



Exercise 3

Given a memory system with the following characteristics:

16MB Virtual Memory with an LRU replacement policy

Page size of 4KB

Main memory of 32KB

Physical cache of 8KB, with 64B blocks, set-associative with 2 blocks per set/and LRU replacement policy

1) Obtain the virtual and physical address format (from the point of view of the virtual memory and the cache memory).

Given the following program to execute:

```
int A[16384];  
for (i=0; i<16384; i++)  
    red+= A[i];
```

Associative page table		
Page number	Frame number	Last access
100	0	0
101	1	1
200	2	2
201	3	3
300	4	4
301	5	5
400	6	6
401	7	7

Assuming A starts in virtual address 0x100000 and **red** variable is stored in a register:

2) How many virtual pages are used?

3) How many hits and misses occur?

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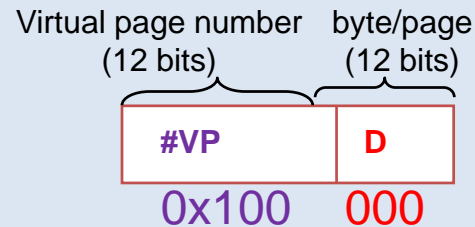
1) Virtual address

Assume a computer with 16MB Virtual Memory with an LRU replacement policy
Page size of 4KB

Address space: 16 MB = 2^{24} bytes

Page size: 4 KB = 2^{12} bytes

Fields of the virtual address





2) Physical address

Assume a computer with main memory of 32KB

Page size of 4KB

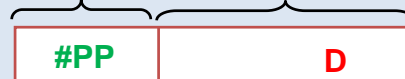
Memory: 32 KB = 2^{15} bytes

So, physical addresses have 15 bits

There are 8 page frames in memory: 0x0 to 0x7

Fields of the physical address

Physical page number (3 bits) byte/page (12 bits)



Page size: 4 KB = 2^{12} bytes

3) Physical Address for the cache



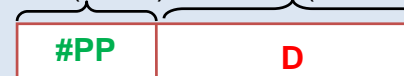
Physical cache of 8KB, with 64B blocks, set-associative with 2 blocks per set and LRU replacement policy

$$\frac{2^{13} \text{ bytes}}{64 \text{ bytes/line}} = 128 \text{ lines}$$

$$\frac{128 \text{ lines}}{2 \text{ lines/set}} = 64 \text{ sets}$$

Fields of the physical address

Physical page number (3 bits) byte/page (12 bits)



3 6 6





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4) Virtual pages

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```

Assuming A starts in virtual address 0x100000 and red variable is stored in a register:

How many virtual pages are used?

Page size: 4 KB = 2^{12} bytes

The size of A is: 2^{14} integers = 2^{16} B

So, A takes up 16 pages.

Since the program reads all elements, it uses all 16 pages.



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Assuming A starts in virtual address 0x100000 and **red** variable is stored in a register:

2) How many virtual pages are used?

3) How many hits and misses occur?



5) Hits and misses

Given the following program to execute:

```
int A[16384];  
for (i=0; i<16384; i++)  
    red+= A[i];
```

Assuming A starts in virtual address 0x100000 and red variable is stored in a register:

How many hits and misses occur?

	Virtual address
A[0]	0x100000
A[1024]	0x101000
A[2048]	0x102000
	...
A[15360]	0x10F000

The program reads pages 0x100 to 0x10F (16 pages). The number of accesses is 16384.

Since we don't know the code size we will answer only pages needed for data.



5) Hits and misses (2)

The program reads 16 pages, from 0x100 to 0x10F

Pages 100
and 101
are already
in memory.
HIT

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The number of misses is 14.
The number of hits is $16384 - 14 = 16370$.