PROBLEM SOLVING ASSIGNMENT-1

1. How many 128 × 8 RAM chips are needed to provide a memory capacity of 2048 bytes?

2. How many address bits are required to address the block of 256 MB with 2 byte per block?

3. Given a hard disk system with 500 tracks, 100 sectors per track, 500 bytes per sector and rotation speed of 600 RPM. Find the average time taken for transferring 250 bytes from the disk?

4. A program of size 64MB is stored on disk which supports an average seek time of 30ms and rotation time of 20ms. Page size is 4MB and track size is 32MB. If the pages of the program are contiguously placed on disk, then find the total time required to load the program from disk in ms.

5. Consider a typical disk that rotates at 15000 RPM and has a transfer rate of 50×10^6 bytes/sec. If the average seek time of the disk is twice the average rotational delay and the controller's transfer time is 10 times the disk transfer time. What is the average time (milliseconds) to read or write a 512-byte sector of the disk?

6. Consider a direct mapped cache of size 16 MB with block size of 4 KB. The size of main memory is 16 GB. Find the number of bits in the block offset, in the cache lines and in the tag field.

7. Given a direct mapped cache of size 512 KB with block size of 1 KB. The tag field contains 7 bits. What is the main memory size?

8. Consider a direct mapped cache of size 32 kilobyte with 8 bytes per block. The size of main memory is 16 megabytes. Find the number of bits in the block offset, in the cache lines and in the tag field.

9. Consider an associative mapped cache of size 512 KB with block size of 1 KB. The size of main memory is 128 MB. Find the number of lines in the cache and the number of bits in the tag field.

10. Given a memory size of 32 GB and cache size of 32 KB with block size of 1KB. Find the number of sets in the cache, cache lines and bits in the tag field, using 4-way set associative mapping.

11. Consider a 4-way set associative cache consisting of 128 lines with a line size of 64 words. The CPU generates a 20-bit address of a word in main memory. Find the number of bits in the tag, line and word fields.

12. Consider a 2-way set associative mapped cache of size 1024 KB with block size 1 KB. There are 7 bits in the tag. Find the following:
    a. Number of sets in the cache
    b. Size of main memory.

SOLUTIONS :-

1. $\frac{2048}{128} = 16$ chips

2. $256\,MB = 2^8 \times 2^{20}$ Bytes
$= 2^{28}$ Bytes

$\log 2^{28} = 28$ bits are required.

3. Avg. Seek time :-
$\frac{\Sigma 0+1+2+3+4+\ldots+499}{500} = 249.5\,ms$

Avg. rotational delay : 0.1 rotation per sec.
$\therefore$ avg = 50ms.

Data tranfer time :-
In one rotation, $100 * 500 = 50000\,KB$.
$\therefore 250\,B = 0.1 \times \frac{250}{50000} = 0.5\,ms$

Avg. time $= 249.9 + 50 + 0.5 = 300\,ms$.

4. Total tracks = $64/32 = 2$.

Time taken to load = 2 (seek time + ½ rotation time + rotation time)

$= 2(30 + \frac{1}{2} \times 20 + 20) = 120$ ms.

5. Disk latency = seek time + Rotat^n time + transfer + controller overhead.

Avg. rotational delay = $\frac{15000}{60} \times \frac{1}{2}$ ms

Avg seek time = 2 × (Avg. rot. delay) = 4 ms

Transfer time = $512 \times \frac{1}{50 \times 10^6 \text{ Bytes/sec}} = 10.24\mu s$

Controller = $10 \times 10.24\ \mu s$

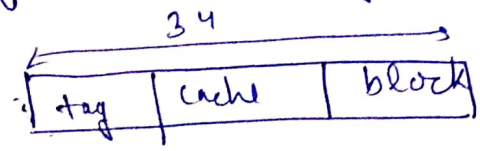
= 0.1 ms.

Disk latency = $4 + 2 + 0.1 + (10.24 \times 10^{-3})$

= 6.1 ms.

6. m/m size $= 2^4 \times 2^{30}$ B $= 2^{34}$ B

Number of bits in physical address = 34.



no. of bits in block offset $= 2^{12}$ B $\Rightarrow$ 12

No. of cache blocks $= \frac{2^4 \times 2^{20}}{2^{12}} = 2^{12}$.

$\therefore$ no. of tag bits $= 34 - 12 - 12 = 10$.

Ans → 10

7. Let no. of bits in physical address = x

$x = 7 + 9 + 10 = 26$

$\therefore$ m/m size = 64 MB (2^{26} B).

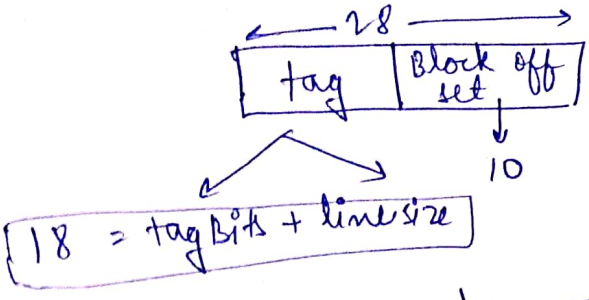
8. m/m size $= 2^{24}$ B

$\therefore$ no. of bits in block offset $= 2^3$ Bytes $\Rightarrow 3$

no. of bits in cache field $= \frac{2^{15}}{2^3}$ Bytes $\Rightarrow 12$

$\therefore$ no. of tag bits $= 24 - 3 - 12 \Rightarrow 9$.

9. m/m size = 2^{28} Bytes

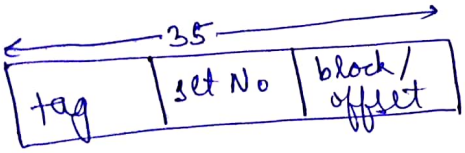


no. of line in cache = $\frac{2^{19}}{2^{10}} = 2^9$

tag bits = 9.

10. memory size = 2^{35} Bytes.

∴



No. of bits in block offset = 2^{10} Bytes => 10

No. of lines in cache = $\frac{2^{15}}{2^{10}}$ Bytes => 32 lines

No. of sets in cache: $\frac{32}{4}$ lines => 8

no. of tag bits = 35 - 8 - 10

=> 17

11. No. of sets = $\frac{128}{4}$ = 32 (4 way association).

total → 64 words ⇒ 2^6 to identify word.

∴ line offset = 5 bits.

word offset = 6 bits.

tag bits = 20 − 5 − 6 = 9 bits.

12. No. of cache lines = $\frac{2^{20}}{2^{10}}$ ⇒ 2^{10} = 1024

∴ No. of sets = 1024/2 = 512 ⇒ 2^9

∴ line offset = 9

tag bits = 7 (given).

block offset = 10.

∴ size of m/m = 2^{9+7+10} = 2^{26} Bytes

= 64 MB.

a) 1024 sets

b) 64 MB.