Chapter 3

Problem 3.4

(b) α real.

(c) When they commute.

Problem 3.5

(a) x, $-i$, $-\left(\frac{d}{dx}\right)$.

(b) a_- .

Problem 3.6

The Hermitian operator $\hat{Q}$ has eigenvalues $-n^2$, $n = 0, 1, 2, \ldots$ with normalized eigenfunctions $\frac{1}{\sqrt{2\pi}} e^{\pm in\phi}$. The spectrum is discrete and each eigenvalue with $n > 0$ is doubly degenerate while the eigenvalue 0 is non-degenerate.

Problem 3.7

(b) $\sinh(x)$ and $\cosh(x)$.

Problem 3.9

(a) Infinite square well.

(b Potential barrier.

(c) Delta function well.

Problem 3.11

$$\Phi(p,t) = \frac{1}{(\pi m\hbar\omega)^{1/4}} \exp\left\{-\frac{p^2}{2m\hbar\omega} - i\omega t/2\right\}$$

Probabilty for getting a momentum value outside the classical range is 0.16.

Problem 3.17

(a) $\frac{d}{dt}\langle\Psi|\Psi\rangle = 0$.

(b) $\frac{d}{dt}\langle H\rangle = 0$.

(c) $\frac{d\langle x\rangle}{dt} = \frac{\langle p\rangle}{m}$.

(d) $\frac{d\langle p\rangle}{dt} = \langle -\frac{\partial V}{\partial x}\rangle$

Problem 3.18

$\sigma_H = \frac{1}{2}(E_2 - E_1)$, $\sigma_x^2 = \frac{a^2}{4}\left[\frac{1}{3} - \frac{5}{4\pi^2} - \left(\frac{32}{9\pi^2}\right)^2 \cos(3\omega t)\right]$, $\frac{d\langle x\rangle}{dt} = \frac{8\hbar}{3ma}\sin(3\omega t)$.

Problem 3.23

Eigenvalues are $\pm\sqrt{2}E$. Eigenvectors are $\frac{1}{\sqrt{2(2\mp\sqrt{2})}}\left[|1\rangle + (\pm\sqrt{2} - 1)|2\rangle\right]$.

$$H = E\begin{pmatrix} 1 & 1 \\ 1 & -1 \end{pmatrix}.$$

Problem 3.27

(a) ψ_1.

(b) b_1 with probability $9/25$ and b_2 with probability $16/25$.

(c) $\frac{337}{625}$.

Problem 3.37

(a) $e^{-ict/\hbar}\begin{pmatrix} 0 \\ 1 \\ 0 \end{pmatrix}$.

(b) $e^{-iat/\hbar}\begin{pmatrix} -i\sin(bt/\hbar) \\ 0 \\ \cos(bt/\hbar) \end{pmatrix}$.