Operating System

11 Virtual Memory = 2^{48} Bytes

$= 2^8 \cdot 2^{40}$ Bytes

$= 256$ TB

$1KB = 2^{10} B$

$1MB = 2^{20} B$

$1GB = 2^{30} B$

$1TB = 2^{40} B$

a) Offset size = $\log_2$ (page size in Bytes)

$= \log_2 (4KB)$

$= \log_2 (4 \times 1024)$

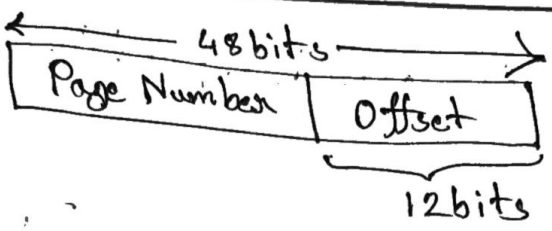
$= 12$ bits

b) No. of virtual pages = $\frac{\text{Virtual Mem. size}}{\text{Page size}}$

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

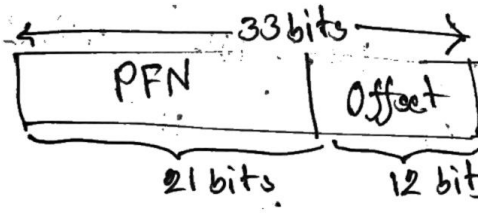
$= 2^{36}$ Bytes

c)



No. of bits for VPN = 48 - 12 = 36 bits

d) Physical address = $\log_2$(Physical Mem. Size)



$= \log_2(8\,GB)$

$= \log_2(8 \times 2^{30}) = 33$ bits

∴ Number of bits for PFN = 33 - 12 = 21

e) Number of PTEs = No. of Virtual Pages

$= \frac{\text{Virtual Memory size}}{\text{Page size}}$

$= \frac{2^{48}}{2^{12}} = 2^{36}$ Bytes

∴ Page table size = No. of PTEs × PTE size

$= 2^{36} \times 4$ bytes

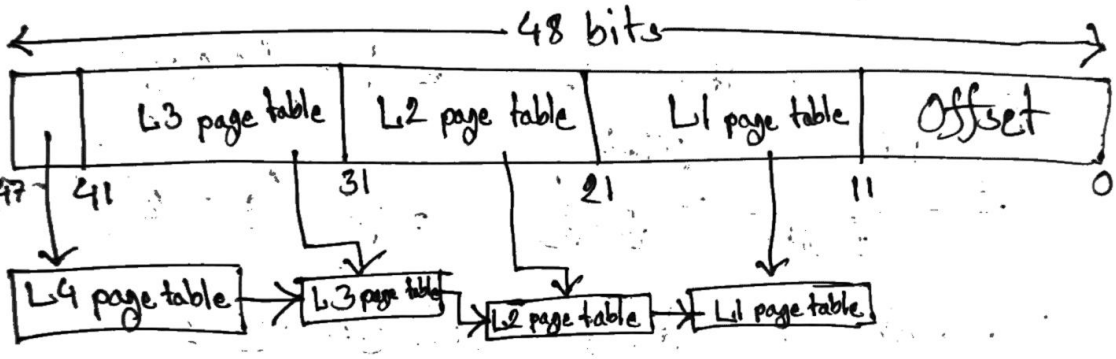
$= 2^{30} \times 2^6 \times 2^2$ bytes

$= 1\,GB \times 256 = 256\,GB$

c) No. of bits for each level page table = $\log_2\left(\frac{\text{Page size}}{\text{PTE size}}\right)$

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

$= 10$ bits



4.c) Using data from ①,

Maximum required pages for L2 page table,

$= \frac{\text{No. of PTEs}}{\text{No. of PTEs in each page}}$

$= \frac{2^{36}}{2^{10}} = 2^{26} = 2^6 \cdot 2^{20}$

No of PTEs in each page $= \frac{2^{12}}{4} = 2^{10}$

Maximum required pages for L2 page table $= \frac{2^{26}}{2^{10}} = 2^{16}$

$= 64K$ pages.

similarly, for L3 $= \frac{2^{16}}{2^{10}} = 2^6$ pages

" L4 $= \left\lceil \frac{2^6}{2^{10}} \right\rceil = 1$

∴ Total pages required $= 2^{26} + 2^{16} + 2^6 + 1$

$= 2^{48} + 1$

Minimum page requirement for the multi level page tables = Number of levels = 4