# Quantum Mechanics 2

Problem Set 1
Kharazmi University

March 4, 2023

**Conceptual Problems:**

**Problem 1.1.** What is the difference between the quantum harmonic oscillator and the classical one? *Hint: The ground state energy is the key!

**Problem 1.2.** Briefly, describe what is the classical angular momentum.

**Problem 1.3.** What is the meaning of relation 1? What is the implication of the relation?

$$[\hat{L}, \hat{H}] = 0 \tag{1}$$

**Mathematical Problems:**

**Problem 1.4.** As far as we will come through Ladder operators for the angular momentum of a quantum harmonic oscillator (Me or Dr.Vahedi). As a review, drive creation, and annihilation operator of a quantum harmonic oscillator (for the following Hamiltonian) and use them to rewrite the Hamiltonian.

$$\hat{H} = \frac{1}{2}(\hat{P} + i\omega x)(\hat{P} - i\omega x) + \frac{\omega\hbar}{2} \tag{2}$$

**Problem 1.5.** Consider $L|\Psi\rangle = m|\Psi\rangle$, Where $L = -i\hbar\frac{\partial}{\partial\theta}$, $m$ is the eigenvalue of $L$ (actually $m$ is the magnetic quantum number), and $\Psi$ is the eigenvector. By solving the differential equation, find the 3.

$$m = n\hbar, \tag{3}$$

where $n \in \mathbb{Z}$.
*Hint: Take $\Psi$ as a function of $\theta$!

**Problem 1.6.** Solve **Exercise 5.1**, page.325, Zettili (2nd Edition).