LAST TIME:

interpretation of double slit experiment

- individual photon spread out, sees both slits + interferes with itself.
- described by some kind of spread out wave BUT still hits a specific spot on screen
- wave only tells us PROBABILITY of hitting wall at specific place
- this probability matches intensity pattern from ordinary light

by the way... electrons, neutrons, etc... behave in the <u>same way</u> in a double slit experiment.

- get pattern corresponding to

$$\lambda = \frac{h}{p}$$

h ← Planck's constant

p ← momentum

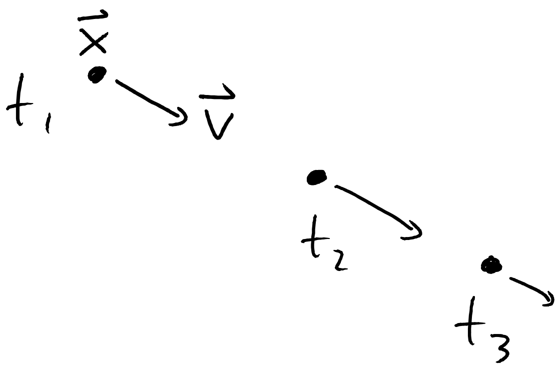
predicted by de Broglie

MODEL: particle described by WAVEFUNCTION $\psi(x,t)$ that evolves like a wave

$|\psi|$ largest here

- $|\psi(x,t)|^2$ tells us PROBABILITY DENSITY for finding particle at position x at time t.

Classical model:



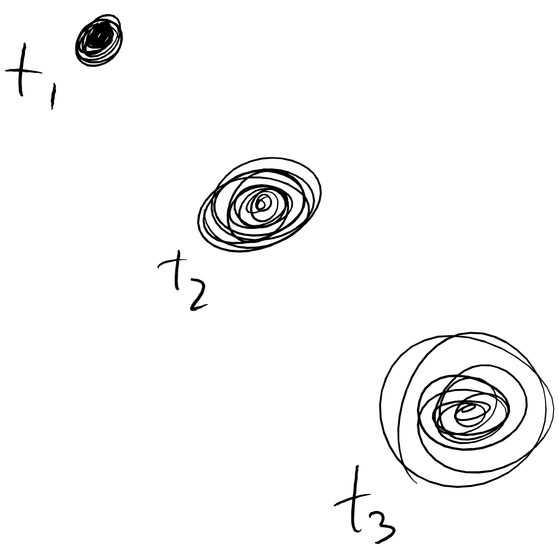
change governed by Newton's Laws:

$$\frac{d\vec{v}}{dt} = \frac{1}{m}\vec{F}$$

$$\frac{d\vec{x}}{dt} = \vec{v}$$

Quantum model:

$\psi(x)$ changes with time



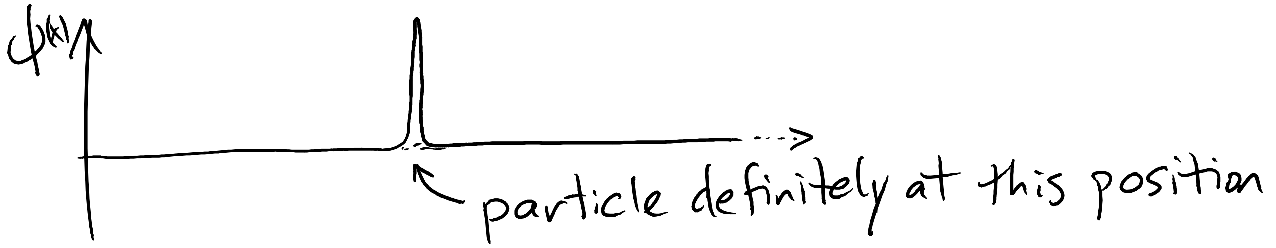
What are Newton's Laws for wavefunctions?

Start simple: pure waves

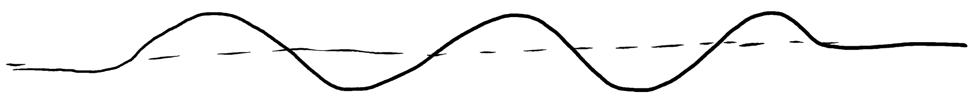
These describe particles with a definite momentum $p = \frac{h}{\lambda}$

a particle in such a state is a MOMENTUM EIGENSTATE

Compare to POSITION EIGENSTATE



Real traveling particle: somewhere in between = WAVEPACKET



- spatial extent of packet must be greater than wavelength

☆ particles with well-defined velocity/momentum/wavelength can't have definite position ☆

HEISENBERG UNCERTAINTY PRINCIPLE:

$$(\Delta x)(\Delta p) \geq \frac{h}{4\pi}$$

Δx ← uncertainty in position = range of values in which we're likely to find particles

Δp ← uncertainty in momentum

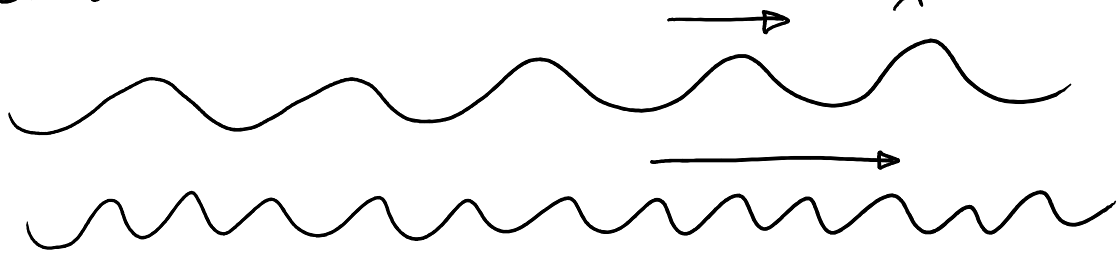
- expect packet to travel at velocity $\frac{p}{m}$ = particle speed

$$V = \frac{p}{m} = \frac{h}{\lambda m}$$

* packet also spreads out since finite packet length ⇒ some uncertainty in momentum *

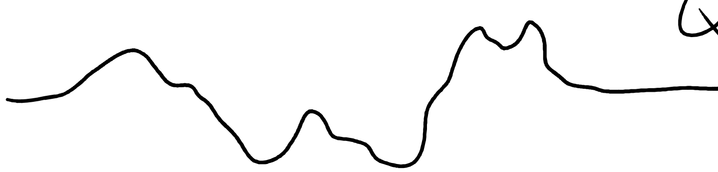
- in limit of long packet (pure wave), no spreading, so complete time dependence is just travelling sinusoidal wave:

$v \propto \frac{1}{\lambda}$



aside: using $f = \frac{v}{\lambda}$, $\lambda = \frac{h}{p}$, we get:

$$hf = \frac{p^2}{2m} = E$$ (same as for photons)



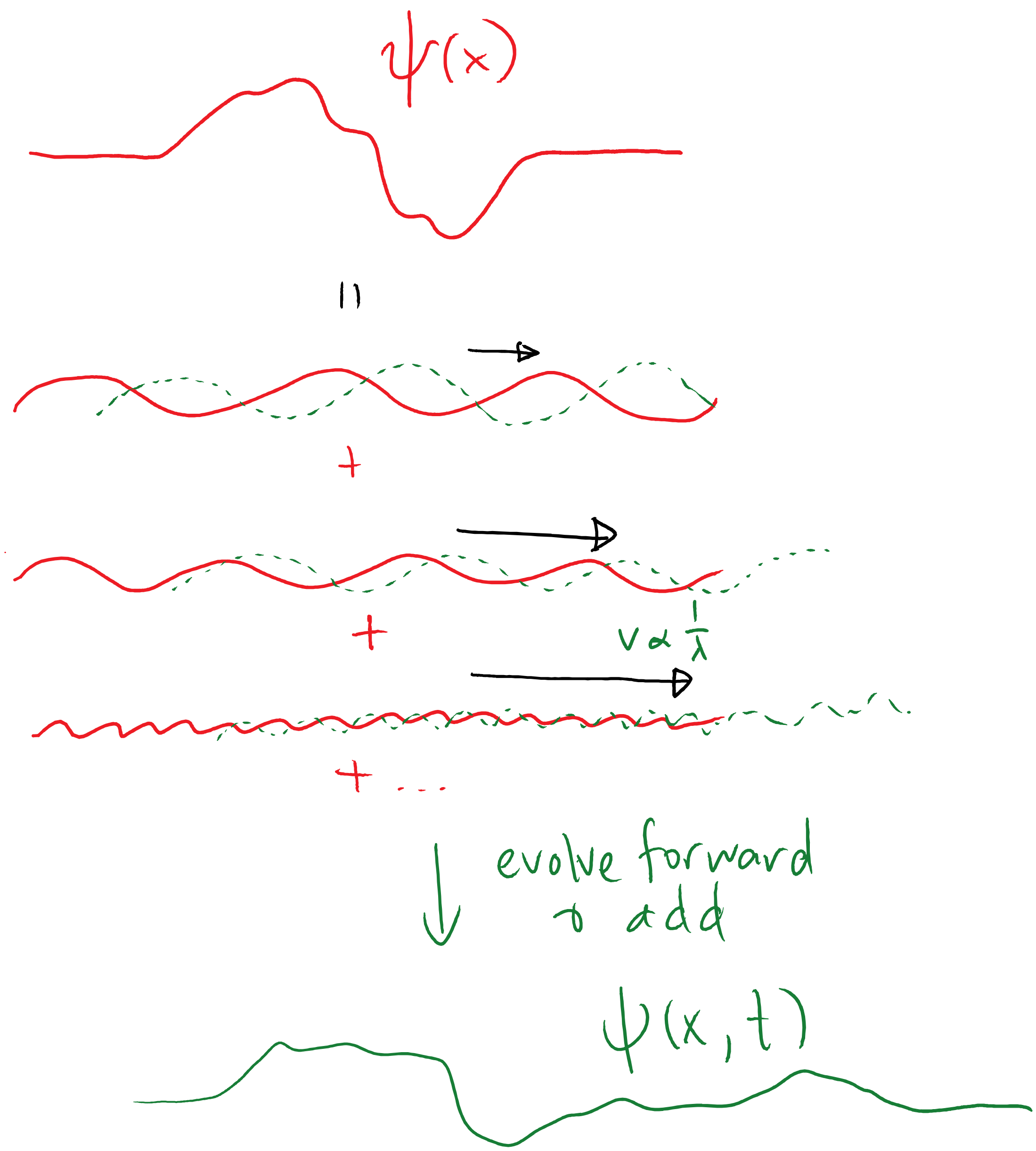
Q: How can we find time dependence of general wavefunction?

A:

① Write $\psi(x, t=0)$ as a sum of pure waves

② Evolve pure waves as above to time t

③ Add them up again to get $\psi(x,t)$!



This procedure is equivalent to solving a differential eqn. called SCHRÖDINGER'S EQUATION.

$$\frac{d\psi}{dt} = \text{constant} \times \frac{d^2\psi}{dx^2}$$