
ASSESSMENT 2

END OF SEMESTER 2

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) 00000000000000_2
- (b) 1111111111111_2
- (c) 1101_2
- (d) 1110_2
- (e) 10001_2
- (f) 10100101_2
- (g) I don't know

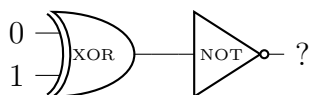
7. What is 110001_2 in decimal?

- (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) $\left\{ \begin{pmatrix} 1 \\ 0 \end{pmatrix}, \begin{pmatrix} 0 \\ 1 \end{pmatrix} \right\}$
 - (b) $\left\{ \begin{pmatrix} 1 \\ 1 \end{pmatrix}, \begin{pmatrix} 0 \\ -1 \end{pmatrix} \right\}$
 - (c) $\left\{ \begin{pmatrix} -1 \\ 0 \end{pmatrix}, \begin{pmatrix} 1 \\ 0 \end{pmatrix} \right\}$
 - (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) $\langle X \rangle = \sum_x xP(X = x)$
 - (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

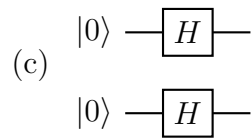
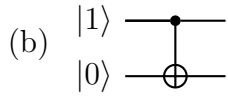
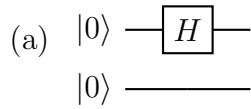
20. What is the vector form of the quantum state $|\psi\rangle = \alpha|0\rangle + \beta|1\rangle$?

- (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

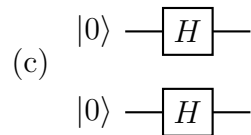
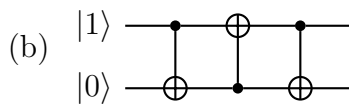
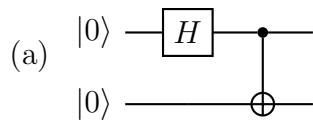
Quantum Circuits

23. Which circuit produces an equal superposition state?



(d) I don't know

24. Which circuit produces an entangled state?



(d) I don't know

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



(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

Additional Questions

37. What is a qubit?
- (a) A unit of information encoded in a three-level quantum system
 - (b) A unit of information that is encoded in a two-level quantum system
 - (c) A unit of information with a value between 0 and 1
 - (d) A system that can exist in only one of two states
 - (e) I don't know
38. Which of the following is NOT true about quantum measurement?
- (a) A measurement collapses the quantum state.
 - (b) Repeated measurements are needed to determine more complete information about a quantum state.
 - (c) Measurement is the final step in the quantum circuit model.
 - (d) A quantum state is never affected by a measurement.
 - (e) All of the above are true.
 - (f) I don't know
39. Which of the following is NOT true about quantum information science (QIS)?
- (a) QIS exploits quantum principles to transform how information is acquired, encoded, manipulated, and applied.
 - (b) QIS encompasses quantum computing, quantum communication, and quantum sensing, and spurs other advances in science and technology.
 - (c) QIS employs quantum mechanics, a well-tested theory that uses the mathematics of probability, vectors, algebra, trigonometry, complex numbers, and linear transformations to describe the physical world.
 - (d) QIS combines information theory and computer science, following the laws of quantum mechanics, to process information in fundamentally new ways.
 - (e) All of the above are true.
 - (f) I don't know
40. Which of the following statements best describe the advantage quantum computation provides over classical computation?
- (a) Quantum electronics perform each operation more quickly than classical computers
 - (b) Qubits are physically smaller than classical transistors
 - (c) Quantum algorithms leverage special properties of quantum mechanics to solve certain types of problems more efficiently
 - (d) I don't know

41. Which property of quantum systems allow for more efficient computation?
- (a) Superposition
 - (b) Entanglement
 - (c) Interference
 - (d) All of the above
 - (e) None of the above
 - (f) I don't know
42. Which of the following is NOT true about oracles?
- (a) They can be used to get an answer to a YES/NO question
 - (b) They can be used to get the output of a complex, unknown function
 - (c) They are used in many quantum algorithms, including Deutsch-Josza and Grover's
 - (d) They can only take a single qubit as input
 - (e) I don't know
43. What technique does Grover's algorithm use to locate the winner state for search?
- (a) Linear Search
 - (b) Amplitude Amplification
 - (c) Binary Search
 - (d) Mixed State Modification
 - (e) All of the above
 - (f) None of the above
 - (g) I don't know
44. Which of the following quantum protocols enables the transmission of 2 classical bits of information via 1 qubit (assuming an entangled pair has already been distributed between the sender and receiver)?
- (a) Quantum Teleportation
 - (b) Superdense Coding
 - (c) BB84 Quantum Cryptography
 - (d) All of the above
 - (e) None of the above
 - (f) I don't know

45. Which of the following quantum protocols enables the transmission of quantum information via a classical communication channel (assuming an entangled pair has already been distributed between the sender and receiver)?
- (a) Quantum Teleportation
 - (b) Superdense Coding
 - (c) BB84 Quantum Cryptography
 - (d) All of the above
 - (e) None of the above
 - (f) I don't know
46. Which of the following quantum protocols enables two parties to statistically deduce whether or not they have securely distributed a key via a quantum communication channel?
- (a) Quantum Teleportation
 - (b) Superdense Coding
 - (c) BB84 Quantum Cryptography
 - (d) All of the above
 - (e) None of the above
 - (f) I don't know
47. Which of the following is the best hardware platform for quantum computing?
- (a) Superconducting Qubits
 - (b) Trapped Ions
 - (c) Nuclear Magnetic Resonance
 - (d) Photonics
 - (e) Majorana Fermion
 - (f) There is not yet a 'best' platform; each has pros and cons
 - (g) I don't know
48. Which of the following is NOT true about quantum decoherence?
- (a) Ideally, a quantum computer has really short/small decoherence times
 - (b) Decoherence time is the amount of time that a qubit preserves its quantum properties.
 - (c) Quantum systems lose their coherence as a result of interacting with the environment.
 - (d) We can improve decoherence times by making the transition from $|1\rangle$ to $|0\rangle$ harder.
 - (e) All the above are true.
 - (f) I don't know

49. Which of the following are metrics we can use to characterize the performance of our states and gates in quantum hardware?
- (a) T1 Time (Relaxation Time)
 - (b) T2 Time (Ramsey Oscillation)
 - (c) Gate Fidelity (i.e. Randomized Benchmarking)
 - (d) All of the above
 - (e) None of above
 - (f) I don't know
50. Which of the following is true about the IBM Quantum Experience simulators?
- (a) The statevector simulator is noiseless and simulates the 'ideal' output.
 - (b) The qasm simulator simulates the result of a measurement on actual quantum hardware, including noise.
 - (c) Since the simulators are classical, they can only simulate output for circuits which do not demonstrate quantum advantage.
 - (d) All the above
 - (e) None of the above
 - (f) I don't know
51. Which of the following is NOT a good practice for running quantum circuits?
- (a) If possible, choose a chip with high gate fidelities and large T1/T2 times.
 - (b) Perform repeated measurements of the circuit, using at least a few hundred if not thousands of shots.
 - (c) Make sure there are no redundant / obsolete operations in your circuit (potentially by using a quantum compiler).
 - (d) Ensure your circuit matches the connectivity of your chip.
 - (e) All of the above are good practices.
 - (f) I don't know