3	Mon. 9/15 Tues 9/16 Wed. 9/17 Fri. 9/19	**2.3.1** (rest of) Harmonic Oscillator – algebraic *part2* **2.3.2** Harmonic Oscillator – analytic (Q10.6) **2.4** Free Particle (Q11)	**Daily 3.M** **Weekly 3** **Daily 3.W** **Daily 3.F**
4	Mon. 9/22 Tues 9/23	**2.4** Free Particle, Gaussian Wave Packet (problem 2.22 in class)	**Daily 4.M** **Weekly 4**

Equipment

- Load our full Python package on computer
- Discrete Finite Well.py & DiscretePIB.py
- Griffith's text
- Moore's text
- Printout of second computational reading.
- Printout of roster with what pictures I have

In general, could we go over an example problem/calculation in class so that we can work through the homework a bit more efficiently?"Spencer
I agree, I think having another problem to work out would be helpful Jessica

Could we quickly go over the hermitian conjugate. I understand it in a formulaic sense but going over it quickly could real clear things up with it."

Kyle B,

"Since we pretty much covered 2.3.1 in class maybe towards the end of class we could get into deriving the recursion formulas in 2.3.2?"

Casey P,

Daily 3.M Monday 9/15 2.3.1 (rest of) Harmonic Oscillator – algebraic *part2* :

1. *Conceptual*: In words, explain the concept and usefulness of ladder operators.
2. *Conceptual*: What is a hermitian conjugate?
3. *Math:* If you haven't already, finish off numbers 2 and 3 from last Friday.
4. *Math:* In number 4 for last Friday, you got started on one of the weekly problems due tomorrow. You may not yet have worked out part (c) which asks you to find $\langle T \rangle$ and $\langle V \rangle$, but you should be able to answer this question: what do you expect $\langle T \rangle + \langle V \rangle$ to be and why?
5. *Starting Weekly HW:* By now, you should have made a good attempt at all of the weekly HW problems; keep that rolling.

Update for Wednesday's replace $\langle x \rangle$ with $\langle x^2 \rangle$ (otherwise it's trivially 0)

Check dailies

Things we've acquired so far and will use today:

Statistical Interpretation

$$|\Psi(x,t)|^2 = \text{Probability Density}$$

$$\langle Q(x,p)\rangle = \int \Psi_n^*(x,t) Q\left(x, \tfrac{\hbar}{i}\frac{\partial}{\partial x}\right)\Psi_n(x,t)dx$$

$$\hat{p} = \frac{\hbar}{i}\frac{\partial}{\partial x}(\ )$$

Time-Independent Schrodinger Equation

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

$$\Psi_n(x,t) = \psi_n(x)\varphi_n(t)$$

$$i\hbar\frac{\partial}{\partial t}\varphi_n(t) = E\varphi_n(t) \qquad \psi_n(x)E = -\frac{\hbar^2}{2m}\frac{\partial^2}{\partial x^2}\psi_n(x) + V(x)\psi_n(x)$$

$$\varphi_n(t) = e^{-i\frac{E_n}{\hbar}t}$$

2.3 The Harmonic Oscillator

$$\hat{a}_+ \equiv \frac{1}{\sqrt{2m\hbar\omega}}(-i\hat{p} + m\omega x) \text{ and } \hat{a}_- \equiv \frac{1}{\sqrt{2m\hbar\omega}}(i\hat{p} + m\omega x) \qquad [\hat{a}_-, \hat{a}_+] = 1$$

$$\hat{H}\psi_n(x) = \frac{1}{2m}\left(\hat{p}^2 + (m\omega x)^2\right)\psi_n(x) = \hbar\omega\left(\hat{a}_-\hat{a}_+ - \tfrac{1}{2}\right)\psi_n(x) = \hbar\omega\left(\hat{a}_+\hat{a}_- + \tfrac{1}{2}\right)\psi_n(x)$$

$$c_n\psi_{n+1}(x) = \hat{a}_+\psi_n(x) \quad E_{n-1} = E_n - \hbar\omega$$

$$d_n\psi_{n-1}(x) = \hat{a}_-\psi_n(x)$$

$$\psi_o = \left(\frac{m\omega}{\pi\hbar}\right)^{1/4} e^{-\left(\frac{m\omega}{2\hbar}\right)x^2}$$

$$E_n = \left(n + \tfrac{1}{2}\right)\hbar\omega \qquad \psi_n(x) = \frac{1}{\sqrt{n}}(\hat{a}_+)\psi_{n-1}(x) = \frac{1}{\sqrt{n!}}(\hat{a}_+)^n\psi_o(x)$$