MONASH University

FACULTY OF INFORMATION TECHNOLOGY

FIT1047 Introduction to computer systems, networks and security – Oct 2022

Assignment 1 – Numbers 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, 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 18 November 2022**
Submission	• 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 2.14.6 (link is in Moodle).
Assessment Criteria	Marks are awarded for the *correctness* of the calculations, the *explanations* of how the tasks were solved, and the documentation of *test cases* where required. The instructions contain an individual marks breakdown for these components.
Late Penalties	• 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: • 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 .pdf document with the answers to the questions and your workings.**
2) **A separate .zip archive with the Logisim files along with your Truth Table for Part 2.**

Part 1: Number Systems (15 marks)

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

Task 1.1 Representing numbers in binary (9 marks)

Explain briefly (at most 200 words):

- the advantages and disadvantages of scientific notation (floating point representation).
- critically compare different binary representations of numbers: sign-and-magnitude, one's complement and two's complement.

Marks (for each representation):
Correct, with both advantages and disadvantages: 3 marks
Critical analysis: 6 marks

Task 1.2 Converting to hexadecimal (6 marks)

Encode your **negated** student ID number (for example, if student ID is 1234567 then use -1234567, which is a signed integer in Base 10):

- as a 32-bit two's complement binary number, and
- represent this 32-bit two's complement binary number in hexadecimal notation.

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 access this 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 `X1,X2,X3,X4` and two output values `Z1,Z2`.

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. 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.

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., `X1,Z2`). Boolean AND is written without a symbol, e.g., `X1X2`. Boolean OR is written with the + symbol, e.g., `X1+X2`. Negation is written using an overline, e.g., $\overline{X1}$. **Important:** when writing terms like NOT X1 AND NOT X2, there must be a clear gap in the overlines, e.g., $\overline{X1}\ \overline{X2}$. **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 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.