Department of Computer Science	**Operating Systems**
VU University Amsterdam	**17.12.2015**

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

1 For each of the following system calls, give a condition that causes it to fail: `fork`, `exec`, and `unlink`. *8pt*

2 What is the difference between user mode and kernel mode? Can a full system be designed to run entirely and permanently in user mode or kernel mode? If so, what are the consequences? *8pt*

3 Using a sample execution run, show how the following concurrent program can come to a deadlock with N unconsumed items. *9pt*

```
1  process producer()
2  {
3    while(true)
4    {
5      produce_item();
6      if (count == N)
7        sleep();
8      enter_item();
9      count = count + 1;
10     if (count == 1)
11       wakeup(consumer);
12   }
13 }
```

```
1  process consumer()
2  {
3    while(true)
4    {
5      if (count == 0)
6        sleep();
7      remove_item();
8      count = count - 1;
9      if (count == N-1)
10       wakeup(producer);
11     consume_item();
12   }
13 }
```

4 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? Explain. *8pt*

5 A machine has a 32-bit address space and an 8-KB page. The page table is entirely in hardware, with one 32-bit word per entry. When a process starts, the page table is copied to the hardware from memory, at one word every 100 nsec. If each process runs for 100 msec (including the time to load the page table), what fraction of the CPU time is devoted to loading the page tables? *8pt*

6 What is the difference between a major and a minor page fault? Does sharing code pages across running program instances (i.e., processes) affect the number of major and/or minor page faults? *9pt*

7 Free disk space can be kept track of using a free list or a bitmap. Disk addresses require D bits. For a disk with B blocks, F of which are free, state the condition under which the free list uses less space than the bitmap (assume BLOCK_SIZE $\gg$ D). For D having the value 16 bits, express your answer as a percentage of the disk space that must be free. *8pt*

8 Describe the disk accesses needed in the worst case to read a byte from a file in UNIX-like file systems using i-nodes with support for up to triple indirect blocks (*Hint:* other than read accesses, one write access is also needed). *8pt*

9 Disk requests come in to the driver for cylinders 10, 22, 20, 2, 40, 6, and 38, in that order. A seek takes 10 msec per cylinder moved. How much seek time is needed for:

(a) First-come, first served.

(b) Closest cylinder next (Shortest Seek Time First).

(c) Elevator algorithm (initially moving upward).

In all cases, the arm is initially at cylinder 20. *9pt*

10 Describe the flow of control from the moment that a device generates an interrupt to the moment that the first instructions of an interrupt handler are executed. Also, once the execution of the handler has terminated, what is scheduled next? *8pt*

11 A system has two processes and three identical resources. Each process needs a maximum of two resources. Is deadlock possible? Explain your answer. *8pt*

12 Consider a system, which has a number of processes, but none of them is runnable, although there is no deadlock. Now answer the following questions:

1. How can a system get in this state?
2. What does the processor execute in such a situation?
3. How can a process in the system become runnable again?

9pt