ASSESSMENT 1

START OF SEMESTER 1

Why go quantum?

1. What is quantum computing?

    (a) Simulating quantum mechanics on modern computers.

    (b) Making use of the weirdness of quantum mechanics to solve problems that normal computers cannot.

    (c) Injecting quantum mechanics into classical computers to increase their computing speed.

    (d) Using computers to discover new laws of quantum physics.

    (e) I don't know

2. Which of the following does NOT describe a qubit?

    (a) The outcome of a quantum algorithm.

    (b) The basic unit of quantum information.

    (c) The quantum analog of a classical bit.

    (d) A two-level/state quantum mechanical system.

    (e) I don't know

3. Which famous quantum algorithm enables efficient prime factorization and has the potential to ruin modern (RSA) cryptography?

    (a) Deutsch-Josza Algorithm

    (b) Grover's Algorithm

    (c) Bose-Einstein Algorithm

    (d) Variational Quantum Eigensolver

    (e) Shor's Algorithm

    (f) I don't know

4. What does Moore's Law tell us?

(a) The number of transistors on a microchip doubles every two years.

(b) Quantum computers are exponentially improved each year.

(c) Qubits double in speed each year.

(d) Classical computation power improves linearly each year.

(e) I don't know

5. What field are people looking to apply quantum computing to?

(a) Chemistry

(b) Finance

(c) Biology

(d) Machine Learning

(e) All of the above

(f) None of the above

(g) I don't know

Classical Computation

6. What is 13_{10} in binary?

    (a) 0000000000000_2

    (b) 1111111111111_2

    (c) 1101_2

    (d) 1110_2

    (e) 10001_2

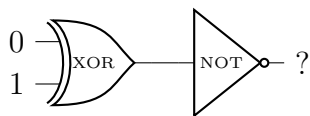   (f) 10100101_2

    (g) I don't know

7. What is 110001_2 in decimal?

    (a) 6

    (b) 37

    (c) 49

    (d) 50

    (e) 71

    (f) I don't know

8. Which of the following runtimes is $O(n^2)$?

    (a) $O(n!)$

    (b) $O(e^n)$

    (c) $O(1)$

    (d) $O(25n^2 + n^3)$

    (e) $O(3 + n + 2n^{20})$

    (f) I don't know

9. What is the output of the following logic circuit?

    (a) 0

    (b) 1

    (c) 10

    (d) 01

    (e) I don't know

Mathematics for Quantum

10. What is the standard form of the complex number $e^{i\theta}$?

    (a) $1 + i\theta$

    (b) $\cos\theta + i\sin\theta$

    (c) $(e + i)\cos\theta$

    (d) I don't know

11. Which of the following forms an orthonormal basis in 2 dimensions?

    (a) $\{\begin{pmatrix} 1 \\ 0 \end{pmatrix}, \begin{pmatrix} 0 \\ 1 \end{pmatrix}\}$

    (b) $\{\begin{pmatrix} 1 \\ 1 \end{pmatrix}, \begin{pmatrix} 0 \\ -1 \end{pmatrix}\}$

    (c) $\{\begin{pmatrix} -1 \\ 0 \end{pmatrix}, \begin{pmatrix} 1 \\ 0 \end{pmatrix}\}$

    (d) I don't know

12. Which of the following expressions gives the expectation of a random variable X?

    (a) $\langle X \rangle = xP(X = x)$

    (b) $\langle X \rangle = \sum_x xP(X = \text{x})$

    (c) $\langle X \rangle = \prod_x xP(X = x)$

    (d) I don't know

Quantum Gates

13. Which of the following gates maps a pure qubit state into a superposition?

    (a) Hadamard

    (b) Pauli X

    (c) Pauli Y

    (d) Pauli Z

    (e) CNOT

    (f) I don't know

14. Which of the following gates acts as a quantum phase-flip/shift?

    (a) Hadamard

    (b) Pauli X

    (c) Pauli Y

    (d) Pauli Z

    (e) CNOT

    (f) I don't know

15. Which of the following gates acts as a quantum bit-flip?

    (a) Hadamard

    (b) Pauli X

    (c) Pauli Y

    (d) Pauli Z

    (e) CNOT

    (f) I don't know

Quantum Mechanics

16. The double slit experiment demonstrates which quantum property of electrons?

    (a) Quantized Charge
    (b) Wave-particle duality
    (c) Electron-light interaction
    (d) I don't know

17. Which of the following is a superposition state?

    (a) $|0\rangle$
    (b) $\frac{1}{\sqrt{2}}(|0\rangle + |1\rangle)$
    (c) $|0\rangle \otimes |1\rangle$
    (d) I don't know

18. Which of the following is an entangled state?

    (a) $|01\rangle$
    (b) $\frac{1}{\sqrt{2}}(|00\rangle - |11\rangle)$
    (c) $\frac{1}{\sqrt{2}}(|00\rangle + |10\rangle)$
    (d) I don't know

19. What is the normalization condition for the quantum state $|\psi\rangle$?

    (a) $\langle\psi|\psi\rangle = 1$
    (b) $\langle\psi|\psi\rangle = 0$
    (c) $\langle 1|\psi\rangle = 1$
    (d) I don't know

20. What is the vector form of the quantum state $|\psi\rangle = \alpha\,|0\rangle + \beta\,|1\rangle$?

    (a) $\begin{pmatrix} 0 \\ \beta \end{pmatrix}$

    (b) $\begin{pmatrix} \alpha \\ \beta \end{pmatrix}$

    (c) $\begin{pmatrix} \beta \\ \alpha \end{pmatrix}$

    (d) $\begin{pmatrix} \alpha \\ 0 \end{pmatrix}$

    (e) I don't know

21. The geometric interpretation of a qubit state is a vector on a
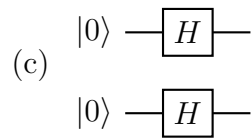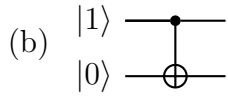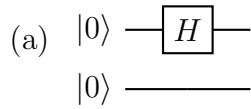
(a) Bloch Sphere

(b) Minkowski Hyperboloid

(c) 4D Hypercube

(d) I don't know

22. Given the quantum state $|\psi\rangle = \frac{1}{\sqrt{5}}|\alpha\rangle - \frac{2i}{\sqrt{5}}|\beta\rangle$, what is the probability of measuring state $|\beta\rangle$?

(a) $\frac{1}{25}$

(b) $\frac{16}{25}$

(c) $\frac{1}{5}$

(d) $\frac{4}{5}$

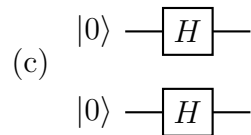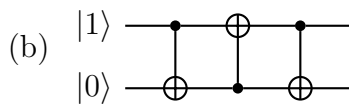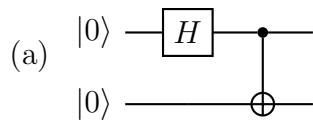(e) $-\frac{1}{5}$

(f) $\frac{4i}{5}$

(g) I don't know

Quantum Circuits

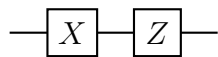23. Which circuit produces an equal superposition state?

(a) $|0\rangle$ —[H]—
$|0\rangle$ ———

(b) $|1\rangle$ —●—
$|0\rangle$ —⊕—

(c) $|0\rangle$ —[H]—
$|0\rangle$ —[H]—

(d) I don't know

24. Which circuit produces an entangled state?

(a) $|0\rangle$ —[H]—●—
$|0\rangle$ ———⊕—

(b) $|1\rangle$ —●—⊕—●—
$|0\rangle$ —⊕—●—⊕—

(c) $|0\rangle$ —[H]—
$|0\rangle$ —[H]—

(d) I don't know

25. What is the matrix representation of the following circuit?

—[X]—[Z]—

(a) $\frac{1}{\sqrt{2}} \begin{pmatrix} 1 & 1 \\ 1 & -1 \end{pmatrix}$

(b) $\begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix} \begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix}$

(c) $\begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 0 & 1 & 0 \end{pmatrix}$

(d) I don't know

Quantum Computing/Mechanics 101

26. Which famous thought experiment illustrates the idea of superposition?

    (a) The "Glove in Box" Experiment

    (b) Pavlov's Dog

    (c) Schrodinger's Cat

    (d) Fermi Paradox

    (e) I don't know

27. Which of the following weird quantum properties enables us to create pairs/groups of quantum states that cannot be described independently of one another (irrespective of distance)?

    (a) Superposition

    (b) Entanglement

    (c) Quantum Interference

    (d) I don't know

28. Which of the following weird quantum properties enables us to create a quantum state which is a linear combinations of several classical states simultaneously?

    (a) Superposition

    (b) Entanglement

    (c) Quantum Interference

    (d) I don't know

29. Which of the following weird quantum properties enables quantum states to constructively and destructively interact with one another?

    (a) Superposition

    (b) Entanglement

    (c) Quantum Interference

    (d) I don't know

30. Which of the following best describes a *quantum circuit*?

    (a) Quantum logic applied to classical bits.

    (b) A sequence of qubits to which quantum gates are applied and a quantum measurement is performed.

    (c) XOR, AND, and COPY gates applied to qubits.

    (d) A classical circuit used to control a quantum computer.

    (e) I don't know

31. Which of the following best describes *quantum advantage*?

   (a) Quantum computers will be able to do everything classical computers can do, but faster and better.

   (b) Quantum algorithms will be much easier to write and execute than classical algorithms.

   (c) Quantum circuits will be much easier to design and run than classical circuits.

   (d) Quantum computers will leverage strange properties of quantum mechanics to solve certain challenging problems faster than classical computers.

   (e) I don't know

32. Which of the following best describes a *quantum algorithm*?

   (a) A classical algorithm designed to simulate a quantum system and solve hard problems.

   (b) A quantum circuit specially designed to leverage entanglement, superposition, and quantum interference to solve computing problems more efficiently than classical computers.

   (c) A classical circuit which mimics quantum logic gates to demonstrate strange quantum effects.

   (d) A classical algorithm which is run on a quantum computer, making it faster than an algorithm run on a classical computer.

   (e) I don't know

33. If I repeatedly create and measure a qubit (via the standard $\{|0\rangle, |1\rangle\}$ basis) in the superposition state $\frac{1}{\sqrt{2}}(|0\rangle + |1\rangle)$, what outcome do I expect?

   (a) $|0\rangle$ 100% of the time

   (b) $|1\rangle$ 100% of the time

   (c) $\frac{1}{\sqrt{2}}(|0\rangle + |1\rangle)$ 100% of the time

   (d) $|0\rangle$ 50% of the time and $|1\rangle$ 50% of the time

   (e) $|0\rangle$ 25% of the time and $|1\rangle$ 75% of the time

   (f) $|0\rangle$ 75% of the time and $|1\rangle$ 25% of the time

   (g) I don't know

34. Imagine I create a qubit in the superposition state $\frac{1}{\sqrt{2}}(|0\rangle + |1\rangle)$, and perform a quantum measurement (via the standard $\{|0\rangle, |1\rangle\}$ basis). Suppose the outcome of this measurement is the state $|0\rangle$. What outcome would I expect if I measure this qubit again in the same basis (assuming I do not apply anymore gates to the qubit)?

   (a) $|0\rangle$

   (b) $|1\rangle$

   (c) $\frac{1}{\sqrt{2}}(|0\rangle + |1\rangle)$

   (d) I don't know

35. Imagine I create the two-qubit entangled state $\frac{1}{\sqrt{2}}(|00\rangle + |11\rangle)$. Now, I perform a measurement on the first qubit and find that it is in the state $|1\rangle$. What can I say about the state of the second qubit?

   (a) It is in the state $|0\rangle$

   (b) It is in the state $|1\rangle$

   (c) It is in the state $\frac{1}{\sqrt{2}}(|0\rangle + |1\rangle)$

   (d) There is a 50% chance it is in the state $|0\rangle$ and a 50% chance it is in the state $|1\rangle$

   (e) I can't say anything about the state of the second qubit without measuring it as well

   (f) I don't know

36. Imagine I create the two-qubit entangled state $\frac{1}{\sqrt{2}}(|01\rangle + |10\rangle)$. Now, I perform a measurement on the first qubit and find that it is in the state $|1\rangle$. What can I say about the state of the second qubit?

   (a) It is in the state $|0\rangle$

   (b) It is in the state $|1\rangle$

   (c) It is in the state $\frac{1}{\sqrt{2}}(|0\rangle + |1\rangle)$

   (d) There is a 50% chance it is in the state $|0\rangle$ and a 50% chance it is in the state $|1\rangle$

   (e) I can't say anything about the state of the second qubit without measuring it as well

   (f) I don't know