Cardiff School of Computer Science and Informatics
Coursework Assessment Pro-forma

Module Code:	CMT304
Module Title:	Programming Paradigms
Lecturer:	Frank C. Langbein
Assessment Title:	Quantum Computing
Assessment Number:	3 of 3
Date Set:	21st March 2022
Submission date and Time:	2nd May 2022 at 9:30am
Return Date:	30th May 2022

Note that there has been a change to the CMT304 module as announced by the module leader at the start of spring term. This means that there is only one portfolio coursework this term. So in total there are only three parts of the portfolio coursework and this is the third and last part.

This assignment is worth $1/3$ of the total marks available for this module. If coursework is submitted late (and where there are no extenuating circumstances):

1. If the assessment is submitted no later than 24 hours after the deadline, the mark for the assessment will be capped at the minimum pass mark;
2. If the assessment is submitted more than 24 hours after the deadline, a mark of 0 will be given for the assessment.

Your submission must include the official Coursework Submission Cover sheet, which can be found here:
`https://docs.cs.cf.ac.uk/downloads/coursework/Coversheet.pdf`

Submission Instructions

All submissions must be via Learning Central. Upload the following files in a **single zip file**, `[student number].zip`:

Description		Type	Name
Cover Sheet	**Compulsory**	One PDF (.pdf) file	`[student number].pdf`
Report	**Compulsory**	One PDF (.pdf) file	`report.pdf`

Any deviation from the submission instructions above (including the number and types of files submitted) may result in a mark of zero for the assessment or question part.

Staff reserve the right to invite students to a meeting to discuss coursework submissions.

Your submissions will be checked for plagiarism. Your work must be your own and you must independently solve the problem and submit your own solution. Any other material or sources of information you use must be referenced. Code and text you submit will be compared with other submissions and various other sources on and

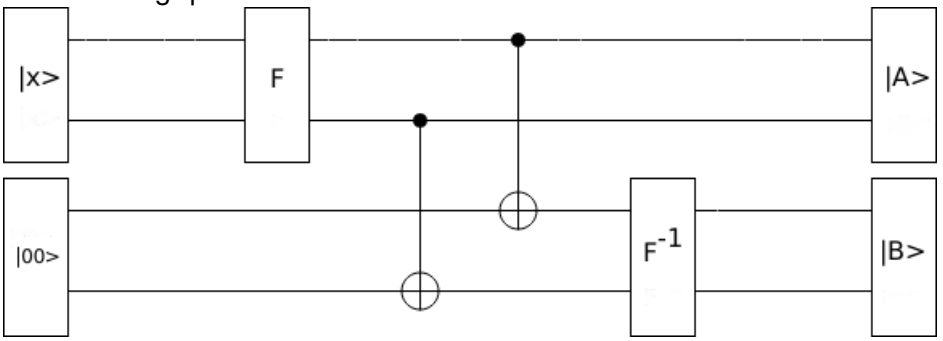
off the Internet. Any substantial similarities of your submission to unreferenced work or material not created by yourself will be subject to academic misconduct procedures. Marks will only be assigned for work you have done yourself (incl. finding and discussing material from references, but not the referenced work).

Background

This is assignment **three** of a portfolio that will be composed of **three** assignments. Each of the three assignments is worth $1/3$, summing up to 100% of the total marks available for this module.

Assignment

Consider the following quantum circuit:



It consists of two CNOT gates in the middle of the circuit. The two-qubit input quantum register $|x\rangle$ is in some arbitrary quantum state that forms its input and can be set by the user. The other two-qubit input quantum register $|00\rangle$ is in the ground state. The gate F is an unknown quantum operation (this means it is an arbitrary, but fixed gate on two qubits, but you do not know what it does). The gate F^{-1} computes the inverse operation of F.

1. Analyse the operation of the circuit to determine what the values of the two three-qubit output quantum registers $|A\rangle$ and $|B\rangle$ are, depending on the properties of F and $|x\rangle$. Clearly justify your answer.
2. Explain how you could, if possible, determine the operation of the gate F from this circuit (you can execute the circuit as many times as you wish). Furthermore, discuss what this means for the difference between quantum computing and a classical computing paradigm of your choice (working with bits instead of qubits).

Answers should be provided in a report of up to 500 words. The word limit is an upper limit, not a target length. Text longer than the word limit may be ignored.

Learning Outcomes Assessed

- Explain the conceptual foundations, evaluate and apply various programming paradigms, such as logic, functional, scripting, filter-based programming, pattern matching and quantum computing, to solve practical problems.
- Discuss and contrast the issues, features, design and concepts of a range of programming paradigms and languages to be able to select a suitable programming paradigm to solve a problem.

Criteria for assessment

The maximum marks for this part are 100, assessed according to the following scale:

Fail	0	No document has been submitted.
	$1-19$	The circuit operation has not been identified correctly and the justification is not correct. There is no discussion of how to identify F and the related difference between classical and quantum computing.
	$20-49$	There is a discussion of the circuit operation that shows some insights, but the operation is not correctly identified and the justification is incomplete. The approach of how to identify F shows some insights, but is not suitable and failed to consider the related differences between classical and quantum computing.
Pass	$50-59$	The circuit operation has been correctly identified, with some mistakes, and the justification shows some understanding of the involved quantum operations. The approach of how to identify F points in the direction, but incompletely considers related classical as well as quantum computing concepts.
Merit	$60-69$	The circuit operation has been correctly identified, depending on F and $\|x\rangle$, and the justification is suitable, even if there are minor mistakes or incomplete arguments. The approach to try to identify F is suitable and well explained, but it focuses mainly on either the quantum or the classical computing context.
Distinction	$70-100$	The circuit operation has been correctly identified, depending on F and $\|x\rangle$, and the justification is complete. The report shows a clear understanding of the quantum operations and cases involved that create the full operation. The approach to identify F, where possible, is suitable, fully explained, and clearly considers the related differences between classical and quantum computing.

Feedback and suggestion for future learning

Feedback on your coursework will address the above criteria. Feedback and marks will be returned on the 30th of May 2022 via Learning Central. This will be supplemented with oral feedback on request.