The following is an actual exam which was given during a previous semester when the schedule of topics was similar to the calendar this semester.

Note that three of the questions (#5, #6 and #7) focused on a computer project from that semester (material which we did not over this semester).

******************************************************************************
* Answer Key                                                               *
*                                                                           *
*  01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 *
*  C  A  E  A  B  D  D  D  B  D  A  C  E  D  A  D  B  C  A  E  B  A  E  E  *
*                                                                           *
*  25 26 27 28 29 30                                                        *
*  B  C  D  A  D  B                                                         *
******************************************************************************

Directions:

a. DO NOT OPEN YOUR EXAM BOOKLET UNTIL YOU HAVE BEEN TOLD TO BEGIN.

b. This exam booklet contains 30 questions, each of which will be weighted equally. The exam is worth 180 points (18% of your course grade).

c. You may use one 8.5" x 11" note sheet (both sides) during the examination. No other reference materials or electronic devices (such as calculators) may be used during the examination.

d. You may not ask questions once the examination has begun.

If there is a structural problem with your exam booklet, such as a missing page or poorly printed page, please bring your exam booklet to the proctor.

If you believe that a question is ambiguous or contains a typographic error, write your interpretation of the question on the same page as the question, then put a note on the cover sheet of your exam booklet.

e. You should choose the single best alternative for each question, even if you believe that a question is ambiguous or contains a typographic error. If a question has more than one correct answer, full credit will be awarded for any correct answer.

f. Please fill in the requested information at the top of this exam booklet.

g. Use a #2 pencil to encode any information on your OMR form (bubble sheet).

h. Please encode the following on the OMR form:

   -- Last name and first initial
   -- MSU PID
   -- Exam form (1 X)

i. Only answers recorded on your OMR form will be counted for credit. Completely erase any responses on the OMR form that you wish to delete.

j. You must turn in this exam booklet and the OMR form when you have completed the exam. When leaving, please be courteous to those still taking the exam.
01. Consider the Linux commands shown in Figure 1. What will be displayed if the command given below is entered at the next shell prompt?

```
grep 'MSU' exam1.data | sort -k5,5n | head -1
```

A) Carter,_Anson        SR   MSU  33   24  21  45  15  30  
B) Harper,_Kelly        SR   MSU  35   14  14  28  12  24  
C) Turner,_Bart         SR   MSU  35    3   8  11  13  34  
D) Tuzzolino,_Tony      FR   MSU  33    4   3   7  19  46  
E) None of the above.

02. Consider the Linux commands shown in Figure 1. What will be displayed if the command given below is entered at the next shell prompt?

```
sort -k7,7nr -k3,3b exam1.data | head -1
```

A) Sylvester,_Mike      SO   KSU  36   21  24  45  14  28  
B) Carter,_Anson        SR   MSU  33   24  21  45  15  30  
C) Schock,_Harold       FR   UOM  35    3  11  14  19  38  
D) Tuzzolino,_Tony      FR   MSU  33    4   3   7  19  46  
E) None of the above.

03. Consider the Linux commands shown in Figure 2. What will be displayed if the command given below is entered at the next shell prompt?

```
examine check quiz test
```

A) All of the lines in the file "check" which contain the pattern "quiz" and contain the pattern "test".
B) All of the lines in the file "quiz" which contain the pattern "check" and contain the pattern "test".
C) All of the lines in the file "check" which contain the pattern "quiz" and do not contain the pattern "test".
D) All of the lines in the file "quiz" which contain the pattern "check" and do not contain the pattern "test".
E) None of the above.
04. Which of the following statements about interrupts on a Linux system is correct?

A) An interrupt generated by the expiration of a process’s time quantum will cause a mode switch and a process switch.
B) An interrupt caused by an invalid machine language instruction in the current process will cause a mode switch, but not a process switch.
C) An interrupt generated by a disk drive when an input operation is completed will cause a mode switch and a process switch.
D) All of the above.
E) None of the above.

05. The C/C++ program shown in Figure 3 is executed on a Linux system. Under what circumstances will variable "flag" contain a non-zero value?

A) When the user does not have permission to read "/local/midterm".
B) When "/local/midterm" does not exist.
C) When "/local/midterm" is a directory.
D) All of the above.
E) None of the above.

06. The C/C++ program shown in Figure 3 is executed on a Linux system and variable "flag" equals zero. Which of the following C/C++ statements will set variable "value" to a non-zero value when all users have permission to read "/local/midterm"?

A) value = (buffer.st_mode >> 2) & 00001;
B) value = buffer.st_mode & S_IROTH;
C) value = buffer.st_mode & 00004;
D) All of the above.
E) None of the above.

07. The C/C++ program shown in Figure 3 is executed on a Linux system. Under what circumstances will variable "result" contain a non-zero value?

A) When "/local/Backup/Exams" does not exist.
B) When the user does not have permission to enter "/local/Backup".
C) When "/local/Backup/Exams" is a not directory.
D) All of the above.
E) None of the above.
The following questions refer to Stalling’s Process State Transition Diagram with seven states.

08. Which of the following might cause a process to move from the Running state to the Blocked state?
   A) The process has requested access to a shared resource.
   B) The process is waiting for a child process to exit.
   C) The process has requested that the OS write to an existing file.
   D) All of the above.
   E) None of the above.

09. Which of the following might cause a process to move from the Blocked state to the Blocked/Suspend state?
   A) The event for which the process was waiting has occurred.
   B) The OS has detected that there are no processes in the Ready state.
   C) The process has requested that the OS read from an existing file.
   D) All of the above.
   E) None of the above.

10. Which of the following might cause a process to move from the Running state to the Exit state?
    A) The process has attempted integer division by zero.
    B) The process has been terminated by its parent process.
    C) The process has attempted to execute a privileged instruction.
    D) All of the above.
    E) None of the above.

11. Which of the following might cause a process to move from the Ready state to the Ready/Suspend state?
    A) The OS has detected that all of primary storage has been allocated.
    B) The process has requested access to a shared resource.
    C) The event for which the process was waiting has occurred.
    D) All of the above.
    E) None of the above.

12. Which of the following might cause a process to move from the Running state to the Ready state?
    A) The process is waiting for a child process to complete.
    B) The process has requested that the OS create a new file.
    C) The process has used up its time quantum.
    D) All of the above.
    E) None of the above.

13. Which of the following might cause a process to move from the Blocked state to the Running state?
    A) The process was dispatched by the OS.
    B) All of the child processes of the process have completed.
    C) The event for which the process was waiting has occurred.
    D) All of the above.
    E) None of the above.
const char* msg[] = { "AAA", "BBB", "CCC", "DDD", "EEE", "FFF" };

int main()
{
    int status, i = 0;

    printf( "%s ", msg[i] );
    fflush( stdout );
    if (fork() == 0)
    {
        i = i + 3;
        printf( "%s ", msg[i] );
        fflush( stdout );
    }
    else
    {
        wait( &status );
        i = i + 1;
        printf( "%s ", msg[i] );
        fflush( stdout );
    }

    printf( "%s ", msg[i] );
    fflush( stdout );

    exit( 0 );
}

14. Consider the C/C++ program shown in Figure 4. What is the effect of calling function "fork" in function "main"?

A) It will return a random number in the set {0,1}.
B) It will create a new thread within the current process.
C) It will force function "main" to split into two threads.
D) It will create a new process by duplicating the current process.
E) None of the above.

15. The C/C++ program shown in Figure 4 is executed on a Linux system with one CPU. How many unique process control blocks and unique process ID numbers are generated when the program is executed?

A) Two process control blocks and two process ID numbers.
B) Two process control blocks and one process ID number.
C) One process control block and two process ID numbers.
D) One process control block and one process ID number.
E) None of the above.

16. The C/C++ program shown in Figure 4 is executed on a Linux system with two CPUs. What will be displayed by the program?

A) AAA AAA DDD DDD EEE EEE
B) AAA AAA DDD DDD BBB BBB
C) AAA DDD DDD EEE EEE
D) AAA DDD DDD BBB BBB
E) None of the above.
const char* msg[] = { "AAA", "BBB", "CCC", "DDD", "EEE", "FFF"};

void* sub( void* arg )
{
    long n = (long) arg;
    sleep( 5-n );
    printf( "%s ", msg[n] );
    pthread_exit( NULL );
}

int main()
{
    pthread_t tid[4];
    long i = 0;
    printf( "%s ", msg[i] );
    for (i=0; i<4; i++) pthread_create( &tid[i], NULL, sub, (void*) i );
    for (i=0; i<4; i++) pthread_join( tid[i], NULL );
    printf( "%s
", msg[i] );
    return 0;
}

17. Consider the C/C++ program shown in Figure 5. What is the effect of executing the "for" statement containing the call to function "pthread_join"?

   A) It will call function "sub" four times.
   B) It will force function "main" to wait until four threads return.
   C) It will attach four threads to the current process.
   D) It will create one process out of four threads.
   E) None of the above.

18. The C/C++ program shown in Figure 5 is executed on a Linux system with two CPUs. How many unique process ID numbers and thread ID numbers are generated when the program is executed?

   A) Two process ID numbers and five thread ID numbers
   B) Two process ID numbers and four thread ID numbers
   C) One process ID number and five thread ID numbers
   D) One process ID number and four thread ID numbers
   E) None of the above.

19. The C/C++ program shown in Figure 5 is executed on a Linux system with two CPUs. What will be displayed by the program?

   A) AAA DDD CCC BBB AAA EEE
   B) AAA DDD CCC BBB AAA AAA
   C) AAA AAA BBB CCC DDD EEE
   D) AAA AAA BBB CCC DDD AAA
   E) None of the above.
Initialization of shared variables:
flag[0] = flag[1] = false;
turn = 0;

Entry section:
flag[i] = true;
turn = j;
do {} while (flag[j] and (turn==j));

Exit section:
flag[i] = false;

20. Consider Figure 6. Assume two processes (P_i and P_j) share a critical resource. If both of the processes use the entry and exit sections correctly to guard their critical sections, which of the following is correct?

A) Starvation may occur.
B) Deadlock may occur.
C) A violation of mutual exclusion may occur.
D) All of the above.
E) None of the above.

21. Consider Figure 6. Assume two processes (P_i and P_j) share a critical resource. If one of the processes use the entry and exit sections correctly to guard its critical section, but the other process omits the exit section, which of the following is correct?

A) Starvation may occur.
B) Deadlock may occur.
C) A violation of mutual exclusion may occur.
D) All of the above.
E) None of the above.

Initialization of shared variable:
Lock = 0;

Entry section:
Key = 1;
do Swap( &Key, &Lock ) while Key != 0;

Exit section:
Lock = 0;

22. Consider Figure 7, where "Swap" is an atomic operation. Assume five processes share a critical resource. If all five of the processes use the entry and exit sections correctly to guard their critical sections, which of the following is correct?

A) Starvation may occur.
B) Deadlock may occur.
C) A violation of mutual exclusion may occur.
D) All of the above.
E) None of the above.
Initialization of semaphore (with FIFO queue):

   S = 1;

Entry section:
   wait(S)

Exit section:
   signal(S)

23. Consider Figure 8. Assume four processes share a critical resource. If all four of the processes use the entry and exit sections correctly to guard their critical sections, which of the following is correct?

   A) The bounded waiting requirement is violated.
   B) The progress requirement is violated.
   C) There is no busy waiting.
   D) All of the above.
   E) None of the above.

24. Consider Figure 8. Assume four processes share a critical resource. If all four of the processes use the entry and exit sections correctly to guard their critical sections, which of the following is correct?

   A) Starvation may occur.
   B) Deadlock may occur.
   C) A violation of mutual exclusion may occur.
   D) All of the above.
   E) None of the above.

25. Consider Figure 8. Assume four processes share a critical resource. If three of the processes use the entry and exit sections correctly to guard their critical sections, but one process omits the exit section, which of the following is correct?

   A) Starvation may occur.
   B) Deadlock may occur.
   C) A violation of mutual exclusion may occur.
   D) All of the above.
   E) None of the above.

26. Consider Figure 8. Assume four processes share a critical resource. If three of the processes use the entry and exit sections correctly to guard their critical sections, but one process omits the entry section, which of the following is correct?

   A) Starvation may occur.
   B) Deadlock may occur.
   C) A violation of mutual exclusion may occur.
   D) All of the above.
   E) None of the above.
27. Consider Figure 9. Which of the following statements about the critical section of function "consumer" is correct?

A) Line 26 through line 28 (inclusive) is the critical section.
B) Line 25 through line 28 (inclusive) is the critical section.
C) Line 26 through line 27 (inclusive) is the critical section.
D) Line 25 through line 27 (inclusive) is the critical section.
E) None of the above.

28. Consider Figure 9. In order to control access to its critical section, the statements shown below must be inserted into function "producer":

```c
sem_wait( &B );
sem_post( &B );
```

Which of the following statements is correct?

A) The call to "sem_wait" must be inserted between lines 38 and 39, and the call to "sem_post" must be inserted between lines 41 and 42.
B) The call to "sem_wait" must be inserted between lines 37 and 38, and the call to "sem_post" must be inserted between lines 41 and 42.
C) The call to "sem_wait" must be inserted between lines 38 and 39, and the call to "sem_post" must be inserted between lines 40 and 41.
D) The call to "sem_wait" must be inserted between lines 37 and 38, and the call to "sem_post" must be inserted between lines 40 and 41.
E) None of the above.

29. Consider Figure 9. In order to synchronize the two functions, the statement shown below must be inserted into function "consumer" or function "producer":

```c
sem_wait( &A );
```

Which of the following statements is correct?

A) The call to "sem_wait" should be inserted immediately after the CS exit section in function "producer".
B) The call to "sem_wait" should be inserted immediately after the CS exit section in function "consumer".
C) The call to "sem_wait" should be inserted immediately before the CS entry section in function "producer".
D) The call to "sem_wait" should be inserted immediately before the CS entry section in function "consumer".
E) None of the above.

30. Consider Figure 9. In order to synchronize the two functions, the statement shown below must be inserted into function "consumer" or function "producer":

```c
sem_post( &C );
```

Which of the following statements is correct?

A) The call to "sem_post" should be inserted immediately after the CS exit section in function "producer".
B) The call to "sem_post" should be inserted immediately after the CS exit section in function "consumer".
C) The call to "sem_post" should be inserted immediately before the CS entry section in function "producer".
D) The call to "sem_post" should be inserted immediately before the CS entry section in function "consumer".
E) None of the above.
The C/C++ source code shown below is a program to implement the producer/consumer problem with a bounded buffer. Note that each source code statement is identified with a line number as a comment.

```c
/* 1*/  void consume( double );   // Consume an item (type "double")
/* 2*/  void produce( double* );  // Produce an item (type "double")
/* 3*/  void start_threads();     // Create producer and consumer threads
/* 4*/
/* 5*/  double buffer[5];
/* 6*/  int in, out, num;
/* 7*/
/* 8*/  sem_t A, B, C;
/* 9*/
/*10*/  int main()
/*11*/  {
/*12*/    in = out = num = 0;
/*13*/    sem_init( &A, NULL, 0 );
/*14*/    sem_init( &B, NULL, 1 );
/*15*/    sem_init( &C, NULL, 5 );
/*16*/    start_threads();
/*17*/  }
/*18*/
/*19*/  void consumer()
/*20*/  {
/*21*/    double item;
/*22*/
/*23*/    while (1)
/*24*/    {
/*25*/      num--;
/*26*/      item = buffer[out];
/*27*/      out = (out + 1) % 5;
/*28*/      consume( item );
/*29*/    }
/*30*/  }
/*31*/
/*32*/  void producer()
/*33*/  {
/*34*/    double item;
/*35*/
/*36*/    while (1)
/*37*/    {
/*38*/      produce( &item );
/*39*/      buffer[in] = item;
/*40*/      in = (in + 1) % 5;
/*41*/      num++;
/*42*/    }
/*43*/  }
```