Quantum (PHYS 290): Midterm Info

Fall 2025 v0.7

1. Some of our favorite expressions

Constants:

$$\hbar = h/2\pi = 1.05 \times 10^{-34} \text{ J s } = 6.58 \times 10^{-16} \text{ eV s},$$
$$m_e = 9.11 \times 10^{-31} \text{ kg } = 0.511 \text{ MeV/c}^2,\ m_p = 1.67 \times 10^{-27} \text{ kg } = 938 \text{ MeV/c}^2$$
$$e = 1.60 \times 10^{-19} \text{ C } \quad c = 2.998 \times 10^8 \text{m/s}$$

a phasor is $z = re^{i(kx \pm \omega t)}$ typically we time average and use $z = re^{ikx}$

The probability or intensity is

$$P = |z|^2$$

Interference and diffraction for double slits

$$d \sin\theta = n\lambda,\ a \sin\theta = m\lambda$$

$$I(\theta) = I_o \left[\frac{\sin\left(\frac{\pi a \sin\theta}{\lambda}\right)}{\frac{\pi a \sin\theta}{\lambda}} \right]^2 \cos^2\left(\frac{\pi d \sin\theta}{\lambda}\right)$$

Schrödinger time-dependent equation with Ψ, t

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

$$\lambda = \frac{h}{p} \text{ and } \hat{p} = -i\hbar\frac{d}{dx}$$

The expectation value of Q is

$$\langle Q \rangle = \sum_i Q_i P(i)$$

The probability that a particle will be found in the interval $a \le x \le b$ in the state $\psi(x)$ is

$$P(a \le x \le b) = \int_a^b \psi^*(x)\psi(x)dx$$

For a particle of mass m in a box of width L the spatial wavefunctions are

$$u_n = \sqrt{\frac{2}{L}} \sin\left(\frac{n\pi x}{\lambda}\right) \text{ with energies } E_n = \frac{n^2\hbar^2\pi^2}{2mL}$$

Uncertainty: For addition and subtraction, if $q = x \pm y$ then $\delta q = \sqrt{\delta x^2 + \delta y^2}$. For multiplication and division then, if $q = x/y$ then add the relative uncertainties in quadrature

$$\frac{\delta q}{q} = \sqrt{\left(\frac{\delta x}{x}\right)^2 + \left(\frac{\delta y}{y}\right)^2}$$

For a general calculated quantity $q = q(x, ..., z)$ then

$$\delta q = \sqrt{\left(\frac{\partial q}{\partial x}\delta x\right)^2 + ... + \left(\frac{\partial q}{\partial z}\delta z\right)^2}$$

2. Areas of focus

- Complex numbers
- Section 1.4 amplitudes, probabilities, and the experiment of Grangier at al.
- The photoelectric effect: class notes, pages 9-12, Guide 3 problem 8
- Section 1.5 and lab single photon interference and problem 1.27
- Section 1.6 and class notes on interference
- Section 2.1 atom interferometery and problem 2.5
- Schrödinger's equation
- Section 3.2 particle in a box