



THE UNIVERSITY OF
WAIKATO
Te Whare Wānanga o Waikato

2015 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

TURN OVER

Section A
Computing Concepts

1. A 32 bit 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 32 bit sign/magnitude and in 32 bit 2's complement form.
 - (b) Write down in decimal the values of the largest and smallest 32 bit sign/magnitude and 32 bit 2's complement integers.

(5 marks)

2. Subtract the eight bit binary number 00010101 from 00101010. Show your working, 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 $\frac{3}{4}$.
 - (a) Convert the binary fraction 0.00101_2 to a decimal fraction.
 - (b) Write $\frac{5}{16}$ as a binary fraction.
 - (c) Can you write $\frac{1}{5}$ as a binary fraction? Discuss.

(5 marks)

4. My computer has as storage or memory devices a 128GB solid state drive, a 1TB 'spinning' hard drive and 8GB of main memory. What are these three different kinds of storage? What kinds of data would be 'stored' on each and for how long? How quickly can my computer access data on each type of storage? Why is it useful or necessary to have all three?

(5 marks)

5. In our modern society people spend a great deal of time working with screens, on television sets, phones, tablets, game consoles, laptops or desk computers. Some commentators argue that this reduces human contact and will have a negative impact on society. Present two arguments for and two arguments against the proposition “we spend too much time staring at screens”.

(5 marks)

6. 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)

7. Early versions of Unix (an old operating system that was the inspiration for Linux) ran on computers with as little as 64KB of memory, running at clock speeds of 10MHz. My current laptop has 8GB of memory and seems to have 2GB of it in use even when I am not running any applications. Its clock speed is 2.1GHz and it has 4 processors. My elderly relative, who was a computer user back in the 1970's, says that the computers in those days seemed quite responsive and powerful. In fact programmers could sometimes compile and test their work more quickly on those old machines than is possible today on modern machines with much more memory and processing power. Why do modern machines use so much memory? What has been the benefit from a user's or programmer's perspective of faster computers with more memory?

(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 the squares of the numbers from 1 to a given number N. For example, when N is 5, the sum is

$$1 \times 1 + 2 \times 2 + 3 \times 3 + 4 \times 4 + 5 \times 5$$

Which results in $1 + 4 + 9 + 16 + 25$ giving 55

(6 marks)

9. There is a rectangle on your screen. Its top left corner pixel is at location (a, b) – meaning the bth pixel from the left in the ath row of pixels. Your rectangle is w pixels wide and h pixels high. Consider a pixel which is the xth pixel from the left in the yth row of pixels. Write an expression that returns true if the (y, x) pixel is outside the rectangle, false otherwise.

(6 marks)

10. Given an integer N and a character C, write a fragment of code that outputs N lines: the first line having one character, the second two, ... making an empty triangle of C characters and spaces.

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

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

(6 marks)

11. As part of a game, you want the user to enter a number between 1 and 9. Write a fragment of code that prompts the user to enter a number, reads the value they entered, and checks to see if it is in the range 1 to 9. If the number is not in the required range you should display an error message and ask the user to try again. If they enter an invalid number 10 times, your program should just give them the value 5.

(6 marks)

CONTINUED

12. 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:   svoool
```

(6 marks)

13. A 'palindrome' is a string which reads the same from left to right or from right to left. One famous example is "able was I ere I saw elba" – as might have been said by Napoleon after he was exiled to the island of Elba. You are given a string S. Write a fragment of code which returns true if S is a palindrome, false otherwise.

(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 Analysing a Program

15. Consider the following code fragment.

```
int I, J, K, L, T, U;

K = 0;
while (K < M)
{
    R[K] = 0;
    K = K + 1;
}

I = N - 1;
L = M - 1;
while (I >= 0)
{
    J = N - 1;
    K = L;
    U = 0;
    while (J >= 0)
    {
        T = U + R[K] + A[I] * B[J];
        R[K] = T % 10;
        U = T / 10;
        J = J - 1;
        K = K - 1;
    }
    R[K] = U;
    I = I - 1;
    L = L - 1;
}
```

Where

- A and B and R are arrays of integers
- N and M are positive integer values
- Arrays A and B' each have N elements, and R has M elements.
- 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]
- The % operator calculates remainder after integer division.
For example, 7%3 is 1 because 7 divided by 3 has remainder 1
- The / operator is integer division.
For example, 7/3 is 2.

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) What happens if the fragment is run with $N = 5$, $M = 11$, array A holding values 5, 7, 6, 2, 1 and array B holding values 1, 3, 2, 5, 0? What values will be in the array R afterwards. (7 marks)
- (b) What would have happened if the array A had held the values 0, 0, 0, 0, 1? (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 three 'while' loops. How many times was the body of each loop executed with the data in part (a) of this question? If the N was increased to 10 and M to 21, how many times would the body of each loop be executed? (4 marks)
- (e) Write down an (approximate) formula or otherwise provide an explanation of the time the program will take to run for arbitrary values of N – you may assume that M is equal to $2 * N + 1$. (4 marks)