

## Homework #9

due **Monday, November 22, 2010**

*NB: This is a very important HW set, key to following much of the rest of the course.*

Griffiths problems 2.8, 2.14, 3.23, 3.27 + the following:

Johnson 9.1 On the interval  $0 \leq x \leq a$ , consider the basis functions  $\phi_n(x) = \sqrt{\frac{2}{a}} \sin\left(\frac{n\pi x}{a}\right)$

Compute the matrix elements  $\langle \phi_m | \hat{x} | \phi_n \rangle$  and  $\langle \phi_m | \hat{p} | \phi_n \rangle$ .

Johnson 9.2 Suppose you start with a state vector  $|v_0\rangle = \begin{pmatrix} 0 \\ 1 \end{pmatrix}$ . Now suppose you

“measure” it with the matrix  $\mathbf{H} = \begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix}$ . (You found its eigenvalues and eigenvectors

back in problem 8.1.) What are the possible outcomes of a *single* measurement? What are the probabilities for each possible outcome? What is the average outcome of many measurements (that is, what is the expectation value of  $\mathbf{H}$  for this state?)

Johnson 9.3 The same as problem 9.2, only starting with the vector  $|v_1\rangle = \frac{1}{\sqrt{5}} \begin{pmatrix} 2 \\ -1 \end{pmatrix}$ .

Johnson 9.4 You have a particle of mass  $m$  in a harmonic oscillator potential  $\frac{1}{2} m \omega^2 x^2$ . It is in the ground state. What is the g.s. wavefunction? Now suppose suddenly you shift the harmonic oscillator potential to the right by a distance  $x_0 = \sqrt{\hbar/m\omega}$ , that is, the potential is now  $\frac{1}{2} m \omega^2 (x - x_0)^2$ . What is the g.s. wfn for this new potential? If the particle starts off in the g.s. of the old potential, what is the probability to find it in the g.s. of the new potential?

Extra credit: Griffiths problems 3.12, 3.22, 3.24