CSci 402 - Operating Systems

Final Exam (PM Section)

Fall 2021

(11:00:00am - 11:40:00am, Friday, December 10)

Instructor: Bill Cheng

Teaching Assistant: Zhuojin Li

(This exam is open book and open notes.
Remember what you have promised when you signed your
Academic Integrity Honor Code Pledge.)

Time: 40 minutes

_____-
Name (please print)

Total: 38 points

_____-
Signature

Instructions

1. This is the first page of your exam. The previous page is a title page and does not have a page number. Since this is a take-home exam, no need to sign above since you won't submit this file.
2. Read problem descriptions carefully. You may not receive any credit if you answer the wrong question. Furthermore, if a problem says *"in N words or less"*, use that as a hint that N words or less are expected in the answer (your answer can be longer if you want). Please note that points may get *deducted* if you put in wrong stuff in your answer.
3. If a question doesn't say `weenix`, please do not give `weenix`-specific answers.
4. Write answers to all problems in the **answers text file**.
5. For non-multiple-choice and non-fill-in-the blank questions, please show all work (if applicable and appropriate). If you cannot finish a problem, your written work may help us to give you partial credit. We may not give full credit for answers only (i.e., for answers that do not show any work). Grading can only be based on what you wrote and cannot be based on what's on your mind when you wrote your answers.
6. Please do *not* just draw pictures to answer questions (unless you are specifically asked to draw pictures). Pictures will not be considered for grading unless they are clearly explained with words, equations, and/or formulas. It's very difficult to draw pictures in a text file and you are not permitted to submit additional files other than the answers text file.
7. For problems that have multiple parts, please clearly *label* which part you are providing answers for.
8. Please ignore minor spelling and grammatical errors. They do not make an answer invalid or incorrect.
9. During the exam, please only ask questions to *clarify* problems. Questions such as "would it be okay if I answer it this way" will not be answered (unless it can be answered to the whole class). Also, you are suppose to know the definitions and abbreviations/acronyms of *all technical terms*. We cannot "clarify" them for you. We also will **not** answer any clarification-type question for multiple choice problems since that would often give answers away.
10. Unless otherwise specified and stated explicitly, multiple choice questions have one or more correct answers. You will get points for selecting correct ones and you will lose points for selecting wrong ones.
11. When we grade your exam, we must assume that you wrote what you meant and you meant what you wrote. So, please write your answers accordingly.

(Q1) (2 points) Which of the following statements are correct about what happens when an appplication running inside a virtual machine makes a system call?

(1) the system call will eventually get turned into an upcall to reach the guest OS
(2) the system call would trap into the VMM first
(3) the system call will eventually be emulated by the VMM
(4) the system call will first be intercepted by the dynamic linker inside the VMM
(5) none of the above is a correct answer

Answer (just give numbers): 1, 2

(Q2) (2 points) Which of the following statements are **correct** about **microkernel**?

(1) one main differences between a message port and a Unix pipe is that you can assign names to Unix pipes
(2) access control in a microkernel system typically is based on user IDs and group IDs just like a traditional Unix system
(3) almost all microkernel implementations have good performance
(4) in the design of the microkernel architecture, device drivers cannot be moved into user space
(5) none of the above is a correct answer

Answer (just give numbers): _____

(Q3) (2 points) Which of the following statements are correct about the **NOR** vs. **NAND** flash memory technologies?

(1) a NOR flash is more suitable to be used in a file system than a NAND flash
(2) for writing, a NAND flash is page-erasable but not block-erasable
(3) a NAND flash is byte-addressable
(4) a NOR flash is byte-addressable
(5) for a NAND flash, the smallest addressable unit for reading is a page

NAND is page-addressable

Answer (just give numbers): 4, 5

(Q4) (2 points) Which of the following statements are correct about **physical vs. virtual addresses** on a 32-bit machine?

(1) there is a system call a user thread can call to ask the OS to convert a user space virtual address into physical address
(2) a thread uses physical addresses when it first got created in the kernel and switch to use virtual addresses when it runs in the user space for the first time
(3) a device driver uses physical addresses to execute code but use virtual address to access data on a device
(4) a user thread can use physical addresses if it makes a system call and turns into a kernel thread
(5) none of the above is a correct answer

Answer (just give numbers): _____

(Q5) (3 points) Let's say that you have four threads A, B, C, and D and you are using the basic **round-robin (RR) / time-slicing** scheduler with a very small time slice. At time zero, all four threads are in the run queue and their processing times are shown in the table below. Assuming that there are no future arrivals into the run queue, please complete the table below with the "waiting time" of all four threads and the "average waiting time" (AWT) of these four threads and write the results on your answer sheet. Please make it very clear which waiting time is for which thread and which one is the AWT. For non-integer answers, you can use fractions or decimals with two digits after the decimal point. Your answer must not contain plus or multiplication symbols. You must use the definition of "waiting time" given in lectures.

	A	B	C	D	AWT (1 pt)
T (hrs)	8	5	6	8	-
wt (hrs)	27	20	23	27	24.25

(Q6) (2 points) Which of the following statements are correct about **vfork**()?

(1) **fork**() is usually faster than **vfork**()
(2) if **vfork**() is used, the parent process and the child process can never run "concurrently" even if the programmer's code is perfect
(3) **fork**() and **vfork**() are equivalent
(4) **vfork**() is best used by expert programmers because it's tricky to use it correctly
(5) none of the above is a correct answer

Answer (just give numbers): _____

(Q7) (3 points) Let's say that you have four threads A, B, C, and D and you are using **stride scheduling**. You have decided to give thread A 5 ticket, thread B 9 tickets, thread C 5 tickets, and thread D 6 tickets. The initial pass values that **you must used** for the four threads are shown below along with the "winner" of the iteration 1. Please run **stride scheduling** to fill out all the entries (pass values) in the table and keep track of the "winner" in each round. For **iterations 2 through 7**, please write on your answer sheet the "winner" and the winning pass value of that iteration. (For example, you would write "A:4" for iteration 1 since A is the "winner" of iteration 1 and the winning pass value is 4.) You must use the **smallest possible integer stride values** when calculating all the pass values. If you get the stride values wrong, you will not get any partial credit for this problem.

itr	A	B	C	D
1	(4)	17	23	31
2		17		
3	22			
4			23	
5		27		
6				31
7		37		

(Q8) (2 points) Which of the following statements are correct about **futex**?

(1) the best place to use a futex is inside the kernel
(2) futex is considered "fast" because if the futex is available, a user thread can lock it quickly in user space without making a system call
(3) if a futex is currently **locked** and not being released, a thread calling `futex_lock()` must enter the kernel to wait for the lock to be released
(4) futex is designed to work only in multi-CPU systems and will not work in single-CPU systems
(5) in order for a futex to function correctly when there are multiple CPUs, the kernel is ~~required~~ to be a ~~non-~~preemptive kernel

Answer (just give numbers): _____

(Q9) (2 points) A **disk map** of a S5FS **inode** contains 13 disk block pointers. If a disk block is 1KB in size, which of the following are **possible file sizes** if an inode's **disk map** contains non-null block numbers in the first 12 entries and the last entry is null?

(1) 200 MB
(2) 960 KB
(3) 24 MB
(4) 96 MB
(5) 100 KB

10KB+256KB+64MB+16GB

Answer (just give numbers): _____

(Q10) (2 points) A correct implementation of **straight-threads synchronization** for a single CPU system is shown here:

```
void mutex_lock(mutex_t *m)
{
  if (m->locked) {
    enqueue(m->queue,
        CurrentThread);
    thread_switch();
  } else
    m->locked = 1;
}
```

```
void mutex_unlock(mutex_t *m)
{
  if (queue_empty(m->queue))
    m->locked = 0;
  else
    enqueue(runqueue,
        dequeue(m->queue));
}
```

Let's say that thread X owns mutex **m1** and thread Y owns a different mutex **m2**. Which of the following statements are correct about what would happen if thread Y calls **mutex_lock(m1)**?

(1) thread X will enter **mutex_unlock()** immediately and thread Y will return from mutex_lock() immediately with mutex **m1** locked
(2) thread Y will go to sleep in the run queue
(3) thread X will enter **thread_switch()** and thread Y will return from **thread_switch()** immediately
(4) thread Y will go to sleep in **m1**'s mutex queue
(5) thread Y will enter **thread_switch()** and thread X will return from **thread_switch()** immediately

Answer (just give numbers): _____

(Q11) (2 points) Which of the following statements are **correct** about **executing sensitive instructions** in an IBM 360 **virtual machine**?

page 765

(1) when a sensitive instruction is executed in the **VMM**, the sensitive instruction will get emulated by the VMM
(2) when a sensitive instruction is executed in the **virtual user mode** inside the **virtual machine**, the sensitive instruction will get emulated by the VMM
(3) when a sensitive instruction is executed in the **privileged mode** of the **real machine**, it should cause a trap into the VMM
(4) when a sensitive instruction is executed in the **virtual privileged mode** inside the **virtual machine**, it should get delivered to the guest OS
(5) none of the above is a correct answer

Answer (just give numbers): _____

(Q12) (2 points) Let's say that you are using a **rate-monitonic scheduler** to schedule 4 periodic tasks with $T_1 = 0.5$, $P_1 = 4.5$, $T_2 = 1$, $P_2 = 5$, $T_3 = 0.5$, $P_3 = 5.5$, and $T_4 = 1$, $P_4 = 6$. Let's say that you schedule all 4 period tasts to start a time = 0. Since the total utilization is too large to guarantee that all jobs will meet their deadlines, the only way to know is to simulate the **rate-monitonic scheduler**. How many seconds into the simulation would be the first time all 4 jobs would start executing at exactly the same time again? Please just give a numeric answer (no partial credit for this problem).

(Q13) (2 points) Let's say that the address space of a user space in **weenix** looks like the following:

```
      VADDR RANGE        PROT  FLAGS    MMOBJ     OFFSET    VFN RANGE
0x0803a000-0x08049000   rw-  PRIVATE 0xcfe0c034 0x0000d 0x0803a-0x08049
0x08049000-0x0804d000   r-x  PRIVATE 0xcfe0c004 0x0000e 0x08049-0x0804d
0x0804d000-0x08062000   rw-  PRIVATE 0xcfe0c064 0x0000b 0x0804d-0x08062
```

If you get a page fault with vaddr = 0x0805c668, what **pagenum** would you use to lookup a page frame when you are handling a page fault? Please just give an integer value answer (no partial credit for this problem).

(Q14) (2 points) Which of the following statements are correct about the **popf machine instruction** in a **traditional Intel x86 processor**, i.e., non-Vanderpool?

(1) executing `popf` in the user mode will not cause a trap while executing it in the privileged mode will cause a trap
(2) `popf` behaves differently when it is executed in the user mode and in the privilege mode
(3) executing `popf` will not cause a trap in either user mode or privileged mode
(4) executing `popf` in the user mode causes a trap while executing it in the privileged mode does not
(5) `popf` is a privileged instruction and not a "sensitive instruction"

Answer (just give numbers): _____

(Q15) (2 points) Which of the following is correct about **management of page frames**?

(1) in Linux, user pages can be found in all three physical memory "zones"
(2) if the idea of "working set" is fully implemented in the OS, thrashing can be prevented
(3) if "local allocation" is used in the OS, thrashing can still happen
(4) in Linux, a dirty and inactive page frame must be freed/deallocated after it has been "cleaned" (i.e., content written back to disk)
(5) none of the above is a correct answer

Answer (just give numbers): _____

(Q16) (2 points) Which of the following statements are correct about **paravirtualization**?

(1) a paravirtualized OS is indistinguishable from the real OS in the sense that it can also run on the hardware the real OS was designed to run on
(2) VMware is well-known for its paravirtualization patent binary writing
(3) one way to implement paravirtualization is to to fix the hardware so that an OS can run inside a virtual machine without modification
(4) inside a commercial paravirtualized OS, usually there are no device drivers
(5) none of the above is a correct answer

Answer (just give numbers): _____

(Q17) (2 points) Which of the following statements are correct about virtual machine (VM) and virtual machine monitor (VMM)?

(1) when virtual machine is used, the OS of the real machine is often referred to as the guest OS
(2) VMM is also known as "hypervisor"
(3) VMM is a terminal device that's used to interact with a virtual machine
(4) VMM is a user space program that runs inside a virtual machine
(5) when virtual machine is used, the guest OS runs in the user mode of the real machine

Answer (just give numbers): _____

(Q18) (2 points) Which of the following statements are correct about having a **monolithic kernel**?

(1) the main disadvantage of a monolithic kernel is not-so-great reliability
(2) a monolithic kernel is typically more robust (i.e., crashes less) because it's not broken into little pieces
(3) the main advantage of a monolithic kernel is performance
(4) the Linux kernel is a monolithic kernel
(5) a monolithic kernel encourages system programmers to write more elegant code

Answer (just give numbers): _____

CSci 402 - Operating Systems
Final Exam (DEN Section)
Spring 2020

(9:00am - 9:40am, Friday, May 8)

Instructor: Bill Cheng

Teaching Assistant: Ben Yan

(This exam is closed book, closed notes, closed everything.
No "cheat sheet" allowed.
No calculators, cell phones, or any electronic gadgets.)

Time: 40 minutes

_____-
Name (please print)

Total: 32 points

_____-
Signature

Instructions

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(Q1) (2 points) Which of the following statements are correct about a **terminal driver** and a **pseudo-terminal driver**?

(1) for a pseudo-terminal, the input and output (on the device end) comes from and goes to a device
(2) pseudo-terminal does not behave like a terminal at all
(3) both pseudo-terminal driver and terminal driver are kernel drivers
(4) for a pseudo-terminal, the input and output (on the device end) comes from and goes to an application
(5) a pseudo-terminal driver runs in user space while a terminal driver runs in the kernel

Answer (just give numbers): _____

(Q2) (2 points) Let's say that you have three threads A, B, and C and you are using **stride scheduling**. You have decided to give thread A 2 tickets, thread B 4 tickets, and thread C 5 ticket. The initial pass values that **you must used** for the three threads are shown below along with the "winner" of the iteration 1. Please fill out all the entries (pass values) in the table. For **iterations 2 through 5**, please write on your answer sheet the "winner" and the winning pass value of that iteration. (For example, you would write "B:2" for iteration 1 since B is the "winner" and the winning pass value is 2.) You must use the **smallest possible integer stride values** when calculating the pass values. Please note that if you get the stride values wrong, you will not get any partial credit for this problem.

itr	A	B	C
1	5	(2)	4
2			4
3	5		
4		7	
5			8

(Q3) (2 points) Which of the following statements are correct about **network device drivers** and **terminal device drivers**?

(1) their abstractions to user applications are completely different
(2) in network communication, data needs to be passed from one layer to another without copying
(3) network drivers deal with binary data while terminal drivers deal with non-binary data
(4) one major difference between the two is the data rate they must deal with
(5) most of the work performed by a network device driver is done as "deferred processing"

Answer (just give numbers): _____

(Q4) (2 points) A correct implementation of **straight-threads** (i.e., no interrupt) **synchronization** on a single processor is shown here:

```
void mutex_lock(mutex_t *m)
{
  if (m->locked) {
    enqueue(m->queue,
        CurrentThread);
    thread_switch();
  } else
    m->locked = 1;
}
```

```
void mutex_unlock(mutex_t *m)
{
  if (queue_empty(m->queue))
    m->locked = 0;
  else
    enqueue(runqueue,
        dequeue(m->queue));
}
```

Let's say that thread X owns mutex **m**. Which of the following statements are correct about what would happen if another thread (thread Y) calls **mutex_lock(m)**?

(1) thread Y will enter the run queue and will try to lock the mutex again next time when it runs
(2) thread X will enter **mutex_unlock()** immediately and thread Y will return from mutex_lock() immediately with the mutex locked
(3) thread Y will enter **m**'s mutex queue and thread X will not be affected
(4) thread X will enter **thread_switch()** and thread Y will return from thread_switch() immediately
(5) thread Y will enter **thread_switch()** and thread X will return from thread_switch() immediately

Answer (just give numbers): _____

(Q5) (2 points) Which of the following statements are correct about having a **monolithic kernel**?

(1) its main advantage is performance
(2) its main disadvantage is reliability
(3) it's more robust (i.e., crashes less) because it's not broken into little pieces
(4) it encourages system programmers to write more elegant code
(5) none of the above is correct

Answer (just give numbers): _____

(Q6) (2 points) Which of the following statements are correct about virtual machine monitor (VMM)?

(1) VMM is a terminal device that's attached to a virtual machine
(2) VMM is an application that runs inside a virtual machine
(3) in the virtual machine approach, the VMM runs in the user mode of the real machine
(4) VMM is sometimes referred to as the "hypervisor"
(5) in the virtual machine approach, the OS of the "real machine" is the VMM

Answer (just give numbers): _____

(Q7) (2 points) What are the reasons the **line-disciplining code** is made into a separate **module**? (Please note that the word "locale" below refers to "language-specific issues" in the line-discipline module.)

(1) modularity: separate the device dependent part from the device independent part in handling the terminal device
(2) make the code for dealing with different locales easier to write since system programmers won't have to worry about hardware specific characteristics
(3) make terminal device drivers easier to write because device manufacturers won't have to write code to deal with different locales
(4) performance: make the terminal device seem more responsive
(5) none of the above is correct

Answer (just give numbers): _____

(Q8) (2 points) Let's say that you have three threads A, B, and C and you are using the basic **round-robin (RR) / time-slicing** scheduler with a very small time slice. At time zero, all three threads are in the run queue and their processing times are shown in the table below. Assuming that there are no future arrivals into the run queue, please complete the table below with the "waiting time" of all three threads and the "average waiting time" (AWT) of these three threads and write the results on your answer sheet. Please make it very clear which waiting time is for which thread and which one is the AWT. For non-integer answers, you can use fractions or decimals with two digits after the decimal point. Your answer must not contain plus or multiplication symbols. You must use the definition of "waiting time" given in lectures.

	A	B	C	AWT
T (hrs)	5	4	6	-
wt (hrs)	14	12	15	41/3

(Q9) (2 points) Which of the following statements are correct about **I/O virtualization**?

(1) I/O virtualization is not a big problem in building virtual machines on servers because only a small number of devices need to be supported
(2) in VMware's solution to I/O virtualization, most device drivers in the guest OS must be rewritten so that they can be supported
(3) I/O virtualization in building virtual machines on popular end-user machines is challenging because it's virtually impossible for virtual machine vendors to support all devices
(4) in Xen's solution to I/O virtualization, only a few device drivers in the guest OS has to be rewritten in order for Xen to use them
(5) VMware's I/O virtualization solution performs faster than Xen's solution

Answer (just give numbers): _____

(Q10) (2 points) For a terminal, input characters may need to be processed/edited in some way before they reach the application. What **data structures** are used to **solve this problem**? Please select the best answer below (i.e., **only one** answer).

(1) a pair of input/output buffers
(2) an address translator
(3) a hash table and a B+ tree
(4) a partial-line queue and a completed-line queue
(5) none of the above is correct

Answer (just give numbers): _____

(Q11) (2 points) Which of the following statements are correct about the **popf machine instruction** in a regular **Intel x86 processor**?

(1) executing it in the user mode causes a trap while executing it in the privileged mode does not
(2) it behaves differently when it is executed in kernel and user modes
(3) executing it even in the privileged mode would cause a trap
(4) executing it in either the user mode or the privileged mode won't cause a trap
(5) none of the above is correct

Answer (just give numbers): _____

(Q12) (2 points) Which of the following statements are correct about what happens when a user process that runs in a virtual machine makes a system call?

(1) the system call is converted into another system call for the VMM
(2) the system call is ~~emulated~~ by the guest OS
(3) the system call would first trap into the ~~guest OS~~ VMM
(4) the system call is intercepted by the dynamic linker in the VMM
(5) none of the above is correct

Answer (just give numbers): _____

(Q13) (2 points) Which of the following statements are correct about **paravirtualization**?

(1) it means to fix the hardware so that an OS/kernel can run in a virtual machine without modification
(2) it means that the virtualized OS/kernel is a modified version of the real OS/kernel
(3) VMware is well-known for ~~its paravirtualization~~ patent
(4) a Xen system uses paravirtualization
(5) none of the above is correct

Answer (just give numbers): _____

(Q14) (2 points) Which of the following statements are correct about **executing a sensitive instruction** in an IBM 360 **virtual machine**?

(1) when a sensitive instruction is executed in the **VMM**, it should causes an additional trap into the VMM itself
(2) when a sensitive instruction is executed in the **virtual privileged mode** of the **virtual machine**, it should cause a trap into the VMM
(3) when a sensitive instruction is executed in the **virtual user mode** of the **virtual machine**, it should cause a trap into the VMM
(4) when a sensitive instruction is executed in the **privileged mode** of the **real machine**, it should cause a trap into the VMM
(5) none of the above is correct

Answer (just give numbers): _____

(Q15) (2 points) What are the **OS approaches** to fix the **reliability** problem of a **monolithic kernel** to reduce kernel crashes?

(1) never release a kernel unless it's completely bug-free
(2) run the entire system (kernel+applications) inside a virtual machine
(3) shrink the code that must run in the privileged mode
(4) make the kernel code "open-source" so that anyone can look for bugs in the kernel
(5) none of the above is correct

Answer (just give numbers): _____

(Q16) (2 points) For a terminal, it is possible that characters can arrive from the keyboard even though there isn't a waiting read request from an application. It is also possible that characters generation are too fast for the terminal to display characters. What **data structures** are used to **solve these two problems**? Please select the best answer below (i.e., **only one** answer).

(1) an address translator
(2) a partial-line queue and a completed-line queue
(3) a pair of input/output buffers
(4) a hash table and a B+ tree
(5) none of the above is correct

Answer (just give numbers): _____

CSci 402 - Operating Systems

Final Exam (PM Section)

Spring 2020

(3:00pm - 3:40pm, Wednesday, May 13)

Instructor: Bill Cheng

Teaching Assistant: (N/A)

(This exam is closed book, closed notes, closed everything.
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No calculators, cell phones, or any electronic gadgets.)

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11. When we grade your exam, we must assume that you wrote what you meant and you meant what you wrote. So, please write your answers accordingly.

(Q1) (2 points) Which of the following statements are correct about the basic (two-level) virtual memory scheme where a virtual address is divided into a virtual page number (say 20 bits) and an offset (say 12 bits) on a 32-bit machine?

(1) during the lifetime of a user process, the mapping of virtual pages to physical pages stays the same
(2) a physical address is obtained by adding a physical page number with the 12-bit offset
(3) an entry in a page table contains a 20-bit physical page number no matter how much physical memory is present
(4) when performing a virtual to physical address translation, the least-significant 12-bits of the virtual address (i.e., the offset) must equal to the least-significant 12-bits of the translated address
(5) the virtual page number is just an index into a page table which has 2^{20} entries

Answer (just give numbers): 4,5 4,5是对的，slides 336页

(Q2) (2 points) Which of the following statements are correct about the **NOR** vs. **NAND** flash memory technologies?

(1) a NOR flash is not page-erasable but only block-erasable
(2) for a NOR flash, you can read/write individual bytes
(3) a NAND flash is page-addressable
(4) for a NAND flash, you can read/write individual bytes
(5) none of the above is correct

Answer (just give numbers): 2,3 2，3是对的，slides684页

(Q3) (2 points) Which of the following statements are correct about **undo journaling** and **redo journaling**?

(1) in redo journaling, you record "after images" in the log
(2) in undo journaling, you record "after images" in the log
(3) in redo journaling, you record "before images" in the log
(4) in undo journaling, you record "before images" in the log
(5) you record the same information into the log no matter if you are using undo journaling or redo journaling

Answer (just give numbers): 1,4 1，4是对的，slides617页

(Q4) (2 points) Which of the following statements are correct about using the **multi-level feedback queue** to schedule both interactive and non-interactive jobs?

(1) if a thread blocks before using up a full time slice, you should try to decrease its priority
(2) if a thread uses a full time slice, you should try to increase its priority
(3) if a thread blocks before using up a full time slice, you should try to increase its priority
(4) if a thread uses a full time slice, you should try to decrease its priority
(5) none of the above is correct

Answer (just give numbers): 4 4是对的，slides846页

(Q5) (2 points) Which of the following statements are correct about using **base and bounds** registers in a **segmented virtual memory** scheme?

(1) the base and bounds scheme can be extended to provide the ability to map an entire file or part of it into a memory segment
(2) the base and bounds scheme can be extended to provide backing-store for memory segments
(3) the base and bounds scheme can be extended to provide read-only vs. read-write access control for memory segments
(4) the base and bounds scheme can be extended to provide copy-on-write for memory segments
(5) none of the above is correct

Answer (just give numbers): 2,3,4 1，2，3，4都是对的，307页开始都有讲到

(Q6) (2 points) Which of the following statements are correct about using the **aging** mechanism for a **multi-level feedback queue**?

(1) aging is not necessary since threads can never starve if you use a multi-level feedback queue
(2) aging is a way to improve throughput for a multi-level feedback queue
(3) aging is a way to solve the starvation problem for a multi-level feedback queue
(4) if aging is used, the scheduler may increase a thread's priority if the thread has not run for a long time
(5) none of the above is correct

3，4是对的，846页

Answer (just give numbers): 3,4

(Q7) (2 points) Which of the following statements are correct about **linear page tables**?

(1) to translate a virtual address to a physical address in a linear page table requires the use of two page tables
(2) in a linear page table scheme, all page table entries in all page tables contains a virtual page number
(3) in a linear page table scheme, all page table entries in all page tables contains a physical page number
(4) in a linear page table scheme, a page table entry may contain a virtual page number while another page table entry may contain a physical page number
(5) none of the above is correct

Answer (just give numbers): 1, 4

1，4应该是对的，slides没有，在lecture19part2种里口头讲了

(Q8) (2 points) Let's say that you have three threads A, B, and C and you are using **stride scheduling**. You have decided to give thread A 2 tickets, thread B 3 tickets, and thread C 4 ticket. The initial pass values that **you must used** for the three threads are shown below along with the "winner" of the iteration 1. Please fill out all the entries (pass values) in the table. For **iterations 2 through 5**, please write on your answer sheet the "winner" and the winning pass value of that iteration. (For example, you would write "B:2" for iteration 1 since B is the "winner" and the winning pass value is 2.) You must use the **smallest possible integer stride values** when calculating the pass values. Please note that if you get the stride values wrong, you will not get any partial credit for this problem.

itr	A	B	C
1	5	2	4
2	5	6	4
3	5	6	7
4	11	6	7
5	11	10	7

A 2 : 6
B 3 : 4
C 4 : 3

这个答案全对，
第一步：根据ticket求出stride，A：6，B：4，C：3

```
stride = 1 / ticket
```

第二步：每轮pass值里最小的胜出，pass = pass + stride，输了的pass值不变。
第三步：比较更新后的pass值。
如此循环。

(Q9) (2 points) Let's say that you have three threads A, B, and C and you are using the basic **round-robin (RR) / time-slicing** scheduler with a very small time slice. At time zero, all three threads are in the run queue and their processing times are shown in the table below. Assuming that there are no future arrivals into the run queue, please complete the table below with the "waiting time" of all three threads and the "average waiting time" (AWT) of these three threads and write the results on your answer sheet. Please make it very clear which waiting time is for which thread and which one is the AWT. For non-integer answers, you can use fractions or decimals with two digits after the decimal point. Your answer must not contain plus or multiplication symbols. You must use the definition of "waiting time" given in lectures.

	A	B	C	AWT
T (hrs)	2	7	6	-
wt (hrs)	6	15	14	11.67

答案全对
按照ABC的耗时由小到大排列计算顺序
A<C<B
WTa = 3 x 2 = 6
WTc = 2 x (6-2) + 6 = 14
WTb = 1 x (7-6) + 14 = 15
AWT = (6 + 14 + 15)/ 3 = 11.67

(Q10) (2 points) Which of the following statements are correct about **physical vs. virtual addresses** on a 32-bit machine?

(1) a user process uses physical addresses for code when it's running in the kernel and uses virtual addresses when it's running in user space
(2) a device driver uses physical addresses for both code and data
(3) a system call can be used for a user process to convert a virtual address to physical address
(4) a kernel process uses physical addresses for code when it is created and switch to use virtual addresses when it's running for the first time
(5) none of the above is correct

5是对的，slides296页

Answer (just give numbers): 5

(Q11) (2 points) Which of the following are useful approaches to **reduce page fault latency**?

(1) use a pageout daemon
(2) use a FIFO replacement policy
(3) prefetching
(4) use a larger translation lookaside buffer
(5) lazy evaluation

Answer (just give numbers): 1, 3

1，3是对的，slides410页

(Q12) (2 points) Which of the following statements are correct about the **free block list** in **S5FS**?

(1) the head and tail of the free block list in S5FS is stored in the superblock
(2) it is organized into a hash table
(3) it is organized into a doubly-linked list
(4) each node in the free block list in S5FS can contain up to 99 disk block pointers
(5) none of the above is correct

5应该是对的，265页

Answer (just give numbers): 5,

(Q13) (2 points) Which of the following statements are correct about **scheduling**?

(1) in a **multi-processor** system, **cache affinity** means that after a thread has run on a particular processor, it's beneficial to schedule it on the same processor next time it runs
(2) rate-monotonic scheduling can be used to schedule non-periodic jobs
(3) in a hard real-time system, a rate-monotonic scheduler usually performs better (i.e., schedule more jobs) than a EDF (earliest deadline first) scheduler
(4) priority inversion is not possible if all you have are kernel threads
(5) in a **multi-processor** system, to take advantage of **cache affinity**, it's better to use **one shared queue** for multiple processors because you won't have to **load balance**

1是对的，931页

Answer (just give numbers): 1,

(Q14) (2 points) Considering only **clustered hash page table** schemes and **(non-clustered) hashed page table** schemes, which of the following statements are correct?

(1) the performance of non-clustered hash page tables depends on the lengths of the hash conflict/collision resolution chains
(2) the performance of clustered hash page tables is independent of how address space is allocated
(3) clustered hash page tables would perform better if address space is truly sparsely allocated
(4) non-clustered hash page tables would perform better if contiguous virtual pages are used (such as in weenix)
(5) none of the above is correct

1，2是对的，362页

Answer (just give numbers): 1, 2,

(Q15) (2 points) Which of the following statements are correct for a **forward-mapped (multilevel) page tables** where a 32-bit virtual address is divided into a 10-bit page directory number, a 10-bit page table number, and a 12-bit offset (such as an x86 processor)?

(1) a multilevel page table scheme is preferred over the basic (two-level) page table scheme because address translation is faster
(2) the basic (two-level) page table scheme is more space efficient than the multilevel page table scheme
(3) at least two entries in a page directory table must be valid, even in weenix
(4) a page directory table is the same size as a page table
(5) a page directory table is the same size as a physical memory page

Answer (just give numbers): 3,4 这题不会

4

(Q16) (2 points) Which of the following statements are correct about using **base and bounds** registers in a **segmented virtual memory** scheme?

(1) the bounds register contains a virtual address
(2) the bounds register contains a physical address
(3) the base register contains a virtual address
(4) the base register contains a physical address
(5) none of the above is correct

Answer (just give numbers): 3, 应该选4吧，307页

CSci 402 - Operating Systems
Final Exam (DEN Section)
Spring 2021

(9:00:00am - 9:40:00am, Friday, May 7)

Instructor: Bill Cheng

Teaching Assistant: Ben Yan

(This exam is open book and open notes.
Remember what you have promised when you signed your
Academic Integrity Honor Code Pledge.)

Time: 40 minutes

_____-
Name (please print)

Total: 38 points

_____-
Signature

Instructions

1. This is the first page of your exam. The previous page is a title page and does not have a page number. Since this is a take-home exam, no need to sign above since you won't submit this file.
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3. If a question doesn't say `weenix`, please do not give `weenix`-specific answers.
4. Write answers to all problems in the **answers text file**.
5. For non-multiple-choice and non-fill-in-the blank questions, please show all work (if applicable and appropriate). If you cannot finish a problem, your written work may help us to give you partial credit. We may not give full credit for answers only (i.e., for answers that do not show any work). Grading can only be based on what you wrote and cannot be based on what's on your mind when you wrote your answers.
6. Please do *not* just draw pictures to answer questions (unless you are specifically asked to draw pictures). Pictures will not be considered for grading unless they are clearly explained with words, equations, and/or formulas. It's very difficult to draw pictures in a text file and you are not permitted to submit additional files other than the answers text file.
7. For problems that have multiple parts, please clearly *label* which part you are providing answers for.
8. Please ignore minor spelling and grammatical errors. They do not make an answer invalid or incorrect.
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10. Unless otherwise specified and stated explicitly, multiple choice questions have one or more correct answers. You will get points for selecting correct ones and you will lose points for selecting wrong ones.
11. When we grade your exam, we must assume that you wrote what you meant and you meant what you wrote. So, please write your answers accordingly.

(Q1) (2 points) For a terminal, input characters may need to be processed/edited in some way before they reach the application. Which of the following **data structures** are used to solve this problem?

(1) a completed-line queue
(2) a translation lookaside buffer
(3) a partial-line queue
(4) a B tree and a hash table
(5) none of the above is a correct answer

Answer (just give numbers): _____

(Q2) (2 points) In a **segmented virtual memory** system with **base and bounds** registers, the basic scheme uses **one pair of base and bounds registers in the MMU** for each of the 4 basic memory segments. Which of the following statements are correct about extending this basic scheme?

(1) to provide support for memory-mapped files, more pairs of base and bounds registers are required in the MMU
(2) there is nothing that needs to be added to the MMU to provide support for "backing store"
(3) to add support for "backing store", access protection bits are added to each pair of base and bounds registers
(4) to provide access protection to memory segments, a validity/present bit needs to be added to each pair of base and bounds registers
(5) none of the above is a correct answer

Answer (just give numbers): _____

(Q3) (2 points) Which of the following are bits inside a PTE (page table entry) in **weenix** (which runs on an x86 CPU)?

(1) a "present" bit
(2) a "private/shared" bit
(3) a "user/kernel" bit
(4) an "execute" bit
(5) none of the above is a correct answer

Answer (just give numbers): _____

(Q4) (3 points) Let's say that you have four threads A, B, C, and D and you are using **stride scheduling**. You have decided to give thread A 2 ticket, thread B 3 tickets, thread C 4 tickets, and thread D 2 tickets. The initial pass values that **you must used** for the four threads are shown below along with the "winner" of the iteration 1. Please run **stride scheduling** to fill out all the entries (pass values) in the table and keep track of the "winner" in each round. For **iterations 2 through 7**, please write on your answer sheet the "winner" and the winning pass value of that iteration. (For example, you would write "A:3" for iteration 1 since A is the "winner" of iteration 1 and the winning pass value is 3.) You must use the **smallest possible integer stride values** when calculating all the pass values. If you get the stride values wrong, you will not get any partial credit for this problem.

itr	A	B	C	D
1	3	5	9	10
2				
3				
4				
5				
6				
7				

(Q5) (2 points) Which of the following statements are **incorrect** about **I/O virtualization**?

(1) in Xen's solution to I/O virtualization, only a few device drivers in the guest OS has to be rewritten in order for Xen to use them

(2) I/O virtualization in building virtual machines for desktop machines is challenging because it's virtually impossible for virtual machine vendors to support all devices

(3) I/O virtualization is not as big of a problem in building virtual machines for high performance servers because only a small number of devices need to be supported

(4) in VMware's solution to I/O virtualization, most device drivers in the guest OS must be rewritten so that they can be supported

(5) Xen's I/O virtualization solution performs better than VMward's I/O virtualization solution

Answer (just give numbers): _____

(Q6) (2 points) which of the following statements are correct about the **N x 1 (two-level)** thread implementation model?

(1) in this model, it's not necessary to trap into the kernel when locking and unlocking mutexes
(2) in this model, when a user thread makes a system call and gets blocked inside the kernel, other threads in the same process can still run as long as they don't make system calls
(3) this model is used in the old days when the kernel didn't know about multithreading in user space programs
(4) in this model, thread creation and destruction still have to be implemented as system calls
(5) in this model, when one user thread wants to give up the processor to switch to another user thread in the same process, it must make a system call

Answer (just give numbers): _____

(Q7) (2 points) A correct implementation of **straight-threads** (i.e., no interrupt) **synchronization** on a single CPU is shown here:

```
void mutex_lock(mutex_t *m)
{
  if (m->locked) {
    enqueue(m->queue,
        CurrentThread);
    thread_switch();
  } else
    m->locked = 1;
}
```

```
void mutex_unlock(mutex_t *m)
{
  if (queue_empty(m->queue))
    m->locked = 0;
  else
    enqueue(runqueue,
        dequeue(m->queue));
}
```

Let's say that thread X owns the mutex **m** (i.e., has it locked). If thread X calls **mutex_unlock()** and the mutex queue is **not** empty, the thread at the head of the mutex queue (let's call it thread Y) is supposed to own the mutex next. The above code would dequeue thread Y from the mutex queue and enqueue thread Y to the run queue **without unlocking the mutex**. Referring to the above code, which of the following statements are correct about **the next time thread Y will run** in the CPU?

(1) since thread Y is the new mutex owner, thread Y will call **mutex_lock()** again and will successfully lock mutex **m**
(2) thread Y go into zombie state before returning from **thread_switch()**
(3) thread Y will return from the **thread_switch()** function inside **mutex_lock()** as the owner of mutex **m**
(4) it is possible that thread Y would wake up inside **thread_switch()** but go to sleep again insdie **thread_switch()** without returning from **thread_switch()**
(5) even though thread Y is the new mutex owner, thread Y will still call **mutex_lock()** and may go to sleep again in **thread_switch()**

Answer (just give numbers): _____

(Q8) (2 points) Which of the following statements are correct about a **SJF (shortest job first)** scheduler?

(1) it generally has a smaller variance in waiting time than other schedulers
(2) it appears to have a high throughput
(3) it's a scheduler that's inherently unfair to long jobs
(4) "starvation" at the scheduler cannot occur with this scheduling policy
(5) compared with some other schedulers, this scheduler can have a large average waiting time for the jobs that are in run queue

Answer (just give numbers): _____

(Q9) (2 points) Which of the following statements are correct about **paravirtualization**?

(1) the paravirtualized guest OS cannot run directly on the real hardware
(2) the guest OS cannot tell if it's running on the real machine or inside a virtual machine
(3) one main disadvantage of paravirtualization is performance
(4) compared with full virtualization, paravirtualization can deal with "sensitive instructions" much easier
(5) only limited amount of modifications can be made to the guest OS when paravirtualization is used

Answer (just give numbers): _____

(Q10) (2 points) Which of the following statements are correct about **shadow objects** if we want **copy-on-write** and **fork()** to work together?

(1) a chain of shadow objects is maintained in a double-linked circular list in weenix
(2) a shadow object holds pages that were copy-on-write but have never been modified
(3) if a virtual memory segment is read-only, its first mmobj must be a shadow object
(4) if a virtual memory segment is privately mapped and writable, you must use a shadow object for its first mmobj
(5) if a virtual memory segment is shared-mapped, you must use a shadow object for its first mmobj

Answer (just give numbers): _____

(Q11) (2 points) A **disk map** of a S5FS **inode** contains 13 disk block pointers. If a disk block is 1KB in size, which of the following are **possible file sizes** if a file's disk map contains non-null block numbers in the first 12 entries and the last entry is null in its **disk map**?

(1) 80 MB
(2) 600 KB
(3) 7 MB
(4) 50 KB
(5) 400 MB

Answer (just give numbers): 2.3

(Q12) (3 points) Let's say that you have four threads A, B, C, and D and you are using the basic **round-robin (RR) / time-slicing** scheduler with a very small time slice. At time zero, all four threads are in the run queue and their processing times are shown in the table below. Assuming that there are no future arrivals into the run queue, please complete the table below with the "waiting time" of all four threads and the "average waiting time" (AWT) of these four threads and write the results on your answer sheet. Please make it very clear which waiting time is for which thread and which one is the AWT. For non-integer answers, you can use fractions or decimals with two digits after the decimal point. Your answer must not contain plus or multiplication symbols. You must use the definition of "waiting time" given in lectures.

	A	B	C	D	AWT
T (hrs)	9	7	4	4	-
wt (hrs)	24	22	16	16	19.5

(Q13) (2 points) Which of the following statements are correct about **pseudo-terminal driver** vs. **terminal driver**?

(1) typically, pseudo-terminal driver and terminal driver are both user space drivers
(2) a terminal driver typically runs in kernel while a pseudo-terminal driver typically runs in user space
(3) for a pseudo-terminal, the input and output (on the device end) comes from and goes to an actual device
(4) for a pseudo-terminal, the input and output (on the device end) comes from and goes to an application
(5) none of the above is a correct answer

Answer (just give numbers): _____

(Q14) (2 points) Which of the following statements are correct about approaches to deal with the problem caused by the **popf** instruction so that a virtual machine can be built for **x86 processors**?

(1) with paravirtualization, all sensitive instructions are replaced with hypercalls only at run time and not at compile time
(2) in Intel's solution, the hypervisor runs in a new CPU mode
(3) in Intel's solution, the `popf` instruction is disabled so that it won't cause any problem
(4) in VMware's solution is a compile-time solution, i.e., sensitive instructions are replaced with hypercalls when kernel is compiled
(5) none of the above is a correct answer

Answer (just give numbers): _____

(Q15) (2 points) Which of the following statements are **incorrect** about **undo journaling** and **redo journaling**?

(1) in undo journaling, you record "before images" in the log
(2) in redo journaling, you record "before images" in the log
(3) you record the same information into the log no matter if you are using undo journaling or redo journaling
(4) in undo journaling, you record "after images" in the log
(5) in redo journaling, you record "after images" in the log

Answer (just give numbers): _____

(Q16) (2 points) Which are the reasons the **line-disciplining code** is made into a separate **module**?

(1) performance: make the terminal device appear to be more responsive
(2) modularity: separate the device dependent part from the device independent part in handling the terminal device
(3) modularity: make the code for dealing with language-specific issues separate from the code to deal with hardware specific characteristics
(4) protection: hardware manufacturers should not be trusted to access kernel data structures
(5) none of the above is a correct answer

Answer (just give numbers): _____

(Q17) (2 points) Which of the following statements are **incorrect** about **microkernel**?

(1) almost all microkernel implementations have good performance
(2) in the design of the microkernel architecture, even device drivers can be moved into user space
(3) one main differences between a message port and a Unix pipe is that a message port can be named
(4) access control in a microkernel system typically is based on user IDs and group IDs just like a traditional Unix system
(5) none of the above is a correct answer

Answer (just give numbers): _____

(Q18) (2 points) Let's say that you are using **extensible hashing** to speed up directory lookup. If $h_3(''proc.c'') = 4$, which of the following are possible values of $h_5(''proc.c'')$?

(1) 36
(2) 12
(3) 20
(4) 44
(5) none of the above is a correct answer

Answer (just give numbers): _____

CSci 402 - Operating Systems

Final Exam (PM Section)

Summer 2020

(10:00:00am - 10:40:00am, Tuesday, August 4)

Instructor: Bill Cheng

Teaching Assistant: Ben Yan

(This exam is open book and open notes.
Remember what you have promised when you signed your
Academic Integrity Honor Code Pledge.)

Time: 40 minutes

_____-
Name (please print)

Total: 32 points

_____-
Signature

Instructions

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(Q1) (2 points) Which of the following statements are correct about **vfork()**?

(1) **vfork()** is equivalent to **fork()**
(2) **vfork()** is best used by experienced system programmers because it can be tricky to use it correctly
(3) **vfork()** is faster than **fork()** if used properly
(4) if **vfork()** is used, the parent process and the child process cannot run "concurrently"
(5) none of the above is correct

2，3，4对，461页

Answer (just give numbers): 2, 3, 4

(Q2) (2 points) Let's say that you have four threads A, B, C, and D and you are using **stride scheduling**. You have decided to give thread A 4 tickets, thread B 3 tickets, thread C 2 tickets, and thread D 1 ticket. The initial pass values that **you must used** for the four threads are shown below along with the "winner" of the iteration 1. Please fill out all the entries (pass values) in the table. For **iterations 2 through 5**, please write on your answer sheet the "winner" and the winning pass value of that iteration. (For example, you would write "A:4" for iteration 1 since A is the "winner" and the winning pass value is 4.) You must use the **smallest possible integer stride values** when calculating the pass values. Please note that if you get the stride values wrong, you will not get any partial credit for this problem.

3 4 6 12

itr	A	B	C	D
1	(4)	6	9	8
2	7	(6)	9	8
3	(7)	10	9	8
4	10	10	9	(8)
5	10	10	(9)	20

A B C D
4 3 2 1
3 4 6 12

(Q3) (2 points) Which of the following statements are correct about virtual machine monitor (VMM)?

(1) in the virtual machine approach, the OS of the "real machine" is the VMM
(2) VMM is an application that runs inside a virtual machine
(3) in the virtual machine approach, the VMM runs in the user mode of the real machine
(4) VMM is a terminal device that's attached to a virtual machine
(5) VMM is sometimes referred to as the "hypervisor"

Answer (just give numbers): 1, 5

1，5是对的，772页

(Q4) (2 points) Considering only **clustered hash page table** schemes and **(non-clustered) hashed page table** schemes, which of the following statements are correct?

(1) the performance of clustered hash page tables is independent of how address space is allocated
(2) non-clustered hash page tables would perform better if contiguous virtual pages are used (such as in weenix)
(3) clustered hash page tables would perform better if address space is truly sparsely allocated
(4) the performance of non-clustered hash page tables depends on the lengths of the hash conflict/collision resolution chains
(5) none of the above is correct

1, 4吧

Answer (just give numbers): _____

(Q5) (2 points) Which of the following statements are correct about the basic (two-level) virtual memory scheme where a virtual address is divided into a virtual page number (say 20 bits) and an offset (say 12 bits) on a 32-bit machine?

(1) virtual page number is just an array index into a page table which has 2^{20} entries
(2) an entry in a page table contains a 20-bit physical page number no matter how much physical memory is present
(3) a physical address is obtained by adding a physical page number with the 12-bit offset
(4) when performing a virtual to physical address translation, the least-significant 12-bits of the virtual address (i.e., the offset) must equal to the least-significant 12-bits of the translated address
(5) during the lifetime of a user process, the mapping of virtual pages to physical pages stays the same

1, 4

Answer (just give numbers): _____

(Q6) (2 points) Which of the following statements are correct about **undo journaling** and **redo journaling**?

(1) in undo journaling, you record "before images" in the log
(2) in redo journaling, you record "after images" in the log
(3) you record the same information into the log no matter if you are using undo journaling or redo journaling
(4) in undo journaling, you record "after images" in the log
(5) in redo journaling, you record "before images" in the log

1, 2

Answer (just give numbers): _____

(Q7) (2 points) Which of the following statements are correct about the **FIFO** scheduler?

(1) it's inherently unfair to long jobs
(2) it can have a large average wait time
(3) it can "starve" some jobs
(4) it has the largest variance in wait time among all scheduling disciplines
(5) it appears to have high throughput

2，对819页

Answer (just give numbers): 2,

(Q8) (2 points) A correct implementation of **straight-threads** (i.e., no interrupt) **synchronization** on a single processor is shown here:

```
void mutex_lock(mutex_t *m)
{
  if (m->locked) {
    enqueue(m->queue,
        CurrentThread);
    thread_switch();
  } else
    m->locked = 1;
}
```

```
void mutex_unlock(mutex_t *m)
{
  if (queue_empty(m->queue))
    m->locked = 0;
  else
    enqueue(runqueue,
        dequeue(m->queue));
}
```

run current thread

Let's say that thread X owns mutex **m**. Which of the following statements are correct about what would happen if another thread (thread Y) calls **mutex_lock(m)**?

(1) thread X will enter **thread_switch()** and thread Y will return from thread_switch() immediately
(2) thread X will enter **mutex_unlock()** immediately and thread Y will return from mutex_lock() immediately with the mutex locked
(3) thread Y will enter **thread_switch()** and thread X will return from thread_switch() immediately
(4) thread Y will enter the run queue and will try to lock the mutex again next time when it runs
(5) thread Y will enter **m**'s mutex queue and thread X will not be affected

5对，看码很明显

Answer (just give numbers): 5

(Q9) (2 points) What are the **OS design approaches** to fix the **reliability** problem of a **monolithic kernel** to reduce kernel crashes?

(1) use dynamic kernel modules so that unreliable kernel module can be unloaded while the rest of the kernel is running
(2) run the entire system (kernel+applications) inside a virtual machine
(3) shrink the code that must run in the privileged mode
(4) never release a kernel unless it's completely bug-free
(5) none of the above is correct

2，3应该对
731页

Answer (just give numbers):

(Q10) (2 points) Which of the following statements are correct about **shadow objects** if we want **copy-on-write** and **fork()** to work together?

(1) in **weenix**, a chain of shadow objects is maintained in a double-linked circular list
(2) if a virtual memory area/segment is shared-mapped, you must use a shadow object for its mmobj
(3) a shadow object holds pages that were copy-on-write but have never been modified
(4) if a virtual memory area/segment is privately mapped and writable, you must use a shadow object for its mmobj
(5) if a virtual memory area/segment is read-only, its mmobj must be a shadow object

Answer (just give numbers): _____

4对，476页

(Q11) (2 points) Let's say that you have three threads A, B, and C and you are using the basic **round-robin (RR) / time-slicing** scheduler with a very small time slice. At time zero, all three threads are in the run queue and their processing times are shown in the table below. Assuming that there are no future arrivals into the run queue, please complete the table below with the "waiting time" of all three threads and the "average waiting time" (AWT) of these three threads and write the results on your answer sheet. Please make it very clear which waiting time is for which thread and which one is the AWT. For non-integer answers, you can use fractions or decimals with two digits after the decimal point. Your answer must not contain plus or multiplication symbols. You must use the definition of "waiting time" given in lectures.

	A	B	C	AWT
T (hrs)	9	7	8	-
wt (hrs)	24	21	23	22.67

全对

(Q12) (2 points) Which of the following statements are correct about **futex**?

(1) futex is not fast at all because it uses **CAS()** operations
(2) the best place to use a futex is inside the kernel
(3) if a futex is **not locked** by any thread, `futex_lock()` must enter the kernel to obtain the lock
(4) if a futex is **locked** by another thread, a system call is often required for the calling thread to obtain the lock
(5) futex is designed to work in both single-processor and multi-processor environments

Answer (just give numbers): _____

2，4，53页

(Q13) (2 points) Which of the following statements are correct about **paravirtualization**?

(1) the paravirtualized guest OS most likely cannot run on the real hardware
(2) the main disadvantage of paravirtualization is performance
(3) you can only make limited amount of modifications to the guest OS
(4) paravirtualization can deal with "sensitive instructions" quite easily
(5) the guest OS cannot tell if it's running on the real machine or a virtual machine

1对，737页

Answer (just give numbers): _____

(Q14) (2 points) Which of the following statements are correct about the **popf machine instruction** in a regular **Intel x86 processor**?

(1) executing it even in the privileged mode would cause a trap
(2) executing it in either the user mode or the privileged mode won't cause a trap
(3) it behaves differently when it is executed in kernel and user modes
(4) executing it in the user mode causes a trap while executing it in the privileged mode does not
(5) none of the above is correct

3对，771页 2，3

Answer (just give numbers): _____

(Q15) (2 points) Which of the following statements are correct about **backing store**?

(1) read-only mapping of a file sometimes need a backing store in swap space
(2) pages in a shadow object always need a backing store in swap space
(3) read-write shared mapping of a file sometimes need a backing store in swap space
(4) read-write private mapping of a file sometimes need a backing store in swap space
(5) none of the above is correct

选5吧
感觉都不对阿

Answer (just give numbers): _____

(Q16) (2 points) Which of the following are useful approaches to **reduce page fault latency**?

(1) use a FIFO replacement policy
(2) prefetching
(3) lazy evaluation
(4) use a larger translation lookaside buffer
(5) use a pageout daemon

2，5 410页

Answer (just give numbers): _____

CSci 402 - Operating Systems

Final Exam

Summer 2021

(10:00:00am - 10:40:00am, Tuesday, August 3)

Instructor: Bill Cheng

Teaching Assistant: (N/A)

(This exam is open book and open notes.
Remember what you have promised when you signed your
Academic Integrity Honor Code Pledge.)

Time: 40 minutes

_____-
Name (please print)

Total: 38 points

_____-
Signature

Instructions

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3. If a question doesn't say `weenix`, please do not give `weenix`-specific answers.
4. Write answers to all problems in the **answers text file**.
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6. Please do *not* just draw pictures to answer questions (unless you are specifically asked to draw pictures). Pictures will not be considered for grading unless they are clearly explained with words, equations, and/or formulas. It's very difficult to draw pictures in a text file and you are not permitted to submit additional files other than the answers text file.
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11. When we grade your exam, we must assume that you wrote what you meant and you meant what you wrote. So, please write your answers accordingly.

(Q1) (2 points) Let's say that the address space of a user space in **weenix** looks like the following:

```
      VADDR RANGE       PROT  FLAGS    MMOBJ     OFFSET    VFN RANGE
0x08039000-0x08048000   rw-  PRIVATE 0xcfe0c034 0x0000d 0x08039-0x08048
0x08048000-0x0804e000   r-x  PRIVATE 0xcfe0c004 0x00009 0x08048-0x0804e
0x0804e000-0x0805f000   rw-  PRIVATE 0xcfe0c064 0x00003 0x0804e-0x0805f
```

If you get a page fault with vaddr = 0x0805d668, what **pagenum** would you use to lookup a page frame when you are handling a page fault? Please just give an integer value answer (no partial credit for this problem).

18

(Q2) (2 points) Which of the following statements are correct about the **FIFO** scheduler?

(1) it appears to be a fair scheduling policy
(2) compared with some other schedulers, this scheduler can have a large average waiting time for the jobs that are in run queue
(3) it's a scheduler that's inherently unfair to long jobs
(4) it has the largest variance in waiting time among all scheduling disciplines
(5) "starvation" at the scheduler is a common problem for this scheduling policy

Answer (just give numbers): _____

(Q3) (2 points) Which of the following statements are correct about the **NOR** vs. **NAND** flash memory technologies?

(1) for a NAND flash, the smallest addressable unit for reading is a ~~block~~ page
(2) a NOR flash is byte-addressable
(3) a NAND flash is ~~byte~~-addressable
(4) a NAND flash is more suitable to be used in a file system than a NOR flash
(5) ~~for writing, a NAND flash is page-erasable but not block-erasable~~

Answer (just give numbers): 2, 4

NAND is block-erasable but not block-erasable

(Q4) (2 points) Which of the following statements are correct about the **popf machine instruction** in a **traditional Intel x86 processor**, i.e., non-Vanderpool?

(1) `popf` behaves differently when it is executed in the user mode and the privilege mode
(2) `popf` is considered to be a "sensitive instruction"
(3) executing `popf` in either the privileged mode or the user mode will cause a trap
(4) executing `popf` in the user mode causes a trap while executing it in the privileged mode does not
(5) executing `popf` in the user mode will not cause a trap while executing it in the privileged mode will cause a trap

Answer (just give numbers): 1, 2

(Q5) (2 points) Which of the following statements are **correct** about **I/O virtualization**?

(1) I/O virtualization in building virtual machines for desktop machines is challenging because it's virtually impossible for virtual machine vendors to support all devices
(2) in VMware's solution to I/O virtualization, ~~most~~ a few device drivers in the guest OS must be rewritten so that they can be supported
(3) in Xen's solution to I/O virtualization, only a few device drivers in the guest OS has to be rewritten in order for Xen to use them
(4) I/O virtualization is not as big of a problem in building virtual machines for high performance servers because only a small number of devices need to be supported
(5) VMware's I/O virtualization solution performs better than Xen's I/O virtualization solution

Answer (just give numbers): 1, 3, 4

(Q6) (2 points) What are the **OS design approaches** to fix the **reliability** problem of a **monolithic kernel** to reduce kernel crashes?

(1) use dynamically loaded kernel modules so that unreliable kernel module can be unloaded while the rest of the kernel is running
(2) shrink the size of the kernel code that must run in the privileged mode
(3) never release a kernel unless it's completely bug-free
(4) run unreliable part of the kernel in user space
(5) none of the above is a correct answer

Answer (just give numbers): 1, 2, 4

(Q7) (2 points) Let's say that you are using a **rate-monitonic scheduler** to schedule 4 periodic tasks with $T_1 = 0.5$, $P_1 = 3$, $T_2 = 1$, $P_2 = 3.5$, $T_3 = 0.5$, $P_3 = 4$, and $T_4 = 1$, $P_4 = 5.5$. Let's say that you schedule all 4 period tasts to start a time = 0. Since the total utilization is too large to guarantee that all jobs will meet their deadlines, the only way to know is to simulate the **rate-monitonic scheduler**. How many seconds into the simulation would be the first time all 4 jobs would start executing at exactly the same time again? Please just give a numeric answer (no partial credit for this problem).

(Q8) (2 points) Which of the following statements are correct about **futex**?

(1) if a futex is currently **locked** and not being released, a thread calling `futex_lock()` must enter the kernel to wait for the lock to be released
(2) the best place to use a futex is inside the kernel
(3) in order for a futex to function correctly when there are multiple CPUs, the kernel is required to be atomic with respect to that futex
(4) futex is not fast at all because it uses **CAS()** operations
(5) futex is designed to work only in multi-CPU systems and will not work in single-CPU systems

Answer (just give numbers): 1, 3

(Q9) (2 points) Which of the following statements are correct about **pseudo-terminal driver** vs. **terminal driver**?

(1) typically, pseudo-terminal driver and terminal driver are both user space drivers
(2) for a pseudo-terminal, the input and output (on the device end) comes from and goes to an actual device
(3) for a pseudo-terminal, the input and output (on the device end) comes from and goes to a special kernel process
(4) a terminal driver typically runs in kernel while a pseudo-terminal driver typically runs in user space
(5) none of the above is a correct answer

Answer (just give numbers): _____

(Q10) (2 points) Which of the following statements are correct about a **B+ tree of order** $m = 9$?

(1) since m is 9, it's okay for an intermediate node (i.e., neither a root node nor a leaf node) to have 5 child nodes
(2) since m is 9, the root node must have at least 4 child nodes
(3) since m is 9, the height of the B+ tree must be strictly less than 9
(4) since m is 9, it's okay for an intermediate node (i.e., neither a root node nor a leaf node) to have 4 child nodes
(5) since m is 9, the height of the B+ tree must be strictly greater than 5

Answer (just give numbers): _____

(Q11) (2 points) Which of the following statements are correct about **physical vs. virtual addresses** on a 32-bit machine?

(1) a process uses physical addresses to execute code when it is created in the kernel and switch to use virtual addresses when it runs in the user space for the first time
(2) a device driver uses physical addresses to execute code but use virtual address to access data on a device
(3) there is a system call a user process can call to convert a user space virtual address into a corresponding kernel space virtual address
(4) a user process uses physical addresses when it's running in the kernel and uses virtual addresses when it's running in user space
(5) none of the above is a correct answer

Answer (just give numbers): 5

(Q12) (2 points) Which of the following statements are correct about **terminal device drivers** vs. **network device drivers**?

(1) network drivers deals with binary data while terminal drivers only deals with non-binary data
(2) in network communication, data needs to be passed from one kernel module to another without copying to achieve acceptable performance
(3) for a terminal, data needs to be passed from one kernel module to another without copying to achieve acceptable performance
(4) their abstractions to applications are completely different
(5) most of the work performed by a ~~terminal~~ network device driver is done as "deferred processing"

Answer (just give numbers): 2

(Q13) (2 points) The first procedure of an **idle thread** is shown here:

```
void idle_thread() {
  while (1) {
    euqueue(runqueue, CurrentThread);
    thread_switch();
  }
}
```

Which of the following statements are correct about such an **idle thread**?

(1) an idle thread is a thread in user space that never gives up the CPU
(2) an idle thread can never be in the zombie state since it does not self-terminate
(3) an idle thread is often used in the kernel even when there is only one CPU
(4) an idle thread does not need a thread control block because it never needs to wait for I/O
(5) an idle thread can never sleep in a mutex queue or an I/O queue

Answer (just give numbers): _____

(Q14) (2 points) A correct implementation of **straight-threads** (i.e., no interrupt) **thread switching** on a **single CPU** is shown here (assuming that the run queue is never empty):

```
void thread_switch() {
  thread_t NextThread, OldCurrent;

  NextThread = dequeue(RunQueue);
  OldCurrent = CurrentThread;
  CurrentThread = NextThread;
  swapcontext(&OldCurrent->context, &NextThread->context);
}
```

Which of the following statements are correct about using the above code in a **multiple-CPU** system?

(1) cannot use the code as-is because `thread_switch()` is missing an argument that specifies which CPU to use
(2) cannot use the code as-is because **swapcontext()** must include an argument to specify which CPU to use for context swapping
(3) cannot use the code as-is because **CurrentThread** must be an array since we have multiple CPUs
(4) cannot use the code as-is because **RunQueue** must be an array since we have multiple CPUs
(5) cannot use the code as-is because if a single **RunQueue** is used, accessing **RunQueue** must be synchronized across multiple CPUs

Answer (just give numbers): _____

(Q15) (3 points) Let's say that you have four threads A, B, C, and D and you are using the basic **round-robin (RR) / time-slicing** scheduler with a very small time slice. At time zero, all four threads are in the run queue and their processing times are shown in the table below. Assuming that there are no future arrivals into the run queue, please complete the table below with the "waiting time" of all four threads and the "average waiting time" (AWT) of these four threads and write the results on your answer sheet. Please make it very clear which waiting time is for which thread and which one is the AWT. For non-integer answers, you can use fractions or decimals with two digits after the decimal point. Your answer must not contain plus or multiplication symbols. You must use the definition of "waiting time" given in lectures.

	A	B	C	D	AWT (1 pt)
T (hrs)	3	7	5	5	-
wt (hrs)	12	20	18	18	17

(Q16) (3 points) Let's say that you have four threads A, B, C, and D and you are using **stride scheduling**. You have decided to give thread A 5 ticket, thread B 4 tickets, thread C 4 tickets, and thread D 7 tickets. The initial pass values that **you must used** for the four threads are shown below along with the "winner" of the iteration 1. Please run **stride scheduling** to fill out all the entries (pass values) in the table and keep track of the "winner" in each round. For **iterations 2 through 7**, please write on your answer sheet the "winner" and the winning pass value of that iteration. (For example, you would write "A:5" for iteration 1 since A is the "winner" of iteration 1 and the winning pass value is 5.) You must use the **smallest possible integer stride values** when calculating all the pass values. If you get the stride values wrong, you will not get any partial credit for this problem.

itr	A	B	C	D
1	11	10	7	(5)
2			7	
3		10		
4	11			
5				25
6	39			
7			42	

(Q17) (2 points) Which of the following statements are correct about a **SJF (shortest job first)** scheduler?

(1) it generally has a smaller variance in waiting time than other schedulers
(2) it appears to have a high throughput, although it cannot achive a throughput higher than one job per second
(3) compared with some other schedulers, this scheduler can have a large average waiting time for the jobs that are in run queue
(4) it is possible that long jobs may "starve" if short jobs keep arriving
(5) it's a scheduler that's inherently unfair to long jobs

Answer (just give numbers): _____

(Q18) (2 points) Which of the following statements are correct about thread implementation strategies?

(1) one problem with the M x N model is priority inversion
(2) N x 1 model is preferred over 1 x 1 model because N x 1 model can achieve higher parallelism
(3) one problem with the N x 1 model is priority inversion
(4) one problem with the 1 x 1 model is that it's slow because system calls are slow
(5) the scheduler activations model is a variation on the one-level model

Answer (just give numbers): _____

CSci 402 - Operating Systems

Alternate Final Exam

Summer 2021

(7:00:00pm - 7:40:00pm, Tuesday, August 3)

Instructor: Bill Cheng

Teaching Assistant: (N/A)

(This exam is open book and open notes.
Remember what you have promised when you signed your
Academic Integrity Honor Code Pledge.)

Time: 40 minutes

_____-
Name (please print)

Total: 38 points

_____-
Signature

Instructions

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11. When we grade your exam, we must assume that you wrote what you meant and you meant what you wrote. So, please write your answers accordingly.

(Q1) (2 points) Which of the following statements are correct about **real-time** systems and threads?

(1) a real-time thread is a thread that uses timer-related system calls
(2) there is not much difference between a soft real-time system and a hard real-time system
(3) a real-time thread is a thread that must start running inside the CPU before a deadline
(4) a real-time thread is a thread that can schedule itself to run at the time it wants without the help of the scheduler
(5) none of the above is a correct answer

Answer (just give numbers): 3

(Q2) (2 points) Which of the following statements are correct about virtual machine monitor (VMM)?

(1) VMM is a user space program that runs inside a virtual machine
(2) VMM is a terminal device that's used to interact with a a virtual machine
(3) when virtual machine is used, the VMM runs in the user mode of the real machine
(4) in modern days, VMM is referred to as "hypervisor"
(5) when virtual machine is used, the OS of the "real machine" is the VMM

Answer (just give numbers): 4,5

(Q3) (2 points) Which of the following statements are correct about **directed processing**?

(1) the "signals" mechanism in Unix is less general than the Windows APC mechanism
(2) in "directed processing", a kernel thread is used to execute code for a user process without going into the user space
(3) the "signals" mechanism in Unix is a form of "directed processing"
(4) in "directed processing", a user thread is used to execute code inside the kernel
(5) the "signals" mechanism in Unix is more general than the Windows APC mechanism because it uses an upcall

Answer (just give numbers): 1,3

(Q4) (2 points) Which of the following statements are correct about the basic (two-level) virtual memory scheme where a virtual address is divided into a virtual page number (say 20 bits) and an offset (say 12 bits) on a 32-bit machine?

(1) during the lifetime of a user process, the mapping of virtual pages to physical pages stays the same
(2) when performing a virtual to physical address translation, the least-significant 12-bits of the virtual address (i.e., the offset) must equal to the least-significant 12-bits of the translated address
(3) an entry in a page table contains a 20-bit physical page number no matter how much physical memory is present
(4) a physical address is obtained by adding a physical page number with the 12-bit offset
(5) virtual page number is just an array index into a page table which has 2^{20} entries

Answer (just give numbers): 2, 5

(Q5) (2 points) Which of the following statements are correct about approaches to deal with the problem caused by the **popf** instruction so that a virtual machine can be built for **x86 processors**?

(1) in Intel's solution, the hypervisor runs in "ring 0"
(2) in Intel's solution, the `popf` instruction is disabled so that it won't cause any problem
(3) in VMware's solution is a compile-time solution, i.e., sensitive instructions are replaced with hypercalls when kernel is compiled run time
(4) with paravirtualization, sensitive instructions are replaced with hypercalls at the time the kernel is compiled recompile
(5) none of the above is a correct answer

Answer (just give numbers): 4

(Q6) (2 points) Which of the following statements are correct about the **round-robin (RR) / time-sliced** scheduler?

(1) with this scheduler, "starvation" at the scheduler cannot occur
(2) it generally has a smaller average waiting time than SJF scheduling
(3) time-slice values should be as large as possible to improve average waiting time
(4) time-slice values should be as small as possible to improve average waiting time
(5) it generally has a smaller variance in waiting time than SJF scheduling

Answer (just give numbers): 1,5

(Q7) (2 points) which of the following statements are correct about the **N x 1 (two-level)** thread implementation model?

(1) in this model, when a user thread makes a system call and gets blocked inside the kernel, other threads in the same process can still run as long as they don't make system calls
(2) in this model, when one user thread wants to give up the processor to switch to another user thread in the same process, it must make a system call
(3) in this model, thread creation and destruction still have to be implemented as system calls
(4) in this model, it's not necessary to trap into the kernel when locking and unlocking mutexes
(5) this model is used in the old days when the kernel didn't know about multithreading in user space programs

Answer (just give numbers): 4 5

(Q8) (2 points) Let's say that you are using **extensible hashing** to speed up directory lookup. If $h_3(''proc.c'') = 5$, which of the following are possible values of $h_5(''proc.c'')$?

(1) 29
(2) 51
(3) 43
(4) 37
(5) none of the above is a correct answer

Answer (just give numbers): 1

(Q9) (2 points) Which of the following statements are correct about **paravirtualization**?

(1) the paravirtualized guest OS cannot run directly on the real machine hardware
(2) compared with full virtualization, it is more difficult for paravirtualization to deal with "problematic" sensitive instructions
(3) the guest OS cannot tell if it's running on the real machine hardware or inside a virtual machine
(4) only limited amount of changes can be made to the guest OS when paravirtualization is used
(5) one main adadvantage of paravirtualization is performance

Answer (just give numbers): 1,5

(Q10) (3 points) Let's say that you have four threads A, B, C, and D and you are using **stride scheduling**. You have decided to give thread A 6 ticket, thread B 5 tickets, thread C 7 tickets, and thread D 6 tickets. The initial pass values that **you must used** for the four threads are shown below along with the "winner" of the iteration 1. Please run **stride scheduling** to fill out all the entries (pass values) in the table and keep track of the "winner" in each round. For **iterations 2 through 7**, please write on your answer sheet the "winner" and the winning pass value of that iteration. (For example, you would write "B:4" for iteration 1 since B is the "winner" of iteration 1 and the winning pass value is 4.) You must use the **smallest possible integer stride values** when calculating all the pass values. If you get the stride values wrong, you will not get any partial credit for this problem.

itr	A	B	C	D
1	6	7	(4)	9
2				
3				
4				
5				
6				
7				

(Q11) (2 points) Which of the following statements are correct about **crash resiliency** in file systems?

(1) a major problem with "soft update" is hierarchical dependency among modified disk blocks
(2) journaling is not available to file systems that uses "extents"
(3) to provide crash resiliency in Linux file systems, ext3 uses journaling while ext4 does not use journaling
(4) to provide crash resiliency in Linux file systems, "shadow paging" is preferred over transaction-based approaches
(5) none of the above is a correct answer

Answer (just give numbers): 5

(Q12) (2 points) Which of the following statements are correct about **backing store**?

(1) pages in a shadow object must have its backing store in swap space
(2) read-only mapping of a file must have its backing store in swap space
(3) read-write shared mapping of a file must have its backing store in swap space
(4) read-write private mapping of a file must have its backing store in swap space
(5) none of the above is a correct answer

Answer (just give numbers): 3, 4

(Q13) (2 points) Which of the following statements are correct about **shadow objects** if we want **copy-on-write** and **fork()** to work together correctly?

(1) if a virtual memory segment is read-only, its first mmobj must be a shadow object
(2) a shadow object holds pages that were copy-on-write but have never been modified
(3) if a virtual memory segment is shared-mapped, you must use a shadow object for its first mmobj
(4) a chain of shadow objects is maintained in a double-linked ~~circular~~ list in weenix
(5) if a virtual memory segment is privately mapped and writable, you must use a shadow object for its first mmobj

Answer (just give numbers): 5

(Q14) (2 points) Which of the following statements are **correct** about **microkernel**?

(1) almost all microkernel implementations have good performance
(2) access control in a microkernel system typically is based on user IDs and group IDs just like a traditional Unix system
(3) in the design of the microkernel architecture, even device drivers can be moved into user space
(4) one main differences between a message port and a Unix pipe is that a message port can be named
(5) none of the above is a correct answer

Answer (just give numbers): ~~4~~ 5

(Q15) (2 points) Which are the reasons the **line-disciplining code** is made into a separate **module**?

(1) modularity: make the code suitable to be moved into usre space or be kept inside the kernel
(2) performance: make the terminal device appear to be more responsive
(3) modularity: separate the device dependent part from the device independent part in dealing with terminal devices
(4) protection: hardware manufacturers should not be trusted to access kernel data structures
(5) none of the above is a correct answer

Answer (just give numbers): 3

(Q16) (2 points) Let's say that the address space of a user space in **weenix** looks like the following:

```
      VADDR RANGE       PROT  FLAGS    MMOBJ     OFFSET    VFN RANGE
0x0803a000-0x08049000   rw-  PRIVATE 0xcfe0c034 0x0000e 0x0803a-0x08049
0x08049000-0x0804d000   r-x  PRIVATE 0xcfe0c004 0x0000f 0x08049-0x0804d
0x0804d000-0x08062000   rw-  PRIVATE 0xcfe0c064 0x0000a 0x0804d-0x08062
```

If you get a page fault with vaddr = 0x0805c668, what **pagenum** would you use to lookup a page frame when you are handling a page fault? Please just give an integer value answer (no partial credit for this problem).

0x00019 25

(Q17) (3 points) Let's say that you have four threads A, B, C, and D and you are using the basic **round-robin (RR) / time-slicing** scheduler with a very small time slice. At time zero, all four threads are in the run queue and their processing times are shown in the table below. Assuming that there are no future arrivals into the run queue, please complete the table below with the "waiting time" of all four threads and the "average waiting time" (AWT) of these four threads and write the results on your answer sheet. Please make it very clear which waiting time is for which thread and which one is the AWT. For non-integer answers, you can use fractions or decimals with two digits after the decimal point. Your answer must not contain plus or multiplication symbols. You must use the definition of "waiting time" given in lectures.

	A	B	C	D	AWT (1 pt)
T (hrs)	4	5	6	5	-
wt (hrs)					

(Q18) (2 points) Which of the following statements are **correct** about **executing sensitive instructions** in an IBM 360 **virtual machine**?

(1) when a sensitive instruction is executed in the **privileged mode** of the **real machine**, it should cause a trap into the VMM
(2) when a sensitive instruction is executed in the **VMM**, it should causes an additional trap into the VMM itself
(3) when a sensitive instruction is executed in the **virtual privileged mode** (inside a **virtual machine**), it should cause a trap into the VMM
(4) when a sensitive instruction is executed in the **virtual user mode** of the **virtual machine**, it should cause a trap into the VMM
(5) none of the above is a correct answer

Answer (just give numbers): 3 4