The National School of Artificial Intelligence
Computer Architecture
Computer Components

Assignment 01

Exercise 1:

1. Our favorite program runs in 10 seconds on computer A, which has a 2 GHz clock. We are trying to help a computer designer build a computer, B, which will run this 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 computer B to require 1.2 times as many clock cycles as computer A for this program. What clock rate should we tell the designer to target?
2. Suppose we have two implementations of the same instruction set architecture. Computer A has a clock cycle time of 250 ps and a CPI of 2.0 for some programs, and computer B has a clock cycle time of 500 ps and a CPI of 1.2 for the same program. Which computer is faster for this program and by how much?
3. A compiler designer is trying to decide between two code sequences for a computer. The hardware designers have supplied the following facts:

	A	B	C
CPI	1	2	3

Table 1.1: CPI for each instruction class

For a particular high-level language statement, the compiler writer is considering two code sequences that require the following instruction counts:

Code sequence	A	B	C
1	2	1	2
2	4	1	1

Table 1.2: Instruction counts for each instruction class

Which code sequence executes the most instructions? Which will be faster? What is the CPI for each sequence?

4. A given application written in Java runs 15 seconds on a desktop processor. A new Java compiler is released that requires only 0.6 as many instructions as the old compiler. Unfortu-

nately, it increases the CPI by 1.1. How fast can we expect the application to run using this new compiler? Pick the right answer from the three choices below:

a.

$$\frac{15 \times 0.6}{1.1} = 8.2sec \tag{1.1}$$

b.

$$15 \times 0.6 \times 1.1 = 9.9sec \tag{1.2}$$

c.

$$\frac{15 \times 1.1}{0.6} = 27.5sec \tag{1.3}$$

5. How do you measure fastest? Consider the three different processors P1, P2, and P3 executing the same instruction set. P1 has a clock cycle time of 0.33 ns and CPI of 1.5; P2 has a clock cycle time of 0.40 ns and CPI of 1.0; P3 has a clock cycle time of 0.25 ns and CPI of 2.2.
   a. Which has the highest clock rate? What is it?
   b. Which is the fastest computer? If the answer is different than above, explain why. Which is the slowest?
   c. How do the answers for a and b reflect the importance of benchmarks?

Exercise 2:

Consider three different processors, P1, P2, and P3, executing the same instruction set. P1 has a 3 GHz clock rate and a CPI of 1.5. P2 has a 2.5 GHz clock rate and a CPI of 1.0. P3 has a 4.0 GHz clock rate and a CPI of 2.2.

1. Which processor has the highest performance expressed in instructions per second?
2. If the processors execute a program in 10 seconds, find the number of cycles and the number of instructions.
3. We are trying to reduce the execution time by 30%, but this leads to an increase of 20% in the CPI. What clock rate should we have to get this time reduction?

Exercise 3:

Consider two different implementations of the same instruction set architecture. The instructions can be divided into four classes according to their CPI (classes A, B, C, and D). P1 with a clock rate of 2.5 GHz and CPIs of 1, 2, 3, and 3, and P2 with a clock rate of 3 GHz and CPIs of 2, 2, 2, and 2.

Given a program with a dynamic instruction count of 1.0E6 instructions divided into classes as follows: 10% class A, 20% class B, 50% class C, and 20% class D, which is faster: P1 or P2?

1. What is the global CPI for each implementation?
2. Find the clock cycles required in both cases.

Exercise 4:

Assume a 15 cm diameter wafer has a cost of 12, contains 84 dies, and has 0.020 defects/cm^2. Assume a 20 cm diameter wafer has a cost of 15, contains 100 dies, and has 0.031 defects/cm^2.

1. Find the yield for both wafers.
2. Find the cost per die for both wafers.
3. If the number of dies per wafer is increased by 10% and the defects per area unit increases by 15%, find the die area and yield.
4. Assume a fabrication process improves the yield from 0.92 to 0.95. Find the defects per area unit for each version of the technology given a die area of 200 mm^2.