3 HOURS

ANSWER ALL 4 QUESTIONS

Electronic calculators are not permitted.

Question 1

Answer both part (a) and part (b).

a) Study these C++ functions and answer the questions that follow.

```
int isr(char *s1, char *s2)
{
     int len = strlen(s1);
     if (strlen(s2) != len)
          return 0;
     else {
          for (int i = 0; i < len; i++)
               if (s1[i] != s2[len - i - 1])
                    return 0;
          return 1;
     }
}
int isp(char *s)
{
     return isr(s, s);
}
```

i) What value is returned by each of the following calls to the function *isp*:

```
isp("ab") ;
isp("aba") ;
isp("") ;
```

[3 marks]

ii) Describe as succinctly as you can what the two functions *isr* and *isp* do. [7 marks]

QUESTION 1 CONTINUED OVER PAGE

b)

Write brief answers on any ***three*** of the following six topics.

i) Describe the sequence of actions that takes place when a function is called in C++. [5 marks]

ii) What are the main reasons to use pointers in C++ programs? [5 marks]

iii) How do you recognise the declaration or definition of a constructor function within a class? If a class has a constructor function, when is it called and what is its purpose? [5 marks]

iv) Explain how the precedence and associativity of operators allows an unambiguous meaning to be given to an output statement like:

```
cout << x + 1 << "\n";
```

[5 marks]

v) Describe some of the operations provided for doing input by the class of which *cin* is a standard instance. [5 marks]

vi) The *isp* function in the first part of this question is not very efficient. Re-write the function so as to improve its performance. Which of the changes that you have made do you think is likely to be the most significant?
(Minor errors in C++ syntax will not be penalised.) [5 marks]

END OF QUESTION 1

QUESTION 2 C1 1996

Answer any *two* parts from (a), (b), (c).

Part (a)

The following instructions are a part of a UART interrupt routine. In this example:

- The routine *getchar* reads a character from the UART and returns it in register D0
- The code *rti* means "return from interrupt"
- *CSR* is the address of the UART's status register which has the format:

?	?	?	?	?	?	RDN	WDN

where *RDN* implies "read done" and *WDN* implies "write done". (The other bits are irrelevant to the question.)

```
1 | uartio:     mov.l   D0,     (A7)-
2 |             mov.b   CSR,    D0
3 |             and.b   D0,     0x02
4 |             jne     L1
5 |             bsr     getchar
6 |             mov.b   D0,     inchar
7 |             mov.l   (A7)+   D0
8 |             rti
9 | L1:         ...
```

i) Describe the operation of these instructions paying particular attention to the purpose and effect of those in lines 1, 2, 3, 4, 7, and 8. [9 marks]

ii) What will be on the top of the stack when the instruction in line 8 is executed and how did it get there? [3 marks]

QUESTION 2 CONTINUES OVER PAGE

Part b)

i) Briefly describe the Fetch/Execute cycle of a simple processor. [6 marks]

ii) Describe how the technique of pipelining may be used to speed up instruction execution. Indicate how the use of variable-length instructions and branch instructions impact the technique. [6 marks]

Part c)

i) What is meant by "*Direct Memory Access*" (*DMA*) and why is it employed? [3 marks]

ii) Implementation of *DMA* typically involves extra bus lines to signal "*bus request*" (*BREQ*) and "*bus grant*" (*BGRNT*). Explain how these signals are used and the role played by *daisy-chaining* in bus arbitration. [6 marks]

iii) The processor is often given the lowest priority in a bus arbitration scheme. Why is this and what effect does it have on processor performance? [3 marks]

END OF QUESTION 2

QUESTION 3

Answer any *two* parts from (a), (b), (c).

Part (a)

A process executes a system call which reads one character from a keyboard. Outline the key events and state changes which will occur in a multiprocessing operating system between the execution of the system call and until the eventual passing of a character to the process. [12 marks]

QUESTION 3 CONTINUES OVER PAGE

Part (b)

A processor has a 32-bit address space and has a *Memory Management Unit* which uses 2048 byte pages.

i) How many bits will be allocated to the page addresses and how many virtual pages will there be? If virtual page 1 is mapped onto physical page 8, to what physical address will virtual address 0x00000b12 will be mapped? [4 marks]

ii) Show, with the aid of a diagram, how a page table is used in the implementation of virtual memory in such a system. Explain what a *page fault* is and how it is handled. [6 marks]

iii) Explain how paging can be used to provide multiple virtual memory spaces within a multiprocessing system. [2 marks]

Part (c)

In this question you are asked to write a small program. This should be written in a representative assembly language. You will not be marked on the accuracy of your use of any particular language, however, you must restrict yourself to typical assembly language constructs and must make clear the meaning of any novel notations you introduce.

i) An array of positive, 32-bit integers is stored in successive memory locations starting at address 0x8000. The number of integers in the array is held in register D1. Write a program, **using indexed addressing,** to find the largest integer and store it in register D0**.** [8 marks]

ii) What is meant by "position-independent code"? Explain how your program in part i) could be modified to make it position-independent. [4 marks]

END OF QUESTION 3

QUESTION 4 C1 1996

Answer All parts a, b and c.

An advertising company wishes to build a computer system to process live televised football matches so as to replace pictures of advertising hoardings around the ground with virtual advertisements for alternative products whose manufacturers and retailers are prepared to pay a suitably high fee. All the leading stadia have been surveyed, the positions and dimensions of the advertising boards recorded on computerised databases and the virtual advertisements to replace them prepared. When a match is to be televised, it is planned to record the pan and tilt of the TV cameras from two gyroscopes attached to each camera and to use this information to replace pictures of the actual advertisements at the appropriate positions in the TV images, prior to broadcast.

Typically the TV camera has a 30 degree field of view, reduced to 10 degrees for close-ups. There are approximately 100 advertising boards at each stadium which may each be assumed normally to fill about one tenth of the picture with at most three boards visible at any one time. Their positions and dimensions are known in camera co-ordinates to an accuracy of 0.005 degrees.

(a) Discuss why the computer system that has to be built to solve this problem may be described as a real-time system. [6 marks]

(b) The specification of the gyroscopes is as follows: bandwidth 5 kHz, range 0.01- 150 degrees/sec, accuracy 0.003 degrees/sec. Describe how the analog signals from such a gyroscope may be converted to suitable digital signals and discuss what method you would use to read this data into the computer system. [7 marks]

(c) Management of the advertising company would like to use dedicated cables to transmit very high quality digital TV pictures to the studio at 50 Hz in colour using three identical colour channels each digitised to 8 bits in wide-screen 16:9 format with 1152 active lines. The pictures would then be processed in the studio prior to broadcasting at lower resolution for viewing. Discuss whether this is a sensible option, describing the problems you would expect to meet in implementing such a system and indicate briefly what kind of computer architecture you might adopt. You should aim to discuss the important issues, only giving brief quantitative details where needed to support your arguments and conclusions.

[12 Marks]

END OF PAPER