

# Quantum Chemistry Seminar 1

Basics of Quantum Theory

### Exercise 1 (Shamal)

Find all the complex numbers  $c$  so that function  $\varphi(x) = ce^{-x^2/2}$  be normalized (to unity).

Calculate the mean values of the position and linear momentum of a particle confined to the  $x$ -axis in the (quantum) state given by function  $\varphi(x)$ .

### Exercise 2 (Shaho)

Evaluate the commutator of position and momentum operators of a particle confined to a line,  $\hat{X} = x$  and  $\hat{P} = -i\hbar \frac{d}{dx}$ , and derive the Heisenberg uncertainty relations by inserting the  $[\hat{X}, \hat{P}]$  to the general uncertainty relations given in lesson 1.

(Hint: Apply the commutator to a general function,  $f(x)$ , and use the rule for derivatives of function products.)