This is a closed book (and notes) examination. Answer all questions on the exam itself. Take the number of points assigned to each problem and the amount of space provided for your answer as a measure of the length and difficulty of the expected solution. The exam totals 100 points.
1. (6 points) During execution of a program, it is possible that a “protection violation” (called a segmentation fault in Unix) occurs when the MMU maps the virtual address to its physical address in memory. What is this and why does it occur?

2. (12 points) The address space of a process consists of space for code, data, a heap and a stack. In the space below indicate for each of these:

(a) code
(b) data
(c) heap
(d) stack
3. (12 points) In the initial portion of Project 4 you implemented a server where you handle each request before reading the next. In the project you go on to build a multi-threaded server where a thread is created to handle each request. A third approach that could be used is to fork a new process to handle each request. In space below, indicate an advantage and a disadvantage of each the three approaches.

(a) Single process, no threads

(b) Single process, multi-threaded

(c) Multiple processes

4. (12 points) The boundary tag (linked list) policy can be used to manage a chunk of memory.

(a) What does this policy do when it receives a request to allocate memory?

(b) What does this policy do when it receives a request to return previously allocated memory?

(c) What is an advantage of using this approach relative to other approaches that could be used?

(d) What is a disadvantage of using this approach relative to other approaches that could be used?
5. (10 points) A device driver is typically organized into a lower and upper half with a shared buffer in between. What is contained in the shared buffer for the input portion of a terminal device driver to read a character from a keyboard? Sketch the code (at the level of detail given in class) for each of the upper and lower portions of the terminal input device driver.

6. (14 points) A present, modified (dirty) and referenced bit are associated with each page in the page table for a process. When are each of these bits set and cleared? How are each of these bits used in paging?

   (a) Present Bit

   (b) Modified (Dirty) Bit

   (c) Reference Bit
7. (10 points) What are the three time factors involved in positioning the disk head and reading/writing a disk block? What approaches are used to reduce (if possible) each of these factors for given a set of disk requests.

8. (14 points) Consider a page reference string for a process with three frames available to it. Assume that demand paging is used (no pages are preloaded). Show which page references cause a page fault for each of the following page replacement policies. For each page fault either indicate it is a cold-start page fault or indicate which page is replaced.

   (a) 0 1 3 1 2 0 1 1 0 1  Policy: First In, First Out

   (b) 0 1 3 1 2 0 1 1 0 1  Policy: Least Recently Used

   (c) 0 1 3 1 2 0 1 1 0 1  Policy: Belady’s Algorithm (Min)

   (d) If the number of frames available is increased, could the use of any of these policies actually cause more page faults to occur (for this or other reference strings)?
9. (10 points) It may be possible to identify sets of pages within a process that are needed together. For example, all pages that contain local variables for a procedure. Assume that it is possible to identify these sets of pages prior to execution and that these page sets are available to the operating system. Describe how to modify the operating system’s virtual memory manager to account for these page sets. Your modifications should attempt to keep all or none of the pages within a set in memory. Assume that the clock page replacement policy is being used.