

NIA:

STUDENT NAME:

**I. (20 points)** This problem illustrates the building of the water molecule  $H_2O$ . There are two kinds of threads, Oxygen and Hydrogen. In order to create a water molecule 2 atoms of hydrogen and one atom of oxygen are needed:

- When an oxygen thread arrives and less than two blocked hydrogen threads are present, it blocks until two hydrogen threads are available.
- When an oxygen thread arrives and more than two blocked hydrogen threads are present it wakes them up and they bind into a water molecule.
- When a hydrogen thread arrives and it is the only hydrogen thread or there is no oxygen thread, it blocks.
- When a hydrogen thread arrives and there are another hydrogen thread and one oxygen thread around, it wakes them up and they bind into a water molecule.

Implement a solution to the water molecule problem based on semaphores. You are given all the necessary variables and you are asked to fill only the body of the threads Oxygen and Hydrogen.

**Hint: Think about whale matching problem, which was discussed in class.**

```
semaphore mutex=1; // mutex to insure mutual exclusion when
    accession o_atoms and h_atoms
int o_atoms=0; // number of arrived oxygen threads
int h_atoms=0; // number of arrived hydrogen threads
semaphore o_wait=0; // semaphore for waiting oxygen threads
semaphore h_wait=0; // semaphore for waiting hydrogen threads
```

```
Oxygen() {
```

```
}
```

```
Hydrogen() {
```

```
}
```

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II. (10 points) Suppose N processes with IDs 0, 1, 2, ..., N-1 need to share some critical region of code, which only one at a time is allowed to execute, and where they are required to repeatedly cycle through this section in the natural order 0, 1, 2, ..., N-1. If `turn` is a shared integer variable initialized to zero, and `current_pid` is the ID of the currently executing process, and each executes the following pseudo-code, could a race condition occur? Why or why not? Justify your answer.

```
while( TRUE ){
    while( turn != current_pid ) /* wait */ ;
    critical region();
    turn = (turn + 1) % N;
    noncritical region();
}
```

III. (10 points) Consider a swapping system in which memory consists of the following hole sizes in memory order: 10K, 4K, 20K, 15K, and 9K. Which hole is taken for successive segment requests of: (a) 8K (b) 12K (c) 10K for first fit, best fit, and worst fit.

IV. (20 points) Assume that the data blocks of the files from a file system are stored compactly on a disk partition with size 40 Kbytes. The file block size is 4KBytes. The file system stored currently two files f1 and f2. The file f1 has a total size of 10Kbytes and has his 3 blocks are stored in this order at addresses 12K, 0K and 32K. The file f2 has a total size of 6Kbytes and has his 2 blocks stored in this order at addresses 20K and 4K. You are required to:

a) Draw the blocks of the files f1 and f2 on the following disk layout

|    |    |    |     |     |     |     |     |     |     |
|----|----|----|-----|-----|-----|-----|-----|-----|-----|
| 0K | 4K | 8K | 12K | 16K | 20K | 24K | 28K | 32K | 36K |
|    |    |    |     |     |     |     |     |     |     |

b) Comment on the existing internal and external fragmentation on disk. Identify the disk blocks and disk regions that cause internal/external fragmentation.

c) How is it possible to reduce external fragmentation for the given disk content?

d) How is it possible to reduce internal fragmentation for the given disk content?

V. (10 points) Suppose that a file system contains the following soft links:

```
/software -> /local/software
/software/file.c -> /local/software/file.c
/local/software/bin/wp -> /software/wp/bin/wp
/local/software/xyz -> /software/xyz
```

Assume that all other pathname components correspond to directories or ordinary files that exist, have appropriate permissions, etc. What do (i) `/software/bin/wp` and (ii) `/software/xyz/file.c` refer to? For each, explain the sequence of actions taken by the file system to “resolve” the pathname into a reference to a file.

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**VI. (10 points)** Quiz questions (*NOTE: A correct answer scores 1point, a wrong answer subtracts 0.25 points, an unanswered question scores 0 points*)

|        | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|--------|---|---|---|---|---|---|---|---|---|----|
| Answer |   |   |   |   |   |   |   |   |   |    |

1. Mutual exclusion means:
  - a) When one process executes a piece of code, it “excludes” all the others from executing at the same time.
  - b) When one process executes a piece of code, it “excludes” all the other from executing it at any time in the future
2. What is not true about a test-and-set operation:
  - a) It is an atomic operation
  - b) It swaps two memory locations
  - c) It can be used to insure mutual exclusion.
3. A critical section may help prevent:
  - a) Race condition
  - b) Deadlock
  - c) Mutual exclusion.
4. Busy waiting means:
  - a) Performing some useful computation while waiting for a condition to change.
  - b) Blocking a CPU while waiting for a condition to change.
  - c) Continuously checking if a condition has changed.
5. Which one is **not** an advantage of a dynamic library:
  - a) Reduces memory footprint.
  - b) Facilitates bug fixes.
  - c) Reduces the run times of its routines
  - d) Reduces the utilized disk size.
6. Paging avoids:
  - a) Internal fragmentation.
  - b) External fragmentation.
  - c) Segmentation.
  - d) Swapping.
7. The file open count is useful for:
  - a) Managing the number of files open by a process.
  - b) Managing the number of files open by the OS.
  - c) Counting the number of processes opening the same file .
8. Which of the following file locks allows file modifications:
  - a) Shared lock.
  - b) Exclusive lock.
9. Which structure is **not** possible for a directory hierarchy?
  - a) Acyclic graph.
  - b) Graph with cycles.
  - c) Tree with infinite height.
  - d) Tree with finite height.
10. **Unix semantics** specifies:
  - a) A write to a file becomes visible to other users after the file is closed.
  - b) A write to a file becomes visible to other users after a configurable time.
  - c) A write to a file becomes visible to other users immediately.
  - d) Writes to a file may become visible to users in any order.

**VII. (20 points)** Give definitions of the following concepts in maximum 3 lines:

1. Race condition
2. Priority inversion
3. Shared libraries
4. Internal fragmentation
5. Access rights
6. Hard link