2010 SCHOLARSHIP EXAMINATION

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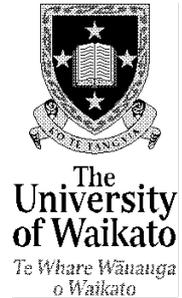
DEPARTMENT	Computer Science
COURSE TITLE	Computer Science Scholarship
TIME ALLOWED	Two Hours
NUMBER OF QUESTIONS IN PAPER	Fifteen
NUMBER OF QUESTIONS TO BE ANSWERED	Fifteen
VALUE OF EACH QUESTION	The value of each question is indicated.
GENERAL INSTRUCTIONS	Candidates are to answer ALL questions in the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

Section A
Computing Concepts

1. What are the largest and smallest whole numbers that can be stored as a 16 bit binary value.

(5 marks)

2. Add the eight bit binary numbers 00101011 and 00111101. Show your work, including carry bits.

(5 marks)

3. Computer programming languages allow us to store and work with values like 10.5 and $1.2 * 10^{15}$ – values that involve fractions or are very large or very small. Depending on the programming language they might be referred to as floats, singles, or real numbers. Although we can store large and small values like 10000000 and 0.00000001, calculations do not always give the results that might be expected. For example

$$(10000 + 0.00034) – (10000 + 0.00021)$$

should give 0.00013 as a result. In practice we will get the answer 0. Explain.

(5 marks)

4. When we buy a computer we are usually told how much hard disk space it has and how much main memory. What are hard disk and main memory; what are they used for when the computer is running and when it is turned off; and roughly how much of each would you expect if you were buying a new computer today?

(5 marks)

5. What is a computer operating system? In your answer you should describe four things that an operating system does. For each of the four, you should state whether or not the operating system on a mobile phone would include that capability.

(5 marks)

6. A high definition television frame has 1920 by 1080 pixels. Each pixel is transmitted as 24 bits of information (8 bits each for the red, green and blue colour components). Television systems in New Zealand work at 25 frames per second. How much data per second would there be in a full HD television transmission? In practice a full HD signal can be stored or transmitted at 19.4 megabits/second. How is this possible?

(5 marks)

7. A modern computer has two components that perform calculations. One is the main processor (CPU), the other is the graphics processor (GPU). They are different in that the CPU is usually programmed to perform calculations one after another, whereas the GPU is usually organized to work on many – up to 1000 – calculations simultaneously. Describe one computing problem that is best solved by working one step at a time and one that can be solved with many calculations being performed simultaneously. Explain why each problem is best suited to its given style of computation.

(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. Where this is the case you should describe the problem, choose and implement a solution.**

8. Write instructions to add together the numbers from 22 to 88 – i.e. 22 + 23 + … + 88.

(6 marks)

9. Write a fragment of code that takes a string (array of characters) of length N and counts the number of times the letter 'e' occurs in the string.

(6 marks)

10. Write a fragment of code to search through an integer array A of length N, to see if a particular value V occurs in the array. If the value occurs your program should display 'Yes', otherwise 'No'. *Note: If the value V occurs more than once in the array, your program should display 'Yes' only once.*

(6 marks)

11. Write a fragment of code to display a rectangle of '*' characters with R rows and C columns. For example if R was 3 and C was 10, your fragment should produce

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

(6 marks)

12. Write a fragment of code that takes a series of digits stored in a string (array of characters) of length N and returns their value as an integer. For example, given the string "0012", return the integer 12. You may assume that the array holds only digits in the range '0' to '9', and that N is no greater than 7.

(6 marks)

13. A curtain has little holes in the tape that runs along its top edge, into which we can place hooks from which the curtain will be hung. Usually there are more holes than hooks and we want to place the hooks so that there is one at each end and the rest are spread as evenly as possible along the curtain. For example with 5 holes and three hooks we can place the hooks in holes 1, 3 and 5, leaving one space between each hook. With 6 holes and three hooks we can't be perfectly even. Either 1, 3 and 6 or 1, 4 and 6 are solutions that are as good as we can achieve.

Write a code fragment that lists the holes into which we should place hooks when there are K hooks and H holes. (Note there isn't always a single solution here – but your solution should be as close to an even spread as you can make it.)

(6 marks)

14. One method for finding square roots is binary subdivision. To find the square root of 2, for example, it works as follows. We start by guessing at numbers bigger and smaller than the square root. 1 is less than the square root of 2 (because 1^1 is 1) and 2 is greater than its square root (because 2^2 is 4). Consider the average of our bigger and smaller numbers: 1.5. If we square 1.5 we get 2.25, which is bigger than 2. We can conclude that the square root of 2 is smaller than 1.5 – now we know it is between 1 and 1.5 Next check the average of 1 and 1.5: 1.25. Repeating this process allows us to get closer and closer to the square root.

Write a fragment of code to find the square root of a number x (with x > 1).

(6 marks)

Section C
Problem Solving

15. Consider the following code fragment.

```
int lowest, middle, highest;

lowest = 0;
highest = N - 1;

while (lowest < highest)
{
    middle = (lowest + highest) / 2;
    if (goal > a[middle])
    {
        lowest = middle + 1;
    }
    else
    {
        highest = middle;
    }
}
```

where 'a' is an array of integers whose values have been sorted into ascending order and 'goal' holds an integer value. Note: We assume that the array has N elements, and that they will be accessed as a[0], a[1], ..., a[N-1]

(a) Describe what happens if the fragment is run with $N = 10$, goal $= 38$ and the 10 elements of the array 'a' hold values $10, 27, 38, 59, 60, 76, 79, 80, 82$ and 86 respectively.

(7 marks)

(b) What would have happened if the value of goal had been 39 (with N and a having the same values as in part (a) ?

(4 marks)

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

(2 marks)

(d) How many times does the 'if' statement get executed with $N = 10$?

(4 marks)

(e) If N was 20, how many times would the 'if' statement be executed?

(2 marks)

(f) Can you write down an (approximate) formula or otherwise provide an explanation of the number of times the 'if' statement is executed for arbitrary N.

(4 marks)