2017 SCHOLARSHIP EXAMINATION

WRITTEN SECTION

DEPARTMENT   Computer Science

COURSE TITLE   Year 13 Scholarship

TIME ALLOWED   Two Hours

NUMBER OF QUESTIONS   Fifteen
IN PAPER

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TO BE ANSWERED

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. A 16 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. Multiply the eight bit binary number 00010011 by 00001110. 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 ½, 0.01_2 represents ¼, and 0.11_2 represents (½ + ¼) or ¾.

    (a) Convert the binary fraction 0.0101_2 to a decimal fraction.

    (b) Write $5/_{16}$ as a binary fraction.

    (c) Consider the binary fraction $0.010101010101…_2$ where the 01 pattern repeats indefinitely. What decimal fraction does this get closer and closer to?

    (5 marks)

4. A friend uses a phone and digital cameras to take photographs. They have been copying the pictures onto a laptop for storage. However, the laptop's disk is nearly full and it is getting old. Your friend is worried about losing the photographs. What advice would you offer for safely storing their photographs?

    (5 marks)

5. Nothing could seem safer than sitting in the comfort of your own home, using the internet for mail, browsing, watching videos and shopping. However, there are dangers. Briefly describe three things that might get you into trouble, or cause you personal or economic harm, while using the internet.

    (5 marks)

6. Programs like Skype allow you to use a computer to make video calls. The same kind of software can be extended to support video conferences, where a group of people, all at different locations, can speak to and see each other; each person's screen showing small live images of each of the other participants. Such a conference can be managed in one of two ways. The first, peer-to-peer, has each participant send and receive video directly to each of the other participants. The second, client-server, has each participant send video to a single server computer which then re-broadcasts the signal to each of the others. Making reasonable assumptions about video quality, and ignoring the requirements for transmitting sound, roughly estimate the amount of information that must be transmitted over the network for 10 participants in each system.

    (5 marks)

7. List and very briefly describe five responsibilities of the 'operating system' of a computer.

    (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 display a string S of characters N times on N lines. For example, if N is 5 and the string S is "hello" your output should appear as follows.

    ```
    hello
    hello
    hello
    hello
    hello
    ```

    (6 marks)

9. The user interface of a drink dispensing machine has boxes that a user can touch to turn on or off selections. There are three buttons to select a base drink (Lemon, Coke or Iced Tea) and two buttons to select an additional syrup to add (Vanilla and Ginger). A valid drink selection involves one base drink and zero or one syrup. Write an expression that returns true if a drink is valid. You may assume that the variables L, C, I, V and G hold the current state of the selection buttons respectively. For example the expression 'L' is true if the Lemon selection is on; the expression 'L and C' is true if both Lemon and Coke are selected.

    (6 marks)

10. Given a string S (array of characters) of length N, write a fragment of code that counts the number of times the letter 'e' occurs in the string (either as a capital 'E' or as lower case 'e'). For example with S = "this is an easy exercise" and N = 24, the result should be 4.

    (6 marks)

11. Given a string S (array of characters) of length N, write a fragment of code that counts the number of times pairs of identical letters occur together in the string. For example the string "hello" has a pair of 'l's, so should give a result of one. The string "bubble bubble toil and trouble" has two pairs (both 'bb'). Note: A letter should only be counted as part of one pair, so the string "aaa" has only one pair and "aaaa" has two.

    (6 marks)

TURN OVER

12. As part of the input of a program, you want the user to enter a number between 1 and 99. Write a fragment of code that requests a number from the user. If they enter an incorrect number, your code should tell them that their number was invalid and allow them to try again. When they enter a valid number, your code should thank them and display the number entered. A sample interaction might look like this (user input is underlined).

```
Enter value: 0
Your number was invalid
Enter value: 225
Your number was invalid
Enter value: 32
Thank you - you entered the value 32.
```

(6 marks)

13. You are given a 32 bit integer value N and a character array of length 30. Write instructions to convert the integer into the corresponding character sequence followed by an asterisk '*' character to signal the end.

For example: If N is 12327. You should put '1', '2', '3', '2', '7', '*' into the first 6 locations of the array.

(6 marks)

14. Consider the graph below. It shows part of the curve defined by

$$y = -2x^3 + 10x^2 + 37x + 60$$

.

TURN OVER
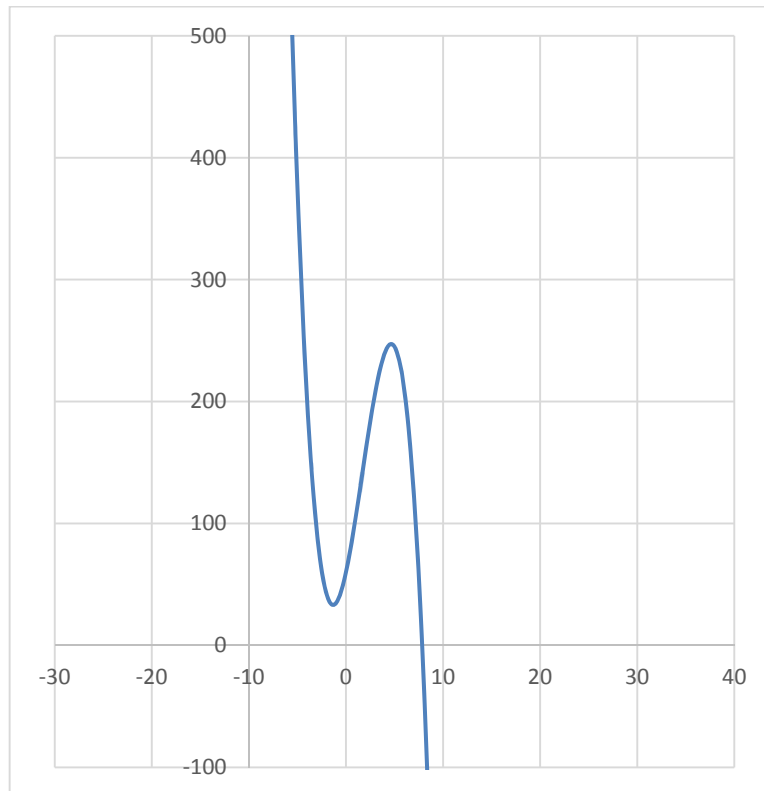
The graph shows that y is zero for x somewhere between 0 and 10, probably close to 8. An algorithm for finding the value of x for which y is zero can be based on the observation that y is positive before the zero point and negative afterwards. If we start with the fact that the zero lies between x=0 and x=10 we can make progress by calculating the value of y half way between 0 and 10 – ie: at 5. The fact that it is positive there (actually 245) tells us that the zero lies between 5 and 10. We can then check the mid-point of that range (7.5) and decide whether the zero is in range 5-7.5 or range 7.5-10. Continuing in this way we can obtain an accurate value. Write a fragment of code to find the value of x for which y is zero.

(6 marks)

Section C
Analysing a Progam

15. Consider the following code fragment.

```
P = 0;
Q = 0;
R = 0;
T = A[0];

while (Q < N)
{
    if (P < K)
        P = P + L;
    else
        P = P - K;

    S = A[P];
    A[P] = T;
    T = S;

    if (P == R)  // This means "if P is equal to R"
    {
        P = P + 1;
        R = P;
        T = A[P];
    }

    Q = Q + 1;
}
```

Where
- A is an array of integers
- K and L are small positive integer values
- N is a positive integer (whose value is always set to K+L)
- P, Q, R, S and T are integer variables
- Array A has N 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]

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) Consider starting the fragment with array A holding values 1,2,3,4,5,6,7 in
elements A[0], A[1], … A[6] respectively, K holding the value 5, L holding the
value 2 and N holding the value 7. What values will be in the array A afterwards.

(7 marks)

(b) What would have happened if the array A held the values `1,2,3,4,5,6;`
K held the value 2; L held the value 4; and N held 6?

(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 two 'if' statements. How many times was the body ('then' part)
of the second 'if' statement executed with the data in part (a) of this question? How
many times was it executed with the data in part (b)?

(4 marks)

(e) If K were 35 and L were 7, how many times would the body of the second 'if'
statement be executed.

(4 marks)