$VAS = 4\ MB$
$= 2^{22}\ B$

$\underline{\underline{\text{Page size}}} = \underline{4\ KB} = 2^{12}\ B$, $PTE = ?$ if $\underline{PT}$ has to fit in $\underline{\underline{\text{one page exactly}}}$

$$VA = \underbrace{\boxed{\overset{\text{entries in PT}}{10} \;\Big|\; 12}}_{22 \text{ bits}}$$

$\underline{\underline{PTS}} = \text{entries} * PTE$

$2^{12} B = 2^{10} * PTE$

$PTE = 2^2 B = 4\ B$

VAS = 4 GB , Page size = 128 KB   PTE = ? if PT has to fit in one page exactly?

$= 2^{32}$ B $= 2^{17}$ B

$$VA = \underbrace{\boxed{\;15\;} \boxed{\;\overset{\text{p off}}{17}\;}}_{32}$$

$$PTS = \underbrace{\text{Entries}} * PTE$$

$$2^{17} = 2^{15} * PTE$$

$$PTE = 2^{2} = 4\text{ B}.$$

VAS = 128 TB   PS = 32 MB   PTE = ?

$= 2^{47}$ B $= 2^{25}$ B.

$2^{22} \rightarrow$ entries

$$VA \quad \underbrace{\boxed{\;22\;} \boxed{\;25\;}}_{47}$$

PS = PTS = entries * PTE

2^{25} B = 2^{22} * PTE

$\Rightarrow$ PTE = 2^3 = 8 B.

VAS = 256 MB , PTE = 4 B , Pages size = ? so that Page table fits in one page exactly.

$= 2^{28}$ B

$$VA = \underbrace{\overset{\text{no of pages}}{\boxed{\;y\;}}\;\overset{\text{Page offset}}{\boxed{\;x\;}}}_{28}$$

2^x is Page size

$$x + y = 28$$

PTS = PS = entries × PTE

$$2^x = 2^y * 2^2 \Rightarrow x - y = 2$$

~~Kb~~

KB

$x = 15$,

$\Rightarrow$ Page size = 32 KB. ✓

$VAS = 512\,KB$, $PTE = 2B$, $PS = ?$

$= 2^{19}\,B$

$$VA = \underbrace{\boxed{\overset{P\,no}{x} \;\Big|\; \overset{P\,off}{y}}}_{19}$$

$$x + y = 19$$

$$PTS = 2^{x} \times 2 = 2^{y}$$

$$y - x = 1$$

$$2y = 20$$

$$y = 10 \Rightarrow PS = 2^{10} = \underline{\underline{1KB}}.$$

$VAS = 16\,GB$, $PTE = 4B$, $PS = ?$

$= 2^{34}\,B$

$$VA = \underbrace{\boxed{\overset{PNO}{x} \;\Big|\; \overset{P\,off}{y}}}_{34}$$

$$x + y = 34$$

$$2^y = 2^x * 2^2$$

$$\Rightarrow y - x = 2$$

$$2y = 36$$

$$y = 18$$

$$\Rightarrow 2^{18} = 256\,KB.$$

Gate 01) Consider a m/c with 64 MB physical memory and 32-bit virtual add. If page size = 4 KB, what is approximate size of PT?

a) 16 MB b) 8 MB c) 2 MB d) 24 MB.

Page no

VA = | 20 | 12 |

32

frame no

PA = | 14 | 12 |

26

PTS = no of pages * frame no bits

$= 2^{20} * 14 \approx 16 \rightarrow 2B$. ✓

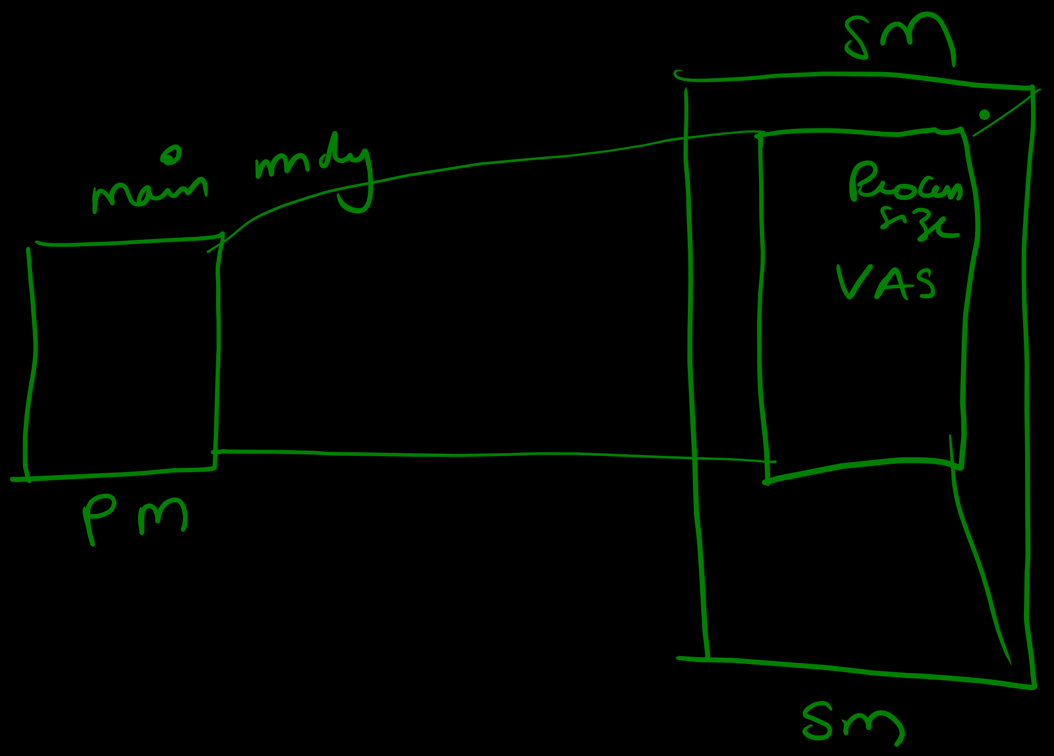
Closest is "C"

Gate 99: which of the following is advantage of virtual memory:

Ans: Programs larger than physical memory size can be run.

Gate 05) In a virtual memory system, the address space ~~Asp~~ specified by the address lines of CPU must be more than the physical memory size and less than the secondary memory size.

$PM < VM < SM$



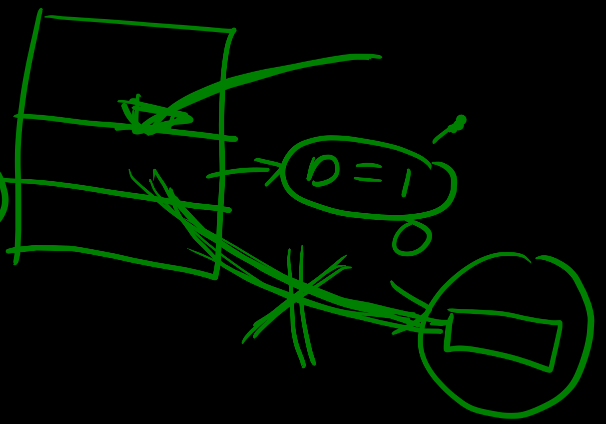
Gate: Dirty bit for a page in page table

a) Helps avoid unnecessary writes on paging device

b) Helps maintain LRU info → Reference bit

c) Allows only read on a page → Protection bit

d) None



Gate

A Computer supports 32 bit virtual address as well as 32 bit PA. Since the VAS is of same size as PAS, the OS designers decided to get rid of ~~entri~~ vm entirely. which of the following is true?

~~a)~~ ans) multi user cannot be supported.

Process size = memory size

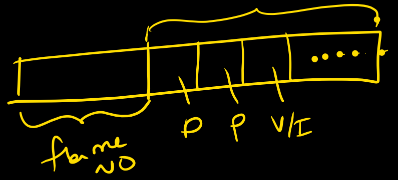
So only ~~only~~ one process can be in memory.

Gate 02

VA = 32, PA = 32, Byte addressable. Page size = 4 KB.

Two level Paging. PTE = 4 B

How many bits are available for storing protection and other information in each PTE.



VA | 10 | 10 | 12

$\underbrace{10 \mid 10}_{\text{2 levels of paging.}}$

VA = $\underbrace{\boxed{}}_{32}$

PA = $\underbrace{20 \mid 12}_{32}$

fNO = 20 bits

PTE = 4 B = 32 bits.

$\therefore$ extra bits = 32 − 20 = 12.

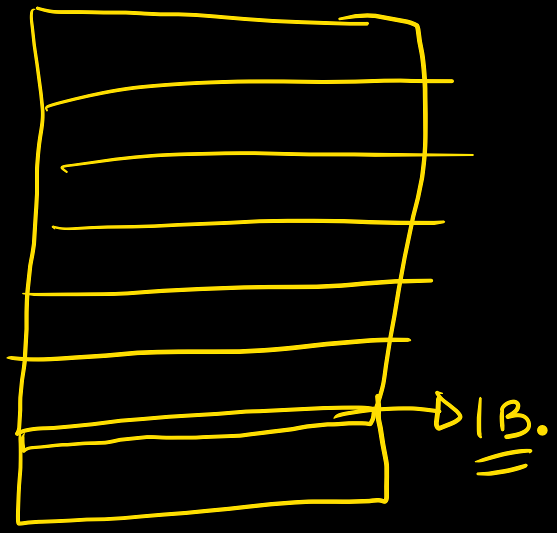
Gate 08)

1) Dirty
2) R/W
3) Reference
4) valid

a) Page initialization
b) write-back policy
c) Page protection
d) Page replacement policy.

~~matt~~ match the above

How to find optimal page size:



$\frac{0B \text{ \& } 1 \text{ page}}{2}$

$\frac{0+1}{2}$ $\cancel{X}$ $\left(\frac{p}{2}\right)$ wasted on average.

Page = 1KB
Process = 10 KB.
Pages = 10.
0 page wasted

Page = 1KB
Process: 10KB+1B
Pages = 11.
1 page almost wasted.

$\therefore \frac{0+1}{2} p$

$\boxed{\left(\frac{p}{2}\right)}$.

Paging $\frac{P}{2}$ is wasted on average.

Page table is also overhead.

VAS = Process size = S bytes, Page size = P B.

Then $PTS = \frac{S}{P} * e \rightarrow$ PTE.

$\therefore$ Total over head = $\frac{P}{2} + \frac{S}{P} * e$.

minimise it.

$$\frac{d(OH)}{dP} = 0 \Rightarrow P = \sqrt{2 S e}$$

$S \rightarrow$ VAS, $e \rightarrow$ PTE

$\rightarrow$ VAS = 4 KB $\quad$ PTE = 8 B $\quad$ $p = ?$

Page size.

$$P = \sqrt{2Se}$$

$$= \sqrt{2 \times 2^{12} \times 2^{3}} = \sqrt{2^{16}}$$

$$= 2^{8}$$

$$= 256 \text{ B.}$$

If VAS = 16 MB , PTE = 2 B   PS = ?

$$P = \sqrt{2Se}$$

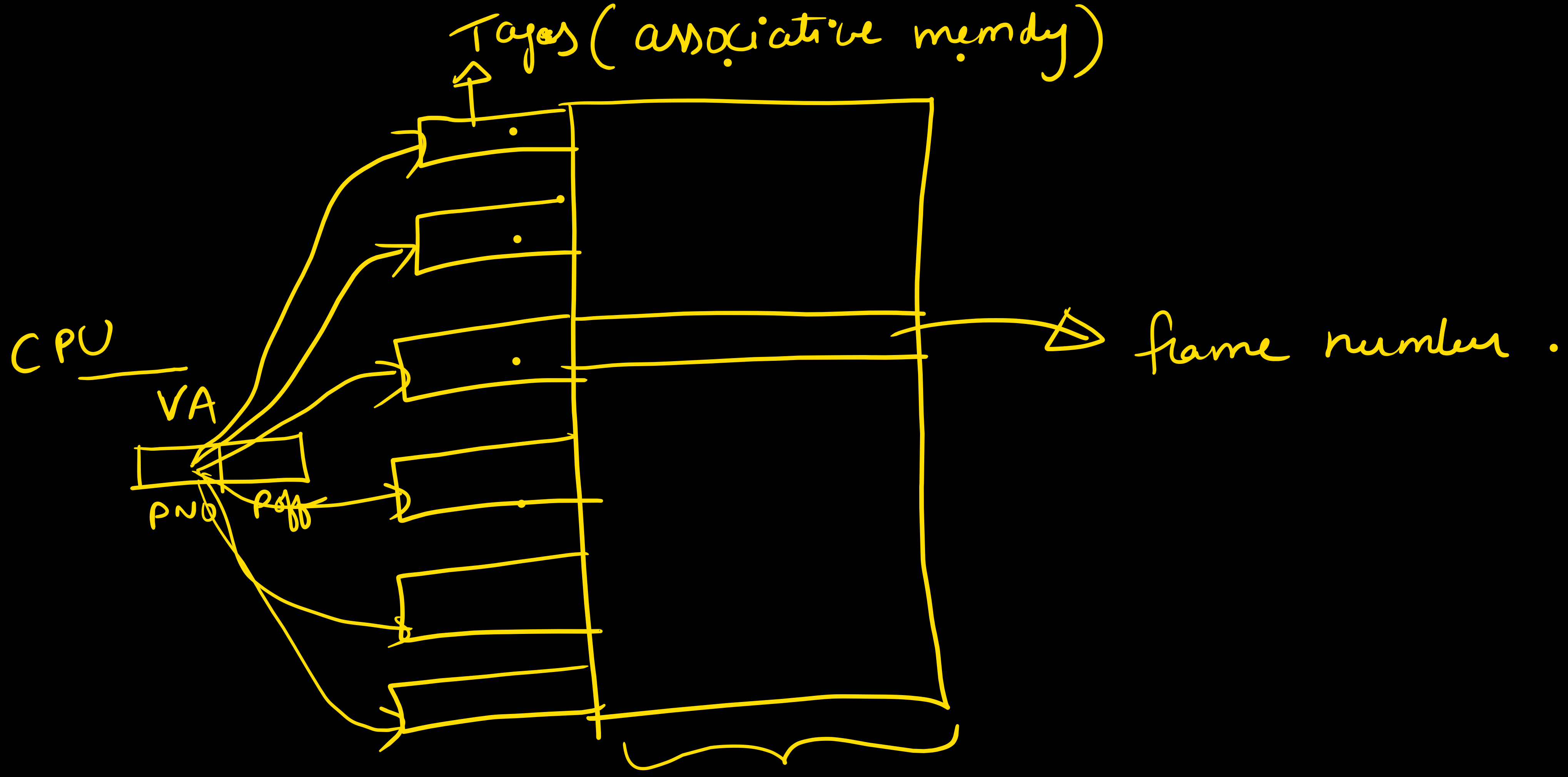
$$= \sqrt{2 * 2^{24} * 2} = 2^{13}$$

$$= 8 \text{ KB.}$$

TLB: Translation lookaside buffer.

↳ special cache
which is faster than main memory and
cheaper than Registers.

we will store frequently used Page table entries
in the TLB.



frequently used PTEs
will be in TLB.

main memory access time = 100 nS

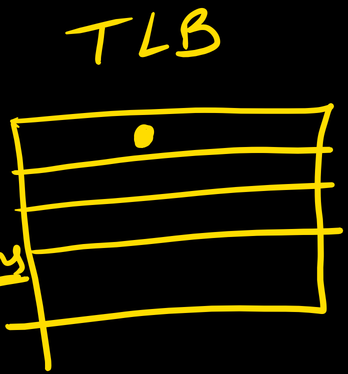
TLB access time = 20nS.

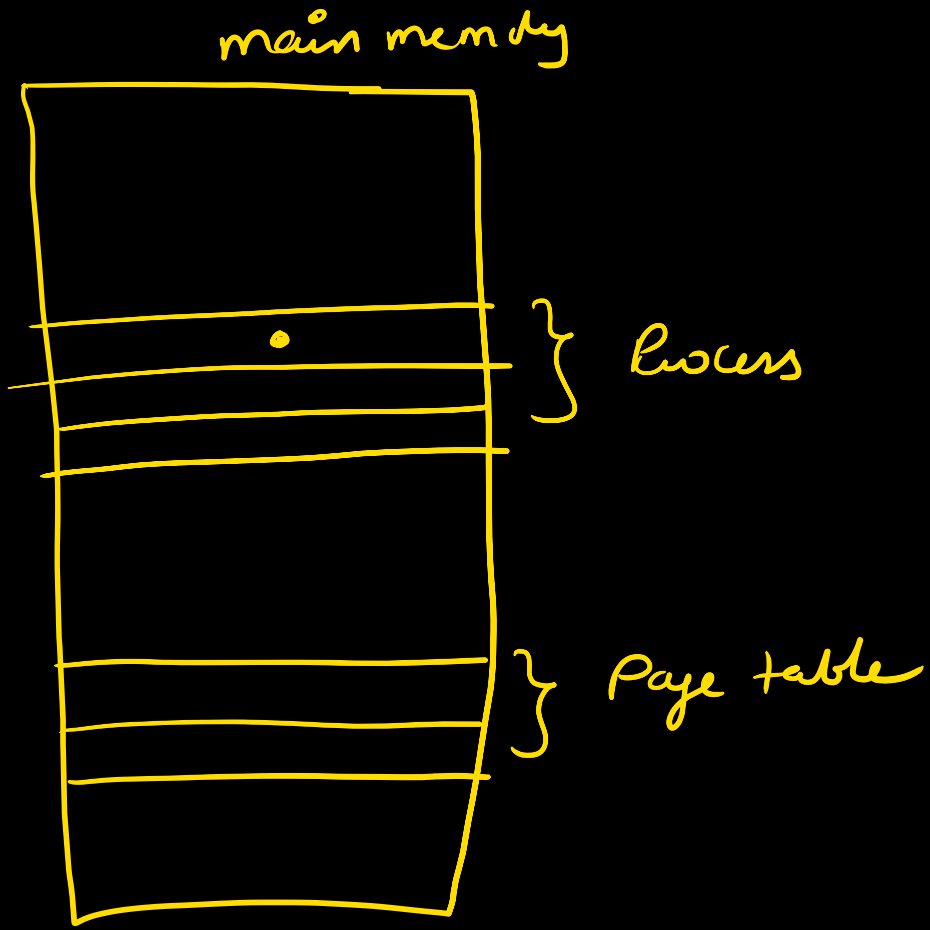
TLB hit

$$= \underbrace{20ns}_{TLB} + \underbrace{100ns}_{Process}.$$

TLB miss

$$= \underbrace{20nS}_{\text{search in TLB}} + \underbrace{100ns}_{PT} + \underbrace{100ns}_{Process}$$





Effective access time

$$= \underbrace{p}_{\text{TLB hit rate}}(\underbrace{t}_{\text{TLB search}} + \underbrace{m}_{\text{accessing word in process}}) + \underbrace{(1-p)}_{\text{TLB miss rate}}(\underbrace{t}_{\text{TLB search}} + \underbrace{m}_{\text{access Page table}} + \underbrace{m}_{\text{access the process.}})$$

'l' levels of paging.

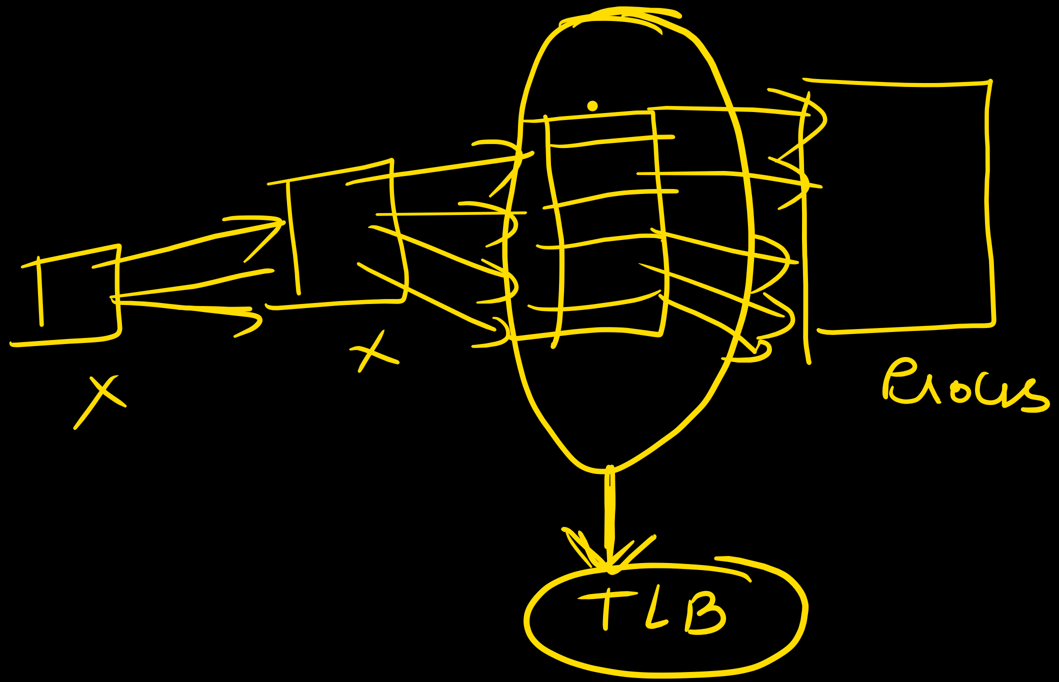
$$= p\,(t+m) + (1-p)\,(t + \underbrace{l \times m}_{l \text{ level of paging.}} + m)$$

Gate 08) A paging scheme uses TLB. A TLB access takes 10 ns and main memory access takes 50 ns. What is effective access time (in ns) if TLB hit ratio is 90% and there is no page fault.

a) 54 b) 60 c) 65 d) 75

$$\underline{\underline{0.9}}\,(10 + 50) + 0.1\,(10 + 50 + 50)$$

$$= 65$$



x
x
Blocks
TLB

TLB access time = 20 ns   mm acc time = 100 ns   LPB Hit = 80%

PT levels = 1   EMAT = ?

$$(0.8)(20 + 100) + (0.2)(20 + 100 + 100)$$

$$= 140 \text{ ns}.$$

TLB access = 20 ns   MM acc = 100 ns   TLB H = 80%   PT levels = ~~2~~ 3

EMAT = ?

$$0.8 \times 120 + 0.2 \times \cancel{320}\ 420$$

$$= \cancel{160}\ 180 \text{ ns}$$

TLB Acc = 20 nS, mm acc = 100 nS PT = 1 EMAT = 130 ns, then

TLB H = ?

$$130 = x(120) + (1-x)(220)$$

$$\Rightarrow x = \underline{\underline{90\%}}.$$

Summary on TLB : TLB access $= t$, main memory AT $= m$

TLB miss rate $= p$

$$EMAT = \underbrace{p}_{\text{miss}}\,(t + \underbrace{m}_{\text{1 level}} + m) + \underbrace{(1-p)}_{\text{hit}}\,(t + m)$$

$$= \cancel{pt} + \cancel{2}mp + t + m - \cancel{pt} - \cancel{pm}$$

$$y = c + mx$$

$$EMAT = \underbrace{m + t} + \underbrace{pm}$$