Computer Organization for Ph.D. Candidacy

1. (20%) A program runs in 10 seconds on machine A, which has a 400-MHz clock. Machine B is designed to run the same program in 6 seconds. The designer has determined that a substantial increase in the clock rate is possible, but this increase will affect the rest of the CPU design, causing machine B to require 1.2 times as many clock cycles as machine A for this program. What clock rate should we tell the designer to target?

2. (20%) Consider the machine with three instruction classes and CPI measurements as follows:

Instruction class	CPI for this instruction class
A	1
B	2
C	3

   Now suppose we measure the code for the same program from two different compilers and obtain the following data:

Code from	Instruction counts (in billions) for each instruction class		
	A	B	C
Compiler A	5	1	1
Compiler B	10	1	1

   Assume that the machine's clock rate is 500 MHz. Which code sequence will execute faster according to MIPS? According to execution time?

3. (10%) The representation of a MIPS floating-point number is shown as (s, *exponent*, *significand*), where s is the sign of the floating-point number (1 means negative), *exponent* is the value of the 8-bit exponent field (including the sign of the exponent), and *significand* is the 23-bit number in the fraction.

   What decimal number is represented by this word?

1	1	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

4. (20%) What is the difference of **instruction-level parallelism** and **data-level parallelism**. Please provide an example for each one.

5. (15%) Suppose we have a processor with a base CPI of 1.0, assuming all references hit in the primary cache, and a clock rate of 4GHz. Assume a main memory access time of 100ns, including all the miss handling. Suppose the miss rate per instruction at the primary cache is 2%. How much faster will the processor be if we add a secondary cache that has a 12.5ns access time for either a hit or a miss and is large enough to reduce the miss rate to main memory to 0.5%?

6. (15%) What is the average disk access time to read or write a 512B sector for a disk rotating at 15,000 RPM with average seek time of 0.7 ms, a 10MB/sec transfer rate, and a 0.2 ms controller overhead?