Performance

CPU time = CPU clock cycle * clock cycle time (s)
time to execute a given program
= CPU clock cycle / clock rate (MHz)

CPU clock cycle = instruction count * $\frac{\text{clock cycles}}{\text{instructions}}$
= ins. count * CPI

CPU time = ins. count * CPI * clock rate
= ins. count * CPI / clock rate

easy
doesn't reflect actual performance.
MIPS = ins. count / (execution time * 10^6)
million instruction per second

easy
same as MIPS
MFLOPS = Floating point operation / (exec. time * 10^6)
million floating point operation per second

Computer System Architecture

Tutorial 2:

1. A benchmark program is run on an 80 MHz processor. The executed program consists of 100,000 instruction execution, with the following instruction mix and clock cycle count:

	Instruction Type	Instruction Count	Cycle per Instruction
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a	Integer Arithmetic	45000	1
b	Data Transfer	32000	2
c	Floating Point	15000	2
d	Control Transfer	8000	2

Determine the effective CPI, MIPS rate, and execution time for this program

2. The performance of a 100MHz microprocessor P is measured by executing 10,000,000 instruction of benchmark code, which is found to take 0.25s. What are the values of CPI and MIPS for this performance experiment? Is P likely to be superscalar?

3. Suppose that a single-chip microprocessor P operating at clock frequency of 50MHz is replaced by a new model P', which has **the same architecture** as P but has a clock frequency of 75MHz.

   a. If P has a performance rating of p MIPS for a particular benchmark program Q, what is the corresponding MIPS rating p' for P

   b. P takes 250s to execute Q in a particular personal computer system C. On replacing P by P' in C, the execution time of Q drops only to 220s. Suggest a possible reason for this disappointing performance improvement.

4. 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 a given benchmark program, 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?

5. A compiler designer is deciding between two codes for a particular machine. Based on the hardware implementation, there are three different classes of instructions: Class A, Class B, and Class C, and they require one, two, and three cycles respectively.

First code has 5 instructions: 2 of A, 1 of B, and 2 of C.

Second code has 6 instructions: 4 of A, 1 of B, and 1 of C.

Which code is faster?

By how much?

What is the CPI for each code?

1. clock rate = 80 MHz 100 000 inst.
CPI? MIPS rate? exec time?

	ins. count	F_{ins}	CPI	CPI × F_{ins}
a	45 000	0.45	1	0.45
b	32 000	0.32	2	0.64
c	15 000	0.15	2	0.30
d	8000	0.08	2	0.16
	100 000			CPI = 1.55

$\frac{45000}{100000}$ clock cycle per instruction

CPU Time = ins. count × CPI / clock rate
1/clock cycle
= 100 000 × 1.55 / 80 × 10^-6
= 1.9375×10^{-3} s

MIPS = ins. count / ($1.9375 \times 10^{-3} \times 10^6$)
= 51.613

Exec time = 1.9375×10^{-3} s

2. clock rate = 100 MHz 10 000 000 ins. exec. time = 0.25 s
CPI? MIPS?

CPU time = ins. count × CPI / clock rate
$0.25 = \frac{10\,000\,000 \times \text{CPI}}{100 \times 10^6}$
CPI = 2.5

MIPS = 10 000 000 / (0.25×10^6)
= 40

4. Comp A => clock cycle = 250 ps CPI = 2.0
Comp B => clock cycle = 500 ps CPI = 1.2

$\frac{\text{exec time A}}{\text{exec time B}} = \frac{\cancel{\text{ins count}}}{\cancel{\text{ins count}}} \times \frac{\text{CPI}}{\text{CPI}} \times \frac{\text{clock cycle}}{\text{clock cycle}}$

$= \frac{2 \times 250 \times 10^{-12}}{1.2 \times 500 \times 10^{-12}}$

$= \frac{5 \times 10^{-10}\ s}{6 \times 10^{-10}\ s}$

$\frac{\text{exec time A}}{\text{exec time B}} = \frac{0.5\ ns}{0.6\ ns}$ => A > B by $\frac{1.2 \text{ times}}{0.1\ ns}$

3. clock rate P = 50 MHz
P' = 75 MHz

a. P MIPS = p at Q benchmark, P' MIPS

50 MHz => MIPS = p
75 MHz => MIPS = $\frac{75}{50}$ p
= 1.5 p

b. P => exec time = 250 s
P' => exec time = 220 s

CPU time = ins. count × CPI / clock rate
=> may causes by CPI
higher clock rate ≠ lower CPI

5.

Class	Code 1	F_{code1}	Code 2	F_{code2}	CPI	CPI × F_{code1}	CPI × F_{code2}
A	2	0.4	4	4/6	1	0.4	4/6
B	1	0.2	1	1/6	2	0.4	2/6
C	2	0.4	1	1/6	3	1.2	3/6
	5 ins		6 ins			2.0	1.5

$\frac{\text{Code 2}}{\text{Code 1}} = \frac{1.5}{2} = 1.33$ Code 2 is faster than Code 1 by 133% (0.5 CPI)