

**Homework 6**  
**Performance, Recursion and Floating Point Representation**  
**Maximum points: 80**

**Directions**

This assignment is due Friday, 11<sup>th</sup> November 2005 by 5:00 PM.

**Learning Objectives**

In the process of completing this homework assignment, students will develop their abilities to

- Determine the performance of a processor.
- Determine how different parameters affect the performance of a machine
- Apply Amdahl's law to determine how much speedup can be obtained by improving an architecture.
- Interpret and represent floating point numbers
- Write recursive procedures.

**General Instructions**

1. Submit your solutions on a separate sheet of paper.

**Problems**

1. [15 points] Problem 4.10 (page 273) from Hennessey and Patterson.
2. You are going to enhance a machine, and there are two possible improvements: either make multiply instructions run four times faster than before, or make memory access instructions run two times faster than before. You repeatedly run a program that takes 100 ns to execute. Of this time, 20% is used for multiplications, 50% for memory access instructions, and 30% for other tasks. For each of the following, compute the speedup relative to the original machine:
  - a. [5 points] Improve only multiplication?
  - b. [5 points] Improve only memory accesses?
  - c. [5 points] Improve both multiplication and memory accesses?
3. Machine M1 has a **single-cycle** implementation. The time required for the execution of each type of instruction is given below, as is the frequency distribution of the instructions for a program P1.

Instruction type	Time to execute an instruction	Frequency distribution for program P1
R-type	6ns	44%
LW	8ns	24%
SW	7ns	12%
Branch	5ns	18%
J	2ns	2%

- a. [5 points] What should be the minimum clock cycle time for this machine? Explain.
  - b. [5 points] If P1 has 4539 instructions, what is its CPU execution time on M1?
  - ~~5.c.~~ [5 points] Given the above frequency distribution for the instructions for P1, determine what percent of the CPU execution time, the CPU is idle.
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4. [10 points] Convert the following decimal numbers to single precision IEEE 754 floating point format:
    - a. -21.625
    - b. 9.25
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- ~~6.5.~~ [15 points] The following bit patterns are floating point numbers in single precision IEEE 754 format. Convert them to decimal:
    - a. 1 1001 1000 011011000000000000000000
    - b. 0 0111 1011 001100000000000000000000
    - c. 0 0000 0000 011100000000000000000000

Problem 6 is on the following page.

6. [10 points] The incomplete MIPS procedure below computes the recursive function

$foo(a,b) =$	}	$b, \text{ if } a = 0$
		$foo(a-1, b-a) * b, \text{ otherwise}$

Finish the procedure by adding the code for the procedure entrance, the recursive procedure call, and the procedure exit. Do not modify any of the given code, and be sure to follow the MIPS convention for register usage.

Hint:  $\$t0$  and  $\$s0$  hold the local values of  $a$  and  $b$ , respectively.

You may write the answer to this question in the boxes provided and attach the sheets with the rest of your solutions.

```
foo:
    # Procedure entrance
```

```

    # if (a == 0) return b
    bne $t0, $zero, Else
    move $t1, $s0
    j    Exit

    # otherwise, return foo(a-1,b-a)*b
Else: sub $t2, $t0, 1
      sub $t3, $s0, $t0
      # Recursive procedure call
```

```
mul $t1, $t1, $s0
```

```
Exit: move $v0, $t1
      #Procedure exit
```

