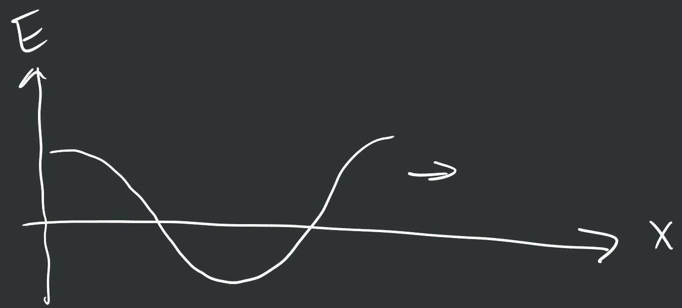
Chapter 7 - Superposition - when waves combine at the same place at the same, the displacements add together

$$\psi = \psi_1 + \psi_2$$



same frequency

$$E_1(x,t) = E_1 \cos(kx_1 - \omega t + \phi_1)$$

$$E_2(x,t) = E_2 \cos(k x_2 - \omega t + \phi_2)$$

different phase

$$\alpha_1 = kx_1 + \phi_1$$

$$\alpha_2 = kx_2 + \phi_2$$

phase difference $\rightarrow$ $\alpha_2 - \alpha_1 = k(x_2 - x_1) + (\phi_2 - \phi_1)$

What if : $\alpha_2 - \alpha_1 = 2\pi \cdot m$ } $\rightarrow$ even integer of π

$\uparrow$ any integer

$$E_R = E_1 + E_2 = E_1 \cos(\alpha_1 - \omega t) + E_2 \cos(\alpha_2 - \omega t)$$

$$= E_1 \cos(\alpha_1 - \omega t) + E_2 \cos(2\pi \cdot m + \alpha_1 - \omega t)$$

$$\cos(x) = \cos(x + 2\pi \cdot m)$$

$$= \underbrace{(E_1 + E_2)}_{\text{constructive interference}} \cos(\alpha_1 - \omega t)$$

<u>But</u>, <u>what if</u> $\alpha_2 - \alpha_1 = (2m-1)\pi \; \Big\} \rightarrow$ odd integers of π.

any integer

$$E_t = E_1 + E_2 = E_1 \cos(\alpha_1 - \omega t) + E_2 \cos(\alpha_2 - \omega t)$$

$$= E_1 \cos(\alpha_1 - \omega t) + E_2 \cos(\alpha_1 + (2m+1)\pi - \omega t)$$

$$-\cos x = \cos(x + (2m-1)\pi)$$

destructive interference $\rightarrow$

$$= (E_1 - E_2) \cos(\alpha_1 - \omega t)$$

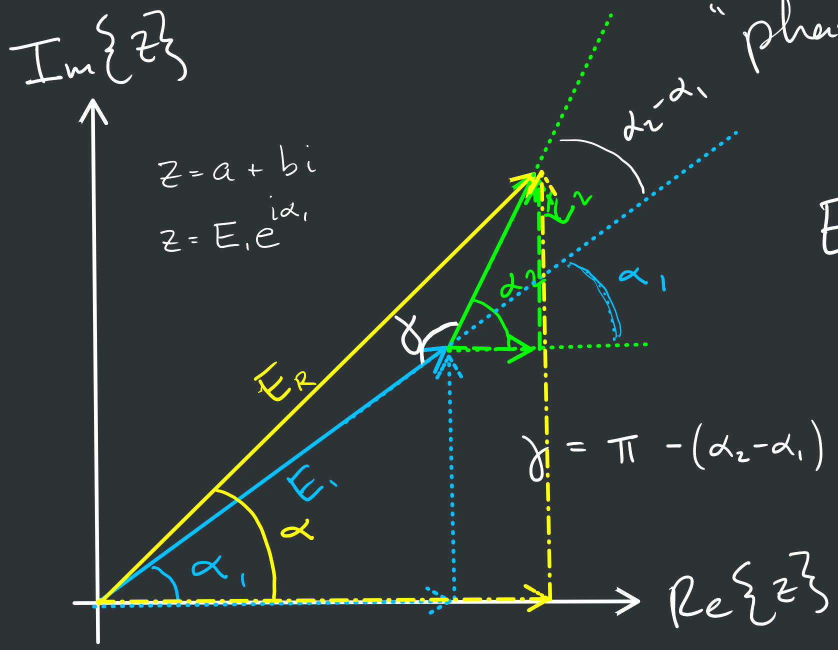
What if any other phase shift?

↳ switch from trig to complex notation

$$E_R = E_1 + E_2 = Re\left\{E_1 e^{i(\alpha_1 - \omega t)} + E_2 e^{i(\alpha_2 - \omega t)}\right\}$$

$$= Re\left\{e^{-i\omega t}\underbrace{\left(E_1 e^{i\alpha_1} + E_2 e^{i\alpha_2}\right)}\right\}$$

"phasor diagram" → treat complex number like vectors



$$E_R(x,t) = Re\left\{E_R e^{i(\alpha - \omega t)}\right\}$$

? ?

$$E_R^2 = E_1^2 + E_2^2 - 2E_1E_2 \underbrace{\cos\gamma}$$

$\cos(\pi - \alpha_2 + \alpha_1)$

$-\cos(-\alpha_2 + \alpha_1)$

$-\cos(\alpha_1 - \alpha_2)$

$$E_R^2 = E_1^2 + E_2^2 + 2E_1E_2\cos(\alpha_1 - \alpha_2)$$

$$\tan\alpha = \frac{E_1\sin\alpha_1 + E_2\sin\alpha_2}{E_1\cos\alpha_1 + E_2\cos\alpha_2}$$