

Name: SOLUTION

ID: _____

No calculators, notes, or textbooks allowed. Show all your work for full credit.

Time limit: 20 mins

Problem 1: Consider a **word-addressable** computer with 32MB ($\text{MB} = 2^{20}$) of main memory and a cache capable of storing a total of 16KB ($\text{KB} = 2^{10}$) of data.

- (a) How many bits are needed to address main memory?

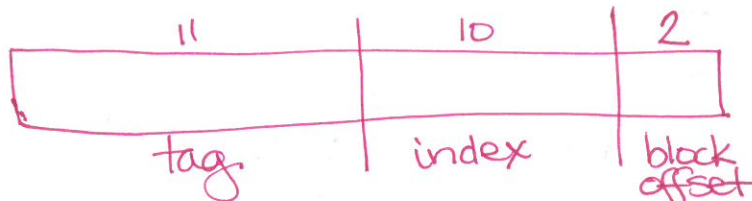
$$\frac{2^{25}}{2^2} = 2^{23} \text{ words} \Rightarrow 23 \text{ bits.}$$

- (b) Assume the cache is direct-mapped with block size of 16 bytes. What is the format of the memory address (tag, index, block)? Specify the size and position of each field.

$$16 \text{ bytes} = 4 \text{ words}$$

$$2^{14} \text{ bytes in cache}$$

$$\frac{2^{14}}{2^4} = 2^{10} \text{ cache index}$$

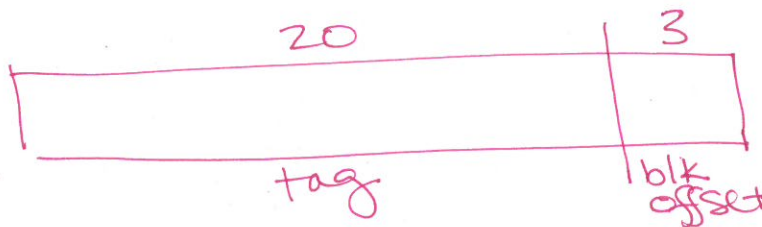


- (c) Assume the cache is fully associative with block size of 32 bytes. What is the format of the memory address (tag, index, block)? Specify the size and position of each field.

$$32 \text{ bytes} = 8 \text{ words} = 2^3$$

$$\frac{2^{14} \text{ bytes in cache}}{2^5 \text{ (block size)}} = 2^9 \text{ blocks in cache}$$

but fully assoc so no index



- (d) Assume the cache is 2-way set associative with block size of 16 words. What is the format of the memory address (tag, index, block)? Specify the size and position of each field.

$$16 \text{ words} = 64 \text{ bytes} = 2^6 \text{ bytes}$$

$$\frac{2^{14}}{2^6} = 2^8 \text{ cache blocks} = 2^7$$

2-way



- (e) Assume the cache is 4-way set associative with a block size of 64 bytes. How many sets are in the cache?

$$\frac{2^{14}}{2^6} = 2^8 \Rightarrow \frac{2^8 \text{ cache blocks}}{2^2 \text{ -way}} = 2^6 \text{ ~~index~~ sets in cache}$$

Problem 2: Suppose we have a **byte-addressable** computer with main memory of 2^8 bytes. This computer has a 4-way set associative 16-byte cache with 2 bytes per cache block. The computer accesses a number of memory locations throughout the course of running a program. The system accesses memory addresses (in hex) in this exact order: 6E, B9, 17, E0, 4E, 4F, 50, 91, A8, AB, AD, 93, and 94.

(a) Which bytes (label all values of the cache block) are in each entry of the cache after the sequence is complete?

2^8 bytes \Rightarrow 8 bit address

16 byte cache

2 bytes per block

8 blocks

4 way = 2 sets

6E 0110 1110
B9 1011 1001
17 0001 0111
E0 1110 0000
4E 0100 1110
4F 0100 1111
50 0101 0000
91 1001 0001
A8 1010 1000
AB 1010 1011
AD 1010 1101
93 1001 0011
94 1001 0100

	BB/B9	E0/E1	50/51	A8/A9
Set 0	AC/AD	94/95		
Set 1	6E/6F	16/17	4E/4F	90/91
	AA/AB	92/93		

(b) What was the miss ratio assuming the cache was empty at the start?

6E Miss

B9 miss

17 miss

E0 miss

4E miss

4F Hit

50 miss

91 miss

A8 miss

AB miss

AD miss

93 miss

94 miss

Replaces 6E/6F

Replaces BB/B9

Replaces 16/17

Replaces E0/E1

$12/13 = 92.3\%$ miss