

FIT1047 Introduction to computer systems, networks and security – S1 2023

Assignment 1 – Numbers, Encodings and Boolean Logic

Purpose	Number representations and Boolean circuits are at the core of all computer systems and programs. In this assignment, you will demonstrate your knowledge of number systems, character encodings and that you can construct and simplify Boolean formulas and circuits. The assignment relates to Unit Learning Outcomes 1 and 2.
Your task	Complete the individual tasks as detailed in the instructions below. You need to submit a document that details your workings, as well as Logisim files for the resulting circuits.
Value	15% of your total marks for the unit The assignment is marked out of 45 marks.
Word Limit	No overall word limit (see instructions for word limits of individual tasks)
Due Date	11:55 pm Friday 24 March 2023
Submission	<ul style="list-style-type: none">• Via Moodle Assignment Submission.• Turnitin will be used for similarity checking of all submissions.• This is an individual assignment (group work is not permitted).• Handwritten work is not accepted.• DRAFT submission is not assessed.• Logisim circuits will be assessed using version 3.8.0 or 3.7.2 (link is in Moodle).• In this assessment, you must not use generative artificial intelligence (AI) to generate any materials or content in relation to the assessment task.
Assessment Criteria	Marks are awarded for the <i>correctness</i> of the calculations, the <i>explanations</i> of how the tasks were solved, and the documentation of <i>test cases</i> where required. The instructions contain an individual marks breakdown for these components.
Late Penalties	<ul style="list-style-type: none">• 10% deduction per calendar day or part thereof for up to one week• Submissions more than 7 calendar days after the due date will receive a mark of zero (0) and no assessment feedback will be provided.
Support Resources	See Moodle Assessment page
Feedback	Feedback will be provided on student work via: <ul style="list-style-type: none">• general cohort performance• specific student feedback ten working days post submission

INSTRUCTIONS

This assignment has two parts. Make sure you read the instructions carefully.

You need to submit two files through the Moodle Assignment activity:

- 1) A document with the answers to the questions and your workings.
- 2) A separate .zip archive with the Logisim files for Part 2 along with your individualised assignment specification.

Part 1: Number Systems and Character Encodings (15 marks)

In this part of the assignment, you will demonstrate your knowledge of number systems, character encodings and conversion between different systems.

Follow the link on Moodle to access your personalised character encoding table.

Important: Your encoding table is different from the one other students are working with. Only download the file while you are correctly logged into Moodle with your own student account.

Task 1.1 Character encodings (6 marks)

Look up the first three letters of your last name (use upper case for the first letter followed by lower case for the rest) in the given encoding table¹. Each letter in the encoding table is mapped to a hexadecimal number. Convert the hexadecimal numbers into 7-bit (unsigned) binary, decimal and octal and produce a table like this:

Character	Hex	Decimal	7-bit Binary	Octal
(1st character)				
(2nd character)				
(3rd character)				

Show your working.

Task 1.2 Upper case to lower case and lower case to upper case (9 marks)

You will now need to swap the case of two of the characters from Task 1.1. This means that upper-case characters now become lower-case characters, and the other way around.

1.2.1: Describe the arithmetic operations that need to be performed to convert from upper case to lower case and from lower case to upper case, based on the concrete character encoding table that you have been given. (3 marks)

¹ If your last name only has two letters, add the first letter of your first name. Use the names as registered in the Monash system, i.e., using only English alphabet characters.

1.2.2: Use 8-bit two's complement arithmetic to perform the conversion from upper-case to lower-case for the first character of your last name, and from lower-case to upper-case for the second character. (3+3 marks)

Show your working.

Correct result: 3 marks. Working: 3 marks.

Part 2: Boolean Algebra (30 marks total)

Follow the link on Moodle to access your personalised truth table for this task.

Important: Your truth table is different from the one other students are working on. Only download the file while you are correctly logged into Moodle with your own student account.

The truth table you download describes a Boolean function with four input values x_1, x_2, x_3, x_4 and two output values z_1, z_2 .

The main result of this part will be a logical circuit correctly implementing this Boolean function in the Logisim simulator.

Each task below needs to be documented and explained.

Task 2.1: Boolean Algebra Expressions (10 marks)

Write the Boolean function as Boolean algebra terms using the Sum of Product (SOP) form. First, think about how to deal with the two outputs. Then, describe each single row in terms of Boolean algebra. Finally, combine the terms for single rows into larger terms.

Briefly explain these steps for your particular truth table (e.g., explain for one particular row how you come up with the Boolean terms for that row, and then explain how you combine all rows). This explanation should be no more than a few sentences.

Also write the Boolean function as Boolean algebra terms using the Product of Sum (POS) form with brief explanation of steps (e.g. how you combine all rows).

Correctness of the result: 7 marks (marks will be deducted for individual errors)

Explanation: 3 marks

Notation: Use the following symbols and notation for writing Boolean algebra expressions. Variables are upper-case (e.g., X_1, Z_2). Boolean AND is written without a symbol, e.g. X_1X_2 . Boolean OR is written with the + symbol, e.g. $X_1 + X_2$. Negation is written using an overline, e.g. $\overline{X_1}$. **Important:** when writing terms like NOT X_1 AND NOT X_2 , there must be a clear gap in the overlines, e.g. $\overline{X_1} \overline{X_2}$. Tip: **you can use the equation function in Word or Google Docs to create overlines.**

Task 2.2: Logical circuit in Logisim (10 marks)

Model the resulting Boolean terms (using SOP form) from Task 2.1 in a single Logisim circuit, using only the basic gates AND, OR, NOT. You can use gates with more than two inputs. **See the template on the next page for how to structure your circuit.**

Briefly explain your construction (as for Step 1, a short explanation is enough).

Test your circuit using values from the truth table and document at least 3 test cases. You can take screenshots of your Logisim window to document the tests.

Correctness of the circuit: 5 marks (marks will be deducted for individual errors)

Explanation: 2 marks

Test cases: 1 mark per documented test case

Task 2.3: Optimised circuit (10 marks)

The goal of this task is to find a **minimal** circuit using only AND, OR, and NOT gates. Based on the truth table and Boolean algebra terms from Step 1, optimise the function **using Karnaugh maps**.

You will need to create two Karnaugh maps, one for each output. Your documentation must show

- 1) the maps,
- 2) the groups found in the maps
- 3) the reduced Boolean functions derived from the maps and how the maps relate to terms in the optimised Boolean functions.

Then **use Logisim to create a minimal circuit**, using only AND, OR, and NOT gates.

Test your optimised circuit using values from the truth table and **document your tests**.

Correctness of Karnaugh maps: 4 marks (2 for each map, marks will be deducted for individual errors)

Documentation of groups and reduced Boolean functions: 4 marks

Logisim circuit and documentation: 2 marks

Logisim Template

Structure your circuits as shown in the Logisim diagram below.

