Sheet 1

1)

P1	P2	P3	
			#Inst
1.5	1.0	2.2	CPI
3×10^9	2.5×10^9	4×10^9	Cr

a) $IPS = \frac{Cr}{CPI}$

• P_2 has the highest instructions per second ($2.5\times10^9\ s^{-1}$)

b) $\#Inst = \frac{E_T\, Cr}{CPI} = E_T\, IPS$

P1	P2	P3
2×10^{10}	2.5×10^{10}	1.82×10^{10}

$\#Cycles = \#Inst.\, CPI = E_T\, Cr$

3×10^{10}	2.5×10^{10}	4×10^{10}

c) P1 P2 P3

P1	P2	P3	
1.5	1.0	2.2	CPI old
3×10^9	2.5×10^9	4×10^9	Cr old

Reduce Execution time by 30%

reduce

- $\frac{E_{old} - E_{new}}{E_{old}} = 1 - \frac{E_{new}}{E_{old}} = 0.3$
- $E_{new} = 0.7\,E_{old}$

$(\#Inst.\ CPI.\ C_T)_{new} = 0.7(CPI\ \#Inst.\ C_T)_{old}$

→ #Inst. is the Same

→ $\frac{CPI_{new}}{CPI_{old}} = 1.2$

- $C_{T\,new} = (0.7/1.2)C_{T\,old}$
- $Cr_{new} = \frac{1.2}{0.7}Cr_{old} = 1.71\,Cr_{old}$

P1	P2	P3	
5.13GHz	4.275GHz	6.84GHz	Crnew

$$MIPs = \frac{\#Instructions}{E_T(10^6)} = \frac{C_r}{CPI(10^6)}$$

Changes with Program.
• Million instructions Per second.

→ dep. on cores

$$E_T = \#Cycles \times C_T \text{ with } \#Cycles = \underbrace{CPI}_{\text{dep on compiler, language, algorithm}} \times \#Inst.$$

$$\text{and } \underbrace{C_T}_{\text{dep. on tech, cores}} = \frac{1}{C_r}$$

* All dep. on ISA

$$E_T|_{\text{After Improvement}} = E_T|_{\text{Affected}} + E_T|_{\text{unaffected}}$$

$$\hookrightarrow \frac{E_T|_{\text{before}}}{n} \leftarrow \text{amount of improvement.}$$

Percentage difference of A w.r.t B $\frac{Q_A - Q_B}{Q_B} \times 100$

$Q \begin{cases} \text{Performance (Fast×)} \\ \text{time (Slow×)} \end{cases}$

Speed up/Slow down of A w.r.t B $\frac{Q_A}{Q_B}$

FDEMW Stages
- load All 5
- Store No Wr
- branch No Mem, Wr
- ALU No Mem.

Processor
- Pipelined
  - $T_{cycle} = T_{longest\ stage}$
  - $T_{Tot.} = K T_c + (n-1) T_c$ — n: no. of instr.
- Non Pipelined
  - Single Cycle
    - $T_{Inst.} = T_{cycle} = \sum T_{stages}$
    - $T_{Tot.} = n\, T_{Inst}$
  - Multi Cycle
    - $T_c = T_{longest\ stage}$
    - $T_{Inst.} = K T_c$ //K: no. of needed stages.
    - $T_{Tot.} = \sum_i K_i T_c$

2)

P1	P2	
10^6	10^6	#Inst
$0.1(1)+0.2(2)+0.5(3)+0.2(3) = 2.6$	$0.1(2)+.2(2)+0.5(2)+0.2(2) = 2.0$	CPI
2.5×10^9	3×10^9	C_r
2.6×10^6	2×10^6	#Cycles
$\frac{2.6}{2.5} \times 10^6 = 1.04 \times 10^6$	$\frac{2}{3} \times 10^6 = 0.67 \times 10^6$	E_T (ns) $= \frac{\#Cycles}{C_r}$

→ P1 is slower.

3)

A	B	
10^9	1.2×10^9	#I
1.1	1.5	E_T (sec.)

a)

1×10^{-9}	1×10^{-9}	C_T
$\frac{1.1}{10^9 \times 10^{-9}} = 1.1$	$\frac{1.5}{1.2 \times 10^0} = 1.25$	CPI

$$CPI = \frac{E_T}{\#I \cdot CPI}$$

b) $E_{T_x} = E_{T_y}$ $\qquad \frac{C_{T_x}}{C_{T_y}} = ?$

//Processor x running A's Code //...y running B's Code (Compiled)

The CPI is intact as only the clock has Changed. (Assume two Processors have same ISA, cores ; only Clock has Changed)

it's slower!

$$\#I \; CPI \; C_T \Big|_x = \#I \; CPI \; C_T \Big|_y$$

$$\frac{C_r|_x}{C_r|_y} = \frac{C_T|_y}{C_T|_x} = \frac{CPI_x}{CPI_y} \cdot \frac{I_x}{I_y} = \frac{1.1}{1.25} \times \frac{10^9}{1.2 \times 10^9} = .733$$

c) New Compiler

$\# I = 6 \times 10^8$

$CPI = 1.1$ → Cr Const. across all.

- It's explicitly the same processer as in Part A so we can use the CPI values

$$\text{SpeedUp}|_{\frac{C}{A}} = \frac{\text{Perf}|_C}{\text{Perf}|_A} = \frac{10^9 \times 1.1}{6 \times 10^8 \times 1.1} = 1.67$$

(Perf $\propto \frac{1}{\# \text{Cycles}}$ at Const. Cr)

$$\text{Speed UP}|_{\frac{C}{B}} = \frac{P_C}{P_B} = \frac{1.2 \times 10^9 \times 1.25}{6 \times 10^8 \times 1.1} = 2.27$$

Performance

4) $T_{\text{before}} = 250s = 180 + 70$

$= (85 + 40 + 55) + 70$

load/Store, brach, int, Float

a) $T_{\text{After}} = T_{\text{Affected}} + T_{\text{unaffected}} = 0.8 \times 70 + 85 + 40 + 55$

$= 236s$

- $\frac{250 - 236}{250} \times 100 = $ by 5.6%

b) $T = 195 + t_{int}$

$T_{After} = 250 - 250 \times 0.2 = 200$

$t_{int_{new}} = 5$ $\qquad$ $t_{int_{old}} = 55$

Should be improved by $\frac{55-5}{55} \simeq 91\%$

c) $T = 210 + t_{branch}$

$T_{After} = 200$, impossible. t_{branch} is at least zero.

5)

	float	int	L/S	branch
#Inst. (10^6)	50	110	80	16
CPI	1	1	4	2

$Cr = 2 \times 10^9$ // useless. Perf $\propto \frac{1}{\#Inst\,CPI}$ at const. Cr

$\#Cycles = 50 \times 1 + 110 \times 1 + 80 \times 4 + 16 \times 2 = 512 \ (\times 10^6)$

a) Should require half the no. of Cycles

$$256 = 462 + 50\,CPI_{new}$$

unaffected time

+ve float.

//IMPOSSIBLE

$\text{Time}|_{\text{After}} > \text{Time}|_{\text{unaffected}}$ else its impossible

$\propto$ #Cycles

b) $256 = (512 - 80 \times 4) + 80\,CPI_{new}$

unaffected = total − to be affected

*

$CPI_{new} = 0.8$ // improve by reducing it by $\frac{4-0.8}{4} = 80\%$

c) $T_{\text{After}} = 512 - ((110+50) \times 0.4 + (80 \times 4 + 16 \times 2)\,0.3)$

reduce by

$= 342.4$ (33.125% improvement)

//reduction