Date: 1402/03/31

In the name of God

Department of Physics
Shahid Beheshti University

COMPUTATIONAL PHYSICS

Final Exam

(Time allowed: 3 hours)

NOTE: Send your programs, plots and results to movahedsadegh [at] gmail.com and amitida3513 [at] gmail.com

Theoretical parts

1. **Genetic Algorithm**: In a simple genetic algorithm, explain in details the various parts for determining next generation using current members. (15 points)

2. **Quantum Algorithm**:
   A: Quantum teleportation is a technique for transportation quantum states, even in the absence of a quantum communications channel linking the sender of the quantum state to the recipient. The quantum circuit of teleportation is indicated in Fig. 1. Write the state of the system in each part and explain what is the final state? Suppose that $|\psi\rangle = a|0\rangle + b|1\rangle$. (10 points)
   B: What are the Grover and Deutsch algorithms good for and what are their advantages? (10 points)

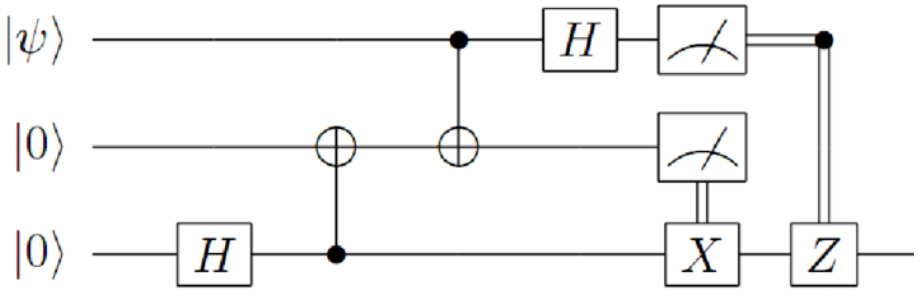

Figure 1: A typical quantum circuit of teleportation

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3. **Explicit and Implicit methods**: For following partial differential equation in the plane, compare the explicit and implicit numerical methods.

$$\frac{\partial f(t,r)}{\partial t} = -\vartheta \nabla f(t,r)$$

Suppose that $\vartheta > 0$ Which approaches would be proper for it? Why? (10 point)

4. Compare the MCMC and HMC methods. Write at least 2 differences. (10 points)

Numerical parts

5. For the given series, compute the discrete first derivative. Since the data is not smooth, therefore, in principle, the derivative does not exist, to overwhelm this discrepancy,
A: Write the four and six neighbors from the center methods for first derivative. (10 points)
B: Using the four and six neighbors from the center method, compute the first derivative of data. (10 points)

6. According to RKF45 method, solve following differential equation governing the location of point charge in the axial of loop:

$$\frac{d^2y}{dt^2} - f_{friction} + p\frac{y}{(y^2+R^2)^{3/2}} = qE_{ext}(t)$$

A: Suppose that $y(t=0)=1$, $\dot{y}(t=0)=0$, $E_{ext}(t)=\sin(0.2t)$, $f_{friction}=-0.4\dot{y}^2$, $p=2$.
B: Suppose that $y(t=0)=1$, $\dot{y}(t=0)=0$, $E_{ext}(t)=0$, $f_{friction}=-0.4\dot{y}^2$, $p=2\cos(t)$.
For each part, plot the phase diagram. Deduce the chaotically of your results. (25 points)

Good luck, Movahed