Q1. (a)

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

= $\log_2$ (4 kB)

= $\log_2$ (4 × 1024)

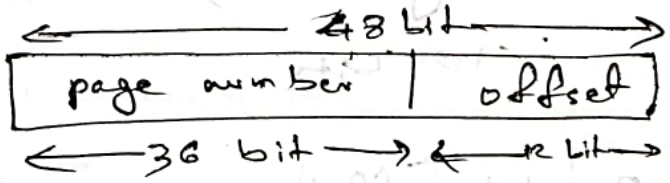
= 12 bits

(b) number of virtual pages = $\frac{\text{Virtual memory size}}{\text{page size}}$

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

$= 2^{36}$ bytes

c)



bits for VPN = 48 − 12 = 36 bit

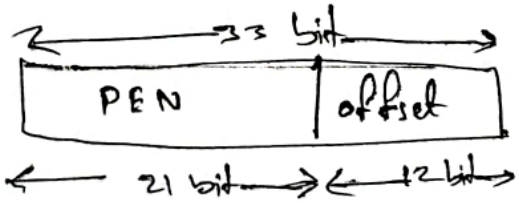
d) Physical address = $\log_2$ (Physical memory size)

= $\log_2$ (8 GB)

= $\log_2$ ($2^3 \times 2^{30}$)

= 33 bits

Number of bits for PFN : 32 − 12 = 21 bits



e) Size of single page table = No of PTEs × PTE size

= No of virtual pages × 4 bytes

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

= $2^{38} \times 2^{30}$ bytes

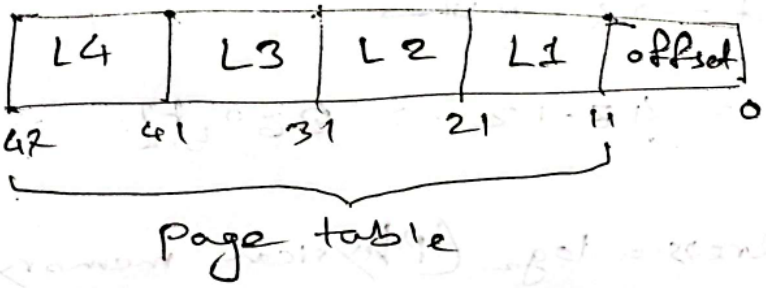
= 256 GB

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



2. Memory required for = 1024 x Memory per process

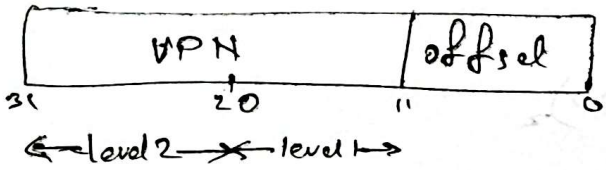
= 1024 x 4 MB = 4 GB

Memory per process = 4 MB

No of pages = $\frac{\text{Virtual Address}}{\text{Page size}}$

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

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



L2 = entries x entry size

= 2^{10} x 4 bytes

= 4 kB

L1 = 2^{10} x 4 kB

= 4 MB

Memory per process = L1 + L2

≈ 4 MB

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

= 33 bit

Bits for ~~PFN~~ PFN = 33 − 12

= 21 bits

PTE size = 21 + 10 = 31 bits

⇒ 4 bytes (rounded up)

No. of PTE = $\frac{\text{Page size}}{\text{Entry size}}$

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

3. (a) given

Virtual Page Number	Physical Frame
0	8
1	3
2	11
3	1

So,

Virtual address = $(20)_{10}$

$= (010100)_2$

VPN : $(01)_2$ offset : $(0100)_2$

$= (1)_{10}$ $= (4)_{10}$

∴ Physical address : PFN × Page space + offset

$= 3 \times 16 + 4 = 52$ (Ans)

(b) V.A. = $(40)_{10}$ = $(101000)_2$

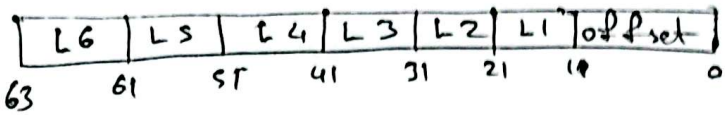
VPN : $(10)_2$ = $(2)_{10}$

offset = $(1000)_2$ = $(8)_{10}$

Physical Address : $11 \times 16 + 8 = 184$ (Ans)

4. (a) 6 levels

(b)



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

5. 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 : 0x032A0AF

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