DEPARTMENT OF COMPUTER SCIENCE

COLORADOSCHOOLOFMINES
EARTH • ENERGY • ENVIRONMENT

CSCI 341: Computer Organization
WS 10: CPU Performance

1	Write the equation relating performance and execution time. Solution: performance=1/execution time
2	Define clock period and clock frequency. Compare and contrast the two. Solution: Clock period: duration of clock cycle Clock frequency: cycles per second
3	What are a couple areas in which performance can be improved? Solution: Reducing the number of clock cycles Increasing the clock rate
4	Write the equation for clock cycles. Solution: Clock Cycles=Instruction Count*Cycles per Instruction
5	Write the equation for CPU time. Solution: CPU Time=Instruction Count*CPI/Clock Rate
6	Calculate the average CPI from the table below.

Operation	Frequency	CPI
ALU	40%	1
Load	30%	5
Store	25%	3
Branch	5%	2

	Solution: $CPI_{Average} = 0.4 * 1 + 0.3 * 5 + 0.25 * 3 + 0.05 * 2 = 2.75$
7	Explain Ambhal's law. What does it say about performance enhancement? Solution: Ambhal's law states that improving one aspect of a computer's performance will not have a proportionate effect on the computer's overall performance.
8	Explain the difference between response time and throughput, and give an example outlining how these two concepts are different. Solution: While throughput and response time (also referred to as latency) can sometimes be construed, the difference can be outlined in an example such as this one: fiber optic cables and a cargo ship carrying a container of harddrives have the same throughput (i.e. the average amount of data per time is the same), but the latency of the ship is trillions of times larger than that of the fiber optic line.
9	A metric n denotes that computer A is n times faster than computer B. Give n in terms of the execution time of computer A and B. Solution: (Execution Time B)/(Execution Time A) = n
10	What is the execution time of program X if the *clock period* is 5 ns (nanoseconds) and the program requires 21.9 million cycles to finish execution. Solution: 21.9 * 10^6 * 5 * 10^(-9) = 0.1095 seconds

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Computer A has a clock cycle time of 700 ps (picoseconds) and an average CPI of 4.2 for program X. Computer B has a clock rate of 0.7 GHz (gigahertz) and an average CPI of 3.1 for program X. Which computer executes program X faster and by how much faster is it than the other computer?

Solution:
Computer A time per instruction: 700 * 10^-12 * 4.2 = 2.94 * 10^-9

Computer B time per instruction: 3.1 / (0.7 * 10^9) = 4.429 * 10^-9

Computer A is faster for program X by a factor of 4.429 * 10^-9/2.94 * 10^-9 = 1.51

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For a particular program X, there are three types of instructions: FP, memory access, and arithmetic/logic. This program X is run on a computer with a clock cycle time of 500 ps, and there are 10 million instructions total in the program. Use the table below demonstrating each instruction's CPI and percent composition of the program to find the execution time of the program.

Instruction Type	**FP**	**Memory Access**	**Arithmetic/**
CPI	2.4	5	1.2
Composition of Total Program	50%	30%	20%

Solution:

First, find the average CPI for the whole program: (0.5 * 2.4) + (0.3 * 5) + (0.2 * 1.2) = 2.94

Next, we can use the standard equation execution time = CPI * Instructions * clock cycle time.

Execution Time = 2.94 * 10 * 10^6 * 500 * 10^-12 = 0.0147 seconds.

13 Computer A runs a program with half of the total execution time of computer B. Computer A has a clock rate of 4 GHz, and an average CPI of 2.8, while computer B has a clock period of 500 ps, and a composition of instructions described in the table below. Find the missing CPI X in the table below.

Instruction Type	**FP**	**Memory Access**	**Arithmetic/**
CPI	3	**X**	0.8
Composition of Total Program	19%	39%	42%

Solution:

Computer A time per instruction: 2.8 / 4 GHz = 7 * 10^-10 seconds

Computer B time per instruction: 7 * 10^-10 seconds * 2 = 14 * 10^-10 seconds

14 * 10^-10 seconds = 500 * 10^-12 * (3 * .19 + 0.8 * 0.42 + 0.39 * X)

2.8 = (3 * .19 + 0.8 * 0.42 + 0.39 * X) = 0.906 + 0.39 * X
1.894 = 0.39 * X
X = 4.856