

# CS 631-01 Processor Design Pipelining

Single cycle

Multi cycle

Pipelined

## Doing Laundry

### Laundry steps

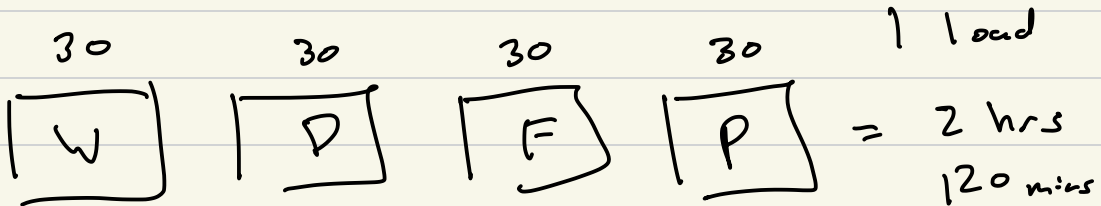
1) Wash

each step takes 30 min

2) Dry

3) Fold

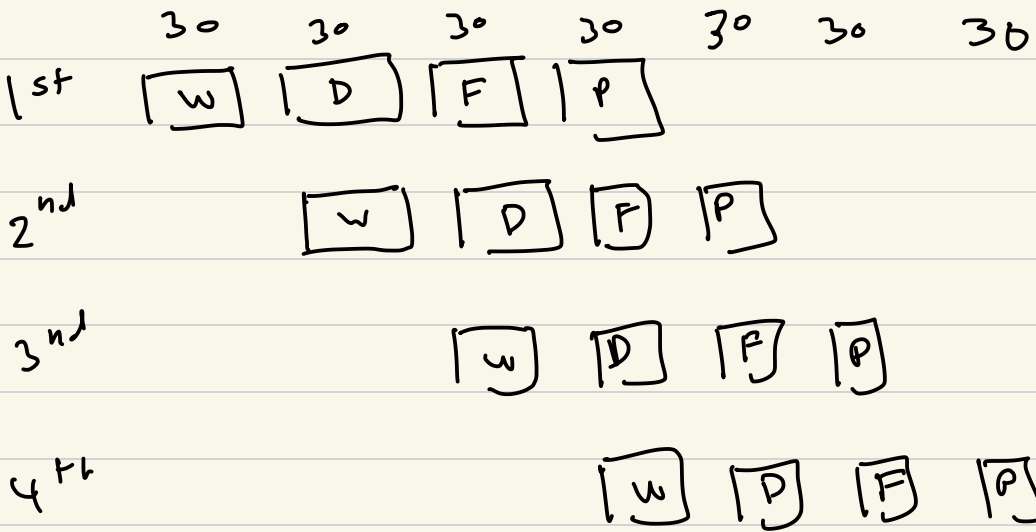
4) Put away



W D F P W D F P

4 hrs  
2 loads

Pipeline Laundry



Pipelined

2 loads 2.5 hrs (150 mins)

4 loads 3.5 hrs (210 mins)

Serial

4 hrs

8 hrs

100 loads ?

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

Pipelined: approx  $100 \times 0.5 = 50 \text{ hrs}$

Exact

$$2 \text{ hrs} + 99 \cdot (0.5)$$

$$(4 \times 0.5) + (100-1) \times (0.5)$$

$$= 2 \text{ hr} + 99 \cdot 0.5$$

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

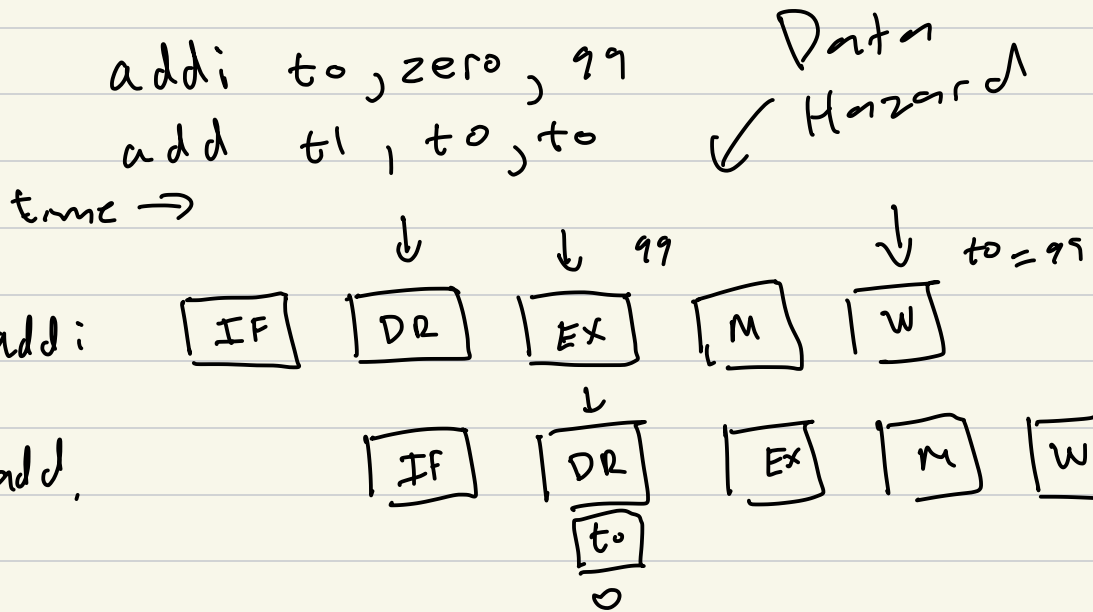
$$= \boxed{51.5 \text{ hrs}}$$

$1/n$  speedup, where  $n$  is  
the number of stages,

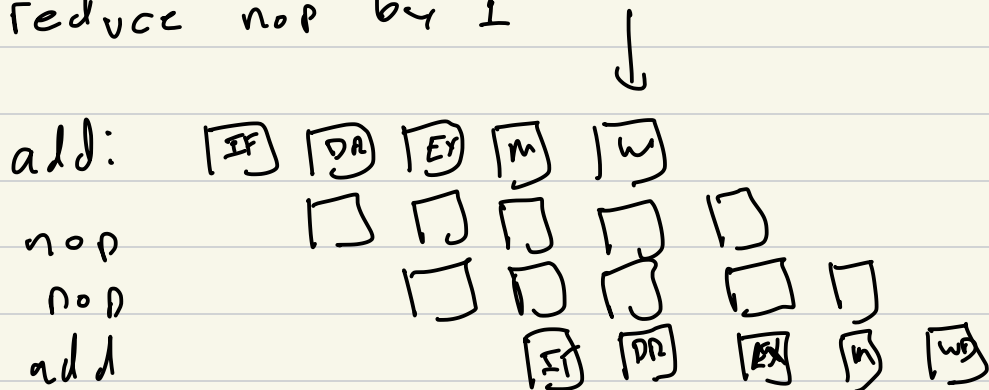
Processor Pipeline Hazards

Data Hazards

Control Hazards



reduce nop by 1



invert clock to the RegFile

