MACQUARIE UNIVERSITY
Division of Information and Communication Sciences

END-OF-YEAR EXAMINATIONS 2003

Course: COMP226 - Computer Architecture

Date: Monday, 17 November, 2003, 9:20 am

Time Allowed: Three hours + ten minutes reading time

Number of Questions: Eight ???XXX (8)

Total Marks: 180

Instructions: Answer ALL questions.

The examination is in two sections.
Section A is on SPARC assembler, Digital Logic, and Pipelining.
Section B is on I/O and Memory Management.

Answer Sections A and B in separate books.
Indicate the section clearly on the outside of each book.
Ensure that your name and student number are clearly marked on
each answer book.

Calculators are not permitted.

Dictionaries are not permitted.

If you wish to spread your time evenly, you should spend about
one minute for each mark.

SECTION A. SPARC Assembler, Digital Logic and Pipelining

QUESTION 1. (30 marks)

The `OR` instruction takes three registers as parameters. It takes the words from the first two registers, and calculates their `OR` (by `OR`ing the 32 corresponding bits from each word). It then puts its answer (sometimes called the *bitwise* `OR` of the two numbers) in the third register.

Write a fragment of SPARC assembler which will use an `OR` instruction to count the number of bits with value 1 in the 32 bit word contained in register 3.

Your code should display the answer by printing "The count is . . . " (where the dots are replaced by your answer!).

Remember to use the `OR` instruction, and try to make your code reasonably efficient.

Work out your solution first on scrap paper and then copy it neatly into your book. Comment your solution clearly.

QUESTION 2. (30 marks)

(a) (15 marks)
Assemble the following SPARC assembly code into SPARC machine code.

```
        .text
        ld [%r7], %r3
  top:  add %r3, %r2, %r3
        subcc %r3, %r5, %r0
        blt top
        inc %r2
```

Show your working for each line of code, and then present your final answer as five lines of 32 bit words written in hexadecimal.

The SPARC reference card is included at the back of this examination paper.

(b) (15 marks)

Use the Hardware Description Language presented in lectures to describe what happens on each of the five stages of the standard pipeline when the `subcc` instruction in part (a) is executed. You only need to indicate actions which are relevant for the `subcc` instruction (so although the second stage of the pipeline is used to determine whether or not a branch should be taken, you will not need to mention those details in your answer to this question because they are not relevant when a `subcc` instruction is being executed).

QUESTION 3. (30 marks)

(a) (21 marks)
What is forwarding?

What is a pipeline interlock?

Explain where forwarding and/or interlocks occur in the following code. In each case indicate which lines of code are involved and precisely what happens to carry out the forwarding and/or interlocks.

```
        ld [%r7], %r3          ! line 1
  top:  add %r3, %r2, %r3      ! line 2
        subcc %r3, %r5, %r0    ! line 3
        blt top                ! line 4
        inc %r2                ! line 5
```

(b) (9 marks)
Draw a diagram which shows how to construct an OR gate using three transistors. Draw diagrams which show how to construct a half-adder and a flip-flop using AND, OR and NOT gates.

SECTION B. Memory Management and I/O... (Use a separate book)

QUESTION 4. (XX marks)