5.8 Observables and Operators

An "observable" is any particle property that can be measured.

Quantum mechanics associates an "operator" with each of these observables. Using the operator we can calculate the average value of the corresponding observable.

An operator operates on whatever wavefunction that follows it. The quantity operated on is called the "operand".

$\frac{d}{dx} f(x)$ means take the derivative

$\frac{d}{dx}$: operator; $f(x)$: operand

$$\langle Q \rangle = \int_{-\infty}^{+\infty} \Psi^* [Q] \Psi \, dx$$

Q : observable [Q] is the associated operator.

The order is important.

The momentum operator is $[p] = i\hbar \frac{\partial}{\partial x}$

$$[x^2] = x^2$$

The position operator $[x] = x$

The K.E. operator $[K] = \frac{[p]^2}{2m} = -\frac{\hbar^2}{2m}\frac{\partial^2}{\partial x^2}$

$$\langle K \rangle = \int_{-\infty}^{+\infty} \Psi^* \left(-\frac{\hbar^2}{2m}\frac{\partial^2 \Psi}{\partial x^2}\right) dx$$

The total energy operator $[H] = [K] + [U]$

or Hamiltonian $= -\frac{\hbar^2}{2m}\frac{\partial^2}{\partial x^2} + U(x)$