

**Q18.** Which of the following is an appropriate reason for using a real-time OS in an embedded system?

- a) A graphical user interface is provided from an ease-of-use perspective with a real-time OS.
- b) A real-time OS guarantees the highest levels of system security and reliability.
- c) No data is lost even if an application program hangs up with a real-time OS.
- d) With a real-time OS, there is a mechanism available to respond within a limited time.

**Q19.** Which of the following is software that can be used without charge but has restrictions on modification and redistribution?

- a) Freeware
- b) Package software
- c) Public domain software
- d) Shareware

**Q20.** Which of the following is an appropriate explanation of the function of an actuator?

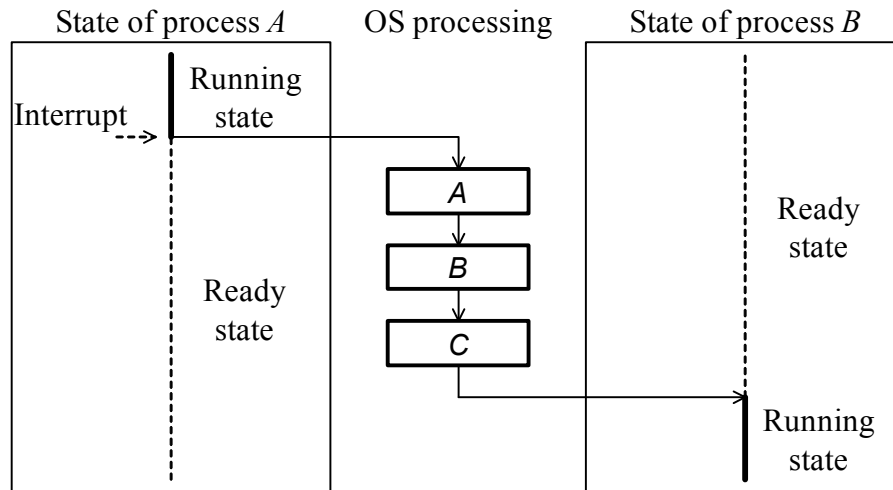
- a) It changes an analog electrical signal into a digital electrical signal, which a computer can process.
- b) It changes an electrical control signal that a computer supplies into a mechanical motion.
- c) It identifies a physical quantity and changes it into an electrical signal.
- d) It is used in devices such as keyboards or touch panels to enter data into a computer.

**Q10.** Which of the following is an appropriate description of XML?

- a) An exclusive editor is required to produce XML documents.
- b) It is an integration of the logical structure and document style.
- c) It is based on HTML and offers more extended functions.
- d) The attributes and logical structure of a document can be defined with user-defined tags.



**Q17.** In the switching procedure of processes in the multiprogramming shown in the figure below, which of the following is an appropriate combination of OS processing from *A* to *C*?



	<i>A</i>	<i>B</i>	<i>C</i>
a)	Restoration of the running state	Selection of the process	Saving of the running state
b)	Saving of the running state	Restoration of the running state	Selection of the process
c)	Saving of the running state	Selection of the process	Restoration of the running state
d)	Selection of the process	Restoration of the running state	Saving of the running state

**Q16.** Which of the following is an appropriate description of the dispatcher in an operating system?

- a) A function in which multiple tasks appear to be running simultaneously on a single processor
- b) The allocation of the right to use a processor for a ready process
- c) The context that is the information required for process execution
- d) The determination of the order of execution for each process

**Q17.** Among the processes that are performed by a compiler for a procedural language, which of the following is the process that is performed first?

- a) Lexical analysis
- b) Optimization
- c) Semantic analysis
- d) Syntactic analysis (parsing)

**Q19.** Which of the following represents appropriate handling for open source software according to OSI's definition?

- a) For open- source software that is created for a specific industry, the scope of publishing of the source code can be limited to that industry.
- b) If open- source software is to be modified for uses such as internal use by a company without being redistributed, the modified part of the source code does not have to be published.
- c) When open- source software is modified and redistributed, the same license as the original software must be used for distribution so that the distribution conditions are remain the same as the original software.
- d) When open- source software is redistributed by a third party as a product, the developer of the open- source software can charge a license fee to the third party.

**Q16.** When the number of concurrently running programs is increased in a virtual storage system with a small and insufficient main memory capacity, which of the following is the state in which the overhead of the system increases and the processor utilization of the applications decreases?

- a) Bottleneck
- b) Fragmentation
- c) Paging
- d) Thrashing

**Q17.** When the least recently used (LRU) method is used for swapping a block between cache memory and main memory, which of the following is a block in cache memory to be replaced?

- a) A block for which the longest period of time has elapsed since it was added
- b) A block for which the longest period of time has elapsed since it was last referenced
- c) A block that has been referenced the least frequently
- d) A block that has not been referenced for a certain period of time

**Q17.** Which of the following is an appropriate explanation of a memory leak?

- a) An increase in the number of applications executed concurrently causes most processing time to be spent for paging because of a lack of main memory, and results in an extreme reduction of throughput.
- b) It is a method to insert required modules into main memory when there is a restriction on the size of the program area during execution.
- c) Part of main memory reserved during operation is not released because of a bug in the OS or an application, and as a result, the usable area of main memory decreases.
- d) The total amount of free space available for use in main memory is sufficient, but no space can be reserved for loading a large program because of fragmentation.

**Q19.** Which of the following is an explanation of an absolute path name in a file system?

- a) The path name from the current directory to the target file
- b) The path name from the home directory to the target file
- c) The path name from the root directory to the target file
- d) The shortest path name among path names from a certain directory to the target file



**Q20.** Which of the following is the main purpose of optimization by a compiler?

- a) To improve the maintainability of a program
- b) To make debugging of a program easier
- c) To reduce the execution time of a program
- d) To reduce the time needed to generate object codes

**Q21.** Which of the following is the OSS that is provided as an integrated development environment for software?

- a) Apache Tomcat
- b) Eclipse
- c) GCC
- d) Linux

**Q16.** Which of the following is an appropriate explanation of paging?

- a) A method of memory management in which multiple records are read and written as a block on an auxiliary storage
- b) A method of memory management in which the main memory is divided into multiple areas so that reading and writing can be performed simultaneously
- c) A method of memory management in which the programs are relocated for execution in a different area of the main memory
- d) A method of memory management in which the virtual memory space and real memory space are divided into fixed-length blocks for management

**Q18.** In the figure below, data are sent continuously for  $T$  seconds from the send task to the receive task. When the volume of the data sent per second is  $S$  and volume of the data received per second is  $R$ , which of the following is an appropriate relational expression for buffer size  $L$  for a buffer that does not overflow? Here, the transmission speed for the send task is faster than the transmission speed for the receive task, and there is sufficient time between the transmissions.



- a)  $L < (R - S) \times T$
- b)  $L < (S - R) \times T$
- c)  $L \geq (R - S) \times T$
- d)  $L \geq (S - R) \times T$

**Q20.** A real-time OS performs preemptive scheduling on a priority basis and schedules two (2) tasks *A* and *B*. When *A* has a higher priority than *B*, which of the following is an appropriate task management by the real-time OS?

- a) When *A* is launched during the execution of *B*, *B* is assigned a “ready” status and *A* is executed.
- b) When *A* is launched during the execution of *B*, *B* is assigned a “waiting” status and *A* is executed.
- c) When *B* is launched during the execution of *A*, *A* is assigned a “ready” status and *B* is executed.
- d) When *B* is launched during the execution of *A*, *A* is assigned a “waiting” status and *B* is executed.

**Q5.** A regular expression  $[A-Z]^+[0-9]^*$  represents a set of character strings. Which of the following character strings belongs to this set? Here, the regular expression follows the rules below.

$[A-Z]$  represents a single uppercase English character.

$[0-9]$  represents a single decimal digit.

$*$  indicates zero or more occurrences of the preceding element.

$+$  indicates one or more occurrences of the preceding element.

a) 456789

b) ABC+99

c) ABC99\*

d) ABCDEF

**Q8.** Which of the following is an explanation of a recursive call?

- a) To allow a function to use itself from within its body
- b) To execute processes in an event-driven way rather than in a predetermined order
- c) To keep a function in memory after its execution in order to reuse
- d) To undo an execution of process when it fails

**Q18.** Which of the following is an appropriate usage method of the priority-based preemptive scheduling that is used in an embedded real-time operating system?

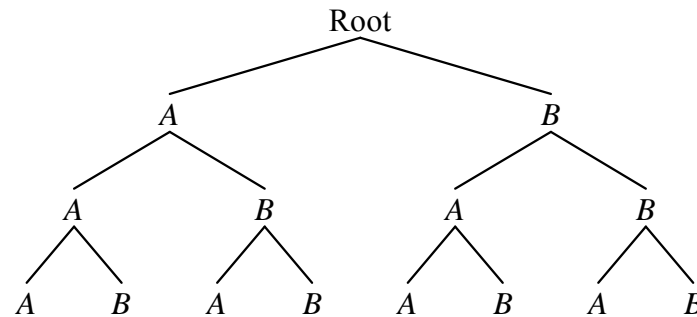
- a) It is used when evenly assigning the execution time for each task.
- b) It is used when tasks are processed according to their importance and urgency.
- c) It is used when tasks are processed sequentially from the earlier arriving times.
- d) It is used when tasks are processed sequentially from the shorter processing times.



**Q19.** Multiple directories named *A* and *B* are managed in the structure shown in the figure below. Which of the following is the case in which the current directory is moved so that “*B\A\B*” is the current directory? Here, the method for directory designation is as below, and  $\rightarrow$  indicates the order of movement.

[Method for directory designation]

- (1) A directory is referenced as “directory name\  $\cdots$  \directory name”, where the directories on the path are aligned and delimited with “\” in sequence, followed by “\” and the directory name.
- (2) The current directory is represented by “.” (a period).
- (3) The directory one (1) hierarchical level above is represented by “..” (two periods).
- (4) When a reference begins with a “\”, it is assumed that the root directory is omitted at the leftmost position of the reference.
- (5) When a reference does not start with “\”, “.”, or “..”, it is assumed that “.\” is omitted from the leftmost position of the reference.



- a)  $\backslash A \rightarrow \dots \backslash B \rightarrow \dots \backslash A \backslash B$   
c)  $\backslash B \rightarrow \backslash A \rightarrow \backslash B$

- b)  $\backslash B \rightarrow \dots \backslash B \backslash A \rightarrow \dots \backslash B$   
d)  $\backslash B \backslash A \rightarrow \dots \backslash B$

**Q20.** In the virtual memory of a paging system, which of the following is a cause that increases the number of page fault occurrences?

- a) An access to a page that has not been accessed for a long time in main memory
- b) An increase in access to a page that does not exist in main memory
- c) An increase in access to a page that exists in main memory
- d) An increase in the ratio of pages that are updated among the pages in main memory

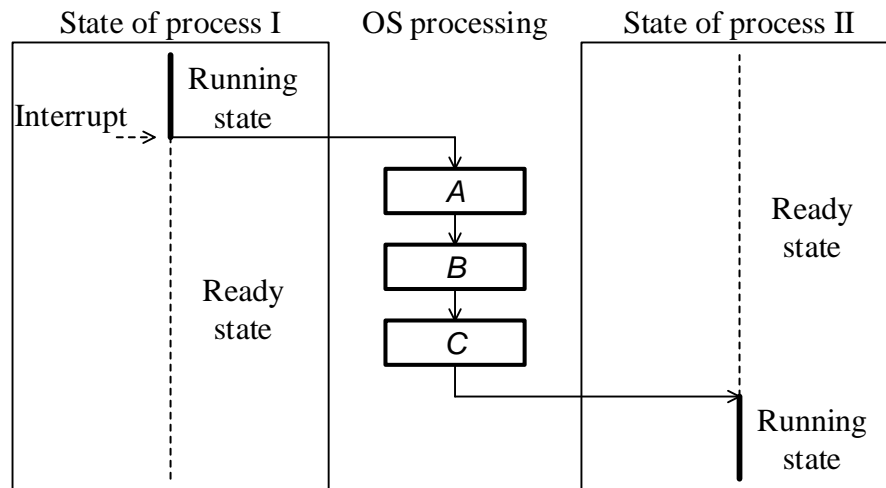
**Q16.** Which of the following is a page fault in a virtual memory system?

- a) An access to a page that is mapped in the virtual memory, but not loaded in the physical memory
- b) A hardware error in the physical memory
- c) A program attempting to insert more data than it can hold in the physical memory
- d) A reference to a page that another program is currently using in the virtual memory

**Q18.** Which of the following is classified as a function of a static test tool?

- a) Calculating the coverage from the paths executed by the test
- b) Detecting an error in a program by analyzing the source code
- c) Generating a driver or stub necessary for the module to be tested
- d) Generating the data to test a specific path of the program

**Q19.** For a multiprogramming switching procedure of processes shown in the figure below, which of the following is an appropriate combination of OS processing for A through C?



	A	B	C
a)	Restoration of the running state	Selection of the process	Saving of the running state
b)	Saving of the running state	Restoration of the running state	Selection of the process
c)	Saving of the running state	Selection of the process	Restoration of the running state
d)	Selection of the process	Restoration of the running state	Saving of the running state

**Q20.** Which of the following is the appropriate function of a linker?

- a) Creating a load module from multiple object modules, etc. by performing operations such as cross-reference resolution
- b) Loading a load module into main memory before execution
- c) Monitoring program execution and logging the execution result for each step
- d) Registering a created program to a library

**Q17.** In input/output management, which of the following is an appropriate function of a buffer?

- a) Enabling an input/output device to be handled in the same way as a file
- b) Enabling the use of an input/output device without the need to consider its unique specifications by creating a data exchange layer between an input/output device and a processing device
- c) Notifying a processing device when an input/output device becomes available for use
- d) Reducing the difference in processing speed by establishing a special area of memory between an input/output device and a processing device

**Q18.** Which of the following is the backup method that requires the longest time to backup but the shortest time to restore?

- a) Differential backup
- b) Full backup
- c) Incremental backup
- d) Synthetic full backup



**Q19.** In UNIX, which of the following is a function that links the standard output of a command directly to the standard input of another command?

- a) Background job
- b) Brace expansion
- c) Pipe
- d) Redirect

**Q20.** Which of the following is an appropriate explanation of optimization in a compiler?

- a) Analyzing the source code and generating an object code with an improved run-time processing efficiency
- b) Generating an intermediate code for an interpreter rather than generating an object code
- c) Generating an object code that displays the called subprogram name or the content of a variable at a particular point in time during the execution of the program
- d) Generating an object code that operates in a computer with a different architecture from the computer in which the compiler is implemented

**Q24.** Which of the following is used to control the visual styles of HTML documents, such as text sizes, text colors, or page layout?

- a) CMS                      b) CSS                      c) RSS                      d) Wiki

**Q28.** When a storage location is to be calculated from a key value, which of the following methods enables the same calculation result to be obtained from different key values?

- a) B+ tree index
- b) Bitmap index
- c) Hash index
- d) Inverted index

**Q19.** In virtual memory management, which of the following page replacement methods replaces the page for which the most time has passed since it was last used?

- a) FIFO                      b) LFU                      c) LIFO                      d) LRU

**Q20.** The methods for representing the results of syntactic analysis in a compiler include quadruplet format.

(Operator, Operand 1, Operand 2, Result)

This format indicates that the application of the operator to operand 1 and operand 2 outputs the result. For which of the following expressions does the series of quadruplets below represent the syntactic analysis? Here,  $T_1$ ,  $T_2$ , and  $T_3$  indicate temporary variables.

( $*$ , B, C,  $T_1$ )

( $/$ ,  $T_1$ , D,  $T_2$ )

( $+$ , A,  $T_2$ ,  $T_3$ )

a)  $A+B*C/D$

b)  $A+B*C/T_2$

c)  $B*C+A/D$

d)  $B*C+T_1/D$

**Q22.** Which of the following is a method that performs integration of the modules that configure a program during execution of the program?

- a) Dynamic linking
- b) Interpreter
- c) Overlay
- d) Static linking

**Q7.** In Java technologies, which of the following is the specification of creating reusable software components that have frequently used functionalities?

- a) Java applet
- b) Java application
- c) JavaBeans
- d) JavaScript



**Q8.** Which of the following best describes the characteristics of XML?

- a) The style languages such as XSL and CSS used in HTML can also be used in XML.
- b) XML allows a tag to be defined in order for an easier data exchange between information systems over the network.
- c) XML is developed on its own specification, whereas HTML is on the SGML basis.
- d) XML is HTML based and has some features added primarily for a performance improvement of displaying a web page.

**Q16.** Which of the following occurs when a program attempts to access a page that is mapped in the virtual address space, but is not located in the main memory? Here, the OS supports paging.

- a) Fatal error
- b) Page fault
- c) Scheduling error
- d) Segmentation fault

**Q17.** Which of the following is an appropriate explanation of spooling?

- a) It determines the execution order for jobs that are loaded into a system according to characteristics and priority.
- b) It sends communication data to a pre-registered agent instead of sending it directly to a counterpart.
- c) It temporarily saves input data from a keyboard to the queue in the main memory.
- d) It temporarily saves output data for a low-speed device, such as a printer, to a high-speed hard disk, and then sends it to the intended device.

**Q20.** Which of the following is an open source integrated development environment that includes software and support tools for application development?

- a) Eclipse
- b) Perl
- c) PHP
- d) Ruby

**Q19.** When the multiplicity of processing is increased in the virtual memory of a computer system, page-in and page-out operations occur very frequently, and the response speed of the system decreases suddenly. What is this phenomenon called?

- a) Memory compaction
- b) Overlay
- c) Roll-out
- d) Thrashing

**Q21.** Which of the following is an appropriate explanation for a non-preemptive scheduling method?

- a) A task cannot move to a running state until another task in the running state either moves to the waiting state by itself or finishes.
- b) Each time a new task becomes the ready state, a comparison is made for all tasks in the ready state from the standpoint of the remaining execution time, and the tasks are executed in an order starting from the shortest execution time.
- c) When a task becomes the ready state, a comparison is made between the priority of the task and that of the one in the running state at that time, and the task with the higher priority moves to the running state.
- d) When a task in the running state does not move to the waiting state within a predetermined time period, the task is interrupted, and the next task in the waiting queue moves to the running state.

**Q23.** According to the Open Source Definition by OSI (Open Source Initiative), which of the following is the appropriate description concerning open source licensing?

- a) The license allows any party to freely use, modify, and distribute a program. A royalty fee is required only if the program is redistributed commercially.
- b) The license allows authors to put usage restrictions on a program to prevent such program from being used in business activities.
- c) The license requires that all derivative works must be kept secret if the derivative works are based on an original program.
- d) The license requires that the source code of a program must be made available either for free or at a reasonable reproduction cost.

**Q4.** Which of the following is a language processor that produces executable code for other platforms than the one on which the language processor itself is running?

- a) Cross compiler      b) Emulator      c) Generator      d) Simulator



**Q18.** A real-time OS, which performs preemptive scheduling based on priority, schedules the tasks *A* and *B*. When *A* has a higher priority than *B*, which of the following is an appropriate action that is performed by the real-time OS?

- a) When *A* is launched during the execution of *B*, *B* is put into a “ready” state and *A* is executed.
- b) When *A* is launched during the execution of *B*, *B* is put into a “waiting” state and *A* is executed.
- c) When *B* is launched during the execution of *A*, *A* is put into a “ready” state and *B* is executed.
- d) When *B* is launched during the execution of *A*, *A* is put into a “waiting” state and *B* is executed.

**Q19.** Which of the following is an appropriate explanation of the spooling function?

- a) Execution of the programs is temporarily suspended, and control is transferred to the control program.
- b) If a CPU becomes idle because of the execution of input/output instructions while executing a certain task, the CPU is assigned to another task.
- c) The access time to auxiliary storage devices is reduced by providing a buffer pool consisting of multiple buffers and by increasing the probability of accessing buffers located in the main storage.
- d) The overall processing power of a system is enhanced by performing data transfer between the main storage and low-speed input/output devices via auxiliary storage devices.

**Q20.** Which of the following is an explanation of an absolute path name of a file system?

- a) It is the path name from the current directory up to the target file.
- b) It is the path name from the home directory up to the target file.
- c) It is the path name from the root directory up to the target file.
- d) It is the shortest path name from among the several path names from a directory up to the target file.

**Q24.** Which of the following is the standard used to describe the look and formatting of markup language documents such as HTML and XHTML?

a) CMS

b) CSS

c) RSS

d) Wiki

**Q18.** Among the descriptions concerning process scheduling, which of the following is an appropriate explanation of the round robin method?

- a) CPU resources are allocated to each process in order of priority specified in advance when a particular event occurs.
- b) CPU resources are allocated to each process in order of processing time from shortest to longest.
- c) CPU resources are allocated to the first executable process in the queue when an interval-timer interrupt is generated.
- d) CPU resources are allocated to the process that needs to start immediately when some kind of interrupt is generated.

**Q21.** Which of the following is an appropriate explanation of optimization in a compiler?

- a) Generating an intermediate code used for an interpreter rather than generating an object code
- b) Generating an object code that displays the called subprogram name or the contents of a variable at a particular point of time during the execution of the program
- c) Generating an object code that operates in a computer with a different architecture from the computer in which the source code is complied
- d) Generating an object code with improved run-time processing efficiency by analyzing the source code

**Q17.** Among the combinations of the storage management and the multiplicity of programs in a multiprogramming environment, which of the following is the combination where “thrashing” is most likely to occur?

	Storage management	Multiplicity of programs
a)	Real storage system	Large
b)	Real storage system	Small
c)	Virtual storage system	Large
d)	Virtual storage system	Small

**Q18.** Which of the following is an appropriate explanation concerning a memory leak?

- a) An increase in the number of applications executed concurrently causes excessive paging, and results in an extreme reduction of throughput.
- b) In the system with a restriction on the size of memory allocated to the running programs, each program module is loaded into main memory only when needed.
- c) Part of main memory occupied during application execution is not released because of a bug of the application or OS, and the usable space of main memory decreases.
- d) The total amount of free space available in main memory is sufficient, but no space can be used for loading a large program because of noncontiguous memory blocks.



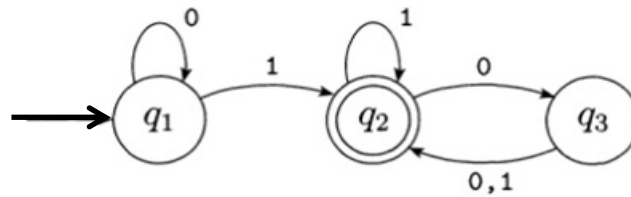
**Q19.** In a white box test, which of the following is used to evaluate the proportion of lines of code that are executed?

- a) Assertion checker
- b) Simulator
- c) Static code analysis
- d) Test coverage analysis

**Q20.** When the source code based on OSS licensed under GPL is not released to the public, which of the following is regarded as a violation of the license?

- a) A company develops and sells an interface kit between OSS and other application software.
- b) A company obtains, modifies, and sells OSS through the company's own operations or activities.
- c) A company outsources the modification of OSS to another company for the purpose of internal use.
- d) A company sells its own software whose performance test has been performed by using OSS.

**Q3.** The figure below shows the state transition diagram of an automaton. If the automaton stops in the accepting (i.e., final) state when an input string is terminated, then the input string is recognized as valid. Which of the following describes the necessary and sufficient conditions so that an input string can be valid? Here, the double circle marked with “ $q_2$ ” represents the accepting state. The leftmost arrow pointing to “ $q_1$ ” represents the starting state.



- a) An input string must contain at least one 1 and any even number of 0s following the last 1.
- b) An input string must contain at least one 1 and any number of 0s before or after the last 1.
- c) An input string must contain at least one 1 and any odd number of 0s.
- d) An input string must contain at least one 1 at the end of the string.

**Q23.** Among the explanations of task scheduling methods, which of the following has the highest possibility that a specific task continues to wait for the allocation of CPU time?

- a) Each task is added to the end of the Ready queue in order of arrival into the system, and the CPU time is always allocated to the first task in the Ready queue.
- b) Each task is executed in the order listed in the Ready queue. Once a fixed period of time has elapsed, the execution of the task is suspended and it is added to the end of the Ready queue.
- c) The priority of each task is determined, and each task is executed in high to low priority order. The priority is increased gradually according to the length of the waiting time until the CPU time is allocated.
- d) The processing is executed from the task with the estimated shortest processing time. The subsequent task is started when the processing being executed is either completed or has been suspended for some reason.

**Q25.** Which of the following is an appropriate explanation of the LRU method that is used as a page replacement algorithm?

- a) The page that has existed for the longest time is replaced.
- b) The page that has not been used for the longest time is replaced.
- c) The page that was last referenced is replaced.
- d) The page that was referenced the least number of times is replaced.

**Q29.** Which of the following is the case where outline fonts rather than bitmap fonts are effective and suitable for use on an output device such as a display or a printer?

- a) Both single-byte and double-byte characters are displayed.
- b) Characters are displayed on the screen as quickly as possible.
- c) Characters are displayed with uniform width.
- d) Characters are enlarged using a given scale factor.

**Q31.** Which of the following is a mechanism that is used for defining the style of a Web page?

- a) CMS                      b) CSS                      c) PNG                      d) SVG

**Q11.** Which of the following is the most appropriate characteristic of XML?

- a) XML can define any tag in order to make it easy to exchange data between information systems over the network.
- b) XML can use the same style languages, such as XSL and CSS, as those used in HTML.
- c) XML has some functions added to HTML for the primary purpose of improving the display performance of a Web page.
- d) XML is different from HTML developed on the basis of SGML, and is based on its own unique specifications.



**Q22.** There are cases where the unused storage space is divided into lots of small and isolated areas because of repeated allocation and release of storage area by an OS. Which of the following is the terminology applicable to such cases?

- a) Fragmentation
- b) Partitioning
- c) Segmentation
- d) Swapping

**Q23.** Which of the following is the virtual storage technique that can resolve external fragmentation rather than internal fragmentation by dividing virtual address space into fixed-length areas?

- a) Framing
- b) Interleaving
- c) Paging
- d) Thrashing

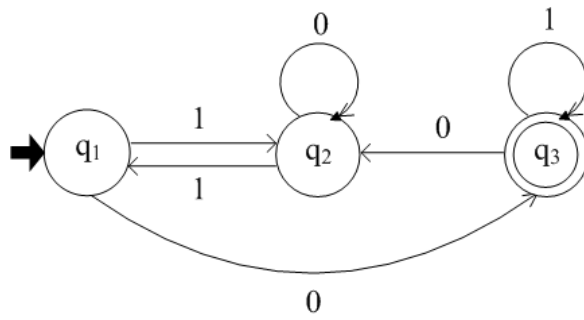
**Q25.** Which of the following is a technique that binds the modules constituting a program at the time of executing the program?

- a) Dynamic linking
- b) Interpreter
- c) Overlay
- d) Static linking

**Q26.** Which of the following is an OSS tool that is provided as the IDE (Integrated Development Environment) of software?

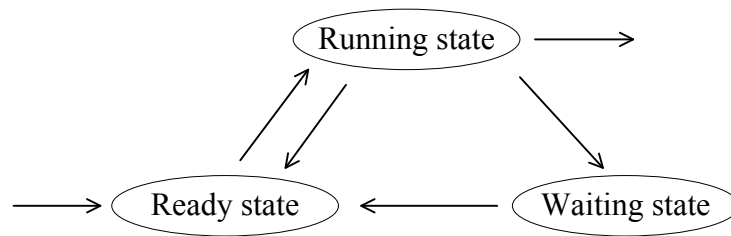
- a) Apache
- b) Eclipse
- c) Linux
- d) Mozilla

- Q5.** The figure below shows the state transition diagram of an automaton. Which of the following is a bit string for which the automaton stops in the accepting (or final) state after the entire bit string has been read? Here, the double circle marked with “ $q_3$ ” represents the accepting state.



- a) 1011      b) 1100      c) 1101      d) 1110

**Q20.** The diagram below shows the state transition of the tasks in a multitasking computer system. When does a task in the running state move to the ready state?



- a) When a process based on an I/O request is completed
- b) When a task is generated
- c) When a task with a higher priority is set to the ready state
- d) When an I/O request is issued

**Q21.** In memory pool management of a real time system using various sizes of memory resources, which of the following is an appropriate characteristic of the fixed-length method in comparison with the variable-length method?

- a) The memory efficiency is good, and the processing speed for allocation and deallocation is slow and constant.
- b) The memory efficiency is good, and the processing speed for allocation and deallocation is slow and variable.
- c) The memory efficiency is poor, and the processing speed for allocation and deallocation is fast and constant.
- d) The memory efficiency is poor, and the processing speed for allocation and deallocation is fast and variable.

**Q23.** When the number of concurrently running programs is increased in a virtual storage system with the small and insufficient capacity of main memory, which of the following is the state in which the overhead of the system increases and the processor utilization of the applications decreases?

- a) Bottleneck
- b) Fragmentation
- c) Paging
- d) Thrashing



**Q24.** Which of the following is the language processor that translates and executes a source program written in high-level language, on a line-by-line basis?

- a) Assembler
- b) Compiler
- c) Generator
- d) Interpreter

**Q25.** For the purpose of monitoring the execution process of a program in order of time, which of the following is used as a dynamic debugging tool that records the contents of the memory and registers as well as the execution sequence of program instructions?

- a) Assertion checker
- b) Code auditor
- c) Inspector
- d) Tracer

**Q12.** Which of the following is a program attribute of software that can be repeatedly called and executed without reloading after completion of the execution but cannot be called and executed by multiple programs at the same time?

- a) Recursive      b) Reentrant      c) Relocatable      d) Reusable

**Q24.** Which of the following is the characteristic of a dynamically relocatable program?

- a) The program currently in the computer memory can be moved to other locations of the memory during execution time.
- b) The program has the capability to run simultaneously and concurrently in response to requests from multiple tasks.
- c) The program is called by a program and then called again by another program at any time after completion of the execution.
- d) The program is divided into small fixed-length segments beforehand in order to execute them in sequence with small main memory.

**Q28.** Which of the following is an appropriate explanation of optimization in a compiler?

- a) Generating intermediate codes for an interpreter instead of generating object codes
- b) Generating object codes that display the sub-program names called during execution time or the content of variables at a certain point in time
- c) Generating object codes that enhance run-time performance through the analysis of program codes
- d) Generating object codes that run on a computer with an architecture different from the computer used to compile programs

- Q6.** When the figure below shows the process flow of a compiler that is used for procedural languages, which of the following is the appropriate combination that should be inserted into blanks *A* through *C*?



	<i>A</i>	<i>B</i>	<i>C</i>
a)	Lexical analysis	Semantic analysis	Syntax analysis
b)	Lexical analysis	Syntax analysis	Semantic analysis
c)	Semantic analysis	Syntax analysis	Lexical analysis
d)	Syntax analysis	Lexical analysis	Semantic analysis

**Q11.** Which of the following is the most appropriate purpose of using DTD (Document Type Definition) with XML?

- a) It is used to check if a well-formed XML document is valid.
- b) It is used to check if XML syntax rules are met.
- c) It is used to describe constraints imposed on XML data types.
- d) It is used to perform XML syntax analysis.

**Q21.** Which of the following provides a job management function in OS that selects a program with the highest execution priority in the job queue and allocates resources required for the program?

- a) Initiator
- b) Master scheduler
- c) Reader
- d) Writer



**Q23.** In a preemptive multitasking OS environment, when a process is preempted by another process with a higher priority, which of the following is the appropriate state where the former process is to be placed?

- a) Ready                      b) Running                      c) Terminated                      d) Waiting

**Q29.** Which of the following is the specification for dividing frequently-used functions of a Java program into reusable components that can be deployed in a network on any major operating system platform?

- a) Java applet
- b) Java application
- c) JavaBeans
- d) JavaScript

**Q19.** In memory pool management for real-time systems that use memory resources of various sizes, which of the following is an appropriate characteristic of the fixed-length method in comparison with the variable-length method?

- a) Memory efficiency is high, and processing speed to allocate or release memory is slow and constant.
- b) Memory efficiency is high, and processing speed to allocate or release memory is slow and inconstant.
- c) Memory efficiency is low, and processing speed to allocate or release memory is fast and constant.
- d) Memory efficiency is low, and processing speed to allocate or release memory is fast and inconstant.

**Q20.** Which of the following is the method of improving the throughput of the entire system by transferring data from main memory to a low-speed output device via a high-speed auxiliary storage device?

- a) Blocking
- b) Paging
- c) Spooling
- d) Swapping

**Q21.** Which of the following is an appropriate description concerning the use of an application on a computer with virtual memory?

- a) A specially designed module for using virtual memory needs to be embedded in the application.
- b) In order to use virtual memory, each individual application needs to be configured to use virtual memory.
- c) Insufficient main memory causes excessive page faults during running the application and reduces the system throughput.
- d) Only those applications that are installed on the hard disk in advance can use virtual memory.

**Q24.** Which of the following is a language processor that can be used to create a program suited to the processing objectives, based on necessary conditions, such as input, process, and output, specified by parameters?

- a) Assembler      b) Compiler      c) Generator      d) Interpreter

**Q11.** Which of the following is the programming language that is interpreted and executed directly from source code or bytecode and can be used as batch control programs or embedded as part of application programs?

- a) Functional language
- b) Logic language
- c) Object-oriented language
- d) Script language

**Q12.** When XML is compared with HTML, which of the following functions is enabled only by using XML?

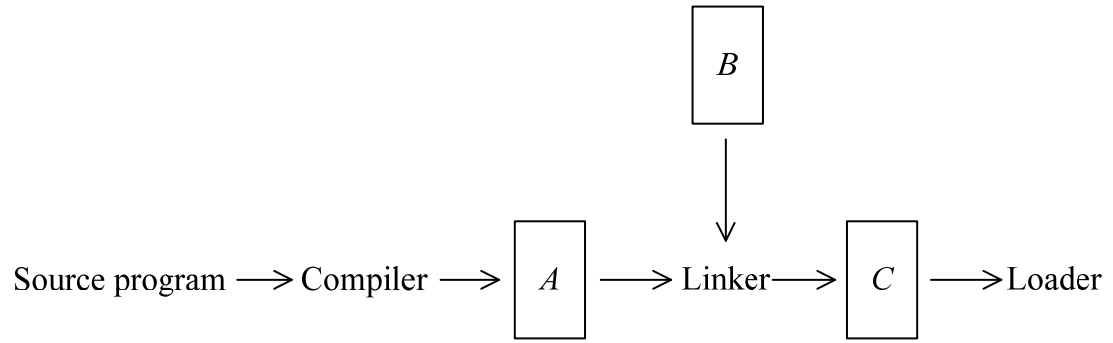
- a) Describing documents by using tags
- b) Displaying dynamic web pages
- c) Embedding hyperlinks to other documents
- d) Exchanging structured information



**Q22.** In the virtual memory of a paging system, when a page that does not exist in main memory is accessed, which of the following shows the appropriate order of processes and states? Here, there is no empty page frame available in main memory.

- a) Decision of the page for replacement → Page fault → Page-out → Page-in
- b) Decision of the page for replacement → Page-in → Page fault → Page-out
- c) Page fault → Decision of the page for replacement → Page-in → Page-out
- d) Page fault → Decision of the page for replacement → Page-out → Page-in

**Q24.** The diagram below shows the flow from program translation to execution. Which of the following is the appropriate combination of inputs and outputs to and from compiler, linker, and loader?



	<i>A</i>	<i>B</i>	<i>C</i>
a)	Library module	Load module	Object program
b)	Load module	Library module	Object program
c)	Load module	Object program	Library module
d)	Object program	Library module	Load module

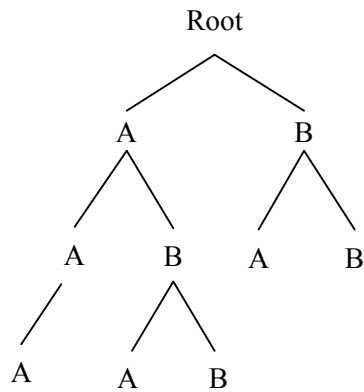
**Q25.** Which of the following is an appropriate description concerning open source software defined by OSI?

- a) When open source software is created for a specific industry, its source code can be released exclusively to that industry.
- b) When open source software is modified such as for internal use but not redistributed, the modified source code is not required to be released to the public.
- c) When open source software is redistributed after modification, it is required to be distributed under the same distribution conditions and license as the original work.
- d) When open source software is redistributed as a product by a third party, the developer of the original software can charge a license fee to the third party.

**Q22.** Which of the following is the most appropriate set of major functions supported by an OS?

- a) Compiler management, I/O management, and network management
- b) Data management, job management, and task management
- c) Development tool management, job management, and memory management
- d) I/O management, multimedia management, and security management

**Q23.** Multiple directories having the names “A” and “B” are managed in the structure shown below.



When the current directory is changed in order of “\A\B → .. → ..\B → .\A”, which of the following is the resulting current directory? Here, directories are specified as follows:

[Methods to specify directories]

- (1) A directory is referenced as “directory name\...\directory name”, where the directories on the path are listed and separated with “\” (backslash) in sequence, followed by “\” and the directory name.
- (2) The current directory is represented by “.” (one period).
- (3) The directory one level above is represented by “..” (two periods).
- (4) When a reference begins with “\”, it is assumed that the root directory is omitted from the beginning of the reference.
- (5) When a reference does not start with “\”, “.”, or “..”, it is assumed that “.\”, which means that the reference is under the current directory, is omitted from the beginning of the reference.

a) \A

b) \A\A

c) \A\B\A

d) \B\A

**Q24.** Which of the following is an appropriate explanation of the spooling function?

- a) Execution of the programs is temporarily suspended, and control is transferred to the control program.
- b) If a CPU becomes idle because of the execution of input/output instructions while executing a certain task, the CPU is assigned to another task.
- c) The access time to auxiliary storage devices is reduced by providing a buffer pool consisting of multiple buffers and by increasing the probability of accessing buffers located in the main storage.
- d) The overall processing power of a system is enhanced by performing data transfer between the main storage and low-speed input/output devices via auxiliary storage devices.

**Q26.** Which of the following appropriately describes the role of task management?

- a) It controls I/O devices and operates them properly and efficiently.
- b) It controls multiprogramming and uses the CPU effectively.
- c) It provides access methods to various types of auxiliary storage devices in the way that does not depend on those devices, and reduces the workload in creating application programs.
- d) It provides virtual memory space and uses real memory effectively.

**Q27.** Which of the following is the appropriate explanation of the hash method?

- a) Access method that calculates the storing address of a record from its key value using a function
- b) Access method that uses a conversion table of the key values and the storing addresses of records
- c) Access method that uses the storing address of the next record stored in each record
- d) Direct access method that uses the key value of a record as its storing address



**Q28.** Which of the following groups of CASE tools is used only in a particular stage of the software development life cycle and is designed to work cooperatively with other CASE tools in an integrated and consolidated environment?

- a) Component CASE tools
- b) Integrated CASE tools
- c) Lower CASE tools
- d) Upper CASE tools

**Q29.** The LRU method can be used as one of the methods for replacing blocks between the cache memory and the main memory. Which of the following blocks is subject to replacement by this method?

- a) A block that has not been referenced for a certain period of time
- b) The block with the lowest reference frequency
- c) The block with the longest time since it was loaded
- d) The block with the longest time since it was referenced last

**Q30.** As one of the virtual storage methods, virtual address space is divided into fixed-length areas. What is such a fixed-length area called?

- a) Frame                      b) Page                      c) Sector                      d) Segment

**Q38.** Which of the following is the main purpose of optimization performed by a compiler?

- a) To improve the maintainability of a program
- b) To make it easy to debug a program at source code level
- c) To reduce program execution time
- d) To reduce the time to generate an object program

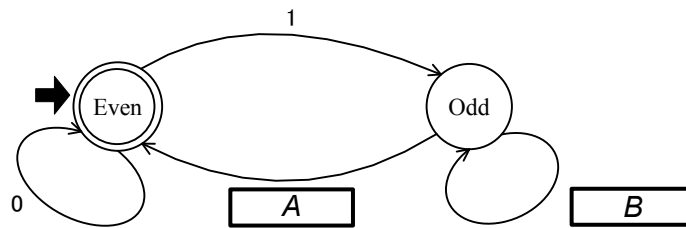
**Q39.** Which of the following is the international standard of the document description language that defines how to describe the logical structure and makes it easy to manage and exchange electronic documents?

- a) DML                      b) HTML                      c) SGML                      d) UML

**Q40.** Which of the following software, as represented by Linux, requires the freedom to redistribute, inclusion of the source code at redistribution, and consent to modify derived software?

- a) Componentware
- b) Middleware
- c) Open source software
- d) Shareware

**Q11.** The figure below shows the state transition diagram of an automaton that accepts bit strings with even numbers of 1s. The double circle marked with “Even” represents the accepted state. Which of the following combinations should be inserted in the blank boxes labeled *A* and *B*?



	<i>A</i>	<i>B</i>
a)	0	0
b)	0	1
c)	1	0
d)	1	1

**Q28.** With which of the following task scheduling methods is it highly possible for a specific task to continue to wait for the allocation of CPU resources?

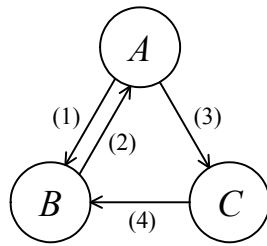
- a) A priority is given to each task, and the tasks are performed in order from highest to lowest. A higher priority is reassigned according to the elapsed time waiting for CPU allocation.
- b) Tasks are executed in the order in which they were placed in the CPU queue. Execution is suspended after a certain period of time, and the task is moved to the end of the CPU queue.
- c) The task with the shortest estimated processing time is executed first. The next task is initiated when the currently executed task is completed or suspended for some reason.
- d) When a task reaches the system, it is added to the end of the executable queue, and CPU resources are always allocated to the first task on the executable queue.



**Q30.** Which of the following is the appropriate purpose of using semaphores?

- a) For avoiding the occurrence of slashing
- b) For implementing segmentation
- c) For implementing stacks easily
- d) For managing shared resources

**Q29.** The figure below shows the state transition diagram of a certain process. Which of the following is the appropriate combination of States *A*, *B*, and *C*?



[Factors for State Transitions]

- (1) The right to use the CPU is transferred to another process with a higher execution priority.
- (2) The right to use the CPU is given.
- (3) Waiting for completion of an input/out operation
- (4) An input/output operation is completed.

	State <i>A</i>	State <i>B</i>	State <i>C</i>
a)	Ready	Running	Waiting
b)	Ready	Waiting	Running
c)	Running	Ready	Waiting
d)	Running	Waiting	Ready

**Q30.** Which of the following is the appropriate explanation of spooling?

- a) Communication data is sent to a substitute device registered in advance instead of being directly transferred to the communication destination.
- b) Input data from the keyboard is temporarily saved in the queue of the main memory.
- c) Output data to a low speed device such as a printer is temporarily stored on a high speed hard disk and later sent as output to that target device.
- d) The order of execution for jobs requested in the system is determined according to their priorities and characteristics.

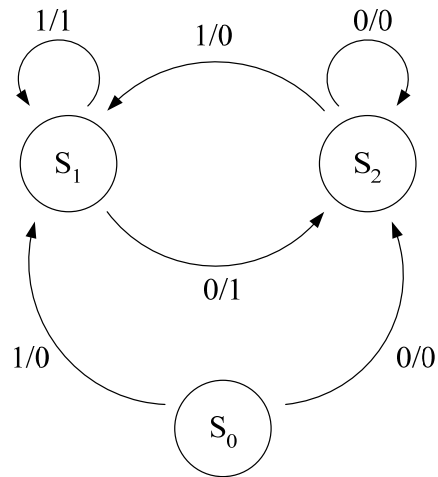
**Q31.** Which of the following is the appropriate set of major functions supported by an OS?

- a) Compiler management, I/O management, and network management
- b) Data management, job management, and task management
- c) Development tool management, job management, and memory management
- d) I/O management, multimedia management, and security management

**Q51.** Which of the following is an appropriate description concerning a characteristic of job scheduling in a computer system?

- a) In a system on which interactive processing and batch processing are mixed, it is expected that the response performance of interactive processing is improved by giving a higher priority to interactive processing.
- b) In the FCFS (first-come first-served) scheduling, it is possible to guarantee throughput and response time because the CPU is assigned equally among jobs.
- c) In the time slice scheduling, where the OS forcibly switches jobs assigned to the CPU, throughput goes down due to frequent timer interrupts.
- d) It is expected that overall throughput is improved by giving a higher priority to CPU-bound jobs than to I/O-bound jobs, because the CPU waiting time can be reduced.

- Q7.** The state diagram shown below is a simple Mealy machine. Which of the following transitions is NOT possible in the diagram? Here,  $S_0$ ,  $S_1$ , and  $S_2$  are states. Each edge is labeled with “ $j / k$ ” where  $j$  is the input and  $k$  is the output.



- a)  $S_0 \rightarrow S_1 \rightarrow S_2 \rightarrow S_1 \rightarrow S_1 \rightarrow S_2$
- b)  $S_0 \rightarrow S_1 \rightarrow S_2 \rightarrow S_1 \rightarrow S_2 \rightarrow S_0$
- c)  $S_0 \rightarrow S_2 \rightarrow S_1 \rightarrow S_2 \rightarrow S_1 \rightarrow S_2$
- d)  $S_0 \rightarrow S_2 \rightarrow S_2 \rightarrow S_1 \rightarrow S_2 \rightarrow S_2$

**Q27.** In a multiprogramming environment, there is a need to limit access to shared resources; that is, the current process has exclusive use of the assigned resources for some period of time. Which of the following appropriately describes the function to successfully implement this type of exclusive control?

- a) A dispatcher is used to determine which resource should be allocated to which process and to restrict access to a specific resource.
- b) A semaphore variable is used to indicate the status of common resource.
- c) An interrupt is generated to signal to all processes that the use of a specific resource is restricted for some period of time.
- d) Spooling is used to enable exclusive control of a process by means of a queue.

**Q28.** In virtual memory systems, serious degradation of system performance may occur due to a large number of page faults. Which of the following terms most appropriately describes this situation?

- a) Caching      b) Paging      c) Swapping      d) Thrashing



**Q34.** Which of the following is an appropriate language that can be used to develop applications running mainly on Web browsers?

- a) Java Applet
- b) JavaBeans
- c) JavaScript
- d) Java Servlet

**Q56.** Which of the following is the general-purpose markup language that allows its users to define their own tags and to facilitate the sharing of data across different information systems, particularly via the Internet?

- a) HTML                      b) SGML                      c) UML                      d) XML

**Q32.** Which of the following is a method whereby the relevant program is read into main memory and the CPU reads out and executes it sequentially?

- a) Addressing method
- b) Direct program control method
- c) Stored program method
- d) Virtual memory method

**Q33.** Which of the following functions is a part of OS task management?

- a) CPU allocation
- b) File protection
- c) I/O execution
- d) Spool control

**Q35.** Which of the following has the feature whereby only minimally limited OS functions, such as memory management and process management, are supported and other OS functions, such as the file system, are implemented as server processes?

- a) Microkernel
- b) Monolithic kernel
- c) Multithread
- d) Single user mode

**Q39.** In some systems, the system manually or automatically determines memory blocks which are no longer referenced by a program and reorganizes the memory space so that it can be available for subsequent allocation. What is this process called?

- a) Fragmentation
- b) Garbage collection
- c) Swapping
- d) Thrashing

**Q44.** In some circumstances, a program may be still running when it is called again by another program. Which of the following is the appropriate characteristic that should be implemented to execute this program correctly?

- a) Recursive
- b) Reentrant
- c) Relocatable
- d) Reusable

**Q45.** Which of the following is the language processing program that generates, on a certain computer, object programs that can be executed on another computer that has a different instruction set?

- a) Cross compiler
- b) Emulator
- c) Generator
- d) Optimizing compiler



- Q46.** Which of the following is the standardized document description language that prescribes methods, as an international standard, for describing the logical structures and attributes of documents using tags and facilitates the management and exchange of electronic documents?
- a) DML                      b) HTML                      c) SGML                      d) STEP

**Q34.** Which of the following is an appropriate description concerning the role of a shell in an OS?

- a) It allows mouse operations, instead of keyboard operations, such as selecting commands from menus and selecting items on setup screens in an application.
- b) It holds reference information for frequently used files and directories so that users can use these items even if they do not know the actual paths.
- c) It interprets the commands entered by the user and instructs the OS to execute the corresponding functions.
- d) It performs efficient security management and mutual exclusion (exclusive control) when multiple users simultaneously access common resources.

**Q35.** Which of the following terms refers to the function that adjusts all address dependent locations within a program to correspond to the load position when the program is loaded into main memory prior to its execution?

- a) Optimization      b) Recompilation      c) Reloading      d) Relocation

**Q36.** The table shows the priorities of five tasks A to E. When each task is independently executed, the processing sequences and times associated with CPU and I/O devices are also shown in the table. Which of the tasks B to E should be combined together with task A assigned a “high” priority so that there may be no idle time of CPU from starting of execution of the combined tasks to ending of both tasks? Here, I/O operations never conflict with each other, and any overhead involved in the OS can be ignored. The number in parentheses denotes each processing time.

	Task	Priority	Processing sequence and time (in milliseconds) during independent execution
	A	High	(3) → I/O (3) → CPU (3) → I/O (3) → CPU (2)
a)	B	Low	CPU(2) → I/O (5) → CPU (2) → I/O (2) → CPU (3)
b)	C	Low	CPU(3) → I/O (2) → CPU (2) → I/O (3) → CPU (2)
c)	D	Low	CPU(3) → I/O (2) → CPU (3) → I/O (1) → CPU (4)
d)	E	Low	CPU(3) → I/O (4) → CPU (2) → I/O (5) → CPU (2)

**Q43.** Which of the following statements concerning programming languages appropriately describes Java?

- a) It enables the creation of applets and other programs that run in web browsers. The applets can be run on any environment where virtual machines are implemented.
- b) It incorporates object-oriented concepts of class and inheritance into C and has upper compatibility with C.
- c) It is a markup language used on the Web and describes the document structure using tags. It enables the creation of hypertext that links text, movies, etc.
- d) It is an interpreter-type, object-oriented language developed in the 1970's and includes editor, debugger, and other integrated development environment as well as OS functions.

**Q17.** An OS chooses a process for CPU execution based on the First-Come-First-Serve (FCFS) scheduling algorithm. There are four processes, P1, P2, P3, and P4, and their-arrival times and burst times are shown in the table below. Which of the following is the appropriate combination of waiting times for the processes to be executed? Here, the arrival time is the time at which a process enters the ready queue and is ready for execution, the burst time is the time a process requires for CPU execution, and the waiting time is the period of time a process spends in the ready queue waiting for the CPU to start execution.

Unit: milliseconds

Process	Arrival time	Burst time
P1	0	3
P2	2	5
P3	4	7
P4	5	2

	P1	P2	P3	P4
a)	0	1	4	10
b)	0	2	4	5
c)	0	3	5	7
d)	0	3	8	15

**Q17.** In Round Robin scheduling, the CPU-time is shared among processes on the basis of the predefined time slot. There are four processes, namely P1, P2, P3, and P4, and their corresponding CPU-execution times are shown in the table below. All four (4) processes arrive at time 0, in the given order, and waiting time is the total time for which a process has to wait before it obtains its time slice for execution. Each time slot is 10 milliseconds. Which of the following is the average waiting time in milliseconds for the processes to be executed in Round Robin?

Process	CPU-execution time
P1	10
P2	23
P3	7
P4	3

- a) 10.75                      b) 14.25                      c) 15.00                      d) 16.75

**Q18.** Among the page replacement methods in virtual memory management, which of the following is the LRU control method?

- a) Each page is managed by appending a reference flag and a change flag, and pages without reference or change are replaced with higher priority.
- b) One of the pages in main memory is randomly chosen with the same probability and then replaced.
- c) The page that has been stored in the main memory for the longest time is replaced.
- d) The page that has not been referenced the longest time is replaced.



**Q19.** Which of the following is an appropriate function of a linker?

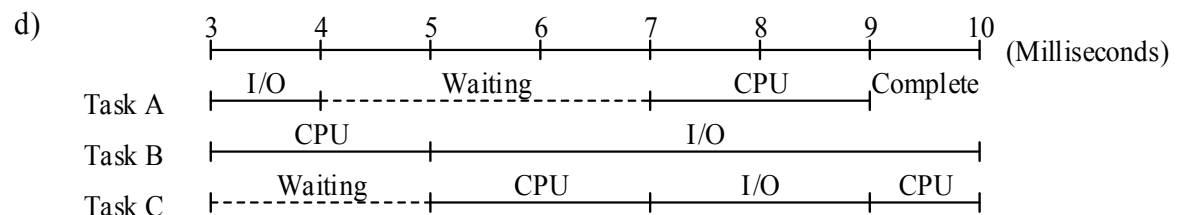
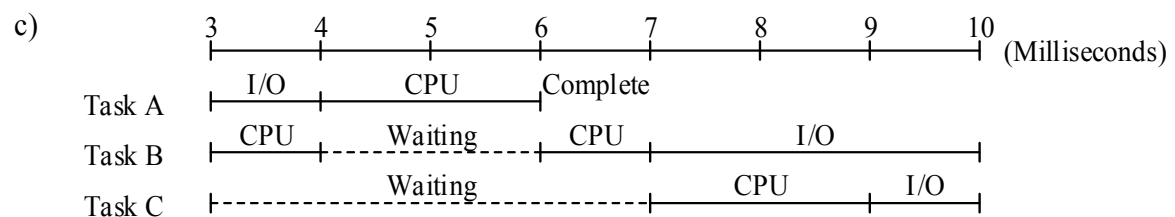
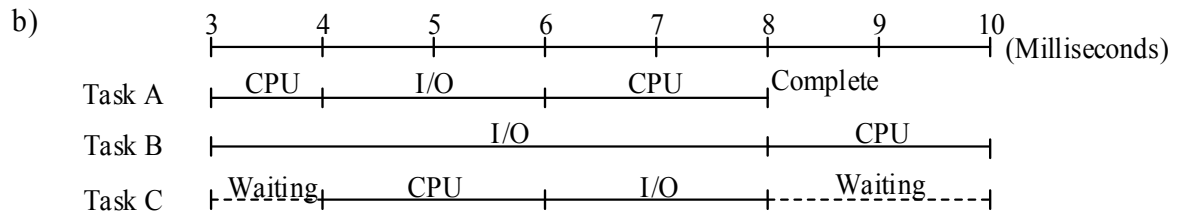
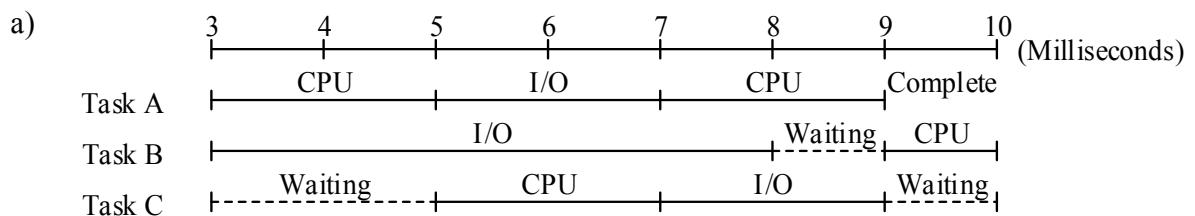
- a) To load a load module to the main memory ahead of execution
- b) To monitor the execution of a program and to record the execution results for each step
- c) To perform a resolution of cross references and to create one (1) load module from multiple object modules
- d) To register a created program in a library

**Q20.** Which of the following is the appropriate explanation of sequence control for controlling industrial devices?

- a) It is based on fuzziness, such as “slightly more” or “slightly less.”
- b) It is resistant to unexpected disturbances because it continuously detects the amount of control and reflects it on the control.
- c) It steps through each phase of control one after another according to a predefined order or set of conditions.
- d) It takes corrective action in advance by assuming the occurrence of disturbances when disturbances can be expected.

**Q18.** The table below shows the priority of three tasks, *A* through *C*, and the operation sequence and the processing time of the CPU and the I/O device when each task is executed independently. Which of the following represents the scheduling condition during the time period of 7 ms after 3 ms have elapsed since *A* through *C* became simultaneously ready for execution? Here, there is no I/O contention, and the overhead of the OS is not considered. And the numbers in parentheses indicate processing time, and “waiting” in the answer group indicates that the task is ready and is waiting for the allocation of the CPU.

Task	Priority	Operation sequence and processing time (ms) for individual execution
A	High	CPU(2) → I/O(2) → CPU(2)
B	Medium	CPU(3) → I/O(5) → CPU(2)
C	Low	CPU(2) → I/O(2) → CPU(3)



**Q18.** Assume that there are three pages in the real memory that can be allocated by the LRU method. Which of the following is the number of page faults for the page reference string shown below? Here, three pages are initially empty, and filling of an empty page is not considered as a page replacement operation. The numbers are the page IDs that come to the system from left to right.

Page reference string	2	4	1	1	2	7	3	4	6	5	5	1	2
-----------------------	---	---	---	---	---	---	---	---	---	---	---	---	---

a) 4

b) 5

c) 6

d) 7

**Q20.** The four jobs *A* through *D* are executed based on the conditions below and printed. How many seconds is it until all printing is completed after a job is started?

[Conditions]

- (1) All jobs are launched at once, and executed by the CPU with a multiplicity of one.
- (2) Job *A* has the highest priority, followed by *B*, *C*, and *D*.
- (3) After each job is executed, a spooling function prints each job in turn on a single printer.
- (4) The execution time and printing time when each job is executed separately are as shown in the table.
- (5) Other overheads are not considered.

Unit: seconds

Job	CPU Execution time	Printing time
<i>A</i>	50	50
<i>B</i>	30	40
<i>C</i>	20	30
<i>D</i>	40	20

- a) 100                      b) 160                      c) 190                      d) 280

**Q11.** Which of the following is the average cycles per instruction (CPI) of a computer that can execute 1 billion instructions per second with a clock rate of 2.4 GHz?

a) 0.04

b) 0.12

c) 2.4

d) 25

**Q18.** An operating system (OS) chooses a process for CPU execution based on a scheduling algorithm. Consider four processes, P1, P2, P3, and P4, and their corresponding arrival times along with their burst times shown in the table below. Which of the following is the correct combination of waiting times for the processes to be executed in the First-Come-First-Serve (FCFS) scheduling algorithm? Here, the arrival time is the time at which a process arrives in the ready queue, the burst time is the time required by a process for CPU execution, and the waiting time is the period of time spent by a process in the ready queue for CPU to start the execution.

Unit: millisecond

Process	Arrival time	Burst Time
P1	0	6
P2	2	4
P3	4	9
P4	5	7

	P1	P2	P3	P4
a)	0	2	4	5
b)	0	4	6	14
c)	6	4	9	7
d)	6	6	13	12

**Q19.** On a virtual memory computer, the number of pages that can be allocated to the real memory is three (3), and the two (2) algorithms of FIFO and LRU are used for selecting the page to be removed. When a page reference string shown below accesses the three (3) pages, which of the following is an appropriate combination of the number of page replacement operations? Here, the three (3) pages are initially empty and filling of an empty page is not considered as a page replacement operation.

1, 3, 2, 1, 4, 5, 2, 3, 4, 5

	FIFO	LRU
a)	3	2
b)	3	6
c)	4	3
d)	5	4



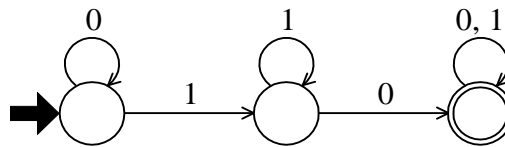
- Q17.** As shown below, there is a set of processes, with the length of the CPU-burst time given in milliseconds, and the processes arrive in the order of P1, P2, P3, P4, and P5 with the arrival time of all processes at  $t = 0$ .

Process	Burst Time
P1	14
P2	5
P3	6
P4	5
P5	7

Which of the following is the average turnaround time of five (5) processes from P1 through P5 with the first-come first-served (FCFS) scheduling algorithm?

- a) 10                      b) 15                      c) 20                      d) 25

**Q4.** Which of the following bit strings is accepted by the automaton described in the state transition diagram below? Here, each string is processed one bit at a time in sequence from the left.



a) 0000

b) 0111

c) 1010

d) 1111

**Q17.** In a direct organization file that has a range of storage addresses one (1) through six (6), the data is stored under the conditions below. Which of the following is the key value of the data that is stored in address one (1)?

[Conditions]

- (1) Data is stored in the order of key values three (3), four (4), eight (8), 13, 14, and 18.
- (2) The storage address is the value that is the remainder obtained by dividing the key value of data by five (5) and then adding one (1) to it.
- (3) If the storage address is already occupied, the data is stored in the next address. This process is repeated until the data is stored. The next address of the last address is the first address.
- (4) In the initial status, nothing is stored in the file.

- a) 8                      b) 13                      c) 14                      d) 18

**Q16.** Below is the list of processes, P1, P2, P3, and P4, and their burst time for CPU scheduling algorithms.

<u>Process</u>	<u>Burst time (millisecond)</u>
P1	9
P2	5
P3	7
P4	4

Which of the following combinations is the average waiting time in millisecond for a First-Come, First-Serve (FCFS) scheduling and Shortest-Job-First (SJF) scheduling given that the process arrives in the order P1, P2, P3, and P4, and the latency can be ignored. Note that the burst time is the actual time required to complete a process.

	Average process waiting time under FCFS	Average process waiting time under SJF
a)	9.5	6.25
b)	9.0	7.0
c)	11.0	7.25
d)	11.5	8.0

**Q18.** Round robin (with a time allocation of 3 seconds) is used as a scheduling method for three processes in the order of  $P_1$ ,  $P_2$ , and  $P_3$ , shown in the table below. What is the total waiting time (in seconds) of  $P_3$  that elapses before its execution completes? Here, the arrival time is the time at which a process joins the ready queue.

Unit: seconds

Process	Execution time	Arrival time
$P_1$	24	0
$P_2$	15	10
$P_3$	12	13

a) 35

b) 38

c) 45

d) 48

**Q18.** In a paged virtual memory system, the LRU method is used in the page replacement algorithm. When the page frame assigned to the main memory is 4, and pages are accessed in the order of 1, 2, 3, 4, 5, 2, 1, 3, 2, 6, which of the following page is replaced at the time of accessing page 6? Here, no page exists in the main memory in the initial state.

- a) 1                      b) 2                      c) 4                      d) 5

**Q19.** There is a system in which the print requests waiting for output are assigned to an available printer in an order of  $A$ ,  $B$ , and  $C$ , and then the printer available first among the three (3) printers  $A$  through  $C$  of the same model. If the print time of each print request is 5, 12, 4, 3, 10, and 4 (minutes) in the order of the requests waiting for output, which of the following lists of printers is arranged in an order starting from the longest time assigned for printing? Here, all printers are available in the initial state.

- a)  $A, B, C$                       b)  $B, A, C$                       c)  $B, C, A$                       d)  $C, B, A$

**Q6.** There is a language defined by a context-free grammar with the production rules below:

$$E \rightarrow T + E \mid T$$

$$T \rightarrow F * T \mid F$$

$$F \rightarrow ( E ) \mid C$$

$$C \rightarrow 0 \mid 1 \mid 2 \mid 3 \mid 4 \mid 5 \mid 6 \mid 7 \mid 8 \mid 9$$

In this grammar, non-terminals are E, T, F, and C; terminals are parentheses, plus sign, asterisk, and numbers; E is the start symbol. Which of the following shows that the expression  $7 + 3 * (6 + 4)$  is a sentence of this language?

a)  $E \rightarrow 7 + 3 * (F + T)$

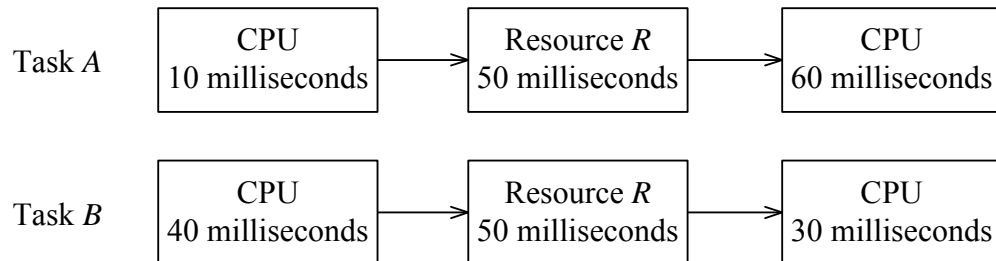
b)  $E \rightarrow 7 + 3 * E$

c)  $E \rightarrow 7 + 3 * (T)$

d)  $E \rightarrow 7 + T * (E)$



**Q22.** There is a system composed of two (2) CPUs, and the CPU that is not in use is assigned to a task for which there is an execution request. When two (2) tasks *A* and *B* are run on this system, these tasks exclusively use a common resource *R*. The figure below shows the usage periods of the CPUs and resource *R* for tasks *A* and *B*, and the order in which the tasks are run. When the execution of both the tasks is started simultaneously, how much time, in milliseconds, is required until the completion of processing of both the tasks? Here, both the CPU and resource *R* are available when tasks *A* and *B* are started.



- a) 120                      b) 140                      c) 150                      d) 200

**Q17.** In a paged virtual memory, the LRU method is adopted for the page replacement algorithm. When the page frame allocated to the main memory is 4, which of the following page is to be replaced when page 6 is accessed if the pages are accessed in the order of page 1, 2, 3, 4, 5, 2, 1, 3, 2, 6? Here, no page exists in the main memory in the initial state.

- a) 1                                      b) 2                                      c) 4                                      d) 5

**Q19.** When SRT (Shortest Remaining Time), also known as SRTF (Shortest Remaining Time First), is used as a scheduling method for three processes  $P_1$  through  $P_3$  shown in the table below, what is the total waiting time (in seconds) of  $P_2$  that elapses before its execution completion?

Unit: second

Process	Length of execution time	Time of arrival
$P_1$	20	0
$P_2$	25	15
$P_3$	10	30

a) 5

b) 10

c) 15

d) 20

**Q16.** The table below shows the priorities of three tasks together with the operation sequence and processing time of the CPU and I/O device when each task is executed in a stand-alone mode. What is the idle time (in milliseconds) of the CPU from the moment when all three tasks become ready to execute simultaneously until the execution of the three tasks is completed? Here, there is no I/O contention, and the overhead of the OS can be ignored. In the table, the number enclosed in parentheses shows the processing time for each operation.

Priority	Operation sequence and processing time (in milliseconds) when each task is executed in a stand-alone mode
High	CPU (3) → I/O (5) → CPU (2)
Medium	CPU (2) → I/O (6) → CPU (2)
Low	CPU (1) → I/O (5) → CPU (1)

- a) 1                      b) 2                      c) 3                      d) 4

**Q21.** A certain computer system runs in a multi-programming environment using a non-preemptive “shortest job first” algorithm. In this system, when four CPU-bound jobs  $P_1$  through  $P_4$  arrive at the job queue as shown in the table below, what is the average waiting time (in minutes) of the four jobs in the queue? Here, the job queue is empty at the beginning, so the first job can be executed immediately after its arrival.

Job	Execution time (minutes)	Arrival time (hh:mm)
$P_1$	7	1:00
$P_2$	4	1:02
$P_3$	1	1:04
$P_4$	4	1:05

a) 3.0

b) 4.0

c) 4.75

d) 5.3

**Q22.** When CPU processing and printing are performed for four jobs under the conditions below, how many minutes does it take to complete them from the start of the first CPU processing until the end of the last printing?

[Conditions]

- (1) The multiplicity of jobs is 1 during execution.
- (2) The CPU processing time of each job is 20 minutes.
- (3) 400 Mbytes of printing data are spooled for each job when the CPU processing ends. The printing function of the OS operates after spooling is completed, and printing is performed by the printer.
- (4) One printer is available, and the printing speed is 10 minutes per 100 Mbytes.
- (5) The functions of CPU processing and printing can operate in parallel, and do not affect each other.
- (6) The time period that is not mentioned in the conditions, such as the time required for spooling, can be ignored.

- a) 120                      b) 160                      c) 180                      d) 240

**Q25.** In a page-based virtual memory system, which of the following is the appropriate combination of page replacement algorithms that have less page faults for two page strings R1 and R2 shown below? Here, three page frames are allocated to main memory, and no page exists in main memory in the initial state.

R1: 1, 2, 3, 2, 4, 2, 5, 2, 3, 4

R2: 1, 2, 3, 4, 2, 5, 3, 1, 2, 5

	Paging algorithm for R1	Paging algorithm for R2
a)	FIFO	FIFO
b)	FIFO	LRU
c)	LRU	FIFO
d)	LRU	LRU

**Q26.** A byte-code program written in Java can be executed in two methods: one method for executing it by an interpreter and the other method for executing it after compilation by a compiler. When these methods are compared under the conditions below, approximately how many byte-code lines are required for the program to be executed by the compiler method (including compile time) faster than by the interpreter method?

[Conditions]

- (1) Execution time is proportional to the lines of code in the program.
- (2) When a program of 100 lines of byte-code is executed by an interpreter, it takes 0.2 seconds, whereas when the same program is executed after it is compiled, it takes 0.003 seconds.
- (3) 0.1 seconds per 100 lines of code are required to compile.
- (4) In the compiler method, 0.15 seconds of overhead are always required for file I/O, launching the compiler, and other tasks, regardless of the lines of code in the program.
- (5) The time required to download the program files and other processes can be ignored.

a) 50

b) 75

c) 125

d) 155



**Q24.** When four jobs *A* through *D* shown in the table below are executed on a first-come first-served basis, which of the following is the average waiting time (in minutes) in the job queue? Here, the job queue is empty before job *A* arrives.

Job	Arrival time (hh:mm)	Execution time (minutes)
<i>A</i>	0:00	4
<i>B</i>	0:02	6
<i>C</i>	0:05	3
<i>D</i>	0:10	2

- a) 2.5                      b) 3.75                      c) 4.25                      d) 6.75

**Q25.** CPU utilization of a computer system can be improved by using multiprogramming. If there is one process in memory, the CPU utilization is  $(1-p)$ . Here, " $p$ " is the fraction of time (e.g., I/O time) that a process spends away from the CPU. If there are " $n$ " processes in memory, the probability of " $n$ " processes waiting for an I/O is  $p * p * \dots * p$  ( $n$  times). The CPU utilization is equal to  $(1 - p^n)$ . When the system has enough main memory space to hold four processes and each process waits for I/O completion during 50% of the execution time, which of the following is the percentage of the CPU time wasted by waiting for I/O completion?

- a) 6.25                      b) 12.5                      c) 87.5                      d) 93.75

**Q22.** A certain computer system runs in a multi-programming environment using a non-preemptive algorithm. In this system, two processes  $A$  and  $B$  are stored in the process queue, and  $A$  has a higher priority than  $B$ . The table below shows estimated execution time for each process; for example, process  $A$  uses CPU, I/O, and then CPU sequentially for 30, 60, and 30 milliseconds respectively. Which of the following is the estimated time in milliseconds to complete both  $A$  and  $B$ ? Here, the multi-processing overhead of OS is negligibly small. In addition, both CPU and I/O operations can be executed concurrently, but I/O operations for  $A$  and  $B$  cannot be performed in parallel.

Unit: millisecond

Process name	Execution time		
	CPU	I/O	CPU
$A$	30	60	30
$B$	45	45	–

- a) 120                      b) 135                      c) 165                      d) 210

**Q23.** A certain computer system runs in a multi-programming environment using a non-preemptive “shortest job first” algorithm. In this system, four processes  $A$ ,  $B$ ,  $C$ , and  $D$  arrive sequentially in the process queue every 1 millisecond. The table shown below includes estimated execution time for each process; for example, process  $A$  uses CPU, I/O, and then CPU sequentially for 4, 5, and 4 milliseconds respectively. Which of the following is the third completed process? Here, the multi-processing overhead of OS can be ignored, and both CPU and I/O operations can be executed concurrently.

Unit: millisecond

Process name	Execution time		
	CPU	I/O	CPU
$A$	4	5	4
$B$	3	4	2
$C$	2	4	3
$D$	4	3	2

a)  $A$

b)  $B$

c)  $C$

d)  $D$

**Q25.** There is a virtual memory system in which the FIFO or LRU page replacement algorithm can be used as a page replacement algorithm. There are 4 page frames available in real memory, and a process makes the list of page references as follows:  $2 \rightarrow 3 \rightarrow 6 \rightarrow 4 \rightarrow 6 \rightarrow 3 \rightarrow 1 \rightarrow 2 \rightarrow 4 \rightarrow 6$ . How many page faults occur during execution of this process using the FIFO and LRU page replacement algorithms separately? Here, all page frames are empty at the beginning of the process.

	FIFO	LRU
a)	2	4
b)	4	2
c)	6	8
d)	8	6

**Q11.** Which of the following is included as an element of a set of character strings represented by a regular expression “[A–Z]+[0–9]\*”? Here, the regular expression follows the rules described below.

[A – Z] denotes a single alphabetical letter.

[0 – 9] denotes a single numeral.

The symbol “\*” denotes zero or more repetitions of the immediately preceding regular expression.

The symbol “+” denotes one or more repetitions of the immediately preceding regular expression.

- a) 456789                      b) ABC99\*                      c) ABC+99                      d) ABCDEF

**Q29.** When a printing operation is performed under the conditions shown below, what is the minimum number of megabytes necessary as the total capacity of the spool file?

[Conditions]

- (1) The same job is executed continuously four times with multiplicity 1.
- (2) It takes 20 minutes to execute the job in a standalone mode.
- (3) The standalone job secures a 400-Mbyte print-spool file, where the printing data is stored.
- (4) After the job is executed, the contents of the spool file are processed by the printing function of the OS.
- (5) The OS deletes the spool file at the completion of the printing. Here, the time for this deletion can be ignored.
- (6) There is exactly one printer, and its printing speed is 10 Mbytes per minute.
- (7) Job execution and printing can be performed in parallel without one affecting the other.

- a) 400                      b) 800                      c) 1,200                      d) 1,600

**Q31.** The FIFO method is used as the page replacement algorithm in virtual memory. There are 3 page frames available in real memory, and a reference list of the virtual page numbers “1, 4, 2, 4, 1, 3” was allocated to real memory in this order as shown in the table below. The table, up through “assigning step 3”, shows the status of the real memory pages just after each of the first three page numbers “1, 4, 2” of the reference list was allocated to real memory. Which of the following should be inserted in the bold-lined box that indicates the last status of the real memory pages just after the remaining page numbers were referenced?

Assigning step	Virtual page number referenced	Status of real memory pages		
1	1	1	–	–
2	4	1	4	–
3	2	1	4	2
4	4			
5	1			
6	3			

a) 

1	4	3
---	---	---

b) 

2	3	4
---	---	---

c) 

3	4	2
---	---	---

d) 

4	1	3
---	---	---



**Q28.** A certain computer system runs in a multi-programming environment using a non-preemptive “shortest job first” algorithm. In this system, four processes  $A$ ,  $B$ ,  $C$ , and  $D$  arrive sequentially in the process queue every 1 millisecond. The table shown below includes estimated execution time for each process; for example, process  $A$  uses CPU, I/O, and then CPU sequentially for 4, 5, and 5 milliseconds respectively. When 14 milliseconds elapse after the arrival of the first process  $A$ , which of the following processes is executed in CPU? Here, the multi-processing overhead of OS can be ignored, and both CPU and I/O operations can be executed concurrently.

Unit: millisecond

Process Name	Execution time		
	CPU	I/O	CPU
$A$	4	5	5
$B$	3	4	6
$C$	2	3	3
$D$	4	3	2

a)  $A$

b)  $B$

c)  $C$

d)  $D$

**Q11.** In a certain computer system, a simple hash function called the division method is used for page-based address translation. By using this method, a pair of new logical page number “101000” and its corresponding physical page number “0010” is stored into the page table shown below. Which of the following indexes is used to place them in the table? Here, the given logical page number is divided by 7, and its remainder is used as the index of the page table. If the slot specified by the index value is already taken, the table is searched forward from that slot to find the next empty slot.

Page table

Index	Logical page number	Physical page number
000	Empty	Empty
001	001111	1110
010	Empty	Empty
011	000011	0001
100	001011	0011
101	000101	1010
110	Empty	Empty
111	Empty	Empty

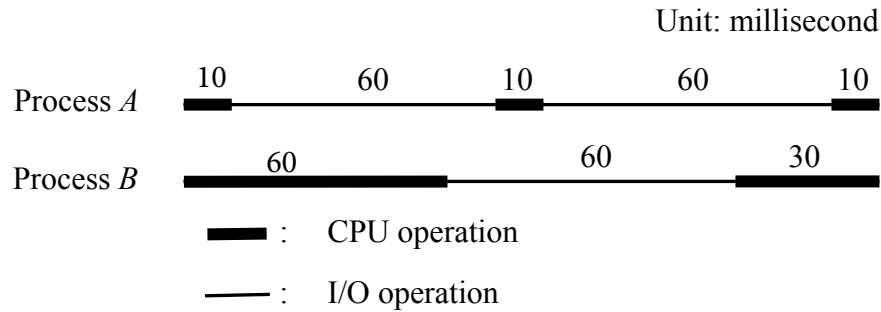
a) 000

b) 010

c) 110

d) 111

**Q29.** Two processes  $A$  and  $B$  with the same priority are executed in a round-robin method with a time slice of 30 milliseconds on a single CPU, but they use respectively different I/O devices. When they are executed as a standalone process, their processing times and sequences are shown in the figure below. How long (in milliseconds) does it take to complete both processes? Here, the two processes are alternately executed; that is, the first is  $A$ , the second  $B$ , and then  $A$  again. The multi-processing overhead of OS can be ignored, and both CPU and I/O operations can be executed concurrently.



- a) 150                      b) 160                      c) 170                      d) 180

**Q30.** The FIFO method is used as the page-replacing algorithm in virtual memory. There are 3 page frames available for a program in main memory, and the page numbers referred to by a program are  $4 \rightarrow 3 \rightarrow 2 \rightarrow 1 \rightarrow 3 \rightarrow 5 \rightarrow 2$  in this order. How many times does page-in occur during execution of the program? Here, nothing is loaded into main memory in the initial state.

a) 2

b) 3

c) 5

d) 6

**Q25.** A CPU has four blocks of cache memory. Using the LRU (Least Recently Used) replacement algorithm, which memory blocks are stored in the cache memory after the execution of the following sequence of access to memory blocks: 1 2 3 4 5 2 5 4 1 5 2 3? Here, at the start of the memory access, the four cache blocks are empty and used in sequence until all the blocks are occupied. In other words, the cache blocks contain memory blocks “1 2 3 4” after access to the first four memory blocks.

a) 1 2 3 5

b) 1 5 2 3

c) 3 2 5 1

d) 5 2 1 3

**Q34.** When variables shared among tasks are updated, an unexpected result may occur if synchronous control among tasks is not performed. When the initial value of the variable  $x$  shared among tasks is 3, the final value of  $x$  is expected to be 12 if task A executes the assignment statement " $x = x + x$ " and if task B executes the assignment statement " $x = x \times x$ ." Which of the following is the appropriate execution sequence that can return the expected result? Here, each assignment statement is executed by being divided into four portions as shown below.

<p>Task A (<math>x = x + x</math>)</p> <p>a1: The value of <math>x</math> is referred to and is saved as <math>e</math>.</p> <p>a2: The value of <math>x</math> is referred to and is saved as <math>f</math>.</p> <p>a3: <math>e + f</math> is computed and is saved as <math>g</math>.</p> <p>a4: The value of <math>x</math> is updated by means of <math>g</math>.</p>	<p>Task B (<math>x = x \times x</math>)</p> <p>b1: The value of <math>x</math> is referred to and is saved as <math>h</math>.</p> <p>b2: The value of <math>x</math> is referred to and is saved as <math>i</math>.</p> <p>b3: <math>h \times i</math> is computed and is saved as <math>j</math>.</p> <p>b4: The value of <math>x</math> is updated by means of <math>j</math>.</p>
--	--

- a)  $a1 \rightarrow a2 \rightarrow b1 \rightarrow b2 \rightarrow a3 \rightarrow a4 \rightarrow b3 \rightarrow b4$
- b)  $a1 \rightarrow b1 \rightarrow b2 \rightarrow b3 \rightarrow b4 \rightarrow a2 \rightarrow a3 \rightarrow a4$
- c)  $b1 \rightarrow a1 \rightarrow a2 \rightarrow a3 \rightarrow a4 \rightarrow b2 \rightarrow b3 \rightarrow b4$
- d)  $b1 \rightarrow b2 \rightarrow b3 \rightarrow a1 \rightarrow a2 \rightarrow a3 \rightarrow a4 \rightarrow b4$

**Q26.** The sequence of virtual page numbers shown below is encountered in the course of execution of programs on a computer with virtual memory.

[Sequence of virtual page numbers]

3 4 2 6 4 7 1 3 2 6 3 5 1 2 3

In the computer, the LRU page replacement policy is adopted. Main memory has a capacity of 5 pages for programs, and each page is initially empty. What is the page hit ratio (percentage of times that the referenced page is found in main memory) rounded to the nearest integer value?

- a) 20                      b) 33                      c) 50                      d) 67

**Q37.** In a search system, when search was first performed under condition A, there were 5,000 search results. When further narrowed down with condition B, 30% of these search results remained. If search first performed under condition B produces 10,000 search results, what percentage will remain when these are further narrowed down with condition A?

- a) 15                      b) 30                      c) 35                      d) 60