Question 1. *(10 points) Describe the difference between internal and external fragmentation. What effect does each of the following memory management schemes have on each type of fragmentation: (i) segmentation, and (ii) paging?*

Question 2. *(10 points) Explain why systems using paging choose a page size that is a power of 2 (e.g., $2^8 = 256$ bytes, $2^9 = 512$ bytes, etc). Could a system use a page size that is not a power of 2?*

Question 3. *(10 points) Consider a byte-addressable system with a page size of 32 bytes and a total physical memory size of 512 bytes.*

1. *How many bits are needed for a virtual address (such that a process can use all physical memory)? Of these, how many bits are needed for the page number (p) and how many for the offset (d)?*

2. *Assuming the (partial) page table shown below, translate virtual address "124" to a physical address (i.e., the kth byte of physical memory). Show your calculations.*

Page	Frame
0	5
1	12
2	9
3	7
4	15
...	...

Question 4. *(10 points) In a paged memory system, explain the difference between the valid bits in the translation look-aside buffer (TLB) and the valid bits in a page table.*

Question 5. *(10 points) Describe the problem that a multi-level page table attempts to solve and summarize how it does so.*

Question 6. *(10 points) Suppose that we modified the second chance algorithm for page replacement to use two reference bits instead of one (i.e., the "reference bit" is now a two-bit value). How would you modify the algorithm to take advantage of this? Give both a pro and a con of your modified algorithm versus the standard single reference bit approach.*

Question 7. *(10 points) Explain why continuously increasing the number of active processes on a machine will eventually result in the CPU utilization of the machine dropping to near zero.*