CML 100: 2014-2015
Quantum Tutorial 1

(Submit answers to Q. 5 and 7 on 5th September 2014 during the lecture: Remember to write your group # along with the name and entry #)

1. In algebra it can be easily shown that $(P + Q)(P - Q) = P^2 - Q^2$. What is the value of $(P + Q)(P - Q)$ if P and Q are operators? Under what conditions will this result be equal to $P^2 - Q^2$.

2. Find $[z^3, \frac{d}{dz}]$ and $[\frac{d^2}{dx^2}, ax^2 + bx + c]$.

3. Which of the following functions cannot be solutions of the Schrödinger equation for all values of x? Why not? (a) $A\sec(x)$; (b) $A\tan(x)$; (c) $A\exp(x^2)$; (d) $A\exp(-x^2)$.

4. Write down the Hamiltonian for the following systems: (a) a particle of mass m in a cubical box of side a; (b) a particle of mass m in a spherical box of radius a; (c) a particle of mass m moving on the x-axis subjected to a force directed towards the origin, of magnitude proportional to the distance from the origin; (d) an electron moving in the presence of a nuclear charge $+Ze$; (e) two electrons moving in the presence of a fixed nucleus of charge $+Ze$.

5. (a) Evaluate the probability of locating a particle in the middle third of 1-D box. (b) Find the probability that a particle in a box L wide can be found between $x = 0$ and $x = L/n$ when it is in the nth state.

6. Many proteins contain metal porphyrin molecules. These molecules are approximated as square planar and contain $26\ \pi$ electrons. If the edge of the molecule is ~1000 pm, then what is the predicted lowest energy absorption of the porphyrin molecule?

7. The possible values obtained from a measurement of a discrete variable, x, are 1, 2, 3, and 4. (a) If the respective probabilities are 1/4, 1/4, 1/4, and 1/4, calculate the expectation values of x and x^2. (b) If the respective probabilities are 1/12, 5/12, 5/12, and 1/12, calculate the expectation values of x and x^2.