- Lab due tonight

- HW due Monday

Measuring/Computing Performance
1.4, 1.8, 1.9

Performance

- 1.4, 1.8, 1.9
- Accurately and fairly compare the performance of different systems
- Learn how to use performance metrics

Performance metrics

- Execution time and Performance

Machine X

$$\text{Performance}_X = \frac{1}{\text{Execution Time}_X}$$

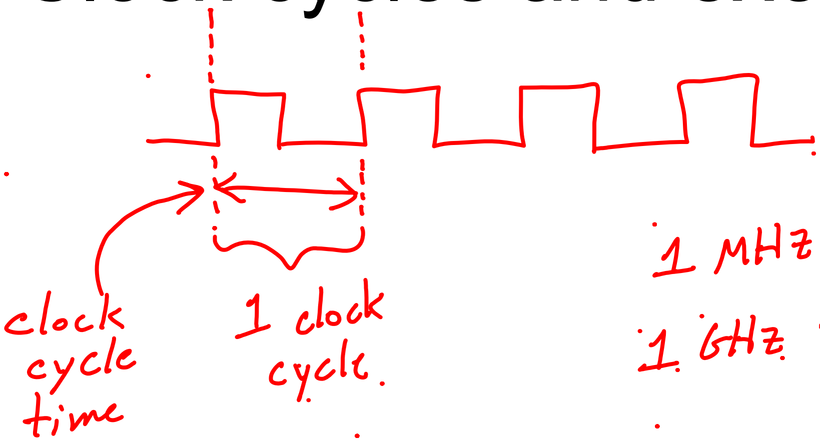
running some benchmark

- X in N times faster than Y

$$N = \frac{\text{Perf.}_X}{\text{Perf.}_Y} = \frac{\text{Exec. Time}_Y}{\text{Exec. Time}_X}$$

Calculating Execution Time

- Clock cycles and execution time



$1\ \text{MHz} = 10^6$ clock cycles/sec

$1\ \text{GHz} = 10^9$ clock cycles/sec

$$\text{Exec. Time}_X = \text{cpu clock cycles for program} \times \text{clock cycle time} = \frac{\text{total cpu clock cycles}}{\text{clock rate}}$$

how long machine X takes on benchmark

Lab 2 (due Wed. 10/15)

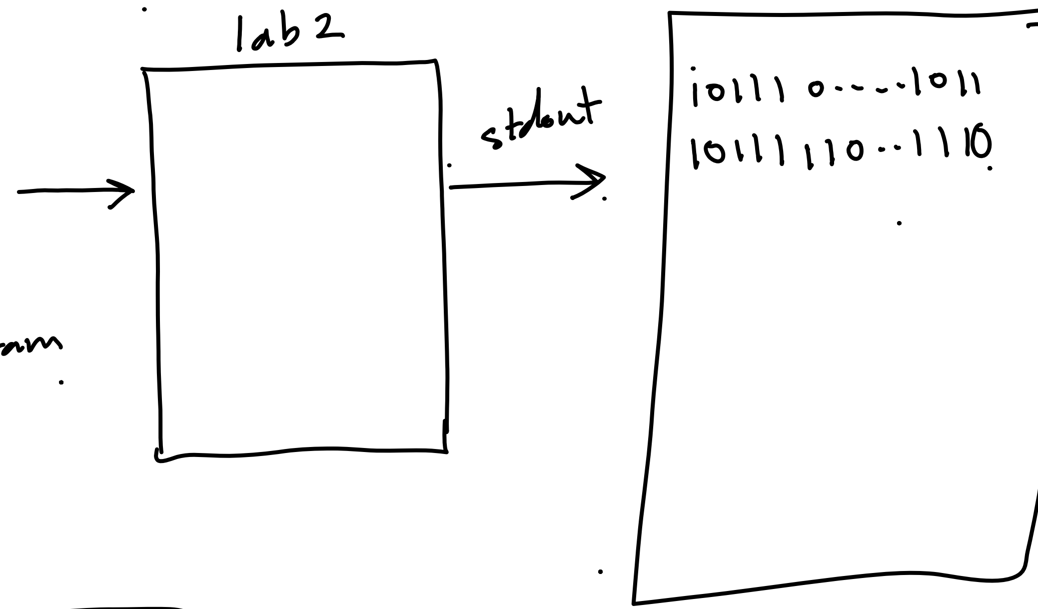
- HW due today

assembly file

```
# file 1
add $v0, $0, $a0
loop: add .....

j end # end of program
beq ...., ...., loop
end:
lw $a0, -8($t0)
loop2:
    #.....
    #.....
    add.....
```

C/C++/Java



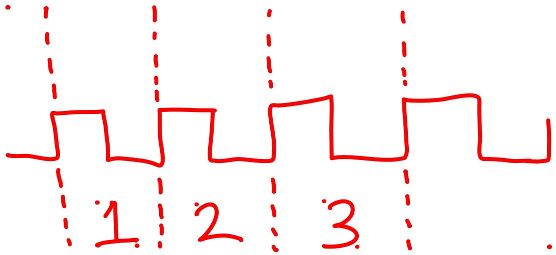
- handle unimplemented instructions

2-pass assembler:

1. find all labels
2. convert the instructions to machine code

Example 1

Machine X can perform a task in 11 seconds. Machine Y can perform the same task in 17 seconds. How much faster is X than Y?



CPI

- HW2 (next Wed.)
  - 1.4.1
  - 1.4.3
  - 1.5.1a
  - 1.5.2a

Cycles Per Instruction -

arithmetic + logical { add, or, sub, and, addi

↑ in general 1 CPI

beq, bne } conditional branches

lw, sw } memory

- different classes of instructions take different # of cycles

# of different inst. classes

cycles per inst. for ith class

$$\text{total \# of clock cycles} = \sum_{i=1}^{n} C_i \times CPI_i$$

count of inst. in the ith

Example 2

Inst. class	CPI
A	1
B	2
C	4

CPU dependent

	Instruction Counts		
Code sequence	A	B	C
1 old compiler	3	1	3
2 new compiler	0	3	3

2 different compilers produce code sequences 1 and 2. Which is faster? What is the CPI for each sequence?

1) $\overset{C_A}{3} \cdot \overset{CPI_A}{1} + 1 \cdot \overset{CPI_B}{2} + 3 \cdot \overset{CPI_C}{4} = 17$ cycles

faster

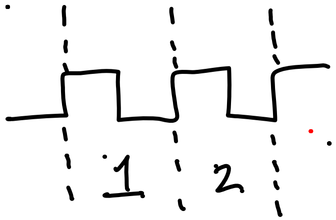
average CPI $= \dfrac{\text{total cyc.}}{\text{total inst.}}$

$17/7 = 2.43$

2) $0 \cdot 1 + 3 \cdot 2 + 3 \times 4 = 18$ cycles

$18/6 = 3$

Calculating Execution Time



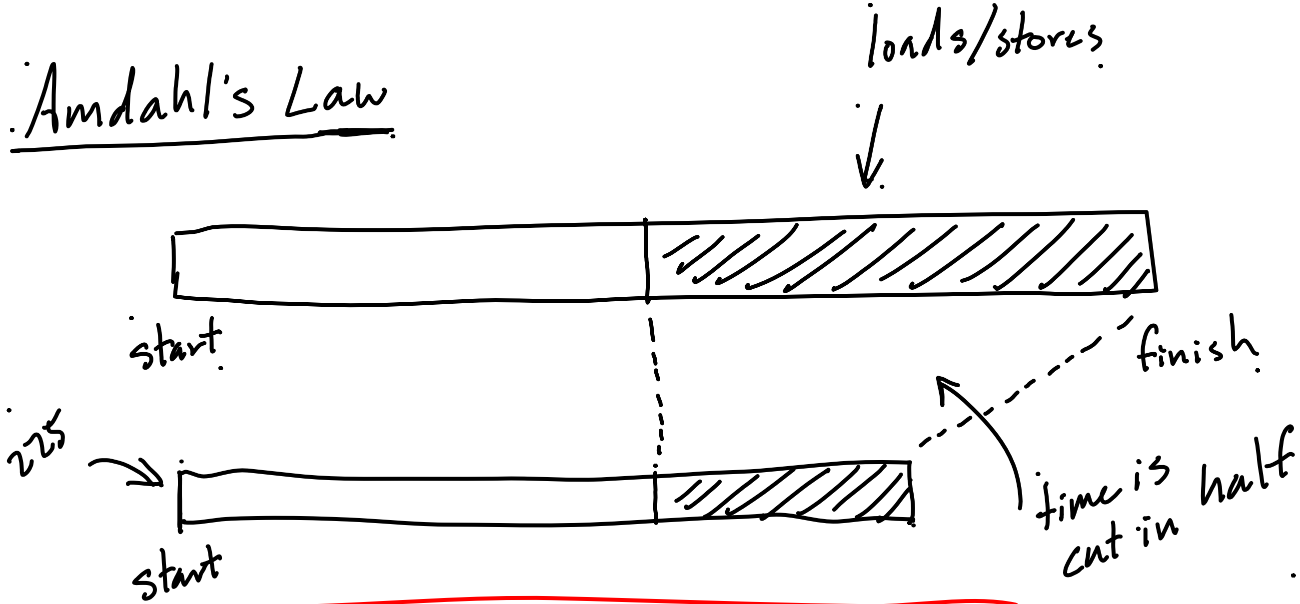
$$\text{Exec. Time} = \text{total \# of clock cycles} \times \text{clock cycle time}$$

$$\text{Exec. Time} = \text{total \# of instructions} \times \text{CPI} \times \text{clock cycle time}$$

average CPI

Improving execution time

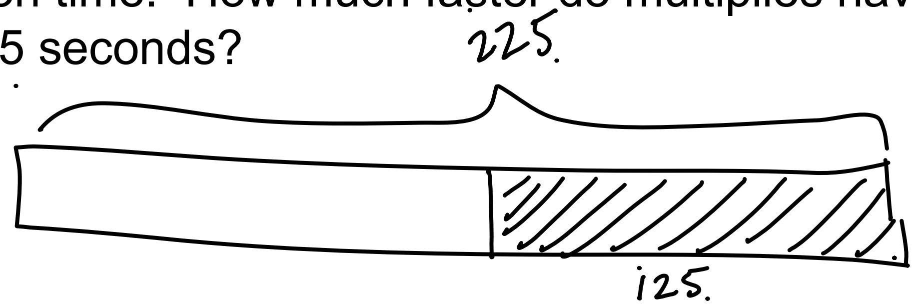
Amdahl's Law



$$\text{Exec. Time after improvement} = \frac{\text{Exec. Time affected}}{\text{Amount of improvement}} + \text{Exec. Time not affected}$$

Example 3

A program takes 300 seconds to execute. Multiplies account for 125 seconds of the execution time. How much faster do multiplies have to be to execute program in 225 seconds?



$$225 = \frac{125}{N} + 175$$

$N = 2.5$ times