

Laboratory Exercise 5

cpe 453 Winter 2026

Due by 11:59:59pm, Monday, March 9th.

The Written Exercises (problems) are to be done individually.

Problems

1. (T&W 4-1) A computer system has enough room to hold four programs in its main memory. These programs are idle waiting for I/O half the time. Assuming that all I/O operations are distributed randomly with even probability—that is, any given process is blocked waiting for I/O with probability 1/2 at any given time in its execution—what proportion of the time will you expect the CPU to be idle?
2. (T&W 4-4) Using the page table of Fig. 4-8 in T&W, give the physical address corresponding to each of the following virtual addresses:
 - (a) 20
 - (b) 4100
 - (c) 8300
3. (T&W 4-8) A computer with a 32-bit address uses a two-level page table. Virtual addresses are split into a 9-bit top-level page table field, an 11-bit second-level page table field, and an offset. How large are the pages and how many are there in the address space?
4. (T&W 4-14) A computer has four page frames. The time of loading, time of last access, and the *R* and *M* bits for each page are as shown below (the times are in clock ticks):

Page	Loaded	Last Ref.	<i>R</i>	<i>M</i>
0	126	279	0	0
1	230	260	1	0
2	120	272	1	1
3	160	280	1	1

- (a) Which page will NRU replace?
 - (b) Which page will FIFO replace?
 - (c) Which page will LRU replace?
 - (d) Which page will second chance replace?
5. (Based on T&W 4-15) If FIFO page replacement is used with four page frames and eight pages, how many page faults will occur with the reference string 0713272013 if the four frames are initially empty. What will be the final contents of memory?
6. Repeat Problem 5 for LRU replacement.

7. (T&W 4-20) It has been observed that the number of instructions executed between page faults is directly proportional to the number of page frames allocated to a program. If the available memory is doubled, the mean interval between page faults is also doubled. Suppose that a normal instruction takes 1 microsecond, but if a page fault occurs, it takes 2001 microseconds (i.e. 2 msec to handle the fault). If a program takes 60 seconds to run, during which time it gets 15,000 page faults, how long would it take to run if twice as much memory were available?
8. (T&W 5-10) The UNIX system has a call to read a directory entry. Since directories are just files, why is it necessary to have a special call? Can users not just read the raw directories themselves?
9. (T&W 5-16) It has been suggested that the first part of each UNIX file be kept in the same disk block as its i-node. What good would this do?
10. (T&W 5-17) The performance of a file system depends on the cache hit rate (fraction of blocks found in the cache) if it takes 1 msec to satisfy a request from the cache, but 40 msec to satisfy a request if a disk read is needed, give a formula for the mean time required to satisfy a request if the hit rate is h . Plot this function for values of h from 0 to 1.0.
11. (T&W 5-20) A disk has 4000 cylinders, each with 8 tracks of 512 blocks¹. A seek takes 1 msec per cylinder moved. If no attempt is made to put the blocks of a file close to each other, two blocks that are logically consecutive (i.e. follow one another in the file) will require an average seek, which takes 5 msec. If, however, the operating system makes an attempt to cluster related blocks, the mean interblock distance can be reduced to 2 cylinders and the seek time reduced to 100 microsec. How long does it take to read a 100 block file in both cases, if the rotational latency is 10 msec and the transfer time is 20 microsec per block?
12. (T&W 5-24) Two computer science students, Carolyn and Elinor, are having a discussion about i-nodes. Carolyn maintains that memories have gotten so large and so cheap that when a file is opened, it is simpler and faster just to fetch a new copy of the i-node into the i-node table, rather than search the entire table to see if it is already there. Elinor disagrees. Who is right and why?

What to turn in

For the Written Problems: individually written solutions to the problems according to the guidelines set forth in the syllabus.

Since paper won't work this quarter, submit via `handin` to the `lab05` subdirectory of the `pn-cs453` account, as a pdf or text file.²

¹These numbers strike me as a little suspect, but that doesn't really change the nature of the problem.

²I only have LibreOffice, and you don't want to see what it'll do to your nicely crafted Word document...