

Assignment - 1

Section - 4 [PBK]

Ques 1 :-

Given,

(C)

$$C/W_x = 20$$

$$D_x = 10 \text{ cm}$$

$$R_x = \frac{10}{2} \text{ cm}$$

$$D/W_x = 89$$

$$\text{Def}/A_x = 0.023 \text{ defects/cm}^2$$

$$C/W_y = 15$$

$$D_y = 20 \text{ cm}$$

$$R_y = \frac{20}{2} \text{ cm}$$

$$D/W_y = 100$$

$$\text{Def}/A_y = 0.031 \text{ defects/cm}^2$$

$$Yield_x = \frac{1}{(1 + (\text{Defects per area} \times \frac{\text{Die Area}}{2}))^2}$$

$$= \frac{1}{(1 + (0.023 \times \frac{\text{Die Area}}{2}))^2}$$

$$= \frac{1}{(1 + (0.023 \times \frac{3.1857}{2}))^2}$$

$$\approx 0.93$$

$$D/W = \frac{\text{Wafer Area}}{\text{Die Area}}$$

$$\text{Die Area} = \frac{\text{Wafer Area}}{D/W}$$

$$= \frac{\pi \times (\frac{10}{2})^2}{89}$$

$$= 3.1857$$

$$Yield_y = \frac{1}{(1 + (\text{Defects per area} \times \frac{\text{Die Area}}{2}))^2}$$

$$= \frac{1}{(1 + (0.031 \times \frac{\text{Die Area}}{2}))^2}$$

$$= \frac{1}{(1 + (0.031 \times \frac{3.1416}{2}))^2}$$

$$\approx 0.91$$

$$D/W = \frac{\text{Wafer Area}}{\text{Die Area}}$$

$$\text{Die Area} = \frac{\text{Wafer Area}}{D/W}$$

$$= \frac{\pi \times (\frac{20}{2})^2}{100}$$

$$= 3.1416$$

$$d) C/D_x = \frac{\text{Cost per wafer}}{\text{Dies per wafer} \times \text{Yield}}$$

$$= \frac{20}{89 \times 0.93}$$

$$= 0.24$$

$$C/D_y = \frac{\text{Cost per wafer}}{\text{Dies per wafer} \times \text{Yield}}$$

$$= \frac{15}{100 \times 0.91}$$

$$= 0.16$$

Ques 2:

	A	B	C	D
CPI _{PS}	2	2	3	6
CPI _{XB}	5	4	2	1
IC	$1 \times 10^6 \times 3 = 3 \times 10^5$	$1 \times 10^6 \times 5 = 5 \times 10^5$	$1 \times 10^6 \times 1 = 1 \times 10^5$	$1 \times 10^6 \times 1 = 1 \times 10^5$

$$\text{Rate}_{PS} = 2.7 \text{ GHz} = 2.7 \times 10^9 \text{ Hz}$$

$$\text{Rate}_{XB} = 3 \text{ GHz} = 3 \times 10^9 \text{ Hz}$$

$$\text{Instruction Count} = 1 \times 10^6$$

a) For Play Station,

$$\begin{aligned} \text{Clock Cycles} &= (2 \times 3 \times 10^5 + 2 \times 5 \times 10^5 + 3 \times 1 \times 10^5 + 6 \times 1 \times 10^5 \\ &= 9 \times 10^6 \end{aligned}$$

$$\begin{aligned} \text{Avg. CPI} &= \frac{9 \times 10^6}{1 \times 10^6} \\ &= 9 \end{aligned}$$

For XB BOX,

$$\begin{aligned} \text{Clock Cycles} &= (5 \times 3 \times 10^5 + 4 \times 5 \times 10^5 + 2 \times 1 \times 10^5 + 1 \times 1 \times 10^5 \\ &= 3.80 \times 10^6 \end{aligned}$$

$$\begin{aligned} \text{Avg. CPI} &= \frac{3.80 \times 10^6}{1 \times 10^6} \\ &= 3.8 \end{aligned}$$

$$\begin{aligned} \text{So, Difference} &= (9 - 3.8) \\ &= 0.2 \end{aligned}$$

$$\begin{aligned} b) \text{Ex time}_{PS} &= \frac{\text{Instruction Count} \times \text{CPI}}{\text{Rate}} \\ &= \frac{10^6 \times 9}{2.7 \times 10^9} \\ &= 0.00148 \text{ s} \end{aligned}$$

$$\begin{aligned} \text{Ex time}_{PS} &= \frac{\text{Instruction Count} \times \text{CPI}}{\text{Rate}} \\ &= \frac{10^6 \times 3.8}{3 \times 10^9} \\ &= 0.00126 \text{ s} \end{aligned}$$

$$\begin{aligned} \text{Difference} &= (0.00148 - 0.00126) \\ &= 0.22 \end{aligned}$$

Execution time of a Reference processor

Reference time is provided by SPEC

Measured time is the Execution time of a given

$$\begin{aligned} c) \text{Spec Ratio} &= \frac{\text{Reference Time}}{\text{Measured Time}} \\ &= \frac{120}{\text{Inst. Count} \times \text{CPI} \times \text{C.e.T}} \\ &= \frac{120 \times 10^{-3}}{10^6 \times 9 \times \frac{1}{2.7 \times 10^9}} \\ &= 81 \end{aligned}$$

Ques - 3

Processor	CPI	Rate
P1	1.5	3 GHz
P2	1.0	2.5 GHz
P3	2.2	4 GHz

Instruction Count = x

[Same for all Processors]

$$a) \text{ Performance (IPS)} = \frac{\text{Clock Rate}}{\text{CPI}}$$

$$P_{P1} = \frac{3 \times 10^9}{1.5} = 2 \times 10^9$$

$$P_{P2} = \frac{2.5 \times 10^9}{1} = 2.5 \times 10^9 \Rightarrow \text{highest perf.}$$

$$P_{P3} = \frac{4 \times 10^9}{2.2} \approx 1.82 \times 10^9$$

$$b) \text{ CPU Time} = 10s$$

$$\text{CPU time} = \frac{IC \times \text{C.P.I.}}{\text{freq}}$$

$$\Rightarrow IC = \frac{\text{CPU time} \times \text{freq}}{\text{C.P.I.}}$$

$$IC(P1) = \frac{10 \times 3 \times 10^9}{1.5} = 2 \times 10^{10}$$

$$IC(P2) = \frac{10 \times 2.5 \times 10^9}{1.0} = 2.5 \times 10^{10}$$

$$IC(P3) = \frac{10 \times 4 \times 10^9}{2.2} = 1.8 \times 10^{10}$$

$$\text{CPU time} = \frac{\text{CPU clock cycles}}{\text{Freq}} = \frac{IC \times \text{CPI}}{\text{Freq}}$$

$$\Rightarrow \text{CPU clock cycles} = IC \times \text{CPI}$$

$$\therefore \text{Clock Cycles (P1)} = 2 \times 10^{10} \times 1.5 = 3 \times 10^{10}$$

$$\therefore \text{Clock Cycles (P2)} = 2.5 \times 10^{10} \times 1 = 2.5 \times 10^{10}$$

$$\therefore \text{Clock Cycles (P3)} = 1.8 \times 10^{10} \times 2.2 \approx 3.96 \times 10^{10}$$

the more digit
you take after
fraction the less
error you get!

Rate = cycles completed per second

for P1,

$$3 \times 10^9 \text{ cycles} \dots 1s$$

$$\therefore 1 \text{ s} \dots \frac{1}{3 \times 10^9} \text{ s}$$

$$\therefore 1.5 \text{ s} \dots \frac{1.5}{3 \times 10^9} \text{ s}$$

[1 ins = 1.5 cycles]

So,

$$1 \text{ ins. takes } \frac{1.5}{3 \times 10^9} \text{ s to complete}$$

$$\frac{1.5}{3 \times 10^9} \text{ s to complete} - 1 \text{ ins.}$$

Rate

$\therefore 1 \text{ s} \dots 1 \text{ ins. } \frac{3 \times 10^9}{1.5 \text{ s}} \text{ ins.}$

$$\text{Performance (IPS)} = \frac{\text{Clock Rate}}{\text{CPI}}$$

c)

Processor	CPI	New CPI
P1	1.5	1.8
P2	1.0	1.2
P3	2.2	2.64

$$\text{CPU Time}_{\text{new}} = IO - (10 \times 3) \\ = 70$$

$$\text{CPU Time} = \frac{I \cdot C \times \text{CPI}}{\text{Freq.}}$$

$$\Rightarrow \text{Freq.} = \frac{I \cdot C \times \text{CPI}}{\text{CPU Time}}$$

$$F(P_1) = \frac{I \cdot C \times \text{CPI}}{\text{CPU Time}} = \frac{2 \times 10^{10} \times 1.8}{70} \cong 5.14 \text{ GHz}$$

$$F(P_2) = \frac{I \cdot C \times \text{CPI}}{\text{CPU Time}} = \frac{2.5 \times 10^{10} \times 1.2}{70} \cong 4.28 \text{ GHz}$$

$$F(P_3) = \frac{I \cdot C \times \text{CPI}}{\text{CPU Time}} = \frac{1.8 \times 10^{10} \times 2.64}{70} \cong 6.39 \text{ GHz}$$

Ques - 4

$$\text{CPU Time} = 250 \text{ s}$$

Add	Sub	Left-Shift	
70 s	85 s	40 s	
			= 105 s min. $\Rightarrow (250 - 105) = 55$

$$a) T_{\text{new}} = (70 \times 0.8) + 85 + 40 + 55 \\ = 236 \text{ s}$$

$$\text{time reduced} = (250 - 236) = 14 \text{ s} \\ = \frac{14}{250} \times 100\% \cong 5.6\%$$

$$b) T_{\text{new}} = (250 \times 0.8) = 200 \text{ s}$$

$$T_{\text{add}} + T_{\text{sub}} + T_{\text{min.}} = 70 + 85 + 55 = 210 \text{ s} > T_{\text{new.}}$$

No

Ques 5:

$$MIPS = \frac{\text{Clock Rate}}{\text{CPI} \times 10^6}$$

$$\text{MIPS}(P_1) = \frac{4 \times 10^9}{0.9 \times 10^6}$$

$$= 4.44 \times 10^3$$

$$\text{MIPS}(P_2) = \frac{3 \times 10^9}{0.75 \times 10^6}$$

$$= 4 \times 10^3$$

$$P(P_1) = \frac{4 \times 10^9}{5 \times 10^9 \times 0.9} = 0.889$$

$$P(P_2) = \frac{3 \times 10^9}{1 \times 10^9 \times 0.75} = 4$$

$$\text{Rate}(P_1) = 4 \text{ GHz} = 4 \times 10^9 \text{ Hz}$$

$$\text{CPI}(P_1) = 0.9$$

$$\text{Ins. Count} = 5 \times 10^9$$

$$\text{Rate}(P_2) = 3 \text{ GHz} = 3 \times 10^9 \text{ Hz}$$

$$\text{CPI}(P_2) = 0.75$$

$$\text{Ins. Count} = 1 \times 10^9$$

$\text{MIPS}(P_1) > \text{MIPS}(P_2)$

$P_{\text{en}}(P_1) < P_{\text{en}}(P_2)$

False

Ques - 6

$$\text{power} = I \cdot L \times V^2 \times F$$

$$\begin{aligned} \frac{P_{\text{new}}}{P_{\text{old}}} &= \frac{I_{\text{old}} \times 0.85 \times (V \times 0.813)^2 \times F \times 0.813}{I_{\text{old}} \times V^2 \times F} \\ &= \frac{I_{\text{old}} \times 0.85 \times \cancel{V} \times 0.813^2 \times \cancel{F} \times 0.813}{\cancel{I_{\text{old}}} \times \cancel{V}^2 \times \cancel{F}} \\ &= 0.4605 \end{aligned}$$

about

The new processor uses almost half (0.4605) power of the old processor.

Ques - 7

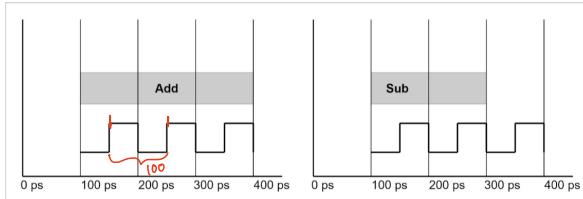


Figure 1: Represents 1 add instruction

Figure 2: Represents 1 sub instruction

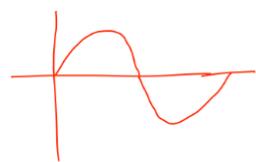
Figure 1: Represents 1 add instruction

Figure 2: Represents 1 sub instruction

Program A

Class	Add	Sub
CPI	3	2
IC	21	3

$$\frac{(21 \times 3) + (3 \times 2)}{24} = 2.875$$



Program A is divided into two classes according to their **CPI** (Add and Sub).

The **instruction counts** are 21 and 3 respectively. Reference for **program A** is 1080ps.

Now, answer the following questions,

a) What is the Clock period? **Hint:** follow any of the figures

b) What is the frequency?
[1] $F_{req} = \frac{1}{100 \times 10^{-12}} = 10^{10} \text{ Hz} = 10 \times 10^9 \text{ Hz} = 10 \text{ GHz}$

c) What is the CPI for Add and Sub?

[2] $\text{Clock Cycle per ins.} = \frac{3}{2}$

d) What is the Avg. CPI?

[2] 2.875

e) Find out the execution time of the program?

[2]

f) Find the SPEC ratio?

[1]

g) If you want to improve the performance by 1.2 times, what improvement do you need to include in the program's add operation?

[2]

$$\begin{aligned} \text{Ex/CPU time} &= \frac{\text{Ins/Prog} \times \text{CPI} \times \text{Clock Period}}{1080 \text{ ps}} \\ &= 24 \times 2.875 \times 100 \times 10^{-12} \\ &= 6.9 \times 10^{-9} / 6900 \text{ ps} \end{aligned}$$

Ref. time

$$\text{Spec Ratio} = \frac{\text{CPU time} / \text{Execution time}}{\text{Ref. time}}$$

g)

$$\text{Time improved} = \frac{T_{affected}}{n} + T_{unaff.} = \frac{1080 \text{ ps}}{6900 \text{ ps}}$$

$$\Rightarrow \frac{6.9 \times 10^{-9}}{1.2} = \frac{6.0375 \times 10^{-9}}{n} + 8.625 \times 10^{-10} = 0.1565$$

$$\Rightarrow n = 1.235$$

$$\begin{aligned} T_{aff.} &= 21 \times 2.875 \times 100 \times 10^{-12} \\ &= 6.0375 \times 10^{-9} \end{aligned}$$