THE UNIVERSITY OF WAIKATO
Te Whare Wānanga o Waikato

2012 SCHOLARSHIP EXAMINATION

WRITTEN SECTION

DEPARTMENT	Computer Science
COURSE TITLE	Year 13 Scholarship
TIME ALLOWED	Two Hours
NUMBER OF QUESTIONS IN PAPER	Fifteen
NUMBER OF QUESTIONS TO BE ANSWERED	Fifteen
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. The earliest personal computers used 16 bit numbers to address memory, allowing a maximum of $2^{16} = 65536$ bytes of memory. Later machines moved to 20 bit addresses, then 32 and most recently 48. How much memory is possible with 20, 32 and 48 bit addresses?

(5 marks)

2. Multiply the eight bit binary numbers 00101010 and 00000101. 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 ½, 0.01_2 represents ¼, and 0.11_2 represents ½ + ¼ or ¾. How is one tenth represented as a binary fraction? [Hint: It may not be possible to represent it exactly.]

(5 marks)

4. Recently I have bought a tablet computer with 32GB of memory and a laptop with 500GB. Why are these two kinds of computer sold with such different amounts of memory? What effect will that have on the kinds of things I can do with each computer?

(5 marks)

5. A modern business desktop computer may have 2 or 4 CPU's. A good gaming machine might have 8 CPU's, to say nothing of thousands of GPU (Graphics Processing Unit) cores. However, when I am sitting at either kind of computer I am usually only doing one thing at a time, playing a game, writing a document or programming some new application. Even if I have several applications open on my screen, I am still only working with one at a time. Is there any value in having more than one CPU? Discuss!

(5 marks)

6. It is often useful to compress data. For example, a single camera image on a 5 mega pixel camera consists of approximately 15 million bytes of data. An example from my camera phone is actually stored as a compressed (.jpg) file of just under 1 million bytes. How is it possible to store 15 million bytes of data in just 1 million bytes of storage?

(5 marks)

7. Security is a concern with modern computers – not just for secret military projects, but for ordinary people carrying out ordinary day to day activities on their computers. A friend has recently purchased a new computer and has been warned to be careful using the internet. They ask you for advice about risks and precautions. What would you tell them? In your answer you should describe some of the problems they could suffer and things they should do to minimise the danger.

(5 marks)

CONTINUED

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, choose and implement a solution.

8. Write instructions to calculate the factorial of a given number, i.e. multiply all of values from 1 to that number. For example the factorial of 5 is 1 * 2 * 3 * 4 * 5 => 120.

(6 marks)

9. Write a fragment of code that takes a string (array of characters) containing an email address (e.g. “bob@waikato.ac.nz”) and displays a string containing the part of the address up to, but not including, the “@” symbol (e.g. “bob” in the example).

(6 marks)

10. Write a fragment of code to count the number of words in a string. A word is defined as a sequence of non-blank characters separated by one or more blanks, except that a word at the start of the string may have no blanks before it, and a word at the end of the string may have no blanks after it. A "blank" is a space character (ASCII 32). For example, the string “Examinations are not usually fun.” has 5 words.

(6 marks)

11. 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)

12. Write a fragment of code that takes an integer N and a character C, and outputs a square of N lines each with N characters. Line one must have the digit '1' followed by N-1 C's. The second line has a C, the digit '2', and N-2 C's, and so on. The digit on the each line should be the least significant digit of the line number.

    Example output for values N=15 and C = '*' should appear as follows:

```
1**************
*2*************
**3************
***4***********
****5**********
*****6*********
******7********
*******8*******
********9******
*********0*****
**********1****
***********2***
************3**
*************4*
**************5
```

(6 marks)

13. You are given two strings: Key and Message. Both strings consist of only lower case letters of the alphabet. The idea is to use Key to encode Message for secret transmission. Key has the 26 letters of the alphabet in some random order. The first letter of Key will be used to encode 'a', the second to encode 'b', etc. Write a program fragment to encode message.

    Example:

Key:	zyxwvutsrqponmlkjihgfedcba
Message:	hello
Output:	svool

(6 marks)

14. Write a fragment of code that takes a string containing a word, and generates a telephone number based on the standard cellphone letter to number mapping (E.161). Return the resulting 'phone' number as an int. For example: "Hello" should return 43556.

(6 marks)

Section C
Problem Solving

15. Consider the following code fragment.

```
int i, j, k;

i = 0;
j = 0;
k = 0;

while (i < M and j < N)
{
    if (A[i] < B[j])
    {
        R[k] = A[i];
        i = i + 1;
    }
    else
    {
        R[k] = B[j];
        j = j + 1;
    }
    k = k + 1;
}

while (i < M)
{
    R[k] = A[i];
    i = i + 1;
    k = k + 1;
}

while (j < N)
{
    R[k] = B[j];
    j = j + 1;
    k = k + 1;
}
```

where 'A' and 'B' are arrays of integers whose values have been sorted into ascending order and 'R' is another array of integers. M and N are integer values. The array 'A' has M elements, and when M is 10 for example, they will be accessed as `A[0], A[1], ..., A[9]`. The array 'B' has N elements, and the array R has M + N elements.

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.

(Question 15 - continued on next page)

(a) Describe what happens if the fragment is run with M = 15 and N = 5; the array 'A' holds values 5, 6, 6, 8, 12, 15, 17, 19, 24, 24, 27, 27, 28, 29, 34 in elements 0 to 15 respectively and the array 'B' holds values 3, 12, 16, 25, 35.

(7 marks)

(b) What would have happened if the array 'B' held values 9, 9, 9, 9, 9 ?

(4 marks)

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

(2 marks)

(d) The code includes three 'while' loops. How many times was the body of each loop executed with the data in part (a) of this question? How many times was the body of each loop executed with the data modified as in part (b)?

(4 marks)

(e) If we ignore the fact that the body of the first loop is a little more complex than the other two and assume that each loop body takes the same time to execute what can we say about the total execution time for the program with different data in arrays 'A' and 'B'?

(2 marks)

(f) Write down an (approximate) formula or otherwise provide an explanation of the time the program will take to run for arbitrary values of M and N.

(4 marks)