Department of Computer Science	**Operating Systems**
VU University Amsterdam	**22.12.2016**

This exam consists of two pages. No calculator, pencil, or open books allowed. Concise answers!

1 Can you implement an operating system entirely in kernel mode? How about entirely or almost entirely in user mode? If so, give examples for both scenarios. *10pt*

2 To a programmer, a system call looks like any other call to a library procedure. Is it important that a programmer knows which library procedures result in system calls? Under what circumstances and why (*Hint*: think about the implications for reliability, security, performance, etc.)? And when system calls are expected, why not issue them directly rather then using library calls? *10pt*

3 Can you design a scheduling algorithm that guarantees that each of 10 processes gets 10% of CPU time on a given CPU? Can you extend this algorithm to prioritize the 3 most important processes over the others? *10pt*

4 Consider the following solution to the mutual-exclusion problem involving two processes $P0$ and $P1$. Assume that the variable `turn` is initialized to 0. Process $P0$'s code is presented below. For process $P1$, replace 0 by 1 and 1 by 0 in the code below. Determine if the solution meets all the required conditions for a correct mutual-exclusion solution. Examine each condition separately. *10pt*

```
1 /* Other code */
2 while (turn != 0); /* Do nothing and wait. */
3 Critical Section /* . . . */
4 turn = 1;
5 /* Other code */
```

5 In a system with threads, is there one stack per thread or one stack per process when user-level threads are used? What about when kernel-level threads are used? Are any of these stacks re-used by the operating system itself when running in kernel mode on behalf of a particular process/thread (e.g., while handling a system call)? Explain. *10pt*

6 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).

1. Which page will NRU replace?
2. Which page will FIFO replace?
3. Which page will LRU replace?
4. Which page will second chance replace?
5. Which page will the optimal algorithm replace?

10pt

Page	Loaded	Last access	R	M
0	126	280	1	0
1	230	265	1	1
2	140	270	0	0
3	110	285	1	1

7 Two memory-intensive user programs (constantly accessing all the memory pages in their working set), one with a small working set and one with a large working set, are running on a system with software-managed TLB. Speculate on whether switching to hardware-managed TLB will improve performance for each process. Would your answer change if a very large TLB were available? *10pt*

8 For a given class, the student records are stored in a file. The records are randomly accessed and updated. Assume that each students record is of fixed size. Which of the three allocation schemes (contiguous, linked list, and file allocation table) will be most appropriate? What if the records are sequentially accessed instead? *10pt*

9 Explain the difference between memory-mapped I/O and I/O ports. Does each of these mechanisms reduce the amount of physical memory address space available for main memory access? How about the amount of virtual memory address space available? *10pt*

10 What are the differences between deadlocks, livelocks, and starvation? Mention one mechanism to handle each one of them. *10pt*