Want to Use I = V/□ for C!

Original world

$i_C = C \times dv_C/dt$

$v_C = A_V \cos(\omega t + \theta_V)$

$i_C = \omega C A_V \cos(\omega t + \theta_V + 90^o)$

Our world

$I_C = V_C/\square_C$

$V_C = A_V x^{\theta_V}$

$\square_C = 1/\omega C x^{90^o}$

V_C
← ×ω
← +90°
← ×C

Generally,

- Now we form a new system expresses V and I as:

Original world	**Our world**	
$v(t) = A_{\mathrm{V}} \cos(\omega t + \theta_{\mathrm{V}})$	$V = A_{\mathrm{V}} x^{\theta_V}$	$V = A_{\mathrm{v}} exp(j\theta_{\mathrm{V}})$
$i(t) = A_{\mathrm{I}} \cos(\omega t + \theta_{\mathrm{I}})$	$I = A_{\mathrm{I}} x^{\theta_I}$	$I = A_{\mathrm{I}} exp(j\theta_{\mathrm{I}})$
R	R	R
C	$1/\omega C x^{90^{\circ}}$	$1/j\omega C$
L	$\omega L x^{90^{\circ}}$	$j\omega L$

- We learned $x = e^{j\theta}$ is proper for
  1) +- merging for KVL / KCL
  2) Uniqueness

KVL or KCL?

- Summation is key for KVL and KCL!

$$A_1\cos(\omega t + \theta_1) + A_2\cos(\omega t + \theta_2) = A\cos(\omega t + \theta)$$

$$A_1 x^{\theta_1} + A_2 x^{\theta_2} = A x^{\theta}$$

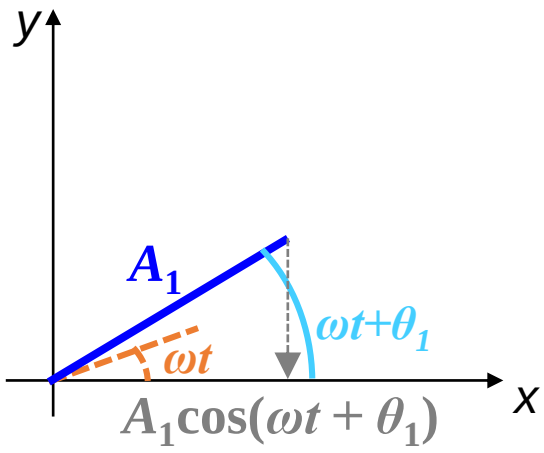
$$A_1 \cos\omega t \cos\theta_1 - A_1 \sin\omega t \sin\theta_1 + A_2 \cos\omega t \cos\theta_2 - A_2 \sin\omega t \sin\theta_2$$

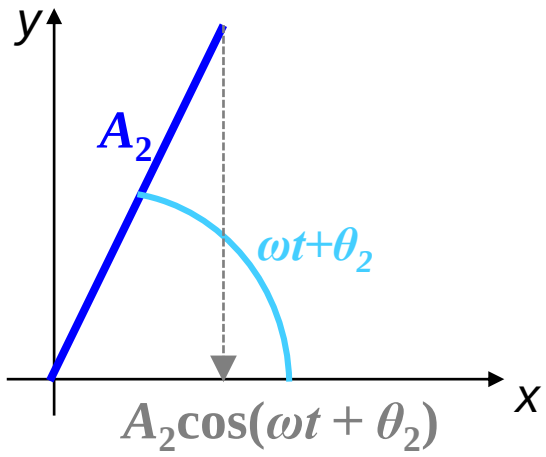
$$= \cos\omega t(A_1\cos\theta_1 + A_2\cos\theta_2) - \sin\omega t(A_1\sin\theta_1 + A_2\sin\theta_2)$$

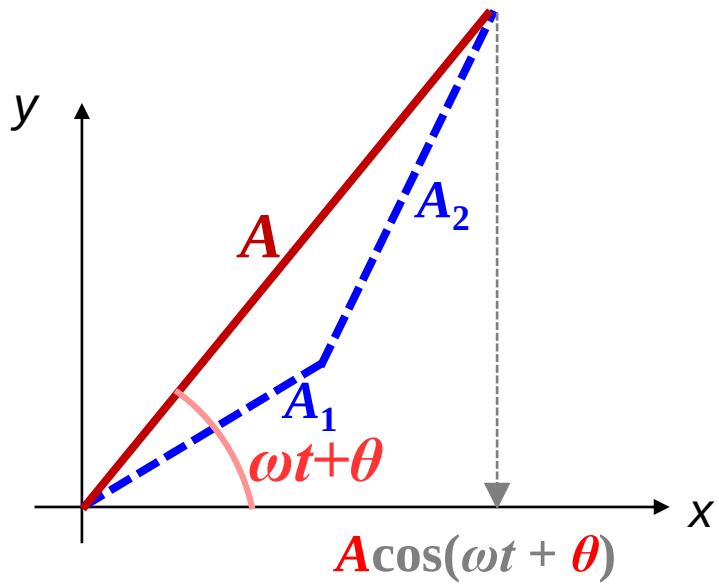
$$= A\cos\omega t(\omega t + \theta)$$

Can’t We Make it Easier?

$$A_1\cos(\omega t + \theta_1) + A_2\cos(\omega t + \theta_2) = A\cos(\omega t + \theta)$$



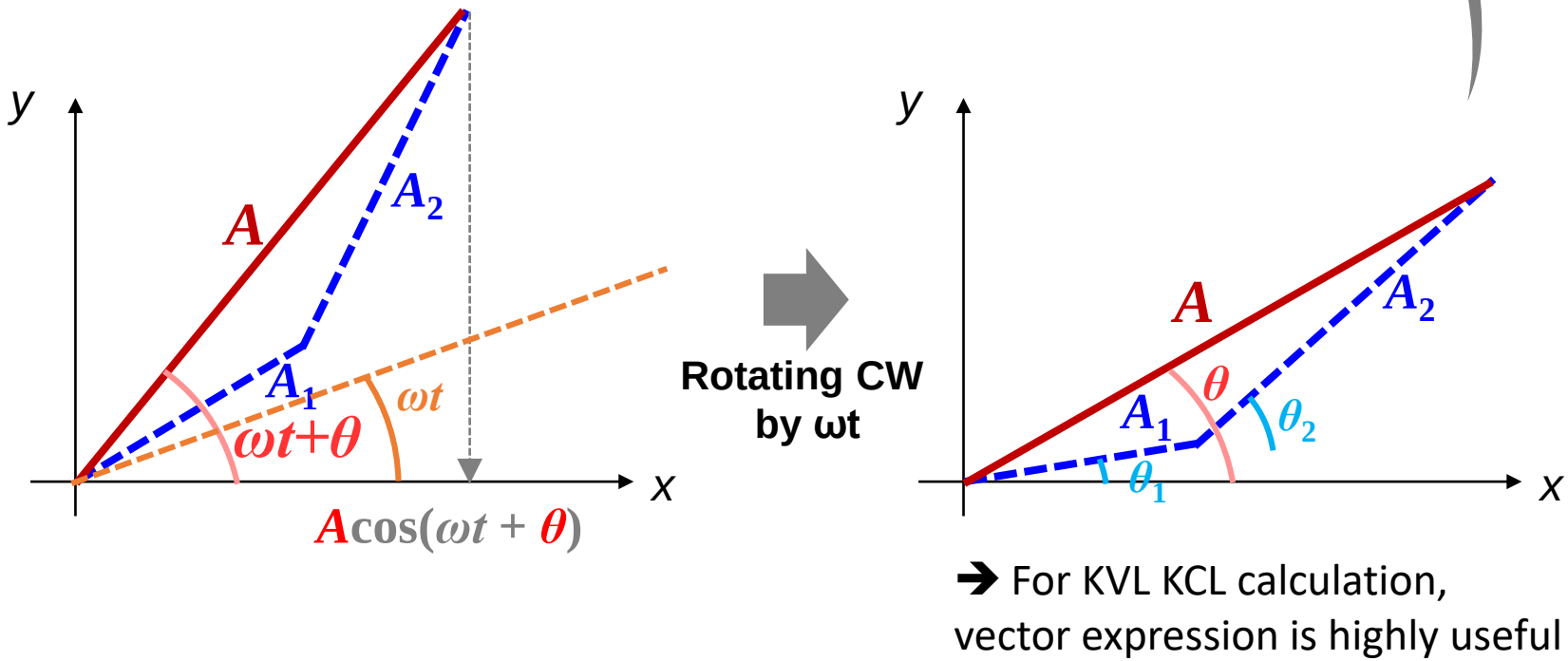




Summation of Sinusoidal Signals

$$A_1\cos(\omega t + \theta_1) + A_2\cos(\omega t + \theta_2) = A\cos(\omega t + \theta)$$

We can "extract" (A, θ) here



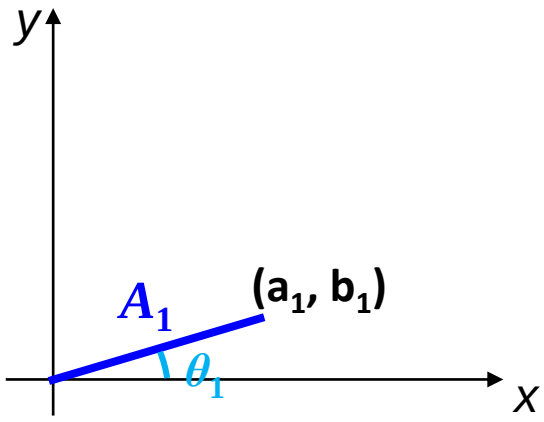
➔ For KVL KCL calculation, vector expression is highly useful

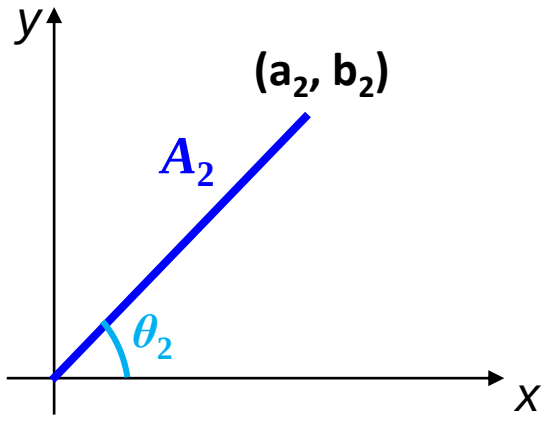
Power of Vector Calculation

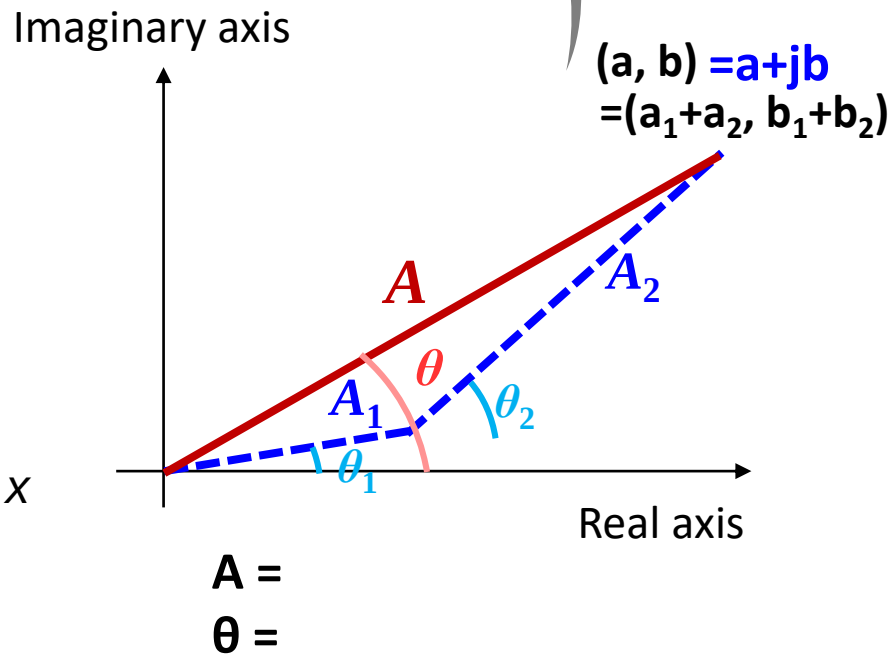
$$A_1\cos(\omega t + \theta_1) + A_2\cos(\omega t + \theta_2) = A\cos(\omega t + \theta)$$

- ✓ For KVL and KCL, (a, b) expression is useful
- ✓ We can guarantee simplicity and uniqueness simultaneously by expressing **a+jb**.

We can "extract" (*A*, θ) here







A =

θ =

Using Euler's Formula!

$A_1\cos(\omega t + \theta_1) + A_2\cos(\omega t + \theta_2) = A\cos(\omega t + \theta)$

$A_1 x^{\theta_1} + A_2 x^{\theta_2} = A x^{\theta}$ ← For Ohm's law

$a_1 + jb_1 + a_2 + jb_2 = a + jb$ ← For KVL and KCL

Is there any we can satisfy both?

That is,

$$A_1 x^{\theta_1} = a_1 + jb_1$$

?!

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

Conclusion

Original world

$v(t) = A_V \cos(\omega t + \theta_V)$

$i(t) = A_I \cos(\omega t + \theta_I)$

R

C

L

Global use of Ohm's law

$V = A_V x^{\theta_V}$

$I = A_I x^{\theta_I}$

R

$1/\omega C x^{90^o}$

$\omega L x^{90^o}$

KVL & KCL

Our world

$V = A_v \, exp(j\theta_V)$

$I = A_I exp(j\theta_I)$

R

$1/j\omega C$

$j\omega L$

We call this as "Phasor"