OPERATING SYSTEMS I

First and Last Name: ………………………………………………………………………………………………………

Year of Study: …………………

5th of February, 2023

No points granted by default; minimum points required to pass exam: ***50p***

EXERCISE 1: PROCESS DEADLOCK PREVENTION (20p)

1. In a system with a single type of resources, there are 8 processes with the following maximal requirements:

Process	**P1**	**P2**	**P3**	**P4**	**P5**	**P6**	**P7**	**P8**
MAX	19	21	23	11	15	17	20	14

a) Specify the minimal value for the total number of available resources, so that the state of the system is considered safe, in the following scenarios:

a1) an initial allocation of resources: `(7, 14, 19, 9, 7, 15, 18, 12)` (7.5p)

a2) an additional allocation of resources: `(10, 0, 0, 1, 0, 1, 1, 1)` (5p)

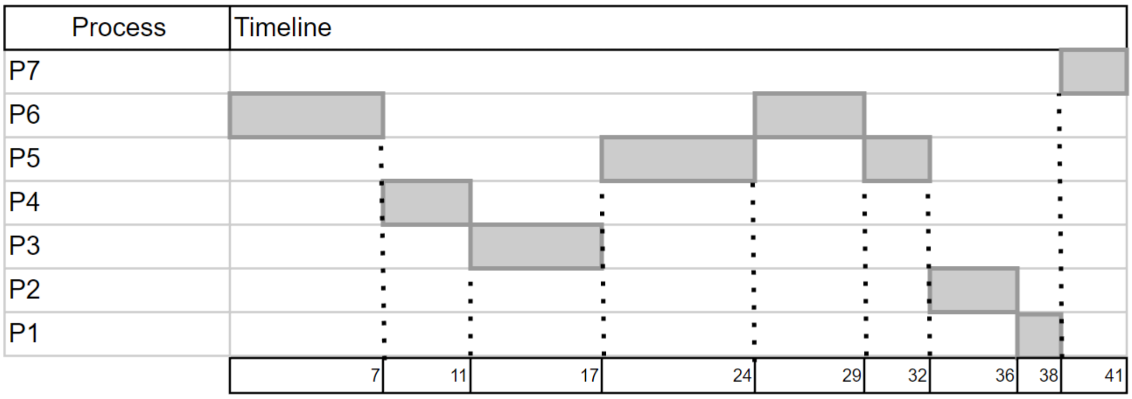
b) Considering an initial allocation of resources of `(7, 14, 19, 9, 7, 15, 18, 12)` and a total number of resources equal to the one determined at a1) earlier, answer the following:

b1) give an example of a request which would trigger a deadlock in the system (2.5p)

b2) two processes request an additional 4 resources, with the state of the system still being safe. One of these processes is **P7**. Find the other process and the maximum number of resources it accessed. (5p)

EXERCISE 2: PROCESS SCHEDULING (35p)

2. A system with 7 processes is scheduled, using the Round Robin algorithm, through the GANTT diagram below. Using the information below, and provided that every process arrives in the system at a different time and as early as possible:



a) Determine the quantum value used for scheduling, as well as the burst and arrival times of these processes according to the diagram above. (5p)
b) Using the information determined at point a), draw the GANTT diagram of the same processes being scheduled using the Shortest Remaining Time Next, Shortest Job First and First In First Out scheduling algorithms. (15p)
c) Compute the turnaround and waiting times for the scheduling performed at point b). (7.5p)
d) What would be the optimal quantum value for pre-emptive scheduling of the processes above? (2.5p)
e) Using the quantum value from point d) above, perform the Round-Robin scheduling again and compare its performance with the scheduling in the diagram above. (5p)

EXERCISE 3: DEADLOCKS (40p)

3. In a system with 4 types of resources (USB port, flash drive, printer, external HDD), there are 5 processes with the following specifics:

Existing resources: **`E = ?`**

Available resources: **`A = ?`**

Current allocation:

$$C = \begin{pmatrix} 3 & 0 & 3 & 3 \\ 4 & 0 & 3 & 3 \\ 4 & 3 & 4 & 0 \\ 0 & 0 & 3 & 3 \\ 4 & 4 & 0 & 3 \end{pmatrix}$$

Requested:

$$R = \begin{pmatrix} 5 & 3 & 4 & 3 \\ 4 & 4 & 0 & 3 \\ 0 & 3 & 3 & 3 \\ 4 & 0 & 0 & 4 \\ 3 & 0 & 0 & 3 \end{pmatrix}$$

a) Determine the total number of available resources **A** in the system if **E** = `(15, 11, 13, 12)`. (2.5p)
b) Determine the minimum number of resources required, for each resource type, so that the system state is still considered safe, if processes 1 and 2 make the following requests: `(1 1 1 1)` and, respectively, `(0, 2, 0, 1)` (15p)
c) Given **E** being the same as at point a) above, give an example of a request that would trigger a deadlock. (2.5p)
d) Assuming **E** = `(18, 11, 16, 15)`, and an initial request for process 1 being `(0 1 0 0)`, as well as an initial allocation for process 2 of `(0 2 0 0)`, find all possible additional requests moving forward so that the state of the system is still considered safe. (20p)

EXERCISE 4: MEMORY MANAGEMENT (20p)

4. A system using a 32-bit Von Neumann architecture has a page size of 8,192 bytes and 40 KB of RAM memory. Access to the pages of the system is happening in the following order: 2, 2, 1, 0, 7, 3, 3, 1, 4, 4, 2, 1, 6, 7, 0, 1, 3, 4, 1, 5, 6, 6, 5, 5, 5, 1, 5, 1, 6.

a) What is the total number of virtual pages and page frames in this system? (1.25p)
b) How many page faults are issued when using the clock, FIF O and optimal algorithms for the accesses above? (15p)
c) Describe the memory mapping of the pages at moment 15 in the scenario above for all three algorithms mentioned. (1.25p)
d) Considering that at moment 15 above you are accessing the virtual address 0xBEEF, what is its corresponding page frame? (2.5p)

EXERCISE 5: CHALLENGES & QUESTIONS (35p)

5. Indicate whether each of the statements below is true or false, and explain your answer *briefly* (10p):

a) Preemptive scheduling algorithms cannot schedule 3 processes on a system with two CPUs, each with one single core. (1.5p)
b) A process cannot voluntarily bypass pre-emption in real-time operating systems, to allow other processes to run. (1.5p)
c) When it comes to scheduling, threads are treated like processes by the operating system's kernel. (1.5p)
d) Data corruption due to unprotected memory writes is the main reason why an interactive operating system is slowing down permanently over time. (1.5p)
e) Page faults happen less often on desktop operating systems with less physical memory. (1.5p)
f) On multi-core processors, it's required to protect data writes to the processor's cache memory with critical regions to avoid data corruption. (2.5p)

Answer the following questions *briefly* (25p):
g) Suppose a friend told you: "It's better to have more processes than threads in any type of interactive operating system". Explain if your friend is right, wrong or both. (5p)
h) The following code snippets modify two variables ***N*** and ***M*** (which are initialized with the values N=5, M=7) in 3 different threads, on a system with 1 CPU, 2 cores and 4 threads:

Thread 0	*Thread 1*	*Thread 2*
`M += N/3;`	`M += -N+5;`	`N /= M*2;`

h.1) Compute the expected result for the variables ***N*** and ***M*** after all threads finish execution in an interactive system, assuming each of the assignment instructions above are atomic instructions. (7.5p)
h.2) Assuming that thread 0 always executes last, and thread 1 has a higher priority than thread 2, compute the value of ***N*** and ***M*** after the execution of the threads complete in an interactive system. (2.5p)

i) Suppose a friend told you: "An operating system designed for immersive gaming (e.g. as in VR gaming setups) allocates I/O-bound processes to a higher priority than CPU-bound processes." Explain whether your friend is correct. (5p)
j) Give an example of a situation when a higher-priority process could prevent the execution of a lower-priority process. (2.5p)
k) If a process has two threads, both highest priority, and a third thread is created (having the lowest priority), what is the priority of the process itself? (2.5p)