

PHYS550 Problem Set 1

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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 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. ■