YOOBEE

COLLEGE OF CREATIVE INNOVATION

Programme

Master of Software Engineering – 180 credits

Course

Quantum Computing

MSE802

(Level 8, 15 credits, Version 1)

Assessment 2

Quantum Project

Weighting within course:

60%

Assessment Tasks to Learning Outcome and GPOs mapping

Tasks	Learning Outcomes	GPOs
Task 1	LO2	GPO2
Task 2	LO1, LO2	GPO1, GPO2
Task 3, Task 4	LO1, LO2, LO4	GPO1, GPO2, GPO4

Objective

The primary goal of this assignment is to provide students with the opportunity to implement diverse quantum computing circuits, test various programs and algorithms on practical quantum computers, and assess the effectiveness of these quantum computing systems.

Assessment Instructions

- This assessment is an ***open-book activity***, you can use your own course and review notes as well as offline or online resources, such as textbooks or online journals.
- You can always ask your tutor if you need further explanation about forming a group or if the instructions are unclear.
- The purpose of this assessment is to assess your knowledge. In the event Yoobee suspects collusion, this will be addressed. For more information on plagiarism, please refer to the Student Handbook.
- Marks and feedback will be returned within 15 days of the submission date.

Learning Outcomes (LOs)

LO1: Critically evaluate quantum information protocols in software engineering using the principles of mathematical structure of quantum mechanics to validate performance claims.

LO2: Design and create quantum circuits for quantum algorithms to run on quantum-computers.

LO4: Communicate the application and critical analysis of quantum concepts to diverse software industry audiences.

Graduate Profile Outcomes (GPOs) covered

GPO1: Develop advanced software engineering knowledge and skills and apply these to solve emerging or existing problems.

GPO2: Utilise highly specialised knowledge and skills to carry out cutting-edge software engineering projects independently and collaboratively.

GPO4: Critically analyse, assess and solve software-related problems using project management tools and techniques, creative thinking and enterprise skills.

Success Criteria:

You need to meet all the requirements of each of the learning outcomes and receive 50% or more to pass this assessment. You are allowed a maximum of three attempts. To meet all the requirements of each of the learning outcomes, you must achieve PASS results for each task item.

Grading:

The final grade will be determined by the score achieved in this assessment based on the following table. Should a second or third attempt be required the maximum contribution toward the overall mark for the tasks that required a second or third assessment attempt is 50%. A late submission is considered a second attempt, so the contribution will be capped at 50%.

Grade	Mark Band Range
A+	Meet all course requirements, mark range (90-100)
A	Meet all course requirements, mark range (85-89)
A-	Meet all course requirements, mark range (80-84)
B+	Meet all course requirements, mark range (75-79)
B	Meet all course requirements, mark range (70-74)
B-	Meet all course requirements, mark range (65-69)
C+	Meet all course requirements, mark range (60-64)
C	Meet all course requirements, mark range (55-59)
C-	Meet all course requirements, mark range (50-54)
D	Did not meet all course requirements, mark range (40-49)
E	Did not meet all course requirements, mark range (0-39)

Submission requirements

- The assignment must demonstrate a well-organized structure with distinct sections corresponding to each designated task.
- For each task, you are expected to submit Python code either written in a Jupyter notebook or Google Colab. Employ clear headings and subheadings within the code to enhance its readability.
- Certain tasks may necessitate supplementary documentation, requiring the incorporation of relevant diagrams, figures, and equations to facilitate the explanation of key concepts.
- Ensure that all sources used in your work are properly cited and referenced. The citations and references should adhere to a consistent citation style, such as APA or IEEE.
- The final submission should be in the form of a compressed zip file, with distinct folders for each task.

Assessment Tasks

Task 1: Entanglement Demonstrations (LO2)

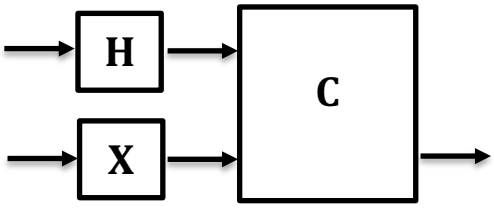
Create an entangled bell state using Cirq and run the system on the Quokka device. The Bell state is given as:

$$|\psi> = \frac{1}{\sqrt{2}}(|00> + |11>)$$

Generate qubits and apply necessary gates to generate the above state. Generate the necessary results accordingly.

Task 2: Qiskit circuits (LO1,2)

Using Qiskit, generate the following circuit:



Measure the output by running it on a quokka device and print the output.

Write a QASM script for a circuit of your own. Use different qubits and various gates to generate the final circuit. Measure the output by running it on a quokka device and print the output.

Task 3: Investigate a quantum code (LO1,2,4)

This is a partially developed interactive tic-tac-toe game designed to illustrate the generation of a quantum circuit through gameplay. To engage with this educational tool effectively, you are required to undertake the following tasks:

- Complete the provided code by filling in any missing instructions or comments.
- Once the code is finalized, participate in multiple instances of the game, and perform an in-depth analysis of the generated code.
- In your capacity as a quantum software engineer, elucidate the purpose, functionality of the code, the gameplay dynamics, and the process through which quantum circuits are generated. Compile your findings in a comprehensive Word document.
- Additionally, explore the various quantum gates employed in circuit generation and provide succinct descriptions of each gate's characteristics and functions in a separate section of your document.
- **Note: the code file is tic_tac_toe_quantum.ijpynb**

Task 4: Machine learning Quantum Analysis (LO1,2,4)

You have been provided with a code designed to address a machine learning problem cantered on image classification. The code generates binary images and employs an optimization function to assess sample images, ultimately yielding a metric. This entire process is executed using a specifically tailored circuit.

Your tasks include:

- Analysing the code, with a particular focus on the circuit component and the problem's formulation. Determine the data input into the circuit and identify the portion that serves as the input. Additionally, elucidate the code's functionality, particularly its quantum aspects, excluding the optimization algorithm.
- Executing the code and monitoring the final output at each iteration. Create additional code to plot the iteration number against the output measure. Also, generate a graph depicting the iteration number against the time required for producing the output.
- Modifying the code to run on your local machine, eliminating the need for the quantum computer or circuit. Measure and document the disparities in performance, both in terms of efficiency and effectiveness.
- Compile a comprehensive report summarizing the tasks above.
- For the final task, you are required to submit a modified code (.ijpynb file) and a word document.
- **Note: the code file is ML_quantum.ijpynb**

Marking Rubric

Criteria & Weighting		E (0-39) %	D (40-49) %	C (50-64) %	B (65-79) %	A (80-100) %
Entanglement Demonstrations	25%	The project is unable to create the entangled Bell state or run it on the Quokka device, indicating a significant failure to execute the core task of the project. Major errors are present in gate application, and there is a lack of results, demonstrating a fundamental failure in implementing quantum computing concepts. The project demonstrates a fundamental lack of understanding of the task, indicating a severe deficiency in comprehension of quantum computing principles.	Unable to create the entangled Bell state or run it on the Quokka device. Major errors in gate application and lack of results. Demonstrates a fundamental lack of understanding of the task.	Attempted to create an entangled Bell state using Cirq but with major errors or missing components. Applied gates with significant inaccuracies. Generated results with significant errors or lack of clarity.	Created an entangled Bell state using Cirq and ran it on the Quokka device. Applied the necessary gates to generate the specified Bell state with minor errors. Generated results with some errors or limited clarity.	Successfully created an entangled Bell state using Cirq and executed it on the Quokka device. Accurately applied the necessary gates to generate the specified Bell state. Generated the correct results and demonstrated a deep understanding of the process. Presented the results clearly and comprehensively.
Qiskit circuits	35%	The project is unable to generate the specified circuit or measure the output accurately, indicating a significant failure to execute the core task of the project. Major errors are present in circuit generation and output measurement, demonstrating a fundamental failure in implementing quantum computing concepts. The project demonstrates a fundamental lack of understanding of the task, indicating a severe deficiency in comprehension of quantum computing principles.	Unable to generate the specified circuit or measure the output accurately. Major errors in circuit generation and output measurement. Demonstrates a fundamental lack of understanding of the task.	Attempted to generate the specified circuit using Qiskit but with major errors or missing components. Measured the output on a Quokka device with significant inaccuracies. Attempted to create a QASM script for a unique circuit with major errors. Measured the output of the custom circuit with significant inaccuracies.	Generated the specified circuit using Qiskit with minor errors. Measured the output on a Quokka device with minor errors or limited clarity. Created a QASM script for a unique circuit with some errors. Measured the output of the custom circuit with some errors or limited clarity.	Successfully generated the specified circuit using Qiskit. Measured the output on a Quokka device accurately and presented it clearly. Created a QASM script for a unique circuit, demonstrating creativity and understanding. Measured the output of the custom circuit accurately and presented it clearly.

Investigate a Quantum Code	25%	The project is unable to complete the code or provide meaningful analysis, indicating a significant failure to execute the core task of the project. Major errors are present in code completion and there is a lack of documentation, demonstrating a fundamental failure in implementing coding concepts. The project demonstrates a fundamental lack of understanding of the task, indicating a severe deficiency in comprehension of coding principles.	Unable to complete the code or provide meaningful analysis. Major errors in code completion and a lack of documentation. Demonstrates a fundamental lack of understanding of the task.	Completed the code with major errors or missing instructions/comments Conducted a limited analysis of the code and its functionality. Provided a Word document with limited information about the code, gameplay dynamics, and circuit generation process. Described various quantum gates with significant inaccuracies.	Completed the provided code with minor errors in instructions and comments. Conducted a satisfactory analysis of the code and its functionality. Provided a Word document explaining most aspects of the code, gameplay dynamics, and circuit generation process. Described various quantum gates with some accuracy.	Successfully completed the provided code with accurate instructions and comments. Conducted an in-depth analysis of the code and its functionality. Provided a comprehensive Word document explaining the code's purpose, functionality, gameplay dynamics, and circuit generation process. Explored and described various quantum gates with precision.
Machine Learning Quantum Analysis	15%	The project is unable to effectively analyse, execute, or modify the code, indicating a significant failure to perform key tasks. Major errors are present in all aspects of the task, demonstrating a fundamental failure in understanding and application. The project demonstrates a fundamental lack of understanding of the task, indicating a severe deficiency in comprehension and execution.	Unable to effectively analyse, execute, or modify the code. Major errors in all aspects of the task. Demonstrates a fundamental lack of understanding of the task.	Attempted to analyse the code but with major errors or omissions. Executed the code with significant inaccuracies and limited understanding. Modified the code for local execution with major errors and provided minimal documentation. Compiled a report with limited information and understanding.	Analysed the code with some accuracy, focusing on the circuit and problem formulation. Executed the code with minor errors, monitored the output, and created acceptable plots. Successfully modified the code for local execution and documented some disparities in performance. Compiled a report summarizing most tasks with satisfactory clarity.	Analysed the code thoroughly with a focus on the circuit component and problem formulation. Executed the code accurately, monitored the output, and created plots as required. Successfully modified the code to run on a local machine and documented disparities in performance. Compiled a comprehensive report summarizing all tasks with clarity and insight.

Note: *The ranges for each grade level encompass the full 11-point grading system as outlined in the accompanying table. Please refer to the table for detailed percentage ranges associated with each letter grade.*