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Time taken 4 hours 26 mins

Grade **30.01** out of 40.00 (75%)

Question 1

Correct

Mark 1.00 out of 1.00

Predict the output of the program given here.

Assume that there is no mixing of printf output on screen if two of them run concurrently.

In the answer replace a new line by a single space.

For example::

good

output

should be written as good output

--

```
int main() {  
    int pid;  
    printf("hi\n");  
    pid = fork();  
    if(pid == 0) {  
        exit(0);  
    }  
    printf("bye\n");  
    fork();  
    printf("ok\n");  
}
```

Answer: hi bye ok ok



The correct answer is: hi bye ok ok

Question 2

Partially correct

Mark 1.25 out of 2.00

Match the snippets of xv6 code with the core functionality they achieve, or problems they avoid.

"..." means some code.

```
void  
panic(char *s)  
{  
...  
panicked = 1;
```

Disable interrupts to avoid another process's pointer being returned



```
void  
yield(void)  
{  
...  
release(&ptable.lock);  
}
```

Release the lock held by some another process



```
void  
acquire(struct spinlock *lk)  
{  
...  
__sync_synchronize();
```

Tell compiler not to reorder memory access beyond this line



```
void  
sleep(void *chan, struct spinlock *lk)  
{  
...  
if(lk != &ptable.lock){  
    acquire(&ptable.lock);  
    release(lk);  
}  
  
void  
acquire(struct spinlock *lk)
```

If you don't do this, a process may be running on two processors parallelly



Disable interrupts to avoid deadlocks



```

struct proc*
myproc(void) {
...
pushcli();
c = mycpu();
p = c->proc;
popcli();
...
}

```

Avoid a self-deadlock



```

static inline uint
xchg(volatile uint *addr, uint newval)
{
    uint result;

    // The + in "+m" denotes a read-modify-write
    // operand.
    asm volatile("lock; xchgl %0, %1" :
        "+m" (*addr), "=a" (result) :
        "1" (newval) :
        "cc");
    return result;
}

void
acquire(struct spinlock *lk)
{
...
getcallerpcs(&lk, lk->pcs);

```

Atomic compare and swap instruction (to be expanded inline into code)



Traverse ebp chain to get sequence of instructions followed in functions calls



Your answer is partially correct.

You have correctly selected 5.

The correct answer is: void

```

panic(char *s)
{
...
panicked = 1; → Ensure that no printing happens on other processors, void
yield(void)
{
...
release(&ptable.lock);
}

```

→ Release the lock held by some another process, void

```

acquire(struct spinlock *lk)
{
...
__sync_synchronize();
}

```

→ Tell compiler not to reorder memory access beyond this line, **void**

```
sleep(void *chan, struct spinlock *lk)
```

```
{
```

```
...
```

```
if(lk != &ptable.lock){
```

```
    acquire(&ptable.lock);
```

```
    release(lk);
```

} → Avoid a self-deadlock, **void**

```
acquire(struct spinlock *lk)
```

```
{
```

```
pushcli();
```

→ Disable interrupts to avoid deadlocks, **struct proc***

```
myproc(void) {
```

```
...
```

```
pushcli();
```

```
c = mycpu();
```

```
p = c->proc;
```

```
popcli();
```

```
...
```

```
}
```

→ Disable interrupts to avoid another process's pointer being returned, **static inline uint**

```
xchg(volatile uint *addr, uint newval)
```

```
{
```

```
uint result;
```

// The + in "+m" denotes a read-modify-write operand.

```
asm volatile("lock; xchgl %0, %1" :
```

```
    "+m" (*addr), "=a" (result) :
```

```
    "1" (newval) :
```

```
    "cc");
```

```
return result;
```

} → Atomic compare and swap instruction (to be expanded inline into code), **void**

```
acquire(struct spinlock *lk)
```

```
{
```

```
...
```

```
getcallerpcs(&lk, lk->pcs);
```

→ Traverse ebp chain to get sequence of instructions followed in functions calls

Question 3

Correct

Mark 1.00 out of 1.00

Which one of the following is not a system call

- a. mount
- b. lseek
- c. open
- d. lock



The correct answer is: lock

Question 4

Partially correct

Mark 1.13 out of 1.50

The following processes are being scheduled using a pre-emptive, priority-based, round-robin scheduling algorithm.

<u>Process</u>	<u>Priority</u>	<u>Burst</u>	<u>Arrival</u>
P_1	8	15	0
P_2	3	20	0
P_3	4	20	20
P_4	4	20	25
P_5	5	5	45
P_6	5	15	55

Each process is assigned a numerical priority, with a higher number indicating a higher relative priority. The scheduler will execute the currently highest priority process for its full duration, unless it gets pre-empted by newly arriving higher priority process. For processes with the same priority, a round-robin scheduler will be used with a time quantum of 10 units. If a process is pre-empted by a higher-priority process, the pre-empted process is placed at the front of the queue of same priority processes (so that its turn continues when higher priority process is over).

The order in which the processes get scheduled is (write your answer without a space, e.g. P1,P2,P3,P4,P5) :

P1,P2,P3,P4,P3,P5,P3,P6,P2



The turn-around time for the process P2 is:

85



The turn-around time for the process P6 is:

15



The process P5 finishes at time unit:

50



0-15 P1

15-20 P2

20-40 P3

40-45 P4

45-50 P5

50-55 P4

55-70 P6

70-80 P4

80-95 P2

--

P2 turnaround time = 95 - 15 = 80

Question 5

Partially correct

Mark 0.33 out of 1.00

Select all the correct statements about Shell

- a. Examples of shell are: bash, ksh, csh, zsh, sh, etc. ✓
- b. Shell converts the application code into system calls. ✗
- c. The essential job of the shell is to fork-exec the specified application ✓
- d. Examples of shell are: bash, ksh, csh, msh, ooosh, nosh, etc.
- e. The default shell for a user is specified in /etc/passwd on typical GNU/Linux systems.
- f. Shell is a layer on top of hardware

The correct answers are: The essential job of the shell is to fork-exec the specified application, Examples of shell are: bash, ksh, csh, zsh, sh, etc., The default shell for a user is specified in /etc/passwd on typical GNU/Linux systems.

Question 6

Correct

Mark 1.00 out of 1.00

In an ext2 file system, if the block size is 4KB and partition size is 64 GB, then the number of block groups will be:

Answer: ✓

$\text{size} * 1024 * 1024 / 4 \rightarrow \text{no of blocks}$

$\text{each group} = 8 * 4 * 1024 \text{ blocks} = 32768 \text{ blocks}$

$\text{so } \text{size} * 1024 * 1024 / (4 * 32768) \text{ number of groups}$

The correct answer is: 512.00

Question 7

Correct

Mark 1.00 out of 1.00

Calculate the average waiting time using
FCFS scheduling
for the following workload
assuming that they arrive in this order during the first time unit:

Process Burst Time

P1	2
P2	6
P3	2
P4	3

Write only a number in the answer upto two decimal points.

Answer: 5.00



P2 waits for 2 units

P3 waits for 2+6 units

P4 waits for 2 + 6 +2 units of time

Total waiting = $2 + 2 + 6 + 2 + 6 + 2 = 20$ unitsAverage waiting time = $20/4 = 5$

The correct answer is: 5

Question 8

Correct

Mark 1.00 out of 1.00

Not a FOSS: Which of the following is/are not a FOSS operating system ?

- a. BSD Unix
- b. Darwin (core kernel of Mac-OS)
- c. GNU/Linux
- d. FreeBSD
- e. Minix
- f. Windows
- g. Open Solaris
- h. xv6



The correct answer is: Windows

Question 9

Incorrect

Mark 0.00 out of 1.00

Will this code work for a spinlock() operation? The intention here is to call compare-and-swap() only if the lock is not held (the if condition checks for the same).

```
void spinlock(int *lock) {  
    {  
        while (true) {  
            if (*lock == 0) {  
                /* lock appears to be available */  
                if (!compare_and_swap(lock, 0, 1))  
                    break  
            }  
        }  
    }  
}
```

- a. No, because this breaks the atomicity requirement of compare-and-test. ✖
- b. Yes, because there is no race to update the lock variable
- c. Yes, because no matter in which order the if-check and compare-and-swap run in multiple processes, only one process will succeed in compare-and-swap() and others will keep looping in while-loop.
- d. No, because in the case of both processes succeeding in the "if" condition, both may end up acquiring the lock.

Your answer is incorrect.

The correct answer is: Yes, because no matter in which order the if-check and compare-and-swap run in multiple processes, only one process will succeed in compare-and-swap() and others will keep looping in while-loop.

Question 10

Correct

Mark 1.00 out of 1.00

The following diagram that explains the concept of multi-threading

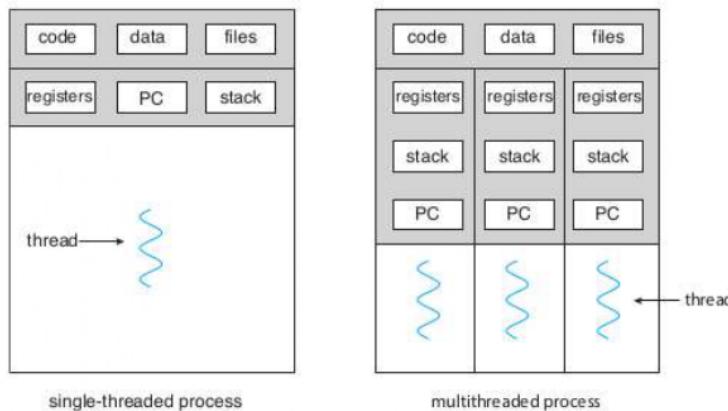


Figure 4.1 Single-threaded and multithreaded processes.

Leads to the following conclusions about implementation of threads

True	False	
<input type="radio"/> ✗	<input checked="" type="radio"/> ✗	A multi-threaded program can be split in multiple ELF files.
<input checked="" type="radio"/> ✗	<input type="radio"/> ✗	The memory management for the process in the kernel should not (most typically) change due to creation of a thread.
<input checked="" type="radio"/> ✗	<input type="radio"/> ✗	Each thread should be represented by a function that starts execution on a separate stack.
<input checked="" type="radio"/> ✗	<input type="radio"/> ✗	Switching between threads requires a "context switch" with change of registers involved in it

A multi-threaded program can be split in multiple ELF files.: False

The memory management for the process in the kernel should not (most typically) change due to creation of a thread.: True

Each thread should be represented by a function that starts execution on a separate stack.: True

Switching between threads requires a "context switch" with change of registers involved in it: True

Question 11

Correct

Mark 1.00 out of 1.00

Match each suggested semaphore implementation (discussed in class)

with the problems that it faces

```
struct semaphore {
    int val;
    spinlock lk;
};

sem_init(semaphore *s, int initval) {
    s->val = initval;
    s->sl = 0;
}

wait(semaphore *s) {
    spinlock(&(s->sl));
    while(s->val <=0)
        ;
    (s->val)--;
    spinunlock(&(s->sl));
}
```

deadlock



```
struct semaphore {
    int val;
    spinlock lk;
    list l;
};

sem_init(semaphore *s, int initval) {
    s->val = initval;
    s->sl = 0;
}

block(semaphore *s) {
    listappend(s->l, current);
    schedule();
}

wait(semaphore *s) {
    spinlock(&(s->sl));
    while(s->val <=0) {
        block(s);
    }
    (s->val)--;
    spinunlock(&(s->sl));
}
```

blocks holding a spinlock



```

struct semaphore {
    int val;
    spinlock lk;
    list l;
};

sem_init(semaphore *s, int initval) {
    s->val = initval;
    s->sl = 0;
}

block(semaphore *s) {
    listappend(s->l, current);
    spinunlock(&(s->sl));
    schedule();
}

wait(semaphore *s) {
    spinlock(&(s->sl));
    while(s->val <=0) {
        block(s);
    }
    (s->val)--;
    spinunlock(&(s->sl));
}

signal(semaphore *s) {
    spinlock(*(&(s->sl)));
    (s->val)++;
    x = dequeue(s->sl) and enqueue(readyq, x);
    spinunlock(*(&(s->sl)));
}

```

not holding lock after unblock



```

struct semaphore {
    int val;
    spinlock lk;
};

sem_init(semaphore *s, int initval) {
    s->val = initval;
    s->sl = 0;
}

wait(semaphore *s) {
    spinlock(&(s->sl));
    while(s->val <=0) {
        spinunlock(&(s->sl));
        spinlock(&(s->sl));
    }
    (s->val)--;
    spinunlock(&(s->sl));
}

```

too much spinning, bounded wait not guaranteed



Your answer is correct.

The correct answer is:

```

struct semaphore {
    int val;
    spinlock lk;
};

sem_init(semaphore *s, int initval) {
    s->val = initval;
    s->sl = 0;
}

wait(semaphore *s) {
    spinlock(&(s->sl));
    while(s->val <=0)
    ;
    (s->val)--;
    spinunlock(&(s->sl));
}

```

→ deadlock,

```
struct semaphore {
    int val;
    spinlock lk;
    list l;
};

sem_init(semaphore *s, int initval) {
    s->val = initval;
    s->sl = 0;
}

block(semaphore *s) {
    listappend(s->l, current);
    schedule();
}

wait(semaphore *s) {
    spinlock(&(s->sl));
    while(s->val <=0) {
        block(s);
    }
    (s->val)--;
    spinunlock(&(s->sl));
}
```

→ blocks holding a spinlock,

```
struct semaphore {
    int val;
    spinlock lk;
    list l;
};

sem_init(semaphore *s, int initval) {
    s->val = initval;
    s->sl = 0;
}

block(semaphore *s) {
    listappend(s->l, current);
    spinunlock(&(s->sl));
    schedule();
}

wait(semaphore *s) {
    spinlock(&(s->sl));
    while(s->val <=0) {
        block(s);
    }
    (s->val)--;
    spinunlock(&(s->sl));
}

signal(semaphore *s) {
    spinlock(*(&s->sl));
    (s->val)++;
    x = dequeue(s->sl) and enqueue(readyq, x);
    spinunlock(*(&s->sl));
}
```

→ not holding lock after unblock,

```
struct semaphore {
    int val;
    spinlock lk;
};

sem_init(semaphore *s, int initval) {
    s->val = initval;
    s->sl = 0;
}

wait(semaphore *s) {
    spinlock(&(s->sl));
    while(s->val <=0) {
        spinunlock(&(s->sl));
        spinlock(&(s->sl));
    }
    (s->val)--;
    spinunlock(&(s->sl));
}
```

→ too much spinning, bounded wait not guaranteed

Question 12

Partially correct

Mark 1.85 out of 3.00

Suppose you are required to implement the priority scheduling algorithm in xv6. Select all the options that correctly reflect the changes that are required to be done in code:

Needed/Optional	Not Needed	
<input checked="" type="radio"/>	<input type="radio"/> <input checked="" type="checkbox"/>	Add a system call (like nice()) that allows to set priority of a process
<input checked="" type="radio"/>	<input checked="" type="radio"/> <input checked="" type="checkbox"/>	Set the priority of the new process to the default(using inheritance) during fork()
<input type="radio"/> <input checked="" type="checkbox"/>	<input checked="" type="radio"/>	Change yield() to re-set the timer value to zero for the process
<input checked="" type="radio"/>	<input type="radio"/> <input checked="" type="checkbox"/>	Insert code in scheduler() after if(p->state != RUNNABLE); continue; by a code that selects the highest priority process.
<input checked="" type="radio"/>	<input type="radio"/> <input checked="" type="checkbox"/>	Add a priority field to the struct proc
<input checked="" type="radio"/>	<input checked="" type="radio"/> <input checked="" type="checkbox"/>	Optionally remove the default timer value of 10000000 in lapticinit()
<input type="radio"/> <input checked="" type="checkbox"/>	<input type="radio"/> <input checked="" type="checkbox"/>	Change scheduler() to calculate the priority of the process using user specified value
<input type="radio"/> <input checked="" type="checkbox"/>	<input type="radio"/> <input checked="" type="checkbox"/>	Change exec() to add a priority to the process.
<input checked="" type="radio"/>	<input checked="" type="radio"/> <input checked="" type="checkbox"/>	Set a new value for the timer before you call swtch() in scheduler()
<input type="radio"/> <input checked="" type="checkbox"/>	<input checked="" type="radio"/> <input checked="" type="checkbox"/>	Change swtch() to set the timer value for the process
<input checked="" type="radio"/>	<input type="radio"/> <input checked="" type="checkbox"/>	The nice() system call needs to acquire the ptable.lock for setting the priority.
<input type="radio"/> <input checked="" type="checkbox"/>	<input checked="" type="radio"/> <input checked="" type="checkbox"/>	Set the priority of the process as per information in ELF file
<input type="radio"/> <input checked="" type="checkbox"/>	<input checked="" type="radio"/> <input checked="" type="checkbox"/>	Change sched() to set the priority of the process.

Add a system call (like nice()) that allows to set priority of a process: Needed/Optional

Set the priority of the new process to the default(using inheritance) during fork(): Needed/Optional

Change yield() to re-set the timer value to zero for the process: Not Needed

Insert code in scheduler() after if(p->state != RUNNABLE); continue; by a code that selects the highest priority process.: Needed/Optional

Add a priority field to the struct proc: Needed/Optional

Optionally remove the default timer value of 10000000 in lapicinit(): Needed/Optional

Change scheduler() to calculate the priority of the process using user specified value: Not Needed

Change exec() to add a priority to the process.: Not Needed

Set a new value for the timer before you call swtch() in scheduler(): Needed/Optional

Change swtch() to set the timer value for the process: Not Needed

The nice() system call needs to acquire the ptable.lock for setting the priority.: Needed/Optional

Set the priority of the process as per information in ELF file: Not Needed

Change sched() to set the priority of the process.: Not Needed

Question 13

Partially correct

Mark 0.75 out of 1.00

It is proposed that when a process does an illegal memory access, xv6 terminate the process by printing the error message "Illegal Memory Access". Select all the changes that need to be done to xv6 for this as True (Note that the changes proposed here may not cover the exhaustive list of all changes required) and the un-necessary/wrong changes as False.

Required	Un-necessary/Wrong	
<input checked="" type="radio"/> <input checked="" type="checkbox"/>	<input type="radio"/> <input checked="" type="checkbox"/>	Change exec to treat text/data sections separately and call allocuvm() with proper flags for page table entries
<input checked="" type="radio"/> <input checked="" type="checkbox"/>	<input type="radio"/> <input checked="" type="checkbox"/>	Add code that checks if the illegal memory access trap was due to an actual illegal memory access.
<input checked="" type="radio"/> <input checked="" type="checkbox"/>	<input type="radio"/> <input checked="" type="checkbox"/>	Change in the Makefile and instruct cc/ld to start the code of each program at some address other than 0
<input checked="" type="radio"/> <input checked="" type="checkbox"/>	<input type="radio"/> <input checked="" type="checkbox"/>	Handle the Illegal memory access trap in trap() function, and terminate the currently running process.
<input type="radio"/> <input checked="" type="checkbox"/>	<input type="radio"/> <input checked="" type="checkbox"/>	Mark each page as readonly in the page table mappings
<input checked="" type="radio"/> <input checked="" type="checkbox"/>	<input type="radio"/> <input checked="" type="checkbox"/>	Ensure that the address 0 is mapped to invalid
<input checked="" type="radio"/> <input checked="" type="checkbox"/>	<input type="radio"/> <input checked="" type="checkbox"/>	Change mappages() to set specified permissions on each page table entry
<input checked="" type="radio"/> <input checked="" type="checkbox"/>	<input type="radio"/> <input checked="" type="checkbox"/>	Change allocuvm() to call mappages() with proper permissions on each page table entry

Change exec to treat text/data sections separately and call allocuvm() with proper flags for page table entries: Required

Add code that checks if the illegal memory access trap was due to an actual illegal memory access.: Un-necessary/Wrong

Change in the Makefile and instruct cc/ld to start the code of each program at some address other than 0: Required

Handle the Illegal memory access trap in trap() function, and terminate the currently running process.: Required

Mark each page as readonly in the page table mappings: Un-necessary/Wrong

Ensure that the address 0 is mapped to invalid: Required

Change mappages() to set specified permissions on each page table entry: Un-necessary/Wrong

Change allocuvm() to call mappages() with proper permissions on each page table entry: Required

Question 14

Correct

Mark 1.00 out of 1.00

Map each signal with it's meaning

SIGSEGV	Invalid Memory Reference	✓
SIGPIPE	Broken Pipe	✓
SIGUSR1	User Defined Signal	✓
SIGCHLD	Child Stopped or Terminated	✓
SIGALRM	Timer Signal from alarm()	✓

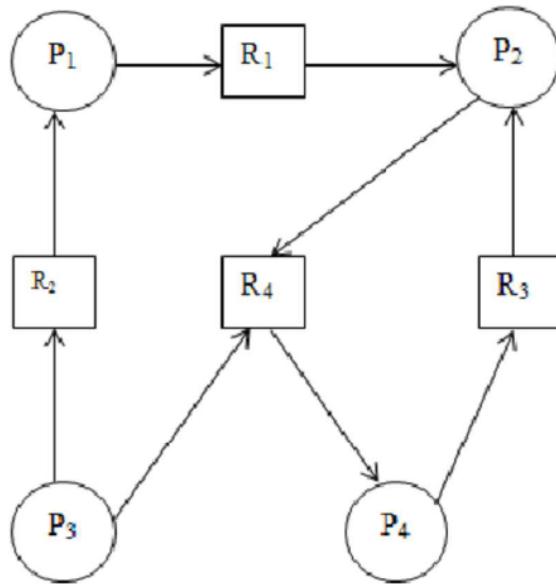
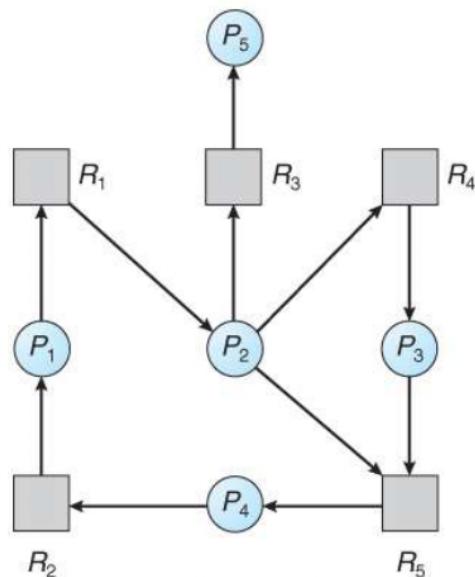
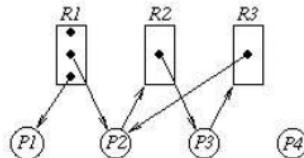
The correct answer is: SIGSEGV → Invalid Memory Reference, SIGPIPE → Broken Pipe, SIGUSR1 → User Defined Signal, SIGCHLD → Child Stopped or Terminated, SIGALRM → Timer Signal from alarm()

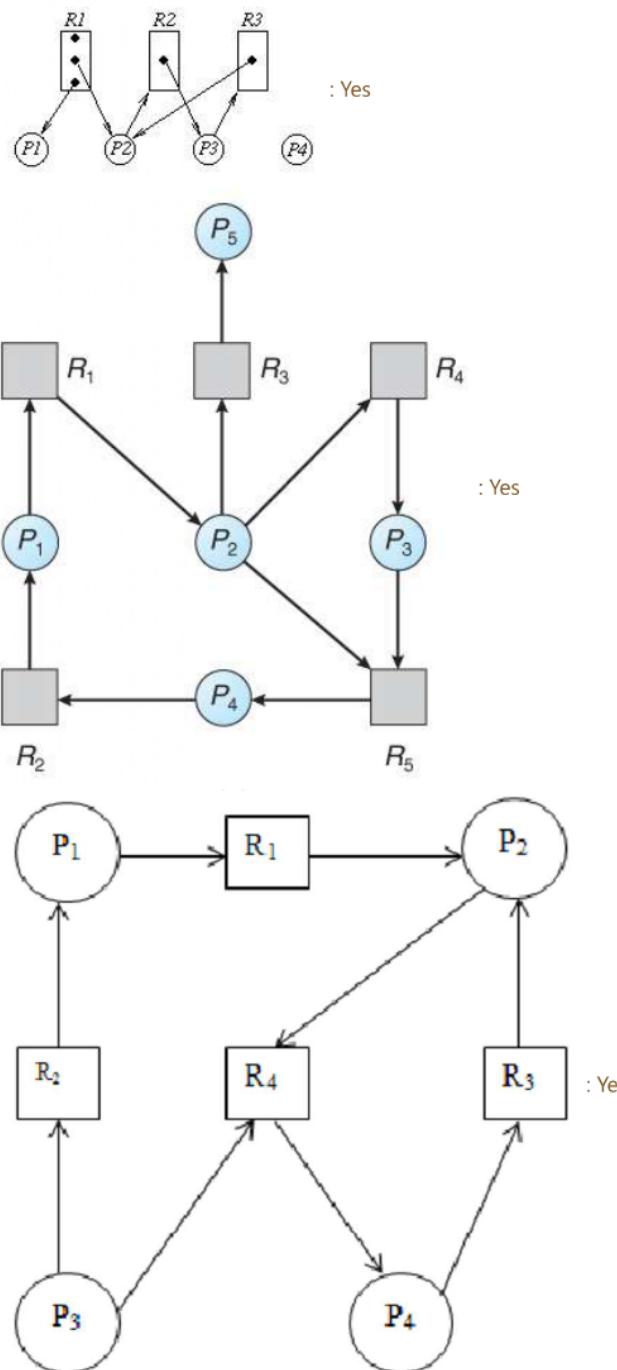
Question 15

Correct

Mark 1.00 out of 1.00

For each of the resource allocation diagram shown,
infer whether the graph contains at least one deadlock or not.

Yes**No**



Question 16

Partially correct

Mark 0.67 out of 1.00

Match the pair

Hashed page table	Linear search on collision done by OS (e.g. SPARC Solaris) typically	✓
Inverted Page table	Linear/Parallel search using frame number in page table	✗
Hierarchical Paging	More memory access time per hierarchy	✓

Your answer is partially correct.

You have correctly selected 2.

The correct answer is: Hashed page table → Linear search on collision done by OS (e.g. SPARC Solaris) typically, Inverted Page table → Linear/Parallel search using page number in page table, Hierarchical Paging → More memory access time per hierarchy

Question 17

Correct

Mark 0.50 out of 0.50

Doing a lookup on the pathname /a/b/b/c/d for opening the file "d" requires reading ✓ no. of inodes. Assume that there are no hard/soft links on the path.

Write the answer as a number.

The correct answer is: 6

Question 18

Partially correct

Mark 0.40 out of 0.50

Which of the following statements are correct about xv6 and multiprocessor support ?

- a. xv6 supports only SMP ✓
- b. xv6 supports a variable number of processors (upto 8) and adjusts it's data structures according to number of processors
- c. Each processor on xv6 starts code execution in mpenter() when first processor sets "started" to 1. ✓
- d. In xv6 on x86, the first processor configures other processors in mpinit() ✓
- e. At any point in time, after main(), the kernel may be parallelly executing on any of the processors. ✓

The correct answers are: xv6 supports only SMP, xv6 supports a variable number of processors (upto 8) and adjusts its data structures according to number of processors, Each processor on xv6 starts code execution in mpenter() when first processor sets "started" to 1., In xv6 on x86, the first processor configures other processors in mpinit(), At any point in time, after main(), the kernel may be parallelly executing on any of the processors.

Question 19

Partially correct

Mark 0.67 out of 1.00

Which of the following instructions should be privileged?

- a. Issue a trap instruction.
- b. Access I/O device. ✓
- c. Turn off interrupts. ✓
- d. Set value of timer. ✓
- e. Modify entries in device-status table. ✓
- f. Switch from user to kernel mode.
- g. Read the clock.

The correct answers are: Set value of timer., Access I/O device., Issue a trap instruction., Switch from user to kernel mode., Modify entries in device-status table., Turn off interrupts.

Question 20

Correct

Mark 1.00 out of 1.00

Write the possible contents of the file /tmp/xyz after this program.

In the answer if you want to mention any non-text character, then write \0. For example abc\0\0 means abc followed by any two non-text characters

```
int main(int argc, char *argv[]) {
    int fd1, fd2, n, i;
    char buf[128];

    fd1 = open("/tmp/xyz", O_WRONLY | O_CREAT, S_IRUSR|S_IWUSR);
    write(fd1, "hello", 5);
    fd2 = open("/tmp/xyz", O_WRONLY, S_IRUSR|S_IWUSR);
    write(fd2, "bye", 3);
    close(fd1);
    close(fd2);
    return 0;
}
```

Answer: ✓

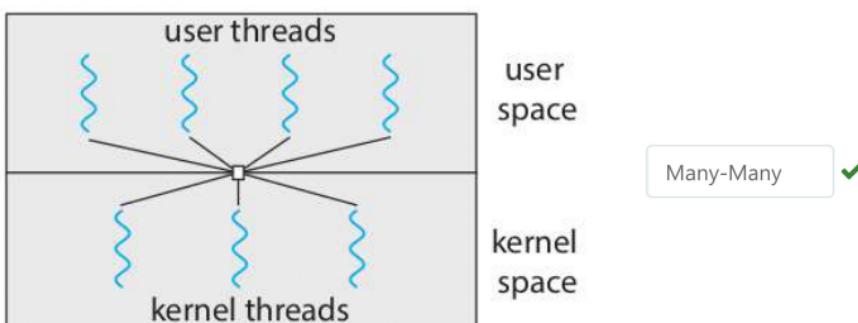
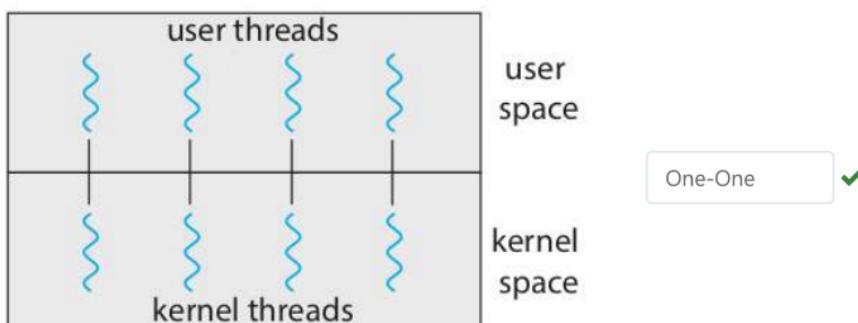
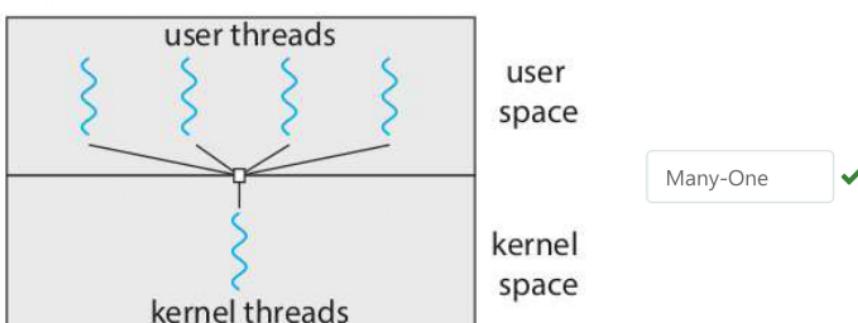
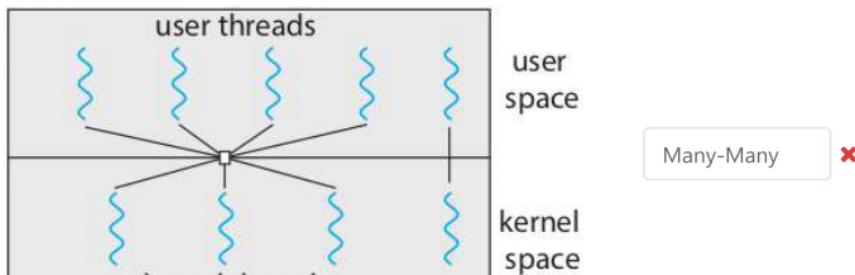
The correct answer is: byelo

Question 21

Partially correct

Mark 0.75 out of 1.00

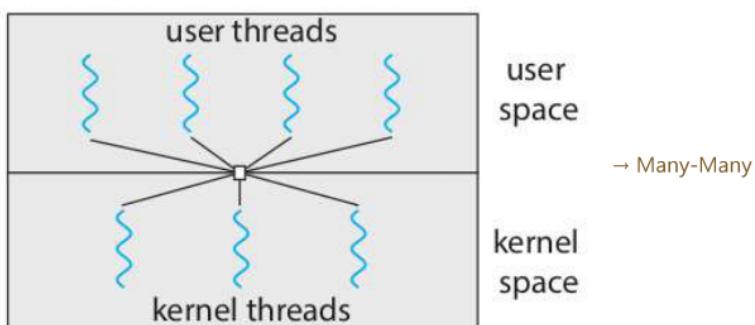
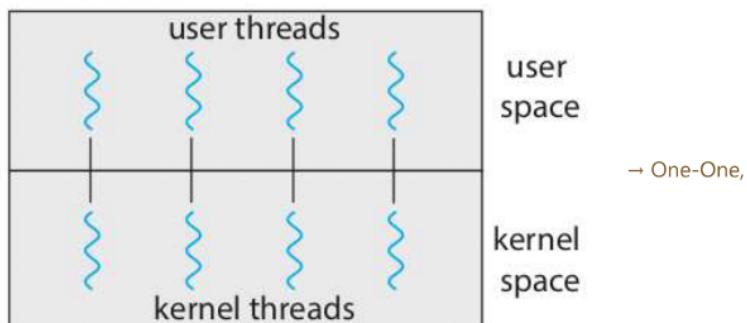
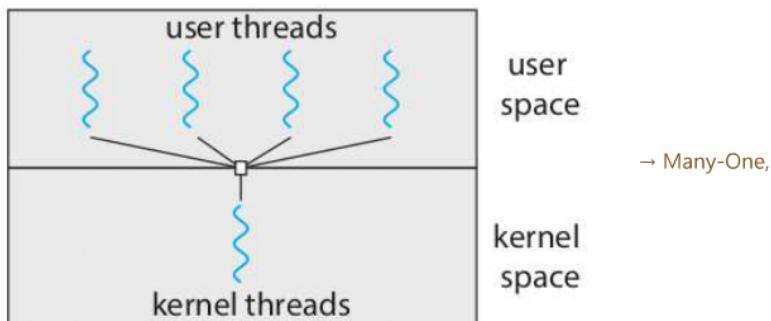
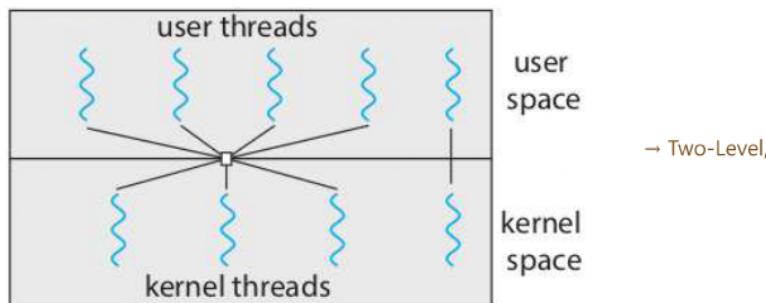
Match the diagram with the threading model



Your answer is partially correct.

You have correctly selected 3.

The correct answer is:



Question 22

Correct

Mark 1.00 out of 1.00

Which one of the following is not a scheduling algorithm

- a. Priority
- b. paging
- c. Multilevel Feedback Queue
- d. FCFS



The correct answer is: paging

Question 23

Partially correct

Mark 1.86 out of 2.00

Given below is an incomplete code for reader-writer lock with preference for readers. Fill in the blanks to complete the code.

Note1:

In your answer, if an expression is to be written, then please separate all tokens by exactly one space in between. For example

i = i + 1 is correct while

i=i+1 is not correct or

i= i +1 is also not correct.

Note2:

Correct: a->b++ (no spaces here!)

Any other notation is incorrect.

Note3: The code of downgrade() and upgrade() has proportional to 4/7 marks.

Code of rwlock:

```
typedef struct rwlock {
    int nActive;
    int nPendingReads;
    int nPendingWrites;
    spinlock_t
    sl
};
```

```
void lockShared(rwlock *r) {
    spin_lock(&r->sl);
```

r->nPendingReads++

```
    ;
```

while(r->nActive < 0)

wait(

&r->canRead

, &r->sl);

r->nActive++;

;

r->nPendingReads--;

spin_unlock(&r->sl);

}

```
void unlockShared(rwlock *r) {
    spin_lock(&r->sl);
```

r->nActive--

;

if(r->nActive == 0) {

spin_unlock(&r->sl);

do_signal(

```

&r->canWrite

✓ );
} else
    spin_unlock(&r->sl);
}

void lockExclusive(rwlock *r) {
    spin_lock(&r->sl);
    r->nPendingWrites++;
    while(r->nActive || r->nPendingReads)
        wait(
            &r->canWrite,
            &r->sl
        );
    r->nPendingWrites--;
}

r->nActive = -1

✓ ;
spin_unlock(&r->sl);
}

void unlockExclusive(rwlock *r) {
    boolean_t wakeReaders;
    int i;
    spin_lock(&r->sl);

    r->nActive = 0

    ✓ ;
    if(r->nPendingReads != 0) {
        for(i = 0; i <
            r->nPendingReads
        ✓ ; i++)
            do_signal(&r->canRead);
    }
    else
        do_signal(
            &r->canWrite
        );
    spin_unlock(&r->sl);
}

void downgrade(rwlock *r) {
    boolean_t wakeReaders;
    int i;
    spin_lock(&r->sl);
    r->nActive =
    1

    ✓ ;
    if(r->nPendingReads != 0)
        for(i = 0; i <
            r->nPendingReads
        ✓ ; i++)
            do_signal(

```

```
&r->canRead  
✓ );  
spin_unlock(&r->sl);  
}  
void upgrade(rwlock *r) {  
    spin_lock(&r->sl);  
    if(r->nActive == 1) {  
        r->nActive =  
        -1  
    }  
    ;  
    } else {  
        r->nPendingWrites++;  
        r->nActive--;  
        while(r->nActive !=  
        0  
    )  
    wait(  
        &r->canWrite  
    , &r->sl);  
  
    r->nPendingWrites--  
    ;  
    r->nActive =  
    -1  
    ;  
    }  
    spin_unlock(&r->sl);  
}
```

Question 24

Partially correct

Mark 0.17 out of 1.00

Select the correct statements about hard and soft links

Select one or more:

- a. Deleting a soft link deletes both the link and the actual file ✗
- b. Deleting a hard link always deletes the file ✗
- c. Soft link shares the inode of actual file ✗
- d. Hard links can span across partitions while soft links can't ✗
- e. Deleting a soft link deletes the link, not the actual file ✗
- f. Hard links share the inode ✓
- g. Soft links increase the link count of the actual file inode ✗
- h. Deleting a hard link deletes the file, only if link count was 1 ✓
- i. Deleting a soft link deletes only the actual file ✗
- j. Hard links enforce separation of filename from it's metadata in on-disk data structures. ✓
- k. Hard links increase the link count of the actual file inode ✗
- l. Soft links can span across partitions while hard links can't ✓

Your answer is partially correct.

You have selected too many options.

The correct answers are: Soft links can span across partitions while hard links can't, Hard links increase the link count of the actual file inode, Deleting a soft link deletes the link, not the actual file, Deleting a hard link deletes the file, only if link count was 1, Hard links share the inode, Hard links enforce separation of filename from it's metadata in on-disk data structures.

Question 25

Correct

Mark 1.00 out of 1.00

which of the following scheduling algorithms discriminate either in favor of or against short processes, from the perspective of minimizing waiting time.

For	Against	
<input type="radio"/> ✗	<input checked="" type="radio"/> ✗	FCFS
<input checked="" type="radio"/> ✗	<input type="radio"/> ✗	Multilevel feedback queues
<input checked="" type="radio"/> ✗	<input type="radio"/> ✗	Round Robin

FCFS: Against

Multilevel feedback queues: For

Round Robin: For

Question 26

Correct

Mark 1.00 out of 1.00

Select T/F for the disk block allocation scheme related statements

True	False	
<input checked="" type="radio"/>	<input type="radio"/> X	Continuous allocation allows to fetch any block with just one seek
<input checked="" type="radio"/>	<input type="radio"/> X	Continuous allocation leads to faster file access
<input checked="" type="radio"/>	<input type="radio"/> X	The unix inode is based on indexed allocation
<input checked="" type="radio"/>	<input type="radio"/> X	FAT uses linked allocation
<input checked="" type="radio"/>	<input type="radio"/> X	Linked allocation does away with file size limitation to a large extent
<input checked="" type="radio"/>	<input type="radio"/> X	NVM storage devices are pushing for search for new block allocation schemes
<input checked="" type="radio"/>	<input type="radio"/> X	Continuous allocation may involve a costly search for free space
<input checked="" type="radio"/>	<input type="radio"/> X	Maximum file size limit is determined by disk block allocation scheme, as one of the factors.

Continuous allocation allows to fetch any block with just one seek: True

Continuous allocation leads to faster file access: True

The unix inode is based on indexed allocation: True

FAT uses linked allocation: True

Linked allocation does away with file size limitation to a large extent: True

NVM storage devices are pushing for search for new block allocation schemes: True

Continuous allocation may involve a costly search for free space: True

Maximum file size limit is determined by disk block allocation scheme, as one of the factors.: True

Question 27

Partially correct

Mark 0.50 out of 1.00

Select which of the following data structures may need an update, in ext2 file system, when 5 bytes get removed from the end of an existing file

Yes	No	
<input checked="" type="radio"/>	<input checked="" type="radio"/>	Inode of the file
<input checked="" type="radio"/>	<input checked="" type="radio"/>	The inode of the parent directory
<input checked="" type="radio"/>	<input checked="" type="radio"/>	The inode bitmap
<input checked="" type="radio"/>	<input checked="" type="radio"/>	A free block on the file-system
<input checked="" type="radio"/>	<input checked="" type="radio"/>	One of the block bitmaps
<input checked="" type="radio"/>	<input checked="" type="radio"/>	The boot sector
<input checked="" type="radio"/>	<input checked="" type="radio"/>	The superblock
<input checked="" type="radio"/>	<input checked="" type="radio"/>	The group descriptor

Inode of the file: Yes

The inode of the parent directory: No

The inode bitmap: No

A free block on the file-system: No

One of the block bitmaps: Yes

The boot sector: No

The superblock: Yes

The group descriptor: Yes

Question 28

Partially correct

Mark 0.67 out of 1.00

Consider this program.

Some statements are identified using the // comment at the end.

Assume that = is an atomic operation.

```
#include <stdio.h>
#include <pthread.h>
long c = 0, c1 = 0, c2 = 0, run = 1;
void *thread1(void *arg) {
    while(run == 1) { //E
        c = c1; //A
        c1++; //B
    }
}
void *thread2(void *arg) {
    while(run == 1) { //F
        c = c2; //C
        c2++; //D
    }
}
int main() {
    pthread_t th1, th2;
    pthread_create(&th1, NULL, thread1, NULL);
    pthread_create(&th2, NULL, thread2, NULL);
    sleep(2);
    run = 0;
    printf(stdout, "c = %ld c1+c2 = %ld c1 = %ld c2 = %ld \n", c, c1+c2, c1, c2);
    fflush(stdout);
}
```

Which statements are part of the critical Section?

Yes	No		
<input checked="" type="radio"/> X	<input type="radio"/> ✓	D	X
<input checked="" type="radio"/>	<input checked="" type="radio"/> X	C	✓
<input type="radio"/> X	<input checked="" type="radio"/>	F	✓
<input checked="" type="radio"/>	<input type="radio"/> X	A	✓
<input checked="" type="radio"/> X	<input type="radio"/> ✓	B	X
<input type="radio"/> X	<input checked="" type="radio"/>	E	✓

As per Remzi's book: "A critical section is a piece of code that accesses a shared variable (or more generally, a shared resource and must not be concurrently executed by more than one thread."

As per Galvin's Book: a critical section, in which the process may be accessing — and updating — data that is shared with at least one other process. The important feature of the system is that when one process is executing in its critical section, no other process is allowed to execute in its critical section.

Since A and C refer to a variable that is shared, it's critical section. Here the hardware guarantees (as = is atomic) that the critical section is accessed by only one thread at a time.

D: No

C: Yes

F: No

A: Yes

B: No

E: No

Question 29

Partially correct

Mark 0.25 out of 0.50

Select all the correct statements related to implementation of a Hypervisor like VirtualBox

- a. The HOST OS determines whether a process (in Guest) or the guest OS itself was doing privileged instruction depending on the privilege level.
- b. When an application runs a privileged instruction it traps into the actual hardware
- c. Typically they run using CPU privilege level 1 or 2 (lower than kernel's but higher than applications) ✓
- d. All Traps in hardware are handled by HOST OS, but Host OS may hand it over to Guest OS if trap was from within guest OS ✓

The correct answers are: Typically they run using CPU privilege level 1 or 2 (lower than kernel's but higher than applications), When an application runs a privileged instruction it traps into the actual hardware, All Traps in hardware are handled by HOST OS, but Host OS may hand it over to Guest OS if trap was from within guest OS, The HOST OS determines whether a process (in Guest) or the guest OS itself was doing privileged instruction depending on the privilege level.

Question 30

Partially correct

Mark 0.75 out of 1.00

For Virtual File System to work, which of the following changes are required to be done to an existing OS code (e.g. xv6)?

- a. The file system specific function pointers, for file system system-calls, need to be setup in the generic inode during lookup.
- b. The filesystem related system calls (e.g. read, write) need to invoke the file system specific functions (e.g. ext2_read, ext2_write, ntfs_read, ntfs_write) using function pointers. ✓
- c. Each file-system writer needs to provide the set of function pointers for VFS, and these function pointers need to be setup in generic inode of "/" of that file system during mount() ✓
- d. Each open() needs to copy the function pointers from the inode of the parent directory into the inode of the child (if not already done), unless it's traversing a mount point. (This may be done as part of lookup() which is called by open()) ✓
- e. The generic inode needs to have a field representing if this inode is a mount point and also to refer/point to the root of the mounted file system's inode.
- f. The lookup() operation needs to check if it's crossing a mount point and call FS specific operations to read inodes/directories ✓
- g. A mount() system call should be provided to mount a partition onto some directory in existing namespace rooted at "/" ✓
- h. The operating system in-memory inode needs to be a generic-inode representing "inode" like data structure across multiple file systems. ✓

The correct answers are: A mount() system call should be provided to mount a partition onto some directory in existing namespace rooted at "/", The filesystem related system calls (e.g. read, write) need to invoke the file system specific functions (e.g. ext2_read, ext2_write, ntfs_read, ntfs_write) using function pointers., The file system specific function pointers, for file system system-calls, need to be setup in the generic inode during lookup., The operating system in-memory inode needs to be a generic-inode representing "inode" like data structure across multiple file systems., The generic inode needs to have a field representing if this inode is a mount point and also to refer/point to the root of the mounted file system's inode., The lookup() operation needs to check if it's crossing a mount point and call FS specific operations to read inodes/directories, Each file-system writer needs to provide the set of function pointers for VFS, and these function pointers need to be setup in generic inode of "/" of that file system during mount(), Each open() needs to copy the function pointers from the inode of the parent directory into the inode of the child (if not already done), unless it's traversing a mount point. (This may be done as part of lookup() which is called by open())

Question 31

Partially correct

Mark 0.29 out of 1.00

Mark the statements as True/False w.r.t. the basic concepts of memory management.

True	False	
<input checked="" type="radio"/>	<input checked="" type="radio"/>	The compiler generates address references for code/data/stack/heap in the executable file, depending on the MM architecture provided by CPU and kernel. ✗
<input checked="" type="radio"/>	<input checked="" type="radio"/>	The compiler interacts with the kernel continuously while compiling a program and obtains the correct set of memory addresses for code/stack/heap/data and then generates the machine code file. ✓
<input checked="" type="radio"/>	<input checked="" type="radio"/>	The kernel ensures that the MMU is setup before scheduling a process and then the CPU/MMU ensures that the address translation takes place. ✓
<input checked="" type="radio"/>	<input checked="" type="radio"/>	When a process is executing, each virtual address is converted into physical address by the CPU hardware directly. ✗
<input checked="" type="radio"/>	<input checked="" type="radio"/>	When a process is executing, each virtual address is converted into physical address by the kernel directly. ✗
<input checked="" type="radio"/>	<input checked="" type="radio"/>	The kernel refers to the page table for converting each virtual address to physical address. ✗
<input checked="" type="radio"/>	<input checked="" type="radio"/>	The compiler generates the address references for code/data/stack/heap in the executable file as per the memory management schema chosen by the compiler itself, and then the kernel ensures that program is executed with this schema. ✗

The compiler generates address references for code/data/stack/heap in the executable file, depending on the MM architecture provided by CPU and kernel.: True

The compiler interacts with the kernel continuously while compiling a program and obtains the correct set of memory addresses for code/stack/heap/data and then generates the machine code file.: False

The kernel ensures that the MMU is setup before scheduling a process and then the CPU/MMU ensures that the address translation takes place.: True

When a process is executing, each virtual address is converted into physical address by the CPU hardware directly.: True

When a process is executing, each virtual address is converted into physical address by the kernel directly.: False

The kernel refers to the page table for converting each virtual address to physical address.: False

The compiler generates the address references for code/data/stack/heap in the executable file as per the memory management schema chosen by the compiler itself, and then the kernel ensures that program is executed with this schema.: False

Question 32

Correct

Mark 1.00 out of 1.00

Consider a computer system with a 32-bit logical address and 8- KB page size. The system supports up to 1 GB of physical memory. How many entries are there in each of the following?

- a. A conventional, single-level page table (write a decimal number):

524288



- b. An inverted page table (number of entries only, write a decimal number):

131072

**Question 33**

Correct

Mark 1.00 out of 1.00

Mark the statements as True/False with respect to Mobile systems and swapping.

True	False	
<input checked="" type="radio"/>	<input type="radio"/> X	Poor throughput between main memory and flash memory is one reason for restriction on use of swap on mobile devices.
<input checked="" type="radio"/>	<input type="radio"/> X	Size of flash memory is one reason for restriction on use of swap on mobile devices.
<input checked="" type="radio"/>	<input type="radio"/> X	Mobile systems generally do not support swapping
<input checked="" type="radio"/>	<input type="radio"/> X	Limited number of write operations that flash memory can tolerate, is one reason for limitations of swapping on mobile devices.

Poor throughput between main memory and flash memory is one reason for restriction on use of swap on mobile devices.: True

Size of flash memory is one reason for restriction on use of swap on mobile devices.: True

Mobile systems generally do not support swapping: True

Limited number of write operations that flash memory can tolerate, is one reason for limitations of swapping on mobile devices.: True

Question 34

Partially correct

Mark 1.38 out of 3.00

Suppose it is required to add the chown() (without notion of a group, just the notion of owner and others) system call to xv6. Select the changes, from the options given below, which are an absolute must to effect the addition of this system call.

Changes w.r.t. other system calls should be selected if those system calls are necessary for the implementation of the chown() system call.

Must	Not-Must		
<input checked="" type="radio"/>	<input checked="" type="checkbox"/>	Add a setuid(), seteuid() system call, callable only by the user with ID or EUID equal to "0" to set the new user id of the process	<input checked="" type="checkbox"/>
<input checked="" type="radio"/>	<input checked="" type="checkbox"/>	Create an application program su.c which itself is a SUID program, and calls setuid() and seteuid() with specified user-ID and then does exec() of a shell.	<input checked="" type="checkbox"/>
<input checked="" type="radio"/>	<input checked="" type="checkbox"/>	Modify exec() to check SUID bit on the executable file and set EUID of the process to UID of the executable	<input checked="" type="checkbox"/>
<input checked="" type="checkbox"/>	<input checked="" type="radio"/>	Add a mode field representing file permissions, inside dinode	<input checked="" type="checkbox"/>
<input checked="" type="radio"/>	<input checked="" type="checkbox"/>	Add a UID field in the struct proc representing the USER-ID of the user who started this process	<input checked="" type="checkbox"/>
<input checked="" type="radio"/>	<input checked="" type="checkbox"/>	Mandatorily create a file like "passwd" which maps user-names to user-IDs and modify other utilities (like "ls") to show user-name instead of user-ID for the files.	<input checked="" type="checkbox"/>
<input checked="" type="radio"/>	<input checked="" type="checkbox"/>	Add the username field to the on disk inode, that is dinode.	<input checked="" type="checkbox"/>
<input checked="" type="radio"/>	<input checked="" type="checkbox"/>	Inherit the UID and EUID of the parent in fork()	<input checked="" type="checkbox"/>
<input checked="" type="checkbox"/>	<input checked="" type="radio"/>	Add a uid field representing the owner, inside dinode	<input checked="" type="checkbox"/>
<input checked="" type="radio"/>	<input checked="" type="checkbox"/>	Add few extra files belonging to different users, using mkfs.c	<input checked="" type="checkbox"/>
<input checked="" type="checkbox"/>	<input checked="" type="radio"/>	Modify mkfs.c to add owner and permissions to each file created	<input checked="" type="checkbox"/>
<input checked="" type="checkbox"/>	<input checked="" type="radio"/>	Add the chown() system call which checks if the user with id "0" is calling this system call and then change the ownership of the on-disk and in-memory inode.	<input checked="" type="checkbox"/>

Not-Must	Not-Must
<input checked="" type="radio"/> <input type="radio"/>	Add a EUID field in the struct proc representing Effective user ID ✖

Add a setuid(), seteuid() system call, callable only by the user with ID or EUID equal to "0" to set the new user id of the process: Not-Must
Create an application program su.c which itself is a SUID program, and calls setuid() and seteuid() with specified user-ID and then does exec() of a shell.: Not-Must

Modify exec() to check SUID bit on the executable file and set EUID of the process to UID of the executable: Not-Must

Add a mode field representing file permissions, inside dinode: Must

Add a UID field in the struct proc representing the USER-ID of the user who started this process: Not-Must

Mandatorily create a file like "passwd" which maps user-names to user-IDs and modify other utilities (like "ls") to show user-name instead of user-ID for the files.: Not-Must

Add the username field to the on disk inode, that is dinode.: Not-Must

Inherit the UID and EUID of the parent in fork(): Not-Must

Add a uid field representing the owner, inside dinode: Must

Add few extra files belonging to different users, using mkfs.c: Not-Must

Modify mkfs.c to add owner and permissions to each file created: Must

Add the chown() system call which checks if the user with id "0" is calling this system call and then change the ownership of the on-disk and in-memory inode.: Must

Add a EUID field in the struct proc representing Effective user ID: Not-Must

Question 35

Partially correct

Mark 0.86 out of 1.00

Mark statements as T/F

All statements are in the context of preventing deadlocks.

True	False	
<input checked="" type="radio"/>	<input type="radio"/> ✗	Mutual exclusion is a necessary condition for deadlock because it brings in locks on which deadlock happens
<input checked="" type="radio"/>	<input type="radio"/> ✗	Circular wait is avoided by enforcing a lock ordering
<input checked="" type="radio"/>	<input type="radio"/> ✗	The lock ordering to be followed to avoid circular wait is a protocol to be followed by programmers.
<input checked="" type="radio"/>	<input type="radio"/> ✗	If a resource allocation graph contains a cycle then there is a possibility of a deadlock
<input type="radio"/> ✗	<input checked="" type="radio"/>	If a resource allocation graph contains a cycle then there is a guarantee of a deadlock
<input type="radio"/> ✗	<input checked="" type="radio"/>	The lock ordering to be followed to avoid circular wait is a code in OS that checks for compliance with decided order
<input checked="" type="radio"/>	<input type="radio"/> ✗	Deadlock is not possible if any of these conditions is not met: Mutual exclusion, hold and wait, no pre-emption, circular wait.

Mutual exclusion is a necessary condition for deadlock because it brings in locks on which deadlock happens: True
Circular wait is avoided by enforcing a lock ordering: True

The lock ordering to be followed to avoid circular wait is a protocol to be followed by programmers.: True

If a resource allocation graph contains a cycle then there is a possibility of a deadlock: True

If a resource allocation graph contains a cycle then there is a guarantee of a deadlock: False

The lock ordering to be followed to avoid circular wait is a code in OS that checks for compliance with decided order: False

Deadlock is not possible if any of these conditions is not met: Mutual exclusion, hold and wait, no pre-emption, circular wait.: True

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