

**Physics 356F: Problem Set #3**  
**assigned 6 November 2013**  
**(due the week of 20 November at the start of tutorial)**

Note: although you have two weeks to complete this, I recommend you start early, as I plan to assign another problem set next week and the final problem set in two weeks.

1. problem 6.9
2. problem 6.11
3. problem 7.4
4. problem 7.7
5. From your knowledge of the raising and lowering operators and their relation to  $X$  and  $P$ , calculate for each of the following states  $\langle X \rangle$ ,  $\Delta X$ ,  $\langle P \rangle$ , and  $\Delta P$ . Comment on the Heisenberg uncertainty relation in each case.
  - (a)  $|0\rangle$
  - (b)  $|n\rangle$
  - (c)  $(|1\rangle + e^{i\phi}|2\rangle) / \sqrt{2}$
  - (d)  $(|1\rangle + |3\rangle) / \sqrt{2}$