

Student Name: _____

School: _____



THE UNIVERSITY OF
WAIKATO
Te Whare Wānanga o Waikato

2008 COMPUTER SCIENCE SCHOLARSHIP EXAMINATION

WRITTEN SECTION

DEPARTMENT	Computer Science
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	Answer ALL FOURTEEN questions in the answer booklet provided.
SPECIAL INSTRUCTIONS	None
CALCULATORS PERMITTED	Yes



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VALUE OF EACH QUESTION	The value of each question is indicated. Marks total to 100.
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CALCULATORS PERMITTED	Yes

TURN OVER

Section A Computing Concepts

1. An 8 bit binary number can hold positive values in the range 0 to 255 (inclusive). We can also use 8 bits to store a signed value – ie: positive and negative values. Explain how this might be done, and show the range of values that would result.

(5 marks)

2. Multiply the two eight bit binary numbers 00001011 and 00001101. Show your work, including carry bits.

(5 marks)

3. There are some fractions that cannot be exactly represented as decimals. For example $1/3$ can be approximated as 0.33333; but no matter how many 3's we write after the decimal point, we cannot get the exact value. The same thing can happen in binary notation [where 0.1_2 represents $1/2$, 0.01_2 represents $1/4$, etc]. Work out an approximation to $1/3$ in binary.

(5 marks)

4. A programmer found a surprising error when moving a graphics program to a new computer. The program draws diagrams composed of straight line segments into a window on the screen. It uses integers to store coordinates for the lines and also uses integer arithmetic to scale the lines to fit the screen. A typical scaling operation would involve multiplying a coordinate value by the window width (in pixels) and dividing by the unscaled diagram width. The program worked correctly on the old computer. On the new computer (with higher resolution screen) the graphics was visibly incorrect in places. What is a likely explanation for this error? Explain how it would lead to faults in the graphics.

(5 marks)

5. My computer usually runs several programs at the same time. For example I can have a word processor, a web browser and a spreadsheet all running simultaneously. Sometimes however, I run an old calculator program. It just waits for me to type in numbers to add, subtract, multiply *etc.*, and gives answers when I want them. When this program is running everything else on my computer seems slow and unresponsive. What might be happening?

(5 marks)

6. In 1995 I purchased a computer. It had a 100MHz processor, 64MB of main memory, and a 400MB hard drive. What do those numbers mean? In your explanation give examples to show how much data could be stored – for example would there be enough space to store a movie or a song in mp3 format. Roughly what values would I expect if I purchased a (fairly inexpensive) new machine today?

(5 marks)

7. Two people each need to download a large file (100 megabytes) over the internet. One has a dial-up connection at 56kilobits/second; the other has an ADSL (broadband) connection at 2 megabits/second. How long would you expect it to take in each case, assuming that the connection speed is the only limit on transfer speed?

(5 marks)

CONTINUED

Section B Programming

Note: In answering questions 8 – 11 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 a fragment of code to find the largest integer in an unordered array of 100 random integers.

(7 marks)

9. Given an array of 365 floating point values (i.e. real values) where each element is the foreign exchange rate of the New Zealand dollar against the Australian dollar for one day of the year, and consecutive elements correspond to consecutive days of the calendar year, write a fragment of code that computes the greatest one-day change in the exchange rate (positive or negative) for that year.

(7 marks)

10. Write a fragment of code that counts how many times the letter 't' or 'e' (in either upper or lower case) occur within a given string (array of characters).

(7 marks)

11. A Tic-Tac-Toe game (i.e. Noughts and Crosses) is typically played on a 3 by 3 grid of cells. At any given moment, each cell has either an 'X' in it, an 'O', or it is blank. A player wins when three cells in a straight line vertically, horizontally or diagonally contain their symbol.

Consider a computer program for Tic-Tac-Toe where the game's state is represented by a nine-character string. The first three characters correspond to the top row of the grid; the next three characters are the middle row; and the last three characters are the bottom row. At any given moment, each character is either an 'X' or an 'O' or a blank. Thus if 'X' has put a mark in the middle cell and 'O' has put a mark in the bottom left corner then the game state would correspond to the string "...X.O.." (where "." is a blank). Write a fragment of code that examines this string and determines whether or not X has won. (N.B. there can be an optional tenth character for the end-of-string or end-of-line marker if you like.)

(7 marks)

12. In Cartesian coordinate geometry, a 'point' is specified by a pair of coordinates, $\langle x,y \rangle$. A line segment is specified by a pair of points. The length of that line segment can be computed using Pythagoras' Theorem (i.e. taking the square root of the sum of the squared differences in the x and y axes of the two end points). A polygon can be represented by an ordered sequence of points (e.g. a triangle has three points; a quadrilateral has four points; etc). Write code to compute the perimeter of a polygon (i.e. the sum of the lengths of all its sides). Use whatever data structure you like to represent a point and a polygon.

(7 marks)

TURN OVER

13. The square root of a positive number, N , lies somewhere between zero and $N/2$. One way to compute the square root is via a binary search. Fix the maximum and minimum possible values and see if the midpoint value between them is the square root of N by multiplying the midpoint by itself and testing the product against N . If the result is equal to N then the midpoint is the solution; otherwise the midpoint is too large or too small, thus it replaces the previous maximum or minimum possible value and the process iterates by finding a new midpoint, and so on. Write code to compute the square root of a number with this algorithm. Remember that the square root might not be exactly representable in binary (because of inadequate precision or because the answer is irrational) so your solution must stop if the same midpoint value is tested twice in a row (i.e. the range has reduced to nothing).

(7 marks)

14. This question is printed on the next page—please turn over.

Section C Problem Solving

14. Consider the following code fragment.

```
int i, j, k, b;

i = 1;
while (i < N)
{
    k = i;
    b = a[k];

    j = i + 1;
    while (j <= N)
    {
        if (a[j] < b)
        {
            k = j;
            b = a[j];
        }
        j = j+1;
    }
    a[k] = a[i];
    a[i] = b;
    i = i+1;
}
```

where 'a' is an array of integers.

- (a) Describe what happens if the fragment is run with $N = 5$ and elements 1 to 5 of the array 'a' initially holding values 11, 23, 21, 17, and 35 respectively.
(10 marks)
- (b) If you had to give this code fragment a name, describing its function, what would you call it?
(2 marks)
- (c) How many times does comparison of the 'if' statement get executed with $N = 5$
(4 marks)
- (d) If N was 10, how many times would the comparison of the 'if' statement be executed
(3 marks)
- (e) Can you write down an (approximate) formula to give the number of times the comparison of the 'if' statement is executed for arbitrary N .
(4 marks)