In-Class Problem 1 - A program runs in 10 sec on computer A, which has a 2GHz clock. Computer B runs the same program in 6 sec, but requires 1.2 times as many clock cycles as Computer A.

What is the clock rate for Computer B?

$$CPU\ Time_A = \frac{Clock\ Cycles}{Clock\ Rate} => Clock\ Cycles = CPU\ Time_A * Clock\ Rate$$

$$= 10sec * 2 * 10^9\ {}^{cycles}/_{sec} = 20 * 10^9 cycles$$

$$Clock\ Cycles_B = 1.2 * Clock\ Cycles_A = 1.2 * 20 * 10^9 cycles = 24 * 10^9 cycles$$

$$CPU\ Time_B = \frac{Clock\ Cycles}{Clock\ Rate} => Clock\ Rate = \frac{Clock\ Cycles}{CPU\ Time_B}$$

$$= \frac{24 * 10^9 cycles}{6\ sec} = 4 * 10^9\ {}^{cycles}/_{sec} = 4GHz$$

In-Class Problem 2 - Suppose we have two implementations of the same instruction set architecture. Computer A has a clock cycle time of 250ps and a CPI of 2.0 for some program. Computer B has a 500ps and a CPI of 1.2 for the same program.

Which computer is faster, and by how much?

It is known that the number of instructions is the same for each program. =>

$$Clock\ Cycles = CPI * Instructions \qquad CPU\ Time = Clock\ Cycles * Clock\ Cycle\ Time$$

$$n = \frac{Execution\ Time_A}{Execution\ Time_B} = \frac{2.0 * I * 250ps}{1.2 * I * 500ps} = 0.83$$

=> Since n < 1, then Execution Time of A is less than B => A is faster by 1/0.83 = 1.2

In-Class Problem 3 - Assume that to spell check a large file 820,000,000 instructions are needed. The instructions in the program are broken into 4 different classes, and each class requires N clock cycles to execute. Specific information is given in the table below. If the total execution time for this program is found to be 1.57 seconds, what is the clock cycle time of the computer on which it was run?

Instruction Class	Clock Cycles per Instruction	Number of Instructions
Branch	3	150,000,000
Store	4	185,000,000
Load	5	260,000,000
ALU / R-type	4	225,000,000

Total Cycles: cycle / inst * inst

$(3 * 150 + 4 * 185 + 5 * 260 + 4 * 225) * 10^6 = 3390 * 10^6$ cycles

Clock Cycle Time = cycles / sec

$3390 * 10^6$ cycles / 1.57 sec = $2159.23 * 10^6$ cycles / sec = $2.159 * 10^9$ cycles / sec = 2.159 GHz

In-Class Problem 4 - Given the following CPI for three instruction classes, and the number of instruction counts for each instruction class on two separate computers, determine which of the two computers is faster, and the average CPI for each.

	A	B	C
CPI	1	2	3

Computer	Instruction Count for Each Instruction Class		
	A	B	C
1	2	1	2
2	4	1	1

$$CPU\ Clock\ Cycles = \sum CPIi * (Instruction\ Count\ i)$$

$CPU\ Clock\ Cycles\ 1 = 1*2+2*1+3*2 = 10$ $\qquad$ $CPU\ Clock\ Cycles\ 2 = 1*4+2*1+3*1 = 9$

$$CPI_{overall} = Clock\ Cycles/(\#\ of\ Instructions)$$

$CPI_1 = \frac{10}{2+1+2} = \frac{10}{5} = 2$ $\qquad$ $CPI_2 = \frac{9}{4+1+1} = \frac{9}{6} = 1.5$

=> Since $CPI_2 < CPI_1$, CPI_2 is faster, since it takes fewer cycles per instruction on average.

In-Class Problem 5 - A given program's execution time is 100ns. The floating point addition, which takes up 20ns of the program's execution, is sped up by a factor of 5. What is the new execution time of the program?

$$Execution\ Time_{new} = \frac{Affected}{Speedup} + Unaffected$$

$$Execution\ Time_{new} = \frac{20ns}{5} + (100ns - 20ns) = 4ns + 80ns = 84ns$$

In-Class Problem 6 - The table below shows instruction-type breakdown for different programs. Using this data, you will be exploring the performance tradeoffs with different changes made to a RISC-V processor

# Instructions				
Compute	Load	Store	Branch	Total
1000	400	100	50	1550

a) Assuming that computes take 1 cycle, loads and store instructions take 2 cycles and branches take 3 cycles, find the execution time for the program on a 3 GHz MIPS processor.

Solution: $CPU\ Time = \frac{CPI*Instructions}{Clock\ Rate}$ =>

$$CPU\ Time = \frac{1*1000+2*400+2*100+3*50}{3GHz} = \frac{1000+800+200+150}{3*10^9} = 2150*10^{-9}sec$$

b) Assuming that computes take 1 cycle, loads and store instructions take 10 cycles and branches take 3 cycles, what is the speed-up of the program if the number of compute instructions can be reduced by one-half?

Solution: $CPU\ Time = \frac{CPI*Instructions}{Clock\ Rate}$ =>

$$CPU\ Time = \frac{1*(1000/2)+2*400+2*100+3*50}{3GHz} = 1650*10^{-9}sec$$

Speedup = 2150/1650 = 1.3