THE PAPUA NEW GUINEA UNIVERSITY OF TECHNOLOGY

DEPARTMENT OF MATHEMATICS AND COMPUTER SCIENCE
SECOND SEMESTER EXAMINATIONS 2022

THIRD YEAR COMPUTER SCIENCE

CS322 - SYSTEMS PROGRAMMING WITH C/C++

TIME ALLOWED – 3 HOURS

INFORMATION FOR CANDIDATES:

1. Write your name, student number, and program of study clearly on the front page of your answer booklet. Do it **now**.
2. You have 10 minutes to read this examination paper. During this time you must **NOT** write **inside** your answer booklet. You can make notes on the examination paper.
3. A scientific calculator is permitted, though **you do not have to use one**.
   Other electronic devices are not permitted. Notes and headphones are not permitted.
4. At the conclusion of the examination you must **immediately** put your pens down. You are **NOT** permitted to write inside your answer booklet after the "end of examination" announcement.
5. You can answer the questions in any order. Start each question on a new page. After you have finished the exam, indicate the order in which you answered questions in the left column of the marks box on the cover of the answer booklet.
6. There are 6 questions.
7. Short well thought out answers to questions are preferred to long answers.

MARKING SCHEME:

Questions 1 and 2 are each worth 20 marks. Questions 3 to 6 are each worth 15 marks.
Total marks is 100. Marks for question parts are shown at the top of each question.

QUESTION 1 [6 + 2 + 2 + 3 + 3 + 4 = 20 marks]

Here is how a typical small C program might start and end:

```
#include <stdio.h>

int main() {
        :
    return 0;
}
```

(a) Explain the meaning and use of the three lines of code containing text.

(b) Write a line of code that might be inserted after the "main()" statement which declares a character data type, and sets its value to the letter A.

(c) The "return 0" statement has different importance in the Unix and Windows operating systems. Explain.

(d) If the "return 0" statement was replaced by (say) "return 5", it would mean something important in a well written program. Explain.

(e) What would the implication of replacing `#include <stdio.h>` with

```
#include <iostream>
using namespace std;
```

(f) `main()` might be replaced by `main(int argc, char * argv[])`. What extra facility does this give our basic C program. Illustrate your answer with an example.

QUESTION 2 [4 + 4 + 2 + 2 + 2 + 6 = 20 marks]

As a low level method of finding the length (in bytes) of integers on her Windows laptop, a student wrote and ran this program:

```
#include <stdio.h>
int main() {
    int i=97, k=99;
    printf( "%p   %p  \n", &i, &k);
    return 0;
}
```

The screen display was `000000022FE50  00000022FE4C`

(a) What do you understand by the "&" operator, giving an example?

(b) Deduce the length of the "int" on the laptop from this output, with an explanation.

(c) How could the "printf" line be changed to display the values of i and k (ie, `97, 99`)?

(d) 97 and 99 are the ascii codes for the characters a and c.
How could the "printf" line be changed to display these characters?

(e) What do you understand by the `\n` in the printf statement.

(f) Explain the syntax of the `printf()` function, and compare it with the `puts()` function.

QUESTION 3 [1 + 3 + 8 + 3 = 15 marks]

This program (which has its includes omitted) will store and display a string:

```
int main() {
    char s[100] = "Christmas is coming";
    char *p = s;
    while ( *p ) {
      printf( "%c", *p );
      p++;
    }
    return 0;
}
```

(a) Complete this: "In C, a string is an ..... of characters".

(b) Character string s looks like it is 19 characters long. In fact it is 20 characters long. Explain the discrepancy.

(c) The output of the program would be `Christmas is coming`
Explain carefully how the C code produces this output.

(d) If the line `strcat( s, " soon." );` is added before the while statement, what would be displayed as program output? Explain.

QUESTION 4 [4 + 4 + 3 + 4 = 15 marks]

This question relates to the following C code (without its include).

```
void test( int i ) {
   i = i + 10;
   printf( "%d  \n", i);
}

int main() {
    int i = 23;
    test( i );
    printf( "%d  \n", i);
    return 0;
}
```

(a) **C passes parameters (to functions) by value.**
Show that you understand this concept by describing what is happening in the above code, and indicate what would be displayed (in the correct order).

(b) Suppose we wanted `test()` to return its updated value of "i" back to the main program. How could we change the above code to do this?

(c) Another method to pass parameters is **by reference**. What values would be printed by the program **IF** C passed by reference rather than by value? Explain.

(d) Passing by reference can be effectively achieved in C by using the address and contents operators. Rewrite the above program to implement this.

QUESION 5 [(2+4+3) +(5+1) = 15 marks]

(a) Consider this linked list program (without its include):

```
struct node {
    int data;
    struct node * nextnode;
};

int main() {
    struct node *t, *top;
    t = (struct node *) malloc(sizeof(struct node));
    t -> data = 35;
    t -> nextnode = 0;
    top = (struct node *) malloc(sizeof(struct node));
    top -> data = 17;
    top -> nextnode = t;
    return 0;
}
```

(i) What do you understand by the line of code `t -> nextnode = 0;` with particular reference to the use of the integer 0.

(ii) Draw a diagram of the linked list after this code runs – showing the nodes an what each pointer points to.

(iii) Write some lines of code that could be inserted just before "return 0" that would move through the linked list and (node by node) display the values of each node's integer. [Hint: For a suitable ?, `printf( "%d ", ? -> data )` will print out one such integer.]

(b) The following c++ object oriented code (without includes) has five missing key words or operators.

```
xxxx Cow {                          //1
    int weight;
  xxxx:                             //2
    Cow() { weight = 0; }
    int feed(int food) {
        weight += food;
        return weight;}
    };

int main() {
    int w;
    Cow * nellie;
    nellie = xxxx( Cow );           //3
    w = nellie xxxx feed(25);       //4
    cout xxxx w;                    //5
    return 0;
}
```

(i) Write down the missing words/operators in the order they appear in the program).

(ii) Using the terminology of OO programming, what is "nellie" (don't say a cow).

QUESTION 6 [(6+2) +(1+2+2+2) = 15 marks]

(a) A C program with one variable 'i' was compiled into this assembly code.

```
        movl   $12, -4(%rbp)
        cmpl   $10, -4(%rbp)
        jle    .L2            * second argument compared to first
        movl   -4(%rbp), %eax
        imull  -4(%rbp), %eax
        addl   $20, %eax
        movl   %eax, -4(%rbp)
.L2:
        . . .
```

(i) Describe line by line what the code is doing, and what value would displayed after the code executes if the single variable value was displayed using a printf statement) .

(ii) Using a gcc compiler, how was this assembly code produced?.

(b) The program below (shown without its includes) was written to demonstrate how to write a threaded program for Unix using C.

```
int main() {
    puts("Program starting");
    fork();
    puts("Program ending");
    return 0;
}
```

(i) If the program was run, what would be the output display?

(ii) Explain how the program works.

(iii) In Unix the "ps" command will show running processes. To see what is happening with this program it needs to be stopped before ending. How could this be done?

(iv) A program like the above might contain a statement like:

```
if ( . . . ) execl(. . .);
```

What is this statement doing?

END OF EXAMINATION