Written examination in Operating Systems

February 17th 2023

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 *hand-written originals* are allowed, but no copies.
- Do *not* use a red pen.
- Time limit: *90 minutes*
- Turn off your mobile phones!

Grade: _____

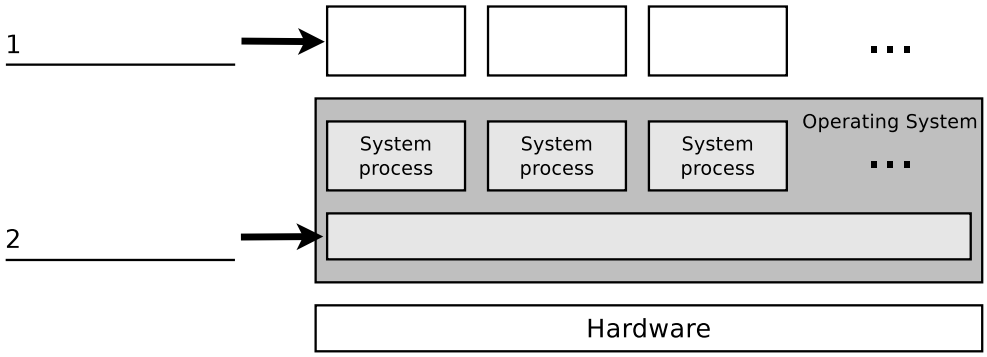
Questions:	1	2	3	4	5	6	7	8	9	10	11	12	**Σ**
Maximum Points:	10	9	12	7	7	7	3	6	8	8	6	7	90
Achieved Points:													

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

Question 1)

Points: ..... of 10

2 Points (1) The diagram shows the basic structure of an operating system.
Fill in the lines the name of the components marked by the arrow.



1 Point (2) Name one task for which batch processing is well suited.

1 Point (3) Batch processing is always...
☐ interactive ☐ non-interactive

1 Point (4) Give the name of the quasi-parallel program or process execution.

1 Point (5) Describe what scheduling is.

1 Point (6) Describe the purpose of memory protection.

2 Points (7) Name the two basic cache write policies.

1 Point (8) Name the cache write policy that leads to inconsistencies.

Question 2)

Points: ..... of 9

1 Point (1) Linux implements a...
☐ monolithic kernel ☐ microkernel ☐ hybrid kernel

1 Point (2) Windows NT4/Vista/XP/7/8/10 implements a...
☐ monolithic kernel ☐ microkernel ☐ hybrid kernel

1 Point (3) Mark the concept that does not require any hardware support:
☐ Direct Memory Access ☐ Interrupt driven ☐ Busy waiting

2 Points (4) Name <u>one</u> advantage and <u>one</u> drawback of monolithic kernels.

1 Point (5) Name <u>two</u> RAID level that improves the reliability.

1 Point (6) Name <u>two</u> RAID level that improves the data transfer rate for write operations.

½ Point (7) Give the net capacity of a RAID 0 array.

½ Point (8) Give the net capacity of a RAID 1 array.

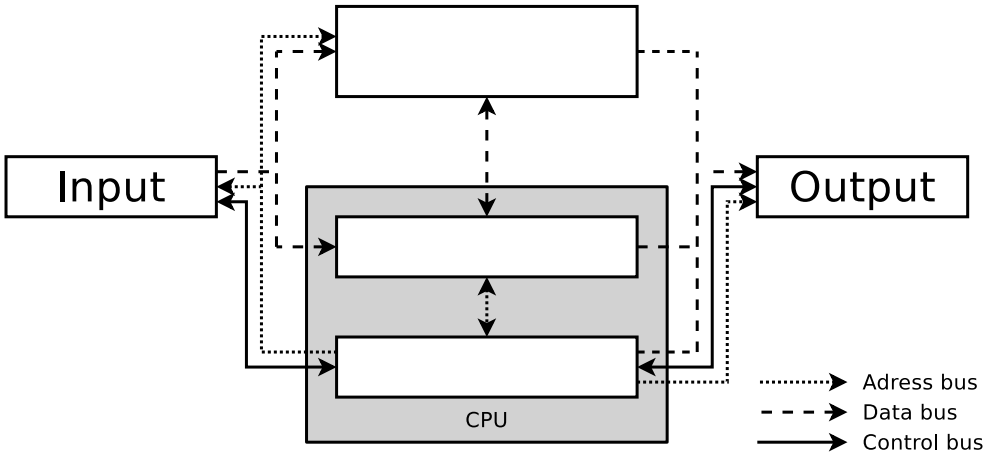
1 Point (9) Give the number of drives that are allowed to fail in a RAID 5 array without data loss.

Question 3)

Points: ..... of 12

3 Points

(1) The diagram shows the Von Neumann Architecture. Fill into the boxes the missing components.



6 Points

(2) Explain briefly how the Von Neumann Cycle works (explain the six steps).

a)

b)

c)

d)

e)

f)

2 Points

(3) Explain what the Memory Management Unit (MMU) is and explain its purpose.

1 Point

(4) Give the maximum number of memory addresses that can be addressed with a 16-bit computer system.

Question 4)

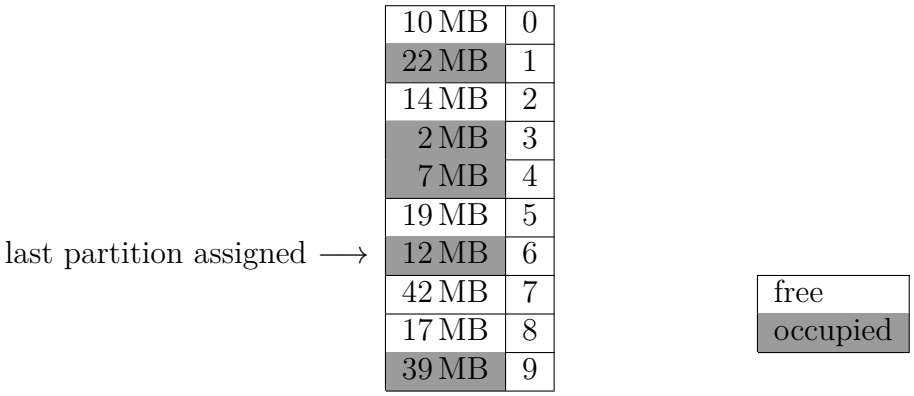
Points: ..... of 7

1 Point (1) Static partitioning can only be implemented using partitions of equal size.

☐ True ☐ False

3 Points (2) The following memory area belongs to a memory with dynamic partitioning. For each of the three algorithms, First Fit, Next Fit, and Best Fit, specify the number of the free partition that the corresponding algorithm uses to insert a process that requires 11 MB of memory.

a) First Fit: _____ b) Next Fit: _____ c) Best Fit: _____



1 Point (3) Name the type(s) of fragmentation that can occur in static partitioning.

1 Point (4) Name the type(s) of fragmentation that can occur in dynamic partitioning.

1 Point (5) Name the type(s) of fragmentation that can occur in buddy memory allocation.

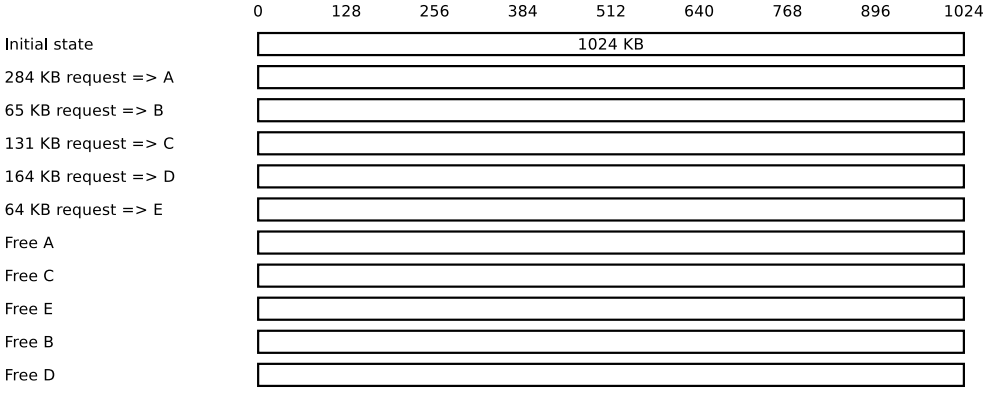
Question 5)

Points: ..... of 7

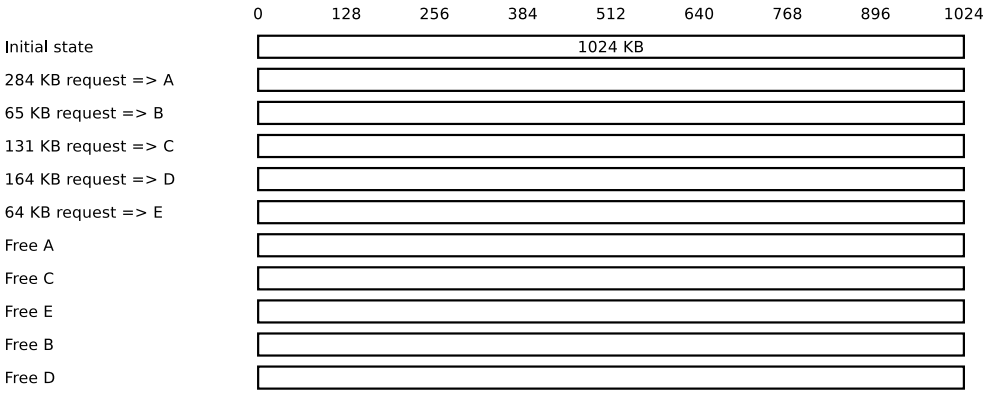
1 Point (1) Explain why virtual memory helps to make more efficient use of the main memory.

1 Point (2) Explain, what mapping is.

5 Points (3) Apply the Buddy Allocation algorithm to the memory depicted in the diagram.



(!!! 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!)

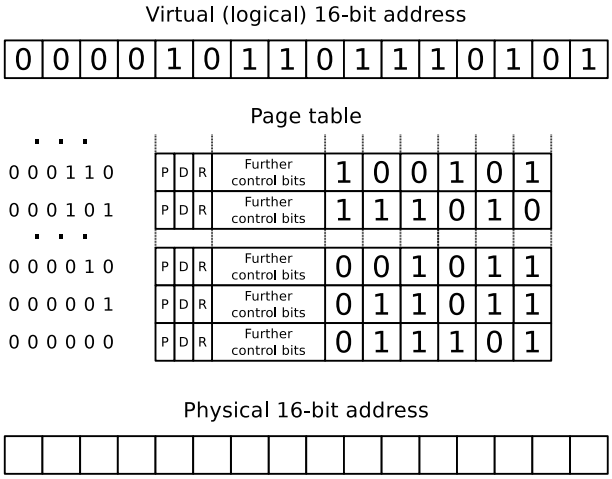


Question 6)

Points: ..... of 7

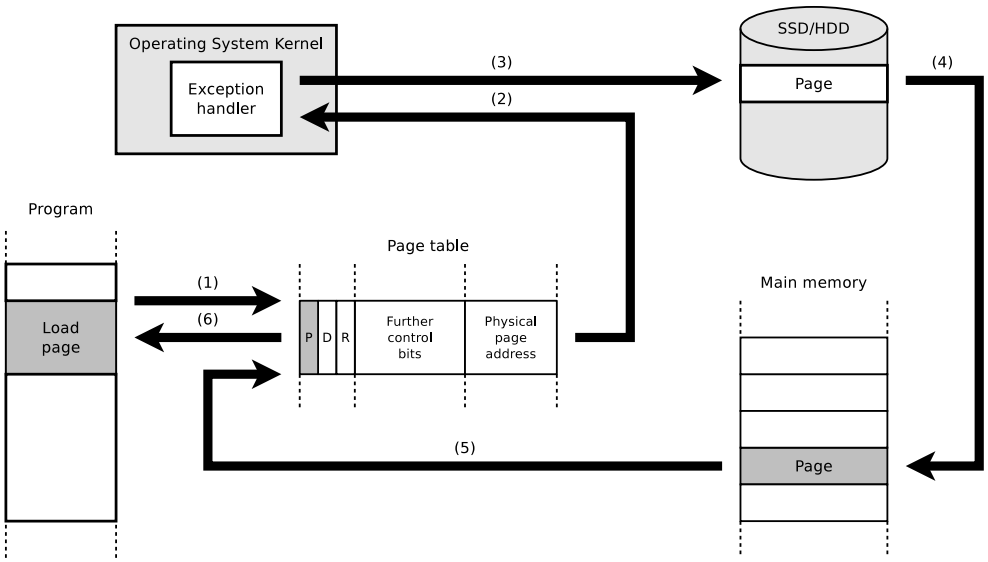
4 Points

(1) Calculate the physical 16-bit memory address using address translation with single level paging. Fill in the single bits in the physical 16-bit address.



3 Points

(2) The diagram shows a page fault exception. Describe the process stages.



(1)

(2)

(3)

(4)

(5)

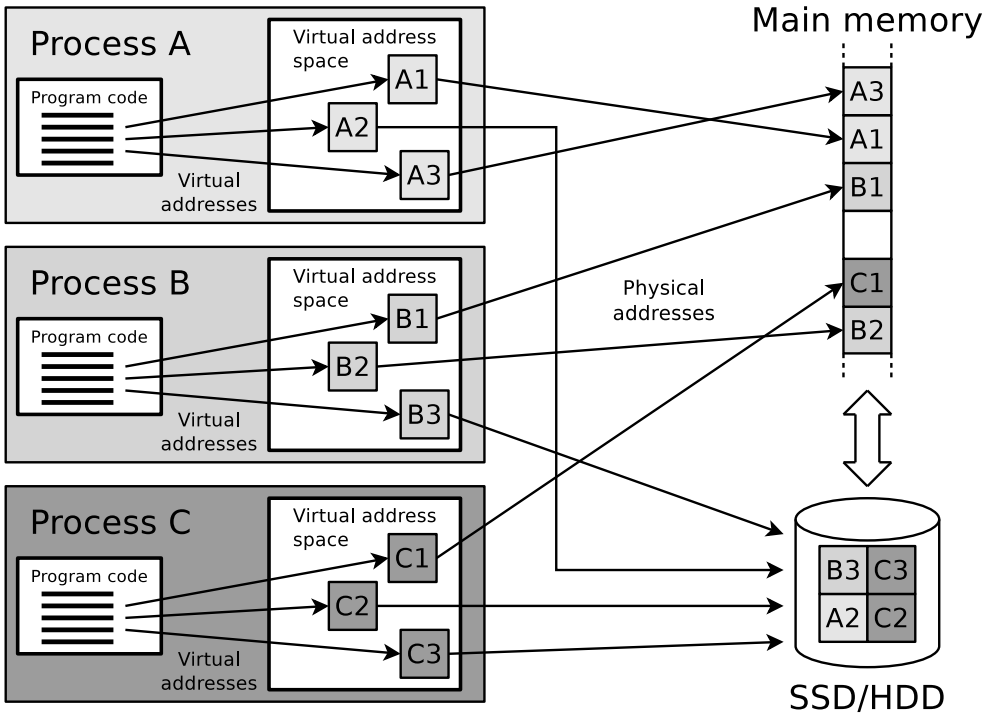
(6)

Question 7)

Points: ..... of 3

3 Points

(1) Explain the relevant processes that can be observed in the diagram. *(!!! Focus on the memory management and the way, different memory technologies are used !!!)*



Question 8)

Points: ..... of 6

4 Points

(1) Mark the statements as true or false.

Statement	**true**	**false**
Inodes store all metadata of files.		
File systems address clusters and not blocks of the storage medium or storage drive.		
The smaller the clusters are, the more overhead for large files occur.		
The bigger the clusters are, the lesser capacity is lost due to internal fragmentation.		
In UNIX, file extensions have always been of great significance.		
Modern file systems operate so efficient that buffering by the operating system is no longer common.		
Absolute path names describe the complete path from the root to the file.		
The separator in path names is identical for all operating systems.		

1 Point

(2) Describe what information the super block of a file system stores.

1 Point

(3) Some file systems use a concept called Copy-on-write (COW). Mark the <u>two</u> answers that apply to such file systems.

When a file is modified, the old clusters in the file system that need to be modified...

☐ are preserved (not changed).
☐ are overwritten with the new modifications.
☐ are erased, by removing the cluster address in the inode.
☐ are copied into new clusters, where the modifications are made.

Question 9)

Points: ..... of 8

8 Points

(1) Perform the access sequence with the replacement strategy Least Frequently Used (LFU) with a cache with a capacity of 4 pages and calculate the hit rate and the miss rate.

Requests:	**1**	**4**	**2**	**3**	**1**	**2**	**5**	**4**	**2**	**3**	**4**	**3**	**4**	**5**
Page 1:														
Page 2:														
Page 3:														
Page 4:														

Hitrate:

Missrate:

(!!! 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!)

Requests:	**1**	**4**	**2**	**3**	**1**	**2**	**5**	**4**	**2**	**3**	**4**	**3**	**4**	**5**
Page 1:														
Page 2:														
Page 3:														
Page 4:														

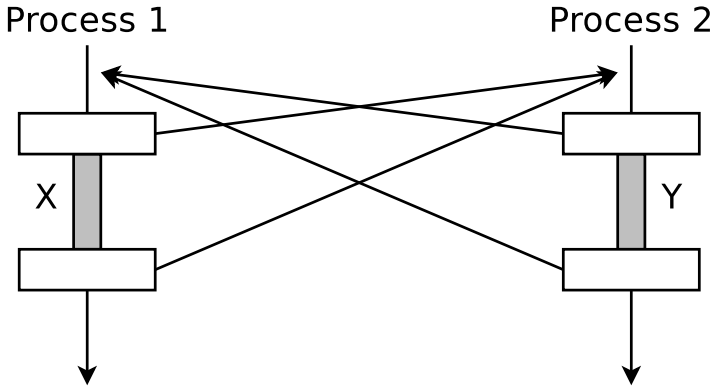
Hitrate:

Missrate:

Question 10)

Points: ..... of 8

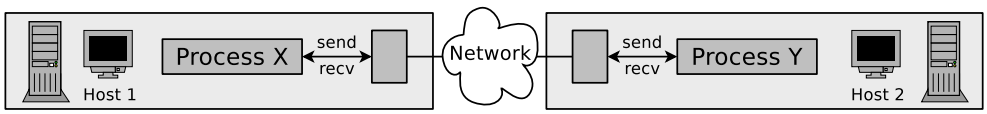
1 Point (1) The figure demonstrates a process synchronization method. Add into the boxes the missing operations.



1 Point (2) Give the name of the process synchronization method shown in (1).

2 Points (3) Describe the functioning of the process synchronization method in (1).

1 Point (4) Give the name of the process synchronization method shown in the diagram.



☐ shared memory ☐ message queue ☐ socket
☐ cricket ☐ pipe anonymous ☐ mutex

2 Points (5) Name <u>two</u> benefits of using the interprocess communication method in (4).

1 Point (6) The interprocess communication method in (4) works bidirectonal.

☐ True ☐ False

Question 11)

Points: ..... of 6

6 Points

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

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

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

$$\text{Request matrix} = \begin{bmatrix} 4 & 3 & 0 & 1 & 2 & 3 \\ 1 & 0 & 2 & 2 & 3 & 1 \\ 5 & 6 & 2 & 2 & 1 & 2 \\ 2 & 0 & 4 & 4 & 4 & 2 \end{bmatrix}$$

Question 12)

Points: ..... of 7

3 Points (1) Consider the following situation:
You start a **process A**, which uses `fork()` to create a child **process B**. Process A should be able to communicate via an interprocess communication method with process B. After the termination of the two processes the ressources of the interprocess communication should be erased automatically by the operating system.

Name the interprocess communication method you would use for this task and explain the reasons for your choice.

1 Point (2) Explain what an environment variable in Linux is.

2 Points (3) Explain the function of the `grep` command-line tool and explain <u>one</u> use-case for `grep`.

1 Point (4) You tried to run `script.sh` but the following happens:

```
$ ./script.sh
permission denied: ./script.sh
```

Give <u>one</u> solution for the command-line shell that allows to execute `script.sh`.