Written examination

Operating Systems

March 5th 2021

Last name: _____

First name: _____

Student number: _____

Mit dem Bearbeiten dieser schriftlichen Prüfung (Klausur) bestätigen Sie, dass Sie diese alleine bearbeiten und dass Sie sich gesund und prüfungsfähig fühlen. Mit dem Erhalt der Aufgabenstellung gilt die Klausur als angetreten und wird bewertet.

By attending this written exam, you confirm that you are working on it alone and feel healthy and capable to participate. Once you have received the examination paper, you are considered to have participated in the exam, and it will be graded.

- Use the provided sheets. Do *not* use own paper.
- You are allowed to use a *self prepared*, *single sided DIN-A4 sheet* in the exam. Only *handwritten originals* are allowed, but no copies.
- You are allowed to use a non-programmable calculator.
- Do *not* use a red pen.
- Time limit: *90 minutes*
- Turn off your mobile phones!

Result:

Question:	1	2	3	4	5	6	7	8	9	10	11	**Σ**	Grade
Maximum points:	6	12	10	6	10	8	5	8	9	6	10	90	—
Achieved points:													

1.0: 90.0-85.5, **1.3**: 85.0-81.0, **1.7**: 80.5-76.5, **2.0**: 76.0-72.0, **2.3**: 71.5-67.5,
2.7: 67.0-63.0, **3.0**: 62.5-58.5, **3.3**: 58.0-54.0, **3.7**: 53.5-49.5, **4.0**: 49.0-45.0, **5.0**: <45

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Question 1)

Points: .....

Maximum points: 6

Give a command that can be used to...

a) print out the path of the present working directory in the shell.

b) create a new directory.

c) create an empty file.

d) concatenate the content of different files or print out the content of a file.

e) print out lines from the end of a file in the shell.

f) print out lines from the beginning of a file in the shell.

g) delete files or directories.

h) place a string in the shell.

i) create a link.

j) search a file for lines, which contain a search pattern.

k) modify the permissions of files or directories.

l) terminate a process.

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Question 2)

Points: .....

Maximum points: 5+5+1+0.5+0.5=12

a) Specify for each storage the access method.

Storage	**Access method**	
CD-ROM/DVD-ROM	☐ sequential	☐ random access
Flash memory	☐ sequential	☐ random access
Punched tape	☐ sequential	☐ random access
Hard disk drive (HDD)	☐ sequential	☐ random access
Main memory (DRAM)	☐ sequential	☐ random access
CD-R/CD-RW/DVD-R	☐ sequential	☐ random access
Punch card	☐ sequential	☐ random access
Magnetic-core memory	☐ sequential	☐ random access
Magnetic tape	☐ sequential	☐ random access
Floppy disk	☐ sequential	☐ random access

b) Specify for each storage how read operations are carried out.

Storage	**Read operation**			
CD-R/CD-RW/DVD-R	☐ electric	☐ mechanic	☐ magnetic	☐ optical
CD-ROM/DVD-ROM	☐ electric	☐ mechanic	☐ magnetic	☐ optical
Floppy disk	☐ electric	☐ mechanic	☐ magnetic	☐ optical
Hard disk drive (HDD)	☐ electric	☐ mechanic	☐ magnetic	☐ optical
Flash memory	☐ electric	☐ mechanic	☐ magnetic	☐ optical
Main memory (DRAM)	☐ electric	☐ mechanic	☐ magnetic	☐ optical
Magnetic-core memory	☐ electric	☐ mechanic	☐ magnetic	☐ optical
Punch card	☐ electric	☐ mechanic	☐ magnetic	☐ optical
Punched tape	☐ electric	☐ mechanic	☐ magnetic	☐ optical
Magnetic tape	☐ electric	☐ mechanic	☐ magnetic	☐ optical

c) Name the two basic cache write policies.

d) Name the cache write policy of question c) that may cause inconsistencies.

e) Name the cache write policy of question c) that causes a lower system performance.

Last name: First name: Student number:

Question 3)

Points: .....

Maximum points: 1+3+1.5+1.5+1+1+1=10

a) Explain why it is impossible to implement the optimal replacement strategy OPT.

b) Mark the memory management method that...

- produces many mini-fragments and works most slowly.
  ☐ First Fit ☐ Next Fit ☐ Best fit ☐ Random
- searches for the free block, which fits best.
  ☐ First Fit ☐ Next Fit ☐ Best fit ☐ Random
- fragments quickly the large area of free space at the end of the address space.
  ☐ First Fit ☐ Next Fit ☐ Best fit ☐ Random
- selects randomly a free block.
  ☐ First Fit ☐ Next Fit ☐ Best fit ☐ Random
- searches for a free block, starting from the latest allocation.
  ☐ First Fit ☐ Next Fit ☐ Best fit ☐ Random
- searches for a free block, starting from the beginning of the address space.
  ☐ First Fit ☐ Next Fit ☐ Best fit ☐ Random

c) Name the three components the CPU contains.

d) Name the three digital bus systems each computer system contains according to the Von Neumann architecture.

e) Explain the tasks of the Southbridge.

f) Explain what a page fault exception causes to occur.

g) Explain what an access violation exception or general protection fault exception causes to occur.

Last name: First name: Student number:

Question 4)

Points: .....

Maximum points: 6

a) Specify the net capacity of a RAID 0 array.

b) Specify the net capacity of a RAID 1 array.

c) Specify the net capacity of a RAID 5 array.

d) Specify the net capacity of a RAID 6 array.

e) Name one RAID level, which improves the data transfer rate for write.

f) Name one RAID level, which improves the reliability.

g) Give the number of drives that can fail in a RAID 0 array without data loss.

h) Give the number of drives that can fail in a RAID 1 array without data loss.

i) Give the number of drives that can fail in a RAID 5 array without data loss.

j) Give the number of drives that can fail in a RAID 6 array without data loss.

k) Name one advantage of software RAID compared with hardware RAID.

l) Name one drawback of software RAID compared with hardware RAID.

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Question 5)

Points: .....

Maximum points: 8+1+1=10

a) Show Belady's anomaly by performing the access sequence with the replacement strategy FIFO once with a cache with a capacity of 3 pages and once with 4 pages. Also calculate the hit rate and the miss rate for both scenarios.

Requests:	**3**	**2**	**1**	**0**	**3**	**2**	**4**	**3**	**2**	**1**	**0**	**4**
Page 1:												
Page 2:												
Page 3:												

Hit rate:

Miss rate:

Requests:	**3**	**2**	**1**	**0**	**3**	**2**	**4**	**3**	**2**	**1**	**0**	**4**
Page 1:												
Page 2:												
Page 3:												
Page 4:												

Hit rate:

Miss rate:

b) Mark the replacement strategy that is implemented by most modern operating systems.

☐ FIFO ☐ Optimal ☐ LRU ☐ Clock ☐ LFU ☐ TTL

c) Explain why fragmentation in memory management is irrelevant for modern operating systems.

Last name: First name: Student number:

Question 6)

Points: .....

Maximum points: 1.5+0.5+0.5+1+0.5+0.5+0.5+1+1+1=8

a) Name the three sorts of process context information the operating system stores.

b) Explain the task of the dispatcher.

c) Explain the task of the scheduler.

d) Explain what a zombie process is.

e) Explain what the PID is.

f) Explain what the PPID is.

g) Explain what the UID is.

h) Describe the effect of calling the system call `fork`.

i) Describe the effect of calling the system call `exec`.

j) Explain why some operating systems have one or more system idle processes.

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Question 7)

Points: .....

Maximum points: 5

a) Call parameters and return addresses of functions contains the...

☐ Data Segment ☐ Stack ☐ Text Segment

b) Variables which get values assigned in global declarations (outside of functions) contains the...

☐ Data Segment ☐ Stack ☐ Text Segment

c) Environment variables of a process contains the...

☐ Data Segment ☐ Stack ☐ Text Segment

d) The program code (machine code) of a process contains the...

☐ Data Segment ☐ Stack ☐ Text Segment

e) Command line arguments of a process contains the...

☐ Data Segment ☐ Stack ☐ Text Segment

f) Local variables of functions contains the...

☐ Data Segment ☐ Stack ☐ Text Segment

g) Describe what a critical section is.

h) Describe what a race condition is.

i) Describe why race conditions are hard to locate and fix.

j) Describe how to avoid race conditions.

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Question 8)

Points: .....

Maximum points: 1+1+1+0.5+0.5+1+1+1+1=8

a) Explain the advantage of using the operations signal and wait compared with busy waiting.

b) Name two problems that can arise from blocking.

c) Explain the difference between signaling and blocking.

d) Mark the scheduling method that is implemented by message queues.

☐ Round Robin ☐ LIFO ☐ SJF ☐ FIFO ☐ LJF

e) Specify how many processes can communicate with each other via a pipe.

f) Explain the effect, when a process tries to write data into a pipe without free capacity.

g) Explain the effect, when a process tries to read data from an empty pipe.

h) Name the two different types of pipes.

i) Name the two different types of sockets.

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Question 9)

Points: .....

Maximum points: 9

a) Mark one sort of inter-process communication, which allows communication over computer boundaries.

☐ Anonymous Pipes ☐ Sockets ☐ Shared Memory ☐ Message Queues

b) Mark one sort of inter-process communication, which can only be used for processes, which are closely related to each other.

☐ Anonymous Pipes ☐ Sockets ☐ Shared Memory ☐ Message Queues

c) Mark one sort of inter-process communication, where synchronization is not done by the operating system. It is a task of the developer.

☐ Anonymous Pipes ☐ Sockets ☐ Shared Memory ☐ Message Queues

d) Mark one sort of inter-process communication, where the data remains intact without a bound process.

☐ Anonymous Pipes ☐ Sockets ☐ Shared Memory ☐ Message Queues

e) Explain the functioning of the `P` access operation of a semaphore.

f) Explain the functioning of the `V` access operation of a semaphore.

g) Explain the difference between Semaphores versus blocking/locking.

h) Explain what a binary semaphore is.

i) Name the Linux/UNIX command that returns information about existing shared memory segments, message queues and semaphores.

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Question 10)

Points: .....

Maximum points: 6

Perform the deadlock detection with matrices and check if a deadlock occurs.

$$\text{Existing resource vector} = \begin{pmatrix} 9 & 6 & 8 & 7 & 6 & 7 \end{pmatrix}$$

$$\text{Current allocation matrix} = \begin{bmatrix} 2 & 0 & 2 & 3 & 2 & 0 \\ 2 & 1 & 2 & 0 & 0 & 3 \\ 1 & 3 & 2 & 1 & 0 & 1 \\ 3 & 1 & 0 & 1 & 1 & 1 \end{bmatrix} \qquad \text{Request matrix} = \begin{bmatrix} 1 & 0 & 2 & 2 & 3 & 1 \\ 5 & 3 & 2 & 2 & 1 & 2 \\ 2 & 0 & 4 & 4 & 4 & 2 \\ 4 & 3 & 0 & 1 & 2 & 3 \end{bmatrix}$$

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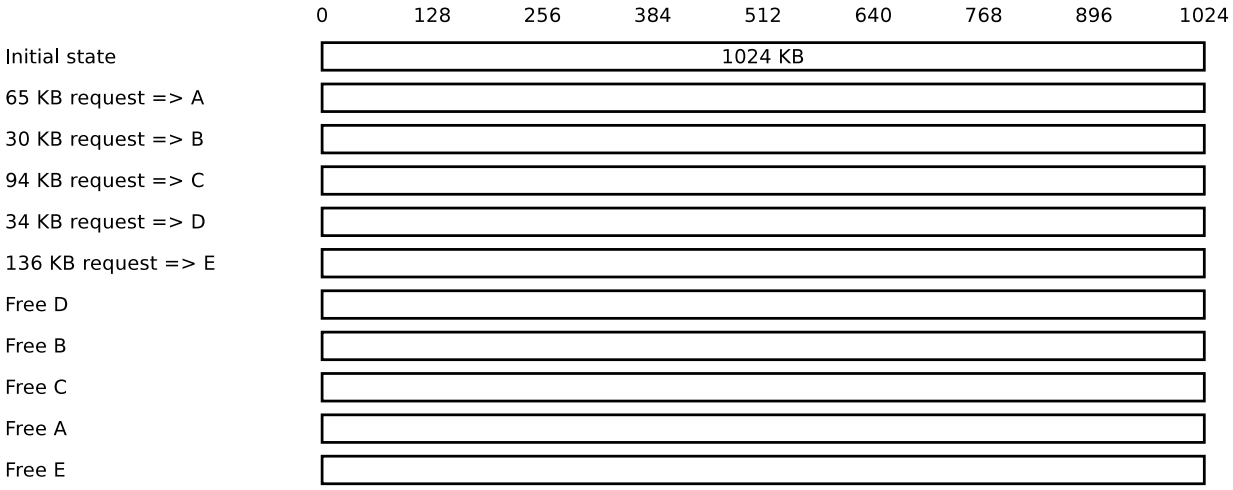
Question 11)

Points: .....

Maximum points: 10

The Buddy method for allocating memory to processes shall be used for a memory with a capacity of 1024 kB. Perform the provided operations and give the occupancy state of the memory after each operation.



(*!!! CAUTION !!! With the second template you can save time, if you want to try it all over again. Mark clearly which one of your solutions shall be considered during the correction!*)