Q-1

Given,

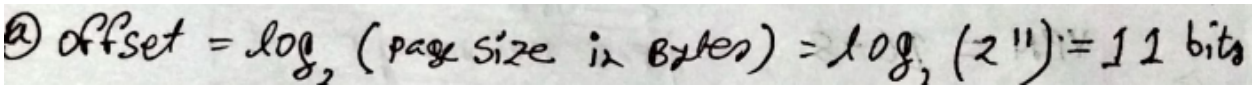
Virtual address = 256 MB = 2^28 bytes

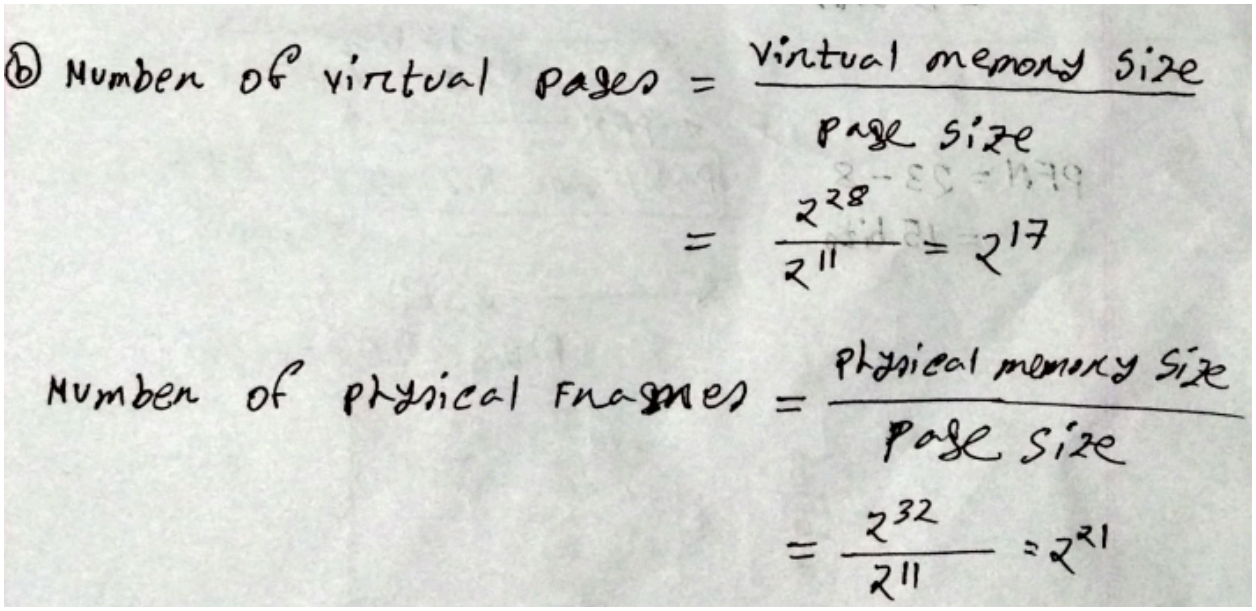
Page Size = 2 KB = 2^11 bytes

Physical RAM = 4 GB = 2^32 ⇒ Physical Address = 32 bits

Flash Size = 7 bits

Maximum processes run = 256





Or,

Physical frame no = Physical Address - Offset = 32 -11 = 21 bits

© Page table size = No. of virtual pages × PTE size

$= 2^{17} \times 4$

$= 2^{19}$ bytes

PTE Size = PFN Size + Flag Size

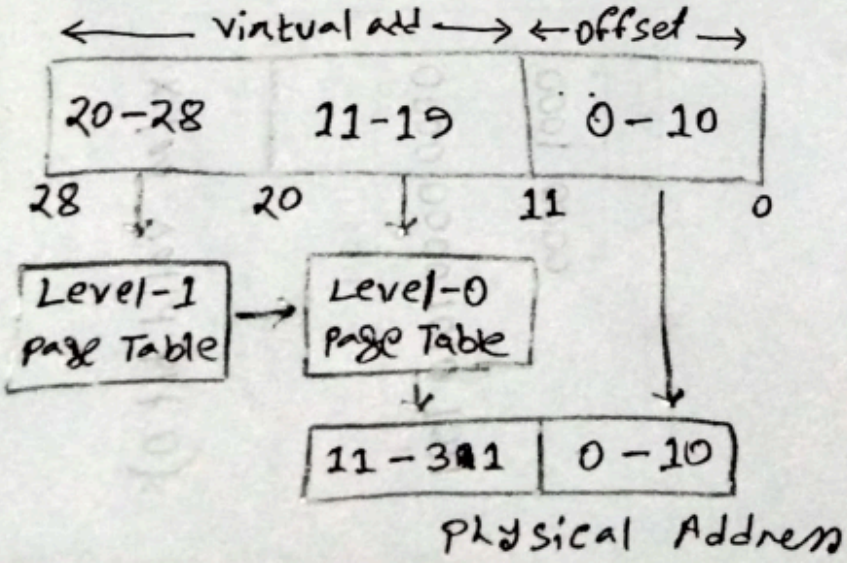
$= 21 + 7$

$= 28$ bits $= \lceil 28/8 \rceil = 4$ bytes

(d) Number of bits required at each level

$= \left\lfloor \log_2 \left(\frac{\text{Page size}}{\text{PTE Size}} \right) \right\rfloor = \left\lfloor \log_2 \left(\frac{2^{11}}{2^2} \right) \right\rfloor = 2^9$

$= 9$ bits



(e) Number of pages required for each level

$$\text{Page table} = \left\lceil \frac{\text{No. of PTEs (Number of virtual Page)}}{\text{No. of PTEs Per Page}} \right\rceil$$

Now,

$$\text{Number of PTEs per page} = \left\lfloor \frac{\text{Page Size}}{\text{PTE Size}} \right\rfloor$$

$$= \left\lfloor \frac{2^{11}}{4} \right\rfloor = 2^9$$

For level-0, space/pages required $= \left\lceil \frac{2^{17}}{2^9} \right\rceil = 2^8$

For level-1, space/pages required $= \left\lceil \frac{2^8}{2^9} \right\rceil = 1$

maximum memory space required to store the pages of All processes $= (2^8 + 1) \times 256$ pages

(f) minimum memory space required to store the page tables of a process = Number of levels x 1 Page

$= 2 \times 1$

$= 2$ pages.

Q-2

- offset = **12 bits**
- Virtual address = 16 bits; ⇒ VPN = 16 − 12 = **4 bits**
- Physical address = 14 bits; ⇒ PFN = 14 − 12 = **2 bits** ⇒ **4 physical frames**
- Page size = **2^12 bytes**

Access	Source (instruction · which add)	Virtual add (bin)	VPN (bin)	VPN (dec)	Hit/Miss	Memory State [Max 4]
1	Inst-1 (only add)	1100 1010 1001 1000	1100	12	Miss	[12]
2	Inst-2 (only add)	0011 1101 1011 1101	0011	3	Miss	[12, 3]
3	Inst-3 (add-1)	1101 0100 1010 0000	1101	13	Miss	[12, 3, 13]
4	Inst-3 (add-2)	1010 0110 0100 0100	1010	10	Miss	[12, 3, 13, 10]
5	Inst-4 (only add)	0001 0100 0101 0111	0001	1	Miss (evict=12)	[3, 13, 10, 1]
6	Inst-5 (add-1)	1100 1111 0101 1110	1100	12	Miss (evict=3)	[13, 10, 1, 12]
7	Inst-5 (add-2)	0111 0100 1101 0101	0111	7	Miss (evict=13)	[10, 1, 12, 7]
8	Inst-6 (only add)	1110 0001 1111 1111	1110	14	Miss (evict=10)	[1, 12, 7, 14]
9	Inst-7 (only add)	0111 0101 0010 0100	0111	7	**Hit**	[1, 12, 14, 7]
10	Inst-8 (only add)	1010 1100 1111 0111	1010	10	Miss (evict=1)	[12, 14, 7, 10]

11	Inst-9 (add-1)	0000 1101 0110 1110	0000	0	Miss (evict=12)	[14, 7, 10, 0]
12	Inst-9 (add-2)	1111 0000 1111 0000	1111	15	Miss (evict=14)	[7, 10, 0, 15]
13	Inst-10 (add-1)	1111 1111 1111 1111	1111	15	**Hit**	[7, 10, 0, 15]
14	Inst-10 (add-2)	0101 0101 0101 0101	0101	5	Miss (evict=7)	[10, 0, 15, 5]

Q-4

Process	**Allocation**	**Max**	**Available**	**Need**	**Safe State**
	A B C D	A B C D	A B C D	A B C D	
T0	3 0 1 4	5 1 1 7	0 3 0 1	2 1 0 3	T2
T1	2 2 1 0	3 2 1 1	3 4 2 2	1 0 0 1	T1
T2	3 1 2 1	3 3 2 1	5 6 3 2	0 2 0 0	T3
T3	0 5 1 0	4 6 1 2	5 11 4 2	4 1 0 2	
T4	4 2 1 2	6 3 2 5		2 1 1 3	

T4 is not in safe state
Maximum number of additional available resources required = **{0, 0, 0, 1}**