

$$\begin{aligned}
 1. (1) \text{ AMAT} &= \text{Hit time} + \text{Miss rate} \times \text{Miss penalty} \\
 &= 1.18 + 7.3\% \times (5.34 + 1.5\% \times 70) \\
 &= 1.64647 \text{ ns}
 \end{aligned}$$

$$(2) \frac{70}{1.18} = 59.322 \text{ cc} \quad \frac{5.34}{1.18} = 4.525 \text{ cc}$$

$$\text{CPI} = 1 + 36\% \times 7.3\% \times 98.5\% \times 4.525 + 36\% \times 7.3\% \times 1.5\% \times (4.525 + 59.322) = 1.14 \text{ cc}$$

2. (1) 3 Hits

Block Address of memory	Hit/Miss	Evicted Block	Contents of Cache				
			0	Set 0	1	2	Set 1
1	M	-				1	
3	M	-				1	3
5	M	2				5	3
1	M	3				5	1
3	M	2				3	1
1	H	-				3	1
3	H	-				3	1
5	M	3				3	5
3	H	1				3	5

(2) 3 Hits

Block Address of memory	Hit/Miss	Evicted Block	Contents of Cache				
			0	Set 0	1	2	Set 1
1	M	-				1	
3	M	-				1	3
5	M	3				1	5
1	H	-				1	5
3	M	2				3	5
1	M	2				1	5
3	M	2				3	5
5	H	-				3	5
3	H	-				3	5

(3) 3 Hits

Block Address of memory	Hit/Miss	Evicted Block	Contents of Cache				
			0	Set 0	1	2	Set 1
1	M	-				1	
3	M	-				1	3
5	M	2				5	3
1	M	2				1	3
3	H	-				1	3
1	H	-				1	3
3	H	-				1	3
5	M	3				1	5
3	M	2				3	5

Head
HeadTail
Head

3. (1). 12948 = 0x3294: TLB Hit, physical address: 0x6294
 4949 = 0xC10B: Page fault, physical address: 0xD10B
 46814 = 0xB6DE: TLB Hit, physical address: 0xC6DE
 13775 = 0x3697: TLB Hit, physical address: 0x6697
 40004 = 0x9C44: Page fault, physical address: 0xEC44
 12707 = 0x31A3: TLB Hit, physical address: 0x61A3
 52236 = 0xCC0C: TLB Hit, physical address: 0xDC0C

TLB:

Valid	Tag	Physical Page Number
1	11	12
1	9	14
1	3	6
1	12	13

Page Table

	Valid	Physical Page Number
0	1	5
1	0	Disk
2	0	Disk
3	1	6
4	1	9
5	1	11
6	0	Disk
7	1	4
8	0	Disk
9	1	14
A	1	3
B	1	12
C	1	13

(2). 12948 = (00 11001010010100)₂: Page table hit
 4949 = (11 00000100001011)₂: TLB hit
 46814 = (10 1101101101110)₂: Page fault
 13775 = (00 11011010010111)₂: TLB hit
 40004 = (10 01110001000100)₂: TLB hit
 12707 = (00 11000110100011)₂: TLB hit
 52236 = (11 00110000001100)₂: TLB hit

TLB:

Valid	Tag	Physical Page Number
1	2	13
1	7	4
1	3	6
1	0	5

Page Table

	Valid	Physical Page Number
00	1	5
01	0	Disk
10	1	13
11	1	6
	1	9
	1	11
	0	Disk
	1	4
	0	Disk
	0	Disk
	1	3
	1	12

(3). Advantages: decrease the happening of page fault

Disadvantages: Page fault penalty increases

(4). $12948 = (001\ 1\ 001010010100)_2$: Page fault

$4949 = (110\ 0\ 000100001011)_2$: Page fault

$46814 = (101\ 1\ 011011011110)_2$: Page Table Hit

$13775 = (001\ 1\ 011010010111)_2$: TLB Hit

$40004 = (100\ 1\ 110001000100)_2$: Page Table Hit

$12707 = (001\ 1\ 000110100011)_2$: TLB Hit

$52236 = (110\ 0\ 110000001100)_2$: TLB Hit

We may assume the TLB is empty initially.

TLB:

	Valid	Tag	Physical Page Number
0	1	110	14
	0		
1	1	001	13
	1	100	9

Page Table

	Valid	Physical Page Number
000	1	5
001	1	13
010	0	Disk
011	1	6
100	1	9
101	1	11
110	1	14
111	1	4
	0	Disk
	0	Disk
	1	3
	1	12