Algorithms and Data Structures

a) (20%) How is an Array different from Linked List? List at least three key differences and explain.

b) (50%) Write in pseudo-code an algorithm that will do the following: given an array of integers, return indices of the two numbers such that they add up to a specific target. You may assume that each input would have exactly one solution, and you may not use the same element twice.

Example:

Given nums = [2, 7, 11, 15], target = 9,
Because nums[0] + nums[1] = 2 + 7 = 9,
return [0, 1].

c) (30%) Report and explain the time complexity of your algorithm in big O notation.
Operating Systems

a) (30%) A simplified view of thread states is **Ready**, **Running**, and **Blocked**, where a thread is either ready and waiting to be scheduled, is running on the processor, or is blocked (i.e. is waiting for I/O.) This is illustrated in the figure bellow. Assuming a thread is in the Running state, answer the following questions: (Be sure to include an explanation of your answer.)

![Thread States Diagram]

Will the thread change state if it incurs a page fault? If so, to what new state? Will the thread change state if it generates a TLB miss that is resolved in the page table? If so, to what new state?

b) (35%) Consider a paging system with the page table stored in memory.

If a memory reference takes 200 nanoseconds, how long does a paged memory reference take?

If we add a TLB, and 75 percent of all page-table references are found in it, what is the effective memory reference time? (Assume that finding a page-table entry in the TLB takes zero time if the entry is there.)

c) (35%) Assume a program has just referenced an address in virtual memory. Describe a scenario how each of the following can occur: (If a scenario cannot occur, explain why.)

- TLB miss with no page fault
- TLB miss and page fault
- TLB hit and no page fault
- TLB hit and page fault