THE UNIVERSITY OF WAIKATO
Te Whare Wānanga o Waikato

2019 SCHOLARSHIP EXAMINATION

WRITTEN SECTION

DEPARTMENT	Computer Science
COURSE TITLE	Year 13 Scholarship
TIME ALLOWED	Two Hours
NUMBER OF QUESTIONS IN PAPER	Fourteen
NUMBER OF QUESTIONS TO BE ANSWERED	Fourteen
VALUE OF EACH QUESTION	The value of each question is indicated.
GENERAL INSTRUCTIONS	Candidates are to answer ALL questions in the answer booklet provided
SPECIAL INSTRUCTIONS	None
CALCULATORS PERMITTED	Yes

Section A
Computing Concepts

1. A binary integer may store values in sign/magnitude or in 2's complement form.

   (a) Write down in binary the largest (positive) and smallest (most negative) integer value that can be expressed in 10 bit sign/magnitude and in 10 bit 2's complement form.

   (b) Write down in decimal the values of the largest and smallest 10 bit sign/magnitude and 10 bit 2's complement integers.

(5 marks)

2. Multiply the eight bit binary numbers 00010011 and 00101110. Show your working, including carry bits.

(5 marks)

3. An assignment has two sections. Marks are given out of 10 for each section and stored in variables A and B. The final grade is a weighted sum of A and B, in which A has twice the weighting of B. Which of the following expressions is likely to work out the final grade correctly (as a percentage), and why?

   (i) Final = (A / 10 * 2 + B / 10) / 3 * 100

   (ii) Final = (100 * A / 10 * 2 + 100 * B / 10) / 3

(5 marks)

4. Computer storage systems use compression to reduce the size of files. This is very common with images, giving a file sizes that may be a small fraction of the total space required to store each pixel separately. Your friend has a clever idea. "*If compressing a file can reduce its storage requirements, then applying the compression again to the already compressed file should reduce its storage requirement even further. Compressing a file again and again could make it smaller and smaller.*" Explain why this idea is incorrect.

(5 marks)

5. Systems often have rules about the passwords we can use. We may be asked to use passwords with a mixture of upper and lower case letters, or passwords which contain digits or punctuation characters. Why is it an advantage to use such passwords? Comment on the likely security value of Mary123 and Wheelbarrow! as passwords.

(5 marks)

6. From the origin of personal computers until 2003 people expected the speed of new computers to double every 18 months. Since that time the basic clock speeds of computers have not changed very much. But for a time after 2003 the number of processors on new computer chips looked likely to steadily increase. In fact that has not happened. Typical modern computers have 4 or 8 processors and have been built that way for some years. Why don't we have more processors?

(5 marks)

7. Your friend is considering a computer upgrade. They can afford only a single improvement to their machine. They have three choices. They can replace their spinning hard drive with a solid state drive; they can increase the memory on their computer from 8GB to 16GB; or they can upgrade their 2 year old graphics card to a new model. They turn to you for an explanation of likely improvement from each option.

(5 marks)

TURN OVER

Section B
Programming

Note: In answering questions 8 – 14 you may find that the question wording does not always fully explain what your program fragment should do in all situations. If this is the case you should describe the issue, then choose and implement a solution.

8. Given integer variables `a`, `b`, `c`, `d`, `e`, and `f` holding values `3`, `5`, `7`, `40`, `2` and `5` respectively explain the calculation involved in evaluating the expression following using the ordinary rules of expression evaluation, and write down the value that will result.

```
(a + b) * c + d / e * f
```

(6 marks)

9. Given integer variables `a`, `b`, `c` and `d`, write down a Boolean expression that will be true if the values stored in those variables are all different and are in ascending order (with `a` smallest and `d` largest).

(6 marks)

10. Write a fragment of code which displays a 'dotted' line of length `L` made up of spaces and '`@`' characters. The pattern of the dotted line should be alternating spaces and '`@`'s, with the first character being an '`@`'. For example, when `L` is `15` your fragment should display

```
@ @ @ @ @ @ @ @
```

(6 marks)

11. Write a fragment of code which displays a hollow diamond shape of height and width D, made of '@' characters. You may assume that D is a positive odd integer. For example, if D is 7 your fragment should display

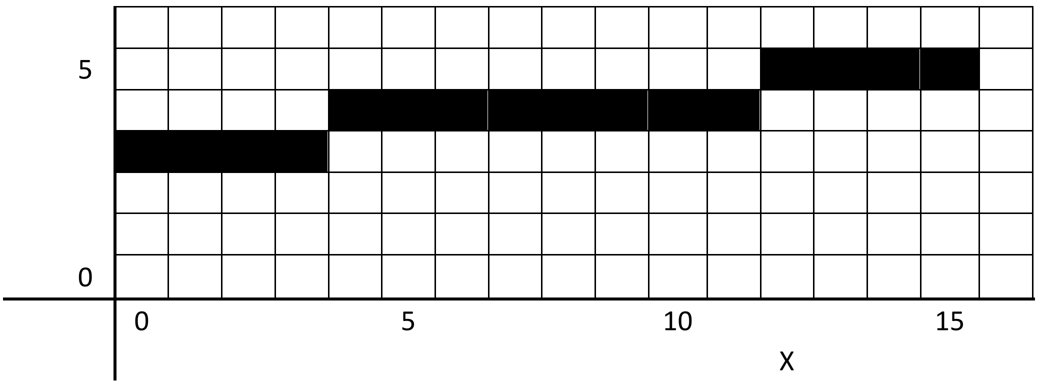
```
   @
  @ @
 @   @
@     @
 @   @
  @ @
   @
```

(6 marks)

12. Given a string `S` (array of characters) of length `N`, write a fragment of code that counts the number of separate words in the string. You may assume that words are made of lower case letters and are separated by one or more spaces. There may or may not be spaces at the start and end of the string. For example, the string "`hello world`" has two words; the string "`purple  people eater `" has three.

(6 marks)

13. Computer screens are usually made as a grid of square pixels. If we want to draw a straight black line on the screen, the best we can do is to set to black the pixels closest to where we would like the line to be. The diagram below shows a line drawn from pixel (0, 3) to pixel (15, 5) as it would appear on screen. Assuming a screen in which all pixels are initially set to white and the availability of a procedure `draw(x,y)` which you can call to set the pixel at x, y to black, write a fragment of code to draw a line from pixel (a,b) to pixel (c,d) for integer variables a, b, c and d.



(6 marks)

Section C
Analysing a Progam

14. Consider the following code fragment.

```
K = 0;
I = 0;
while (I < N)
{
    J = 0;
    while (J < N)
    {
        if (A[I] <= A[J])
        {
            L = A[J] - A[I];
        }
        else
        {
            L = A[I] - A[J];
        }
        if (L > K)
        {
            K = L;
        }
        J = J + 1;
    }
    I = I + 1;
}
```

Where

- `A` is an array of integers
- `N` is a positive integer
- Array A has N elements
- `I, J, K` and L are integer variables
- Arrays are accessed with indices 0, 1, 2, ….
  For example, if `N` is 4 the elements of A are `A[0], A[1], A[2]` and `A[3]`

Hint: Read through this whole question before starting to answer. Parts (a) and (b) ask you to work through the execution of the code fragment with some sample data. Later parts ask more questions about that analysis.

(a) Consider starting the fragment with `N` holding the value `5`; and array `A` holding values `32, 11, 21, 17, 55` in elements `A[0], A[1], … A[4]` respectively. What value will be in the variable `K` afterwards.

(7 marks)

(b) What would have happened if `N` held the value `6`; and the array `A` held the values `10,11,9,7,12,10` ?

(4 marks)

(c) If you had to give this code fragment a name, describing its function, what would you call it?

(4 marks)

(d) The code includes two 'while' statements. How many times was the body of the second `'while (J < N)'` executed with the data in part (a) of this question? How many times was it executed with the data in part (b)?

(4 marks)

(e) If `N` was 10, how many times would the body of the second 'while' statement be executed?

(4 marks)

(f) How would you rewrite this fragment of code to run more quickly?

(6 marks)