Q1. diff b/w registers and L1 cache as cache

- CPU can only directly access registers (as it is part of CPU memory) register memory is much smaller than faster access
- Data loaded in registers is dictated by program unlike L1 cache. This is the main/important/conceptual difference

Q2. Cache is SRAM, smaller, closer to CPU hence making it faster than main memory (DRAM)

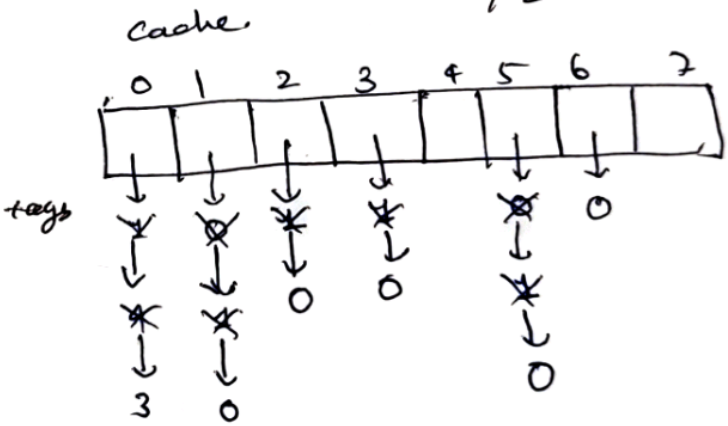
Q3. main memory = 2^8 words.
block size = 2 words
cache memory = 2^3 blocks.

last three bits of main mem block # → 7

word # n → main mem block # $\lfloor n/2 \rfloor$ —DM→ cache block # $\lfloor n/2 \rfloor \% 2^3$ → 8

tag → tag = $(n/2)/2^3 = n/2^4$

word #		cache block #	tag	hit / miss
2		1	0	miss
3		1	0	hit
11		5	0	miss
16		0	1	miss
21	10	2	1	miss
13	6	6	0	miss
64	32	0	4	miss
48	24	0	3	miss
19	9	1	1	miss
11	5	5	0	hit
3		1	0	miss
22	11	3	1	miss
4	2	2	0	miss
27	13	5	1	miss
6	3	3	0	miss
		6	0	miss



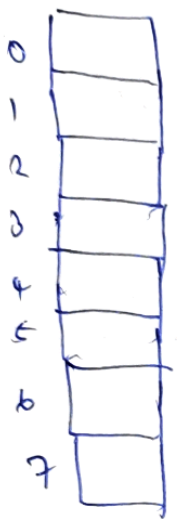
Q4 main memory size = 1024 words. = 2^{10} words

blocks in main memory = 2^9

blocks in cache = 2^3

would be same as Q3

since the seq, is same just tag size would be larger by 2 bits.



Q5. main memory = 32 MB = $2^{10} \cdot 2^{10} \cdot 2^5 = 2^{25}$ bytes

Cache size = 512 KB = $2^{10} \cdot 2^9 = 2^{19}$ bytes.

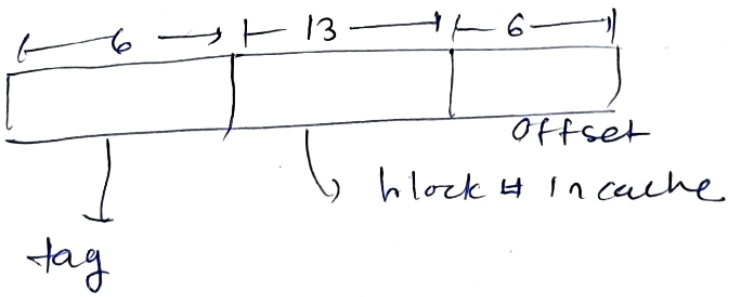
block size = 16-word = $2^4 \cdot 2^2 = 2^6$ bytes.
↳ offset

blocks in cache = $2^{19} / 2^6 = 2^{13}$

Assuming we need valid, dirty bits per block.

25 - (13 + 6)
6

DM:



0 bits comparator

metadata = (tag + 2) bits each block

= $2^{13} \cdot (8 + 2^3)$ bits.

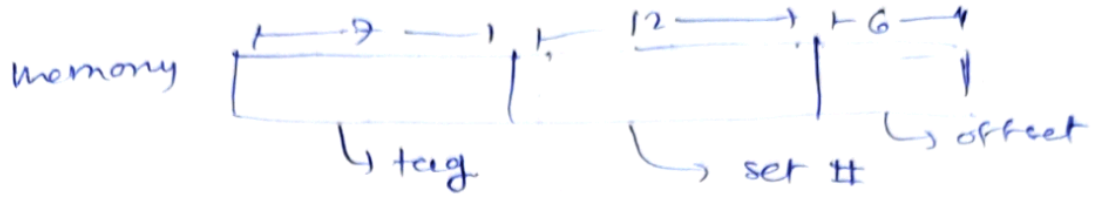
= 2^{16} bytes = 8 KB.

(b) 2 way set associative.

i) each set has 2 blocks

# of sets = $\frac{2^{13}}{2} = 2^{12}$

25 - (12+6)



ii) ~~1 bits each comparator~~

# of comparator = # of blocks in set = 2

iii) # of bits compared / comparator = tag size = 7

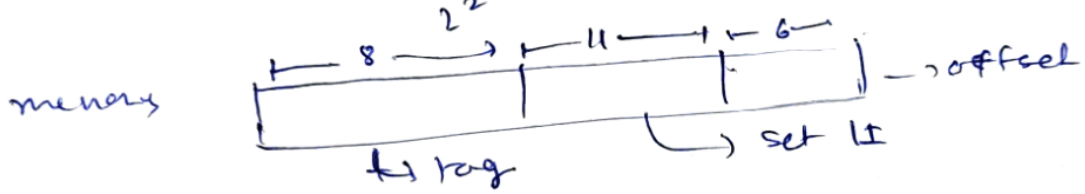
iv) metadata = 9×2^{13} bits = 9×2^{10} bytes = 9 KB

(c) 4 way set associative

each set has 4 blocks.

# of sets = $\frac{2^{13}}{2^2} = 2^{11}$

i)



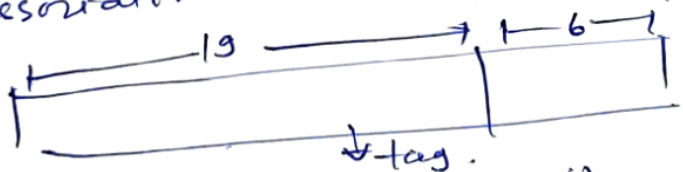
ii) # of comparator = 4

iii) # of bits compared / comparator = 8

iv) metadata size = $(8+2) \times 2^{13}$ bits = 10×2^{10} bytes = 10 KB.

(d) fully associative # of sets = 1

i)



ii) # of ~~bits~~ comparators = 2^{13} = # of blocks in cache.

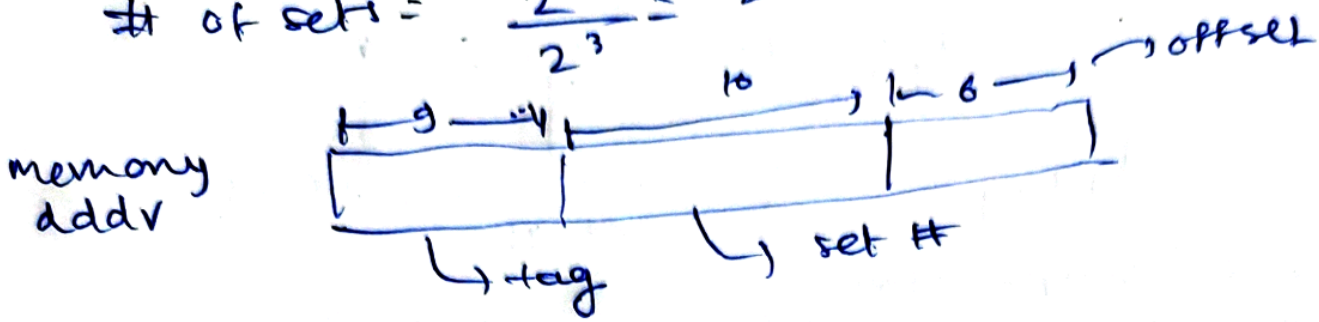
iii) # of bits compared / comparator = 19

iv) metadata size = $(19+2) \times 2^{13}$ bits = 21 KB

(d) 8-way set associative

i) each set has 8 blocks

# of sets = $\frac{2^{13}}{2^3} = 2^{10}$



ii) # of comparators = 8

iii) # of bits comp / comparator = 9

iv) metadata size = $(9+2) \times 2^{13}$ bits

= 11 KB