

Ans) Q/S Hardwore Interacion

→ Hardwore (HW) : performs the real - line translation

using the PTBR . set by the OS.

→ TLB : A fast cache for recent translations , crucial for speed.

→ Protection : Achieved via Valid / Invalid bits and protection bits within the page Table Entries.

Ans) Calculations (16bit VA, 1MB Page)

→ a) Number of Virtual Pages :

$$\text{Pages} = \frac{2^{16} \text{ bytes}}{2^{10} \text{ bytes}} = 2^6 = 64$$

→ b) Page Table size (2-byte entry) :

$$\text{Size} = 64 \text{ entries} \times 2 \text{ bytes/entry} = 128 \text{ bytes.}$$

Ans) Memory Allocation

a) & b) Step- by Step Allocation and unused memory

1 first-fit Allocation (FF)

Step	Process	Size (KB)	Allocation Action	Free Memory Allocation Notes
1	P1	212	Allocated P1 from 1000 KB	788
2	P2	417	Allocated P2 from 788KB	371
3	P3	112	Allocated P3 from 371KB	259
4	P4	426	Cannot Allocate 426 > 259	259

Total Allocated :
b) Total Unused :
Total Allocated :
Best-fit Allocation
Step

1

2

Operating System
Assignment 2

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Ans1} Address Translation (Paging)

- Mechanism: Converts logical address $\langle p, d \rangle$ (CPU output) to physical address $\langle f, d \rangle$ (RAM location) using the page table.
- purpose: Memory protection and enabling non-contiguous allocation.

Ans2} Fragmentation

- Internal: Wasted space within an allocated block (e.g. unused space in the last page)
- External: Free space is scattered in small non-contiguous chunks.
- Mitigation
 - . Paging: Eliminates external, minimizes internal.
 - . Buddy system: Merges adjacent free blocks to reduce external fragmentation.

Ans3} Paging Model Trade-offs

- Model: Hierarchical paging to manage large address spaces.
- Overhead: High / requires multiple page tables per processes
- Speed: Slower but mitigated by the TLB
- fragmentation: Low External; Low Internal

Optimal

6

Best performance, as it removes the page needed furthest in the future.

LRU

7

Performs better than FIFO in general, but equal here.
Does not suffer from Belady's Anomaly.

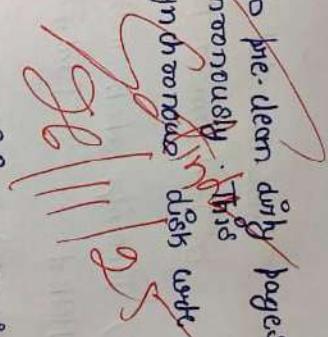
Ans 8) Demand Paging Overhead

a) Additional Time Overhead

- Duty Pages = $1000 \times 30\% = 300$ pages
- Overhead = $300 \times 10\text{ms/Page} = 3,000$ milliseconds.

b) Optimization Technique

→ Prepaging: use a background process to pre-load duty pages by writing them to disk asynchronously. This eliminates the mandatory 10 ms synchronous disk write delay during a page fault.



Ans 9) Autonomous Vehicle Cache Study

a) Working Set Page Replacement

→ Working Set Model: used to determine the minimum required

→ working set for each task.

pages for each task.

→ Guaranteed: full working set size to prevent thrashing and ensure low latency. less critical pages are prioritized for replacement when system memory is tight.

b) Memory Allocation Strategy

→ Strategy: fixed Allocation with Global Page Replacement (or
Priority-Based Allocation).

translates. Total Allocated: $212 + 417 + 112 = 741 \text{ KB}$

or
or b) Total unused Memory (FF) : 359 KB

Step	Process	Size (KB)	Allocate Action	Free Memory Used	in
1	P1	212	P1 from 1000 KB	188) In most
2	P2	417	P2 from 788 KB	371	, monitor
3	P3	112	P3 from 371 KB	259	and p.
4	P4	426	Cannot Allocate	259	ensuring

Total Allocated = 741 KB

b) Total unused Memory: 359 KB

idle
whole

c) Identify which method gives the best utilization and explain why.
Method

JS9

first-fit	41	JS9	min
best-fit	41	259	do
worst-fit	741	259	rand
			self

All three methods provide the same utilization

Ans 7) Page Replacement Simulation & Analysis

Algorithm Page fault (3 frames)

Comment

Susceptible to Belady's Anomaly

fifo

In essential because
it's essential as provides complex handle
conditions.

Effectively on
monitoring pro
moting pro
cesses,

.) In most

and p.

ensuring