September 16

- Assignment 4 due date pushed back to 23rd, better start anyway
- Questions?
- Test 1 review

Question 1

[10] Assume that multiply instructions take 12 cycles and account for 10% of the instructions in a typical program and that the other 90% of the instructions require an average of 4 cycles for each instruction. What percentage of time does the CPU spend doing multiplication?

12 * 0.1 / (12*0.1 + 4*0.9) = 25%

Question 2

[10] Consider a byte-addressable memory and an architecture that manipulates 2-byte words. What is the maximum number of words of memory available if the architecture has addresses that are 16 bits long?

2^16 bytes / (2 bytes/word) = 2^15 words = 32k

Question 3

[10] You MP3 player has 128 Mbytes of memory. A typical MP3 music file requires 128 kbits per second. How many minutes of music can you store?

128 * 2^20 bytes * 2^3 bits/byte / (2^17 bits/sec * 60 sec/min) = 2^13/60 = 136 minutes

2^27 bytes * 2^3 bits/byte / (2^17 bits/sec * 2^6 sec/min) = 128 minutes

Question 4

[10] How many instructions that are 16 bits long fit in 32k bytes of memory?

32k / 2 = 16k

Question 5

[10] Two machines have the same clock rate. What can you say about their performance relative to one another?

Nothing. They might have different ISA's or different CPI's.

Question 6

[10] A certain program executes 200 million instructions. On a 300MHz Pentium II it takes 3 seconds to run. What is the MIPS rating of the processor on this program? What is the average CPI? On a 500MHz Pentium III the program takes 1 second. What is the MIPS rating for this processor? What is the CPI?

MIPS = 200/3 = 66.7, CPI = 300*3/200 = 4.5

MIPS = 200/1 = 200, CPI = 500*1/200 = 2.5

Question 7

[10] Consider the characteristics of two machines M1 and M2. M1 has a clock rate of 500Mhz. M2 has a clock rate of 600MHz. There are 4 classes of instructions (A-D) in the instruction set. In a set of benchmark programs, the frequency of each class of instructions is shown in the table.

Instruction Class	Frequency	M1 CPI	M2 CPI
A	40%	2	2
B	25%	3	2
C	25%	3	3
D	10%	5	4

What is the average CPI for each machine?

M1 = 0.4*2 + 0.25*3 + 0.25*3 + 0.1*5 = 2.8

M2 = 0.4*2 + 0.25*2 + 0.25*3 + 0.1*4 = 2.45

Question 8

[10] How much faster is M2 than M1?

(2.8 / 500) / (2.45 / 600) = 1.37

37% faster.

Question 9

[10] In a certain set of benchmark programs about every 4th instruction is a load instruction that fetches data from main memory. The time required for a load is 50ns. The CPI for all other instructions is 4. Assuming the ISA's are the same, how much faster will the benchmarks run with a 1GHz clock than with a 500MHz clock?

For 4 instructions the time is 50ns + 3*4/R, so the speedup is (50ns + 24ns) / (50ns + 12ns) = 1.19 or about 19%.

Question 10

[10] State Amdahl's Law with an equation.

Timproved = (Tunaffected + Taffected/improvement)

Question 11

[15] You are going to enhance a machine, and there are two possible improvements: either make multiply instructions run 4 times faster than before, or make memory access instructions run 2 times faster than before. You repeatedly run a program that takes 100 seconds to execute. Of this time, 20% is used for multiplication, 50% for memory access instructions, and 30% for other tasks. What will be the speedup if you improve only multiplication? What will be the speedup if you improve only memory access? What will be the speedup if both improvements are made?

Speedup if we improve only multiplication = 100 / (30 + 50 + 20/4) = 100/85 = 1.18

Speedup if we only improve memory access = 100 / (30 + 50/2 + 20) = 100/75 = 1.33

Speedup if both improvements are made = 100 / (30 + 50/2 + 20/4) = 100/60 =1.67

Question 12

In a machine with 32 registers and instructions that specify 3 registers (like MIPS R-format). How many bits of the instruction are required to specify the registers?

15 bits (5 bits for each register)

Question 13

Which of the following instructions that will NOT copy the value of $t2 into $t1.

a. and $t1,$t2,$t2
b. add $t1,$t2,$t2 NO
c. or $t1,$t2,$t2
d. or $t1,$t2,$zero

Question 14

A certain program executes a variable number of floating-point operations and a fixed number of other operations. When the number of floating-point operations is 600×10^6 the program requires 4 seconds to run. When the number of FP operations is 1100×10^6 the program requires 7 seconds to run. What is the CPI for floating-point operations on this 500MHz computer?

You've got enough information here to set up 2 equations in 2 unknowns and to solve for both the time per floating-point operation AND the total time spent in the other operations. But you don't need to do all that since all I ask for in effect is the time per floating point operation. Since the other time is constant we can subtract the two times and the two FP operation counts (essentially subtracting the two equations eliminating the constant term) and we see that 500 million FP operations take 3 seconds. So 3 seconds divided by 500 million FP operation times 500 million cycles per second gives 3 cycles per FP operation.