School of Science, RMIT University
COSC2473 Introduction to Computer Systems
Semester 2, 2020

# Written Assignment

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| Assessment Type | Individual Assignment |
| Due Date | Week 8, Friday 18th September 2020, 11:59pm |
| Marks | 300 marks = 30 % |

## Learning Outcomes

- describe some of the fundamental hardware building blocks of computer systems and some basic algorithms by which they are used
- demonstrate understanding of number systems, such as binary, octal, decimal and hexadecimal.
- use Boolean algebra to model basic algorithms in hardware using logic gates such as binary addition/multiplication, template pattern matching, stream encryption, data multiplexing,
- describe fundamentals of computer architecture and organization, operating systems, and system integration and deployment
- critically review and (re-)design existing computer system specifications for meeting stated performance criteria.
- Describe the layered networking model, basic networking protocols and ways in which data is encoded and transmitted

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## General Comments

This is an individual assignment (300 marks) that contributes 30% of the total assessment.

### Plagiarism

All assignments will be checked with plagiarism-detection software; any student found to have plagiarized would be subject to disciplinary action. Plagiarism includes submitting code that is not your own or submitting text that is not your own. Allowing others to copy your work is also plagiarism. All plagiarism will be penalized, there are no exceptions and no excuses. You have been warned.

### General Requirements

This section contains information about the general requirements that your assignment must meet. Please read all requirements carefully before you start.

1. A penalty of 10% per day of the total marks will apply for each day late, including weekend. After five days, you will receive zero marks.
2. If you want to seek an extension of time for assignment submission, you must have a substantial reason for that, such as unexpected circumstances (see more here: http://www.rmit.edu.au/browse;ID=kehn9bz22r41). Reasons such as, unable to cope with study load, is not substantial. 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.
3. Start each of the four sections below on a new page.

## 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 (http://www.rmit.edu.au/browse;ID=8rwjnkcmfoeez) 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 color information stored in an image. The higher the bit depth of an image, the more colors it can store. The simplest image, a 1-bit image, can only show two colors, 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 colors, while a 24-bit image can display about 16 million colors.

The above paragraph was taken from 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 colors that can be represented in an image – the more bits per pixel the wider the range of colors (Decease, 2015)

This would then be cited in your reference list as:

> Techease, 2015, "What is bit depth?", Retrieved from http://etc.usf.edu/techease/win/images/what-is-bit-depth/ on 8th March 2015 at 7.13pm.

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 cited in the text of your report.

Also, except for 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.

See more comments below about the specifics of a review in section 1.

## Submissions

Before you submit anything, please read through the assignment specifications again carefully. Check that you have followed all instructions. Also check that you have attempted all parts of all questions.

***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.***

## What Happens Next

You will receive your results by about two weeks in Canvas. If you didn't receive your marks or you have questions after you received your marks, please contact your tutor.

## Section 1 – Basic Math (30+25+15+30 = 100 marks)

Please answer the following questions, showing all your working out and intermediate steps.

1. Number Systems (30 marks)

    a. (8 marks) Convert the last four digits of your RMIT student number to binary, octal, and hexadecimal. For example, if your student number is "s1234567", then convert $4567_{10}$ to binary, octal, and hexadecimal.

    b. (7 marks) Convert the last four digits of your RMIT student number to base 13, where $10_{10}=A_{13}$, $11_{10}=B_{13}$, $12_{10}=C_{13}$.

    c. (15 marks) Consider a base 26 number system wherein the letters of the alphabet represent the digits. That is, $A_{26}=0_{10}$, $B_{26}=1_{10}$, $C_{26}=2_{10}$, … $Z_{26}=25_{10}$.

        i. Use the first three letters of your given name, and the first three letters of your surname, as numbers in the base 26 system. Add these two bases 26 numbers together to obtain the sum (in base 26). Show all your working out and intermediate steps. Note: If one of these has less than three letters, repeat the last letter, e.g. LI
        become LII.
        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.

2. Binary Addition and Subtraction (25 marks)

    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 marks) Convert the decimal numbers A and B to 5-bit binary numbers. Using two's complement representation, show

        i. (i) how to subtract the two 5-bit binary numbers (A-B);

        ii. how to translate the binary result back to decimal.

3. Bitwise Operations (15 marks)

    The bitwise operators AND, OR, and XOR allow for bits to be reset (to 0), set (to 1), and inverted (from 0 to 1, and from 1 to 0). Bit masks are strings of bits that allow for a

single bitwise operation on bits. Commonly a bit string is 8 bits long (referred to as a byte). Conventionally, bit strings are indexed from 0 staring with the rightmost digit.

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 |

Find the appropriate bitmask(s) M and bitwise operator(s) for ALL byte A for the following cases, showing all your working out and intermediate steps:

a. (7 marks) Reset the 2 bits on each side and make sure that only these 4 bits are reset in the byte.

b. (8 marks) Toggle the values of the middle 4 bits (the opposite of what it currently is) and set the 2 bits on each side.

4. Number Theory (30 marks)

The "Rule of 9's:" was an old-fashioned way of determining whether a number is divisible by 9. You simply add the digits, and if the result has more than 1 digit, then continue with this number until there is only 1 digit left. This digit shows 9 if the original number was divisible by 9, or if it is any number other than 9, it is the remainder of a division by 9.

For example: 63/9 = 6+3 = 9, so it is divisible. 52614/9 = 5+2+6+1+4 = 18, 1+8=9. If we add to to the previous number and repeat., 52646/9 = 5+2+6+1+6 = 20 = 2 remainder after division by 9. From this pattern, you should see that this would be true for any number.

The reason that this works is that 9 is 1 less than the number base. (There is a similar rule for 11 = number base +1)

Since 9=3x3, there is also a "Rule of 3's" which works the same way. E.g. 67251/3 = 6+7+2+5+1 = 21 = 2+1 = 3. So, it is divisible by 3.

Note that all these number theory rules like the above apply to a number in any number base.

a. (12 marks) Show that this works there exists a "Rule of 15's" for hexadecimal.

i. Talkie the last 3 digits of your user ID, and multiply by 15,

ii. Convert the result into hexadecimal,

iii. Perform hexadecimal addition of the digits until only 1 digit remains ($F_{16}$).

iv. Show that, as 15=3x5, the same rule applies for 3 and 5 as well by repeating the above using 3 and 5 as divisors.

b. (6 marks) Repeat the above using your ID as before, using Octal, where there is a "rule of 7's". There are no subfactors, as 7 is a prime number.

c. (12 marks) Do some research and find out how to determine if a number is divisible by 11. This rule is also based on the number base. Take for example, $5259810/17_{10} = CD76_{16}/11_{16} = 6\text{-}7+D\text{-}C= 0$. So, 52598 **is** divisible by 17.

i. Repeat the above using the "rule of 11" (11 for decimal, 17 for hexadecimal, 9 for octal), and show one example of each as per the above questions. Use the last 3 digits of your student ID multiplied by 11,16,9 respectively as example.

Now you know how to check for divisibility by 17. Cool, no? 😊

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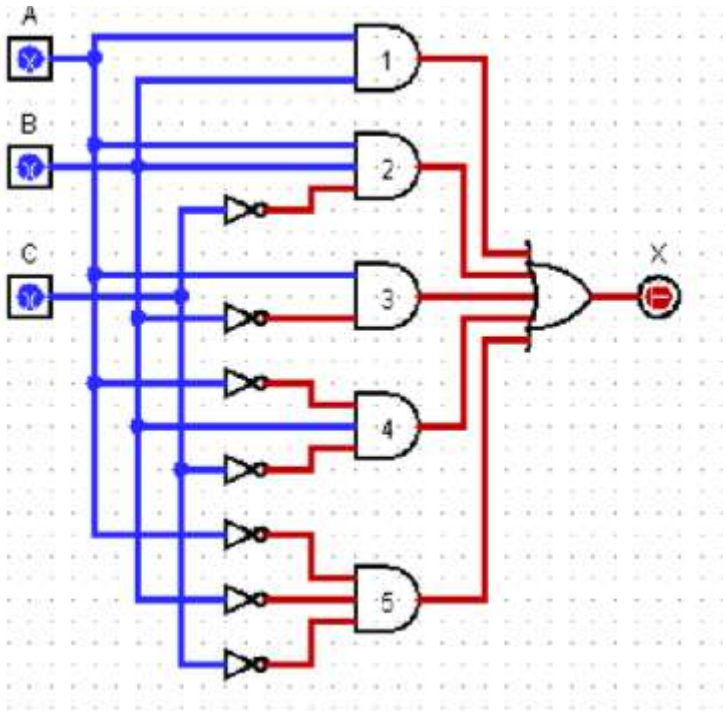
## Section 2 — Logic Simplification using K- Maps & Boolean Algebra

(10+20+20+30+10+10 = 100 marks)

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

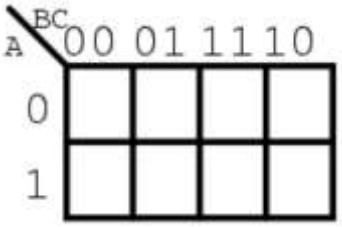
Consider the following circuit,



1. For the above circuit,

   a. (10 marks) Write down the equivalent logic expression (simplification is NOT required - yet). Start by writing down the steps for each numbered gate. These are called minters. You then OR these together.

   b. (20 marks) Following the truth table you just generated and plot the following 3-variable K-map. You may find https://www.youtube.com/watch?v=RO5alU6PpSU useful as an introduction to Karnaugh Maps. In addition, the Week 3 Required Readings also include logic simplification using K-maps.




   c. (20 marks) Show in detail, how to use the above K-map you plotted to simplify the logic expression of the circuit.

   d. (30 marks) Show in detail, how to use Boolean Algebra to simplify the logic expression of part (a), to produce the same or equivalent result in part (c).

   e. (10 marks) Compare these two simplification methods and discuss which is better: Boolean algebra or K-map.

   f. (10 marks) For the two methods in (d), is one always better than the other? When is it not??

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## Section 3 — Review of State of the Art (10+10+30+50 = 100 marks)

In this section, you are required to review the state of the art in a particular aspect of computer systems., What you learn in this course is only static knowledge and will change quickly, so this section is about you developing the ability to critically review the most current information in a topic. See the list of topics below. This means keeping abreast of the latest trends in some area – enough to be able to talk about it with a little bit of homework.

In particular, you are required to find 3 topical academic papers (conference or journal) that are less than 10 years old, that discuss this topic. The easiest place to find academic papers is using "Google Scholar", which lists papers, usually with a PDF link, and lists citations. A citation is a reference to this paper by some other paper. The more citations a pear has, in general, the more popular it is. This may be because it is (one of) the first papers on the topic, and engineers, academics or students got excited about it and did some extension work themselves which they then publish, citing the first paper as their inspiration. Another reason a paper typically gets cited a lot is that it shares some interesting insight about a topic and is a particularly good review. "First or Best" is the motto for getting cited.

In addition, when discussing the topic, you must refer to some actual devices or components by name/number and refer to its specification sheet. As part of the review, you will refer to this device or component to show how it compares with other components of this kind. For example, if the topic is about (say) memory, then the device might be the latest chip of this category, and you'd compare its stated performance with other more common memory chips.

Select a category using the last digit of your RMIT student number: You may choose any one of three categories. For example, if your number ended in 4, you may choose either "Sensors", "Displays" or "Mas storage".

| Last digit | Category | **Last digit** | Category |
|---|---|---|---|
| 0 or 3 or 6 | High Speed Networks | **5 or 8 or 1** | Human Input Devices |
| 1 or 4 or 7 | Sensors | **6 or 9 or 2** | Graphics / VR |
| 2 or 5 or 8 | Memory | **7 or 0 or 3** | Neural Computing |
| 3 or 6 or 9 | CPU | **8 or 1 or 4** | Mass Storage |
| 4 or 7 or 0 | Displays | **9 or 2 or 5** | Wireless Networks |

Tasks

1. (10 marks) A review paper is usually started by describing an event or activity that recently happened that suggests that a solution might be imminent.

   For example, "games are always pushing the performance limits of graphics cards, but now there is a new kid on the block. 'Big Wall' has taken to producing stadium sized shared display in which thousands can share in a single game."

2. (10 marks) You then proceed to list some of the history of that category in order to give readers a sense of where things have come from. Here is where you might list some old classic papers (without reviewing them).

   1. For example, "Large displays have been with stadiums for a long time, notable the Smith and Jones scoreboard (ref) with the flipping digits, and then with 7-segment LED based electronic displays replacing the mechanicals (ref, ref, ref). But the true stadium sized video display is only 25 years old (ref). Most sports people cannot now imagine a game without a replay on the video for dispute handling."

3. (30 marks) We then describe what was missing in all the above cases. This description provides the reason for all the excitement now. At this point, you describe in broad terms the technology that you are going to present. In doing so, you introduce the academic papers that will describe the latest advances and why they are so important. For example:

"What was missing in the great video was interactivity. How can a stadium full of people all play in the same game with a stadium sized display? Smith and Wesson (ref, ref) show how to do this with a 1st person shooter, in which your mobile is the first person, and the wall is a sort of scoreboard/overview/map of the game space. They even periodically pipe some super-scoring audience member's mobile video stream to the big wall for others to enjoy – particularly when it comes down to a 2-person race to the end. According to the specs, this wall can handle …"

Notice how a rhetorical question above introduces the fascinating concept in a single line!

"Adamson (ref) instead uses the wall for target practice by players on the field. In this case, the targeting scanners of the players are all 'pipable' to audience members' mobiles so they can see that player's performance firsthand." The specially designed guns used by the players use a unique feature of the Adamson wall. Its specs say that this feature can allow up to …"

The specifics of the two cases above should have been introduced by the papers that you have gathered, and you might spend a number of paragraphs each describing these features all the while comparing them to each other – in this case, the wall specs.

4. (50 marks) Provide a detailed overview of each paper describing its unique features and their common features.
    1. (10 marks) Paraphrase what the paper is about in a few paragraphs. Try to summarize the paper without getting too much into the details. Importantly, many papers use different names to describe the same thing (for example, latency and response-delay). In your summary, if the terms in the paper are different, be sure to mention this, but a use a common term for your review.
    2. (10 marks) List at least 2 aspects that are in common between the papers that you are describing. For example, in Mass Storage it might be access speed, parallel access, etc.…
    3. (10 marks) Compare the above characteristics with the normal values for the industry to provide a basis for judging why these papers are special. For example, typical storage access speeds available today.
    4. (10 marks) Conclude your review by listing each of the benefits and whether you believe one or the other technology will win out in the end.
    5. (10 marks) Include some figures to make your review paper more interesting, but a few pointers may apply:
        1. If the figure is not yours, you must cite it. An example caption might be: "Figure 1. Cross-section of the wall (from Adamson, 2019)"
        2. If you are using images, you must be especially careful to know where it comes from and to cite it correctly.
5. Expected length for the review part alone: 6-10 pages, including figures and references.

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