1 Direct mapping:-

M. Memory Size = 2^{20} → Address bits = 20 bit

Cache blocks = 32 = 2^5 → Block bits = 5 bit

block size = 16 = 2^4 → offset bits = 4 bit

Tag	Block	offset
11	5	4

Main memory blocks = $\dfrac{2^{20}}{2^4}$ = 2^{16} block

0x0DB63 ⟹ 0000 1101 1011 0110 0011

→ Mapped to Block 22

---

2 Direct mapping:-

Main memory size = 2^{32} → Address bits = 32

Cache blocks = 2^{10} → Block bits = 10

block size = 2^5 → offset bits = 5

Tag	Block	offset
17	10	5

Main memory blocks = $\dfrac{2^{32}}{2^5}$ = 2^{27} blocks

0x000063FA ⟹ 0000 0000 0000 0000 0110 0011 1111 1010

→ Mapped to Block 799

[3] Direct mapping:- → Address bits = 32

Main memory size = 2^{32} → Block bits = 3

Cache blocks = $\dfrac{2^9}{2^6} = 2^3$ → offset bits = 6

Block size = 2^6

Tag	Block	offset	
23	3	6	

Main memory blocks = $\dfrac{2^{32}}{2^6} = 2^{26}$ block

0x13A4498A ⟹ ,0001001110100100001001001,11000,01101

↳ Mapped to Block 6

---

[4] Fully Associative:-

Main memory size = 2^{16} → Address bits = 16

Cache blocks = 2^6

Block size = 2^5 → offset bits = 5.

	Tag	offset	
	11	5	

Main memory blocks = $\dfrac{2^{16}}{2^5} = 2^{11}$ block.

0XF8C9, will be mapped to any free block, and when Cache is full, it will be mapped to specific block based on replacement algorithm.

(5) Fully associative:-

Main memory size $= 2^{24}$ $\rightarrow$ Address bits $= 24$

Cache blocks $= 2^7$

Block size $= 2^6$ $\rightarrow$ offset bits $= 6$

Tag	offset
18	6

Main memory blocks $= \dfrac{2^{24}}{2^6} = 2^{18}$ blocks

(6) Fully associative:

Main memory size $= 2^{24}$

Cache blocks $= 2^7$ same as (5)

Block size $= 2^6$

(7) 2-way set associative:-

Main memory size $= 2^7 * 2^{20} = 2^{27}$ $\rightarrow$ Address bits $= 27$

n. sets $= \dfrac{2^5 * 2^{10}}{2^1} = 2^{14}$ $\rightarrow$ set bits $= 14$

Block size $= 2^6$ $\rightarrow$ offset bits $= 6$

7	14	6
Tag.	Set	offset

B) 2-way set associative:-

a) Main memory size $= 2^1 * 2^{10} * 2^3 = 2^{14}$ $\rightarrow$ Address bits = 14

     n. sets $= 2^2$ $\rightarrow$ Sets bits = 2

     Block size $= 2^3$ $\rightarrow$ offset bits = 3

Tag.	Set	offset
9	2	3

b) First loop:-

     0x8 $\rightarrow$ Miss $\rightarrow$ 00000000000$\underline{01}$ $\underline{000}$

     ∴ Set 1, Block 0 = 0x8 ; 0x9, ..., 0x15

     0x9, 0x10, ..., 0x15 $\rightarrow$ hit in Set 1, Block 0

     0x16 $\rightarrow$ Miss $\rightarrow$ 00000000$\underline{01}$ $\underline{0110}$

     ∴ Set 2, Block 0 = 0x16, 0x17, ..., 0x23

     0x17, 0x18, ..., 0x23 $\rightarrow$ hit in Set 2, Block 0

     0x24 $\rightarrow$ Miss $\rightarrow$ 00000000$\underline{01}$ $\underline{00100}$

     ∴ set 3, Block 0 = 0x24, 0x25, ..., 0x31

     0x25, 0x26, ..., 0x31 $\rightarrow$ hit in set 3, Block 0

     0x32 $\rightarrow$ Miss $\rightarrow$ 0000000$\underline{00}$ $\underline{11000}$

     ∴ Set 0, Block 0 = 0x32, 0x33, ..., 0x39

     0x33 $\rightarrow$ hit in set 0, Block 0.

First
~~Second~~ loop has 4 misses and $(7 \times 3)+1 = 22$ hits

Second loop :-
    0x8, 0x9, 0x10, ----- , 0x31, 0x32, 0x33 → hit

Second loop has 0 Misses and 26 hits

Third loop :-
    0x8, 0x9, ---------- , 0x31, 0x32, 0x33 → hit

Third loop has 0 Misses and 26 hits.

In total, we get 74 hits and 4 misses

∴ hit ratio = $\dfrac{hits}{hits+misses} = \dfrac{74}{78} * 100 = 94.87 \%$

9) Main memory size = 2^{16} → Address bits = 16 bit
    Block size = 2^3 → offset bits = 3 bit

2-way set associative cache :-
    n.of sets = $\dfrac{2^5}{2^1} = 2^4$ → Set bits = 4 bit

Tag	Set	offset
9	4	3

- 4 way set associative.

$$n. \text{ of sets} = \frac{2^5}{2^2} = 2^3 \qquad \longrightarrow \text{Set bits} = 3 \text{ bits}$$

Tag	Set	offset
10	3	3

[10] Main memory size = 2^{21} $\longrightarrow$ Address bits = 21

Block size $= 2^2$ $\longrightarrow$ offset bits = 2

- 2 way set associative.

$$n. \text{ of sets} = \frac{64}{2} = 32 = 2^5 \qquad \longrightarrow \text{Set bits} = 5$$

Tag	set	offset
14	5	2

- 4 way set associative.

$$\text{no. of sets} = \frac{64}{4} = 16 = 2^4 \qquad \longrightarrow \text{Set bit} = 4.$$

Tag.	Set	offset
15	4	2