Assessment Proforma 2024-25

Key Information

Module Code	CM2207
Module Title	Introduction to the Theory of Computation
Module Leader	Dr Richard Booth
Module Moderator	Dr Nico Potyka
Assessment Title	Problem Solving Sheet
Assessment Number	1 of 2
Assessment Weighting	50%
Assessment Limits	

The Assessment Calendar can be found under ‘Assessment & Feedback’ in the COMSC-ORG-SCHOOL organisation on Learning Central. This is the single point of truth for (a) the hand out date and time, (b) the hand in date and time, and (c) the feedback return date for all assessments.

Learning Outcomes

The learning outcomes for this assessment are as follows:

- Use standard methods for proving mathematical properties.
- Demonstrate an understanding of formal languages and automata.

Submission Instructions

The coversheet can be found under ‘Assessment & Feedback’ in the COMSC-ORG-SCHOOL organisation on Learning Central.

You are required to answer 2 multi-part questions on Finite Automata, Regular Languages and Context-Free Languages, as described in detail in the attachment. The answers should be submitted as a single pdf file.

All files should be submitted via Learning Central. The submission page can be found under ‘Assessment & Feedback’ in the CM2207 module on Learning Central. Your submission should consist of two files:

Description		**Type**	**Name**
Coversheet	Compulsory	One PDF (.pdf) file	Coversheet.pdf
Answers to all question parts	Compulsory	One PDF (.pdf) file	[student_number].pdf

Any deviation from the submission instructions above (including the number and types of files submitted) may result in a reduction in marks for the assessment.

If you are unable to submit your work due to technical difficulties, please submit your work via e-mail to comsc-submissions@cardiff.ac.uk and notify the module leader.

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

Assessment Description

The 2 questions are described in detail in the attachment.

Assessment Criteria

Credit will be awarded against the following criteria.

• [Correctness] Do the answers correctly address the requirements of each task?

• [Clarity] Are explanations and summaries easily understandable?

• [Understanding of concepts] Do the answers show an understanding of basic concepts?

Indication of level of attainment:

High 1st 80%+	Students in this range demonstrate an exceptional grasp of concepts, with justifications for answers being both clear and convincing. All questions meet, and exceed, the minimum requirements. Results from module notes are applied appropriately and clearly. The assessment is entirely free from errors and answers adhere strictly to the specific form required where necessary.
1st 70-79%	Students who achieve First Class scores provide convincing justifications for their answers. They have a comprehensive understanding of the concepts and their applications. The assessment is largely free from errors. Results used from the module notes are stated clearly and applied correctly. Minimum requirements have been met and exceeded in most areas.
2.i 60-69%	Upper Second Class students demonstrate a substantial understanding of concepts but may lack depth in a few areas. Justifications for answers are usually clear and fairly convincing. The attempt is mostly error-free, and most requirements are adhered to. They have applied and cited findings from their module notes correctly.
2.ii 50-59%	These students have an adequate understanding of concepts. Justifications are provided but may not always be clear or convincing. There are a few errors in the assessment, and some requirements

	might not be fully met. Uses of results from module notes are appropriate but may not be thoroughly stated.
3rd 40-49%	In this bracket, students have a basic understanding of concepts. Justifications for answers lack clarity and are not always convincing. The assessments contain numerous errors and may fail to meet some requirements. While results from module notes may be used, they may not be correctly applied or stated.
Marginal Fail 30-39%	Students in this category have failed to adequately demonstrate understanding of key concepts. Their justifications for answers lack coherence. The assessment contains significant errors and fails to meet many of the requirements. Evidence of results used from module notes is scant or improperly applied.
Fail 0-29%	Students at this level have a poor grasp of key concepts. Justifications for answers are unclear or absent. The assessment may be riddled with errors and fails to meet most, if not all of the requirements. Evidence of using results from module notes is barely visible or incorrectly applied.

Help and Support

Questions about the assessment can be asked on the Discussion Board on the module's Learning Central pages, or via email to the module team.

Feedback

Feedback on your coursework will address the above criteria. Feedback and marks will be returned on 8/4/2023 via Learning Central.

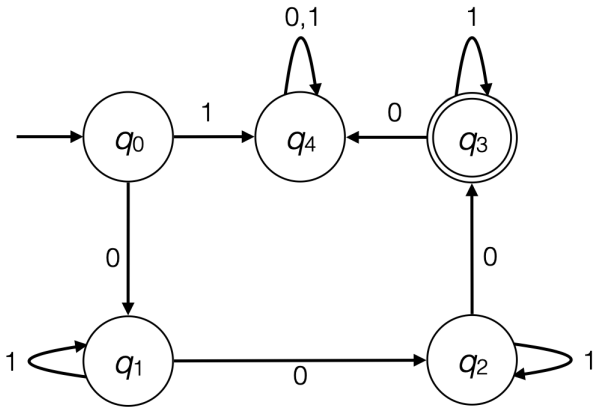
Feedback from this assignment will be useful for CM2207 Problem Sheet 2, as well as related 3rd year modules CM3109 (Combinatorial Optimisation) and CM3112 (Artificial Intelligence).

CM2207 Problem Sheet 1
Spring semester 2025

ANSWER ALL PARTS OF BOTH QUESTIONS. Each question is worth 25 marks and the number of marks available for each question part is indicated.

Question 1: Finite Automata and Regular Languages

(a) The following is a state diagram of a deterministic finite automaton (DFA) M_1:



(i) Give a formal description of M_1, writing down clearly the set of states, alphabet, transition function, start state and accept states of M_1. [3]

(ii) What sequence of states (including the start state) does M_1 go through on input `0010`? [1]

(iii) Describe in plain English the language recognised by M_1? [2]

(iv) Give an NFA to recognise the language A^*, where $A = L(M_1)$. [4]

(b) Consider the regular expression $((\epsilon \cup \mathtt{0})\mathtt{1}^+)^*$.

(i) Write down exactly one string of length 5 that does **not** belong to the language described by this regular expression. [1]

(ii) Describe in plain English, and as succinctly as possible, the set of strings being described by this regular expression. [2]

(c) For the following question part you may assume the following true fact as given:

> **Fact:** *Given an NFA $D_1 = (Q_1, \Sigma, \delta_1, q_0, F_1)$ that recognises language B and an NFA $D_2 = (Q_2, \Sigma, \delta_2, r_0, F_2)$ that recognises language C, there is a way to construct an NFA that recognises $B \cap C$.*

(i) Show that the following statement is true:

> *For any languages B, C, if there is a regular expression representing B and a regular expression representing C then there is a regular expression representing $B \cap C$.*

You must justify your answer, clearly stating **in full** any results from the lecture notes that you rely on in your explanation. (Facts used that were given in the lecture notes may be stated without reproducing their proof.) [5]

(ii) Suppose we are given languages $A_1, A_2, \ldots, A_i$ such that there is a regular expression describing each of them. Is there a regular expression describing $A_1 \cap A_2 \cap \ldots \cap A_i$? Justify your answer by giving a proof, clearly stating which proof strategy, or strategies, from the module you have used for your proof. [7]

Question 2: From Regular to Context-free Languages

(a) Assume $\Sigma = \{0, 1\}$ and let A be the following language

$$A = \{0^n 110^m \mid n + 4 < m\}.$$

(So A contains strings such as 1100000, 011000000, 00110000000, etc.) Is the following statement true or false?:

A is a regular language.

Justify your answer, clearly stating **in full** any result from the lecture notes you use. [8]

(b) Let G_1 be the following context-free grammar:

$$\begin{array}{lcl} S & \rightarrow & \mathtt{a}S\mathtt{c} \mid B \\ B & \rightarrow & \mathtt{b}B\mathtt{c} \mid \epsilon \end{array}$$

(i) What are the variables, terminals and start variable of G_1? [3]

(ii) Write down a derivation from G_1 of the string abcc. [4]

(iii) What is the language generated by G_1? [3]

(c) Explain the relationship between regular languages and context-free languages. Specifically, your answer should discuss whether the following two claims are true: (i) *every regular language is a context-free language*, and (ii) *every context-free language is a regular language*. Your answer should be based on statements and results mentioned in the lecture notes, which should be re-stated **in full**. [4]

(d) Let B be the set of all strings formed by writing n occurrences of a followed by m occurrences of b followed by m occurrences of c followed by $2n$ occurrences of d, where n is greater than or equal to zero, and m is strictly greater than zero. Examples of strings in B would be bc, abcdd, aabcdddd, abbbcccdd. Examples of strings not in B would be abcd, bcd, abbcdd, adbc, the empty string ϵ.

Show that B is a context-free language.

Any definitions, theorems or propositions from the lecture notes that you rely on in your answer must be clearly stated **in full**. [3]