PH 434 Programming Lab – Practical 2 (Date: 22 August 2025)

Practical Class 3 (Dated: 22.08.2025)

Question 1

In quantum mechanics an observable is operator that is Hermitian. Let us consider this obervable to be represented by a 2×2 complex matrix. A matrix is Hermitian if the transpose of its complex conjugate is the identical i.e., $(A^*)^T = A$.

Note that complex conjugate of a matrix is obtained by taking the complex conjugate of all its elements.

Write a Python code that inputs a random complex 2×2 matrix A as a list of 8 real numbers, and store it as 4 tuples representing the matrix elements. Note each tuple contains 2 real numbers representing a complex number i.e., $x + iy = (x, y)$.

The code should output the complex conjugate $(A^*)^T$.

Question 2

Assume you are in charge of elections in your university and want to make a list of all possible candidates. Now the list must contain the name, roll number and department of each candidate.

Write a code to create this list by taking input from users. Your code must do the following:

1. Print the list after each run.
2. Details of a candidate can be added or removed from the list (you can write separate code to add and remove)
3. Details of a specific candidate cannot be changed or edited (only added or removed)

Question 3

Write a code that finds the trace and determinant of a real 3×3 matrix.

Question 4

Let A and B be two 2×2 matrices, such that $A = \begin{pmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{pmatrix}$ and $B = \begin{pmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{pmatrix}$.

The tensor produdct of two 2×2 matrices A and B is a 4×4 matrix defined as:

$$A \otimes B = \begin{pmatrix} a_{11}B & a_{12}B \\ a_{21}B & a_{22}B \end{pmatrix} = \begin{pmatrix} a_{11}\begin{pmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{pmatrix} & a_{12}\begin{pmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{pmatrix} \\ a_{21}\begin{pmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{pmatrix} & a_{22}\begin{pmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{pmatrix} \end{pmatrix}.$$

Write a code that finds the tensor product of two 2×2 real matrices (say σ_x and σ_z).

Question 5

Consider the Pauli matrices, $\sigma_x = \begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix}$, $\sigma_y = \begin{pmatrix} 0 & -i \\ i & 0 \end{pmatrix}$, $\sigma_z = \begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix}$ and the identity matrix $I = \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix}$.

Now all 2×2 complex Hermitian matrices H can be written as: $H = a\mathbb{I} + b\sigma_x + c\sigma_y + d\sigma_z$, where $\{a, b, c, d\} \in \mathbb{R}$.

Write a code that takes a 2×2 Hermitian matrices as an input, and prints $\{a, b, c, d\}$.

Hint: An arbitrary matrix A can generate a Hermitian matrix $H = \frac{1}{2}[A + (A^*)^T]$.

Challenge

This challenge requires additional knowledge of functions, loops and conditional statements.

Consider a box containing a dilute gas of particles. The gas is so dilute that each particle has a unique trajectory inside the box and in any given instant each particle occupies a specific position inside the box.

Say there are 10000 particles inside the box. Now, we are interested in finding the probability of two or more particles "overlapping" i.e. occupying the same position in the box.

Note that the box is sufficiently large -- nothing else is important. However, we are assured that two particles are overlapping.

Write a code that calculates the probablity of finding this overlap after checking the position of n particles. Find the following is true:

1. How many many particles do you need to check to be 99% sure?
2. How many to be achieve 50%?