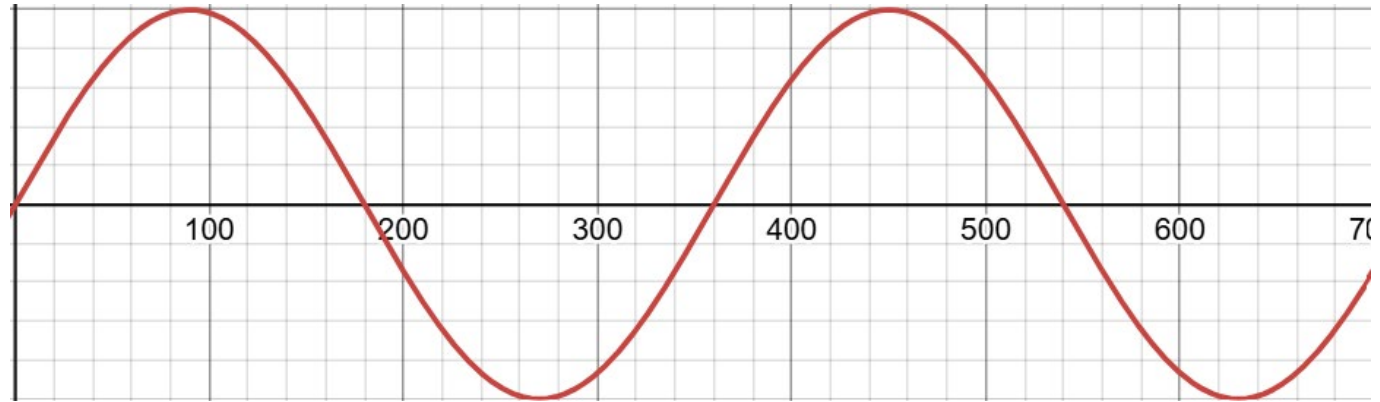
# Understanding Sinusoidal waveforms

- A peak value is the top of the waveform it is determined by the **amplitude**
- At a peak, the conductor is creating the **most amount of voltage** that the circuit is going to get
- A **peak to peak** is the distance between the two peaks **in either way** so it's either the horizontal distance or  $2 \times \text{Peak}$



# Understanding Sinusoidal waveforms

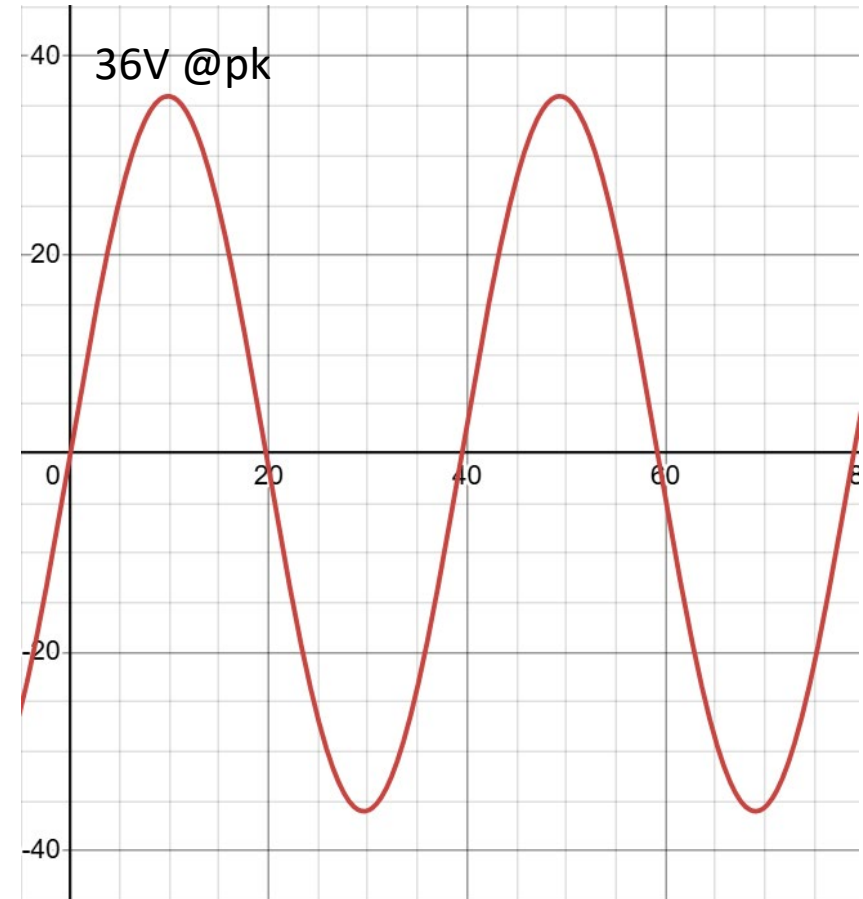
- An average is just the sum of all the values divided by the number of times you added them
- With a full Cycle the average will be 0 as both the positive and negative alternation cancel out
- To work out the average of 1 alternation we do  $0.637 \times \text{Peak}$





# Example of calculating the average

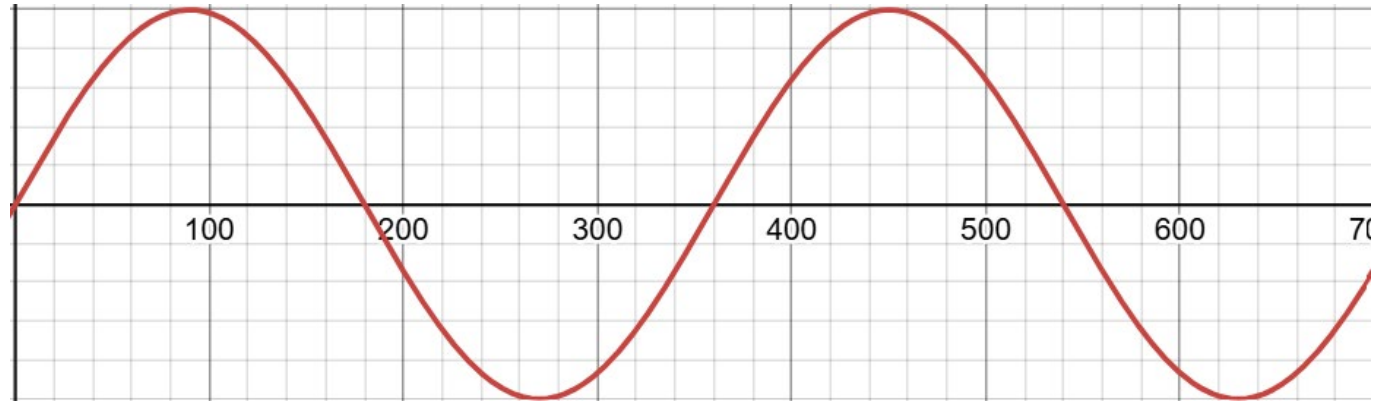
- For the whole cycle, the average is 0
- For the first alteration the average is
  - $0.637 * 36 = 22.932$



# Understanding Sinusoidal waveforms

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- An instantaneous is the value at a given point in the waveform
- To get the instantaneous we put the value of  $t$  into the equation
- $t$  is the angle along the x axis (the number)



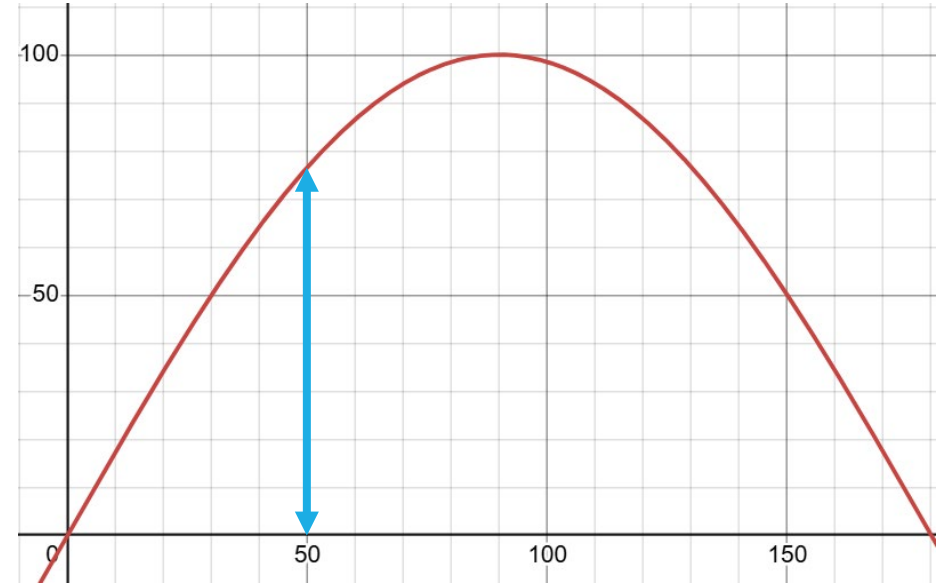
# Example of solving an instantaneous

- To solve an instantaneous, we just plug in our value of x or t into the equation.
- For example, this graph has the equation

$$y = 100 \sin\left(\frac{\pi}{180} t\right)$$

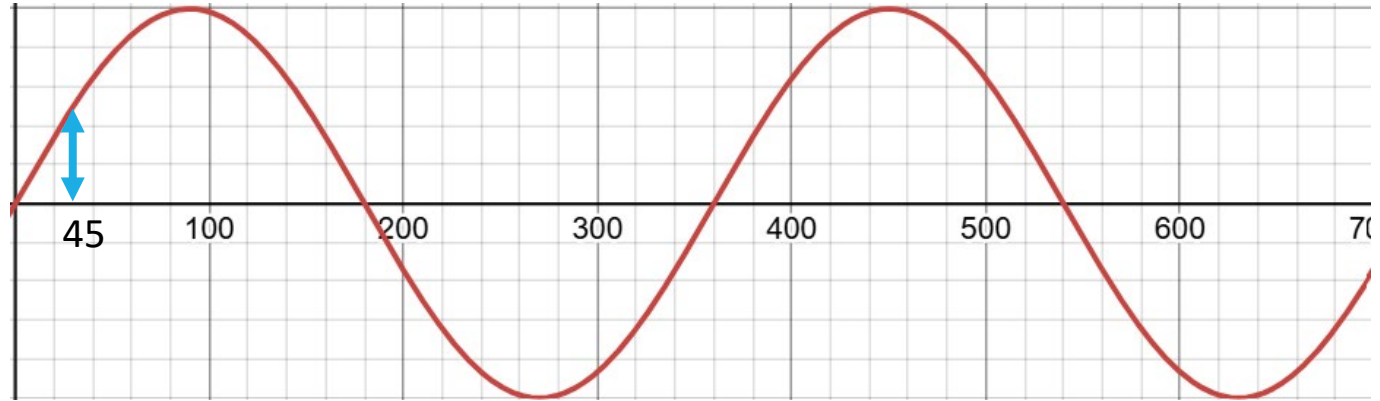
- If we put 50 in as t we get:

$$y = 100 \cdot \sin\left(\frac{\pi}{180} \cdot 50\right) = 76.60444431$$



# Understanding Sinusoidal waveforms

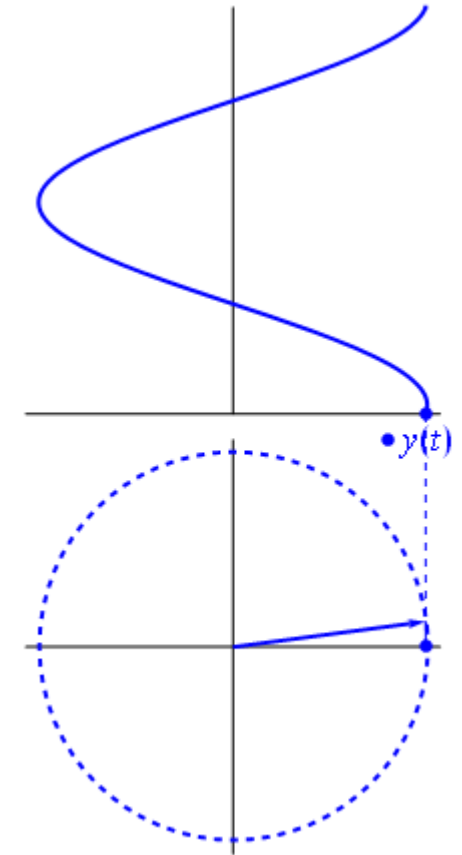
- An effective voltage is defined as the AC value that will give the same heating effect as an equivalent DC voltage
- An effective voltage is often referred to as the RMS or root means square
- To find the effective(RMS) value we can do  $0.707 \times \text{Peak}$



# What is a Phasor?

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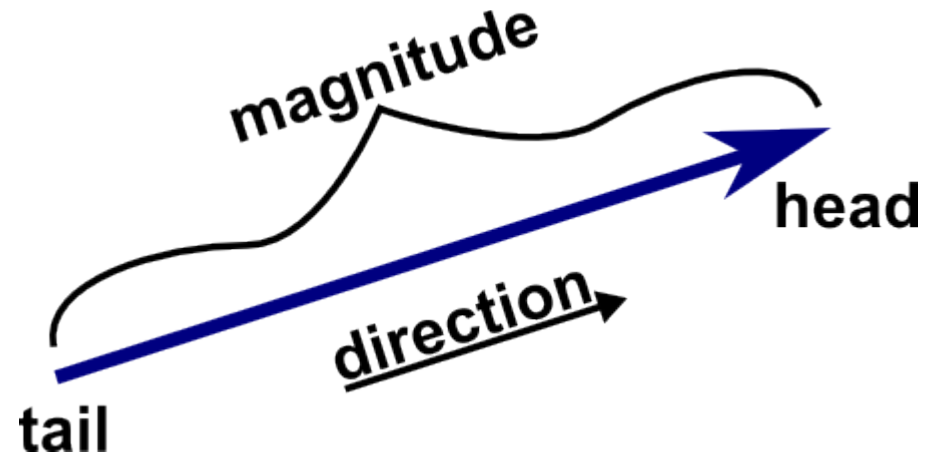
- A Phasor is a rotating vector which can be used to map a sine wave
- The vector rotates at a speed of radians per second
- It allows us to draw out multiple waves easily & use vector math to work out a resultant wave
- It means you can simplify waves certain points in a wave into a more easily to understand format



# Vectors

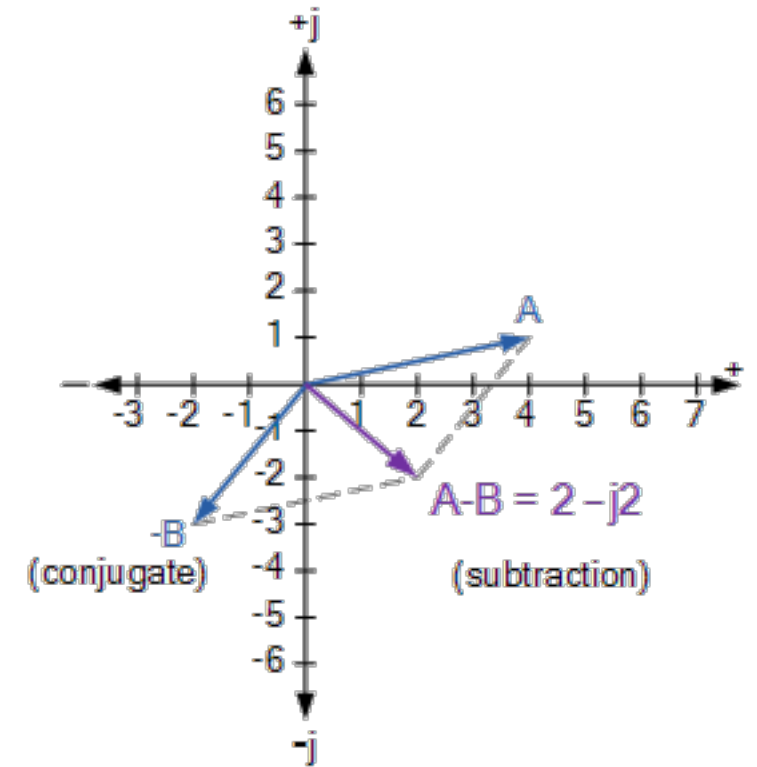
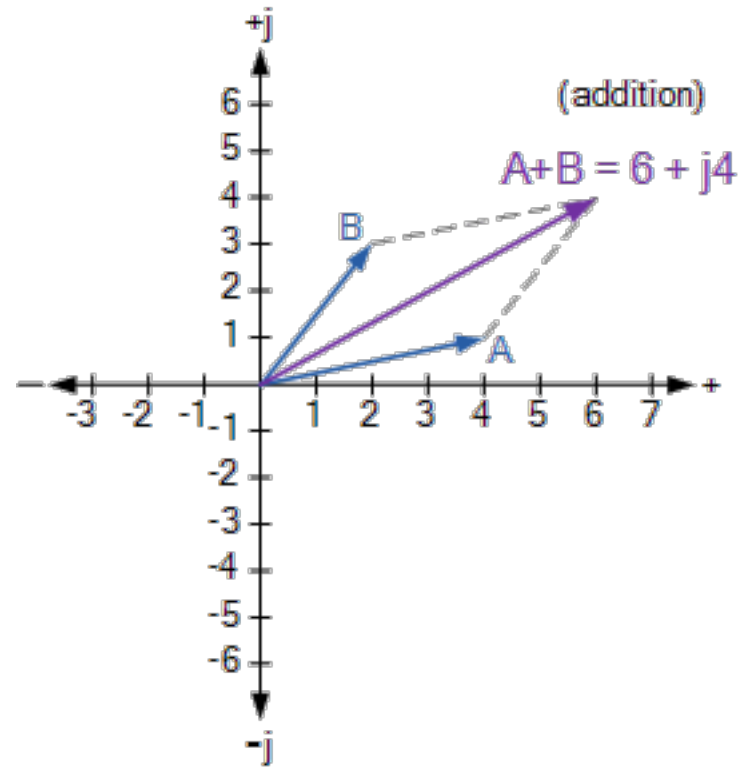
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- A vector is a quantity with both magnitude (size) and direction, commonly represented as an arrow
- In a coordinate system, it's expressed as an ordered list of numbers (e.g.,  $v=[x,y,z]$  in 3D).
- Used in physics, engineering, and computer graphics to represent forces, velocities, and spatial positions.



# Adding Phasors

- When adding or subtracting phasors we can draw them on the same graph
- We can use trigonometry to work out the value of the resultant



# Adding Phasors

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# HV Chart

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- HV charts are just meant to help understanding vector maths
- It allows you to easily split Horizontal and Vertical components of a vector to understand it and find a total resultant vector

	H (Cos)	V (Sin)
$V_1 = v @ \theta$	$= \cos(\theta) * v$	$= \sin(\theta) * v$
$V_2 = v @ \theta$	$= \cos(\theta) * v$	$= \sin(\theta) * v$
$V_T = v @ \theta$		

# Solving an example

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	H	V
$V_1 = 16_v @ 10^\circ$	$= \cos(10) * 16 = 15.76$	$= \sin(10) * 16 = 2.78$
$V_2 = 8_v @ 45^\circ$	$= \cos(45) * 8 = 5.66$	$= \sin(45) * 8 = 5.66$
$V_T =$	$= 15.76 + 5.66 = 21.42$	$= 2.78 + 5.66 = 8.44$

$$\tan(\theta) = \frac{opp}{adj} = \frac{8.44}{21.42} = 0.39 \quad \theta = \tan^{-1} 0.39 = 21.31^\circ$$

$$a^2 + b^2 = c^2 \quad 21.42^2 + 8.44^2 = c^2 \quad \sqrt{21.42^2 + 8.44^2} = c \quad 23.02_v = c$$

$$V_T = 23.02_v @ 21.31^\circ$$

# What is the complex plane

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- The complex plane is a 2D plane where each point represents a complex number, with the x-axis as the real part and the y-axis as the imaginary part.
- Any complex number  $z=a+bi$  is a point on the plane, where  $a$  is the real component and  $b$  is the imaginary component.
- Addition, subtraction, multiplication, and division of complex numbers can be visualised geometrically as translations, rotations, and scaling on the plane.

# Example of plotting on the complex plane

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- Take the complex number  $z=3+4i$ .
- On the complex plane:
  - Plot the real part (3) on the x-axis. Plot the imaginary part (4) on the y-axis.
- Mark the point (3,4) on the plane.
- This point represents the complex number  $z=3+4i$ , and the distance from the origin to this point is its **magnitude** (calculated as  $\sqrt{3^2 + 4^2} = 5$ ).