

Project 06

Remaining work: lab 11 (Qs)

Project 07

Final

single-cycle processor

multi-cycle processor

pipelined processor

Laundry

Laundry Steps

1) wash [W]

2) Dry [D]

3) Fold [F]

4) Put away [P]

Assume:

each step
takes 30 mins

$$\begin{array}{ccccccc}
 30 & & 30 & & 30 & & 30 & & 1 \text{ load} \\
 \boxed{W} & & \boxed{D} & & \boxed{F} & & \boxed{P} & = & 120 \text{ mins} \\
 & & & & & & & & \underline{2 \text{ hrs}}
 \end{array}$$

$$\begin{array}{cccccccc}
 \boxed{W} & \boxed{D} & \boxed{F} & \boxed{P} & \boxed{W} & \boxed{D} & \boxed{F} & \boxed{P} & = 240 \text{ mins} \\
 & & & & & & & & 4 \text{ hrs}
 \end{array}$$

Laundry Pipeline

time $\rightarrow$

	30	30	30	20	30	30	30	
1 st load	$\boxed{W}$	$\boxed{D}$	$\boxed{F}$	$\boxed{P}$				120
2 nd load		$\boxed{W}$	$\boxed{D}$	$\boxed{F}$	$\boxed{P}$			150
3 rd load			$\boxed{W}$	$\boxed{D}$	$\boxed{F}$	$\boxed{P}$		180
4 th load				$\boxed{W}$	$\boxed{D}$	$\boxed{F}$	$\boxed{P}$	210

1 load = 120 mins (2hr)

2 loads = 150 mins (2.5 hrs)

4 loads = 210 min (3.5 hrs)

100 loads?

$$\text{Serial: } 100 \times 2 \text{ hrs} = \boxed{200 \text{ hrs}}$$

Pipelining:

$$\begin{aligned} 2 \text{ hrs} + 30 \times 99 \\ 120 + (30 \times 99) \end{aligned}$$

1st load

$$\begin{array}{c} \text{time} \\ 4 \times (0.5) + (100 - 1) \times (0.5) \end{array}$$

$$2 \text{ hrs} + 99 \times 0.5$$

$$2 \text{ hrs} + 49.5 = \boxed{51.5 \text{ hrs}}$$

4x

1000 loads

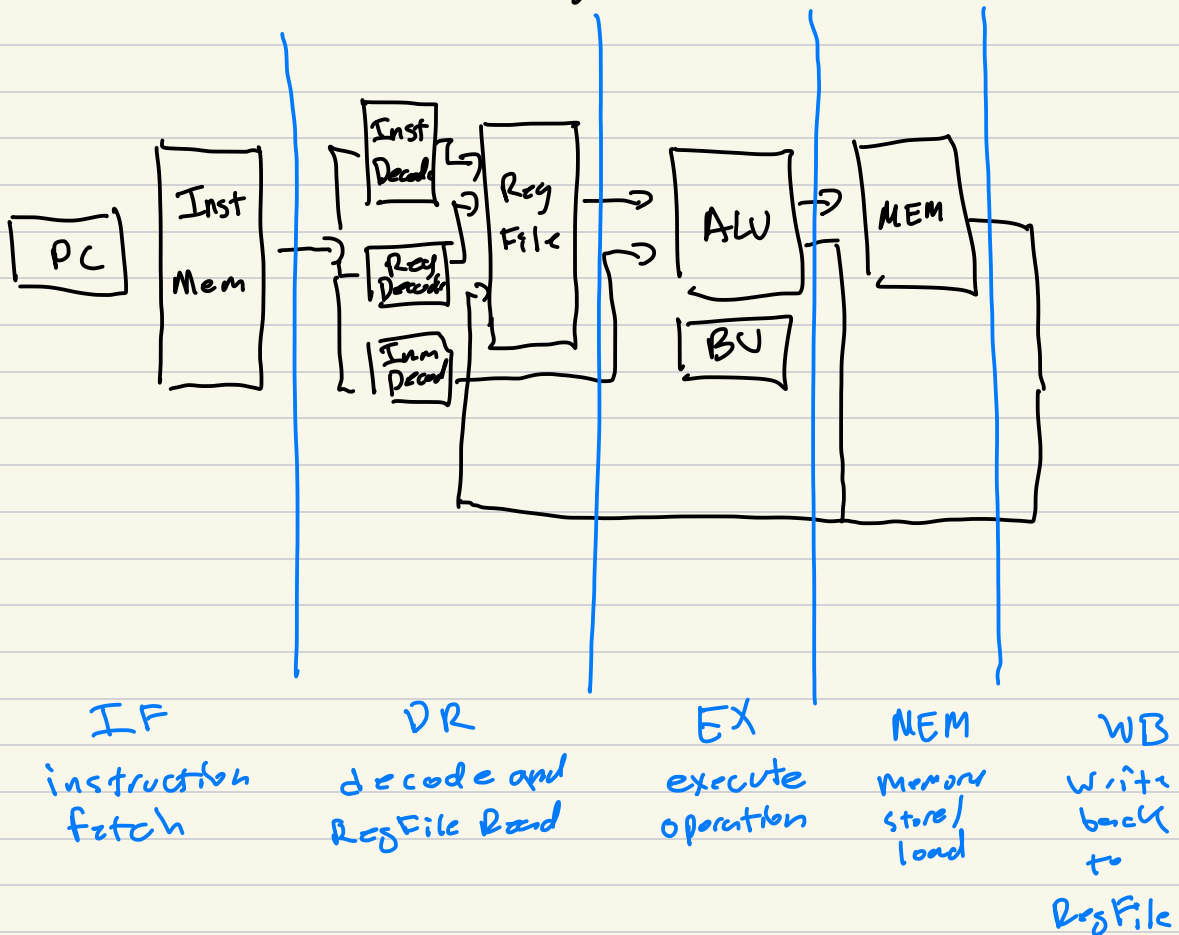
$$\begin{array}{c} 4 \times (0.5) + (1000 - 1) \times 0.5 \\ 2 + 999 \times 0.5 \end{array}$$

$$2 + 499.5 = \boxed{501.5 \text{ hrs}}$$

In principle

A n -stage pipeline can speed up execution by $\frac{1}{n}$

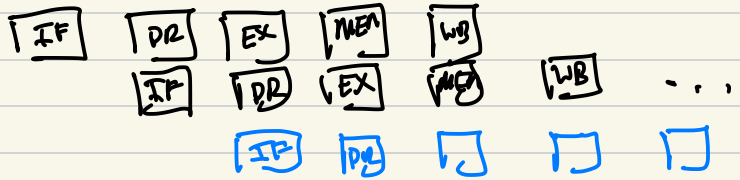
Processor Pipelining



Instruction Pipeline Stages

IF DR EX MEM WB

addi a0, zero, 1
addi a1, zero, 2
addi a2, a0, a1
;



Pipeline Hazards

Data Hazards

Control Hazards (jumps and branches)