system in a safe state? If p_4 requests one more tape drive right now, does this lead to a safe state or unsafe state? What if the request came from p_3 instead of p_4? Show all work.

6. [5 pt] A computer has six tape drives, with n processes competing for them. Each process may need three drives. For which values of n is the system deadlock free?

7. [5 pt] A certain editor has 100K of program text, 30K of initialized data, and 50K of uninitialized data. The initial stack is 10K. Suppose three copies of this editor are started simultaneously. How much physical memory is needed (a) if shared program text is used, and (b) if it is not?

8. [5 pt] Some swapping systems try to eliminate external fragmentation by compaction. Imagine that a computer with 1MB of user memory compacts once every second. If it takes $\frac{1}{2}$ μsec to copy a byte, and the average hole is 0.4 as large as the average segment, what fraction of the total CPU time is used up on compaction?

9. [5 pt] Consider what must happen when a process is loaded in a system that has no memory relocation hardware. How is the job of the process loader in such a system similar to or different from the job of a linker?

10. [8 pt] A system contains four processes and four resources. There are two instances each of resources R_1 and R_2 and one instance each of resources R_3 and R_4. The two instances of R_1 are currently allocated to processes p_1 and p_3 (one each), R_3 is allocated to p_4 and R_4 is allocated to p_2. Each of p_1, p_2, and p_3 have requested an instance of R_2, p_2 has also requested for an instance of R_3, and p_4 requires an instance of R_4.

    (a) Draw a process resource graph corresponding to the above scenario.

    (b) Which processes are blocked?

    (c) Which processes are deadlocked?

    (d) Is the state a deadlock state?

    (e) Does the graph contain a knot? If so, list the nodes constituting the knot.

CS 376 **Operating Systems** Test 2

Name: Maximum Points: 56

Important: This is a closed book test. You should not have anything except the test sheet on your desk. *Do not log into the computer during the test.* Any calculations and rough work should be done on the back side of the test pages only.

1. [5 pt] It is not uncommon for a computer to have and use both a TSL (Test and Set) instruction and another synchronization primitive, such as semaphores or monitors. These two types play a different role, however, and do not compete with each other. Explain why this is so.

2. [5 pt] Round robin schedulers normally maintain a list of all runnable processes, with each process occurring exactly once in the list. What would happen if a process occurred twice in the list? Explain the reason for allowing this.

3. [5 pt] Five batch jobs are waiting to be run. Their expected run times are 9, 6, 3, 5, and X. In what order should they be run to minimize average turnaround time? Show your calculations. What will the expected turnaround time be? Your answer will depend on X.

4. [5 pt] Imagine that a floppy disk contains two large dictionaries, `dict1` and `dict2`, which together almost fill the disk. To find all the words containing "`qu`" the user types the following shell command:

   ```
   cat dict1 dict2 | grep qu
   ```

   `Unix` implements pipelines with two processes connected by a pipe. MS-DOS implements it as though the user had typed:

   ```
   cat dict1 dict2 > temp
   grep qu < temp
   rm temp
   ```

   In what way might the effect of the pipeline differ between `Unix` and MS-DOS?

5. [8 pt] Consider a system with four processes and ten tape drives. Processes p_1 and p_2 have one tape drive each, p_3 has two tape drives, and p_4 has four tape drives. p_1 has indicated the maximum requirement to be six drives, p_2 and p_3 have indicated the same to be five and four, respectively, and p_4 may require three additional drives at some point in the future. Draw a resource allocation graph for the system. Is the