EXAM ON PROCESSES AND SCHEDULING – SPRING 2003
CSC 262 – OPERATING SYSTEMS
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1. **Vocabulary** (32 points). Identify the term defined in class that matches the following definitions.

a. An executing program, plus its data and resources.

b. An executing program with only the minimum data necessary to sustain its execution (typically status registers and call stack). Code, variables, and resources may be shared with other similar entities.

c. This piece of hardware is responsible for signaling the CPU that an interrupt has been requested.

d. This data structure, maintained by the kernel, maintains vital information on all the current processes in the system.

e. This term refers to the a microprocessor operation that cannot be split into two or more simpler operations, and thus cannot be interrupted.

f. This term refers to a situation where the outcome depends unpredictably upon the order of execution of some set of events.

g. This term refers to a set of code where interleavings must be avoided in order to prevent the situation described in item (f) above.

h. This term refers to a situation in which some set of processes are blocked while waiting for an event that can only occur through execution of the processes in the set.

2. **Scheduling** (16 points). A newly proposed operating system will use multiple queues for process scheduling. It will have three process queues: High, Medium, and Low (maintained via a threaded list). Scheduling between the queues is by strict priority scheduling (with pre-emption). Within queues, round-robin scheduling is used. A hypothetical process table for this system is shown below:

Process ID: 0 **Priority: Medium** **Status: Ready** **Next: 4**	**Process ID: 1** **Priority: Low** **Status: Ready** **Next: 1**	**Process ID: 2** **Priority: Medium** **Status: Ready** **Next: 0**	**Process ID: 3** **Priority: High** **Status: Blocked** **Next: 3**	**Process ID: 4** **Priority: Medium** **Status: Ready** **Next: 2**

a. If the dispatcher must choose a process to run from the process table above, which processes could possibly be chosen in accordance with the policies described above?

b. Draw a Gantt chart showing the processes run for the next 500 ms, under the following assumptions: No process terminates, blocks or becomes unblocked during that time; the execution quantum is 100 ms and the switching time is negligible; Process 4 is chosen to run first.

c. What change in circumstances would result in Process 1 running?

d. What change in circumstances would result in Process 3 running?

3. **Deadlock** (16 points). Draw the resource allocation graph for each of the following situations, and determine which processes (if any) are deadlocked in the following situations. Note that in any given scenario, some, none, or all of the processes may be deadlocked.

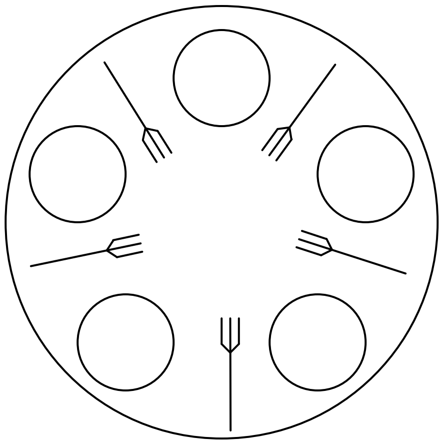
a.	Printer	Plotter	Tape Drive	Disk Buffer
Process A	Has		Has	Has
Process B	Wants	Has	Wants	Wants
Process C		Wants		Wants

b.	Printer	Plotter	Speaker	Microphone	Disk Buffer
Process A	Has		Wants		
Process B	Wants	Has			Wants
Process C				Wants	Has
Process D		Wants	Wants	Has	

4. **Linux Processes** (12 points). Explain how to set and/or modify the priority of a process in Linux, assuming the kernel is using the `SCHED_OTHER` protocol. What limitations are placed on ordinary users (as opposed to root) as far as the ability to set process priorities?

5. **Message Passing** (8 points). A friend is working on a protocol for a branch library's computer system using message passing. The checkout computer in the branch library cannot check out the book without making sure the central library records are updated. The central library computer won't update the records until it is certain the item is being checked out. The cable connecting the branch to the main library has been shorting out lately, and so your friend has been hired to come up with a foolproof mechanism that will make sure both computers act at the same time. She is having some trouble getting a working protocol, and has come to you for advice. What do you suggest to her? Can you help her to write such a protocol?

6. **Semaphores** (16 points). The dining philosophers problem is a classic example in concurrent programming. Five philosophers (represented by processes) sit at a table alternately thinking and eating. To eat, they must pick up the fork to both their left and right, which are shared with the neighboring philosophers on either side. A philosopher attempting to eat will wait (potentially forever) until she has both forks. A philosopher who is done eating will put down both forks and begin thinking. Consider the following solution to the dining philosophers problem, using semaphores:



```
1:     var semaphore fork[5] init 1;
2:     philosopher[i]: process
3:        {think}
4:        if even(i) then  // even(i) tests whether i is not odd
5:           DOWN(fork[i]);
6:           DOWN(fork[(i+1) mod 5]);
7:        else
8:           DOWN(fork[(i+1) mod 5]);
9:           DOWN(fork[i]);
10:       endif;
11:       {eat}
12:       if even(i) then
13:          UP(fork[(i+1) mod 5]);
14:          UP(fork[i]);
15:       else
16:          UP(fork[i]);
17:          UP(fork[(i+1) mod 5]);
18:       endif;
19:    endprocess;
```

a. How would the protocol's behavior change if lines 5 and 6 were exchanged? If there could be a change in behavior, describe a specific scenario where it would be evident.

b. How would the protocol's behavior change if lines 13 and 14 were exchanged? If there could be a change in behavior, describe a specific scenario where it would be evident.

c. Is this protocol deadlock-free? If so, which of the four necessary conditions for deadlock is negated by this algorithm?

d. What are the possible values that fork[i] might take on during the execution of this protocol?