A) How is paging efficiently used in main memory to increase throughput? Justify with necessary examples.
   - 1. Due to paging theres no external fragmentation which ensures process to be allocated even if no continues space available
   - 2. By using virtual memory, big processes can be replaced from main memory in order to create space for new process and allocate that and execute that rather than waiting for all process to completely leave the memory.

B) How cache memory can be used to design an efficient paging hardware. Your answer should have the required diagram with the necessary justification.

- Associative cache or TLB is a cache memory for storing page map to physical memory close to the cpu for faster access and increase effective access time.
- Cpu generates a virtual address including page num and offset which search in TLB the frame num of page - if found then one less memory check.

C) Arrays are stored in contiguous memory locations to optimize access to array elements, yet allocating processes in contiguous memory locations is discouraged. Explain why this is not recommended in terms of space complexity.
- In contiguous allocation, there remains holes after allocation in a partition. Even in variable sized partitioning, there are partitions remain where no process can fit. Hence if multiple array of different size stored in contiguous allocation then there will be lots of holes resulting external fragmentation which leads to no more process be able to alocate even if theres space.

D) How can the user's view of memory be mapped into the main memory?
- Memory management unit (MMU) takes the logical address in the limit register and has the base address for the process and maps a logical address of a process to main memories physical address.

- The mmu uses page table to fetch frame number and then calculates base address.
- After that it adds the offset and maps it.

E) What are the differences between static and dynamic techniques for partitioning main memory?
Static: fixed sized partitioning

1. Memory divided into fixed size partitions
2. Holes created are big and cant be used by another process
3. Pre determinded partitioning can only be used
4. Huge external fragmentation
5. Memory waste

Dynamic partitioning: variable sized partitioning

1. Flexible sizes partitions based on process size
2. In partioned segments further partitions createx
3. Holes created and in there more process can be allocated
4. Still external and internal fragmentation exists
5. Less mem wastage

F) Difference between :

- contiguous allocation
- 1. Process allocated continuesly
- 2. External and internal fragmentation
- 3. Has fixed and variablr sized partitioning
- 4. Creates holes after allocation
- non contiguous allocation
- 1. Memory divided in frames of same size as page. Process is divided into page
- 2. Page is mapped to frame and its not continues meaning a process can be mapped to different frames of the memory
- 3. Internal fragmentation- as if last page has less data
- 4. Uses virtual memory for allocating large process by replacing idle frames in the vm.
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G) Discuss the purpose of MMU.
Mapping logical address to physical address

1. Cpu generates a virtual address
2. Mmu takes page number
3. Checks page table
4. If invalid - raises a page fault
5. Os checks to virtual memory and brings page in memory
6. Mmu take page frame num
7. Calculate bade address
8. Add limit reg
9. Then maps logical address to physical

it also ensures security by base + limit checking

H) Explain how Banker's algorithm can help to find the processes that are causing a deadlock in a system.

- Helps avoid deadlock- if a process will create deadlock it checks it and then doesnt or does allocate it.
- Bankers algorithm allocates some.process and based on resources it checks if deadlock exists or theres a safe state or not.
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I) Describe some strategies for deadlock prevention that can break the hold-and-wait condition.

- Protocol 1: P will request before execution and its req will be granted if all requested are available. (Wait remove)
- Protocol 2: p can request any resource if p doesnt already have any other request. (Hold removal)

J) Explain the disadvantage of using Contiguous allocation and how Paging is more beneficial than Contiguous allocation.

- Disadvantages:
- 1. External fragmentation
- 2. Mem wastage
- 3. Large process cant execute
- 4. Less throughput

Paging:

- 1. No external fragmentation
- 2. Large size process can be allocated using vm
- 3. Efficient allocation
- 4. More throughput
- 5. Better memory utilization
- 6. Internal fragmentation reduced.

K) Explain how the operating system's behavior and hardware mechanism for logical to physical address translation ensure that one process cannot access the memory allocated for another process.

- Cpu checks when a virtual Address for a p is generated using base snd limit registers if it falls within the phy mem range allocated for that process. if not then doesnt give access.
- Mmu ensures that a process can access only its mapped phy address as mmu calculates the phy address.

L) Explain in which term Paging is more beneficial than Contiguous allocation. Illustrate page fault steps and describe briefly.
Term: memory utilization and management.
Page fsult:

1. When page table has page info as invalid it occues
2. Os then brings from vm to m
3. Updstes table and page fault removed

M) List disadvantage of Static and Dynamic memory allocation.

N) Define demand paging
Bringing proceds to memory on demand (virtual memory)