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.

*****************************************************************************
*  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  *
*   D  B  C  D  E  B  E  C  E  A  C  A  E  E  D  C  B  A  E  A  E  C  B  A  *
*                                                                           *
*  25 26 27 28 29 30                                                        *
*   D  C  D  D  C  B                                                        *
*****************************************************************************
01. The C/C++ program shown in Figure 1 is executed on a Linux system. Under what circumstances will variable "A" contain a negative value?

A) When the user does not have permission to read file "/arch/quiz".
B) When file "quiz" does not exist in directory "/arch".
C) When the user does not have permission to access directory "/arch".
D) All of the above.
E) None of the above.

02. The C/C++ program shown in Figure 1 is executed on a Linux system. Assuming that variable "A" contains the value 3, how many bytes will be transferred from file "quiz" to variable "B"?

A) Exactly 0 bytes.
B) No more than 4096 bytes.
C) Exactly 4096 bytes.
D) At least 4096 bytes.
E) None of the above.

03. The C/C++ program shown in Figure 1 is executed on a Linux system. Assuming that variable "A" contains the value 3, how many bytes will be transferred from variable "B" to the standard output stream?

A) Exactly 0 bytes.
B) No more than 4096 bytes.
C) Exactly 4096 bytes.
D) At least 4096 bytes.
E) None of the above.

04. Which of the following statements about interrupts on a Linux system is correct?

A) An interrupt caused by an invalid machine language instruction in the current process will cause a mode switch and a process switch.
B) An interrupt generated by a disk drive when an output operation is completed will cause a mode switch, but not a process switch.
C) An interrupt generated by the expiration of a process’s time quantum will cause a mode switch and a process switch.
D) All of the above.
E) None of the above.
The following questions refer to a uniprocessor system where the OS uses Stalling’s Process State Transition Diagram with seven states.

05. Which of the following might cause a process to move from the Running state to the Exit state?

A) The process requests access to a file which does not exist.
B) The event for which the process is waiting occurs.
C) The process uses up its time quantum.
D) All of the above.
E) None of the above.

06. Which of the following might cause a process to move from the Blocked state to the Ready state?

A) The process requests access to a shared resource.
B) All of the child processes of the process complete.
C) The process is dispatched by the OS.
D) All of the above.
E) None of the above.

07. Which of the following might cause a process to move from the Ready state to the Ready/Suspend state?

A) The process is waiting for a child process to complete.
B) The OS detects that there are no processes in the Blocked state.
C) The process requests access to a shared resource.
D) All of the above.
E) None of the above.

08. Which of the following might cause a process to move from the Running state to the Ready state?

A) The process requests access to a shared resource.
B) The OS detects that all of primary storage has been allocated.
C) The process uses up its time quantum.
D) All of the above.
E) None of the above.

09. Which of the following might cause a process to move from the Ready state to the Running state?

A) The process is granted access to a shared resource.
B) The OS detects that not all of primary storage has been allocated.
C) The process closes 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 Blocked state?

A) The process initiates an input operation on an existing file.
B) An output operation initiated by a different process completes.
C) The OS detects that all of primary storage has been allocated.
D) All of the above.
E) None of the above.
const char* msg[] = { "AAA ", "BBB ", "CCC ", "DDD ", "EEE ", "FFF " }; 

int main()
{
    int flag, i = 3;
    flag = fork();
    write( 2, msg[i], 4 );
    if (flag > 0)
    {
        i = i + 2;
        write( 2, msg[i], 4 );
        i = i - 1;
    }
    else if (flag < 0)
    {
        i = i - 2;
        write( 2, msg[i], 4 );
        i = i + 1;
    }
    else
    {
        i = i + 1;
        write( 2, msg[i], 4 );
        i = i - 2;
    }
    write( 2, msg[i], 4 );
    exit( 0 );
}

11. Consider the C/C++ program shown in Figure 2. What characters will be sent to the standard error stream by the parent process?

A)  DDD EEE CCC
B)  CCC DDD BBB
C)  DDD FFF EEE
D)  CCC EEE DDD
E)  DDD BBB CCC

12. Consider the C/C++ program shown in Figure 2. What characters will be sent to the standard error stream by the child process?

A)  DDD EEE CCC
B)  CCC DDD BBB
C)  DDD FFF EEE
D)  CCC EEE DDD
E)  DDD BBB CCC

13. The C/C++ program shown in Figure 2 is executed on a Linux system with two CPUs. What will be displayed by the program?

A)  CCC EEE DDD CCC DDD BBB
B)  DDD FFF EEE DDD EEE CCC
C)  CCC CCC DDD BBB EEE DDD
D)  DDD DDD EEE CCC FFF EEE
E)  Cannot be determined from the information provided.
14. Consider the C/C++ program shown in Figure 3. What is the affect of executing the "for" statement containing the call to function "pthread_join"?

A) It will attach three threads to the current process.
B) It will create one process out of three threads.
C) It will join three threads into a single thread.
D) It will terminate three threads.
E) None of the above.

15. The C/C++ program shown in Figure 3 is executed on a Linux system with four CPUs. Which of the following is correct?

A) All four of the threads might be in the Ready state simultaneously.
B) All four of the threads might be in the Running state simultaneously.
C) All four of the threads might be in the Blocked state simultaneously.
D) All of the above.
E) None of the above.

16. The C/C++ program shown in Figure 3 is executed on a Linux system with four CPUs. What will be displayed by the program?

A) CCC EEE DDD CCC FFF
B) BBB DDD CCC BBB EEE
C) CCC CCC DDD EEE FFF
D) BBB BBB CCC DDD EEE
E) None of the above.
17. Consider Figure 4, where "Swap" is an atomic operation. Assume three processes share a critical resource. If all three of the processes use the entry and exit sections correctly to guard their critical sections, which of the following is correct?

A) There is no busy waiting.
B) Deadlock cannot occur.
C) Starvation cannot occur.
D) All of the above.
E) None of the above.

18. Consider Figure 4, where "Swap" is an atomic operation. Assume three processes share a critical resource. If all three 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) The mutual exclusion requirement is violated.
D) All of the above.
E) None of the above.

19. Consider Figure 5. Assume two processes (Pi and Pj) 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) The bounded waiting requirement is violated.
B) The progress requirement is violated.
C) The mutual exclusion requirement is violated.
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)

20. Consider Figure 6. 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) There is busy waiting.
B) Deadlock can occur.
C) Starvation can occur.
D) All of the above.
E) None of the above.

21. Consider Figure 6. 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) The bounded waiting requirement is violated.
B) The progress requirement is violated.
C) The mutual exclusion requirement is violated.
D) All of the above.
E) None of the above.

22. Consider Figure 6. Assume five processes share a critical resource. If three of the processes use the entry and exit sections correctly to guard their critical sections, but two processes omit the entry section, which of the following is correct?

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

23. Consider Figure 6. Assume five processes share a critical resource. If three of the processes use the entry and exit sections correctly to guard their critical sections, but two processes omit the exit section, which of the following is correct?

A) Starvation can occur.
B) Deadlock can occur.
C) A violation of mutual exclusion can occur.
D) All of the above.
E) None of the above.
24. Consider Figure 7. Which of the following statements about the critical section of function "producer" is correct?

A) Line 39 through line 41 (inclusive) is the critical section.
B) Line 39 through line 40 (inclusive) is the critical section.
C) Line 38 through line 41 (inclusive) is the critical section.
D) Line 38 through line 40 (inclusive) is the critical section.
E) None of the above.

25. Consider Figure 7. In order to control access to its critical section, the statements shown below must be inserted into function "consumer":

```
sem_wait( &C );
sem_post( &C );
```

Which of the following statements is correct?

A) The call to "sem_wait" must be inserted between lines 25 and 26, and the call to "sem_post" must be inserted between lines 28 and 29.
B) The call to "sem_wait" must be inserted between lines 25 and 26, and the call to "sem_post" must be inserted between lines 27 and 28.
C) The call to "sem_wait" must be inserted between lines 24 and 25, and the call to "sem_post" must be inserted between lines 28 and 29.
D) The call to "sem_wait" must be inserted between lines 24 and 25, and the call to "sem_post" must be inserted between lines 27 and 28.
E) None of the above.

26. Consider Figure 7. In order to synchronize the two functions, the statement shown below must be inserted into function "consumer" or function "producer":

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

Which of the following statements is correct?

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

27. Consider Figure 7. In order to synchronize the two functions, the statement shown below must be inserted into function "consumer" or function "producer":

```
sem_post( &B );
```

Which of the following statements is correct?

A) The call to "sem_post" should be inserted immediately before the CS entry section in function "consumer".
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 after the CS exit section in function "producer".
E) None of the above.
The C/C++ source code shown below implements 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[8];
/* 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, 8 );
/*14*/   sem_init( &B, NULL, 0 );
/*15*/   sem_init( &C, NULL, 1 );
/*16*/   start_threads();
/*17*/ }
/*18*/
/*19*/ void consumer()
/*20*/ {
/*21*/   double item;
/*22*/
/*23*/   while (1)
/*24*/   {
/*25*/     item = buffer[out];
/*26*/     out = (out + 1) % 8;
/*27*/     num--;
/*28*/     consume( item );
/*29*/   }
/*30*/ }
/*31*/
/*32*/ void producer()
/*33*/ {
/*34*/   double item;
/*35*/
/*36*/   while (1)
/*37*/   {
/*38*/     produce( &item );
/*39*/     num++;
/*40*/     buffer[in] = item;
/*41*/     in = (in + 1) % 8;
/*42*/   }
/*43*/ }
```
28. Consider the Linux commands shown in Figure 8. What will be displayed if the command given below is entered at the next shell prompt?

grep 'D' exam1.data | sort -k4,4nr | head -1

A) Martinez,_Victor           AL DET 154 553 65 160 22
B) Desmond,_Ian               AL TEX 156 625 107 178 29
C) Iglesias,_Jose             AL DET 137 467 57 119 26
D) Espinosa,_Danny            NL WAS 157 516 66 108 15
E) None of the above.

29. Consider the Linux commands shown in Figure 8. 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) Desmond,_Ian               AL TEX 156 625 107 178 29
B) Espinosa,_Danny            NL WAS 157 516 66 108 15
C) Kinsler,_Ian               AL DET 153 618 117 178 29
D) Murphy,_Daniel             NL WAS 142 531 88 108 47
E) None of the above.

30. Consider the Linux commands shown in Figure 9. What will be displayed if the command given below is entered at the next shell prompt?

midterm one two three

A) All of the lines in the file "one" which contain the pattern "two" and contain the pattern "three".
B) All of the lines in the file "one" which contain the pattern "two" and do not contain the pattern "three".
C) All of the lines in the file "two" which contain the pattern "one" and contain the pattern "three".
D) All of the lines in the file "two" which contain the pattern "one" and do not contain the pattern "three".
E) None of the above.