1. Deadlock occurs when each process in a set of processes
   a. is waiting for an event (or exclusive-use resource) that only another process can cause (or release).
   b. terminates without closing all of the files it had open.
   c. None of the other answer choices is correct.

2. Which of the following resources is not one which can result in deadlocking processes?
   a. a hardware interrupt
   b. a disk file
   c. the central processor (CPU)

3. Which of the following is an example of a consumable resource?
   a. an I/O device
   b. a system data structure
   c. a message sent through some sort of channel

4. Which of the following is an example of a non-consumable resource?
   a. a memory region
   b. a message sent through some sort of channel
   c. a keyboard input

5. Which of the following resources is considered preemptible by many operating systems?
   a. printers
   b. primary memory
   c. All of the above resources are usually considered preemptible by many operating systems.

6. What usually happens to a process if a resource it is using is preempted?
   a. The process is notified that the resource has been preempted, and is given an opportunity to decide how to continue.
   b. The process is blocked until the resource is restored.
   c. None of the other answer choices is correct.

7. What is the state of a resource that is restored to a process from which it was previously preempted?
   a. The resource will have the state left by the process that used it during the time it was preempted.
   b. The resource will have exactly the same state as when it was previously preempted.
   c. None of the other answer choices is correct.
8. Suppose a process requests a shared lock on a resource, and another process already holds a shared lock. What will happen?
   a. the lock will be converted to an exclusive lock, and the resource will be preempted from the process that held the shared lock.
   b. the process will be granted the shared lock.
   c. the process will not be granted the shared lock, but will be given an indication that the shared lock was not granted; that is, the process will not be blocked.

9. There are four necessary conditions required for deadlock. Who first demonstrated these conditions?
   a. Coffman
   b. Brinch Hansen
   c. Dekker

10. Which of the following is not a necessary condition for deadlock?
    a. circular wait
    b. at least three processes
    c. mutual exclusion

11. What is meant by the hold and wait condition?
    a. Processes must hold at least one unit of a resource if they want to wait on another unit of the same resource.
    b. Processes must hold exclusive use of a semaphore if they wish to wait for another resource.
    c. Processes are allowed to continue holding (for exclusive use) resources while waiting (blocking) for additional resources.

12. What is meant by the no preemption condition?
    a. All of the resources must be preemptible.
    b. None of the resources held by processes can be preempted from those processes.
    c. None of the other answer choices is correct.

13. A resource graph has two types of nodes. What do these nodes represent?
    a. resources and processes
    b. consumable and non-consumable resources
    c. blocked processes and ready processes

14. Assume we have a resource graph that represents a deadlocked state. Also assume we start from a node associated with a deadlocked process and follow directed edges. Which of the following nodes can we always reach in this edge-following?
    a. a node associated with a preemptible resource
    b. the node from which we started
    c. a node associated with an unused resource
15. Consider a given resource graph. Where can we find the nodes for the processes that are deadlocked?
   a. They are the process nodes in the cycle (or cycles) in the graph, if any.
   b. They include each process node with at least one edge pointing to it and at least one edge pointing away from it.
   c. They include each process node with no edges pointing to it.

16. What characterizes the algorithm Tanenbaum calls the ostrich algorithm?
   a. The algorithm searches for process nodes with two incoming edges and one outgoing edge.
   b. It basically means we do nothing, ignoring the possibility of deadlock.
   c. None of the other answer choices is correct.

17. Why might the ostrich algorithm be chosen for a system?
   a. The system was designed to be deadlock free, or the probability of deadlock is so small as to not justify the overhead of one of the other algorithms to deal with deadlock.
   b. Although expensive to implement, the ostrich algorithm is guarantee to prevent deadlock.
   c. None of the other answer choices is correct.

18. The detect and recover approach to dealing with deadlock obviously requires that we detect when deadlock has occurred, and then recover from it. How may the recovery from deadlock be performed?
   a. Terminate processes in the reverse order they were started, terminating the last started process first, until the deadlock disappears.
   b. Identify a deadlocked process and then terminate it, releasing the resources to which it had exclusive use.
   c. None of the other answer choices is correct.

19. The detect and recover approach to dealing with deadlock obviously requires that we detect when deadlock has occurred, and then recover from it. Which of the following approaches may be used to detect deadlocked processes without constructing a resource graph and checking for cycles?
   a. Find processes that have remained blocked for a considerable period of time.
   b. Find processes that have not produced any output for a considerable period of time.
   c. Find processes that are using a great deal of CPU time.

20. What is done when the technique called checkpointing is used?
   a. The contents of all registers are saved.
   b. All information about a running process is periodically recorded and saved so it can be used to restore the process from the saved checkpoint later if desired.
   c. The resource allocation graph is periodically saved so changes in the graph can be detected.
21. What is the essence of techniques used to prevent deadlock?
   a. They deny, or prevent, the occurrence of one (or more) of the necessary conditions for deadlock.
   b. They restrict a process from acquiring exclusive use of any additional resources until it releases exclusive use of all the resources it currently holds.
   c. None of the other answer choices is correct.

22. To eliminate the need for exclusive use of a resource
   a. the resource must be replicated a sufficient number of times, one per process.
   b. techniques must be used to allow the resource to be shared.
   c. None of the other answer choices is correct.

23. What is the traditional approach to allowing a single printer to be shared by many processes?
   a. Each process gets exclusive use of the printer to print a single line of output at a time.
   b. Each process gets exclusive use of the printer to print a single page of output at a time.
   c. Each process writes its printed output to a file; when the output is complete, the file is added to a queue of files to be printed by a single process that has exclusive use of the printer.

24. How can the hold and wait condition, required for deadlock, be reasonably eliminated?
   a. We can require processes to request all resources they require at one time, and not allow them to use any resources until all the resources are available.
   b. Require processes to continually poll for exclusive use of the required resources.
   c. None of the other answer choices is correct.

25. Which of the four conditions necessary for deadlock does Havender's standard allocation pattern prevent?
   a. circular wait
   b. hold and wait
   c. Each of the other answers is one of the conditions prevented by the standard allocation pattern.

26. Suppose three resource types, A, B, and C are assigned numeric codes 1, 2, and 3 for use with Havender's standard allocation pattern. A process has requested, and been given, exclusive use of resource B. Which of the following actions is then not permitted?
   a. requesting use of resource A
   b. requesting use of an additional unit of resource B
   c. Each of the other actions is permitted.
27. Deadlock prevention and deadlock avoidance are separate approaches to deal with the potential for deadlock in a system. Which of these approaches eliminates certain system states that might not lead to deadlock?
   a. It is impossible to tell without examination of each specific system being considered.
   b. deadlock prevention
   c. deadlock avoidance

28. Each time a process acquires or releases exclusive use of a resource, the system enters a new state as indicated by a point on a resource trajectory. What characterizes a state that is called unsafe?
   a. The system is not deadlocked, but depending on which process is next allowed to allocate a resource, the system could become deadlocked.
   b. A process has requested more units of a resource than are available in the system.
   c. None of the other answer choices is correct.

29. Who is responsible for the Banker's algorithm?
   a. Wirth
   b. Tanenbaum
   c. Dijkstra

30. What does the Banker's algorithm do?
   a. After granting each resource request, it determines if the system is in an unsafe state, and if it is, the process state is restored to that specified in its last checkpoint.
   b. Prior to granting each resource request, it determines if the grant would put the system in an unsafe state, and if it would, the request is deferred.
   c. None of the other answer choices is correct.

31. Why is the Banker's algorithm named as it is?
   a. It refers to the incremental increase in priority of processes that are blocked waiting for a resource, mirroring the effect of compound interest.
   b. It suggests the actions taken by a banker with a limited amount of funds to loan, and a number of clients who may collectively want to borrow more than the banker has.
   c. It was developed by Jonas Banker.

32. In two-phase locking, a process sequentially attempts to exclusively allocate the needed resources. If one of the needed resources is not available, the process
   a. relinquishes all of the resources that were successfully allocated, delays a short (perhaps random) period of time, then repeats the request.
   b. relinquishes the last resource requested, waits a random time, and then tries again.
   c. relinquishes the first resource requested, waits a random time, and then tries again.
33. A block input/output device has which of the following characteristics?
   a. It transfers data in blocks that are relatively large.
   b. It is always used to communicate directly with a user.
   c. None of the other answer choices is correct.

34. A device driver
   a. is the cable used to connect a device to a system.
   b. is hardware (i.e. electronics) that stores data until a device is capable of processing it.
   c. is software that handles the detailed interaction between the system and a device.

35. A system has two floppy disk drives. How many floppy disk device drivers are probably present in the system?
   a. one, since similar or identical devices can usually share the same device driver.
   b. at least two, but perhaps more than two, since the potential exists for additional drives to be added to the system.
   c. None of the other answer choices is correct.

36. What is the relationship between a device driver and a device controller?
   a. A device controller is the software that communicates with a device driver.
   b. A device driver is the software that communicates with a device controller.
   c. None of the other answer choices is correct.

37. The interface between a device driver and the rest of the operating system
   a. depends on the device type (for example, floppy disk drivers have a different system interface than hard disk drivers).
   b. is normalized, so every device driver presents the same interface to the operating system.
   c. depends on whether the device is a storage device or not.

38. Which of the following is not a standard bus acronym?
   a. PCI-X
   b. PCB
   c. PCI

39. What is a data channel?
   a. a control unit that manages one or possible more device controllers on a mainframe
   b. a secondary bus on a mainframe computer system that provides reliability in case the primary bus fails
   c. a separate processor on a mainframe that directs the flow of data between I/O devices and primary memory

40. What is the function of a bus adapter?
   a. It connects a data channel to a multibus control unit.
   b. It connects one type of bus to another by performing signal level and timing translation.
   c. It connects a data channel to a data path.
41. The collection of all tracks that can be read or written with a single setting of the heads on a disk is called
   a. a block.
   b. a school.
   c. a cylinder.

42. The time required to move the read/write heads on a disk from their current position to a new position is called
   a. the movement delay.
   b. the head latency.
   c. the seek time.

43. The time required for the desired sector to move so it is appropriately located under a read/write head is called
   a. the transfer time.
   b. the rotational latency.
   c. the flow rate.

44. The time required for data to move between a disk drive and primary memory, once the heads and the disk have been put into the appropriate position, is called
   a. the seek time.
   b. the block time.
   c. the transfer time.

45. The time required to complete a disk I/O operation is the sum of
   a. the seek time, the rotational latency, and the transfer time.
   b. the movement delay, the head latency, and the seek time.
   c. the data rate divided by the flow rate times the block size, the rotational latency, and the seek time.

46. When a disk is not being accessed
   a. the disk rotation may be stopped to save power.
   b. the heads are moved to cylinder 0 in preparation for the next read/write operation.
   c. the disk rotational speed is reduced, but not stopped, thus maintaining some inertia that speeds the startup before the next read/write operation.

47. The smallest unit of data which may be read or written by a physical disk drive is called
   a. a group.
   b. a sector.
   c. a cylinder.
48. The set of tracks on a single disk surface
   a. can be physically reordered (given different track numbers) by a physical controller operation.
   b. is arranged (at least conceptually) as a group of concentric circles.
   c. can be read or written with a single input/output operation by the controller.

49. A sector usually has at least two parts: a preamble and a data region. Which of the following is usually found in the preamble?
   a. information identifying the physical location of the sector on the disk.
   b. the user ID of the user whose process actually wrote the data.
   c. None of the other answer choices is correct.

50. The rotational speed of a disk (when it is operating) is usually
   a. constant, with some tolerance for variation.
   b. completely variable, with lower speeds being selected to reduce power consumption on mobile devices.
   c. None of the other answer choices is correct.

51. A particular disk rotates at 7200 revolutions per minute (which is a common speed). Once the read/write heads have reached the proper cylinder, what is the average rotational delay that will be encountered before data transfer can begin? Assume each sector on the disk is as likely to be read as any other.
   a. 8.333 milliseconds
   b. 1/7200 second
   c. 1/240 second

52. What is the path taken by the electron beam in a CRT used in a video monitor?
   a. The path is top to bottom on the leftmost column, then top to bottom on the next column to the right, and so forth, and finally back to the upper left corner where the cycle repeats.
   b. On each row the path is random, and depends on the data to be displayed on that row. But each row is completed before the next lower row is processed. After the last row is complete, the first row is started again.
   c. The path is left to right on each row, then on to the beginning of the next lower row, ..., and finally back to the upper left corner where the cycle repeats.

53. In early systems, the image to be displayed on a video display was
   a. stored in a mercury delay line.
   b. stored in the computer's primary memory.
   c. None of the other answer choices is correct.

54. In modern systems, the image to be displayed on a video display is located
   a. in a mercury delay line.
   b. in special memory that is located in the video adapter.
   c. None of the other answer choices is correct.
55. The acronym PIXEL standard for
   a. picture element.
   b. picture electrical line.
   c. partial execution limit.

56. What does it mean for memory to be dual ported?
   a. Each read of a byte in the memory is also accompanied by a write operation.
   b. Each read of a byte in the memory must be done twice.
   c. The memory can be accessed (read and written) by the CPU and a device controller at the same time without introducing excessive delay.

57. The acronym DMA stands for
   a. Direct Memory Access
   b. Dual Memory Access
   c. Delay Minimization Algorithm

58. When DMA is used
   a. the CPU, after setting up the DMA, is not directly involved in the transfer of every data byte between memory and an input/output device.
   b. device drivers are simpler.
   c. device controllers are able to operate faster than if DMA is not used.

59. The purpose of interleaving (as applied to disks) is
   a. the logical reordering of the sectors to reduce rotational latency.
   b. the multiplexing of data from two physical sectors on a disk to the disk controller.
   c. the alternation of the CPU between processing an instruction and dealing with an input/output operation.

60. Input/output software is designed in layers. Each layer
   a. provides services to the layer above it, and uses services provided by the layer below it.
   b. deals with only a single device (or device type).
   c. None of the other answer choices is correct.

61. Early operating systems (like CP/M)
   a. had only a single system call for input/output, with parameters identifying the device, the operation to be performed, the memory location of the data, and the number of bytes to be processed.
   b. had separate system calls for input/output on serial ports, keyboard, displays, and disk drives.
   c. None of the other answer choices is correct.
62. When device independence is provided by an operating system,
   a. all devices are managed by a single device driver.
   b. the same system call can be used to read from an arbitrary input source.
   c. None of the other answer choices is correct.

63. What should normally be done if a read operation on a disk produces a physical error?
   a. The device should be marked "off line" and the operator should be notified; the process
      requesting the read should remain blocked.
   b. The operation should be repeated, perhaps a few times, because the error might be
      transient.
   c. None of the other answer choices is correct.

64. The goal of concurrency in input/output systems is
   a. to allow a process to continue operation while one or more input/output operations are in
      progress.
   b. to allow the CPU to be accessing several different physical devices at the same time.
   c. None of the other answer choices is correct.

65. Which of the following devices are usually not shared by processes from several users?
   a. a serial port
   b. a disk drive
   c. a network interface

66. When a disk drive completes a read or write operation, it is common for
   a. an interrupt to be generated.
   b. the process requesting the operation to be blocked.
   c. None of the other answer choices is correct.

67. Which of the following events is likely to be able to generate an interrupt?
   a. a byte has been written to a disk drive.
   b. a disk drive has moved the read/write heads to an adjacent cylinder.
   c. a byte received on a serial port has bad parity.

68. In a system that uses memory-mapped input/output, registers on device controllers appear as
   a. ordinary memory locations that may be read or written.
   b. semaphores.
   c. None of the other answer choices is correct.

69. The first task of the interrupt handler for a device is
   a. to obtain information from device controller registers to determine the reason for the
      interrupt.
   b. to start another input/output operation.
   c. None of the other answer choices is correct.
70. A device driver rarely completes all the work associated with an interrupt from a device's controller. Instead, it will usually
   a. awaken a blocked process to complete the work.
   b. create a new process to handle the rest of the work.
   c. None of the other answer choices is correct.

71. When several devices share the same interrupt, the device driver that handles the interrupt
   a. must poll the devices to determine which of them caused the interrupt.
   b. stops input/output on all but one of the devices, and restarts the operation on the remaining device.
   c. None of the other answer choices is correct.

72. The initialization routine (or component) of a device driver
   a. during system shutdown to place the device into a consistent state.
   b. is invoked during system startup to determine if the device exists, and if so, how many units of the device are present.
   c. None of the other answer choices is correct.

73. The strategy routine in a device driver
   a. determines the best data path through a DMA channel.
   b. queues requests for a block device until they can be processed.
   c. None of the other answer choices is correct.

74. A watchdog timer
   a. is not commonly used by device drivers in modern operating systems.
   b. signals a device driver if an input/output operation does not complete in a reasonable time.
   c. None of the other answer choices is correct.

75. The term logical block refers to
   a. the reason a process will block while waiting on an interrupt from an input/output device's controller.
   b. a group of consecutive physical blocks, or sectors, treated as a single unit for efficiency.
   c. None of the other answer choices is correct.

76. The system buffer pool or buffer cache is used to
   a. hold the identities of all processes that are blocked waiting on a disk input/output operation to complete.
   b. hold copies of blocks that have been read from disk.
   c. hold all blocks that are waiting to be written to a disk.
77. It is common for application languages (like C, C++, and Java) to provide libraries of input/output functions that perform the actual system calls for input/output. When these library functions read or write a disk, for example, they
   a. request data transfers in blocks, rather than in single bytes.
   b. request transfers directly to or from the disk, rather than using the system buffer cache.
   c. None of the other answer choices is correct.

78. If there is only a single process executing in a system and no concurrent input/output is permitted, the disk device drive will process requests
   a. using the C-SCAN algorithm.
   b. using the FIFO algorithm.
   c. using the LOOK algorithm.

79. The SSTF algorithm for disk scheduling orders requests
   a. to minimize seek time.
   b. to minimize transfer time.
   c. None of the other answer choices is correct.

80. The SCAN algorithm is one of a class of disk scheduling algorithms characterized by the name
   a. elevator algorithms.
   b. finite state algorithms.
   c. simplex/duplex algorithms.

81. Assume the SCAN algorithm is in use, the heads are moving up, are currently processing a request on cylinder 20, and the upsweep queue contains 25, 37, and 58. A new request arrives for cylinder 62. It will be placed
   a. before 25 on the upsweep queue.
   b. after 58 on the upsweep queue.
   c. at the tail of the downsweep queue.

82. Assume the SCAN algorithm is in use, the heads are moving up, are currently processing a request on cylinder 20, and the upsweep queue contains requests for cylinders 25, 37, and 58. A new request arrives for cylinder 22. It should be placed
   a. on the downsweep queue.
   b. before cylinder 25 on the upsweep queue.
   c. None of the other answer choices is correct.

83. Assume the SCAN algorithm is in use, the heads are moving up, are currently processing a request on cylinder 20, and the upsweep queue contains requests for cylinders 25, 37, and 58. After processing requests on which cylinder will the algorithm begin a downsweep?
   a. cylinder 25.
   b. It is impossible to tell with the information given.
   c. None of the other answer choices is correct.
84. The primary difference between the SCAN and the LOOK disk scheduling algorithms is  
   a. LOOK defers new requests for the cylinder on which the heads are located, but SCAN  
      adds them to the current queue (that is, the upsweep or downsweep queue that is being  
      processed).  
   b. SCAN moves between the lowest and highest physical cylinder numbers, and LOOK  
      moves between the lowest and highest cylinder numbers at which requests are located.  
   c. None of the other answer choices is correct.  
85. The primary difference between the SCAN and C-SCAN disk scheduling algorithms is  
   a. The SCAN algorithm numbers cylinders starting with 1, but the C-SCAN algorithm  
      numbers them starting with 0.  
   b. SCAN maintains an upsweep and a downsweep queue, but C-SCAN treats the disk as if  
      it were a cylinder, with the lowest numbered cylinder being processed immediately after  
      the highest numbered cylinder.  
   c. None of the other answer choices is correct.  
86. Which of the following is the correct meaning of the RAID acronym?  
   a. Redundant Array of Inexpensive Disks  
   b. Redundant Array of Information Disks  
   c. Reliable Array of Independent Disks  
87. Modern disk controllers  
   a. anticipate the direction in which the heads will move next, and start moving them in that  
      direction even before the next command is given.  
   b. have sufficient memory to store the contents of an entire disk track.  
   c. None of the other answer choices is correct.  
88. Most modern computer systems maintain a battery-powered clock that can provide the date  
    and time. When is this clock normally read?  
   a. at least once every hour.  
   b. only when the system is booted.  
   c. None of the other answer choices is correct.  
89. A programmable timer usually has two registers. One register is decremented each time a  
    fixed frequency oscillator goes through one cycle. When this register reaches zero  
   a. an interrupt is generated.  
   b. the currently running process is terminated.  
   c. None of the other answer choices is correct.  
90. A programmable timer usually has two registers. One register is decremented each time a  
    fixed frequency oscillator goes through one cycle. The other register  
   a. is incremented each time the first register reaches zero.  
   b. is often used to reload the first register when it reaches zero.  
   c. None of the other answer choices is correct.
91. Since a system has a limited number of hardware timers, and many timers may be needed by processes, most systems maintain a queue of virtual timers. These virtual timers are ordered by
   a. the time at which the virtual timers will reach zero.
   b. the inverse order in which the virtual timers were created.
   c. the inverse order in which the timers will reach zero.

92. Suppose the virtual timer queue in a system has timers scheduled to expire in 10, 20, and 30 seconds from the current time. The entries on the virtual timer queue will have delta times of
   a. 10, 20, and 30.
   b. 30, 20, and 10.
   c. 10, 10, and 10.

93. Suppose the delta times on the virtual timer queue, in order, are 5, 10, and 5. A new virtual timer is required for time 18. What will the delta times be, in order, after the new request is added to the queue?
   a. 5, 10, 3, 2
   b. 5, 10, 5, 18
   c. 18, 5, 10, 5

94. A terminal is the term used for several separate devices that are grouped together. What are those devices?
   a. a keyboard and a display
   b. a keyboard and a mouse
   c. None of the other answer choices is correct.

95. An RS-232 terminal is so named because
   a. it uses a standard (RS-232) serial connection between the terminal and a computer system (or modem).
   b. it can receive and send (RS) 232 characters per second.
   c. None of the other answer choices is correct.

96. An X terminal is so named because
   a. it includes an X-mouse.
   b. it uses the X protocol for communication.
   c. None of the other answer choices is correct.

97. An escape sequence is
   a. a sequence of characters used to bypass the password prompt issued by a computer system.
   b. a string of characters, usually beginning with an escape character, that requests a special command for a terminal.
   c. None of the other answer choices is correct.
98. The upper limit on serial data rates (as used with terminals) is about
   a. 56,000 bits per second.
   b. 8192 bits per second.
   c. None of the other answer choices is correct.

99. When a terminal operates in *cooked* mode, each character typed by the user
   a. is displayed.
   b. is checked to see if it is part of an escape sequence.
   c. None of the other answer choices is correct.

100. When a terminal operates in *raw* mode, each character typed by the user
   a. is checked to see if it is a control-C.
   b. is passed immediately to the application without examination by the operating system.
   c. is ignored if it is a function key.

101. One character code sent to a terminal that may require processing by a non-terminal device is
   a. an ALT character.
   b. a bell character.
   c. None of the other answer choices is correct.

102. ASCII is a standard for codes associated with the characters commonly found on terminals. A major problem with ASCII is
   a. it omits many characters used internationally.
   b. it has no support for control characters.
   c. it makes no distinction between upper case and lower case characters.