Computer Organization and Structure

Homework #1
Due: 2012/9/25

1. Which of the following contain circuits that are likely to be combinational and which contain sequential circuits? Explain your rationale.

a. A washing machine that sequences through the soak, wash, and spin cycles for preset periods of time.
b. A three-input majority circuit that outputs a logic 1 if any two of its inputs are 1.
c. A circuit that divides two 2-bit numbers to yield a quotient and a remainder.
d. A machine that takes a dollar bill and gives three quarters, two dimes, and a nickel in change, one at a time through a single coin change slot.
e. A digital alarm clock that generates an alarm when a preset time has been reached.

2. Two different sequences (S1 and S2) are being tested on a 2GHz machine with four different classes of instructions. The CPI of each different Instruction Class (I1, I2, and I3) is as the following table.

Instruction Class	**Cycle for each Instruction (CPI)**
I1	2
I2	4
I3	6

And also, the table below shows the number of different instructions (I1, I2, and I3) used in two different sequences (S1 and S2).

Instruction Class	**S1**	**S2**
I1	6 (billion)	13 (billion)
I2	2 (billion)	3 (billion)
I3	2 (billion)	2 (billion)

a. Which sequence will be faster according to execution time?
b. Which sequence will be faster according to MIPS?
c. From these solutions above, you should understand about the execution times used by each Instruction Class (I1, I2, and I3) in sequence S2. According to Amdahl's Law, how much do we have to improve the speed of Instruction Class: **I3** in order to make the sequence **S2** to run **1.25 times faster** on performance?

3. 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 seconds to execute. Of this time, 20% is used for multiplication, 50% for memory access instructions, and 30% for other tasks.

a. What will the speedup be if you improve only multiplication?
b. What will the speedup be if you improve only memory access?

c. What will the speedup be if both improvements are made?

4. Compilers can have profound impact on the performance of an application on a given processor. This problem will explore the impact compilers have on execution time.

	Compiler A		**Compiler B**	
	# Instructions	**Execution Time**	**# Instructions**	**Execution Time**
Program a.	10^9	1 s	1.2×10^9	1.4 s
Program b.	10^9	0.8 s	1.2×10^9	0.7 s

a. For the same program, two different compilers are used. The table above shows the execution time of the two different compiled programs. Find the CPI for the combination of each program and each compiler given that the processor has a clock cycle time of 1 ns.

b. Assume the average CPIs found in the above sub-question, but that the two compiled programs run on two different processors. If the execution time on the two processors is the same, but how much faster is the clock of the processor running the code produced by Compiler A versus the clock of the processor running the code produced by Compiler B? Please write down the answer for Program a. and Program b. separately.