2014 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. 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 20 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 20 bit sign/magnitude.

   (b) Write down in decimal the values of the largest and smallest 20 bit sign/magnitude integers.

   (5 marks)

2. Multiply the eight bit binary numbers 00101010 and 00010101. 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.

   (a) Convert the binary fraction 0.1011_2 to a decimal fraction.

   (b) Write $^7/_8$ as a binary fraction.

   (c) Can you write $^1/_{10}$ as a binary fraction? Discuss.

   (5 marks)

4. A friend has bought a 15 megapixel digital camera. In discussing their new camera you are asked the following questions.

   (a) What is meant by 15 megapixels? You need to explain to your friend what they can do with an image with this level of detail.

   (b) How much storage is required to hold a raw (uncompressed) 15 megapixel image? For your friend's benefit, can you relate this to some amount of information that they will find meaningful in a common-sense way?

   (5 marks)

5. You have just been appointed to a position in charge of the government anti-terrorism police unit. Your unit has access to all internet traffic occurring in your country (and can access some information from other countries as well), including email and web page access by everyone. You can also request the installation of cameras in public places. You would like to use these capabilities to prevent terrorism. What is possible? What kinds of software would you use? What would you ask your staff to do?

    (5 marks)

6. Modern computing devices offer several ways of inputting data. On a cellphone or tablet you might use a touch interface. On a laptop or desktop you might use a mouse and keyboard. On an artist's desktop computer you might find a system that allows you to draw with a pen-like stylus. For what kinds of data entry are each of these devices best suited? You should think about the nature and amount of data.

    (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 $1 + 2 + 3 + 4 + 5 + 6 => 21$.

   (6 marks)

9. There is a button 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 button is w pixels wide and h pixels high. Given a mouse click at pixel (y, x) on the screen, write an expression that returns true if the mouse click is on the button, false otherwise.

   (6 marks)

10. Write a fragment of code that takes integers N and M, and a character C, and outputs N lines, each of M characters, being an empty box made of C characters and spaces.

    Example output for values N=5, M = 6 and C = '*' should appear as following:

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

    (6 marks)

11. Given an array A of length N holding numbers, write a fragment of code to find and display: the largest value in the array; the smallest value; and the average value.

    (6 marks)

12. Given a string S holding a period character, followed by a sequence of 0's and 1's, write a code fragment to interpret the string as a binary fraction and convert it into a floating point value. For example if S is ".01" the result would be a variable holding the value 0.25. If S is ".101", the result would be 0.625. (Hint: refer to Question 3 of Section A, for an explanation of binary fractions.)
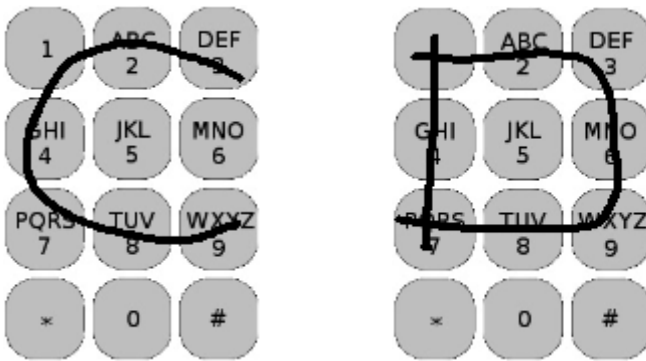
    (6 marks)

CONTINUED

13. Given a two dimensional array A of numbers of size N(rows) by N(columns) write a code fragment to transpose the array. Ie: swap rows and columns. The 5 by 5 array on the left would result in the one on the right.

        1, 5, 7, 4, 3   1, 2, 6, 7, 1
        2, 1, 5, 4, 3   5, 1, 7, 5, 1
        6, 7, 8, 1, 2   7, 5, 8, 4, 7,
        7, 5, 4, 3, 2   4, 4, 1, 3, 7
        1, 1, 7, 7, 7   3, 3, 2, 2, 7

(6 marks)

14. To the right is a picture of a phone keypad. A new text input system for a smartphone has been devised. The screen has a picture of the phone keypad like that shown. Users are allowed to enter text by swiping their fingers over the keypad picture in letter shapes. The swipe for a C and the double swipe for a D are shown below. Software converts each swipe into a string of digits. For example C would be "3214789" and D would be "1471236987". Describe how you would write a code fragment to convert swipe strings into characters. Do not write all the code, just show enough to explain your approach. Do you forsee any difficulties arising with this system?

(6 marks)

TURN OVER

Section C
Analysing a Progam

15. Consider the following code fragment.

```
int I, J, K, S;

S = 0;
I = 0;
K = 1;

while (I < N)
{
    J = 1;
    while (J < K  <and>  I < N)
    {
        A[I] = J;
        S = S + J;
        J = J + 1;
        I = I + 1;
    }
    K = K + 1;
}
```

where 'A' is an array of integers; N is a positive integer value; the array 'A' has N elements, and when N is 30 for example, they will be accessed as A[0], A[1], ..., A[29]; <and> means logical 'and', often written && in modern programming languages.

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 and the fragment.

(a) What happens if the fragment is run with N = 30. What values will be in the array A and the variable S afterwards..

(5 marks)

(b) What would have happened if the variable N had the value 10?

(3 marks)

(c) Explain what the fragment does in words. Note that this isn't identifiable as a fragment that is commonly used – it just fills the array in a particular pattern. Describe that pattern, and what is left in the variable S?

(4 marks)

(d) How many times was the statement `A[I] = J;` executed with the data in part (a) of this question? How many times was it executed with the data in part (b)?

(3 marks)

(e) How would you rewrite this fragment of code with only one 'while' statement. Note that you may need to introduce an 'if' statement.

(3 marks)

(f) Compare your coding from part (e) with than given. Which, in your opinion, is the easier to understand and why?

(5 marks)