

Problem 63. (12 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	5	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

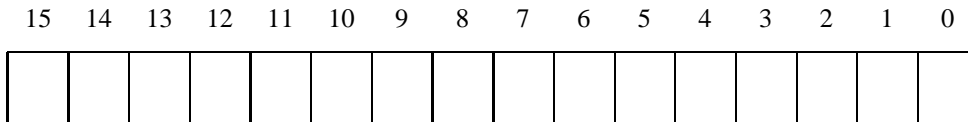
Page Table					
VPN	PPN	Valid	VPN	PPN	Valid
00	6	1	10	0	1
01	5	0	11	5	0
02	3	1	12	2	1
03	4	1	13	4	0
04	2	0	14	6	0
05	7	1	15	2	0
06	1	0	16	4	0
07	3	0	17	6	0
08	5	1	18	1	1
09	4	0	19	2	0
0A	3	0	1A	5	0
0B	2	0	1B	7	0
0C	5	0	1C	6	0
0D	6	0	1D	2	0
0E	1	1	1E	3	0
0F	0	0	1F	1	0

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

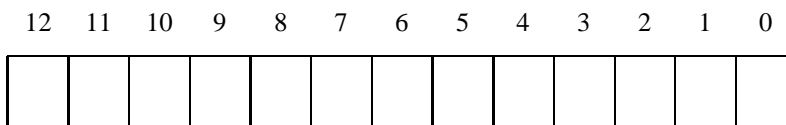
- A. The box below shows the format of a virtual address. Indicate (by labeling the diagram) the fields (if they exist) that would be used to determine the following: (If a field doesn't exist, don't draw it on the diagram.)

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: 1DDE

A. Virtual address format (one bit per box)

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

B. Address translation

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

C. Physical address format (one bit per box)

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

D. Physical memory reference

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