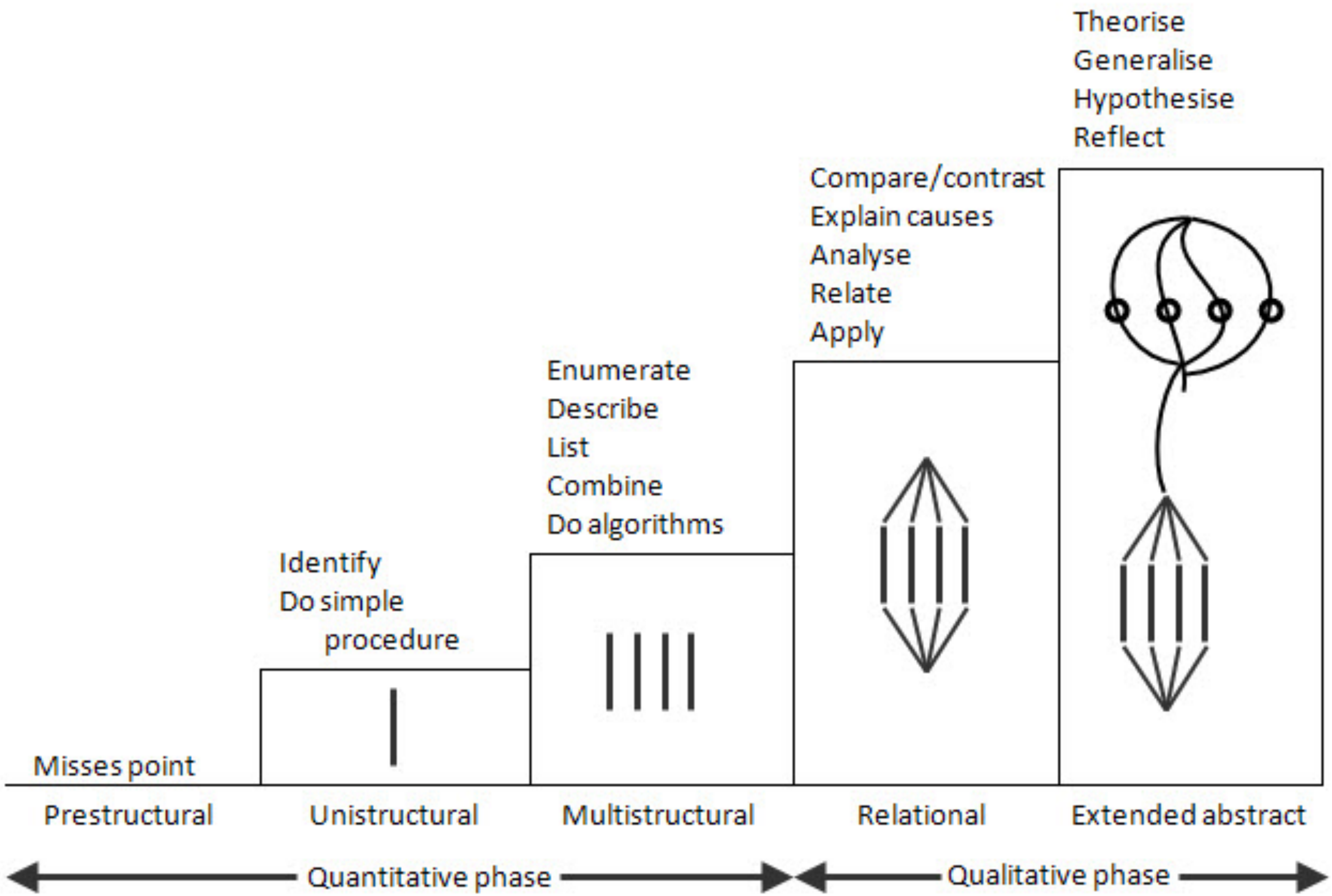
Exam workshop #1

Discussion questions

- What is a good exam question?
- What is a good exam answer?
- What is showing that you have the requested knowledge?
  - …and what doesn´t?

The SOLO learning taxonomy



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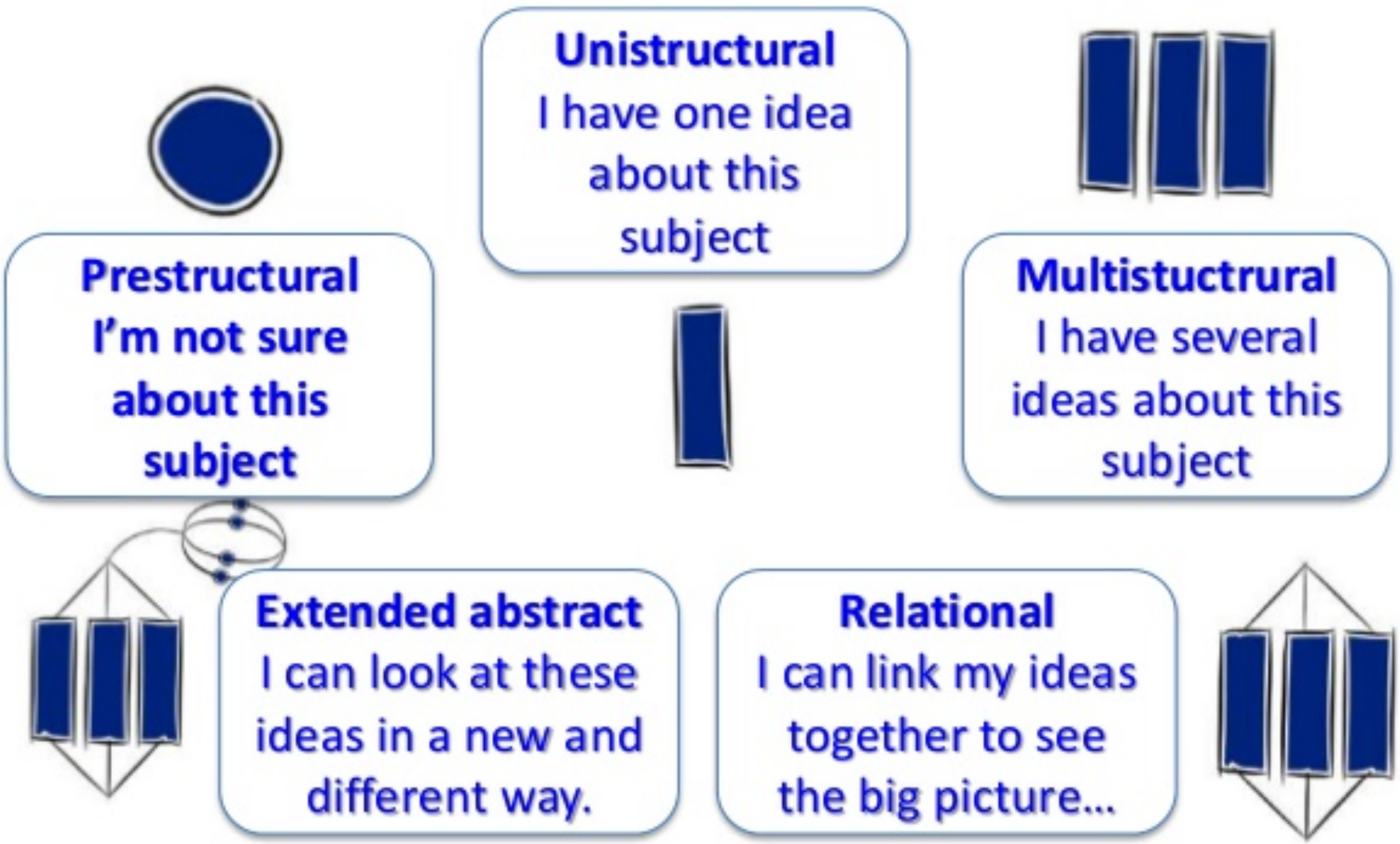
Different types of answers



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Old problem (on sliding window)

TCP and other transport protocols are using a *sliding window* at the sender to define a *sending window* which change in size during communication. The state of the sending window at the sender is defined by these pointers that refer to byte positions in the sender's buffer :

Sender.UNA Sequence number of the first byte of data that has been sent but not yet acknowledged.
Sender.NXT Sequence number of the next byte of data to be sent to the other device
Sender.WND Current size of the maximum sending window at the sender

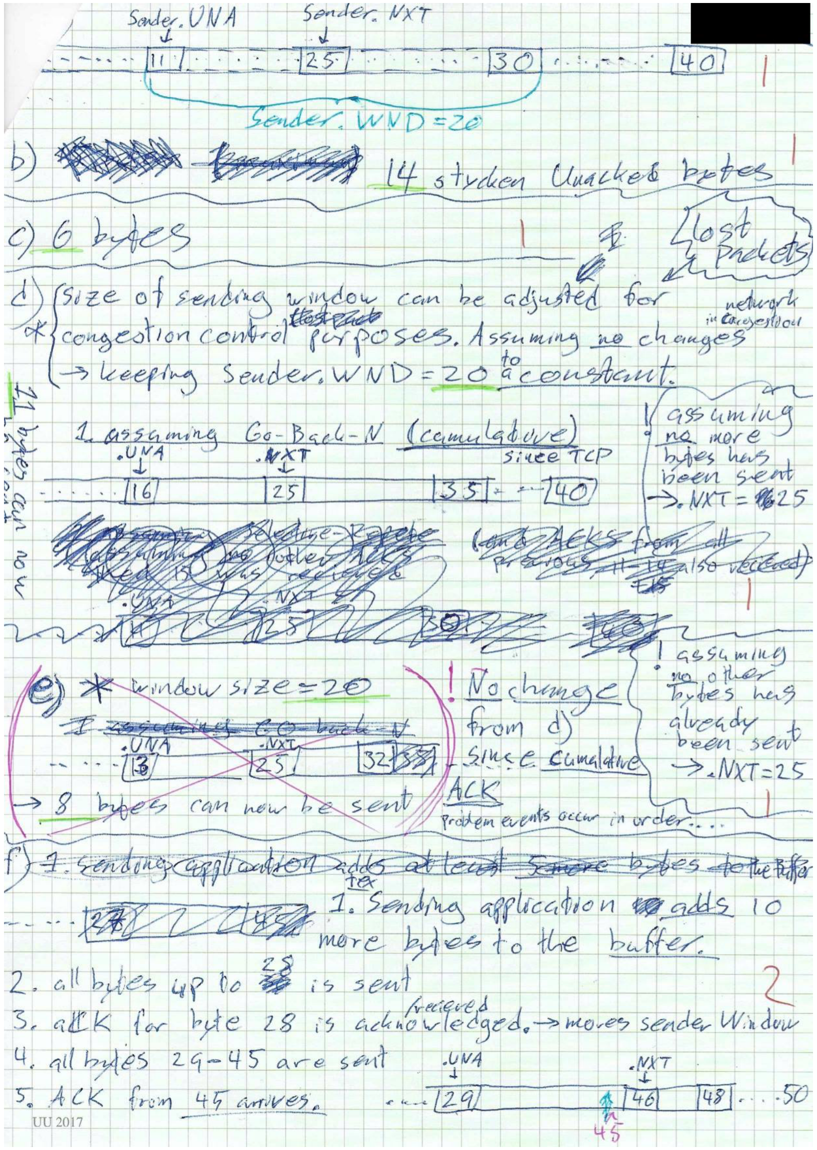
Assume that the sending application has filled the buffer with data to be sent up until sequence number 40.

a) Draw a figure of the buffer at the sender where *Sender.UNA = 11, Sender.NXT = 25 and Sender.WND = 20.* (1p)
b) What is the current number of unacknowledged bytes? (1p)
c) How many additional bytes can be sent immediately? (1p)

For the following subproblems, the events occur in the same order as the subproblems. I.e., in subproblem e), the event presented in subproblem d) has already happened etc.

d) An ACK acknowledging byte 15 arrives. What is the new size of the sending window? How many bytes can now be sent? (2p)
e) An ACK acknowledging byte 12 arrives. What is the new size of the sending window? How many bytes can now be sent? (2p)
f) An ACK acknowledging byte 45 arrives. Assuming this is not an error, explain what prior sequence of events could make this happen. (3p)

Authentic student solution



[redacted]

Sender.UNA ... 11 ... Sender.NXT 25 ... 30 ... 40

Sender.WND = 20

b) ~~Backlog~~ 14 styden Unacked bytes

c) 6 bytes

lost packets

d) {size of sending window can be adjusted for ~~flow control~~ congestion control purposes. Assuming no changes in network congestion → keeping Sender.WND = 20 to a constant.

1. assuming Go-Back-N (cumulative) since TCP

.UNA 16 ... .NXT 25 ... 35 ... 40

assuming no more bytes has been sent → .NXT = 25

~~(and ACKs from all previous, 11-14 also recieved)~~

e) * window size = 20

~~I assuming Go-back-N~~

.UNA 13 ... .NXT 25 ... 32 33

→ 8 bytes can now be sent

No change from d) since cumulative ACK

assuming no other bytes has already been sent → .NXT = 25

Problem events occur in order...

f) ~~1. sending application adds at least 5 more bytes to the buffer~~

1. Sending application adds 10 more bytes to the buffer.

2. all bytes up to 28 is sent

3. ACK for byte 28 is recieved → moves sender Window

4. all bytes 29-45 are sent

5. ACK from 45 arrives.

.UNA 29 ... .NXT 46 ... 48 ... 50

Question criteria

For grade 4

The basic requirement on the submitted questions is that they test understanding of how some theoretical aspect of the course can be applied or used in a specific context rather than just asking to repeat basic facts.

For grade 5

The extended requirement on the submitted questions is that they connect at least two different topics covered in the course to each other.

(At least one of two submitted questions should meet this criteria for grade ‘5’)

Sample exam question (1)

The CPU context:

A. defines whether the CPU is executing in user mode or kernel mode

B. is used to enforce security and protection

C. is saved when transitioning from user space to kernel space

D. includes the stack and the heap

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Sample exam question (2)

In a virtual memory system using paging, the virtual address space is 64 KiB and the physical address space is 8 KiB.

What entry in the page table must exist for the virtual address 0xE3B7 to be translated to the physical address 0x1FB7?

Sample exam question (2)

In a virtual memory system using paging, the virtual address space is 64 KiB and the physical address space is 8 KiB.

What entry in the page table must exist for the virtual address 0xE3B7 to be translated to the physical address 0x1FB7?

The page size is 1 KiB

Sample exam question (2)

Answer: Page 56 is mapped to frame 7

0xE3B7	`1110 0011 1011 0111`
1 KiB pages	`1110 0011 1011 0111`
0x1FB7	`0001 1111 1011 0111`

`111000`	maps to	`00111`	
56	maps to	7	(1 KiB page size)

Follow-up question: **Would larger page sizes work?**

Sample exam question (3)

What is not true about cumulative acknowledgments?

A. One ACK can acknowledge the reception of data from several transmissions

B. Duplicated ACK values can indicate a lost message before a timeout occur

C. The reliable transmission becomes less sensitive for lost acknowledgments

D. It becomes easier to get precise RTT estimates

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Sample exam question (4)

What was the top level goal of the DARPA Internet architecture, which later became the core architecture of the Internet

A. Effective multiplexed utilization of existing interconnected networks

B. Cost-effective technology that permits host attachment with a low level of effort

C. Support for multiple types of communication services and applications

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Why is it hard to establish a happened-before order between two events at clients that each result in a web request from the same server? Because...

A. The local clock may differ between clients

B. Clients may experience different RTT to the server

C. TCP sessions require a 3-way handshake to set up a connection before data transmission can begin

D. Segments are delivered in a best-effort manner, which may cause unpredictable delay variations due to retransmissions

Sample exam question (5)

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Sample exam question (6)

Some variants of TCP reduce the maximum sending window when RTT measurements of incoming ACKs increase. What is the rationale behind this behavior?

A. With increasing RTT, it will be harder to get good RTT samples as input to the timeout setting mechanisms.

B. Increasing RTT means that queues are building up and soon will overflow and cause lost packets.

C. Increasing RTT means that the receivers buffer soon is full which will cause lost data at the receiving end

D. Increasing RTT is a symptom of aggregated cumulative acknowledgments due to a reduced sending speed at the receiver

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Exam contract

- The teacher's responsibility is to
  - Offer an assessment that give students a fair chance to demonstrate their knowledge in the course subject
  - Grade students according to their shown level of knowledge in the assessment
  - Review students knowledge from a qualitative, holistic viewpoint
- The student's responsibility is to
  - Provide the teachers with as good input as possible regarding their subject knowledge

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Grading

- I take the holistic approach, BUT
  - Write clear, concise and READABLE answers to the question asked
    - If I can't read it, I can't grade it
    - If I can't understand you, I can't grade it
    - If you don't answer the question asked, I won't grade it
    - If you produce too much text, it is often an indication that you don't know the answer or haven't understood the question
  - Do not contradict yourself in your answer!

- If you are lacking 1-2 points to get a higher grade, you are supposed to
  - Your exam has then been reviewed an extra time by me and also by at least one other teacher.

Old exam (March 2018)

Problem 1.1: Dual mode operation: [1 pt]

A. makes it possible to execute two processes at the same time.

B. is used to enforce security and protection.

C. is a energy saving technique implemented by all modern CPUs.

D. makes it possible for a system call to return two results at the same time.

Problem 1.2: Exception and interrupts. [1 pt]

A. Exceptions are produced by the CPU control unit while executing instructions and are considered to be asynchronous because the control unit issues them only after terminating the execution of an instruction.

B. Interrupts are external and synchronous.

C. When initiating a system call, a special interrupt is used.

D. Exceptions and interrupts are events that alters the normal sequence of instructions executed by a processor.

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Problem 1.3: Multiprogramming: [1 pt]

A. allows for a single job to get stuck in an infinite loop and block all other jobs from executing.

B. is an extension of multitasking for systems with more than one CPU or CPU cores.

C. gives each job and equal share of CPU time.

D. uses exceptions to notify the system of important events such as the completion of an I/O request.

Problem 1.4: An executable: [1 pt]

A. is a passive entity and contains a stack.

B. is an active entity.

C. is a passive entity.

D. is an active entity and contains a page table.

Problem 1.5: System calls. [1 pt]

A. System calls are handled in user mode.

B. Prior to handling a system call the caller places the return address on the stack.

C. Prior to handling a system call the context of the caller must be saved.

D. A timer interrupt is used to initiate a system call.

Problem 2.1: Individual processes share: [1 pt]

A. signal handlers with each other.

B. heap with each other.

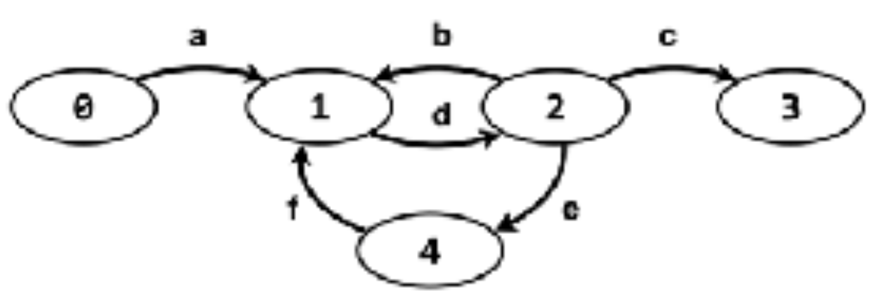
C. heap and stack with each other.

D. neither heap nor stack with each other.

E. only the heap but not the stack with each other.

F. CPU context with each other.

Problem 2:2: In the below figure name the process states 0, 1, 2, 3, and 4. [2 pt]



State	Name	
1	Ready	(0.5 pt)
2	Running	(0.5 pt)
3	Terminated	(0.5 pt)
4	Waiting	(0.5 pt)

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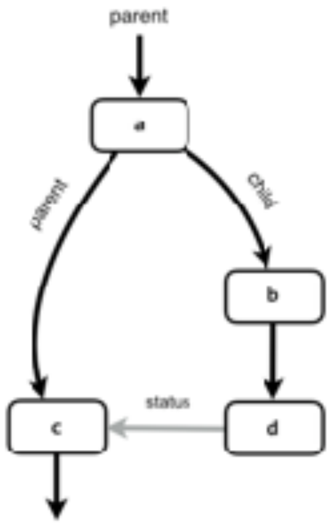
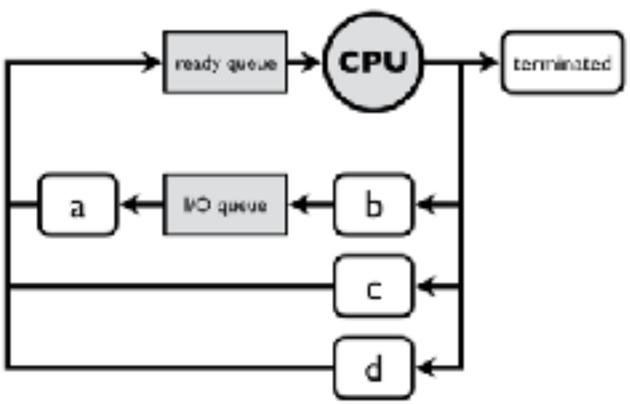
Problem 2.3: Name the four system calls a, b, c and d in the figure below. [2 pt]



	System call	
a	fork	(0.5 pt)
b	exec	(0.5 pt)
c	wait	(0.5 pt)
d	exit	(0.5 pt)

Problem 2.4: Name the events a, b, c, and d in the below diagram. [2 pt]



	Event	
a	I/O req. completion	(0.5 pt)
b	I/O request	(0.5 pt)
c	time slice interupt	(0.5 pt)
d	fork	(0.5 pt)

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Problem 2.5: Zombie processes. [1 pt]

A. A child process becomes a zombie when the parent process terminates before the child.

B. A child process must be an orphan process to become a zombie process.

C. A zombie process don't have an entry in the process table.

D. A child process that terminates always first becomes a zombie before being removed from the process table.

Problem 2.6: For two child process to be able to communicate using a pipe: [1 pt]

A. The parent must create the pipe before creating the children.

B. The first child must create the pipe.

C. The last child must create the pipe.

D. The parent must create the pipe after creating the children.

Problem 3.1: Classification of processes. [1 pt]

A. All batch processes are CPU-bound.

B. All I/O-bound processes are interactive.

C. In order to offer good response time to interactive processes, Linux (like all Unix kernels) implicitly favours I/O-bound processes over CPU-bound ones.

D. A CPU bound process is characterised by many short CPU bursts.

Problem 3.2: In which CPU scheduling algorithm can the convoy effect be observed? [1 pt]

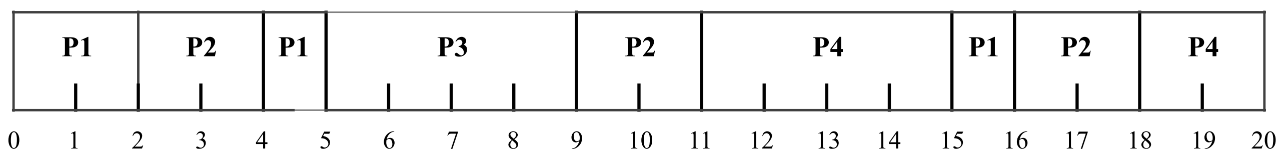
A. Rund robin (RR).

B. Preemptive shortest job first (PSJF).

C. Shortest job first (SJF).

D. First-come, first-served (FCFS).

Problem 3.3: A tuple (PID, A) denotes a process with process identity PID that arrives to the ready queue at time A. In a system the ready queue holds the following processes: (P1, 0), (P2, 1), (P3, 4) and (P4, 8). An unknown scheduling algorithm results in the following Gantt chart.



From the above Gantt chart, calculate the average waiting time and the average response time. [2 pt]

Tip: Remember that 1/2 = 0.5, 1/4 = 0.25, 3/4 = 0.75.

Average response time: 5/4 = 1.25 (1 pt)

Average waiting time: 30/4 = 7.5 (1 pt)

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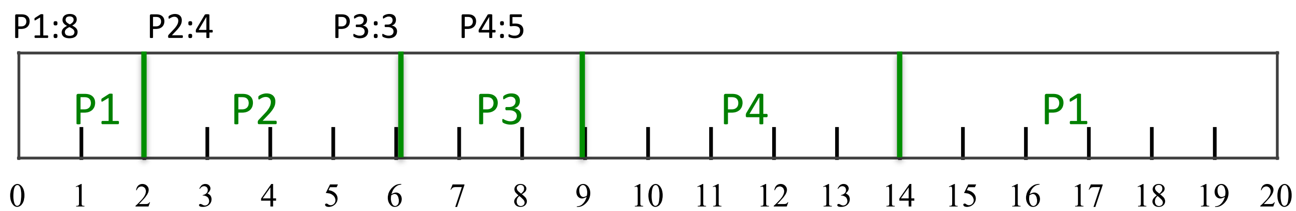
Problem 3.4: A triple (PID, A, B) denotes a process with process identity PID that arrives to the ready queue at time A with CPU burst time B. In a system the ready queue holds the following processes: (P1, 0, 8), (P2, 2, 4), (P3, 5, 3) and (P4, 7, 5). Draw Gantt charts for PSJF and RR with q=3.

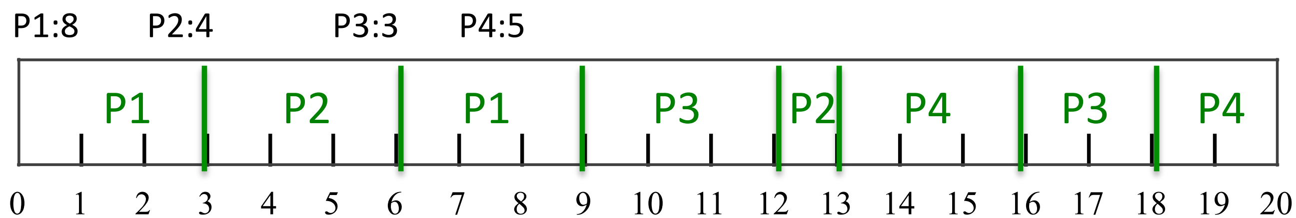
[4 pt]

PSJF



(2 pt)

RR, q = 3



(2 pt)

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Problem 4.1: During a code review in a project using a Java-like language you have found the transfer method.

```
transfer(amount, from, to) {
    atomic { bal = from.balance; }
    if (bal < amount) return NOPE;
    atomic { to.balance   += amount; }
    atomic { from.balance -= amount; }
    return YEP;
}
```

The transfer method have: [1 pt]

A. both data races and race conditions.

B. no data races but race conditions.

C. no data races and no race conditions.

D. data races but no race conditions

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Problem 4.2: Name the four necessary conditions for deadlock. [2 pt]

	Condition	
1	Mutual exclusion	(0.5 pt)
2	No preemption	(0.5 pt)
3	Hold and wait	(0.5 pt)
4	Circular wait	(0.5 pt)

Problem 4.3: Deadlock prevention: [1 pt]

A. is a dynamic method.

B. requires additional apriori information

C. allows for more concurrency compared to deadlock avoidance.

D. allows for less concurrency compared to deadlock avoidance.

Problem 4.4: In the below table four different implementations (A, B, C and D) of a threaded system are shown. In the INIT section a shared boolean variable lock is initialized. Next code for each of the threads in the system is shown. TAS is the atomic test-and-set instruction.

A	B	C	D
INIT	**INIT**	**INIT**	**INIT**
`lock = TRUE;`	`lock = FALSE;`	`lock = FALSE;`	`lock = TRUE;`
Code for each thread	**Code for each thread**	**Code for each thread**	**Code for each thread**

`if (TAS(&lock)) {`
`    // Critical section`
`    lock = FALSE;`
`}`
	`if (TAS(&lock)) {`
	`    // Critical section`
	`    lock = FALSE;`
	`}`
		`while (TAS(&lock));`
		`// Critical section`
		`lock = FALSE;`
			`while (TAS(&lock));`
			`// Critical section`
			`lock = FALSE;`

Which of the above implementations solves the critical section problem without starvation? [1 pt]

A. Implementation A.

B. Implementation B.

C. Implementation C.

D. Implementation D.

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Problem 4.5: The state of a system is defined by the allocation and max matrices together with the available vector below shown below.

Fill in the need matrix. [1 pt]

Determine whether the state is safe by showing each step of the Banker's algorithm using the available matrix and choice vector.

[1 pt]

	Allocation				Max				Need				
Task	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**	**Done**
T_0	4	1	0	0	6	5	6	0					
T_1	2	3	6	0	2	5	6	0					
T_2	4	5	3	1	6	5	3	2					
T_3	0	0	0	1	0	5	7	1					
T_4	2	1	0	0	2	1	0	0					

	Available				
Step	**A**	**B**	**C**	**D**	**Choice**
1	0	2	5	1	
2					
3					
4					
5					
-					-

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	Allocation				Max				Need				
Task	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**	**Done**
T_0	4	1	0	0	6	5	6	0	2	4	6	0	TRUE
T_1	2	3	6	0	2	5	6	0	0	2	0	0	TRUE
T_2	4	5	3	1	6	5	3	2	2	0	0	1	TRUE
T_3	0	0	0	1	0	5	7	1	0	5	7	0	TRUE
T_4	2	1	0	0	2	1	0	0	0	0	0	0	

	Available				
Step	**A**	**B**	**C**	**D**	**Choice**
1	0	2	5	1	T1
2	2	5	11	1	T0
3	6	6	11	1	T2
4	10	11	14	2	T3
5	10	11	14	3	T4
-	12	12	14	3	-

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Problem 5.1: How does paging relate to fragmentation? [1 pt]

A. To minimize external fragmentation the page size must be smaller than the frame size.

B. To minimize internal fragmentation the frame size must be be smaller than the frame size.

C. To prevent external fragmentation the page size must be equal to the frame size.

D. To prevent internal fragmentation the page size must be equal to the frame size.

IEC binary prefixes: 1 KiB = 2^{10} Byte, 1 MiB = 2^{20} Byte and 1 GiB = 2^{30} Byte.

Problem 5.2: While reverse engineering a virtual memory system you have discovered that 8 digit hexadecimal virtual addresses are translated to 7 digit hexadecimal addresses. Further, for all address translations, the three least significant hexadecimal digits are allows identical before and after address translation.

For all of the questions below you must answer using one of the IEC binary prefixes. [3 pt]

Question	Answer	
How large is the virtual address space?	4 GiB	(1 pt)
How large is the physical address space?	256 MiB	(1 pt)
How large is the page/frame size?	4 KiB	(1 pt)

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Problem 5.3: The FAT file system is a variation of: [1 pt]

A. linked allocation.

B. indexed allocation.

C. contiguous allocation

D. the Unix iNode.

Problem 5.4: Indexed file block allocation: [1 pt]

A. suffer from fragmentation and allow random access.

B. do not suffer from fragmentation and allow random access.

C. do not suffer from fragmentation and do not allow random access.

D. suffer from fragmentation and do not allow random access.