QUANTUM MECHANICS I A (FYSA231), Spring 2010

Exercise 1.

1. How large are the following objects in meters (accuracy: human=1 m). The Milky Way, distance between stars in the Milky Way, distance between the Sun and the Earth, size of the Sun, distance between the Moon and the Earth, size of the Moon, size of the Earth, bacterium, virus, cell, wave length of light, molecule, distance between iron atoms in iron, uranium atom, hydrogen atom, hydrogen core, electron, quark.

2. a) What are the masses of electron, proton and neutron in the units of keV?
   b) What is the value of the reduced Plank's constant $\hbar$ in SI units? And in eVs?
   c) Calculate the value of the fine structure constant $\alpha = \frac{1}{4\pi\epsilon_0}\frac{e^2}{\hbar c}$.

3. Solve the differential equation
$$\frac{d^2\phi(x)}{dx^2} + k^2\phi(x) = 0.$$
And mention a physical situation that it describes.

4. Describe shortly one such subatomic phenomena that can not be explained classically.

5. Solve the differential equation:
$$\frac{d^2\phi(x)}{dx^2} + 2\frac{d\phi(x)}{dx} + \phi(x) = 0$$
directly as a second order differential equation and by using Frobenius' method by inserting
$$\phi(x) = x^s \sum_{n=0}^{\infty} a_n x^n$$
into the equation and choosing $a_0 \neq 0$. You should see that s=0 tai s=1. Find the recurrence relation for a_n (for both values of s separately) and finish the series solutions. You should get the same result as solving the differential equation directly. (Later we will need this method when we solve the harmonic oscillator.)