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ECE 5720, Fall 2019

Take Home 4 (Submit on Canvas)

Due: November 21, 2019 (3:00 PM)

Instructions:

- Write your A-number on top of every sheet.
- Make sure that your exam is not missing any sheets, then write your full name on the front.
- The exam has a maximum score of 20 points. You must show your steps clearly to get any credit. Good luck!

1 (20):	
TOTAL (20):	

Problem 1. (3+3+2+5+2+5 points):

The following problem concerns the way virtual addresses are translated into physical addresses.

- The memory is byte addressable.
- Memory accesses are to **1-byte words** (not 4-byte words).
- Virtual addresses are 16 bits wide.
- Physical addresses are 13 bits wide.
- The page size is 512 bytes.
- The TLB is 8-way set associative with 16 total entries.
- The cache is 2-way set associative, with a 4 byte line size and 16 total lines.

In the following tables, **all numbers are given in hexadecimal**. The contents of the TLB, the page table for the first 32 pages, and the cache are as follows:

TLB			
Index	Tag	PPN	Valid
0	09	4	1
	12	2	1
	10	0	1
	08	0	1
	05	7	1
	13	1	0
	10	3	0
	18	3	0
1	04	1	0
	0C	1	0
	12	0	0
	08	1	0
	06	7	0
	03	1	0
	07	5	0
	02	2	0

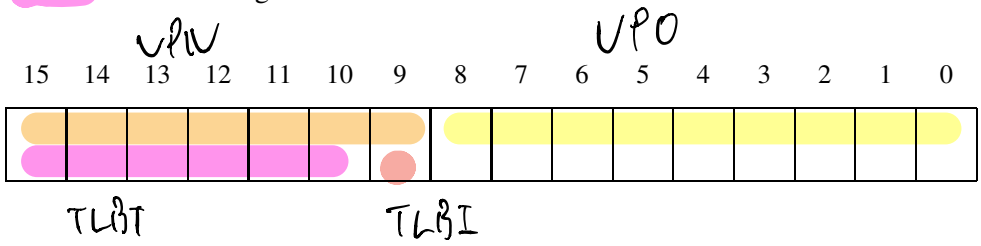
Page Table					
VPN	PPN	Valid	VPN	PPN	Valid
00	6	1	10	0	1
01	5	0	11	5	0
02	3	1	12	2	1
03	4	1	13	4	0
04	2	0	14	6	0
05	7	1	15	2	0
06	1	0	16	4	0
07	3	0	17	6	0
08	5	1	18	1	1
09	4	0	19	2	0
0A	3	0	1A	5	0
0B	2	0	1B	7	0
0C	5	0	1C	6	0
0D	6	0	1D	2	0
0E	1	1	1E	3	0
0F	0	0	1F	1	0

2-way Set Associative Cache												
Index	Tag	Valid	Byte 0	Byte 1	Byte 2	Byte 3	Tag	Valid	Byte 0	Byte 1	Byte 2	Byte 3
0	19	1	99	11	23	11	00	0	99	11	23	11
1	15	0	4F	22	EC	11	2F	1	55	59	0B	41
2	1B	1	00	02	04	08	0B	1	01	03	05	07
3	06	0	84	06	B2	9C	12	0	84	06	B2	9C
4	07	0	43	6D	8F	09	05	0	43	6D	8F	09
5	0D	1	36	32	00	78	1E	1	A1	B2	C4	DE
6	11	0	A2	37	68	31	00	1	BB	77	33	00
7	16	1	11	C2	11	33	1E	1	00	C0	0F	00

Part 1

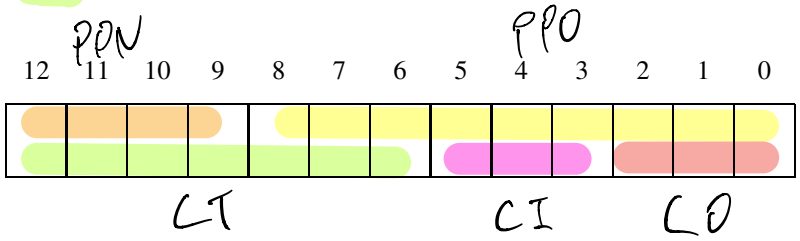
A. The box below shows the format of a virtual address. Indicate (by labeling the diagram) the fields (if they exist) that would be used to determine the following: (If a field doesn't exist, don't draw it on the diagram.)

VPO The virtual page offset
VPN The virtual page number
TLBI The TLB index
TLBT The TLB tag



B. The box below shows the format of a physical address. Indicate (by labeling the diagram) the fields that would be used to determine the following:

PPO The physical page offset
PPN The physical page number
CO The block offset within the cache line
CI The cache index
CT The cache tag



Part 2

For the given virtual address, indicate the TLB entry accessed, the physical address, and the cache byte value returned **in hex**. Indicate whether the TLB misses, whether a page fault occurs, and whether a cache miss occurs.

If there is a cache miss, enter "-" for "Cache Byte returned". If there is a page fault, enter "-" for "PPN" and leave parts C and D blank.

Virtual address: `20AD`

A. Virtual address format (one bit per box)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	1	0	0	0	0	0	1	0	1	0	1	1	0	1

B. Address translation

Parameter	Value
VPN	0x 10
TLB Index	0x 0
TLB Hit? (Y/N)	Y
Page Fault? (Y/N)	N
PPN	0x 0

C. Physical address format (one bit per box)

12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	1	0	1	0	1	1	0	1

D. Physical memory reference

Parameter	Value
Byte offset	0x AD
Cache Index	0x 5
Cache Tag	0x 2
Cache Hit? (Y/N)	N
Cache Byte returned	0x —