1. Deadlock occurs when each process in a set of processes
   a. terminates without closing all of the files it had open.
   b. is waiting for an event (or exclusive-use resource) that only another process can cause (or release).
   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 semaphore
   b. the central processor (CPU)
   c. a hardware interrupt

3. Which of the following is an example of a consumable resource?
   a. a memory region
   b. a disk file
   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 keyboard input
   c. a hardware interrupt

5. Which of the following resources is considered preemptible by many operating systems?
   a. tape drives
   b. primary memory
   c. printers

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. The process is terminated abnormally.

7. What is the state of a resource that is restored to a process from which it was previously preempted?
   a. The resource will be set to a standard initial state.
   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. None of the other answer choices is correct.

9. There are four necessary conditions required for deadlock. Who first demonstrated these conditions?
   a. Peterson
   b. Coffman
   c. Dijkstra
10. Which of the following is **not** a necessary condition for deadlock?
   a. no preemption
   b. circular wait
   c. at least three processes

11. What is meant by the *hold and wait* condition?
   a. Processes must hold exclusive use of a semaphore if they wish to wait for another resource.
   b. Processes are allowed to continue holding (for exclusive use) resources while waiting (blocking) for additional resources.
   c. None of the other answer choices is correct.

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. semaphores and processes
   b. resources and processes
   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 a consumable resource

15. Consider a given resource graph. Where can we find the nodes for the processes that are deadlocked?
   a. They include each process node with at least one edge pointing to it and at least one edge pointing away from it.
   b. They include each process node with no edges pointing to it or away from it.
   c. They are the process nodes in the cycle (or cycles) in the graph, if any.

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. The algorithm has no royalties associated with its use, and can thus be used freely.
   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. Terminate processes in the same order they were started until the deadlock disappears.
   c. Identify a deadlocked process and then terminate it, releasing the resources to which it had exclusive use.
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 are using a very small amount of memory.
   c. Find processes that are using a very large amount of memory.

20. What is done when the technique called *checkpointing* is used?
   a. 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.
   b. The resource allocation graph is periodically saved so changes in the graph can be detected.
   c. Each process periodically makes a system call to inform the system that it is making progress. If it fails to make the call within a specified period, the system assumes the process is deadlocked and terminates it.

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 resources.
   c. None of the other answer choices is correct.

22. To eliminate the need for exclusive use of a resource
   a. the processes that need to use the resource exclusively must be run sequentially, one at a time.
   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. Although exclusive use of the printer is not requested, users agree to have only one process use the printer at a time. If this agreement is violated, the output of multiple processes will be flawed.
   b. 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.
   c. None of the other answer choices is correct.

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. Prevent processes from obtaining exclusive use of any 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. mutual exclusion
   b. circular 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 C
   b. requesting use of resource A
   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. deadlock avoidance
   b. deadlock prevention
   c. neither deadlock avoidance or prevention

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. The system is deadlocked.
   c. None of the other answer choices is correct.

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

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 is terminated.
   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 priority penalty that processes incur if they request exclusive use of resources before the time specified when the process was created.
   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. None of the other answer choices is correct.

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 first resource requested, waits a random time, and then tries again.
   c. is placed on a queue; when the resource that was unavailable becomes available, the process is taken off the queue and the request is repeated.

33. A block input/output device has which of the following characteristics?
   a. It transfers data in one-byte units.
   b. It transfers data in blocks that are relatively large.
   c. None of the other answer choices is correct.

34. A device driver
   a. is hardware (i.e. electronics) that stores data until a device is capable of processing it.
   b. is software that handles the detailed interaction between the system and a device.
   c. None of the other answer choices is correct.
35. A system has two floppy disk drives. How many floppy disk device drivers are probably present in the system?
   a. None, since the floppy disk electronics are integrated into the drive itself.
   b. one, since similar or identical devices can usually share the same device driver.
   c. None of the other answer choices is correct.

36. What is the relationship between a device driver and a device controller?
   a. The device driver and device controller are both hardware components; the device driver is usually physically located in the system, while the device controller is usually physically located in the device being controlled.
   b. A device driver is the software that communicates with a device controller.
   c. They are just different names for the same thing.

37. The interface between a device driver and the rest of the operating system
   a. is normalized, so every device driver presents the same interface to the operating system.
   b. is the same as the interface between the device driver and the device controller.
   c. None of the other answer choices is correct.

38. Which of the following is not a standard bus acronym?
   a. ISA
   b. PCB
   c. SCSI

39. What is a data channel?
   a. a secondary bus on a mainframe computer system that provides reliability in case the primary bus fails
   b. a separate processor on a mainframe that directs the flow of data between I/O devices and primary memory
   c. a device driver for a mainframe computer system

40. What is the function of a bus adapter?
   a. It connects a control unit to a data channel.
   b. It connects one type of bus to another by performing signal level and timing translation.
   c. None of the other answer choices is correct.

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 cylinder.
   b. a group.
   c. a school.

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 flow rate.
   b. the rotational latency.
   c. the transfer time.

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 transfer time.
   b. the movement delay.
   c. the data rate.
45. The time required to complete a disk I/O operation is the sum of
   a. the rotational latency and the transfer time.
   b. the data rate divided by the flow rate times the block size, the rotational latency, and the seek time.
   c. the seek time, the rotational latency, and the transfer 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. None of the other answer choices is correct.

47. The smallest unit of data which may be read or written by a physical disk drive is called
   a. a page.
   b. a group.
   c. a sector.

48. The set of tracks on a single disk surface
   a. is arranged (at least conceptually) as a group of concentric circles.
   b. can be read or written using no more than one command per cylinder.
   c. None of the other answer choices is correct.

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. information about the speed of the disk when the sector was last written.
   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 no tolerance for variation.
   b. variable to a limited extent to maintain a constant data rate regardless of the position of the heads on the disk.
   c. constant, with some tolerance for variation.

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. 1/120 second
   b. It is impossible to tell from the information provided.
   c. 1/240 second

52. What is the path taken by the electron beam in a CRT used in a video monitor?
   a. 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.
   b. 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.
   c. None of the other answer choices is correct.

53. In early systems, the image to be displayed on a video display was
   a. dynamically recomputed by a program every 1/60 second.
   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. on a high speed disk drive.
   c. in special memory that is located in the video adapter.
55. The acronym PIXEL stands for
   a. paired interactive execution limit.
   b. picture element.
   c. None of the other answer choices is correct.

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 byte in the memory has a duplicate.
   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. Delay Minimization Algorithm
   c. Dynamic Motion Accelerator

58. When DMA is used
   a. input/output can only be performed to one device at a time.
   b. 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.
   c. None of the other answer choices is correct.

59. The purpose of interleaving (as applied to disks) is
   a. the alternation of the CPU between processing an instruction and dealing with an input/output oper-
      ation.
   b. the logical reordering of the sectors to reduce rotational latency.
   c. None of the other answer choices is correct.

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. has its own device driver.
   c. None of the other answer choices is correct.

61. Early operating systems (like CP/M)
   a. had no system calls explicitly for input/output, but instead used shared memory to permit processes
      to communicate with devices.
   b. had a single system call for reading a device, regardless of the type of device that was being read.
   c. had separate system calls for input/output on serial ports, keyboard, displays, and disk drives.

62. When device independence is provided by an operating system,
   a. the same system call can be used to read from an arbitrary input source.
   b. all devices can be accessed by all applications.
   c. all devices are managed by a single device driver.

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 synchronize access to several different physical devices.
   b. to allow the CPU to be accessing several different physical devices at the same time.
   c. to allow a process to continue operation while one or more input/output operations are in progress.
65. Which of the following devices are usually not shared by processes from several users?
   a. a network interface
   b. a serial port
   c. None of the other answer choices is correct.

66. When a disk drive completes a read or write operation, it is common for
   a. an interrupt to be generated.
   b. the drive’s heads to be moved to a different cylinder.
   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 byte received on a serial port has bad parity.
   c. None of the other answer choices is correct.

68. In a system that uses memory-mapped input/output, registers on device controllers appear as
   a. semaphores.
   b. ordinary memory locations that may be read or written.
   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. request that the device generate additional interrupts so the work can be completed in later invocations of the interrupt handler.
   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. stops input/output on all but one of the devices, and restarts the operation on the remaining device.
   b. restarts the input/output operations on each device that shares the interrupt.
   c. must poll the devices to determine which of them caused the interrupt.

72. The initialization routine (or component) of a device driver
   a. is invoked during system startup to determine if the device exists, and if so, how many units of the device are present.
   b. is called each time another input/output operation is to be started.
   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 transfers directly to or from the disk, rather than using the system buffer cache.
   b. request data transfers in blocks, rather than in single bytes.
   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 FIFO algorithm.
   b. using the LOOK algorithm.
   c. using the SSTF algorithm.

79. The SSTF algorithm for disk scheduling orders requests
   a. to minimize seek time.
   b. to minimize rotational latency.
   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. finite state algorithms.
   b. elevator 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. after 58 on the upsweep queue.
   b. at the tail of the downsweep queue.
   c. None of the other answer choices is correct.

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. after cylinder 25 on the upsweep 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 25, 37, and 58. After processing requests on which cylinder will the algorithm begin a downsweep?
   a. It is impossible to tell with the information given.
   b. cylinder 58.
   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. SCAN moves between the lowest- and highest-numbered physical cylinders, but C-SCAN only moves between the lowest- and highest-numbered cylinders for which requests are present.
   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. Reliable Array of Independent Disks
   b. Redundant Array of Inexpensive Disks
   c. None of the other answer choices is correct.

87. Modern disk controllers
   a. can handle transfers from several heads on different tracks at the same time.
   b. have sufficient memory to store the contents of an entire disk track.
   c. anticipate the direction in which the heads will move next, and start moving them in that direction even before the next command is given.

88. Most modern computer systems maintain a battery-powered clock that can provide the date and time. When is this clock normally read?
   a. only when the system is booted.
   b. when a process requests the date or time.
   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. the second register is decremented.
   b. the currently running process is terminated.
   c. an interrupt is generated.

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 often used to reload the first register when it reaches zero.
   b. is incremented each time the first register 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 order in which the virtual timers were created.
   c. None of the other answer choices is correct.

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. 30, 20, and 10.
   b. 10, 10, and 10.
   c. 0, 10, and 20.
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. 18, 5, 10, 5
   c. None of the other answer choices is correct.

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 display and a serial port
   c. None of the other answer choices is correct.

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

96. An X terminal is so named because
   a. it uses the X protocol for communication.
   b. it includes an X-mouse.
   c. it can use an arbitrary, unknown (hence, the X) protocol for communication.

97. An escape sequence is
   a. a string of characters, usually beginning with an escape character, that requests a special command for a terminal.
   b. a sequence of characters that is used to reset a keyboard.
   c. None of the other answer choices is correct.

98. The upper limit on serial data rates (as used with terminals) is about
   a. 8192 bits per second.
   b. 56,000 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 checked to see if it is part of an escape sequence.
   b. is displayed.
   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 passed immediately to the application without examination by the operating system.
     b. is ignored if it is a function key.
     c. is checked to see if it is a control-C.

101. One character code sent to a terminal that may require processing by a non-terminal device is
     a. a bell character.
     b. a function key.
     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 makes no distinction between upper case and lower case characters.
     c. None of the other answer choices is correct.