

HW4

Problem 1

a)

Block Size = 4 words = 16bytes

offset = $\log_2 16 = 4$ bits, **offset = [3:0]**

number of block = 256 bytes cache / 16 bytes block = 16

index = $\log_2 16 = 4$ bits, **index = [7:4]**

tag = 32-4-4 = 24bits, tag = [31:8]

b)

Address	Binary	Tag	Index	Offset	Hit/Miss	Replaced
0x00	0000_0000	0x0	0x0	0x0	Miss	NA
0x04	0000_0100	0x0	0x0	0x4	Hit	NA
0x10	0001_0000	0x0	0x1	0x0	Miss	NA
0x84	1000_0100	0x0	0x8	0x4	Miss	NA
0xE8	1110_1000	0x0	0xE	0x8	Miss	NA
0xA0	1010_0000	0x0	0xA	0x0	Miss	NA
0x400	0100_0000_0000	0x4	0x0	0x0	Miss	0x00-0x0F
0x1E	0001_1110	0x0	0x1	0xE	Hit	NA
0x8C	1000_1100	0x0	0x8	0xC	Hit	NA
0xC1C	1100_0001_1100	0xC	0x1	0xC	Miss	0x10-0x1F
0xB4	1011_0100	0x0	0xB	0x4	Miss	NA
0x884	1000_1000_0100	0x8	0x8	0x4	Miss	0x080-0x08F

c)

Hit rate = 3/12 = 25%

d)

Index	Tag	Data
0	0x4	0x400-0x40F
1	0xC	0xC10-0xC1F
2	NA	NA

Index	Tag	Data
3	NA	NA
4	NA	NA
5	NA	NA
6	NA	NA
7	NA	NA
8	0x8	0x880-0x88F
9	NA	NA
A	0x0	0xA0-0xAF
B	0x0	0xB0-0xBF
C	NA	NA
D	NA	NA
E	0x0	0xE0-0xEF
F	NA	NA

Problem 2

a

number of blocks = 48 words / 2 words per block = 24 blocks

number of sets = 24 blocks / 3 blocks per set = 8 sets

block offset = $\log_2 2 = 1$ bit, **offset = [0]**

index = $\log_2 8 = 3$ bits, **index = [3:1]**

tag = 32 - 3 - 1 = 28 bits, **tag = [31:4]**

b

Address	Tag	Index	Offset	Hit/Miss
0x03	0x0	0x1	0x1	Miss
0xB4	0xB	0x2	0x0	Miss
0x2B	0x2	0x5	0x1	Miss
0x02	0x0	0x1	0x0	Hit
0xBE	0xB	0x7	0x0	Miss

Address	Tag	Index	Offset	Hit/Miss
0x58	0x5	0x4	0x0	Miss
0xBF	0xB	0x7	0x1	Hit
0x0E	0x0	0x7	0x0	Miss
0x1F	0x1	0x7	0x1	Miss
0xB5	0xB	0x2	0x1	Hit
0xBF	0xB	0x7	0x1	Hit
0xBA	0xB	0x5	0x0	Miss
0x2E	0x2	0x7	0x0	Miss
0xCE	0xC	0x7	0x0	Miss

Index	Way0	Way1	Way2
0	NA	NA	NA
1	0x02-0x03	NA	NA
2	0xB4-0xB5	NA	NA
3	NA	NA	NA
4	0x58-0x59	NA	NA
5	0x2A-0x2B	0xBA-0xBB	NA
6	NA	NA	NA
7	0xBE-0xBF	0x2E-0x2F	0xCE-0xCF

C

Offset = $\log_2 1 = 0$, no offset, no index

tag = [31:0]

Address	Tag	Index	Offset	Hit/Miss	Way
0x03	0x03			Miss	0
0xB4	0xB4			Miss	1
0x2B	0x2B			Miss	2
0x02	0x02			Miss	3
0xBE	0xBE			Miss	4

Address	Tag	Index	Offset	Hit/Miss	Way
0x58	0x58			Miss	5
0xBF	0xBF			Miss	6
0x0E	0x0E			Miss	7
0x1F	0x1F			Miss	0
0xB5	0xB5			Miss	1
0xBF	0xBF			Hit	6
0xBA	0xBA			Miss	2
0x2E	0x2E			Miss	3
0xCE	0xCE			Miss	4

Index	Content
0	0x1F
1	0xB5
2	0xBA
3	0x2E
4	0xCE
5	0x58
6	0xBF
7	0x0E

Problem 3

a

$$\text{clock cycle time} = \frac{1s}{4 \times 10^9} = 0.25ns$$

$$\text{main memory access} : \frac{100ns}{0.25ns} = 400 \text{ cycles}$$

$$\text{CPI} = 1.5 + 6\% * 400 = 1.5 + 24 = 25.5$$

b

$$\text{CPI} = 1.5 + 6\% * 15 + 4\% * 400 = 18.4$$

c

$$\text{CPI} = 1.5 + 6\% * 30 + 1.5\% * 400 = 9.3$$

d

$$\text{CPI} = 1.5 + 6\% * 15 + 6\% * 4\% * 400 = 3.36$$

Problem 4

a

minimum number of parity bits requires: $2^p \geq d + p + 1$, $d = 128$, $p = 8$

to achieve DED: $8 + 1 = 9$

b

$$0x375 = 0011_0111_0101$$

$$p_1 = 0 \oplus 1 \oplus 0 \oplus 1 \oplus 0 \oplus 0 = 0$$

$$p_2 = 0 \oplus 1 \oplus 1 \oplus 1 \oplus 1 \oplus 0 = 0$$

$$p_4 = 1 \oplus 0 \oplus 1 \oplus 1 \oplus 1 = 0$$

$$p_8 = 1 \oplus 0 \oplus 1 \oplus 1 \oplus 1 = 1, \text{ error}$$

correct data: $0011_0110_0101 = 0x365$

Problem 5

a

Page size = 4KB, offset = $\log_2(4 * 2^{10}) = 12\text{bits}$

offset = [11:0], tag = [31:12]

Table:

Address	Virtual Page	TLB Hit/Miss	Page Table Hit/Miss	Page Fault
0x123D	0x1	Miss	Miss	Yes
0x08B3	0x0	Miss	Hit	No
0x365C	0x3	Hit	Hit	No
0x871B	0x8	Miss	Miss	Yes
0xBEE6	0xB	Miss	Hit	No
0x3140	0x3	Hit	Hit	No
0x2330	0x2	Miss	Miss	Yes

Final TLB

Valid	Tag	Physical Page Number	Time Since Last Access
1	0x2	15	1
1	0x8	14	4
1	0x3	6	2
1	0xB	12	3

Final Page Table

Valid	Physical Page or in Disk
1	5
1	13
1	15
1	6
1	9
1	11
0	Disk
1	4
1	14
0	Disk
1	3
1	12

b

offset = [11:0]

index = [12:12]

tag = [31:13]

Address	Virtual Page	Index	Tag	TLB Hit/Miss	Page Table Hit/Miss	Page Fault
0x123D	0x1	0x1	0x0	Miss	Miss	Yes
0x08B3	0x0	0x0	0x0	Miss	Hit	No
0x365C	0x3	0x1	0x1	Miss	Hit	No

Address	Virtual Page	Index	Tag	TLB Hit/Miss	Page Table Hit/Miss	Page Fault
0x871B	0x8	0x0	0x4	Miss	Miss	Yes
0xBEE6	0xB	0x1	0x5	Miss	Hit	No
0x3140	0x3	0x1	0x1	Hit	Hit	No
0x2330	0x2	0x0	0x1	Miss	Miss	Yes

Valid	Set	Tag	Physical Page Number	Time Since Last Access
1	0	0x1	15	1
1	0	0x4	14	4
1	1	0x1	6	2
1	1	0x5	12	3