



THE UNIVERSITY OF
WAIKATO
Te Whare Wānanga o Waikato

2013 SCHOLARSHIP EXAMINATION

WRITTEN SECTION

DEPARTMENT	Computer Science
COURSE TITLE	Year 13 Scholarship
TIME ALLOWED	Two Hours
NUMBER OF QUESTIONS	Fifteen
IN PAPER	
NUMBER OF QUESTIONS	Fifteen
TO BE ANSWERED	
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

TURN OVER

Section A
Computing Concepts

1. Before modern computers settled on integer sizes of 8, 16, 32, or 64 bits there was a greater variety of options. One early computer used 18 bit integers with sign/magnitude representation.
 - (a) Write down in binary the largest (positive) and smallest (most negative) integer value that can be expressed in 18 bit sign/magnitude.
 - (b) Write down in decimal the values of the largest and smallest 18 bit sign/magnitude integers.

(5 Marks)

2. Multiply the eight bit binary numbers 00111010 and 00010111. Show your work, including carry bits.

(5 Marks)

3. We can use binary numbers to represent fractions as a natural extension of the way in which they are used to represent whole numbers. Just as 100_2 represents 4, 1000_2 represents 8 and 1100_2 represents 12_{10} we have fractions – 0.1_2 represents $\frac{1}{2}$, 0.01_2 represents $\frac{1}{4}$, and 0.11_2 represents $\frac{1}{2} + \frac{1}{4}$ or $\frac{3}{4}$. How is one third represented as a binary fraction? [Hint: It may not be possible to represent it exactly.]

(5 Marks)

4. A friend of yours is a keen digital photographer. They have many thousands of photographs, taken with various of the cameras they own, stored on their home computer. The photographs are very important to your friend, and they turn to you for advice about safely backing them up. Three systems are being considered. One is to write the photographs to DVDs. Another is to write them to a large external hard drive. The third option is to rent storage space from a local Cloud Storage company. For each option explain the advantages and disadvantages.

(5 Marks)

5. Government departments use computer systems to hold data about citizens. For example: the Inland Revenue Department may hold information about peoples' income and tax payments; the Justice Department may hold data on court convictions, traffic infringements and fines owing; the Social Welfare Department may hold data on benefits paid and personal circumstances? An interesting policy issue is whether or not departments should be allowed to exchange information that they hold. Those concerned about civil liberties are nervous about such data exchange. Give and briefly explain one situation in which departments might benefit from exchanging data; and one reason why there might be dangers or difficulties with such sharing.

(5 Marks)

CONTINUED

6. If you visit a modern computer store you will see that they stock at least four types of computing device: desktop computers, laptop computers, tablets, and smart phones. There is considerable overlap in the tasks for which each kind of computer may be used; however each has its own niche. You are advising a friend who wishes to buy one computing device. For each of the four kinds of computer give an example of the kind of task for which it is well suited. You should choose your examples to help your friend make their choice.

(5 Marks)

7. The computing devices we use every day all have 'Operating Systems'. Examples of operating systems are Microsoft Windows, Linux and Android. Why do we need operating systems? Describe 4 important functions performed by an operating system.

(5 Marks)

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 problem, then choose and implement a solution.

8. Write instructions to calculate the sum of all whole numbers from 1 to a given number N. For example, when N is 6, the sum of values from 1 to N is $1 + 2 + 3 + 4 + 5 + 6 \Rightarrow 21$.

(6 Marks)

9. Given a number N, list all numbers between 1 and N (inclusive) that are either multiples of 3 or multiples of 5. If a number is a multiple of both 3 and 5, display a '*' symbol after it. For example, when N is 18 your output should be: 3 5 6 9 10 12 15* 18

(6 Marks)

10. Write a fragment of code that takes an integer N and a character C, and outputs N lines, where on the first line there is one C, on the second two, and so on.

Example output for values $N=5$ and $C = '*'$ should appear as following:

```
*
**
***
****
*****
```

(6 Marks)

11. A prime number is a number which has no divisors other than itself and 1. For example 3, 5, 7, 11 and 13 are prime. A simple way to check to see if a number, N, is prime is to check so see if it is divisible by any of the values 2, 3, 4, ... N-1. Write a fragment of code to do such a check.

(6 Marks)

12. Computer arithmetic is limited in the size of the numbers it can manage. Sometimes we need to do arithmetic on larger numbers. This can be done by storing digits in an array. For example, with an array of size 100, storing a digit (from the range 0 to 9) in each element allows us to represent numbers with 100 decimal digits. Write a code fragment that takes two such arrays (A and B) and calculates the product of the two big numbers, leaving the result in an array C.

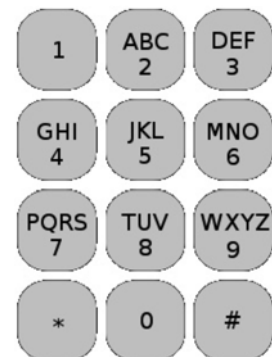
Example: If A holds 0, 0, 0, ..., 0, 0, 2, 1, 3
 and B holds 0, 0, 0, ..., 0, 0, 0, 3, 3
 then C should be 0, 0, 0, ..., 0, 7, 0, 2, 9

(6 Marks)

13. Outline instructions to convert a number (N) in the range 0 to 999 to English text. For example: if N is 21 the output should be “twenty one”; if N is 201 the output should be “two hundred and one”. By ‘outline’ we mean that you do not need to write all instructions in detail. Where a number of lines are very similar, write enough to show the pattern and fill in with “. . .”

(6 Marks)

14. To the right is a picture of a phone keypad. The phone’s owner enters text messages consisting of just upper case letters and spaces by using the 2, 3, 4, 5, 6, 7, 8, 9 and 0 keys on the pad. 0 generates a space. Pressing the 2 key once gives an A, twice gives a B, three times gives a C. Pressing it four times gives an A again, and so forth. Other keys from 3 to 9 work in a similar way. Write a fragment of code to take a string representing a sequence of key presses, and return the text message generated. For example, the string ‘9999944283388833777’ generates the text ‘WHATEVER’. Give an example of a word that cannot be entered using this scheme.



(6 Marks)

Section C
Problem Solving

15. Consider the following code fragment.

```
int i, R, S, T;

R = 0;
S = 0;
T = 0;

i = 0;

while (i < N)
{
    if (A[i] > R)
    {
        T = S;
        S = R;
        R = A[i];
    }
    else
    {
        if (A[i] > S)
        {
            T = S;
            S = A[i];
        }
        else
        {
            if (A[i] > T)
            {
                T = A[i];
            }
        }
    }

    i = i + 1;
}
```

where 'A' is an array of positive integers; N is an integer value. The array 'A' has N elements, and when N is 10 for example, they will be accessed as A[0], A[1], . . . , A[9].

Hint: Read through this whole question before answering 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) Describe what happens if the fragment is run with $N = 10$ and the array 'A' holds values 6, 49, 12, 6, 14, 24, 4, 34, 49, and 12 in elements 0 to 9 respectively.

(5 Marks)

- (b) What would have happened if the array 'A' held values 1, 2, 3, 4, 5, 6, 7, 8, 9, 10?

(3 Marks)

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

(3 Marks)

- (d) The code includes three 'if' statements. How many times was each 'if' statement executed with the data in part (a) of this question? How many times each 'if' statement executed with the data in part (b)?

(3 Marks)

- (e) Give example data values for the array A which would result in each of the 'if' statements being executed 10 times.

(3 Marks)

- (f) Sometimes, when we are concerned about the performance of a piece of code, we want to know what is the 'worst case' execution time; ie: how long it would take to run if we were unlucky enough to give it the data set which it processed most slowly. Of course execution time depends on the speed of the computer we are using. A better way of comparing different programs is to count the number of times they run important statements. Write down a formula or otherwise explain how many 'if' statements the program will execute in the worst case with N items in the array, when N may have any value > 1 .

(3 Marks)

- (g) How would you recode this code fragment to execute fewer 'if' statements in the worst case?

(3 Marks)