

# PHYS550 Problem Set 1

Carlos Salinas

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**Problem 1.1**

A particle's wave function is

$$\psi(x) = C \exp \left[ \frac{ip_0 x}{\hbar} - \frac{(x - x_0)^2}{2a^2} \right] \quad (1)$$

(all parameters are real). Find average values for the coordinate  $x$ , the momentum  $p$  and their fluctuations. Find WF of Eq. (1) in momentum representation.

*Solution.*

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**Problem 1.2**

For a given WF  $\Psi(x, y, z)$  find a probability for a particle to be in the range  $z_1 < z < z_2$  and  $p_1 < p_y < p_2$ .

*Solution.*

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**Problem 1.3**

Find eigenvalues and eigenfunctions of a quantity  $\hat{f} = \alpha\hat{p}_x + \beta\hat{x}$ , where  $\hat{p}_x$  and  $\hat{x}$  are the momentum and the coordinate operators.

*Solution.*

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**Problem 1.4**

Using dimensional analysis, estimate Bohr's orbit for the motion of electron around proton. Disregard numerical factors of the order of a few.

(*Hints:* The proton is heavy – not moving, its mass is not important. Assume the velocity is  $\ll$  speed of light –  $c$  is not important. Only the electron mass, elementary charge and Planck's constant are the important quantities. Also, for a bound orbit potential electric energy is of the order of the kinetic energy.) Clearly explain your steps – do not just write down the answer.

*Solution.* ■