Homework 4

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Problem 1

Configuration	Virtual Addr bits	Physical Addr bits	VPN bits	PPN bits	Offset bits
a. 32-bit OS, 4 KB pages, 1 GB RAM	32	30	20	18	12
b. 32-bit OS, 16 KB pages, 2 GB RAM	32	31	18	17	14
c. 64-bit OS, 16 KB pages, 16 GB RAM	64	34	50	20	14

Advantages of Larger Page Size

- Reduced page-table overhead: fewer entries smaller tables.
- Higher TLB coverage: each entry maps more bytes fewer TLB misses.
- Improved I/O efficiency: larger contiguous transfers fewer disk operations.

Disadvantages of Larger Page Size

- Increased internal fragmentation: more wasted space per page.
- Longer page-fault service time: loading a larger page takes more I/O.
- Potential memory-bandwidth waste: unused data still consumes bus cycles.

Problem 2

Address Stream and VPNs

Virtual Address	VPN (VA $\gg$ 12)
0x0FFF	0
0x7A28	7
0x3DAD	3
0x3A98	3
0x1C19	1
0x1000	1
0x22D0	2

Step-by-Step Results

VA	VPN	Result	PPN	Explanation
0x0FFF	0	TLB miss, PT hit	5	Load VPN 0 $\rightarrow$ PPN 5 into TLB (evict LRU=1)
0x7A28	7	TLB hit	4	Tag 7 already in TLB
0x3DAD	3	TLB hit	6	Tag 3 in TLB
0x3A98	3	TLB hit	6	Repeat access still TLB hit
0x1C19	1	Page fault	13	Allocate PPN 13, update PT and TLB (evict LRU=2)
0x1000	1	TLB hit	13	Just loaded
0x22D0	2	Page fault	14	Allocate PPN 14, update PT and TLB (evict LRU=3)

Final TLB State

Slot	Valid	Tag (VPN)	Physical Page #	LRU Rank (1=oldest, 4=newest)
1	1	2	14	4
2	1	1	13	3
3	1	3	6	2
4	1	7	4	1

Final Page Table

VPN	Valid	Physical Page # / Disk
0	1	5
1	1	13
2	1	14
3	1	6
4	1	9
5	1	11
6	0	Disk
7	1	4
8	0	Disk
9	0	Disk
10	1	3
11	1	12