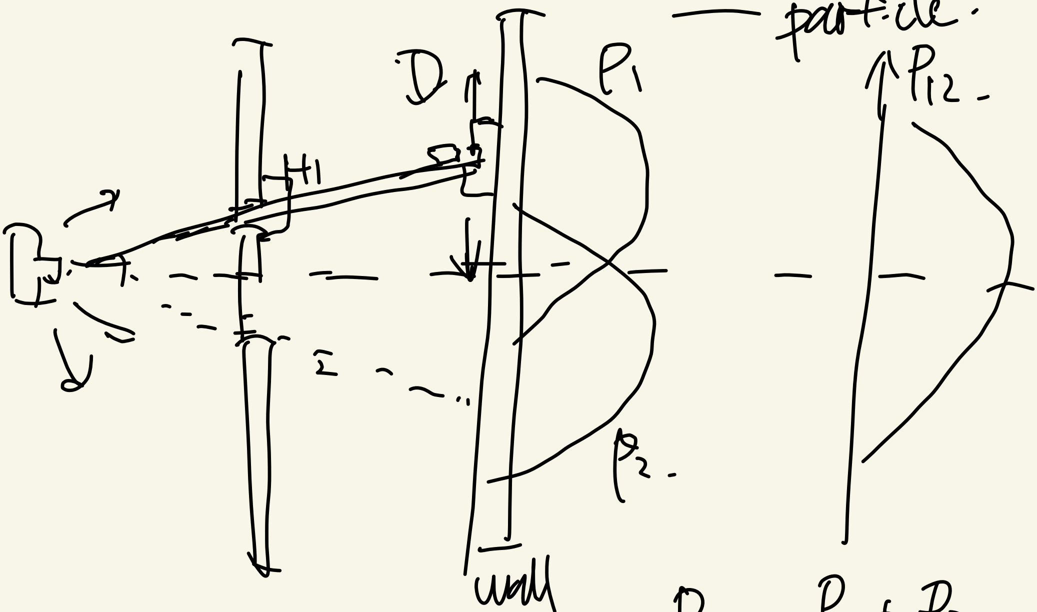
What Is Quantum Mechanics?

Classical Mechanics	Quantum Mechanics
• a point. (center of mass)	• wave function.
• $\boxed{\text{Newton 2nd Law} \quad \vec{F} = m\vec{a}}$	• Schrödinger Equation $\hat{H}\,\lvert\psi(x,t)\rangle = i\hbar\frac{d}{dt}\lvert\psi(x,t)\rangle$
• initial condition.	• initial condition.
$\Downarrow$	$\Downarrow$
deterministic solution	probablistic solution.

$\leftrightarrow$ Hamiltonian mechanics

How is an electron a wave?

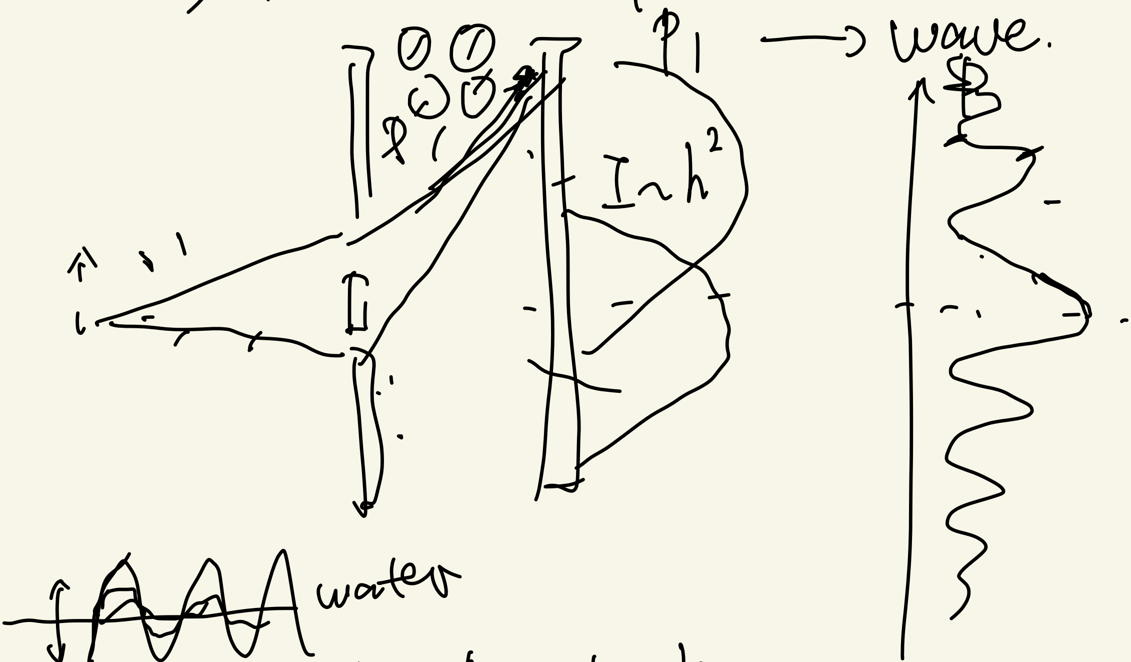
↳ Double slit experiment.



$$P_{12} = P_1 + P_2$$

How is an electron a wave?

(1) Double slit experiment.



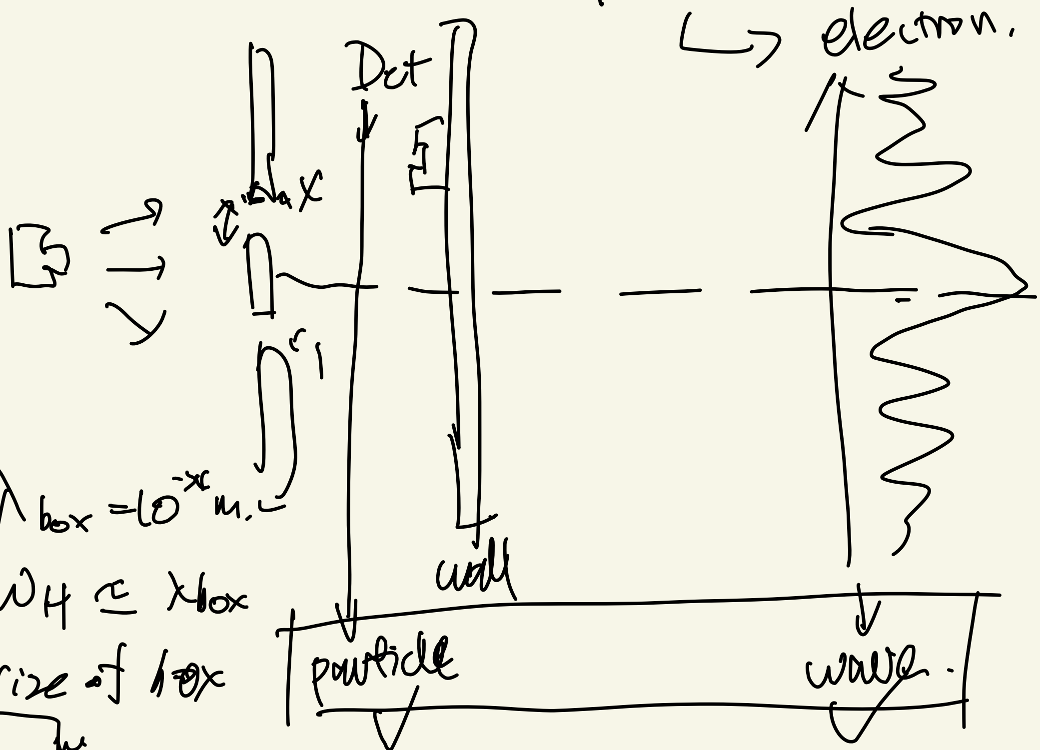
$$\psi = h\cos(kx+\phi)$$

$$h_{12} = h_1 + h_2.$$

$$I \sim h_{12}^2 = |h_1 + h_2|^2$$

How is an electron a wave?

(4) Double Slit experiment.



$\lambda_{box} = 10^{-xx}$ m.

$w_H \simeq \lambda_{box}$

size of box

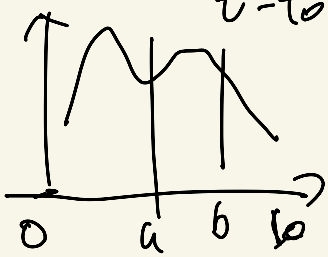
Wave functions!

1) $h_{12} = h_1 + h_2$.

$P_{12} \sim I_{12} = |h_{12}|^2 = |h_1 + h_2|^2 \to$ phase.

2). A particle is described by a wave function. $\psi(x,t)$

3) $t = t_0$



$$\int_a^b |\psi(x,t)|^2 \, dx$$

= Probability of finding particle (a, b) at time t_0

De Broglie Wavelength

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

1kg. 1m/s

$\lambda \approx 10^{-34}$ m

h: planck constant

$= 6.63 \times 10^{-34}$ J/Hz.

$$\frac{h}{2\pi} = \hbar$$

$m \sim 10^{-30}$ kg $v = 1$m/s $\lambda \sim$ atom size

Schrödinger Equation

$$\boxed{\hat{H}\,|\psi(x,t)\rangle = i\hbar \frac{\partial}{\partial t}|\psi(x,t)\rangle}$$

$F = ma$

$\ddot{}$

$\hat{H}$: Hamiltonian operator.

$\psi_1(x,t)$

$\hat{x}, \hat{p}$: operator.

$|\psi_1(x,t)\rangle$

$\hat{H}$: E_{tot} = Kinectic Energy + potential E

$|\psi_1\psi_2\psi_3\rangle$

$$= \frac{p^2}{2m} + V$$

$$\hat{H} = \frac{\hat{p}^2}{2m} + \hat{V}(x) = \left(-\frac{\hbar^2}{2m}\frac{\partial^2}{\partial x^2} + V(x)\right)$$

$\hat{H}|\psi(x,t)\rangle$:

$$\frac{\partial}{\partial x} \to \frac{d}{dx}$$

$$-\frac{\hbar^2}{2m}\frac{\partial^2}{\partial x^2}\psi(x,t) + V(x)\,\psi(x,t)$$

Initial condition

$V(x,t)$ ~~X~~ $V(x)$

$\hat{H}(t)$ is constant

$\Rightarrow \hat{H}$

time-independent SE.

$\psi(x,t) = \psi(x)\boxed{\varphi(t)}$

$$\Rightarrow \begin{cases} \dfrac{d\varphi}{dt} = -\dfrac{iE}{\hbar}\varphi \\ \boxed{-\dfrac{\hbar^2}{2m}\dfrac{d^2\psi}{dx^2} + V(x)\psi(x) = E\psi(x)} \end{cases}$$

$\psi(x,t) = \psi(x)e^{-iEt/\hbar}$