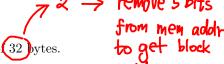# EXERCISE 5

Assume that a computer system is equipped with L1 and L2 caches:

- *L1 data cache* is a 2-way set associative cache with 2 sets and block size of (32) bytes.

- *L1 instruction cache* is a 2-way set associative cache with 2 sets and block size of 32 bytes.

- *L2 unified cache* is a 4-way set associative cache with 4 sets and block size of 32 bytes.

The caches use the Least Recently Used algorithm for the block replacement, and are initially empty.

[handwritten margin note: $2^5 \rightarrow$ remove 5 bits from mem addr to get block addr.]

L1 Instruction cache		L1 Data cache	
0	1	0	1
0x20	0x21	~~0x1000~~ 0x1006	0x1001
0x22	0x23	0x1002	0x1003

L2 Unified cache			
0	1	2	3
0x20	0x1001	0x1002	0x1003
0x1000	0x21	0x22	0x23
		0x1006	

Complete the table below to show how the following memory addresses can be accessed. Write *L1* when the specified memory address is found in one of the L1 caches, *L2* when the memory address is found in the L2 cache, and *Miss* when the memory address is not available in both levels of caches.

Time	Instr Addr	L1/L2/Miss	Data Addr	L1/L2/Miss
1	0x410 0x20	M	0x20000 0x1000	M
2	0x414 0x20	L1	0x20024 0x1001	M
3	0x430 0x21	M	0x20060 0x1003	M
4	0x434 0x21	L1		
5	0x418 0x20	L1		
6	0x400 0x20	L1	0x20004 0x1002	M
7	0x440 0x22	M	0x200C8 0x1006	M
8	0x460 0x23	M	0x20028 0x1001	L1
9	0x450 0x22	L1	0x200C4 0x1006	L1
10	0x430 0x21	L1		
11	0x400 0x20	L1		
12	0x460 0x23	L1		
13	0x440 0x22	L1		

Mem address 0x410 = 0b01000001~~0000~~ --> Block address = 0x20

```
#define N 1000

int array_compare(int A[N], int B[N]) {
  int i;

  for(i=0; i<N, i++) {
    if (A[i] != B[i]) {
      return 0;
    }
  }

  return 1;
}
```

Suppose our computer uses a 2-way set associative cache with 4 sets, and cache line size is 16 bytes (4 integers). Here, we assume that the starting address of the arrays A and B are address 0 and address 0x10000, respectively.

1. What is the hit rate when both arrays are identical?

$$\frac{750}{1000} = 75\%$$

2. What is the hit rate after we make the cache line size be 64 bytes? We still assume that both arrays are still identical. → 16 integers

$$\frac{937}{1000} = 93.7\%$$