Processor Performance

→ Execution time → User CPU time
→ Throughput → Program CPU time

$$\text{Execution time} = \frac{1}{\text{Performance}}$$

$$\text{Exec. time} = \text{clock cycle time (cct)} \times \text{clk cycles}$$

$$\left(\frac{1}{\text{Clk Rate}}\right)$$

A: CPU time = 20 s
CR = 2 GHz

B CPU time = 6 s
$CC_B = 1{,}2 \times CC_A$
$CR_B = ?$

$$20\,s = CC_A \times \frac{1}{2 \cdot 10^9}$$

$$CC_A = 40 \cdot 10^9 \text{ clk cycles}$$

$$6 = 1{,}2\,CC_A \times \frac{1}{CR_B}$$

$$CR_B = \frac{1{,}2\,CC_A}{6} \sim 8\ \text{GHz}$$

CC = Instr. Count (IC) × Avg. clk per instr. (CPI)

A : $CCT_A = 250\ ps$

$CPI_A = 2.0$

B : $CCT_B = 500\ ps$

$CPI_B = 1.2$

a) which is faster?

b) by how much?

$$\frac{CPU\ time_B}{CPU\ time_A} = \frac{CCT_B \times \cancel{IC} \times CPI_B}{CCT_A \times \cancel{IC} \times CPI_A}$$

$$= \frac{500 \times 1.2}{250 \times 2} = 1.2$$

$$\boxed{CPU_{time} = IC \times CPI \times CCT = \frac{IC \times CPI}{CR}}$$

Processor Performance Equation

Instr. Class

	ALU	MEM	Br
CPI	1	2	3

CS	ALU	MEM	Br
1	2	1	2
2	4	1	1

C.S. exec. more instr. (2)

which is faster

$2\times1 + 2 + 6 = 10$ (2)

$4 + 2 + 3 = 9$

b) $$\frac{CPU_{time\ CS_1}}{CPU_{time\ CS_2}} = \frac{2\times1 + 1\times2 + 2\times3}{4\times1 + 1\times2 + 1\times3} = \frac{10}{9}$$

CS2 faster

c) $CPI_{CS1} = \frac{10}{5} = 2\ cc$

$CPI_{CS2} = \frac{CC_{CS_2}}{IC_{CS_2}} = \frac{9}{6} = 1.5\ cc$

	CR	CPI	IPS	$CPU_{time} = 10$	CC	IC
P_1	3GHz	1.3	$2 \cdot 10^9$			
P_2	2,5	1.0	$2{,}5 \cdot 10^9$			
P_3	4,0	2.2	$1{,}8 \cdot 10^9$			

a) highest performance in IPS

b) if $CPU_{time} = 10$
$CC = ?$ $IC = ?$

c) reduce

$$\boxed{CPU_{time} = IC \times CPI \times CCT = \frac{IC \times CPI}{CR}}$$

$$IPS = \frac{IC}{CPU_{time}} = \frac{\cancel{IC}}{\frac{\cancel{IC} \cdot CPI}{CR}} = \frac{CR}{CPI}$$

$$IPS_1 = \frac{3}{1.3} \qquad IPS_2 = 2.5 \qquad IPS_3 = \frac{4.0}{2.2}$$

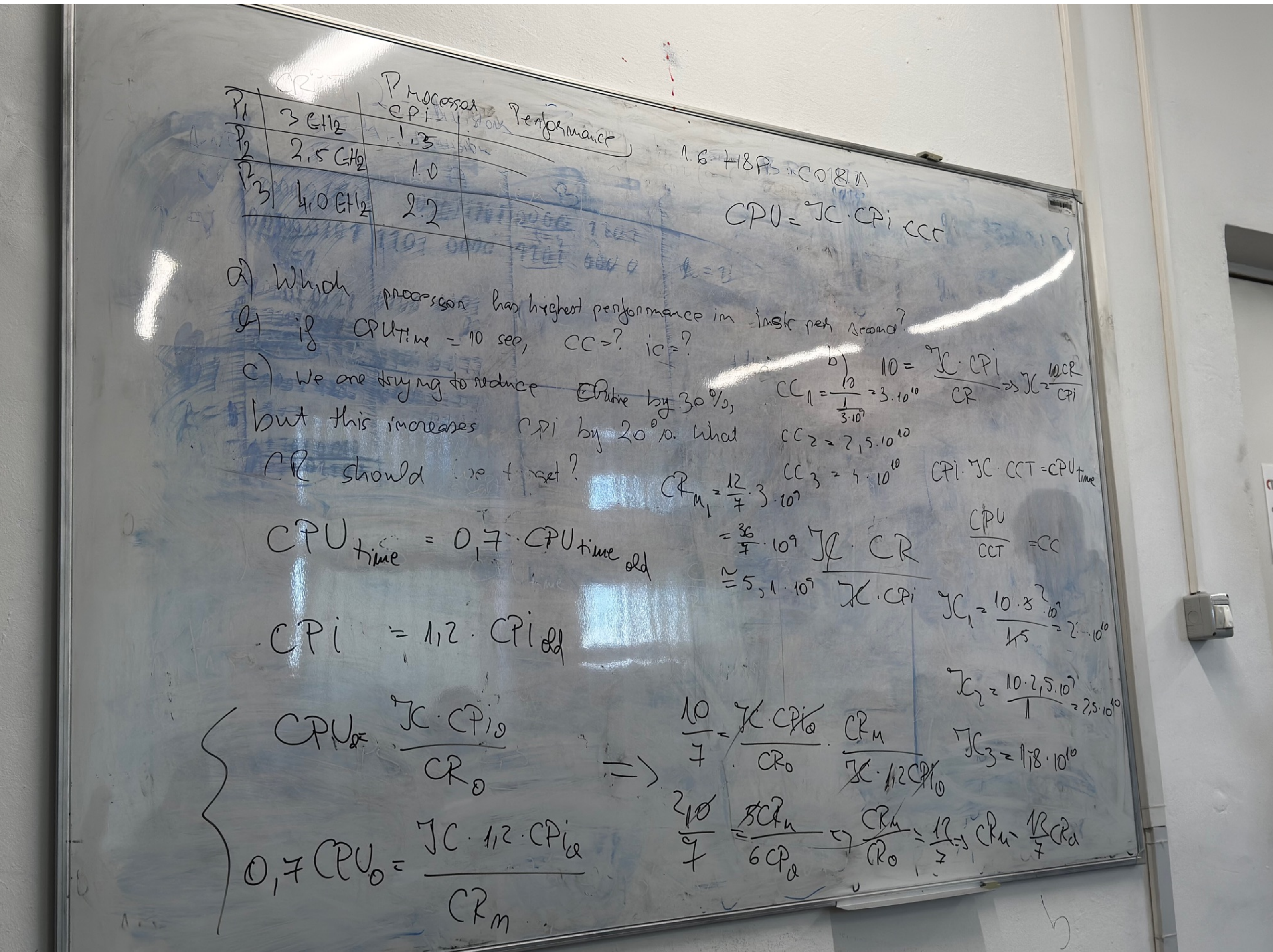
b) $CPU_{time} = \frac{IC \cdot CPI}{CR}$ $\qquad \frac{CPU}{CCT} = CC$

$$IC_1 = \frac{\overbrace{10}^{\text{cpu time}} \cdot \overbrace{3 \cdot 10^9}^{CR}}{\underbrace{1{,}5}_{CPI}}$$

$$IC_2 = \frac{10 \cdot 2{,}5 \cdot 10^9}{1}$$

$$IC_3 = \frac{10 \cdot 4{,}0 \cdot 10^9}{2{,}2}$$

$$CC = \text{Time} \times CR$$



HW1 5 th ed. pg. 55 pb 1.6

1.6 [20] <§1.6> Consider two different implementations of the same instruction set architecture. The instructions can be divided into four classes according to their CPI (class A, B, C, and D). P1 with a clock rate of 2.5 GHz and CPIs of 1, 2, 3, and 3, and P2 with a clock rate of 3 GHz and CPIs of 2, 2, 2, and 2.

Given a program with a dynamic instruction count of 1.0E6 instructions divided into classes as follows: 10% class A, 20% class B, 50% class C, and 20% class D, which implementation is faster?

a. What is the global CPI for each implementation?

b. Find the clock cycles required in both cases.

IC * CPI

$\frac{CC}{CR}$

ISA	CLK Rate	CPI A	B	C	D	CC	Exec
P_1	2,5 GHz	1	2	3	3	$2.6 \cdot 10^6$	
P_2	3 GHz	2	2	2	2	$2 \cdot 10^6$	

$$IC = 10^6$$

10% A 20% B 50% C 20% D

a) $CPI_1 = 1 \cdot 10\% + 2 \cdot 20\% + 3 \cdot 50\% + 3 \cdot 20\%$

$$= \frac{10 + 40 + 150 + 60}{100} = \underline{\underline{2.6}}$$

$CPI_2 = 2 \cdot 10\% + 2 \cdot 20\% + 2 \cdot 50\% + 2 \cdot 20\% =$

$$= \underline{\underline{2}}$$

b) $CC = IC \times CPI$

$CC_1 = 10^6 \times 2.6$ $\quad CC_2 = 10^6 \cdot 2$

c) $Exec.Time = \dfrac{CC}{CR}$

$Exec_1 = \dfrac{2.6 \cdot 10^6}{2.5 \cdot 10^9} = 1,04 \cdot 10^{-3}$

$Exec_2 = \dfrac{2 \cdot 10^6}{3 \cdot 10^9} = 0.66 \cdot 10^{-3}$

CPU_2 far faster than CPU_1