Q1.

a)

offset size = $\log_2$(page size in bytes)

= $\log_2$(4kB)

= $\log_2$(4 × 1024)

= 12 bits

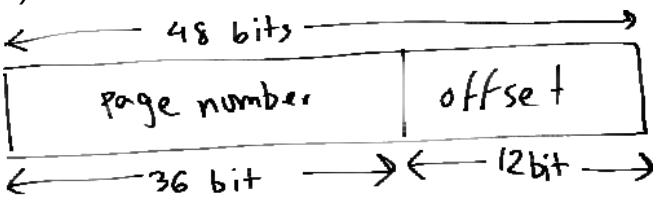
b)

number of virtual pages = $\frac{\text{virtual memory size}}{\text{page size}}$

= $\frac{2^{48} \text{ bytes}}{2^{12} \text{ bytes}}$

= 2^{36} virtual pages

c)



bits for VPN = 48 − 12

= 36 bits

d)

Physical address = $\log_2$(Physical memory size)

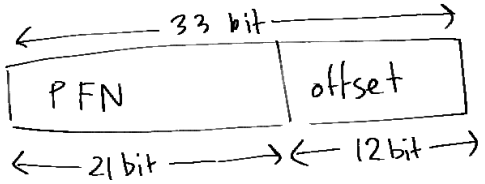
$= \log_2(8GB)$

$= \log_2(2^3 \times 2^{33})$

$= 33$ bits

Number of bits for PFN = $32 - 12$

$= 21$ bits



e)

size of single page table = No. of PTEs X PTE size

= No. of virtual pages x 4 bytes

$= 2^{36} \times 2^2$ bytes

$= 2^8 \times 2^{30}$ bytes

$= 256$ GB

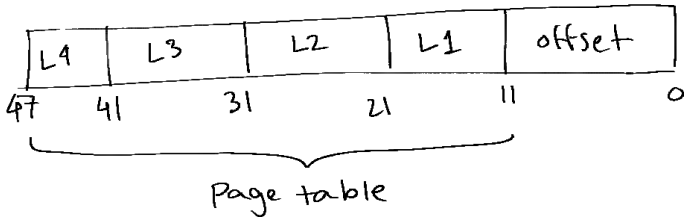
f)

number of bits for each level page table = $\log_2\left(\frac{\text{page size}}{\text{PTE size}}\right)$

$= \log_2\left(\frac{4 \times 1024 \text{ bytes}}{4 \text{ bytes}}\right)$

$= \log_2(1024)$

$= 10$ bits



Q2.

Memory required for all processes = 1024 × Memory per process

= 1024 × 4MB = 4GB

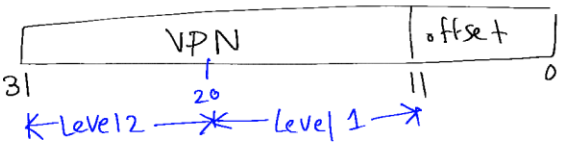
Memory per process = 4MB

No. of pages = Virtual Address / Page Size

$= \frac{2^{32}}{2^{12}} = 2^{20}$

bits for VPN = $\log_2(2^{20})$

= 20 bits



L2 = entries × entry size

$= 2^{10} \times 4$ bytes

= 4KB

L1 = 2^{10} × 4 kB

= 4MB

Memory per process = L1 + L2 ≈ 4MB

Physical Address = $\log_2$ (Physical memory size)

$= \log_2(2^{33})$

= 33 bit

bits for PFN = 33 − 12

= 21 bits

PTE size = 21 + 10 = 31 bits

⇒ 4 bytes (rounded up)

No. of PTE = Page size / Entry size

$= \frac{2^{12}}{4} = 2^{10}$

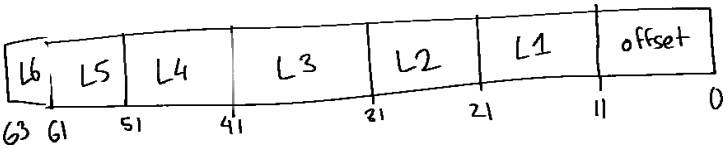
Q3
6 bit virtual address space
16 byte pages/frames
Mapping

VPN	PFN
0	8
1	3
2	11
3	1

Translate virtual to physical (numbers in decimal)
a) 20
b) 40

don’t know how to do this

Q4
a) 6 levels
b)



c)
Maximum number of pages = $2^{44} + 2^{34} + 2^{24} + 2^{14} + 2^{4} + 1$

Q5.
Virtual Address Space: 24 bits
Physical Address Space: 32 bits
Page Size: 4 KB (2^12 bytes) -> 12 bits

VPN = 24 – 12 = 12 bits of virtual address

a) 0000 0000 0011 0000 1010 1111

VPN: 0000 0000 0011 = 0x003 -> 0x032A0 (valid)
Offset: 0000 1010 1111 = 0x0AF

Physical address: 0x032A00AF

b) 0000 0000 0101 0000 0000 0101

VPN: 0000 0000 0101 = 0x005 -> 0x0121A (not valid)
Offset: 0000 0000 0101 = 0x005

Not valid.

c) 0000 0000 0111 0001 1111 0111

VPN: 0000 0000 0111 = 0x007 -> 0x000AB (valid)
Offset: 0001 1111 0111 = 0x1F7

Physical address: 0x000AB1F7