| **Department of Computer Science** | **Operating Systems** |
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| **Vrije Universiteit Amsterdam** | **27.03.2018** |

***This exam consists of one page. No calculator, pencil, or open books allowed. Concise answers!***

*1* When it comes to reading a file on UNIX systems, the library procedure is called *read* and the system call itself is called `read`. Is it essential that both of these have the same name? If not, which one is more important? *10pt*

*2* Modern architectures such as Intel x86 provide several protection rings (e.g., 4) for operating systems to use. How many are commonly used in practice? Why? Can you envision an operating system architecture using a different number of protection rings? *10pt*

*3* Five jobs are waiting to be run. Their expected run times are 9, 6, 3, 5, and 12. In what order should they be run to minimize average response time and why? *10pt*

*4* Using a sample execution run, show how the following concurrent program can come to a deadlock with N unconsumed items. *10pt*

```
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 }
```

*5* Describe the mechanism of how an operating system can let two processes share memory. How is Copy-on-Write related to such mechanism? *10pt*

*6* Many modern architectures such as Intel x86 provide virtual address translation caches that cache partial page table walk results. For instance, in a four-level page table organization, a regular page table walk needs to lookup 4 page tables in memory to translate a virtual address to a physical address. Such a cache may instead directly provide the location of, say, the third-level page table, eliminating the need for the first 2 lookups during the page table walk. How is this different from a TLB? Name one advantage and one disadvantage of this cache compared to a TLB. *10pt*

*7* What is the difference between a hard link and a symbolic link? Give an advantage of each one. *10pt*

*8* A slight modification of the elevator algorithm for scheduling disk requests is to always scan in the same direction. In what respect is this modified algorithm better than the elevator algorithm? *10pt*

*9* Explain the differences between deadlock, livelock, and starvation. Give an example for each scenario. *10pt*

*10* What is the difference between dynamic binary translation (virtualization in software) and hardware virtualization? Name one advantage and disadvantage of dynamic binary translation. *10pt*