

Before Starting Homework

- Do not upload to generative AI.
- Complete the Programming Assignment before beginning the written portion of the homework.
- Answer all questions below.
- **Type** answers and upload to Canvas in PDF format.
- **All listed numbers are base 10 decimals.**

1 Question 1 : Accessing Values from Memory

Assume you have a 4-way associative TLB that holds a total of 8 page entries, and that the TLB initially holds the following:

Set	Tag	PFN	Valid	Tag	PFN	Valid	Tag	PFN	Valid	Tag	PFN	Valid
0	3	-	0	9	13	1	0	-	0	7	2	1
1	3	45	1	2	-	0	4	-	0	10	-	0

Also assume the relevant entries of your page table are listed as follows:

VPN	PFN	Valid
0	0	1
1	-	0
15	14	1
18	13	1

Finally, assume you have a single level of cache that holds 16 lines with 4-byte block size, and that cache initially holds the following:

IDX	Tag	Valid	B0	B1	B2	B3	IDX	Tag	Valid	B0	B1	B2	B3
0	19	1	99	11	23	11	8	13	1	17	19	27	22
1	17	1	77	23	15	2	9	12	1	32	47	81	10
2	15	1	13	7	23	5	10	7	1	1	0	7	12
3	-	0	-	-	-	-	11	3	1	2	7	12	31
4	19	1	99	11	23	11	12	-	0	-	-	-	-
5	15	1	10	7	3	25	13	8	1	92	21	65	1
6	-	0	-	-	-	-	14	14	1	0	17	1	5
7	3	1	7	52	45	3	15	-	0	-	-	-	-

Assume that your page size is 64 bytes and that there is only a single page table (i.e. no hierarchical page tables). Assume the following virtual address are accessed from the TLB, page table, and cache above:

1. 1017
2. 1186
3. 34

For each address, answer the following questions:

- a What are the TLB tag and TLB index?
- b Is the VPN in the TLB?
- c If not in the TLB, is the VPN in the page table?
- d What is the corresponding PFN, if known?
- e What are the cache tag, index, and offset?
- f Is the corresponding data in cache, and if so what is the value?