HW 11
CS411

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1.) Given a virtual memory system with:
- ↳ 37 virtual address bits
- ↳ 32 physical address bits
- ↳ 32KB pages (15 bit page offset)

a. VPN = 37 - 15 = 22 bits
PPN = 32 - 15 = 17 bits

# of Virtual page table entries = 2^{22} = 4,194,304 entries

physical page # needs...

valid + exec + rd + dirty + PPN

1 + 1 + 1 + 1 + 17 = 21 bits ∴

# of bits in page tabe = 21 * 4,194,304 = 88,080,384

 # bits in PPT ≃ $\underline{2^{26.4}}$ bits or $\underline{10^{7.94}}$ bits

b. VPN is now = 38 - 15 = 23 bits

# of VPT entries is now = 2^{23} = 8,388,608

# of PPT bits = 21 * 8,388,608 = 176,160,768 bits

↳ **# of bits in PPT ≃ $2^{27.4}$ bits or $10^{8.25}$ bits**

C. TLB; 32 blocks; 1 entry/block; like (a) except
$\underline{VA = 36}$; PA = 32, PO = 15; assuming valid, exec, rd, & dirty Present

VPN = 36 - 15 = $\underline{21}$ $\log_2(32 \text{ blocks}) = 5$ bits in TLB idx

PPN = 32 - 15 = $\underline{17}$

Val + ex + rd + rd + Tag + PPN = bits/block
1 + 1 + 1 + 1 + 16 + 17 = 37 bits

TLB_Tag = VPN - Idx_{TLB} =
↳ = 21 - 5 = 16 bits for tag

37 * 32 blocks = **1,184 bits in TLB**

d. See diagram on next page

Virtual Address 35 - Bits

Virtual Page Number (VPN) 20 - Bits

Tag 17 - Bits | Block Offset 2 - Bits | Page Offset 15 - Bits

Tag (17 - Bits)

Page Offset (15 - Bits)

Block Offset (2 - Bits)

V (1)	E (1)	R (1)	D (1)	Tag (17 - Bits)	Physical Page Number (17 - Bits)	V (1)	E (1)	R (1)	D (1)	Tag (17 - Bits)	Physical Page Number (17 - Bits)	
												Block 3
												Block 2
												Block 1
												Block 0

17

17

Tag (17 - Bits)

Tag (17 - Bits)

=

=

17

17

15

Hit_1

Hit_0

0

1

2-to-1 Multiplexer

17

Physical Page Number (PPN) | Page Offset 15 - Bits

Hit

Virtual Address 35 - Bits

Two Way Associative TLB
HW 11
Question 1.d)

2.) read time for 1 MB file on hard drive & SSD in MS

a. Hard Drive →

"avg" seek = 3.0/4 = 0.75ms

RPS = 10,000/60 = 166.66

$\frac{1}{2} * \frac{1}{RPS} = 0.003 = 3.0ms$

published avg seek time: 3.0ms
rotation speed: → 10,000 rpm
Overhead: ⟶ 2.0ms
transfer rate: ⟶ 80 MB/s

rot. delay ↓ 3.0ms + "avg" seek ↓ 0.75 + overhead ↓ 2.0ms = 5.75ms

Size independent delay:

transfer time → $\frac{1\ MB}{80\ MB/sec} = 0.0125_s = 12.5ms$ ↓

total file read time = 18.25ms = 12.5ms + 5.75ms

b. SSD → Overhead: 1.5ms
transfer rate: 80MB/s

*Same transfer time because rate & file size are the same
↳ = 12.5ms ∴

total file read time
13.5ms

= 12.5 + 1.5

c. SSD Speed up

↳ $\frac{18.25ms}{13.5ms} = \boxed{1.3519}$