**Study Period 3, 2021 - CPT160**

**Introduction to Computer Systems and Platform Technologies**

# Assignment 1 – Worth 25% (250 marks)

## Due: 23:59 (AEST) on Sunday, 17'th October 2021, Week 7

## Note: Citations / References / Bibliography 20 marks

Some questions of this assignment require independent research. All references used (books, websites, etc.) must be disclosed in your submission. This may be done either through providing citations throughout your work, or by including a list of references / bibliography at the end of the document. Read and follow all the instructions carefully. Failure to do so is not grounds for extensions.

**Plagiarism:**

This is an individual assignment and must be your own work. Plagiarism is a very serious offence. **All assignments will be checked with plagiarism-detection software**

Plagiarism in oral, written, or visual presentations is the presentation of the work, idea or creation of another person, without appropriate referencing, as though it's one's own. Plagiarism is not acceptable and may result in charges of academic misconduct, which carries a range of penalties. It is also a disciplinary offence for students to allow their work to be plagiarised by another student.

## Research, Collaboration and Academic Integrity

There is a research component to this assignment:

- Any direct references, figures, or quotes used must be cited, and
- A bibliography should be included as an appendix at the end of your report.

We will not accept citations from any encyclopedic resource, e.g., Encyclopedia Britannica, Encarta, World Book, Wikipedia (or syndication thereof), and so on.

You may share and discuss any links and references you find relevant to completing this assignment on the discussion forums, so long as you include how you found the resource that you mention.

You are free to refer to textbooks, notes, work in study groups etc. to discover approaches to problems; however, the assignment should be your own individual work.

*Do not ever simply copy and paste what another writer has written. This is stealing. What we need is your own words – your own understanding. If you try to represent someone else's work as your own it will be dealt with severely. Instead, we want you to paraphrase what others have said – to put the concepts they have discussed into your own words.*

When preparing a report such as this it is almost impossible to prepare an accurate report without referring to some resources for assistance to complete the tasks. For this reason, we ask you to reference from where you get your information. We require these references to be formally correct according to one of the standard styles used in research. For example, either the APA or Harvard styles would be acceptable. See the RMIT library reference guides (https://www.rmit.edu.au/library/study/referencing) for further details.

Let us say that I want to use the ideas in the following paragraph to explain bit depth as it relates to images:

> *"Bit depth refers to the colour information stored in an image. The higher the bit depth of an image, the more colours it can store. The simplest image, a 1-bit image, can only show two colours, black and white. That is because the 1 bit can only store one of two values, 0 (white) and 1 (black). An 8-bit image can store 256 possible colours, while a 24-bit image can display about 16 million colours."*

The above paragraph was taken from the website:
http://etc.usf.edu/techease/win/images/what-is-bit-depth/

The first step might be to paraphrase the information about – that is to put the information above into your own words, such as:

> *Bit depth signifies how many colours that can be represented in an image – the more bits per pixel the wider the range of colours (Techease, 2020)*

This would then be cited in your reference list as:

*Techease, 2020, "What is bit depth?" Retrieved from http://etc.usf.edu/techease/win/images/what-is-bit-depth/ at 7 pm on Saturday 11th July, 2020.*
You would reference this citation similarly in the bibliography.

Please note that we require you to have both a reference list and a bibliography. The difference between these two resources is that the bibliography lists all documents that you have read that have contributed to your submission whereas the reference list only lists those documents you have actually cited in the text of your report.
Also, with the exception of very short quotes (less than a line) we require you to put the content in your own words – we are assessing you on your understanding of the course content, after all. If you quote directly from a source, please ensure that the quote is within "talking marks" such as the ones I have just used. Whether you quote directly from a source or paraphrase the source (as I have done above) you still need to cite the source and ensure the source is included in the reference list and bibliography.

**Extensions:**
If you want to seek an extension of time for assignment submission, you must have a substantial reason for that, such as unexpected circumstances. Reasons such as, unable to cope with study load, is not substantial.

Also, you must apply for an extension as soon as possible. Last minute extensions cannot be granted unless it attracts special consideration

Any student wishing an extension must go through the official procedure for applying for extensions and must apply at least a week before the due date Do not wait till the submission due date to apply
for an extension.

**Submission:**
Prepare the answers to this assignment in an electronic format and convert to a single Acrobat PDF
(.pdf) file for submission. Paper submissions are not accepted; if some parts of the assignment have been completed by hand, scan these in and include this in your electronic submission.

This assignment must be submitted electronically via Canvas. Further instructions are at the end of this document.

**Penalties:**
Submission files not in the required format will incur. a penalty of 10% per day of the total available marks will apply for each day being late. After 5 days, you will receive zero mark for the assignment.

**Please find out how to apply for special consideration online at**
https://www.rmit.edu.au/students/student-essentials/assessment-and-results/special-consideration/eligibility-and-how-to-apply

Any student wishing an extension must go through the official procedure for applying for extensions and must apply at least a week before the due date. Do not wait till the submission due date to apply for an extension.

The rubric can be found in Canvas -> Assignments ->Assignment 1

## Task 1 - Number Systems (30 marks)

Give answer to the following questions, show all your working out and intermediate steps. For the questions (a) to (d), use the last four digits of your student number. For example, if your student number is "s1234567", then use X=4567 for this question. **If any of these digits is a "0", use 9 instead.**

a) (5 marks) Convert X from decimal to binary.

b) (2+3 marks) Convert the binary string obtained from your answer to (a) into octal and hexadecimal.

c) (5 marks) Convert X from decimal to base 14, where A, B, C and D correspond to 10, 11, 12 and 13 respectively.

d) (1.5 + 1.5 +2 = 5 marks) Now add $42_{10}$ (42 in decimal) to X and calculate the sum in base 14. Consider the following two calculations:

i. Conversion (base 14 to decimal) before addition (in base 14): convert $42_{10}$ into base 14, then add the two base 14 numbers.

ii. Addition (in decimal) before conversion (decimal to base 14): add $42_{10}$ to X in decimal, then convert the decimal sum into base 14.

Which calculation is simpler? Please explain your answer. How many digits are different from your answer to (c)?

e) (10 marks) Consider a base 26 number system wherein the letters of the alphabet are the digits.

That is, **A=0, B=1, C=2, … Z=25** in base 10.
Use **the first three letters** of your given name as a number in the base 26 system, and the **first three letters** of your surname as another number in the base 26 system.

Add these numbers together to obtain the sum in based 26.
Note:
*If your given name has letters less than two, repeat the first letter (e.g. L becomes LLL).*
*Then a similar way is applied for your surname.*

*Example 1 — if your first name is "Peter" and your surname is "Pan", then add up $PET_{26}$ and $PAN_{26}$, and show the sum in base 26.*
*Example 2 — if your first name is "Peter" and your surname is "Pa", then add up $PET_{26}$ and $PAA_{26}$, and show the sum in base 26.*

## Task 2 - Binary Addition and Subtraction (25 marks)

Please answer the following questions**, showing all your working out and intermediate steps**. For this question, use the last two digits of your student number. (For example, if your student number is "s1234567", then A=7 and B=6) **If either of these digits is a "0", use 9 instead.**

a) (10 marks) Convert the decimal numbers A and B to 4-bit binary numbers. Show how to add together these two 4-bit binary numbers and state whether the answer is valid to 4-bit arithmetic.

b) (15 = 10+5 marks) Convert the decimal numbers A and B to 5-bit binary numbers. Using two's complement representation, show how to:

i. Subtract the two 5-bit binary numbers (−A−B)

**ii.** How to translate the binary result back to decimal.
**(Note if your solution is negative, you must use 2's complement to show the positive equivalent)**

## Task 3 - Bitwise Operations (20 marks)

The bitwise operators AND, OR, and XOR are used to do bit-masking; that is,

- *set* (make 1), *reset* (make 0), *invert (toggle or flip)* (from 0 to 1, or from 1 to 0) a bit (or bits) in a byte (or word).
- *Bit masks* are strings of bits that allow for a single bitwise operation on a bit (or bits).

Commonly a bit string is 8 bits long (referred to as a *byte*). Conventionally, the bits in a bit string are indexed from 0 staring with LSB. Let A = XXXX $XXXX_2$, where each X is a unique bit (0 or 1).

| Byte A | X | X | X | X | X | X | X | X |
|---|---|---|---|---|---|---|---|---|
| Bit Position | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |

For bit-wise operations, let us consider a bit string, e.g., A = 1111 $0000_2$. We will number these bits from 0 to 7, starting from LSB. Now, suppose we want to ensure that bit 7 in A is reset (i.e., made 0).

All the other bits are left untouched. For this purpose, we now must first create a bit-mask M and select an appropriate bitwise operator O. In this example, we create our mask M as 0111 1111 and select the bitwise operator O as AND. Now we perform the operation:

A AND M = 1111 $0000_2$ AND 0111 $1111_2$ = 0111 $0000_2$

Solve the following problems by finding the appropriate bitmask M and bitwise operator O**. You can also choose more than one mask and operator, such as M1, O1 and M2, O2.**
Show all your working out and intermediate steps and use A = XXXX $XXXX_2$ with your mask(s) and operator(s)**:**

a) (4 marks) Reset bit 0, bit 7 and leave the rest untouched.

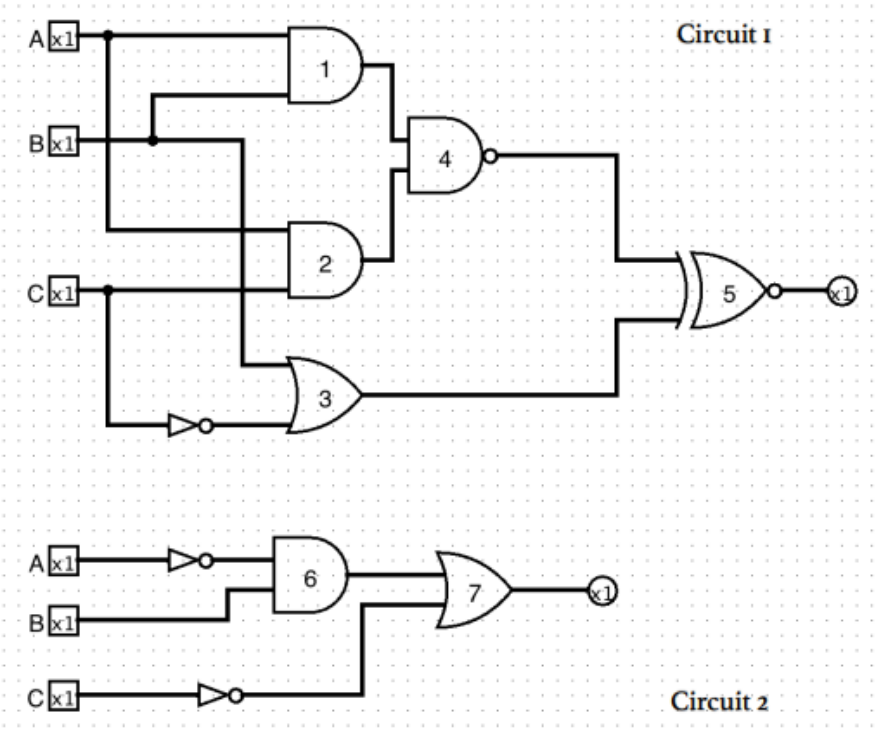
b) (8 marks) Make sure that bit 2 and bit 6, and only these, are reset, the others are set.

c) (8 marks) Toggle the values of the middle 4 bits (the opposite of what they are currently) and set the 2 bits on each side.

## Task 4 - Logic Circuits and Truth Tables (20 marks)

Solve problems related to the two circuits (note the circle is equivalent to a NOT gate) below:
Circuit 1 is the top circuit and Circuit 2 is the bottom one.

Circuit 1 is the top circuit and Circuit 2 is the bottom one.




(a) (4+2= 6 marks) Write down the equivalent logic expression (simplification is NOT required).

(b) (8+4 =12 marks) Write a truth table that shows the final output (O) for inputs A, B and C (Showing all your working out and intermediate steps, i.e., the output of each gate, in the truth table is a column).

(c) (2 marks) Compare the final output columns in these two truth tables. Do these two expressions give the same output?
Hence, are the 2 expressions equivalent?

## Task 5 - Pipelining (20 marks)

Robin, Bryan, Finchie, and Dan each have messages to send via carrier pigeon.

There are three ordered stages to sending a message via carrier pigeon:

1. 25 minutes of **Writing** the message
2. 10 minutes of **Fanning** the ink dry
3. 15 minutes of **Catching** and sending a pigeon

Notes: There is only one pen to share There is also only one fan (without it the ink will never dry) There are multiple pigeons but only one can be caught at a time (They startle easily) Fanning must happen before catching a pigeon (or it will fly off, startled)
**(Hint: Draw timeline diagrams to calculate the total times etc.,)**

a) (4 + 7 = 11 marks) How long does it take for all to send messages sequentially? How long does it take for all of them to send messages pipelined?

b) (4 marks) How and why does pipelining help with the throughput of entire workloads?
The workloads involved in sending 4 messages as described above, in comparison to sending 4 messages sequentially.

c) (2+3 marks) Can pipelining help reduce the latency of any one step in the 4 people sending a message scenario as described above?
Show how the pipeline rate is limited by the slowest pipeline stage.

**Task 6 – CPU Architecture (20 marks)**

Give your answer but do not copy and paste from the "Internet". Quote your references in your "References" / "Bibliography".

(a) (8 marks) Compare and contrast "multithreading" and "multiprocessing" in terms of hardware.

(b) (7 marks) Explain how threads are used by the CPU to process tasks by describing a modern example, e.g., the multi-core mobile phone that you use every day has an interesting organisation of threads.
However, it can be any other modern example of hardware that uses "threads".

(c) (5 marks) What is a warp in GPU architecture and what is the major constraint of its operation

**Task 7 - Memory (5 +5 + 5 +5 = 20 marks)**
**Please explain in your own words for each part of Question 7. Do not "copy and paste" from the "Internet". Quote your references in your "References" / "Bibliography"**

(a) Describe the main features of INTEL's "Optane Memory"?

(b) What are some of the claims made by the "Intel Marketing Department" regarding what Optane Memory provides.

DDR5 memory is the latest computer memory being developed and will eventually replace DDR4 memory.

(c) What are the maximum clocks speeds for DDR4 memory, and what is being proposed for DDR5.

(d) What is the current maximum throughput available for DDR4 and what is proposed for DDR5.

**Task 8 - Hamming & SECDED Code (5+20= 25 marks)**

(a) (5 marks) For data, using 4 Hamming code parity bits determine the maximum number of data bits that can be protected.

(b) A SECDED encoded character has been retrieved, with the hexadecimal value of $E76_{16}$. **You may assume that the SECDED parity is even.**

1. (1 + 4 marks) Was there an error in transmission? Explain your answer.

2. (15 marks) If there was an error, either correct it (reporting the corrected ASCII character) or explain why it could not be corrected (Show your Hamming/SECDED table).

# Advanced Questions (50 marks)

Question 9 — Advanced Question (50 marks) You need to attempt either 9.1 or 9.2 to be eligible for an **HD** for this assignment, **NOT BOTH**

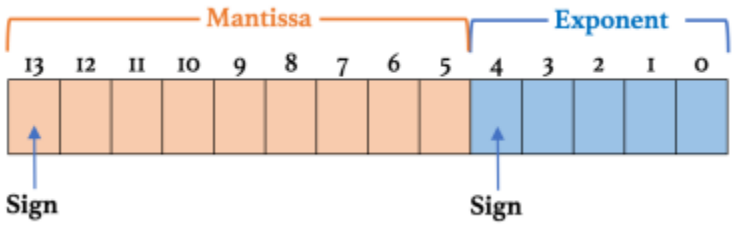
Note: The specifics of these questions have not been covered in lectures. It tests your ability to do independent research, as well as apply the concepts and ideas you have learned to a new situation. Please explain in your own words for each question. Do not "copy and paste" from the "Internet". Do not forget to cite your references.

## Question 9.1 Half-precision Floating-point Format (50 marks)

This is an advanced question

Do some research and find out how real (floating point) numbers are represented in Binary.

**(a)**. Consider the following 14-bit floating-point format, assume 9-bit mantissa, 5-bit exponent, and **the two's complement representation is used for both the mantissa and the exponent.**

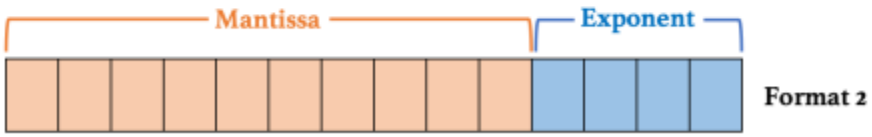



i. (6 marks) How would you encode the largest negative number (or the smallest number) and the smallest positive number using the given format?

ii. (6 marks) Show how to find their decimal equivalent. **Showing all your working out and intermediate steps**

**(b)** (4 marks)

Consider the following two floating point **formats with the same overall size but different size of the internal elements, the two's complement representation is used for both the mantissa and the exponent.**


i. (2 marks) Which format covers **a larger interval**? Which format provides **a higher accuracy**?

ii. (2 marks) Please explain your answer using a few sentences and discuss the trade-off between accuracy and range when representing real binary numbers.

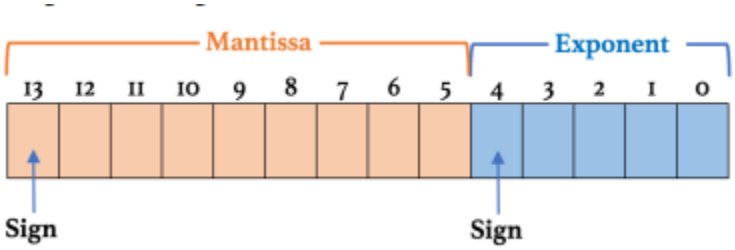
**(c ) For this question, use the last two digits of your student number**. If your student number is "s1234567", then A=7 and B=6.
**If either of these digits is a "0", use 9 instead.**

$x = A + B/10 = 7 + 6/10 = 7.6$

$y = B \div (A \times 10) = 6 \div (7 \times 10) = 0.0857$ (rounded to 4 decimal places)

**Showing all your working out and intermediate steps**

**i.** (6+6= 12 marks) Convert x and y into binary using the following normalised 14-bit floating-point representation, assume 9-bit mantissa, 5-bit exponent**, and the two's complement representation is used for both the mantissa and the exponent.**




ii. (10 marks) Show the various steps needed to add together the two numbers x and y in binary. Your result should be in the normalised form.

iii. (8 marks) Show the steps needed to convert the binary result obtained to the decimal equivalent.

iv. (4 marks) Did you lose precision/accuracy through addition? If so, discuss what is causing this "loss of precision" error. Discuss why “loss of precision” does not occur otherwise.

## Question 9.2 — Logic Simplification using Karnaugh Maps and Boolean Algebra (50 marks)

Do some research and find out how a Karnaugh map is used for reducing logic functions into minimal Boolean expressions.

a) (20 marks) Show in detail, how to use the K-map to simplify the logic expression of **circuit (1) in Question 4**.

b) (20 marks) Show in detail, how to use Boolean Algebra to simplify the logic expression of circuit (1) in Question 4.

c) (5 marks) Compare the above two simplification methods and discuss which is better: Boolean algebra or K-map?

d) (5 marks) What are the limitations of Karnaugh Maps? Explain with an example.

## How to Submit

You should submit your assignment via Canvas using the

Assignments > Assignment 1 Submission.

You may resubmit the assignment if you need to, only the most recent version will be marked.
(Note do not forget to submit references/bibliography at the end of your submission)