

New FE Exam Preparation Book

Vol. 2

Answers &
Explanations



Preparation for

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Examination

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Volume 2

Answers and Explanations

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Section 1

Basic Theory

Q1-1 c)

Representation of a hexadecimal fraction as a decimal fraction)

If a hexadecimal fraction is represented in decimal, the result is typically as shown below.

$$(\dots x_2 x_1 x_0 . y_1 y_2 y_3 \dots)_{16} \\ = \dots + x_2 \times 16^2 + x_1 \times 16^1 + x_0 \times 16^0 + y_1 \times 16^{-1} + y_2 \times 16^{-2} + y_3 \times 16^{-3} + \dots$$

If the hexadecimal fraction 0.C is represented in decimal and calculated as below, the answer is c) 0.75.

$$0.C = (C)_{16} \times 16^{-1} = 12 \times \frac{1}{16} = \frac{12}{16} = \frac{3}{4} = 0.75$$

Q1-2 a)

Representation of a fraction in a radix conversion

This question deals with binary, octal, and decimal values. First, concerning binary and octal values, $2^3=8$ means that a binary value can be split into blocks of three digits and substituted for an octal value. This also means that the notations for octal and binary values are compatible. For this reason, in a radix conversion between a binary value and an octal value, there are no phenomena where a finite fraction becomes an infinite fraction or vice versa. Thus, whether or not the result of a radix conversion becomes a finite fraction or an infinite fraction only needs to be considered between a decimal value and a binary value (octal value).

(1) When a decimal value with a finite fraction is represented in binary value

The examples of a finite fraction and an infinite fraction are clearly shown below.

[Example]

- $(0.5)_{10} = (0.1)_2$: Example of a finite fraction
- $(0.1)_{10} = (0.00011001100110011\dots)_2$: Example of an infinite fraction

(2) When a binary value with a finite fraction is represented in decimal value

The fraction is represented as shown below.

$$a_1 \frac{1}{2} + a_2 \frac{1}{2^2} + a_3 \frac{1}{2^3} + \dots + a_{n-1} \frac{1}{2^{n-1}} + \frac{1}{2^n} \\ 2 \sum_{k=1}^n a_k \frac{1}{2^k} \quad (a_k = 0 \text{ or } 1)$$

$\frac{1}{2^k}$ is a finite fraction, so the previous expression is the sum of a finite fraction and its value is also a finite fraction. Thus, if a binary value with a finite fraction is represented in decimal value, the result is a finite fraction.

- a) (2) shows that this is correct.
- b) This is incorrect, as explained above.
- c) Octal values and binary values are equal, so this contradicts (2) and is incorrect.
- d) (1) shows that this is incorrect for binary and so is also incorrect for octal.

Q1-3 a)

Method for checking if a binary value is a multiple of 16

For an 8-bit unsigned value, the weighting is

$$(2^7 \ 2^6 \ 2^5 \ 2^4 \ 2^3 \ 2^2 \ 2^1 \ 2^0) = (128 \ 64 \ 32 \ 16 \ 8 \ 4 \ 2 \ 1)$$

from the left digit. Each of the upper four digits is a multiple of 16, so no matter which bit is one, it is a multiple of 16. The weighting of each of the lower four digits is a number of 8 or less, and if all digits are aggregated the result is 15, so if any bit is 1 then division by 16 is not possible. Thus, if the lower four bits of a binary value are all zeros, then it is a multiple of 16.

In order to retrieve the lower four bits of x , the logical sum of x and a binary value with 1 in the lower four bits should be calculated. Therefore, a) is appropriate.

Q1-4 c)

Register value after a shift

When overflow does not occur and a binary value is shifted one bit to the left, the value becomes $2^1=2$ times the original value. If the shift is two bits, the value becomes $2^2=4$ times the original value, and if the shift is three bits, it becomes $2^3=8$ times the original value, and so fourth. This is the same as multiplication by the power of two, so if the shift is two bits to the left the value becomes four times the original value. In the conditions of the question, the original number x is added to this value. If x is added to the original value multiplied by four ($4x$), it becomes $5x$, which shows that the value is the original value multiplied by five. Therefore, c) is correct.

- a) If x is shifted one bit to the left, it becomes $2x$, and if x is then added, it becomes $3x$.
- b) If x is shifted two bits to the left, it becomes $4x$.
- d) If the result (i.e., $2x$) of shifting x one bit to the left is added to the result (i.e., $4x$) of shifting x two bits to the left, it becomes $6x$.

Q1-5 c)

2's complement

The 2's complement of a binary number is the value obtained by subtracting the binary number from a reference value (i.e., "the maximum value possible with the same number of digits as the number for which 2's complement is to be calculated" +1). When a negative number is to be represented with 2's complement, the 2's complement of the absolute value of that number is used. In this question, the number of digits is eight, so the result of subtracting the absolute value from 100000000 (the maximum value of eight digits +1) is 10101110. If the absolute value is represented as x , the relationship is as show below.

$$100000000 - x = 10101110 \quad (\leftarrow \text{this is the 2's complement of } x)$$

$$x = 100000000 - 10101110$$

$$x = 01010010$$

Therefore, c) is correct. 2's complement can also be calculated by inverting the bits and adding 1. In the same way, if the reverse operation is performed, 1 is subtracted and the bits are inverted: $10101110 - 1 = 10101101 \rightarrow \text{inversion: } 01010010$). As a result, the same value can be obtained.

Q1-6 c)

Range represented in a fixed point format

In a fixed point format that represents negative numbers with 2's complement, a positive or negative sign is identified as the leftmost bit. 0 is for a positive number and 1 is for a negative number (when the number of 0 is represented, all bits are 0s but this is not a positive number) The maximum positive number that can be represented with n bits has " $n - 1$ " digits.

When a negative number is represented with a 4-bit fixed point number, the result is shown in the table below. An examination of the leading one bit of each binary value in the table shows that it is 0 for a number of 0 or greater and 1 for negative numbers. In order to apply this law, $(1000)_2$ is regarded as -8 , not $+8$.

Decimal value		Binary value
+7	-----	0111
+6	-----	0110
+5	-----	0101
+4	-----	0100
+3	-----	0011
+2	-----	0010
+1	-----	0001
0	-----	0000
-1	-----	1111
-2	-----	1110
-3	-----	1101
-4	-----	1100
-5	-----	1011
-6	-----	1010
-7	-----	1001
-8	-----	1000

Calculated with 2's complement

Based on the above table, if a fixed point number with four bits is considered, $(-8)_{10}$ through $(+7)_{10}$ can be represented. This range can also be represented as $(-2^3)_{10}$ to $(+2^3 - 1)_{10}$. The table below shows the representable range for each length of a fixed point number.

Length of fixed point number	Representable range	Alternative representation	Type of representable number
4-bit	-8 through +7	-2^3 through $+2^3-1$	$2^4(=16)$
8-bit	-128 through +127	-2^7 through $+2^7-1$	2^8
16-bit	-32,768 through +32,767	-2^{15} through $+2^{15}-1$	2^{16}
32-bit	-2^{31} through $+2^{31}-1$	2^{32}
n -bit	-2^{n-1} through $+2^{n-1}-1$	2^n

As such, with a fixed point number of n bits in length, the values that can be represented are -2^{n-1} through $+2^{n-1}-1$. Therefore, c) is correct.

Q1-7 d)

Conversation of decimal values to binary values

This question considers the conversion of decimal integers to unsigned 1-byte binary integers.

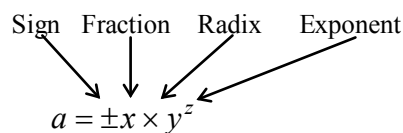
- a) $(120)_{10} = (01111000)_2$
- b) $(127)_{10} = (01111111)_2$
- c) $(170)_{10} = (10101010)_2$
- d) $(240)_{10} = (11110000)_2$

When b) 127 is converted to a binary integer, the number of zero (0) bits differs from that of one (1) bits, so it not a possible answer. Thus, the binary integer with the maximum value should be chosen from a), c), and d). Therefore, d) is correct.

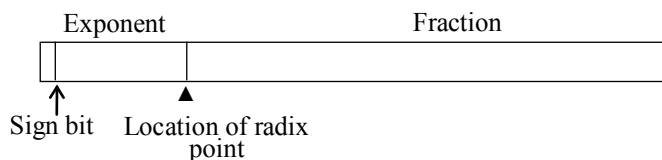
Q1-8 a)

Floating point representation of a real number by using an expression

When the real number a is represented as $a = x \times y^z$ with floating point representation system, the name of each part is as shown below. Therefore, a) is appropriate.



A floating point number that is represented in a data format in a computer is as shown in the figure below.



Q1-9 c)

Errors in floating point arithmetic operations

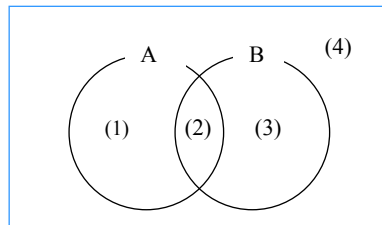
The answer that applies to the question is c) loss of trailing digits. In the addition and subtraction of floating point numbers, before an operation, the values of the exponents of two numbers are adjusted to the appropriate size. In other words, the value of the exponent of the number with the smaller absolute value is adjusted to the value of the exponent of the larger value, and the fraction part of the smaller value becomes zero, which is the cause of the phenomenon. In the addition and subtraction of multiple values, in order to prevent the loss of trailing digits, addition or subtraction is performed after the values are arranged in order of absolute value from smallest to largest. By doing this, the operation is on absolute values that have a small difference, and the loss of trailing digits is unlikely to occur.

- a) Truncation error is an error that occurs in an operation such as an engineering calculation where an infinite fraction is cut off.
- b) Cancellation of significant digits is a phenomenon where the number of valid digits decreases due to normalization of the fraction when two numeric values with the same sign bit and almost the same absolute value are added or subtracted.
- d) Absolute error is the actual value of an error. The ratio of an error to the size of a value is called a relative error.

Q1-10 c)

Relationships that are always valid in sets

The Venn diagram below is considered here.



If sets are represented with (1) through (4) in the above figure so that A is (1) and (2), set B is (2) and (3), and $A \cap B$ is (2), then each option can be replaced as shown below:

a) $A \subseteq (A \cap \bar{B}) \rightarrow (1)(2) \subseteq (1)$

$(1)(2) \subseteq (1)$ means “(1) and (2) is a subset of (1).” A subset means that the elements of a given set are completely contained in another set. In this case, (1) and (2) is not completely contained in (1), so it is not valid.

b) $(A \cup B) \subseteq (\bar{A} \cup \bar{B}) \rightarrow (1)(2)(3) \subseteq (1)(3)(4) \dots$ Not valid

c) $(A \cap B) \subseteq (A \cup \bar{B}) \rightarrow (2) \subseteq (1)(2)(4) \dots$ Valid

d) $(A \cap B) \subseteq (\bar{A} \cap \bar{B}) \rightarrow (2) \subseteq (4) \dots$ Not valid

Therefore, c) is correct.

Q1-11 a)

Equal values in logical expressions

Based on De Morgan's laws:

$$\overline{A \cdot B} = \overline{A} + \overline{B}$$

$$\overline{A + B} = \overline{A} \cdot \overline{B},$$

the given logical expression can be broken down as shown below:

$$\begin{aligned}\overline{(A + B) \cdot (A + C)} &= \overline{(A + B)} + \overline{(A + C)} \\ &= (\overline{A} \cdot \overline{B}) + (\overline{A} \cdot \overline{C}) \\ &= A \cdot \overline{B} + \overline{A} \cdot C\end{aligned}$$

Therefore, a) is correct.

Q1-12 b)

Logical expressions for functions shown in a truth table

In this kind of question, confirmation of each option can ultimately lead to a faster answer. A truth table for each option can be written and considered, but attention should be paid to the fact that each value within the parentheses of the options is a logical product (true only when both values are true) and the parentheses are linked with logical sums (true if at least one is true). Then, an appropriate value should be entered into the variable, and a comparison with the result of $f(x, y, z)$ of the truth table should be performed.

First, the first half of a) to c) is $(x \wedge y)$, so if the values $x = T, y = F$, and $z = T$ of the third row of the truth table are inserted, the result is $x \wedge y = F$.

- a) In the latter half, $y \wedge z = F$, so the overall result is also F. This does not match the result of $f(x, y, z)$ in the truth table.
- b) In the latter half, $\overline{y} \wedge z = T$, so the overall result is also T. This matches the result of $f(x, y, z)$ in the truth table. Therefore, b) is correct.
- c) In the latter half, $\overline{y} \wedge \overline{z} = F$, so the overall result is also F. This does not match the result of $f(x, y, z)$ in the truth table.
- d) Only for this option, the values $x = T, y = T$, and $z = F$ of the second row which make the result of the first half F are inserted. $x \wedge \overline{y} = F$, $\overline{y} \wedge \overline{z} = F$, so the overall result is also F. This does not match the result of $f(x, y, z)$ in the truth table.

The answer is understood to be b), but other values should be inserted for confirmation before finally providing an answer.

Q1-13 d)

The shortest path viewed from a diagram

A question where the number of shortest paths is calculated can be considered as a question about permutations and combinations. The shortest path from P to R is a total of four steps composed of two horizontal and two vertical steps. The path depends on the order of these steps, so the number of combinations of these steps is the number of shortest paths. This can be calculated as a combination that selects two from four.

$$P \rightarrow R: {}_4C_2 = 4 \times 3 / (2 \times 1) = 6$$

In the same way, the number of shortest paths from R to Q is decided by the order in which two horizontal and three vertical steps are taken. This can be calculated as a combination that selects two from five.

$$R \rightarrow Q: {}_5C_2 = 5 \times 4 / (2 \times 1) = 10$$

Here, when P is to be reached from Q , the point R must be passed. Thus, the number of the shortest paths can be calculated by multiplication (independent of each other) of the combinations for P to R and R to Q . The answer is d) $6 \times 10 = 60$ paths.

Q1-14 d)

Calculation of probability

Probability represents the degree of certainty that a given event will occur as a numerical value. It can be calculated with the expression described below:

$$\text{Probability that a given event will occur} = \frac{\text{Number of times a given event can occur}}{\text{Total number of events that can occur}}$$

When one ball is removed from a bag that contains four white balls and five red balls and then another ball is removed without putting the first ball back into the bag, the probability that both balls are red is as shown below:

- Probability that the first ball is red

The number of balls in the bag is nine, of which five are red. Thus, the probability that the first ball is red is $5/9$.

- Probability that the second ball is red

The first ball is not put back into the bag after it is removed, so the number of balls that remain in the bag is eight. As it is assumed that the first ball removed is red, the number of red balls that remain is four. Thus, the probability is $4/8 = 1/2$.

The probability that both balls are red is calculated from the product of both probabilities: $(5/9) \times (1/2) = 5/18$. Therefore, d) is correct.

Q1-15 d)

Calculation of the probability of a change in the weather

A state transition diagram is a diagram that is used to represent a transfer within a finite number of states when the next state is decided only by the current state and an incoming event. State transition diagrams were originally used in the design of sequential circuits for computers. However, as they have the versatility to be used for things such as analysis of grammar in programming languages and task control in operating systems, they can also be used for the description of logic.

For the state transition in this question, when the weather is rainy on a given day, there are three cases in which the weather is clear two days later.

- (1) Probability of day 1 rainy \rightarrow day 2 rainy \rightarrow day 3 clear $= 0.2 \times 0.3 = 0.06$
- (2) Probability of day 1 rainy \rightarrow day 2 clear \rightarrow day 3 clear $= 0.3 \times 0.4 = 0.12$
- (3) Probability of day 1 rainy \rightarrow day 2 cloudy \rightarrow day 3 clear $= 0.5 \times 0.3 = 0.15$

For the probability that is calculated, any of the cases from (1) to (3) can occur, so the sum of the probability for each case is used for calculation. Therefore, the result is $0.06 + 0.12 + 0.15 = 0.33$, and d) is correct.

Q1-16 b)

Variation in character strings

The number of character strings with one character that can be expressed using A and B are the two variations A and B . In the same way, the number of variations for a two-character string is four: AA , AB , BA , BB . The characters that are used are the two characters A and B , so this question can be considered in the same way as binary. In the case of binary, for one digit there are 2^1 variations, for two digits there are 2^2 variations, and for n digits there are 2^n variations that can be represented. In this question, the number of variations that are possible with a length of one to seven characters is considered, and the answer is as follows:

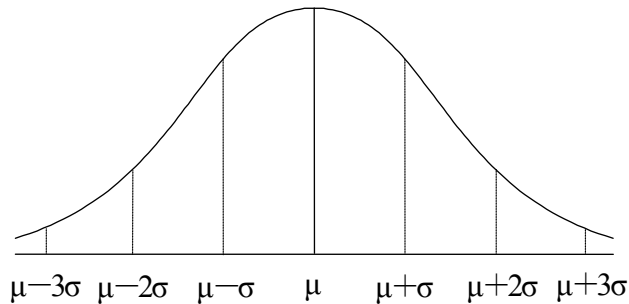
$$2^1 + 2^2 + 2^3 + 2^4 + 2^5 + 2^6 + 2^7 = 2 + 4 + 8 + 16 + 32 + 64 + 128 = 254$$

Therefore, b) is correct.

Q1-17 a)

Graph of normal distribution

A graph that represents normal distribution resembles a symmetric mountain with sides that smoothly approach the horizontal axis. Standard deviation is a statistical index that represents how far each item of data is from the average. In a graph for normal distribution, the relationship between the average and the standard deviation is shown in the diagram below. Therefore, a) is the correct graph. In quality management, as per the three sigma (3σ) rule, if the standard deviation is multiplied by three, most data is within that range, and thus it can be used to manage the degree of variation in quality.



Line of normal distribution (μ is average, σ is standard deviation)

- b) Standard deviation shows the distance between each item of data and the central average, so this is incorrect.
- c), d) The line is not symmetrical, so this cannot be normal distribution.

Q1-18 d)

Operations to round average values to the nearest integer

For N observed values, the average value of the sum S can be calculated with S/N , but this question is about the processing method to round the first decimal place of a value to the nearest integer.

$\lceil \]$ is called a Gauss symbol and represents an integer that does not exceed the value in the square brackets, so the result is an integer value with the fraction rounded. Rounding is an action that rounds up a digit that is 5 or greater and rounds down a digit that is 4 or less. As a technique for calculating numeric values, there is a method that adds 5 to a digit and if that digit is 5 or greater it is forcefully rounded up. By applying this method, for rounding to the nearest integer, $S/N + 0.5$ should be calculated and the digits(s) after the fraction should be discarded. Therefore, d) $\lceil \frac{S}{N} + 0.5 \rceil$ is correct.

In the kind of example below, it is very important to confirm that correct rounding can be performed.

[Example] $3.4 \dots 3.4 + 0.5 = 3.9$ The fraction is discarded to leave 3
 $3.5 \dots 3.5 + 0.5 = 4.0$ The fraction is discarded to leave 4

Q1-19 c)

Sample correlation coefficient

A correlation coefficient is a numeric value that shows the level of association between two items. The possible range of this value is from -1 to 1 . The closer the value gets to 1 the stronger the positive correlation, and the closer the value gets to -1 the stronger the negative correlation. When the correlation coefficient is -0.9 , the options are graph c) or d) which represents a negative correlation. -0.9 is a stronger negative correlation than -0.7 and the stronger the correlation the closer the distribution is to the regression line. Therefore, c) is correct.

Q1-20 a)

Inference mechanism of a knowledge base

A system that uses a knowledge base in a given field and can make inferences close to those made by experts in that field is called an expert system. Therefore, a) is correct.

- b) A neural network is a biological term that represents the mechanism of a brain of a living organism such as a human, but it is also used for a computer system that is modeled on this. For this reason, there are cases where the latter is definitely called an artificial neural network. Almost all current computers are designed with a so called Neumann-type architecture. These computers follow a procedure where each instruction is read from a main memory, execute each instruction, and store the result in the main memory. However, in a neural network, if the same structure as the brain of a biological organism is simulated, it is hoped that the same thought as a biological organism will be possible.
- c) Virtual reality is a technological field that aims to give realistic experiences to humans through realistic stimulation of the five senses such as sight and hearing. This has moved into the fields of games and training.
- d) A fuzzy computer is a computer or software with a mechanism for the representation with fuzzy logic of information that has unclear boundaries such that a fuel tank has “lots of fuel,” “not much fuel,” or “quite a lot of fuel.”

Q1-21 c)

Reverse Polish notation

Reverse Polish notation (postfix notation) is a method for the notation of an arithmetic expression in a computer, and it describes an operator after the subject of an operation. For example, $(X+Y) \times Z$ means that “X” is added to “Y” and then the result (“XY+”) is multiplied by “Z”, therefore it is represented $XY+Z \times$. The order of the operators is considered, and the notation is made without parentheses.

In the given $EF-G \div CD-AB \div \div$, “E” and “F” are the subjects of the first operator “-”, so this means “E-F”. The subjects for the second operator “ \div ” are the result of “E-F” and “G”, so parentheses are added in line with the operation priority and the expression becomes $(E-F) \div G$. Next, the subjects for the third operator “-” are “C” and “D” so this is “C-D”, and the subjects for the fourth operator “+” are “A” and “B” so this is “A+B”. Next, the subjects for the fifth operator “ \div ” are the result of “C-D” and “A+B” so the expression is $(C-D) \div (A+B)$. The subjects for the final operator “+” are the result of $(E-F) \div G$ and $(C-D) \div (A+B)$, so the expression becomes $((E-F) \div G) + ((C-D) \div (A+B))$. Therefore, c) is correct.

Q1-22 a)

BNF and bit strings

As for the basic symbols of BNF (Backus-Naur Form), “ $::=$ ” represents that “the left-hand side is defined as the right-hand side,” and “|” represents “OR.” Elements that are defined are enclosed in angle brackets, and this can be used for a more complex syntax description.

The content that is defined in this question is considered here. $\langle S \rangle$ is defined as “01” or “0 $\langle S \rangle$ 1”, and in a situation where “0 $\langle S \rangle$ 1” is applied it can also be understood that the definition of the $\langle S \rangle$ part is recursive. As such, it can be understood that the following kind of pattern is allowed:

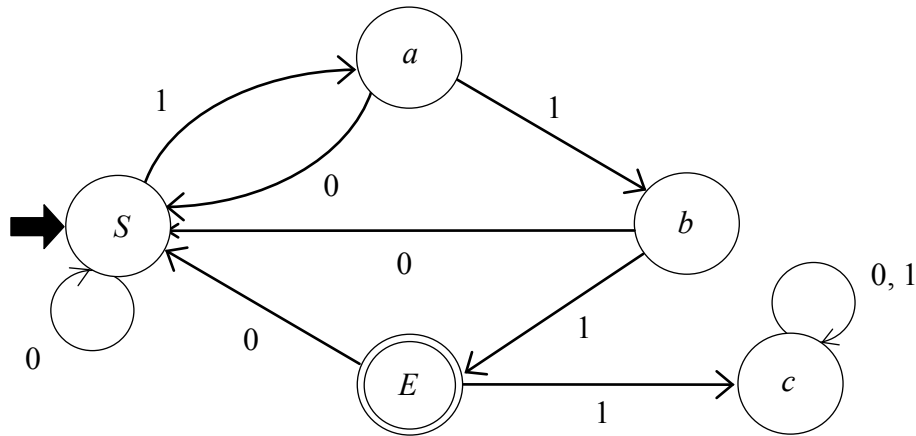
- | | | |
|-----|----------|---|
| (1) | 01 | Result of applying “01” to $\langle S \rangle$ |
| (2) | 0011 | Result of applying (1) to “0 $\langle S \rangle$ 1” |
| (3) | 000111 | Result of applying (2) to “0 $\langle S \rangle$ 1” |
| (4) | 00001111 | Result of applying (3) to “0 $\langle S \rangle$ 1” |
| | \vdots | |

In every case, the left-hand 0s of the center and the right-hand 1s are repeated such that the both numbers are equal. Therefore, a) is correct.

Q1-23 c)

Strings that are accepted by a finite automaton

An automaton is a machine that is driven by input values but is also affected by previous states. Furthermore, a finite automaton is an automaton that has a finite number of states and decides output and the next state from the current state and input. A finite automaton can be represented with the type of state transition diagram that is shown in the question. It should begin with the initial state $\rightarrow \bigcirc$ in the diagram, and should change the state with either 1 or 0. Finally, it should finish with the accepting state \odot . In each state in the diagram, a symbol is assigned as shown below. If the state transition of each character string in the options is followed, the state transitions are as shown in the table below.



a)	0	1	0	1	1
	$S \rightarrow S$	$S \rightarrow a$	$a \rightarrow S$	$S \rightarrow a$	$a \rightarrow b$
b)	0	1	1	1	1
	$S \rightarrow S$	$S \rightarrow a$	$a \rightarrow b$	$b \rightarrow E$	$E \rightarrow c$
c)	1	0	1	1	1
	$S \rightarrow a$	$a \rightarrow S$	$S \rightarrow a$	$a \rightarrow b$	$b \rightarrow E$
d)	1	1	1	1	0
	$S \rightarrow a$	$a \rightarrow b$	$b \rightarrow E$	$E \rightarrow c$	$c \rightarrow c$

Therefore, it can be understood that c) finishes with E .

Q1-24 d)

Methods for shortening character strings

The method for representing data, where the same character or the same bit pattern is repeated, in a short bit string is called run length encoding (i.e., encoding of the length of consecutive data). For example, when the character “A” is repeated 100 times, by representation of this as “100 As” rather than “AAA...AAA” the data can be compressed. Especially in monochrome fax data, there is no information except “black” and “white”, and the same bit pattern is repeated often. As such, in order to reduce the amount of communication, run length encoding is used. Therefore, d) is correct.

- a) EBCDIC is a character code set, and is mainly used in IBM mainframes.
- b) A cyclic code is an error correction code that is attached in order to detect data errors on a transmission channel.
- c) Huffman coding is a method for encoding that was developed in 1952 by David Huffman. In the same way as run length encoding, Huffman coding is an encoding method that efficiently shortens character strings and the like. But, in contrast to run length encoding, which is good for repetitions of the same character or bit pattern, Huffman coding represents frequently used characters as a short bit string, and represents less frequently used characters as a long bit string. For example, in English the letters “e,” “t,” and “s” appear frequently but the letters “q” and “z” do not, so for the former letters a short code is used and for the latter letters a long code is used. By doing this, the data overall can be compressed. In actual Huffman coding, encoding is based on the frequency of occurrence of each character in the subject data.

Q1-25 d)

Logical equation that always hold for odd parity

In odd parity, a parity value p is set so that the number of 1s in the data is odd. Thus, if the number of 1s in d_0, d_1, \dots, d_7 is odd then p is 0, and if the number 1s is even then p is 1.

The representation of the number of 1s in d_0, d_1, \dots, d_7, p with the exclusive-OR operation is considered here. For the odd number of 1s and the even number of 1s, the logical relations are shown below.

$$\cdot \text{Odd number: } d_0 \oplus d_1 \oplus \dots \oplus d_7 \oplus p = 1$$

$$\cdot \text{Even number: } d_0 \oplus d_1 \oplus \dots \oplus d_7 \oplus p = 0$$

$$(\text{Example}) 1 \oplus 1 \oplus 1 = (1 \oplus 1) \oplus 1 = 0 \oplus 1 = 1, \quad 1 \oplus 1 \oplus 0 = (1 \oplus 1) \oplus 0 = 0 \oplus 0 = 0$$

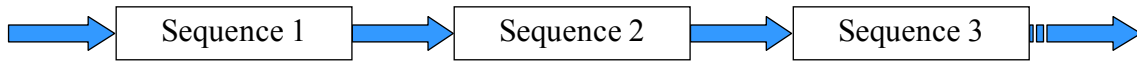
$$1 \oplus 0 \oplus 0 = (1 \oplus 0) \oplus 0 = 1 \oplus 0 = 1, \text{ etc.}$$

Here, the method for odd parity is used, so the logical equation for the odd number of 1s is valid and d) is correct.

Q1-26 a)

Sequence control

Sequence control is a method for control that starts and completes multiple activities in a predefined sequence. Therefore, a) is appropriate. The “sequence” of “sequence control” refers to controls that progress one after another.



- b) This is a description concerning feedforward control. Since the feedback control in c) checks the result of the controlled variable that is assigned and then performs correction, it must perform control after the effects of various external sources of interference have appeared. Feedforward is used to compensate for this flaw in feedback control. However, when only feedforward control is used, the target value for control cannot be reached in some cases, so it is normally used together with feedback control.
- c) This is a description concerning feedback control. This is a method for control that maintains a consecutive physical volume that is the subject of control (such as displacement or speed) at a set level and closes in on a target value.
- d) This is a description concerning fuzzy control. This is a type of feedback control and uses the fuzzy theory to enable control that includes ambiguity. Basically, it is a control method that attempts control by the representation of not only states such as “much” or “little” but also intermediate states such as “slightly more” as “more \times 0.7” and “slightly less” as “less \times 0.7” with numeric values (probabilities).

Q1-27 a)

Operations on stacks

A stack is a data structure that retrieves data with LIFO (Last In First Out). Thus, when data is retrieved from a stack with a “pop,” the data that was stored in the stack with the “push” immediately prior is retrieved. The first pop retrieves 2, the second pop retrieves 4, and the third pop retrieves 5. As a result, 1 and 3 remain in the stack. Therefore, a) is correct. In the text of the question, the push that disappears with the pop should be confirmed while a diagonal line is written as below:

push 1 → ~~push 2~~ → ~~pop~~ → push 3 → ~~push 4~~ → ~~pop~~ → ~~push 5~~ → ~~pop~~

Q1-28 c)

Changes to lists in linked cells

In order to change the list [Tokyo, Shinagawa, Nagoya, Shin-Osaka] to [Tokyo, Shin-Yokohama, Nagoya, Shin-Osaka], the cell after Tokyo should point to Shin-Yokohama not Shinagawa, and the cell after Shin-Yokohama should point to Nagoya. The question reveals that the values in the second column of the table that represents the array represent the number of linked elements. Data that shows the location of the next item of data is called a pointer.

The operation to make the pointer $A(1,2)$ for $A(1,1) = \text{Tokyo}$ point to Shin-Yokohama in row 5 is $5 \rightarrow A(1, 2)$, but if this is performed first it results in the disappearance of the value $A(1, 2) = 2$ that represents the data after “Tokyo.” Due to this, the operation that makes the pointer $A(5, 2)$ for $A(5, 1) = \text{“Shin-Yokohama”}$ point to the next “Nagoya” is performed first. The value ($= 3$) of the pointer $A(2, 2)$ for $A(2, 1) = \text{“Shinagawa”}$ should be assigned to $A(5, 2)$. The operation in the options that has the same meaning as $A(2, 2) \rightarrow A(5, 2)$ is $A(A(1, 2), 2) \rightarrow A(5, 2)$, so c) is correct.

It should be noted that if the same operations are performed in the sequence in a), 5 is assigned to $A(1, 2)$ in the first operation, and in the second operation $A(A(1, 2), 2) \rightarrow A(5, 2)$ becomes $A(5, 2) \rightarrow A(5, 2)$ so the correct process cannot be performed.

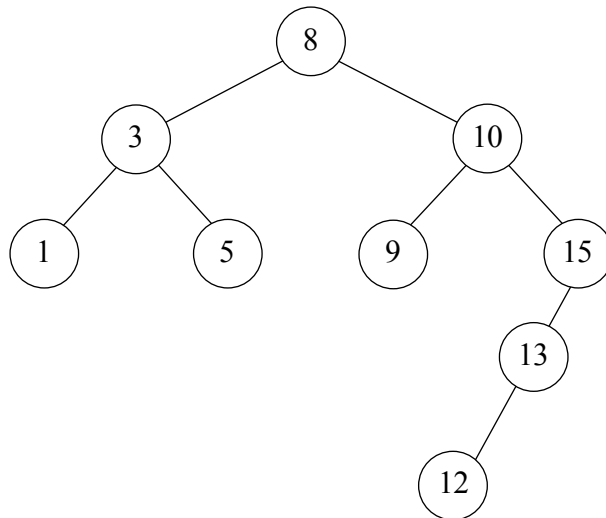
Q1-29 c)

Insertion of data into a binary search tree

The conditions for the binary search tree are as shown below:

Value of left child < value of an element of a given node < value of right child

If a tree with the structure of these conditions is selected from the options, the answer is c).



- a) The value of the node of the left child of node 10 is 9, and the value of the node of its child is 12. Therefore, the conditions are not fulfilled.
- b) The value of the node of the left child of node 10 is 12, and the conditions are not fulfilled.
- d) The value of the node of the right child of node 15 is 12, and the conditions are not fulfilled.

Q1-30 c)

Hash functions

The key is 1094, so the hash value $h(1094) = \text{mod}(1094, 97) = 27$. In the range of 1 through 1000, the keys where the hash value is equal to 1094 are keys where the remainder after division by 97 is 27. The values that are applicable are multiples of 97 plus 27, and the value 27 itself. As such, the number of multiples of 97 that are included in the range of 1 through 1000 is first calculated. $1000 \div 97 = 10$ (remainder 30), and the number of multiples of 97 is 10. Since key x is a multiple of 97 plus 27, " $97 \times 10 + 27$ " gives 997, and this is within 1000. Thus, there are 10 values that are a multiple of 97 plus 27, so including 27 the number of keys where the hash value is equal to 1094 is 11. Therefore, c) is correct.

Q1-31 a)

Explanation of the hash method

Hashing is a method for performing a calculation (hash function) on the key value of a record, and setting the storage location. When data is searched for, by performing the same calculation on the search key, the storage location can be directly accessed. Therefore, a) is appropriate. Also, in this method, with a hash function, the storage location of multiple items of data is sometimes the same. This is called a synonym (collision).

- b) This is an explanation concerning a method for dealing with synonyms in hashing called "chaining". With chaining, in the storage location calculated with a hash function, a pointer to synonym data is stored. Also, when a synonym occurs, the stored address is accessed one after another and the synonym address is stored in the final item of data.
- c), d) To calculate an address from the key value of a record, there are indirect address methods and direct address methods. An indirect method performs a calculation on a key value and converts it to an address. Hashing is an indirect address method. Direct address methods include a method that creates a table with corresponding key values and addresses which is referenced during access (c), and a method that converts a key value into an address (d).

Q1-32 a)

Number of comparisons in a binary search

A binary search is a search method where the subject of the search is sorted in advance and then the range of the search is reduced by repeatedly dividing it in two and searching for the required data. When the required data certainly exists in n data elements, the range of the search is repeatedly divided in half and when only one data element remains the required data is found. Here, when the range of the search is divided in half rounding is performed, so the data can be considered to be found when the number of data elements in the range of the search is one or more and less than two.

At this time, if the number of comparisons is k , then $1 \leq n/2^k < 2$. If each term is multiplied by 2^k , it becomes $2^k \leq n < 2 \times 2^k$ (or $2^k \leq n < 2^{k+1}$), and by using a logarithm with a base of 2 this can be represented as $k \leq \log_2 n < k+1$. The average number of comparisons is an integer value that fulfills this expression, and is approximately $\log_2 n$. Therefore, a) is correct.

Q1-33 c)

Search processing with binary search

This is a flowchart for a binary search. In a binary search, the data to be searched for is already sorted. As such, in comparison the data to be searched and the value located at the center of the search range, it can be understood whether the first half or latter half of the range contains the search data.

In the question, the search data is x , and the target data is stored in array AR of size n . In the evaluation immediately before A and B , a comparison of $AR(k)$ with x is made. Here, $AR(k)$ is the data in the central position of the search range from the previous process $[(lo + hi)/2 \rightarrow k]$ (lo = lowest, hi = highest). If the result of comparison is " $A(k) < x$ ", then x is in the latter half. Also, if the result is " $A(k) > x$ ", x is in the first half. As such, in each of blanks A and B the new search range is set. In blank A , since the latter half is the new range, the upper limit should be left the same and the lower limit should be " $k + 1$ " that represents the next value from the central point k . In blank B , since the first half is the new range, the lower limit should be left the same and the upper limit should be " $k - 1$ " that represents the value before the central point k . Therefore, c) is correct.

Q1-34 d)

Methods for sorting data

For sorting methods, as well as the three basic sorting methods of bubble sort, selection sort, and insertion sort, there are applied sorting methods with a reduced volume of calculations including quick sort, shell sort, and heap sort. Many of the applied sorting methods use recursive algorithms, and it is necessary to understand the basic flow of each algorithm. The heap sort is an improvement of the selection sort. The selection sort is a method that takes the smallest (or largest) data element from a string of data and makes it the first element, and then from the remaining data string takes the smallest (or largest) data element. A heap sort is a sorting method that is based on this selection sort and uses a tree structure called a "heap." Therefore, d) is appropriate.

- a) A quick sort is a method that is an improvement of the bubble sort. It is a method that sorts by repeatedly retrieving a single element of data for comparison and then dividing the data into a group with a value lower than that element of data and a group with a value less than that element of data. The description is of a shell sort.
- b) A shell sort is a method that is an improvement of the insertion sort. It is a method that retrieves data in a data string at a certain interval (gap) and makes it a subset. It then sorts each data string with an insertion sort, reduces the interval further, and sorts the data again. The description is of a bubble sort.
- c) A bubble sort (exchange sort) is a method that compares adjacent elements of data and swaps these elements of data if the order of size is the wrong way around. The description is of a quick sort.

Q1-35 c)

The data structure used in function and procedure calls

When a function or a procedure is called, the process that is running is temporarily halted, the data that is being processed is saved, and the new process is started. A process that is called later is processed first. After this process is finished, the previous process is restarted based on the saved data of the halted process. Saved data in this kind of situation must be processed with the last in first out method. A stack has a last in first out data structure. In a stack, the most recent data is always prioritized over older data and retrieved. Therefore, c) is correct.

- a) A binary search tree is a tree structure where the paths from the root to the leaves proceed so that a node with a smaller key value than the node is linked to one side and a node with a larger key value is linked to the opposite side. Consequently, a high-speed data search can be performed using a key value.
- b) A queue is a data structure that is waiting to be processed that occurs in transaction processing. This data structure is processed in a first in first out manner.
- d) A doubly-linked list is a data structure where each element of a series of data has two pointers that can allow forward and backward movement along the elements.

Q1-36 c)

Recursively defined functions

The value of $f(5)$ is calculated with a recursive function, but $f(5)$ means $n = 5$. Given the expression in the text of the question, when $n = 1$, 1 is returned as the value, and in other situations, the value of $n + f(n - 1)$ is returned. Thus, the equations hold as shown below.

$$\text{When } n=1; \quad f(1) = 1$$

$$\text{When } n=2; \quad f(2) = 2 + f(1) = 2 + 1 = 3$$

$$\text{When } n=3; \quad f(3) = 3 + f(2) = 3 + 3 = 6$$

$$\text{When } n=4; \quad f(4) = 4 + f(3) = 4 + 6 = 10$$

$$\text{When } n=5; \quad f(5) = 5 + f(4) = 5 + 10 = 15$$

As a result, when $n=5$, $f(5) = 15$. Therefore, c) is correct.

Q1-37 d)

Relationship of initial values in a flowchart

In order to execute $(1) \rightarrow (2) \rightarrow (3) \rightarrow (5)$, the relationship " $m < n$ " (i.e., " $a < b$ ") must be valid. Thus, b) or d) is applicable. In (5), " $n - m$ " is assigned to n , and in order to execute $(2) \rightarrow (3) \rightarrow (4)$, " $m > n$ " must be valid at this level. Under these conditions, if the relationship is " $2a = b$ " as in b), then " $m = n$ " holds in the operation in (5) and execution in the order specified is not possible. On the other hand, with " $3a = 2b$ " as in d), " $a \rightarrow m$ " and " $1.5a \rightarrow n$ " are executed in (1), " $n = 0.5a$ " and " $m = a$ " hold in the first operation of (5), and in the next operation (4) after $(2) \rightarrow (3)$ both m and n are $0.5a$. As a result, in the evaluation of the third (2), " $m = n$ " can hold and (6) can be executed. Therefore, d) is correct.

Q1-38 c)

Calculation of the total amount of awards with a decision table

Concerning improvement proposals *A* and *B*, if both are applied to the conditions of the decision table, each proposal is as shown below:

- Improvement proposal *A*
 - Reduced amount of 200,000 yen → Reduced amount of less than 100,000 yen: No
 - Reduced period of 3 days → Reduced period of less than one week: Yes
- Improvement proposal *B*
 - Reduced amount of 50,000 yen → Reduced amount of less than 100,000 yen: Yes
 - Reduced period of 2 weeks → Reduced amount of less than one week: No

Thus, the award for each of improvement proposals *A* and *B* is 1,000 yen, and the total amount is d) 2,000 yen.

Q1-39 b)

Standardization of programming

The standardization of programming aims for an improvement in the quality of programming. It sets rules for the writing of a program, and programs are created based on these rules. As such, anyone who is involved with development and maintenance can easily understand the details of a program. Also, concerning programming where mistakes are easy to make and programming where there is a danger of the occurrence of a security problem, the occurrence of such problems can be prevented by the clarification of the writing method and sharing information. Therefore, b) is appropriate.

- a) Optimization of compilation is not related to the standardization of programming.
- c) The standardization of programming generally depends on the programming language.
- d) Through the standardization of programming, the promotion of program creation with efficient processing is possible, but the definition of a standard execution time is not applicable.

Q1-40 b)

Program structure

A reentrant program can be executed by multiple processes simultaneously. In order to enable this, a program is divided into a procedure part and data part as in the description of b) and a data part must be held for each process. Therefore, b) is appropriate.

- a) A recursive process must be controlled by recording the status of a running program with LIFO (Last-In First-Out).
- c) A serially reusable program can reuse a program that is loaded into main memory without reloading it, and is not a reentrant program. However, a reentrant program is serially reusable.
- d) This is a description of a reentrant program.

Q1-41 c)

Characteristics of object orientated programs

The correct description concerning object oriented programs is c). An object is a bundle of data and methods. A group of such objects is a program.

- a) This is a description concerning a data flow program.
- b) This is a description concerning a procedural program.
- d) This is a description concerning a functional program.

Q1-42 a)

Explanation of a Java servlet

A Java servlet is a program that is developed with the Java language and executed on a Web server. Therefore, a) is appropriate. Servlet is a composite word formed from “server” and “-let” (meaning “small”) and means “small server.” It is executed on a Web server at the request of a client.

- b) A Java program that is downloaded from a server and executed on the client is a Java applet. The name “applet,” as with “servlet,” is a composite word formed from “application” and “-let” and means a small application.
- c) Rules for handling a program developed with Java as an application component are called JavaBeans. JavaBeans is a specific mechanism for component oriented development.
- d) One of the characteristics of the Java language is that a module generated by compiling a source program is an intermediate code called byte code rather than a program in machine language program that depends on the CPU of the computer it runs on. Then, this intermediate code is converted by an execution environment (interpreter) called a Java VM (Virtual Machine) on the computer into machine language program appropriate for the CPU on that computer, and then executed. This mechanism achieves a feature called “multiplatform” that does not select the type of computer that a program runs on. In order to execute a Java servlet, a Java VM is installed on a Web server.

Q1-43 b)

Characteristics of XML

HTML (HyperText Markup Language) is a language for the description of webpages. “Tags” enclosed in angle brackets are used to define the layout of a document. Also, by specifying a URL (Uniform Resource Locator), a document can “link” to another document.

In initial development, XML (eXtensible Markup Language) was positioned as a meta-language for the exchange of structured documents on the Web, but it has progressed to a format also for the exchange of a wide range of data. In addition to the two characteristics (tags and links) of HTML, the meaning of tags can be defined with the DTD (Document Type Definition) function, and the structure of the document itself as well as the data can also be defined.

For example, the tag `<product info> ... </product info>` can be defined and data can be represented. Therefore, b) is the most appropriate.

- a) XML complements the weakness of HTML, which is not suitable for the representation of data or document structure, and does not aim for improvement in the performance of webpage display.
- b) The style sheet languages that can specify the style of an XML document include XSL (eXtensible Style Language) and CSS (Cascading Style Sheets). In order to display an XML document on a Web browser, these convert XML to HTML.
- d) Like HTML, XML was developed based on SGML (Standard Generalized Markup Language). For example, the DTD function of XML is a function that SGML has.

Section 2

Computer System

Q2-1 a)

Execution order of an instruction involving access to the main memory

An instruction is executed in the order of “instruction fetch → instruction decode → effective address calculation → operand fetch → execution.” Therefore, the “operation that is performed between “instruction decode” and “operand fetch” is a) Calculation of an effective address. Here, an operand refers to the data on which the instruction is to be processed.

This operand uses various types of addressing modes, which are classified as follows:

- Direct addressing: specification of an address in the main memory
- Index addressing: specification of an address in the main memory by using the result of adding the value of an index register to the value of the address part
- Relative addressing: specification of a position relative to the position where the its own instruction is stored
- Indirect addressing: specification of the address of the target data in the main memory by using a value stored in an address in the main memory that is indicated in the address part
- Register addressing: specification of an address stored in a register
- Immediate addressing: specification of the value of the address part as the target data

Q2-2 c)

Cause of an external interrupt

Interrupts include internal interrupts that occur as a result of the execution of an instruction within a program, and external interrupts that occur regardless of an executing instruction. Among the options, an interrupt that occurs when a hardware failure is detected as described in c) is classified as an external interrupt. Each of the interrupts mentioned above includes the following:

- External interrupts: An I/O interrupt (e.g., completion of an I/O operation or malfunction of the I/O device), a timer interrupt (e.g., timeout of a timer), and a machine check interrupt (e.g., hardware malfunction or power failure)
 - Internal interrupts: A supervisor call interrupt (e.g., usage of an OS function by a SVC instruction or system call instruction of the running program), and a program interrupt (e.g., divide-by-zero, overflow, execution of an invalid instruction, or page fault)
- a) A page fault that occurs when a page that does not exist in the main memory is accessed by a program instruction is classified as an internal interrupt.
- b) Generally, a system management instruction, which is an OS function, is executed in kernel mode (also called the privileged mode and supervisor mode), and if a privileged instruction such as a system management instruction is executed under the user mode in which general application programs are executed, a privileged instruction violation occurs. Since this privileged instruction violation is a program interrupt, it is classified as an internal interrupt.
- d) A floating-point operation is performed by a program instruction, and as a result, an overflow generates a program interrupt classified as an internal interrupt.

Q2-3 a)

Description concerning the CPU clock frequency of a PC

Clock frequency is the frequency of a signal (clock) generated to determine the timing of an internal operation of a computer, and is expressed in MHz (megahertz) and GHz (gigahertz). One MHz indicates that the signal is generated one million times in one second, and one GHz means that the signal is generated one billion times in one second.

Since the CPU operates synchronously with the clock, generally, the speed of execution of an instruction increases with the frequency. Therefore, the description of a) is appropriate.

- b) The clock frequency is related to the CPU operation, and does not control the communication speed.
- c) The clock frequency is related to the CPU operation, and the rotation speed of a disk is a value specific to a device.
- d) The clock frequency is related to the CPU operation, and the interrupt interval of real-time processing is not directly related to the clock frequency.

Q2-4 d)

Calculating the number of instructions that can be executed in one second

A clock is a signal for determining the timing of an internal operation of a CPU. The clock frequency represents the number of signals generated in one second in MHz (megahertz) or GHz (gigahertz). Normally, a single instruction consists of several basic operations, which are performed in one clock cycle, and therefore, one instruction is executed in several clock cycles. However, when multiple instructions of machine language are executed simultaneously by using a technique called superscalar, the average number of clock cycles for the execution of an instruction can be reduced to below one.

Since the CPU runs at one GHz, this CPU generates one giga clock signals in one second. One clock period is $1 \text{ (second)} \div 1 \text{ G} = 10^{-9} \text{ (seconds)}$. Next, since this CPU “is capable of executing one machine instruction in 0.8 clock cycles on average,” the average execution time of one instruction is $0.8 \times 10^{-9} \text{ seconds}$. Therefore, the number of instructions that can be executed in one second is as follows:

$$\begin{aligned}
 &1 \text{ (second)} \div (0.8 \times 10^{-9}) \text{ (seconds/instruction)} \\
 &= 10^9 \div 0.8 = 1,000,000,000 \div 0.8 \\
 &= 1,250 \text{ million instructions) }
 \end{aligned}$$

Therefore, d) is the correct answer.

Q2-5 c)

CPU performance in MIPS

A clock frequency of 1 GHz indicates that clock signals are generated 1×10^9 times in one second. The average instruction execution time (average number of clock cycles necessary for executing one instruction) of the CPU is calculated from the table of assigned instruction types, and the performance is calculated by dividing the clock frequency by the average instruction execution time.

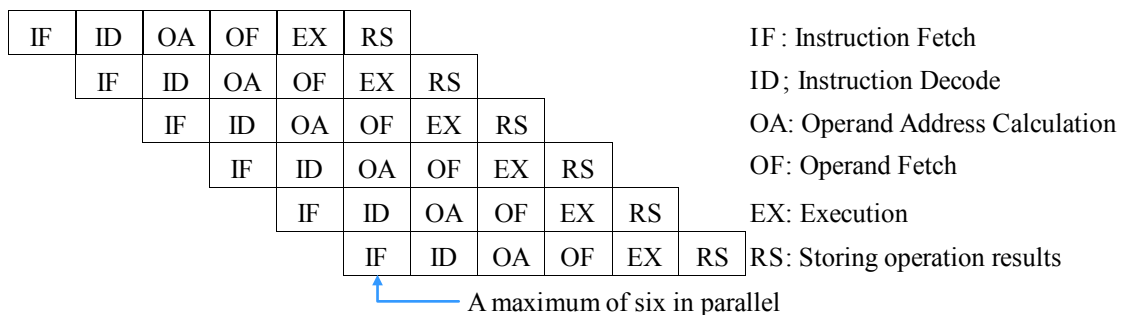
$$\begin{aligned}
 &\text{Average instruction execution time} \\
 &= 10 \times 0.6 + 5 \times 0.4 \\
 &= 8 \text{ (clocks)} \\
 &\text{Performance} = (1 \times 10^9) \div 8 \\
 &= 125,000,000 \text{ (instructions/second)}
 \end{aligned}$$

This becomes 125 MIPS when it is converted to MIPS (Million Instructions Per Second). Therefore, c) is the correct answer.

Q2-6 c)

Pipeline processing in a processor

As shown in the figure below, pipeline processing is a method in which a single processor executes multiple instructions simultaneously by slightly shifting them in stages. Therefore, c) is the correct answer.

**Example of pipeline processing**

- a) This is an explanation of the SIMD (Single Instruction stream Multiple Data streams) method. This method is suitable for matrix operations.
- b) This is an explanation concerning a processor in which pipeline processing is not adopted.
- d) This is an explanation of the MIMD (Multiple Instruction streams Multiple Data streams) method. This method is applicable to a multiprocessor system.

Q2-7 c)

Explanation of superscalar

Superscalar is the technique of simultaneously executing multiple instructions by further dividing the pipeline mechanism into multiple stages with increased processing performance during the execution of multiple instructions. Therefore, c) is the correct answer. In the CPU, when multiple instructions are to be processed in parallel, the simultaneous execution of interrelated multiple instructions must be avoided. In superscalar, the CPU performs this control in the hardware. VLIW (Very Long Instruction Word), on the other hand, omits the time-consuming operation of determining the possibility of parallel processing by the CPU through the compilation of an extremely large group of instructions that must be processed in sequence into a single instruction.

- a) This is an explanation concerning a vector processor.
- b) This is an explanation concerning a super-pipeline.
- d) This is an explanation concerning VLIW.

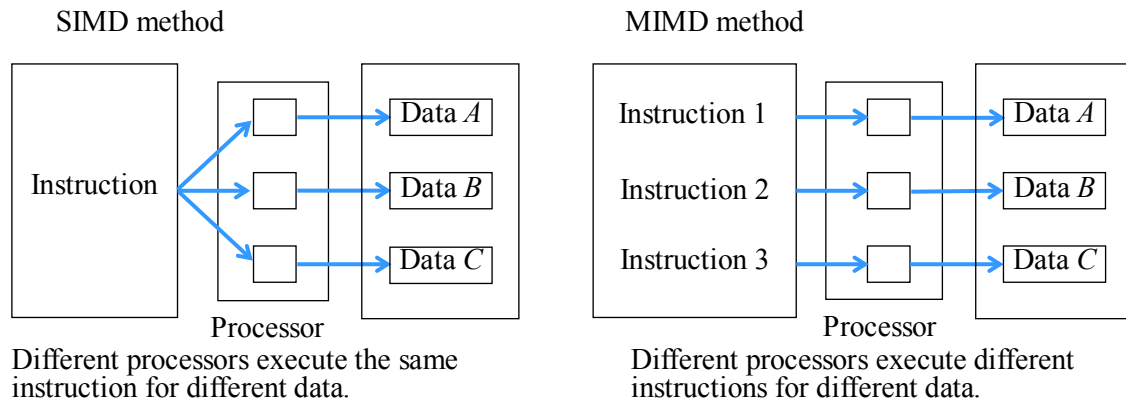
Q2-8 c)

Types of CPU

The method that allows one instruction to perform multiple instances of the same operation simultaneously for different data is c) SIMD (Single Instruction stream Multiple Data streams). SIMD is suitable for multimedia data processing in which the same operation is often repeated for continuous data, and typical examples include processors called GPU (Graphics Processing Unit) that are used exclusively for image processing and vector computers.

All options are a classification of CPU called the Flynn's taxonomy, where S indicates Single, M indicates Multiple, I indicates Instruction, and D indicates Data, and if it is understood that the options are a combination of these, all options need not be memorized. The details other than the correct answer are as follows:

- a) MIMD (Multiple Instruction streams Multiple Data streams)
Multiple processors process multiple data in parallel based on individual instructions for each data. This method is applicable to a general multiprocessor.
- b) MISD (Multiple Instruction streams Single Data stream)
A single piece of data is processed by multiple instructions, but a processor based on this method is not yet implemented in a practical way.
- d) SISD (Single Instruction stream Single Data stream)
A single piece of data is processed by a single instruction. This method is applicable in a general computer that is controlled sequentially by a single processor.

**Q2-9 a)**

Explanation of DRAM

As described in a), DRAM (Dynamic Random Access Memory) is memory that stores one (1) bit depending on whether or not each capacitor is electrically charged. Since DRAM is composed of tiny capacitors, the stored charge is discharged over time, and an operation called “refresh” by which the content is rewritten every few milliseconds is necessary. Although the access speed is slower than SRAM (Static RAM) because of this refresh operation, a simple circuit makes the unit cost per bit low, and memory with a large capacity is easy to manufacture. Therefore, main memory is usually composed of DRAM chips.

- b) It is an explanation of mask ROM (Read Only Memory).
- c) It is an explanation of EPROM (Erasable Programmable ROM).
- d) It is an explanation of SRAM.

Q2-10 b)

Storage device with the shortest access time

In the storage hierarchy, the closer a storage device is to the CPU, the shorter the access time is in general, and the one-time access amount is also small. Inside the CPU, the register that is always used when instructions are executed has the shortest access time, and therefore, b) is the correct answer.

When storage devices are arranged in order of shortest access time first after the register, the order is generally as described below. The approximate access time of each device and the storage capacity must be known.

CPU register < primary (L1) or secondary (L2) cache memory of CPU
 < main memory < hard disk < (optical disk such as CD and DVD) < (magnetic tape)

Q2-11 a)

Description concerning the cache memory

The cache memory is a high-speed buffer storage (a holding area for temporary storage) that is implemented for bridging the difference in the speed of the main memory and CPU. By deploying the memory content that has a high probability of being accessed in cache memory, the access frequency to the main memory is reduced and speed is improved. When a write instruction is executed, the “write through” method rewrites both the cache memory and main memory, and the “write back” method rewrites the cache memory first, and then the main memory when the relevant data is flushed from the cache memory. Therefore, a) is appropriate.

- b) When a cache miss occurs, generally the data is processed in the hardware within the instruction execution cycle, and an interrupt does not occur.
- c) The purpose of the cache memory is to bridge the difference in the speed of the main memory and CPU. It is not meant to bridge the difference in the capacity of the real memory and virtual memory. In reality, the capacity of the cache memory is very small as compared to the capacity of the real memory.
- d) Along with an improvement in the access speed of the semiconductor memory, the operation speed of the CPU is also improving. Because of this, the difference in the speed is not being bridged. As a result, the necessity of the cache memory is not decreasing.

Q2-12 d)

Combination having the shortest effective access time

In order to bridge the difference in the processing performance of the CPU and the access speed of main memory, a cache memory that supports high-speed access is placed between the two. The hit ratio is the probability of existence of the target data in the cache memory. If the target data does not exist in the cache memory, the data is read from the main memory, but if the hit ratio is p , the probability will become $1 - p$.

If the access time of the cache memory is T_c and the access time of the main memory is T_m , the effective access time is $T_c \times p + T_m \times (1 - p)$. If calculation is performed based on the values of each option, d) has the shortest access time as shown below:

- a) $10 \times 0.6 + 70 \times (1 - 0.6) = 6 + 28 = 34$ (nanoseconds)
- b) $10 \times 0.7 + 70 \times (1 - 0.7) = 7 + 21 = 28$ (nanoseconds)
- c) $20 \times 0.7 + 50 \times (1 - 0.7) = 14 + 15 = 29$ (nanoseconds)
- d) $20 \times 0.8 + 50 \times (1 - 0.8) = 16 + 10 = 26$ (nanoseconds)

Q2-13 d)

Calculating the hit ratio of the cache memory

If the access time of the cache memory is T_c , the access time of the main memory is T_m , and the hit ratio is h , the effective access time is $T_c \times h + T_m \times (1-h)$. Since the hit ratio and effective access time of both systems are the same, h can be calculated as follows:

Effective access time of system A = Effective access time of system B

$$15 \times h + 50 \times (1-h) = 10 \times h + 70 \times (1-h)$$

$$15h + 50 - 50h = 10h + 70 - 70h$$

$$25h = 20$$

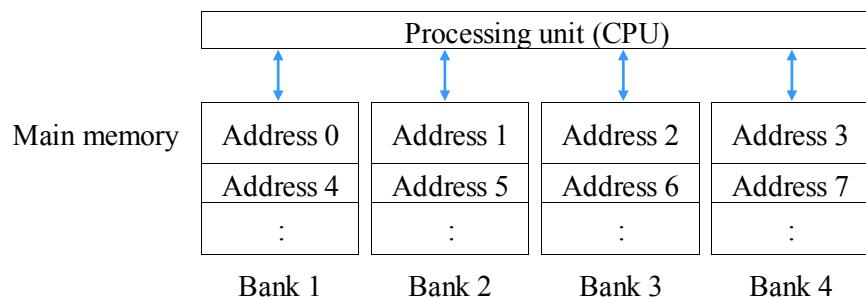
$$h = 0.8.$$

Therefore, the hit ratio is d) 0.8.

Q2-14 b)

Explanation of memory interleaving

Memory interleaving is a technique for the improvement of speed of access to main memory. Main memory is internally divided into multiple sections called banks that operate independently, and as shown in the figure below, by arranging adjacent addresses in separate banks, high speed is achieved through concurrent access. Therefore, b) is appropriate. Memory interleaving is a technique that has been used in general-purpose computers, but currently, it is used in some servers and PCs as well.



- a) When the data to written to the cache memory by the CPU, it is also written to main memory. This method is called “write through.” According to this method, the content of both the cache memory and main memory always match, but because data is also written to the main memory every time it is written to the cache memory, the processing speed during writing declines.
- c) It is a description concerning the purpose of the cache memory.
- d) In the case of CPU architecture in which an instruction cannot be rewritten, if the instruction cache and data cache are separated, writing to the instruction cache is not necessary, which leads to an overall improvement in the cache efficiency. However, this is not directly connected to the method for removing the cause of pipeline processing disruption (such as inclusion of several branch instructions), and is therefore not related to memory interleaving.

Q2-15 a)

Optical disc using organic dye and laser beam

An optical disc that uses organic dye as the recording layer of the storage media, and records data with a laser beam by burning tiny holes called pits is a) CD-R (CD-Recordable). CD-R is a type of CD that allows data to be written only once, and because of burning pits, once data is written, it cannot be erased.

- b) CD-RW (CD-ReWritable) is a type of CD on which data can be written and erased any number of times. Data is recorded by increasing the temperature with a laser beam, and then changing the properties (degree of reflection) of the material of the recording layer.
- c), d) DVD is a storage medium that has the same 12 cm diameter as CD. The recording density is higher in comparison with CD, and depending on the type of DVD, recording on both sides or dual-layer recording is possible. DVD-RAM described in c) is a type of re-writable DVD, and DVD-ROM described in d) is a type of read-only DVD. The method of recording data on DVD-RAM is almost same as CD-RW, and on DVD-ROM, data is recorded by making tiny dents called pits in the same way as in CD-ROM.

Q2-16 c)

Explanation of a system bus

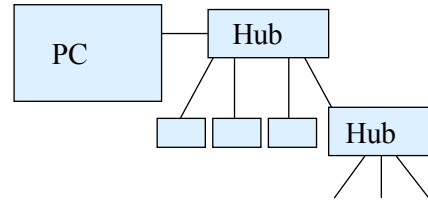
A system bus is a common path (bus) used by the CPU to send data and control signals between main memory and an I/O controller. Therefore, c) is appropriate. Buses are classified with various methods, but if the buses are divided into a computer's internal buses and external buses, the system bus is an internal bus that is the same as the processor bus (connection between the components of the CPU) and memory bus (connection between the CPU and main memory). The external buses include I/O buses for connections between an I/O controller and auxiliary storage, and also for connections between I/O controllers.

- a) This is a description concerning RS-232C.
- b) This is a description concerning DMA (Direct Memory Access) and I/O channels.
- d) This is a description concerning USB. The high-speed mode (480 Mbps) was added from USB2.0, and the super-speed mode (5 Gbps) was added from USB3.0.

Q2-17 c)

Explanation of USB

USB (Universal Serial Bus) is a serial interface that enables the PC and all peripheral devices to be connected via the same connector. By using a USB interface, a maximum of 127 devices can be connected in a tree topology via a hub (this is called the cascade connection). Therefore, c) is the correct answer.



Three types of transfer speeds, namely the low speed (1.5 Mbps), full speed (12 Mbps), and high speed (480 Mbps) are available, and the high-speed mode is supported only by USB2.0. The hot plug is supported, which enables removal and insertion of the connector while power is being supplied to the computer. The super-speed mode (5 Gbps) has been added to USB3.0, with a power supply increased from 500 mA to 900 mA.

- a) The parallel interface used for connecting the PC and the CD-ROM or DVD drive provided in the PC is ATA/ATAPI (AT Attachment/AT Attachment Packet Interface).
- b) The parallel interface used for connecting the hard disk or a printer through a daisy chain is SCSI (Small Computer System Interface; pronounced “skuzzy”) defined by ANSI (American National Standards Institute).
- d) The serial interface that transfers data to a printer by using infrared rays is IrDA (Infrared Data Association).

Q2-18 d)

Characteristic of serial ATA

The IDE (Integrated Drive Electronics) specification, which is the industry common standard for hard disk connection interfaces in PCs, standardized by ANSI (American National Standards Institute) is referred to as the (parallel) ATA (Advanced Technology Attachment) standard. According to this standard, up to two built-in hard disks can be connected within a computer through parallel transfer. Following this, extended standards such as E-IDE (Enhanced IDE) and ATAPI (ATA Packet Interface) were defined, which have enabled the connection of CD and DVD drives besides hard disks.

Serial ATA is aimed at a reduction in operating voltage, reduction in size of the connector and cable, and increase in the transfer speed by using simple serial transfer as the transfer method, and has a transfer speed of 1.5 Gbps and 3 Gbps. Furthermore, the hot swap function that enables removal and insertion of connectors while power is supplied was not supported by parallel ATA, but is supported by serial ATA. Therefore, d) is appropriate.

- a) The SAS controller has upward compatibility with serial ATA, but does not have mutual compatibility.
- b) This refers to SCSI.
- c) In comparison with parallel ATA, the cable thickness and the connector shape are very different.

Q2-19 b)

Software serving as an interface between the OS and a peripheral device

In peripheral devices such as a printer, the details of control methods are different for each model, which makes it impossible to include the control functions of all models beforehand in the OS, and also leads to inefficiency. Therefore, rather than including the control program of the peripheral devices in the OS, a program is made available for each peripheral device as necessary. Such a program that acts as an interface between the OS and a peripheral device is called a “device driver,” so b) is the correct answer.

- a) This is a program that enables software to be embedded in the hard disk for use, and allows the copying of necessary files and specification of the environment settings.
- c) This is a function that is embedded in the OS that manages the connection state of peripheral devices, settings of the drivers, and settings of the interrupt request signal (IRQ) from the peripheral devices.
- d) This is a program that initializes (or formats) media such as floppy disks, hard disks, and MO disks to enable them to be used.

Q2-20 d)

Display characterized by a low-voltage drive and low power consumption, which does not require

The display that emits light by itself when electric voltage is applied, and satisfies all characteristics including “no backlight required,” “low voltage operation,” and “low power consumption” is an Organic Light Emitting Diode (Electro Luminescence), therefore, d) is the correct answer. The OLED display has a structure in which an organic compound that emits light in response to an electric voltage is sandwiched between glass (or plastic) substrates, and displays images when a 5 to 10 volt of direct-current voltage is applied. OLED displays are also available as thin types that have a thickness of 1.8 mm. Unlike liquid crystal displays, a backlight is not needed, which leads to a low power consumption.

- a) CRT (Cathode Ray Tube): This refers to the brown tube in TVs. A surface is coated with a fluorescent material, and an electron beam is deflected by a magnetic field or electrode and made to hit the surface so that the fluorescent material glows. The power consumption is higher than liquid crystal.
- b) PDP (Plasma Display Panel): This is a display in which a gap between two glass plates is filled with gas such as helium or neon, and light is emitted by applying an electrical voltage to the gas. The display is thin, lightweight, and has a high brightness, but consumes more power than liquid crystal.
- c) TFT liquid crystal: This is a display device in which a substance called liquid crystal, whose molecular structure changes in response to electric voltage and the degree of light transmission varies, is inserted between glass substrates. A liquid crystal in which electric voltage is applied by a thin film transistor to each bit of a pixel is called TFT (Thin Film Transistor). Since liquid crystal does not emit light by itself, it needs a backlight.

Q2-21 a)

Explanation of plasma display

A plasma display is a display in which a gap between two thin glass plates is filled with neon gas or xenon gas, and an electrical discharge is produced by applying a high voltage to the gas. Ultra violet rays that are generated by this electrical discharge then hit the red, green, and blue (RGB; three primary colors of light) fluorescent material on the surface of the glass and light is emitted. Therefore, the description in a) is appropriate. At present, the power consumption is not high, and in some cases the power consumption is actually reduced by the addition of the backlight used in liquid crystal displays.

- b) This is a description concerning liquid crystal displays such as a TFT (Thin Film Transistor). Since the display itself does not emit light, a backlight is installed at the back or side of the display as a light source.
- c) This is a description concerning an OLED (Electro-Luminescence) display. An OLED has a structure in which a thin film of an organic substance is sandwiched between electrodes, and this structure has been put into practical use in some places. Unlike a liquid crystal display such as a TFT, a light source is not needed, so the structure can be slimmed down so far as to become a film.
- d) This is a description concerning the brown tube (CRT; Cathode Ray Tube).

Q2-22 b)

Access time of a hard disk

The average access time of a hard disk can be calculated with the following formula:

$\text{Average access time} = \text{Average seek time} + \text{Average rotational latency} + \text{Data transfer time}$

The average seek time is 20 milliseconds.

The average rotational latency is the time required for half (1/2) rotation.

The rotation speed of the disk is 5,000 rpm, that is, 5,000 rotations in one minute (60 seconds).

$$\begin{aligned} \text{Time required for one rotation} &= 60 \div 5,000 \text{ (seconds)} \\ &= 0.012 \text{ seconds} \\ &= 12 \text{ milliseconds} \end{aligned}$$

$$\text{Average rotational latency} = 12 \text{ milliseconds} \div 2 = 6 \text{ milliseconds}$$

If the data transfer time is calculated before the data transfer time is calculated, 15,000 bytes of storage capacity of one track is transferred in 12 milliseconds, which is the time for one rotation, and therefore, the data transfer speed per millisecond will be as follows:

$$15,000 \div 12 \text{ (bytes/millisecond)} = 1,250 \text{ (bytes/millisecond)}.$$

And since one block is 4,000 bytes, the data transfer time will be as follows:

$$\begin{aligned} \text{Data transfer time} &= 4,000 \text{ (bytes)} \div 1,250 \text{ (bytes/milliseconds)} \\ &= 3.2 \text{ (milliseconds)}. \end{aligned}$$

Based on the above, the average access time is

$$20 + 6 + 3.2 = 29.2 \text{ milliseconds}$$

Therefore, b) is the correct answer.

Q2-23 d)

Calculating the number of sectors

Since one block is composed of 8 sectors, the memory capacity per block is
 $500 \text{ bytes} \times 8 \text{ sectors/block} = 4,000 \text{ bytes/block}$.

Since file area is allocated in units of blocks, $2,000 \text{ bytes} \div 4,000 \text{ bytes/block} = 0.5$ (rounded up to 1), to indicate that 1 block is used to store a file of 2,000 bytes. Also, $9,000 \text{ bytes} \div 4,000 \text{ bytes/block} = 2.25$, which is rounded up to 3, to indicate that 3 blocks are necessary to store a file of 9,000 bytes.

Therefore, a total of 4 blocks are allocated, and the necessary number of sectors is $4 \text{ blocks} \times 8 \text{ sectors/block} = 32 \text{ sectors}$. Therefore, d) is the correct answer.

Q2-24 a)

Method of segmenting and storing data on multiple hard disks

Striping refers to the distribution and recording of data of a constant size and the recording it on multiple hard disks so that data is read and written in parallel. In RAID (Redundant Array of Inexpensive Disks), striping corresponds to RAID0. Therefore, a) is the correct answer.

- b) Disk cache: This is a device or function that increases the speed of data exchange between a CPU and disk. The data that is transferred as a block from the hard disk can be stored in the cache to increase the speed of reading.
- c) Blocking: The logical unit of data for I/O is called a block, and collecting several records as blocks is called blocking. For sequential access, processing efficiency can be improved in comparison with cases where data is read record-by-record.
- d) Mirroring: This is a method by which exactly the same data is written to multiple hard disks, and even if a failure occurs in one disk, the data processing is not affected. Mirroring corresponds to RAID1.

Q2-25 c)

Differentiation of RAID configuration

RAID (Redundant Array of Inexpensive Disks) is a technology for improving the speed and reliability of access by consolidating multiple hard disk drives into a single logical disk. The access speed is improved by distributing and storing data in multiple disks and enabling access in parallel (striping). Furthermore, reliability is improved through mirroring of the disk and also by securing data for error correction. Depending on the unit of striping and the method of securing reliability, RAID is classified into six types, namely RAID0 through RAID5. Therefore, c) is the correct answer.

- RAID0: This is a method that performs only striping. Therefore, there is no improvement in reliability.
- RAID1: This is a method that performs only disk mirroring.
- RAID2: This is a method by which striping is performed at the bit level, data for error correction is secured with a dedicated (fixed) disk, and error correction is performed by the hamming method, which is currently still not in practical use.
- RAID3: This is a method by which striping is performed at the bit level, data for error correction is secured with a dedicated (fixed) disk, and error correction is performed by the parity method. By using the parity method instead of the hamming method, the redundant data (data for error correction) can be reduced in comparison with RAID2, which makes this a feasible method. Initially, parity was performed at the bit level, but in practice it is performed at the byte level.
- RAID4: This is a method by which striping is performed at the block level, data for error correction is secured with a dedicated (fixed) disk, and error correction is performed with the parity method, which is currently still not in practical use.
- RAID5: Striping is performed at the block level, and data for error correction is distributed and deployed on each disk. By the distribution and deployment of data for error correction, access to the disk in which the data for error correction is stored, the flaw of RAID4 where access speed is reduced by a bottleneck is improved. RAID5 has been put to practical use together with RAID1.

Q2-26 c)

Configuration of an on-line processing system composed of two systems

A system configuration composed of two systems as shown in the figure in the question is the most common configuration of an on-line system called a duplex system. When the primary system that performs on-line processing breaks down, the processing is switched to the backup system and can be completed by losing only the switching time, which makes this a highly-reliable system. Therefore, c) is the correct answer.

- a) Simplex system: This is a simple system configuration without any redundancy. If any component breaks down, the entire system breaks down.
- b) Dual system: This is a system in which two computers perform the same processing, and the processing results are collated at a fixed interval. Even if one computer breaks down, the processing continues with the other computer. This is a system that has a very high reliability with no loss resulting from a failure, but the cost is very high and the cost performance is low.
- d) Parallel processor system: This is a system composed of multiple processors. In the recent years, multiprocessor workstations with multiple (two to four) processors installed have even appeared, but a parallel processor system indicates a system with a relatively large number of processors, such as a super computer.

Q2-27 a)

Hot standby system

A hot standby system is one of the techniques for improving reliability. A computer system is duplicated, the same application software as the primary (or currently used) system is also installed on the backup system which is left in a standby state, and as soon as a failure occurs in the primary system, the processing is switched to the backup system and continued. Since both the primary system and the backup system operate from the time normal operation starts, the reliability improves, but a certain amount of cost is also involved. On the other hand, a system in which the backup system does not operate but is left in a standby state is called a cold standby system. Under these conditions, the cost is low in comparison with a hot standby system, but some time is taken up in switching the system, so the system stops during the switching time. Therefore, a) is appropriate.

- b), c) In a hot standby system, the backup system operates when the primary system fails (breaks down).
- d) The backup system is in the standby state when the primary system is operating.

Q2-28 a)

Characteristic of a client/server system

A client/server system is a distributed processing system in which a dedicated computer (server) that provides various services and another computer (client) that requests and uses a service operate in coordination while processing is shared over a network. There are various types of server such as a Web server, a mail server, and a database server. Therefore, a) is appropriate.

- b) A client/server system is a distributed processing system, and generally, the server accesses the data resources.
- c), d) A client is a computer that uses the service.

Q2-29 a)

Client/server system using a browser

It is clear from a “client/server system using a browser” that the software for business operations are consolidated on the server, and the client only displays the screens via the browser.

In a client/server system that does not use a browser, software for business operations is necessary for each client, and therefore, maintenance tasks such as version upgrade of the software for business operations must be performed for each client. However, when a browser is used and the software for business operations is consolidated on the server, maintenance needs to be performed only on the server, which reduces the maintenance activities on the client side. Therefore, a) is the correct answer.

- b) Recovery of the server is performed even in systems using a browser.
- c) Construction of a database is necessary, regardless of whether a browser is used or not.
- d) When a browser is used, the maintenance management of login accounts may actually increase in order to prevent unauthorized use.

Q2-30 c)

Technique of improving the access speed of a hard disk

The sequential distribution of data that has been divided into fixed units (such as bits, bytes, or blocks) on multiple disk drives to enable parallel access is called disk striping as described in c). It is the fundamental technique for a disk array.

- a) “Disk at once” is a method for writing to a CD-R according to which no additions can be made once data has been written on it, regardless of the amount of written data. In contrast, the method by which data is written on separate tracks to enable additions to be made is called “track at once”.
- b) Disk cache is a buffer storage placed between the main memory and disk drive, which can be accessed at a higher speed than the disk. Data that has been accessed is retained in the disk cache and imported from there to main memory when the next access request is received. At this time, since the disk is not accessed, the apparent access time of the disk drive can be shortened. Two methods are available to implement this. In one method, software uses part of the main memory, and in the other method an external semiconductor memory in the form of hardware is used.
- d) Disk mirroring is a method of duplicating the same data on two disk drives. Even if one disk fails, the loss of data can be prevented by using the other disk, and processing can be continued.

Q2-31 a)

Explanation of a fault tolerant system

Fault tolerance is the ability to handle failures. A fault tolerant system is set up in consideration of accomplishment of a business operation even when the system partially fails. Therefore, a) is appropriate.

- b) This is a description concerning a backup site.
- c) This is a description concerning a (loosely coupled) multiprocessor system or cluster system.
- d) This is a description concerning a dual system.

Q2-32 a)

Concept of fail safe

Fail safe is the concept of controlling a system in a predetermined safe state so as to prevent any risks as a result of a failure in the system. Therefore, the concept of a) is appropriate. This concept is adopted in systems such as traffic signal control, where a failure of the system poses a threat to life.

- b) This refers to degraded (fall back) operation, and a system that has this function is called a fail soft system.
- c) This is the concept of a redundant system, and is the basic concept of fault tolerance.
- d) In a system operated by an unspecified number of users, the entry of unexpected values and operating methods need to be given consideration. When such an unexpected operation is performed after a strict input check is conducted, the concept of making the occurrence of malfunctions unlikely is called a foolproof design.

Q2-33 d)

Method of storage composed of a high-speed dedicated network

The network to connect storage devices, such as a hard disk drive or a magnetic tape unit, separately from the normal LAN is called SAN (Storage Area Network) d). In the majority of the cases, this storage is configured by connecting one storage device with another through an optical fiber channel to form a network with a higher speed than the normal LAN.

The meaning of the other terms is as follows:

- a) DAFS (Direct Access File System): This is a file sharing protocol focusing on high-speed data transfer that is applied in NAS described in c) below, which suppresses the CPU load and overheads by performing direct communication between applications without going through the OS.
- b) DAS (Direct Attached Storage): This is storage such as a disk array that is directly connected to the server.
- c) NAS (Network Attached Storage): This is a product designed exclusively for storage that enables file transfer only by connecting directly to a network such as LAN.

Q2-34 d)

Explanation of throughput

Throughput is the processing amount per unit time, and “the number of jobs processed per unit time” described in d) corresponds to throughput. Generally, the maximum number of jobs that can be executed simultaneously is fixed, and therefore, each job is completed in the shortest possible time to improve throughput. On the other hand, spooling is a mechanism for removing the operating time of a low-speed peripheral device, such as a printer, from the execution time of a job, and by using this mechanism, the execution time of the job can be reduced. This is useful in improving throughput. Therefore, d) is the appropriate description.

- a) This is an explanation of the turnaround time. Turnaround time is a system performance evaluation indicator that is seen mostly in a batch processing system.
- b) Such an index is not common. It is in no way an explanation of throughput.
- c) The description itself is correct, but it is not an explanation of throughput.

Q2-35 c)

Performance evaluation based on a benchmark

A benchmark test is used to compare and evaluate the performance of a computer by measuring the execution time of standard programs. Therefore, if various types of benchmark tests are performed, the characteristics of a system can be understood by using the results, which implies that the description “useful in selecting the model to be installed” provided in c) is appropriate.

The other descriptions contain the errors described below:

- a) The results of the TPC benchmark are expressed in terms of performance value and cost performance, and a cost scale is used.
- b) For example, Dhrystone is used to measure a computer’s performance of integer operations, and is not a benchmark test for evaluating the performance of the entire computer system.
- d) A benchmark test is used to evaluate a target with a specific purpose, and cannot be referred to as a general evaluation model.

Q2-36 b)

MTBF and MTTR

MTBF is the mean time between failures (the mean of the time period during which operation can be performed continuously), which is calculated as the mean of t_1 through t_n .

$$\text{Mean of } t_1 \text{ through } t_n = (\text{Sum of } t_1 \text{ through } t_n) \div n = \sum_{i=1}^n t_i \div n = \frac{1}{n} \sum_{i=1}^n t_i$$

Similarly, MTTR is the mean repair time, which is calculated as the mean of r_1 through r_n .

$$\text{Mean of } r_1 \text{ through } r_n = (\text{Sum of } r_1 \text{ through } r_n) \div n = \sum_{i=1}^n r_i \div n = \frac{1}{n} \sum_{i=1}^n r_i$$

Therefore, b) is the correct answer.

Q2-37 a)

Scale representing availability in RAS

RAS, a set of indexes or indicators representing the reliability of a system, is formed from the first letter of the words Reliability, Availability, and Serviceability.

Reliability	This expresses how unlikely a failure is. It is expressed by using MTBF (Mean Time Between Failures).
Availability	This expresses the possibility of use when the system is needed. It is expressed by using the availability ($\frac{MTBF}{MTBF+MTTR}$).
Serviceability	This expresses the ease of repair. It is expressed by using MTTR (Mean Time To Repair).

Therefore, a) is the correct answer.

b), c), and d) Even when the total operating time (MTBF+MTTR), MTBF, and MTTR are known, how long normal operation would continue cannot be determined.

Q2-38 c)

About availability

This question focuses on change in availability. As this question deals with either doubling or halving MTBF (Mean Time Between Failures) and MTTR (Mean Time To Repair), the answer can be determined quickly by using specific values. It is understood from below that the availability increases in case of c).

When availability is calculated with an MTBF of 80 and an MTTR of 20,

$$\text{Availability} = \text{MTBF} / (\text{MTBF} + \text{MTTR}) = 80 / (80 + 20) = 80 / 100 = 0.8$$

a) When both MTBF and MTTR are doubled such that MTBF becomes 160 and MTTR becomes 40,

$$\text{Availability} = 160 / (160 + 40) = 160 / 200 = 0.8 \text{ (does not change)}$$

b) When both MTBF and MTTR are halved such that MTBF becomes 40 and MTTR becomes 10,

$$\text{Availability} = 40 / (40 + 10) = 40 / 50 = 0.8 \text{ (does not change)}$$

c) When MTBF is doubled and MTTR is halved such that MTBF becomes 160 and MTTR becomes 10,

$$\text{Availability} = 160 / (160 + 10) = 160 / 170 = 0.9 \text{ (increases)}$$

d) When MTBF is halved and MTTR is doubled such that MTBF becomes 40 and MTTR becomes 40,

$$\text{Availability} = 40 / (40 + 40) = 40 / 80 = 0.5 \text{ (decreases)}$$

For a general understanding, change the expression for calculating the availability as follows:

$$\text{Availability} = \text{MTBF} / (\text{MTBF} + \text{MTTR}) = 1 / (1 + \text{MTTR} / \text{MTBF})$$

According to this expression, when MTBF is increased and MTTR is shortened, the value of $(1 + \text{MTTR} / \text{MTBF})$ in the denominator becomes less, which means that the availability that is reciprocal to this value increases.

Q2-39 d)

Availability of an entire system

The expression for calculating the availability of a system is different when devices are connected in parallel and when devices are connected in series.

When devices are connected in parallel:

$$1 - (1 - \text{Availability of device } A) \times (1 - \text{Availability of device } B)$$

When devices are connected in series:

$$\text{Availability of device } A \times \text{Availability of device } B$$

The devices A and C , and B and D are connected in parallel, and these two sections are connected in series. Each of the sections in which devices are connected in parallel is available when either of the two devices is operating, that is, this section operates as long as both devices have not broken down. In consideration of the conditions of the question, the availability of each of the parallel sections is expressed as follows:

Section in which A and C are connected in parallel:

$$1 - (1 - 0.9) \times (1 - 0.9) = 1 - 0.01 = 0.99$$

Section in which B and D are connected in parallel:

$$1 - (1 - 0.8) \times (1 - 0.8) = 1 - 0.04 = 0.96$$

Since these two sections are connected in series, the availability of the entire system is:

$$0.99 \times 0.96 = 0.9504$$

Therefore, the closest is d) 0.95.

Q2-40 d)

Calculating the printer availability

When the operational state of two printers is expressed by \circ for an available state and \times for an unavailable state, the following four cases are assumed:

- | | |
|---|----------|
| (1) Printer with an availability of 0.7 | \circ |
| Printer with an availability of 0.6 | \circ |
| (2) Printer with an availability of 0.7 | \circ |
| Printer with an availability of 0.6 | \times |
| (3) Printer with an availability of 0.7 | \times |
| Printer with an availability of 0.6 | \circ |
| (4) Printer with an availability of 0.7 | \times |
| Printer with an availability of 0.6 | \times |

The cases in which either of the two printers is available and the other is unavailable are cases (2) and (3). Since the probability of a failure is $(1 - \text{availability})$, the probability of each of the above cases is calculated as below:

$$(2) \quad 0.7 \times (1 - 0.6) = 0.28$$

$$(3) \quad (1 - 0.7) \times 0.6 = 0.18$$

The probability of (2) or (3) is calculated by adding the two cases, which is $0.28 + 0.18 = 0.46$. Therefore, d) is the correct answer.

Q2-41 d)

Calculating the average processing time of a transaction

According to the conditions described in the question, the processing time of this transaction is the sum total of the time of execution of 600,000 instructions and the time required for two file accesses.

First, since the average access time of the disk is 30 milliseconds, the time required for two file accesses is calculated as $30 \times 2 = 60$ milliseconds.

Next, since the CPU performance is 30 MIPS, that is, 30 million instructions can be executed in one second, the time required for executing 600,000 instructions is $600,000 \div 30 \text{ million} = 1 / 50 \text{ seconds} = 20 \text{ milliseconds}$.

Therefore, the average processing time of a transaction is $20 + 60 = 80$ milliseconds, which means that d) is the correct answer.

Q2-42 a)

State transition of a task

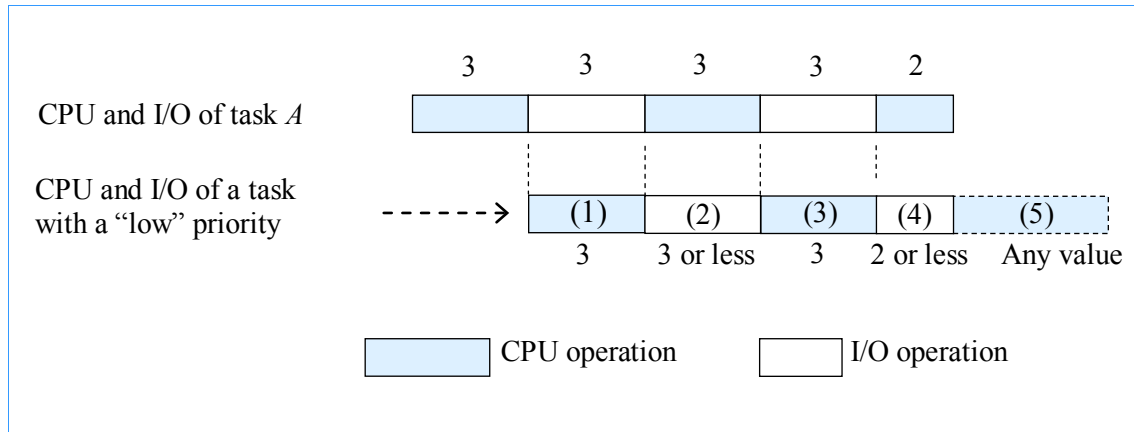
In control for multitasking, a task within a system is managed based on three states: the “running state” is when the task in the system is being performed, the “ready state” is when the task can be executed at any time, but its execution is awaited because the CPU is busy, and the “waiting state” when I/O processing is being performed and its completion is awaited. A figure that shows the transition of these three states is called a state transition diagram of tasks (processes). When a task with a higher priority is set to the ready state, the task in the running state is dispossessed of the right to use the CPU and is set to the ready state. Therefore, a) is the correct answer. Such task switching (involving the appearance of a task with a high priority) is called preemption.

- b) A task that is generated is first set to the ready state.
- c) When the processing of an I/O request ends, transition takes place from the waiting state to the ready state.
- d) When an I/O request is issued, transition takes place from the running state to the waiting state in order to await the completion of the request.

Q2-43 c)

Task execution pattern when the CPU idle time is zero

This question deals with the idle time when the CPU is not operating during the concurrent execution of tasks. First of all, the CPU and I/O processing time of task *A* with a “high” priority is expressed in the form of the following figure:



Consideration should be given to filling the cells (1) through (5) so that the CPU idle time is reduced to zero from the start of the execution of both tasks until the end of the execution of both tasks. In order to reduce the CPU idle time to zero, the processing time for the CPU in (1) becomes 3, and the processing time for the CPU in (3) becomes 3. Since the idle time of I/O is not in question, I/O time in (2) may be 3 or less and I/O time in (4) may be 2 or less. (5) is not related to the idle time of the CPU, and can therefore be any value.

From the above conditions, task *D* described in c) that is executed in the sequence of CPU(3) → I/O(3 or less) → CPU(3) → I/O(2 or less) → CPU(Any value) is the correct answer.

Q2-44 c)

Task scheduling algorithms

The scheduling algorithm by which processing is executed in order starting from the task (job) with the shortest expected processing time is called the SJF (Shortest Job First) algorithm. This algorithm is suitable for preferentially processing tasks that need to be handled immediately, such as online real-time processing, however, when tasks with a short expected processing time arrive in the CPU resource queue in quick succession, the tasks with a long expected processing time wait indefinitely for the allocation of CPU resources, and might not be processed for a long time. Therefore, c) is appropriate.

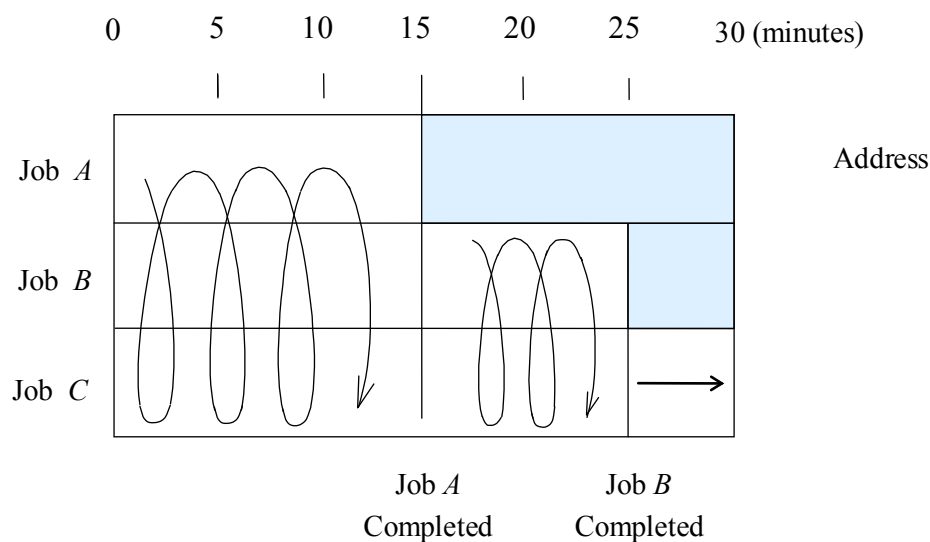
- a) The scheduling algorithm where multiple CPU resource queues are created according to task priority and CPU resources are allocated sequentially starting with the tasks with the highest priority is called priority scheduling. The problem with this algorithm is that CPU resources are not allocated to tasks with a lower priority very often. The process of gradually increasing the priority according to the length of the waiting period so as to deal with this problem is called aging.
- b) The limited time period for which the CPU can be used is called a time quantum or time slice. The scheduling algorithm by which the execution of a task is suspended once the limited time period is reached and the task is appended to the end of the CPU resource queue is called the round robin algorithm. The tasks in the CPU resource queue are processed in sequence, and the allocation of CPU resources to the tasks is ensured.
- d) This is an algorithm by which tasks are processed in order of arrival, and it is called FIFO (First In First Out). Although the subsequent tasks are made to wait, once a certain amount of time has elapsed, CPU resources are eventually allocated to the subsequent tasks as well.

Q2-45 c)

Calculating the elapsed time of a job based on the scheduling algorithm

Since a time quantum is a significantly smaller value in comparison with the processing time of a job, almost the same CPU time is allocated to jobs that are executed simultaneously. First, the three jobs *A* through *C* are executed by allocating a time quantum with the round robin algorithm. Therefore, approximately three times the amount of time taken to execute the jobs separately is needed. As such, the time that elapses before the completion of job *A* (which has the shortest processing time) is 5 (minutes) \times 3 = 15 (minutes). After the completion of job *A*, job *B* and job *C* are executed simultaneously. The time that elapses during this period is approximately twice the time taken to execute the jobs separately. Therefore, the time taken until the completion of job *B* is twice the “remaining time of job *B*” that is 5 (minutes) \times 2 = 10 (minutes). Following this, job *B* (that has the shortest processing time after job *A*) is completed, and finally, job *C* is executed by itself.

In this question, the time that elapses before the completion of job *B* must be determined. This is $15 + 10 = 25$ (minutes), and therefore, c) is the correct answer.



Q2-46 a)

State in which processor utilization decreases

In a virtual memory system, if a program in the virtual memory is larger than the main memory area that can be used in the system, or the number of programs running concurrently is large, paging is performed very frequently. This is called thrashing as described in a) and causes the efficiency of the entire system to decrease.

- b) Fragmentation: This is a state in which the memory inside the storage device is fragmented and a continuous area of the required size cannot be secured, and as a result, a series of memory areas are arranged in a scattered manner. Frequent writing to the storage device and deletion of content causes this state to progress, leading to a decline in system efficiency.

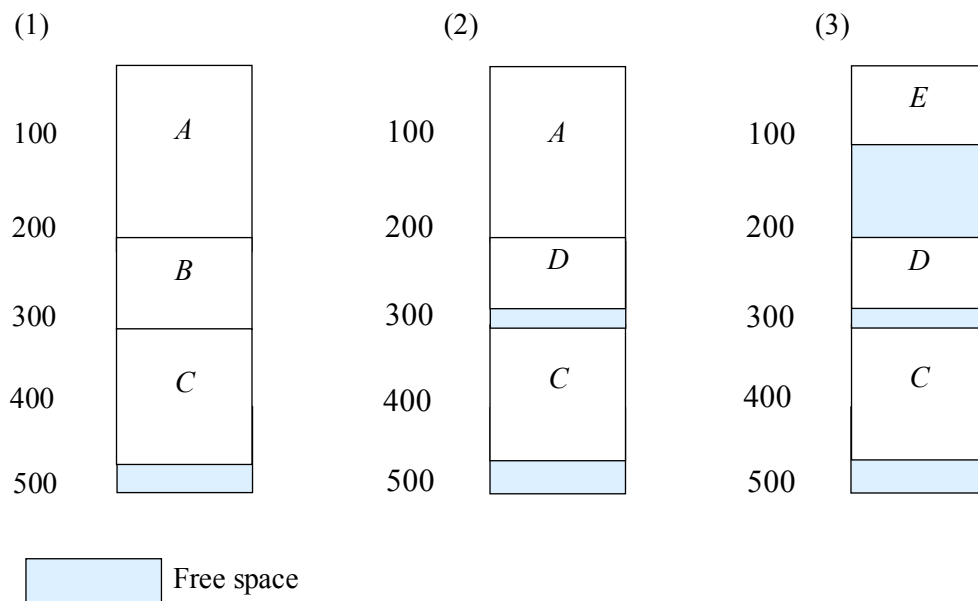
- c) **Paging:** In a virtual memory system, when no space is available in the real memory, the programs in the real memory that are not necessary for the time being are pushed out to an auxiliary storage device (page-out), and a program that might be necessary the next time is imported into that area (page-in). These two operations are called paging. Pages that are paged out are stored and managed at a location called a slot on the auxiliary storage device.
- d) **Bottleneck:** It is a phenomenon in which the performance or capacity of an entire system is severely limited by a resource with the highest amount of load, and which hinders development in situations such as the development of a system.

Q2-47 a)

Free space on the main memory in a variable partition system

The question states that “the modules are loaded from the beginning of a free space, and no other conditions are considered.” Therefore, “Order of loading and unloading” can be considered as follows:

- (1) Load *A* → Load *B* → Load *C* (Loading the modules in order of *A*, *B*, and *C* from the beginning of the main memory)
- (2) Unload *B* → Load *D* (Loading *D* into the area from which *B* is unloaded as *D* can be loaded into that area)
- (3) Unload *A* → Load *E* (Loading *E* into the area from which *A* is unloaded as *E* can be loaded into that area)



Loading from the beginning of the free space implies that if a module can be loaded, it is loaded from the very beginning of the free space scattered throughout the main memory. If the area from which a module has been unloaded is smaller than the size of the module to be loaded next, the module cannot be loaded into that area. However, if the area is large, the module to be loaded next can be loaded. Therefore, free space is available at three areas, and a) is the correct answer.

Q2-48 b)

Effect of a virtual memory system on the main memory

A virtual memory system is a mechanism for providing an address space larger than the capacity of the actual main memory by using an auxiliary storage device. Therefore, b) is the correct answer. In a virtual memory system, a program is divided into several parts beforehand, and only the parts necessary for processing are loaded to the main memory so as to enable the execution of a program with a larger size than the actual memory capacity. The methods for the division of a program include “segmentation” by which a program is divided into meaningful functional units, and “paging” by which a program is divided simply into fixed units (such as 4 KB).

- a) There is no effect on access speed to the main memory. To be exact, in some cases there is a delay equal to the processing time for dynamic address translation. Furthermore, in the virtual memory system, if the physical memory capacity is lower, the divided program is replaced frequently, which increases the required processing time, thus resulting in a delay in the effective access speed of the main memory.
- c) Although in some cases the power consumption of the entire system increases by as much as the amount of usage of the auxiliary storage device, there is no reduction in the power consumption of the main memory.
- d) Non-volatility is the ability to retain stored content even when the power is turned off. Normally, auxiliary storage devices are non-volatile and the main memory is volatile, and this holds true even for a virtual memory system.

Q2-49 d)

Page replacement by the LRU algorithm

According to the LRU algorithm, the page that is not used for the longest time is paged out. In this question, the state of page referencing and page replacement is arranged in a table in view of the fact that “no page exists in the main memory in the initial state”. As a result, it is clear that when page 6 is accessed at the end, it is stored at the position where page 5 was stored. Therefore, d) is the correct answer.

	1	2	3	4	5	6	7	8	9	10
1	1	1	1	1	5	5	5	5	(5)	6
2		2	2	2	2	2	2	2	2	2
3			3	3	3	3	1	1	1	1
4				4	4	4	4	3	3	3

Vertical axis: Page frame

Horizontal axis: Access frequency

Q2-50 c)

Explanation of the spooling function

The spooling (spool) function refers to the I/O process of data using a spool area. The spool area is the storage area for an auxiliary storage device that plays the role of a buffer for releasing the CPU from the I/O operation of a low-speed device. For example, the data to be output to a printer is first stored on a high-speed hard disk device (spool area), and then output to the target printer. In this way, the program can be ended when the data is written to the spool area, and another process can be started. By quickly separating the program from a low-speed I/O device such as a printer, the number of programs that can be executed concurrently can be increased and the low-speed I/O device and CPU can be used effectively, which improves the throughput of the entire system. Therefore, c) is the correct answer.

- a) This is a description concerning scheduling of tasks.
- b) This is a description concerning interrupt.
- d) This is a description concerning buffering that is used when a disk is accessed. A disk cache also achieves a comparable function.

Q2-51 c)

Calculating the number of a page fault

According to the conditions in the question, a single access to the main memory is performed in 200 nanoseconds, and the overhead for a single page fault is 100 milliseconds. Furthermore, a page fault occurs once every 500,000 accesses to the main memory. Based on this, if the average time required to access the main memory 500,000 times is calculated by including the overhead for the one page fault that is expected to occur during this time, it is calculated as the sum total of the time required for 500,000 accesses and the overhead due to the page fault, which is 2×10^{-1} (seconds), as shown in the figure below:

Time required for accessing the main memory 500,000 times	Page fault
$50 \times 10^4 \times 200 \times 10^{-9} = 10^{-1}$ (seconds)	$100 \text{ milliseconds} = 10^{-1}$ (seconds)

The numeric value to be obtained is the maximum number of page faults per second, but since a page fault occurs every 500,000 accesses to main memory, the time period necessary for 500,000 accesses (including the page fault), which was calculated earlier, is used as a unit to determine the maximum frequency of occurrence in one second. Thus, the maximum number of the page faults per second becomes $1 \div (2 \times 10^{-1}) = 5$ (times/second), which means that c) is the correct answer.

Q2-52 c)

Printing process

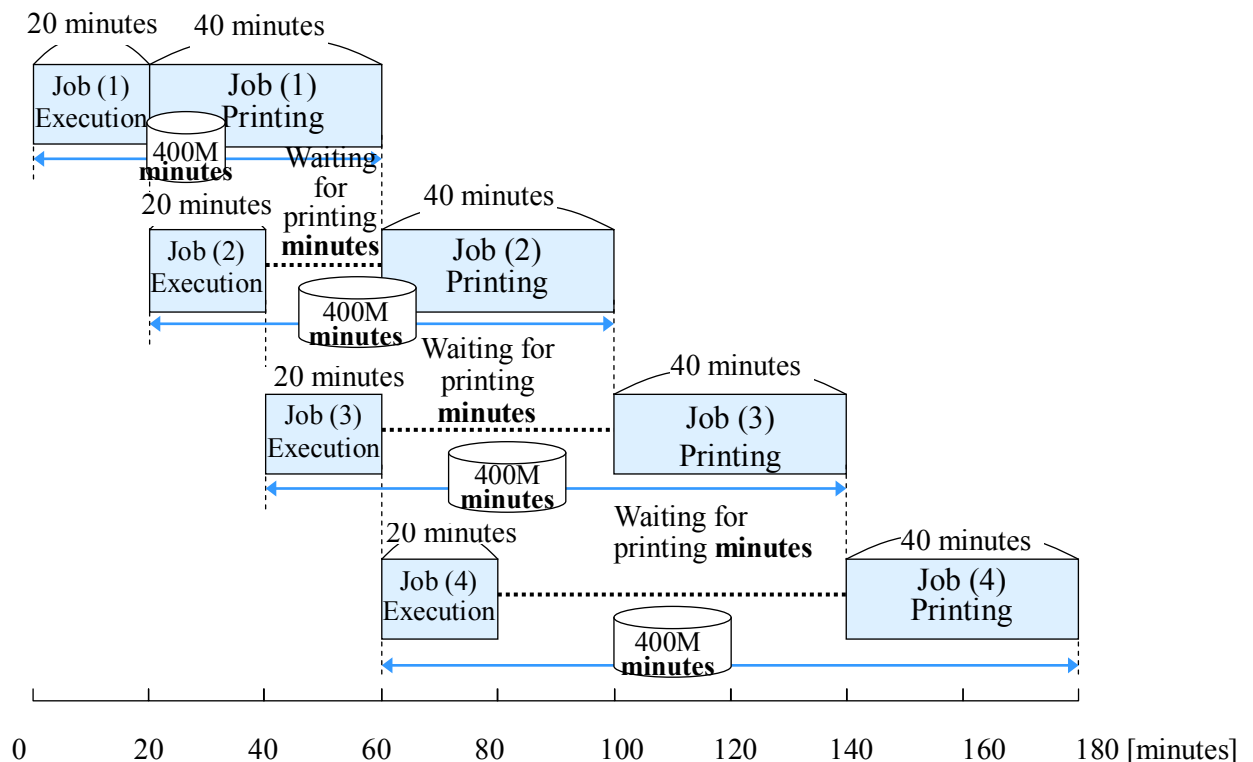
By using an auxiliary storage device as buffer storage in order to bridge the difference in the processing speed of a processor and peripheral devices, storage of the input from the peripheral devices or the output to the peripheral devices in an area inside the auxiliary storage device is called spool control. Furthermore, the file used to store information about input and output in order to perform this spool control is called a spool file.

In the question, point (3) under “Conditions” states that a spool file for printing with a size of 400 MB is secured for the execution of a single job. Furthermore, points (4) and (5) under “Conditions” state that after the execution of a job, the contents of the spool file are processed by the printing function of the OS, and that once printing is completed, the spool file is deleted. Here, the deletion time is ignored. That is, a spool file of 400 MB is required from the time of execution of the job until printing of the print data (the output from the job) with the printing function of the OS is completed.

Here, as stated in point (2) of “Conditions”, the execution time of one job is 20 minutes. Furthermore, as stated in point (6) of “Conditions”, the printing time is 10 minutes for every 100 MB (= 10 MB/minute), and since the size of the spool file is 400 MB, the printing time is calculated with the following expression:

$$400 \text{ (MB)} \div 10 \text{ (MB / minute)} = 40 \text{ (minutes)}$$

According to point (1) of “Conditions”, a job is executed continuously four times with a multiplicity of 1, and according to point (6) of “Conditions” one printer is available. Finally, according to point (7) of “Conditions”, the jobs can be executed and printed in parallel, and these processes do not affect each other. Therefore, if the execution and printing process of the jobs is compiled in chronological order, it appears as shown below.



By 60 minutes from the start of execution of the first job, three spool files of 400 MB each are necessary. However, since the first spool file is deleted after 60 minutes, 400 megabytes need not be secured afresh for the fourth spool file. Thus, three spool files of 400 MB each are required between 40 minutes and 100 minutes after the start of the first job and their capacity becomes 1,200 bytes. Therefore, c) is the correct answer.

Q2-53 b)

Explanation of API in an OS

API (Application Program Interface) is a mechanism for using various functions of the OS from application software, and is a collective term for interfaces, such as the functions, commands, and utilities provided for easy development of a program. Therefore, the description b) is appropriate.

- a) This is an explanation of a mechanism that is used to operate the hardware directly from an application without using APIs (such as Windows DirectX), in order to improve the speed of image rendering.
- c) The mechanism of communication between multiple applications across a network includes a socket, which is a TCP/IP-based communication interface between processes.
- d) This is an explanation concerning the integration of GUIs (Graphical User Interfaces), which includes Motif and OPEN LOOK of UNIX.

Q2-54 b)

Explanation of middleware

Middleware refers to software that functions in an intermediate position between the operating system and application software and provides generalized versions of functions that are commonly used by the application software. It also performs the role of effectively linking the application software and the operating system. Therefore, b) is the appropriate explanation.

- a) This is an explanation of the operating system. It manages various resources such as the hardware and data, and ensures their effective use. Besides control programs in a narrow definition of an OS, language processors and service programs are also included.
 - c) This is an explanation of an ERP (Enterprise Resource Planning) package. An ERP package is a business package that integrates the mission-critical business systems of a company. It can support wide-spread activities from the procurement of raw material to production, sales, and personnel affairs.
 - d) This is an explanation of groupware. Groupware is software that supports a mechanism for collaborative work by a group. It has functions for sharing document information, providing communication tools (such as e-mail and electronic bulletin board), and managing workflow.
- Q2-56d)

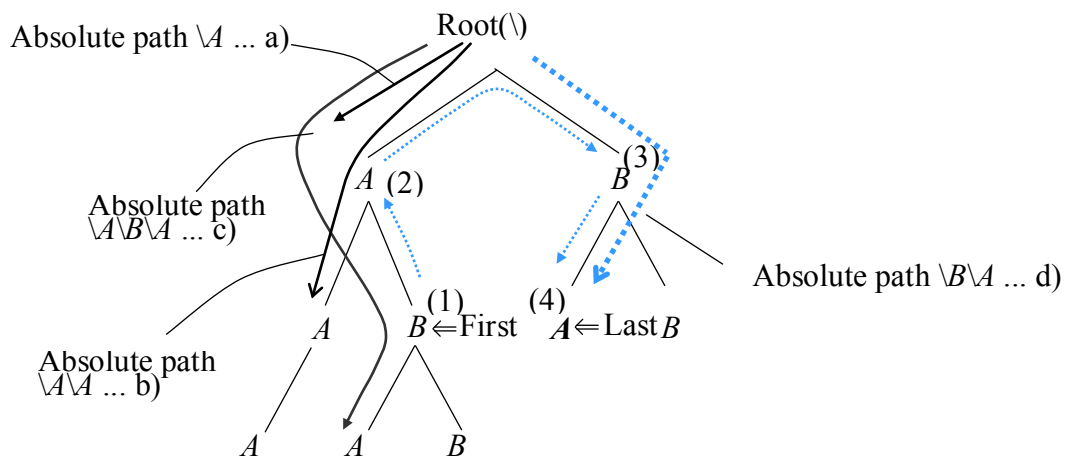
Q2-55 d)

Moving the current directory

A file system that has a hierarchical structure is composed of the root directory itself and files and directories belonging to the root. Files and directories can be specified with an absolute path, which is the path from the root, or by a relative path, which is the path from the directory being handled currently (current directory). As mentioned in the question, when the current directory is moved, the absolute path of the last current directory is to be determined.

- $\backslash A \backslash B$
This is an absolute path. A is the directory immediately below the root, and then B is under that, so the current directory is (1).
- \dots
This means the directory that is one level above. Therefore, the current directory is (2).
- $\dots \backslash B$
Two periods means one level above (2), which is the root. B is under the root. Therefore, the current directory is (3).
- $\dots A$
The current directory is B , which is (3), and the directory A under (3) is the next current directory. Therefore, the last current directory is A , which is (4).

The absolute path of A corresponding to (4) is to be determined. The absolute path of A begins with the root (\backslash) followed by B which is immediately below ($\backslash B$), and then reaches A that is below B . Therefore, the absolute path is $\backslash B \backslash A$ as described in d).



Q2-56 d)

Explanation of archive

In English, archive means a record, storage, or old document. In computer terminology, archive means to compile multiple files into a single file, and store this on a storage device, as described in d). In many cases, in order to effectively use the storage media, or improve the efficiency of backup and distribution, the data is compressed. A file compiled as an archive is sometimes called a stack.

- a) This is an explanation of “data save”.
- b) This is an explanation of file mirroring.
- c) This is an explanation of the update log of the database.

Q2-57 c)

Explanation concerning a language processor

Language processor is a collective term for software that performs processing concerning programs, such as translating the source program coded in a programming language and creating an executable program. After reading the description of each of the options, the description of a generator provided in c) is appropriate.

- a) An assembler is software for creating a machine language program by translating the source program written in a programming language (assembler) with a one-to-one correspondence to machine language. The software that converts a source program into a source program for another processor is called a converter.
- b) An interpreter is software that “executes a program written in a high-level language while interpreting it on a per line basis” as described in d). The description “A microprogram that decodes and executes the program intended for another computer” indicates an emulator. Furthermore, a microprogram is a program installed in a CPU that processes complex machine language instructions like software.
- c) A generator is software that creates a program as appropriate for the purpose of processing by specifying the necessary conditions as parameters, and is the correct description. Among well known generators, RPG (Report Program Generator) is popular. In the recent years, products that generate HTML from created GUI images and those that generate a source program from a structured chart have appeared, and these can also be classified as generators.
- d) A translator is software that converts a source program written in a high-level language into a source program in another high-level language.

Q2-58 c)

Explanation of optimization in a compiler

Optimization of a compiler implies changing a program so as to reduce the execution time and size of the object program without changing the functions of the program. Therefore, c) is appropriate. For example, deletion of redundant instructions, and reorganization of loops and register assignment are performed. Optimization is mostly performed after semantic analysis within the flow of a series of compilation processes.

(Lexical analysis → Syntax analysis → Semantic analysis
→ Code optimization → Code generation)

- a) This is a description concerning an interpreter. An interpreter executes a program while translating it, and therefore, it does not generate an object code.
- b) This is a description concerning a cross compiler.
- d) This is a description concerning a function called snapshot dump that is used for debugging. If the debug mode is set as an option for compilation, most compilers usually generate such object code.

Q2-59 a)

Functions of a programming tool

An inspector is a dynamic analysis tool that displays the content of the data during the execution of a program for the purpose of debugging. Therefore, a) is correct.

- b) A simulator is a tool for simulation and includes terminal simulators that simulate the operation of a specific terminal, and traffic simulators that generate a specific communication pattern. A tool that displays the execution path within a program or between programs is called a tracer.
- c) As described earlier, a tracer is a dynamic analysis tool. In order to simplify the search for functional explanations and data definitions in each program, repositories are used. Repositories are databases for managing the results all together including information described above.
- d) A browser is Web client software for displaying Web pages. A tool that edits the source code of a program based on functions, such as character insertion, deletion, and substitution, is called an editor.

Q2-60 a)

Flow from interpretation of a program until its execution

- (1) A compiler interprets the source program written in the language of that compiler.
- (2) When the compiler interprets the source program, it becomes “A: object program” in machine language or an intermediate language.
- (3) A linker (linkage editor or linkage editing program) performs linkage editing of “B: library” module from several object programs and program libraries, and creates a “C: load module” (executable program). The address at this stage could also be a relative address (depending on the type of computer) so that it can be allocated at any location in the main memory.

- (4) A loader loads a load module into main memory while converting it to a real address and executes it. In current OSs, the OS itself has a function for loading programs (load modules) to main memory, so an individual program such as a loader is not needed.

Therefore, a) is appropriate.

Q2-61 d)

Open source software defined by OSI

OSI (Open Source Initiative) is a non-profit organization that promotes open source. Open source is a software license that enables free browsing of the source code, as well as change and redistribution of the content while protecting the copyright of the software. Software based on this license is called open source software. According to the definition of open source software by OSI, 10 criteria must be fulfilled as conditions for distributing a program. Based on this, when the modified software is redistributed, the source code must be released to the public, however, for private or in-house use and modification, the source code does not need to be released to the public. Therefore, d) is the correct answer.

- a) The use of a program cannot be restricted to only a specific field.
- b) When the open source software is modified and redistributed, its distribution under the same license as the original software must be allowed. However, this does not imply that the modified open source software must be distributed under the same license.
- c) The software developer cannot restrict the sale or free distribution of the open source software by a third party, and cannot ask for royalties or other remuneration concerning sales.

Q2-62 d)

Description concerning the flash memory

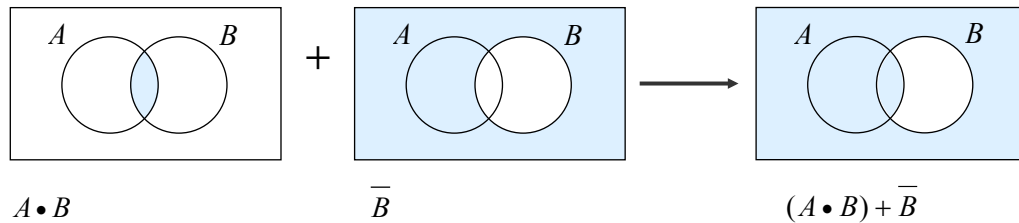
A flash memory is an EEPROM (Electrically Erasable Programmable ROM) that can be erased all at once, and is used as the storage media in digital cameras and IC cards. In terms of semiconductor memory, a rewritable ROM (Read Only Memory) is called PROM, and among PROM, a memory that can electrically delete and write content in each block is called a flash memory (flash EEPROM), which has a property known as non-volatility in that its content cannot be deleted even when power supply is turned off. Therefore, d) is appropriate.

- a) This is a description concerning SRAM (Static RAM). A refresh operation is not necessary and data can be read fast, but the cost is higher than that of DRAM.
- b) This is a description concerning EPROM (Erasable Programmable ROM). It is a type of PROM whose content can be erased by ultraviolet radiation. It is mostly used for storing programs.
- c) This is a description concerning DRAM (Dynamic RAM). It is a semiconductor memory with a simple structure and a high degree of integration, which requires data to be refreshed so that the recorded content is not deleted.

Q2-63 b)

Logic circuit from which the same output is obtained

The given logic circuit is $X = (A \bullet B) + \bar{B}$, which appears as below when depicted with a Venn diagram:



This can also be considered as the logical sum of “A” and “not B”.

Next, the logic circuits of the options are evaluated as below, and the same output results are obtained from the circuit shown in b).

- a) $X = A \bullet \bar{B}$
- b) $X = A + \bar{B}$
- c) $X = A + (A \bullet B) = A$
- d) $X = \overline{A \bullet \bar{B}} = \overline{A} + \overline{\bar{B}} = \overline{A} + B$ (The form is changed using the De Morgan's Law)

For reference, the double negation of De Morgan's Laws can be used to prove this as follows:

$$\begin{aligned}
 X &= A \bullet B + \bar{B} = \overline{\overline{A \bullet B + \bar{B}}} = \overline{\overline{(A \bullet B)} \bullet \bar{B}} \\
 &= \overline{(\overline{A + \bar{B}}) \bullet B} = \overline{\overline{A} \bullet B + \overline{B} \bullet B} = \overline{\overline{A} \bullet B} = A + B
 \end{aligned}$$

Q2-64 a)

Combination of gate devices in a half adder

As this is a half adder, the gate devices can be obtained simply by adding the binary numbers.

When $x + y$ is expressed as a binary number,

0	0	1	1	←	x
<u>+0</u>	<u>+1</u>	<u>+0</u>	<u>+1</u>	←	y
00	01	01	10	←	cz (carry bit and first digit of the sum)

z is calculated with the exclusive logical sum because it becomes 1 when either input is 1.

c is calculated with the logical product because it only becomes 1 in the case of $1 + 1$.

Therefore, the combination of a) is appropriate.

Q2-65 c)

SoC

SoC (System on a Chip) is a system LSI in which several functional circuits are incorporated into a single semiconductor chip. Therefore, c) is appropriate. Although the development cost is higher than the SiP of d), it is suitable for compact products that are in mass production.

- a) This is a description concerning an electronic circuit board such as the motherboard of a PC.
- b) This is a description concerning the chipset of a PC. For example, the Intel 855 chipset by Intel Corporation is a chipset for a notebook PC.
- d) This is a description concerning SiP (System in a Package) in which multiple chips are stored in a single package. System LSI is broadly divided into SoC and SiP. For reference, system LSI is a general-purpose LSI, and custom LSI indicates an LSI that contains the specific functions desired by the user. Custom LSI is divided into a special-purpose ASIC (Application Specific Integrated Circuit) and a programmable FPGA (Field Programmable Gate Array).

Section 3**Technology Elements****Q3-1 d)**

Accessibility

Accessibility is a keyword that refers to the ease of using information systems, such as software, information services, and Web sites, on a user interface. Therefore, d) is the correct answer. The color combination of a screen, design including font size, provision of audio and speech functions, and the attachment of text descriptions of images and audio so that everybody including elderly people and people with disabilities can also adequately access the information systems is also “the degree of achieving universal design in information systems.” In addition, not only items standardized with barrier free design and functions, but it also includes equipment and software that allows independent setting and adjustment of these functions according to the physical characteristics of the user.

- a) This refers to the basic resident register network system. By connecting the administrative agencies and centers all over the country with local public agencies (prefectural and city governments, municipalities), this system makes it possible to share and use information about specific users to whom a resident register code is assigned (recorded in the basic resident register).
- b) This refers to interoperability.
- c) This refers to traceability.

Q3-2 c)

User interface

A user interface that allows frequently-used operations to be performed efficiently is a shortcut key. Frequently-used operations are assigned to keys beforehand, and instead of entering a command or operating a GUI, an operation is performed by simply pressing the corresponding key. One of the main examples is, pressing [Ctrl] and [C] simultaneously performs the copy operation. Therefore, c) is the correct answer.

- a) Undo function (returning to the original) is a user interface for returning to the state prior to making a change.
- b) Online help is a user interface used when the user is not familiar with the operation method.
- d) Progress bar is a GUI indicating the progress of a process.

Q3-3 b)

Input method for GUI screen

Input methods for GUI screen include text box, pop-up menu, list box, radio button, checkbox and the like.

A text box is a method of directly entering characters. It includes an input mode where the maximum number of characters allowed in the relevant fields is set and no restrictions are placed on the input characters, and an input mode where characters allowed in the relevant field are decided, and the entering of any other characters results in an error message and user is asked to re-enter the characters.

A pop-up menu is a menu displayed at any position on the screen, and a user selects his or her intended item from the menu.

In a list box, options are displayed inside a box. An items list is displayed vertically and the user searches for and selects his or her intended item by using a scroll bar on the right side of the list box. The selected item is highlighted by inverting the brightness and colors of the display, and once the input is completed, the highlighted item is entered.

Radio buttons are used when the user is required to select only one item from multiple items displayed beforehand.

A checkbox is used when the user selects as many items as needed from multiple items displayed beforehand.

For the “method of choosing from the list of options” in this question, the possible choices could be pop-up menu, list box, radio button, and checkbox. When there are only a few types of input data, and the content of data is fixed, these methods are effective. Therefore, b) is the correct answer.

- a) As the method in question here is for selecting items, basically the items cannot be modified. When it is necessary to modify each item, a text box with default setting (initial value) is appropriate.
- c) When the input data can take many values, it is cumbersome to search for the value to be selected. Therefore, in most of such cases, a text box is used where the value can be directly entered.
- d) In order to enter a large amount of data such as sentences, a text box is the appropriate method.

Q3-4 b)

Methods for checking data

In balance check, individual tabulation is done with respect to a pair of data items where the final sum total should be balanced, and then it is checked that the difference between total values is zero. Therefore, b) is the appropriate answer.

- a) In the method of using check digits, one digit is appended for the detection of input errors in code. The value of this one digit to be appended is obtained by performing certain calculations on the original code. After that, it is continuously checked whether this relation still holds, and in that way, errors are detected.
- c) A format check is for checking the format of an input field, and not an input item. An input format (categories such as alphabet letters, numeric value, and double-byte characters) is defined for each item, and it is checked whether the actually entered value matches the predefined format. For example, entering a numeric value in the field where only alphabetical characters are allowed results in an error.
- d) A limit check is for checking whether a value entered in a field is within the permissible limit or not. For example, entering \$200 in the field where the value must not exceed \$100 results in an error.

Q3-5 b)

Design principles of input screen

As input screens are screens for entering information that is important for the information system, it is desired to have design principles that help in designing screen layout that is easy to understand and easy to use for users, and that also prevents input errors. Therefore, b) is the correct answer.

- a) In the case of a wrong input, if a program terminates without being able to perform subsequent processes, users cannot use it comfortably.
- c) As users enter data by looking at the input form, layout designed according to the input form is easier to use.
- d) Even if users are proficient with the operation because of frequent use, an error may occur accidentally as long as it is a manual input, and therefore input check cannot be omitted. Moreover, it should be kept in mind that input errors occur until the user becomes proficient with the operation.

Q3-6 c)

Characteristics of various codes

Block code, group classification code, and sequence code that appear in the answer choices have the characteristics listed below respectively.

- Block code: A range of code values is decided for each group, and code values are assigned within this range.
- Group classification code: In this code, each digit has a meaning of code, and in most of the cases, starting in sequence from the top, digits have the meaning of major category, medium category, minor category, and serial number. The typical group classification code is student numbers that contain year of enrollment, department, academic discipline, and roll number.
- Sequence code: As indicated by its name, code names are assigned in the sequence of occurrence.

In addition to these three codes, like product code of electrical appliances, mnemonic code is also a major code that assigns values so that a product can be associated with the code itself.

- a) As one of the advantages mentioned here is “codes in the order of occurrence are assigned,” it indicates sequence code. As this code assigns code values without leaving any interval in between, the number of digits is fewer. However, this code does not consider categories, and therefore it has the characteristics described in disadvantages and application area.
- c) As one of the advantages mentioned here is “each digit has a specific meaning of classifications,” it indicates group classification code. Other characteristics of this code are, the number of digits can easily become large as mentioned under disadvantages, and it can be used when the classification criteria is clear.

As the meaning of the aforementioned two choices is known, it is clear that the correct answer is

- c).
- b) Although the number of digits is fewer compared with the group classification code, block code suffers from the disadvantage that codes cannot be assigned when digits become inadequate in the range allocated to the group. Moreover, in the group classification code, the number of digits is decided from the standpoint of categories. However, in the block code, the range of codes is partitioned by each group, and therefore even if there are restrictions on the number of digits, grouping is possible.

Q3-7 d)

Explanation of usability of Web contents

Usability refers to “ease of use.” The concept of usability of is not only for people with disabilities or elderly people, but it is a term that expresses general ease of use in a broader sense. Therefore, d) is appropriate for the usability of Web contents. In addition, in the international standard ISO 9241-11, “Guidance on usability” is provided as a principle for ergonomically measuring the ease of use of visual display terminals in offices. In this guidance, usability is defined as “the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use.”

- a) This is the concept of universal design.
- b), c) Both are the concepts of barrier free design.

Q3-8 c)

Capacity of audio sampling

Sampling can be considered as “picking up samples.” Audio sampling is a technique of encoding analog data such as audio (that is, converting it into digital format), and fetching the size (amplitude) of a wave at a certain interval from the continuous analog waveform.

Data is sampled 11,000 times per second, and each value is recorded in 8-bits. Based on the fact of “8 bits = 1 byte”, the amount of data sampled in a second is calculated as follows:

$$\begin{aligned} 8 \text{ bits/time} \times 11,000 \text{ times/second} &= 88,000 \text{ (bits/second)} = 11,000 \text{ (bytes/second)} \\ &= 11 \times 10^3 \text{ (bytes/second)} \end{aligned}$$

Therefore, in a flash memory with a capacity of 512×10^6 bytes, audio data of

$$\begin{aligned} (512 \times 10^6 \text{ (bytes)}) \div (11 \times 10^3 \text{ (bytes/second)}) &= 512 \times 10^3 \div 11 \text{ (seconds)} \\ &= 46545.45 \text{ (seconds)}, \end{aligned}$$

$$46545 \div 60 = 775.75 \text{ (minutes) can be recorded.}$$

Therefore, c) 775 (minutes) is the correct answer.

Q3-9 c)

International standard of compression encoding of still image data

When image or audio data is handled in a multiple processing system, the data volume is very large. Therefore, data compression techniques are required. JPEG (Joint Photographic Experts Group) and GIF (Graphics Interchange Format) are the main compression methods for still image information. JPEG is an international standard defined by ISO/IEC. Therefore, c) is the correct answer.

There are two types of JPEG compression methods: lossless compression and lossy compression. In the “lossless” method, when the compressed image data is restored to its original form, it can be fully restored, while in the “lossy” method, the compressed image data cannot be fully restored. Although the compressed image data cannot be fully restored, a human eye hardly feels the difference.

- a) BMP (Bit MaP) is used as a standard graphic format used by Windows. Color and shape data is managed in units of bits. Screen is clear and sharp as data is not compressed, but file size becomes large.
- b) GIF (Graphics Interchange Format) is used as a compressed image format of the lossless compression method. LZW method is used for compression, and the more repeated parts of the same color or pattern, the higher the compression ratio. Therefore, it is more suitable for compressing illustrations. However, it is not yet standardized by international organizations such as ISO.
- d) MPEG (Moving Picture Experts Group) is used as an international standard of compression technology for moving images.

Q3-10 b)

Features of compression methods of still image data

There are two data compression methods: lossless encoding (lossless compression) and lossy encoding (lossy compression). In the lossless encoding method, data before compression and data after compression and decompression process completely matches. In this method, data after decompression completely returns to its original form. Therefore, image quality is constant irrespective of the compression ratio. Therefore, description of b) is appropriate.

On the other hand, in the lossy encoding method, data before compression and data after compression and decompression process does not match completely. Although the quality of data after decompression is reduced, a high compression ratio can be easily achieved. Deterioration in quality is made less noticeable by using audio-visual characteristics, and accordingly it is used for compressing general image and audio data. In JPEG, which is one of the typical still image compression methods, although the lossy encoding method is mainly used, the lossless encoding method is also included as a standard.

- a) The compression ratio is lower in the lossless encoding method in comparison with the lossy encoding method, and the file size becomes larger.
- c) In the lossy encoding method as well, the image size does not become smaller. In most cases, the size is kept the same while the resolution is reduced.
- d) In the lossy encoding method, it is usual that the compression ratio can be changed. However, there is a trade-off between quality and compression ratio.

Q3-11 b)

Explanation of virtual reality

Virtual Reality (VR) is also known as artificial reality. It refers to “information mediated by computers is used for having people experience and feel as though it is the real world.” In virtual reality, objects and space simulated with a computer are displayed by using computer graphics such that they create a perception of the real world.

As described in b), a world created in computers by using technologies such as CG and sensor is presented as the real world. I/O devices, such as an HMD (Head Mounted Display) that provides a stereoscopic view so that objects appear stereoscopic and a data glove that conveys the sensation of touching the objects, are used. It is used in education, training, medical treatment, and design.

- a) This describes “progressive JPEG” (Joint Photographic Experts Group) and “interlace GIF” (Graphics Interchange Format), which is one of the main image file format used on the Internet. When common GIF format image data is displayed, it gradually displays from the top to the bottom of the image while it is downloaded. However, in the interlace GIF, the entire screen first appears in mosaic form, and it gradually becomes clear as the download progresses. Interlace means to weave, and it originates from alternatively moving the scanning lines of display. Moreover, progressive JPEG is also a similar method of display, where even if the download is not complete, the view can get glimpses of the entire image.
- c) This describes simulation, which is one of the applications of virtual reality, but it is not appropriate as an explanation of virtual reality itself.

- d) This refers to VFX (Visual Effects), and it indicates the technique of synthesizing a real recorded subject matter by using computers. SFX (Special Effects) is similar or synonymous to this, but it refers to synthesis technique that does not use computers, and in other words, it is “special photographing.” In some cases, no distinction is made between VFX and SFX.

Q3-12 a)**Computer graphics**

When a shape in computer graphics is drawn, technology used for making the step-like jagged appearance near edges less noticeable is anti-aliasing. An image is displayed by changing the color of pixels constituting the image. However, pixels can only display the color corresponding to the assigned numeric value, and therefore the number of colors that can be simultaneously displayed is only one at maximum. Therefore, a boundary of two colors has a step-like jagged appearance, and it is necessary to assign intermediate color to make it less noticeable. This process is called anti-aliasing. Therefore, a) is the correct answer.

- b) Clipping refers to specifying a portion of an image for restricting the processing range.
- c) Shading refers to assigning shade for giving a three-dimensional appearance.
- d) Morphing is creating an intermediate image from images before and after the change so that the image changes smoothly.

Q3-13 d)**Explanation of relational database**

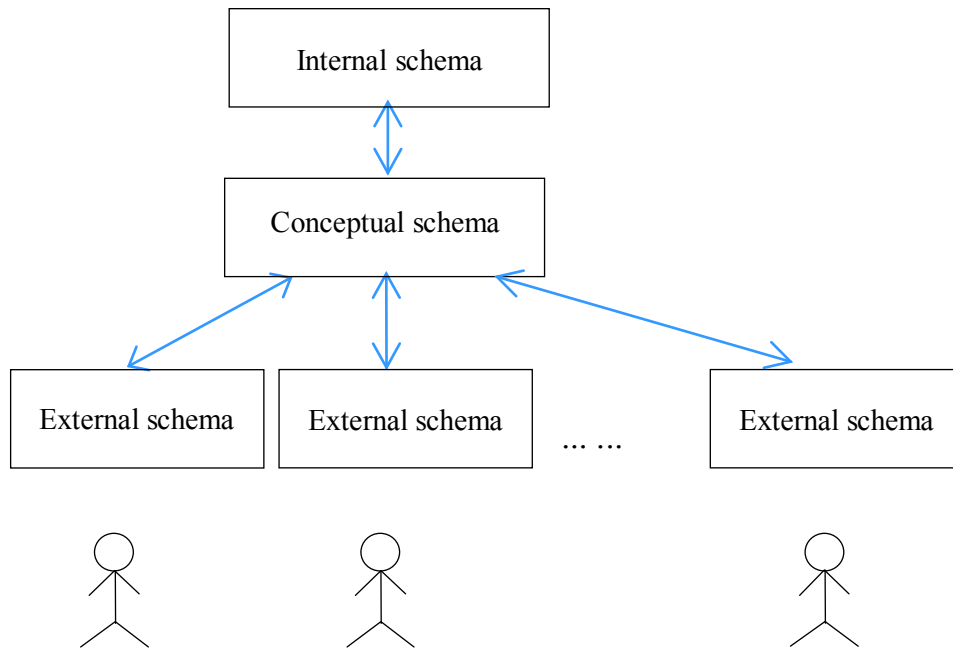
Database models are broadly divided into a relational model and structured model, and the structured model is further classified into a hierarchical model and network model. While the parent-child relationship in a hierarchical model is “1:n”, the parent-child relationship in a network model is “n:m” and it is also called the CODASYL model. Relational model represents the collection of data in several two-dimensional tables, and relation is represented by associating key items between these tables. Therefore, d) is the appropriate explanation.

- a) A hierarchical model database shows relation between data and the hierarchical structure.
- b) A list links the related data by using pointers, and rather than database, it is one of the methods of showing linked structures of data.
- c) An object oriented database (OODB) is formed by combining data and its operation procedure in the form of a database.

Q3-14 b)

Three-schema architecture of database

The three-layer schema architecture is composed of an external schema (a group of data items describing the required logical structure as seen from the viewpoint of an individual user), a conceptual schema (a group of data items describing the logical relation to be originally contained in the data), and an internal schema (a group of data items written in view of hardware, performance, recovery, and security). The relation between these three is shown in the figure below.



Logical data independence is achieved by separating the conceptual schema (which shows the logical relation of data) from the external schema (which shows the view desired by users). In specific terms, even when there is a change in the logical relation of data (addition or deletion of tables or data items), if this change is not related to the view of data desired by users, the schema is not affected by this change. Therefore, b) is the appropriate description.

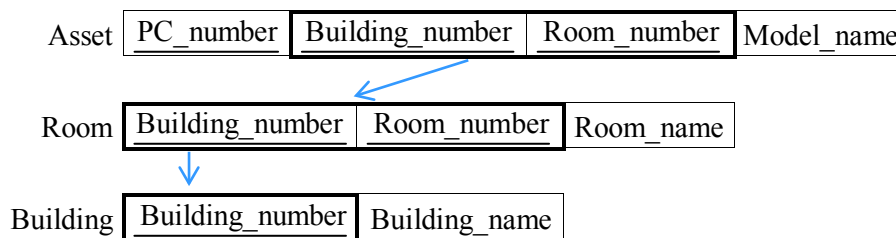
- a) As mentioned above, the three-layer schema architecture refers to external schema, conceptual schema, and internal schema.
- c) (Incorrect) Internal schema → (Correct) Conceptual schema
- d) (Incorrect) External schema → (Correct) Internal schema

Q3-15 b)

Sequence of data entry in table

This question is about referential constraints in a database. Referential constraint refers to the constraint that “when a value in a column of some table refers to another table, a column in the referenced table must also have that value.” In a relational database, the foreign key (an item that is used for association with another table, and that is the primary key of the referenced table) must maintain referential constraint with the primary key of the referenced table.

Here, first it is necessary to understand from the data items of a table how referential constraints are set. In the “Asset” table, PC_number, Building_number, and Room_number are the primary keys. It is required to check whether or not the combination of Building_number and Room_number actually exists in the “Room” table. Moreover, it is also required to check whether or not Building_number in the “Room” table exists in the “Building” table. Summarizing this gives the result shown below.



As the referenced data must be entered first, sequence of data entry in the tables is Building → Room → Assets. Therefore, b) is the appropriate answer.

Q3-16 c)

Primary key of a relational database

The field required for identifying each row is called the primary key, and in the same table no two rows have the same primary key. Therefore, c) is the appropriate answer. In other words, columns that have rows with the same primary value cannot be a primary key.

- Rows can be searched even if search conditions are specified for items other than the column identified as a primary key.
- Arithmetic operations can be performed on any column irrespective of whether it is a primary key or not.
- Multiple columns can be specified as a primary key. In this case, a primary key is also called a composite key.

Q3-17 c)

Third normal form

The outline of procedures until achieving the third normal form is given below.

- First normal form: Separate the repeated parts.
- Second normal form: Separate the attributes that are functionally dependent on the entire composite key (full functional dependency), and that are functionally dependent on only a part of the composite key.
- Third normal form: Other than key data, search the data that can become a key, and separate it.

Applying the tasks involved in this procedure to the answer choices, it is clear that the table in c) is in the third normal form.

- a) Employee_name is functionally dependent on Employee_number only, while Skill_name is functionally dependent on Skill_code only. Therefore, there is no relation between employee and skill.
- b) Employee_name is functionally dependent on Employee_number only, and just like a), conditions of the second normal form are not satisfied. In this situation, when one employee has multiple skills, the same combination of Employee_number and Employee_name is shown redundantly.
- d) There is only one item of Skill_years_of_experience for each employee, and years of experience for each skill cannot be recorded.

Q3-18 d)

Identifying the primary key from functional dependency

A primary key of a relation is a minimum set of attributes with which a tuple of a relation (called a row in SQL) can be uniquely identified. Minimum means that even if one attribute is removed from that set of attributes, it doesn't fulfill the role of a primary key. In other words, it indicates the minimal requirement.

- a) From the details of functional dependency of (1) through (7), it is clear that product number, product name, or quantity cannot be decided from order number only. Therefore, (Order_number) is not the primary key.
- b) Just like a), product number, product name, or quantity cannot be decided. Moreover, in the functional attribute (2), there is $\text{Order_number} \rightarrow \text{Customer_number}$. Therefore, Customer_number can be decided by Order_number, so it does not make sense to add Customer_number (excess or redundant). Although (Order_number, Customer_number) can uniquely identify a tuple, this combination is not minimum. It is clear that it is not the primary key.
- c) With these three attributes, all other attributes can be decided. However, just like b), as it includes Customer_number, it is not minimum, and it cannot be the primary key.
- d) According to the functional dependencies of (1) through (7), all attributes can be decided with (Order_number, Product_number) (identification and equivalent of tuple), and it is minimum. Therefore, it matches the definition of primary key, and d) is the correct answer. Moreover, by comparing with c), it should be kept in mind that the required quality of a primary key is "minimum."

Q3-19 a)

Operation of a relational database

In the operation of a relational database, retrieving the respective rows that satisfy the specified conditions from multiples tables, and then creating a new table (derived table) is called “Join”. Therefore, a) is appropriate.

- b) Project – Retrieving columns (not rows) that meet certain conditions from a table.
- c) Select – Retrieving rows (not columns) that meet certain conditions from a table.
- d) Insert – Inserting specific rows (not columns) in a table.

Q3-20 a)

Data manipulation not subject to referential constraints

Referential constraints are constraints concerning the integrity of reference relationship between tables in a relational database. In a relational database, for referring to an item in another table by using a foreign key, the referring item must exist in the referenced table.

In the three tables provided in the question, items referring to other tables as a foreign key (items indicated with a dotted underline) are Product_code and Customer_code in the Order table, and they refer to the Product table and the Customer table respectively.

- a) The “Customer” table is the referenced table, and new records can be added to this table without any constraints.
- b) The “Product” table is the referenced table, and when the records whose product codes exist in the “Order” table are deleted, constraints are applied.
- c) The “Product” table is the referenced table, and when product codes to be changed exist in the “Order” table, constraints are applied.
- d) As Product_code and Customer_code of the record to be newly added to the “Order” table must already be registered in the “Product” table and the “Customer” table respectively, constraints are applied.

Therefore, a) is the correct answer.

Q3-21 c)

Information that cannot be obtained from data

As one buyer may purchase multiple products, from “Daily sales data of sales agents,” “Daily variation in the number of buyers for each sales agent” cannot be obtained. Moreover, as the Date field is not present in “Product data bought by customers,” “Daily variation in the number of buyers for each sales agent” cannot be obtained. As both “Daily sales data of sales agents” and “Product data bought by customers” have Sales_agenc as a common field, it is possible to join the records in these tables where the Sales_agenc field has the same value. However, even after the daily sales data and product data bought by customers are joined, it is not possible to determine the daily number of buyers. Therefore, c) is the correct answer.

- a) “Daily variation in sales quantity for each product” can be obtained from Date, Product, and Sales_quantity in “Daily sales data of sales agents.”

- b) A single record can be created by joining the records in “Customer data” and “Product data bought by customers” that have the same value in the Customer field. Therefore, “Hot-selling products by gender” can be obtained from Gender, Product, and Sales_quantity.
- d) “Age distribution of the buyers for each sales agent” can be obtained from Customer, Date_of_birth, and Sales_agent.

Q3-22 b)

Description concerning SQL statements

Verifying the results of SQL statements a) through d) including set functions provided in the questions gives the following outcome.

- a) **AVG** is a function for calculating a mean value. Data in the first and the third record is applicable for Product_number NP200 specified in the selection condition, and calculating the mean value for this quantity gives $(3+1) \div 2 = 2$.
- b) **COUNT** is a function for calculating the number of applicable data records. As no specific selection condition is specified, all records are counted. Therefore, the outcome is 4.
- c) **MAX** is a function for calculating the maximum value. Calculating the maximum value of quantity gives 3.
- d) **SUM** is a function for calculating the total value. Data in the third and the fourth record is applicable for date 2006-10-11 specified in the selection condition. Calculating the total quantity for these records gives $1+2=3$.

Based on the above results, the maximum value is obtained in b).

Q3-23 b)

Correct SQL statement

When there is a **GROUP BY** clause in the inquiry, the selection list of the **SELECT** clause must be a column (arithmetic expression including that column) specified in the **GROUP BY** clause, or it must be a constant number or a set function. In other words, if there is a **GROUP BY** clause, only values representing a group can be specified in the **SELECT** clause. b) satisfies this condition, and it is the correct answer.

- a) Although set function is specified in the selection list of the **SELECT** clause, **GROUP BY** clause is not included in this inquiry. Therefore, this can be considered as one group. Set function of a value representing one (1) group is allowed, however, Order_date is not a value (one in this case) representing a group, and hence it cannot be allowed.
- c) There is an error here as the set function is nested.
- d) Since a set function is included in comparison predicate of the **WHERE** clause, there is an error. For specifying a set function, use the **HAVING** clause.

Q3-24 a)

Selection of SQL statement

As this “SQL statement is used to search for Department_code of departments that have less than five employees with the job duty of Programmer,” the retrieval conditions are as follows:

- (1) Employees with the job duty of programmer
- (2) Departments that have less than five employees falling under (1)

Normally, an SQL statement that joins the “Department” table and the “Employee” table by using Department_code can be considered, and then employees with a Job_duty of Programmer can be retrieved. However, only the “Employee” table is provided in the question statement. Therefore, as given in answer choices, let the “Employee” tables be S1 and S2, and S2 be the correlated subquery to be referred for one row of S1.

Here, “departments that have less than five employees with the job duty of Programmer” means that not only those departments that have one to four employees as programmer, departments with no employees as a programmer should also be considered.

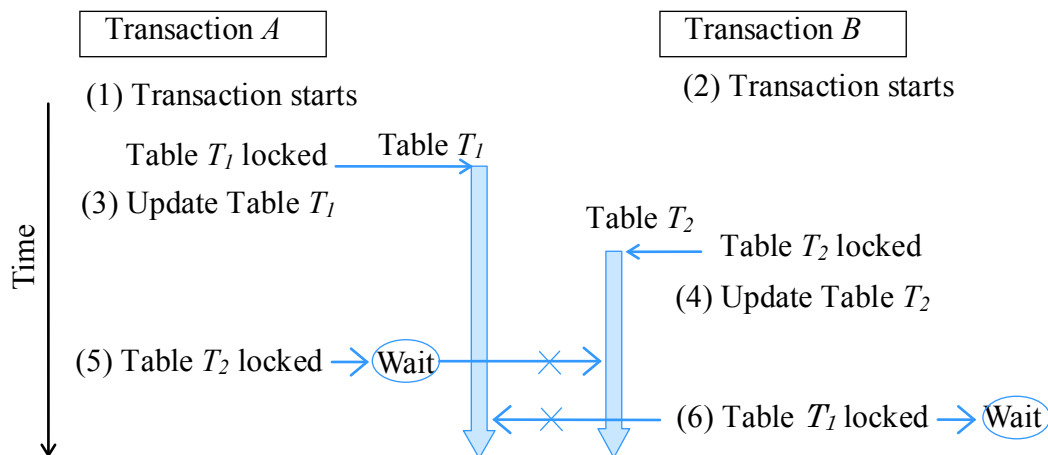
- a) S2 is referred to for one row of S1, and the number of rows of Employee_number that have the same Department_code and Job_duty of Programmer are tabulated with the COUNT function. As a result, the Department_code of rows that have less than five (including zero (0)) as an outcome is retrieved from S1. However, as a result of referring to S2, all rows that have the same Department_code are retrieved, and therefore the overlapping is removed with DISTINCT. Therefore, Department_code of departments that have less than five employees that have Job_duty of Programmer are searched for, and Therefore a) is the appropriate answer.
- b) With the same method as a), the number of rows where Job_duty is not Programmer is tabulated, and they are retrieved when the number of rows is over five. Having six or more employees who are not a programmer does not necessarily mean that there are less than five programmers.
- c) According to the conditional expressions in the GROUP BY clause and the HAVING COUNT clause, the table S1 is not narrowed down by job duty, and departments that have five or less and even one programmer are searched for under those conditions.
- d) Because the IN clause is used, S2 is referred to for one row of S1, and Department_code where Job_duty is programmer is retrieved, and in that if Department_code is the same as S1 then Department_code of S1 is retrieved. Therefore, departments that have no programmer are not searched for.

Q3-25 d)

Deadlock when a table is updated

Deadlock means when multiple transactions attempt to lock a shared resource, they mutually wait for the unlocking (releasing) of the resource locked by the other party, and they end up perpetually waiting. Key points in this question are: locking is done for each table just before update, and unlocking is done after the transaction is completed.

After the transactions start, Transaction *A* and Transaction *B* lock Table T_1 and Table T_2 respectively, and performs the update process ((3) and (4)). However, unlocking is done after the transaction is completed, and therefore the process continues with tables remaining locked. Prior to process (5), Transaction *A* attempts to lock Table T_2 . However, it is not able to lock as Table T_2 is being used by Transaction *B*, and Transaction *A* gets into the waiting mode (At this stage, Transaction *A* is in waiting mode, but deadlock hasn't occurred). Next, prior to process (6), Transaction *B* attempts to lock Table T_1 . However, it is not able to lock as Table T_1 is being used by Transaction *A*, and Transaction *B* gets into the waiting mode. At this stage (6), both Transaction *A* and Transaction *B* are in mutually waiting mode for resources, and deadlock occurs. Therefore, d) is the correct answer.



Q3-26 a)

Exclusive control of database

When a database record is being used by a transaction, exclusive control of a database is a function that restricts access to this database record by another transaction. In this exclusive control (lock), there is a “shared lock” and an “exclusive lock.” For example, when a record is used for reference purposes, it causes inconvenience if another transaction updates this record while it is being referred to. However, it does not cause any inconvenience even if it is simultaneously referenced by another transaction. In this case, a shared lock is used. In other words, although reference by multiple transactions at a time is permitted, update is not allowed. On the other hand, when a record is used for update purposes, it causes inconvenience if another transaction refers to this record during the process of update. An exclusive lock is used in such case. In an exclusive lock, the corresponding record is exclusively occupied, and even reference to the record is not allowed. Therefore, a) is the appropriate answer. Although shared locks may coexist, other combinations cannot coexist.

Q3-27 d)

Files for database recovery

A backup file is a file where the entire database of a certain point in time is saved. In the case of a media failure, once the media is recovered, by loading the contents of the latest backup file, it is possible to return to the point where the backup was taken. However, it does not return to the state when the failure occurred (down point). Log file (journal file) contains update history (information before update and information after update) for every data item, and therefore the information is recorded in chronological order. With this, the recovered database is updated to the point right before the down point. At that time, information after update is used. This process is called a rollforward process. Therefore, d) is the correct answer.

- a) Transaction file: This file contains update information (daily transaction information) of the master file.
- b) Master file: This file is maintained as a base file. Like a journal, this file contains the most basic information of operations.
- c) Rollback file: This file contains information before update for rollback. However, generally it is included in d) log file.

Q3-28 d)

Techniques of recovering transactions

For a database recovery process, a log is stored in the database management system. In this log, starting point of transaction, information before the data is updated, and information after update are recorded. Moreover, by setting the checkpoint and by generating the log, a transaction identifier (information for identifying the transaction) under execution is generated, and then changes made up to that point in time are written to the database. As the checkpoint is obtained when Transaction T is running, changes made up to obtaining the checkpoint are written on the database. Therefore, in order to restore the database to the point of right after the completion of Transaction T, it is necessary to re-run the process from the checkpoint recorded in the redo log until the completion of transaction, and then write the result to the database. Therefore, d) is the correct answer.

- a) A two phase locking (2PL) is divided into two phases, namely a phase where locks are acquired (growing phase) and a phase where locks are removed (shrinking phase). In the case that a transaction needs multiple locks, instead of locking and unlocking each time to maintain consistency, after the lock is applied, it is necessary to keep the lock until the writing is completed.
- b) Transaction scheduling decides the execution sequence of transactions and lock granularity so that deadlock or inconsistency of update does not occur. Two phase locking in (a) is also a type of transaction scheduling.
- c) Roll back is a recovery technique for the restoration of the database to the state prior to the transaction by using the undo log.

Q3-29 b)

Data mining

Data mining is a technique of uncovering semantic information such as underlying rules and relations in a large amount of historical data. For this, advanced mathematical techniques such as artificial intelligence and statistics are used, and it attempts to predict the future based on past data. As supporting tools for this, software programs equipped with a fast search function through a large amount of data and automatic rule detection algorithms are developed. Therefore, b) is the appropriate description.

- a) Although data mining is used as one of the fast search methods, it is not limited only to that.
- c) This describes data warehouse.
- d) This describes data mart which is a part (or subset) of data warehouse and is rearranged for each department.

Q3-30 a)

Transparency of a distributed database

Distributed database refers to distributing and keeping data in multiple locations, and it functions by mutual cooperation over communication lines. An application program that uses this database can use the entire distributed database as a single database without realizing the physical location of the data. Moreover, transparency of a distributed database means that data can be handled without knowing the storage location of data or other circumstances specific to the distributed database.

Databases reside on “multiple” servers and can be accessed “as if they are operating on one server.” This means that a) is the appropriate choice.

- b) An application program “needs not know” which server’s database should be accessed.
- c), d) A distributed database cannot exist “on one server.”

Q3-31 b)

Communication load between client and database server

An effective method for solving the problem of the communication load of SQL statements is to use a stored procedure function that involves storing typical processes of frequently used SQL statements in the database management system beforehand. Communication load between client and server can be reduced with this function. Therefore, b) is the correct answer.

- a) Redefinition of the index: Although it streamlines the database search, it does not result in the reduction of communication load of the SQL statements.
- c) Reorganization of the database: This is used when repetitive addition, deletion, and update of data lower the storage efficiency of a database. It is not a solution for reducing the communication load.
- d) Use of dynamic SQL: Dynamic SQL is one of the methods of embedded SQL. As SQL statements are still sent in this method, it is not an appropriate solution for reducing the communication load.

Q3-32 a)

Data buffering

As encoding speed and communication speed are represented in bits while size of audio data is represented in bytes, the conversion of everything in units of bytes gives the encoding speed of 8 Kbps and a communication speed of 6 Kbps.

The time required for encoding 1.2 Mbytes of audio data is $1.2 \text{ Mbytes} \div 8 \text{ Kbps} = 150 \text{ seconds}$. On the other hand, the time required for downloading is $1.2 \text{ Mbytes} \div 6 \text{ Kbps} = 200 \text{ seconds}$. Therefore, it is clear that the downloading time is 50 seconds longer than the encoding time. For playing back uninterruptedly, it is necessary to simultaneously complete downloading and encoding. For simultaneously completing both of these, 50 seconds of data buffering is required before the playback is started.

Therefore, a) is the correct answer.

Q3-33 a)

Calculation of bit error

A bit error ratio of 1/600,000 means that an error of one bit occurs in 600,000 bits. A transmission speed of 2,400 bps means that 2,400 bits are transmitted in one second. Therefore, the number of seconds required for transmitting 600,000 bits should be calculated. The required time is $600,000 \text{ (bits)} \div 2,400 \text{ (bits/second)} = 250 \text{ (seconds)}$. Therefore, a) is the correct answer.

Q3-34 c)

Role of DNS server in TCP/IP network

IP addresses used on the Internet at present are 32-bit binary numbers (for practical convenience they are shown by dividing them into four sections of 3-digit decimal number each) that are difficult for ordinary people to understand. Therefore, addresses using character strings called domain names are used. The mechanism for searching for an IP address from a domain name is called a DNS (Domain Name System). For example, it searches for the IP address from the domain name `www.abcdef.co.jp`. A DNS server is a server that has the function of a DNS, and therefore c) is the correct description.

- a) This describes the directory service that manages network resources.
- b) This is an explanation of NAT (Network Address Translation) and IP masquerade. Both are methods for effectively using the limited number of available global IP addresses.
- d) A DHCP (Dynamic Host Configuration Protocol) server has this function. Instead of allocating an IP address to the relevant computer in advance, a DHCP server automatically sets the IP address each time the client's computer requests it.

Q3-35 d)

NAT function of router used for Internet connection

By using the function that converts a private IP address to a global IP address and vice versa as described in d), a device that has a private IP address can access an external network (the Internet). The function that converts addresses in this manner is called NAT (Network Address Translation). Although NAT is divided into narrowly-defined NAT that assigns a global IP address to each device for accessing the Internet, and NAPT (Network Address Port Translation) that allows multiple devices to access the Internet with one global IP address, NAPT is also included in broadly-defined NAT.

- a) This is an explanation of the caching function of a proxy server.
- b) NAT is an address conversion function, and not a function that detects a bit pattern. In addition, a virus check performed by antivirus software is one of the typical examples of functions that detect specific bit patterns.
- c) This is the explanation of a firewall.

Q3-36 a)

10-Mbps LAN based on CSMA/CD

The access control method in CSMA/CD (Carrier Sense Multiple Access with Collision Detection) detects that the carrier is not passing through the transmission path, and then each node starts sending data frames. At this time, if multiple nodes simultaneously send frames, data may collide. The node that detects the occurrence of collision immediately stops sending frames and sends out a jam signal. After a random period of waiting (called back-off time), it is checked whether the carrier is passing through the transmission path, and if the carrier is not passing through, transmission of frames becomes possible. Therefore, a) is correct.

- b) In the case of CSMA/CD, time-division multiplexing of the transmission path is not performed. When frames can be sent, they are sent at the rate of 10 Mbps.
- c) The access control method that involves obtaining tokens is a token passing method.
- d) Transmission method where timeslot is defined for each device, and then data is sent according to the time slots defined is TDMA (Time Division Multiple Access).

Q3-37 c)

Device for interconnecting LANs at the physical layer

When LANs are interconnected, there are predefined devices according to the connection function. For interconnecting LANs at the physical layer (Layer 1) of the OSI basic reference model, c) Repeater is used.

- a) Gateway – A device that supports all protocol conversion functions from Layer 3 and above up to Layer 7.
- b) Bridge – A device that establishes an interconnection at the data link layer (Layer 2).
- d) Router – A device that establishes an interconnection at the network layer (Layer 3).

Nowadays, a hub is widely used for connecting a computer to a LAN, and for interconnecting LANs. However, the hub here indicates a repeater hub equipped with an amplification function at the signal level just like a repeater. In addition to this, like a bridge, there is a switching hub that is equipped with a filtering function based on a MAC address.

Q3-38 c)

Description concerning inter-LAN connection devices

By connecting two LANs, it is possible to create another LAN that has even wider coverage. In this case, the required devices differ depending on the function level of the layer of the OSI basic reference model where the connection is established.

A repeater establishes a connection between segments at the physical layer. The signal is amplified at the bit level, and no specific data identification is done. It merely extends the transmission path. Therefore, c) is the appropriate answer.

- a) A gateway establishes an interconnection between networks that have different protocols in Layer 4 through Layer 7.
- b) A bridge uses the address (MAC number; Media Access Control number) used by the data link layer (Layer 2) to determine whether that packet should be allowed to pass or not (filtering), and enables regenerative relaying.
- d) A router sets the relaying path for data (routing) in Layer 3 based on the IP address.

Q3-39 a)

Specifications newly added or changed in IPv6

An IP address of IPv4 (Internet Protocol version 4) is 32 bits long. Growth in the number of Internet users resulted in the problem of an insufficient number of IP address, and therefore IPv6 is standardized as the next version of IPv4. In this IPv6 (Internet Protocol version 6), the bit size of an IP address is changed from the 32 bits of IPv4 to 128 bits, and therefore a) is the correct answer. In addition, IPv6 is further expanded so that automatic acquisition of IP address, security setting functions for authentication and encryption, and specifying the path at the starting point can be used as standard functions.

Q3-40 a)

Obtaining MAC address from IP address

A protocol for obtaining MAC addresses from IP addresses is the ARP (Address Resolution Protocol) stated in a).

In ARP, the host that wants to get a MAC address sends an ARP request packets containing its known IP address to be inquired to the entire LAN. Every host that receives this ARP request determines whether it is meant for its own IP address, and the host where the APR request matches with the host's IP address returns the ARP response packet containing the MAC address. The MAC address obtained by APR is cached for some time; however, old information is automatically deleted. In addition, the protocol used for obtaining an IP address from its known MAC address is RARP (Reverse ARP).

- b) DHCP (Dynamic Host Configuration Protocol) is a protocol for automatically allocating an IP address when the client is started.
- c) ICMP (Internet Control Message Protocol) is a protocol for determining and providing notification of failures such as an IP packet not reaching its destination.
- d) NAT (Network Address Translation) is a technique for one-to-one inter-conversion of private IP addresses and global IP addresses.

Q3-41 b)

Calculation of network address

In an IP address, the section of digit 1 in the subnet mask is the network part, and the section of digit 0 is the host part. Writing the subnet mask of “255.255.255.240” in binary number gives the following:

IP address	11001000	10101010	01000110	00010011
Subnet mask	11111111	11111111	11111111	11110000
Network address	11001000	10101010	01000110	00010000

An AND operation on an IP address and a subnet mask gives a network address, which in this case is 200.170.70.16. Therefore b) is the correct answer. In addition, in the case of this subnet mask, only the last eight bits are required to be calculated.

Q3-42 c)

Address class of IP address

This question is about IP addresses.

By looking at the bit pattern of the first three bits in an IP address, it is possible to identify the class. An IP address where the first three bits are 000 is Class A, 100 is Class B, 110 is Class C, and 111 is Class D. Class D IP addresses are also called multicast addresses, and they are specially used for simultaneous communication between specific participants only.

Based on the aforementioned bit patterns, the first three bits of the IP address starting with 192 are 110, which is Class C. Therefore, c) is the correct answer. Moreover, in this question, in the list of IP addresses, a private IP address is also provided as an example.

- a) In a Class A IP address, the first three bits must be 000. Therefore, this does not match with 192.168.10.10, where the first three bits are 110.
- b) In a Class B IP address, the first three bits must be 100. Therefore, this does not match with 192.160.10.10, where the first three bits are 110.
- d) In a Class D IP address, the first three bits must be 111. Therefore, this does not match with 192.160.10.10, where the first three bits are 110.

Q3-43 a)

Protocol that dynamically assigns IP address

The protocol that efficiently manages IP addresses by dynamically allocating IP address in a TCP/IP network is a) DHCP (Dynamic Host Configuration Protocol).

DHCP dynamically assigns IP address to the relevant clients when the client is started or when there is a request for the assignment of an IP address, and recovers the assigned IP address when it is shutdown. By dynamically setting network parameters in this way, even if the computer is moved to another sub-network, it can be used without taking the settings of network parameters into consideration.

- b) HTTP (HyperText Transfer Protocol) – Protocol for exchanging files, such as HTML files, between a Web server and a Web browser
- c) LDAP (Lightweight Directory Access Protocol) – Protocol using the directory service that manages information about the environment and e-mail addresses of Internet users
- d) SNMP (Simple Network Management Protocol) – Protocol that manages a network and defines the method for data exchange between the management system and network devices under the scope of management.

Q3-44 d)

Upper-layer protocol of IP

As IP falls under the network layer of the OSI basic reference model, the transport layer above it should be considered. The transport layer achieves communication between applications (processes) residing on different hosts. Although the transport layer has protocols such as TCP and UDP, the connectionless protocol where flow control, sequence control, and establishment of connection are not performed is UDP (User Datagram Protocol) in d).

Although the reliability of UDP is low, it is easy to implement and offers high speed service, and therefore it is used for real-time applications of video and audio such as Internet broadcast and Internet telephony, and applications that exchange a small amount of data intermittently.

- a) ICMP (Internet Control Message Protocol) – In the case of an error in a router or a host, this protocol provides notification of the error status to the source. It works in the network layer of the OSI basic reference model.
- b) PPP (Point to Point Protocol) – This protocol located below IP connects two sites over a WAN in a multi-vendor multi-protocol environment, and works in the data link layer of the OSI basic reference model.
- c) TCP (Transmission Control Protocol) – This is a highly reliable protocol for an application that continuously handles large amounts of data. Like UDP, it works in the transport layer of the OSI basic reference model; however, it establishes a physical connection and has the functions for acknowledgement and sequence control.

Q3-45 d)

Network management protocol of TCP/IP

The network management protocol used in the TCP/IP environment is d) SNMP (Simple Network Management Protocol). Information about the failure of devices connected to the network and about the connection can be tracked, and the load on each device can be monitored based on the amount of data sent and received.

- a) NNTP (Network News Transfer Protocol) – This protocol is used for reading and posting articles on the Netnews where in-group discussions are held on the Internet, and groups are formed for each of the specific topics.
- b) NTP (Network Time Protocol) – This protocol is used to adjust the internal clock of a computer by accessing a server located on the network and obtaining the correct time.

- c) SMTP (Simple Mail Transfer Protocol) – This protocol is used for the exchange of e-mails between mail servers. Moreover, e-mails are forwarded from the client to the server by using SMTP. However, for delivering e-mails to the client from the mail server, other protocols such as POP and IMAP are used.

Q3-46 a)

Technology enabling virtual dedicated network

- VPN (Virtual Private Network) is a technology that uses authentication technology and encryption technology so that a public line can be used like a virtual dedicated line. Originally, it was technology for using telephone lines, but as Internet connections became commonly available IP-VPN was designed for usage on the Internet, which is a public network. Its advantage is the cost reduction compared to actually building a dedicated line. Therefore, a) is the correct answer.
- b) IPv6 is the latest standard of the IP protocol used on the Internet. The IP protocol widely used at present is IP version 4 (IPv4), and it is composed of 32 bits. However, due to rapid growth in the number of Internet users, there were concerns that IP addresses would be exhausted. Therefore, IP version 6 (IPv6) was formulated for solving this problem. Since IPv6 is composed of 128 bits, it allows the use of an enormously large number of IP addresses in comparison with IPv4. In addition, packet encryption and authentication of packet sender are provided as standard functions.
 - c) PBX (Private Branch Exchange) is a private branch exchange used in companies. It is used for the connection between internal phones and between public line and internal phones.
 - d) VoIP (Voice over Internet Protocol) is a technology that implements the so called “Internet phone,” where audio is converted into digital data and stored in IP packets for communication. Special tools are required for using it, and in many cases, the counterparties that can be dialed are also restricted. However, since a normal IP network is used, communication charges are less expensive and independent of talking distance.

Q3-47 b)

Session management in a system that is using browser

The HTTP protocol basically releases a session in a one-time data transaction. Therefore, with the information specified, it is difficult to quickly change the contents of the next webpage. In order to solve this, the Web server transfers the data for user identification to the browser, and by presenting this data to the Web server when the browser accesses the Web server again, the Web server identifies that access is from the same user and can provide a series of services. The mechanism that enables this process is b) Cookie.

- a) CGI (Common Gateway Interface) is an interface that runs a program (CGI program) prepared on the Web server based on the browser’s request, and transfers the results to the browser. While a normal webpage is a static file, dynamically created webpages can be delivered with CGI.
- c) SSL (Secure Sockets Layer) provides safe communication that is encrypted. It allows the exchange of private or money-related information on the Internet without allowing another person to access this information.

- d) URL (Uniform Resource Locator) is a description method for indicating the location of information resources on the Internet, and it consists of protocol name, domain name, and file path.

Q3-48 c)

Explanation of SMTP

SMTP (Simple Mail Transfer Protocol) is a protocol for forwarding e-mails on the Internet. It is used when e-mails are forwarded between mail servers and when a user sends an e-mail to the mail server. Moreover, when the user receives e-mails from the mail server, the protocol known as POP is used. Therefore, c) is the correct answer.

- a) This describes HTTP (Hyper Text Transfer Protocol). When a URL which is a Web site address is specified, the “http://” at the beginning of the URL indicates this protocol.
- b) This describes DTP (Desk Top Publishing). DTP is the task of creating and editing block copy of publication matter on a computer or a workstation, and the printing it with a printer or an image setter. Data to be handled can also be a combination of characters, diagrams, and photographs.
- d) This describes a document description language also known as a markup language. Using commands called tags enclosed with < >, the document structure and layout other than characters can also be specified. Some markup languages are as follows:
 HTML (Hyper Text Markup Language)
 SGML (Standard Generalized Markup Language)
 XML (eXtensible Markup Language)

Q3-49 b)

Explanation of ADSL splitter

A splitter is a device that separates and combines an audio signal and data signal in a high speed digital communication service such as ADSL that uses subscriber phone lines (copper lines). It is installed at the both ends of a telephone line (switching center and telephone subscriber). In ADSL, as audio signals and data signals pass through the same line, noise is mixed and this slows down the transfer rate. Therefore, by using a splitter, incoming signals are separated into signals for telephone equipment and signals for an ADSL modem. On the other hand, a splitter combines outgoing signals and passes them through the telephone lines. Therefore, the answer is b).

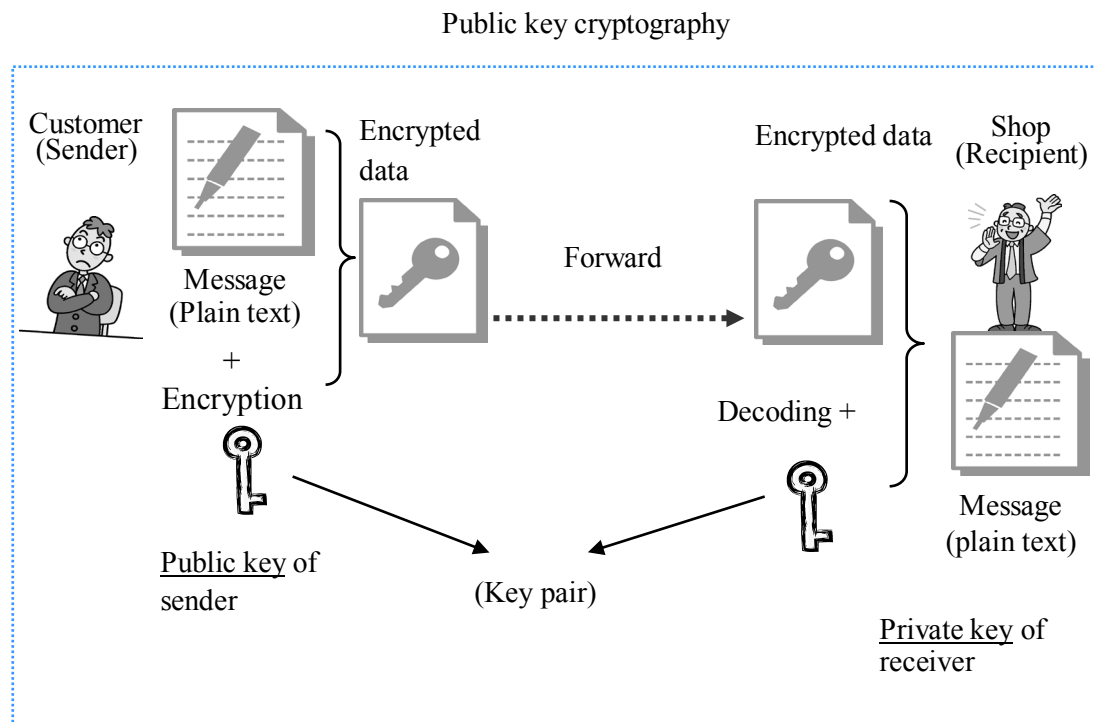
- a) A splitter is connected to a telephone line.
- c), d) As described earlier, the only function of splitter is the separation and combination of signals. It is not the ADSL transmission device, and it does not have any error correction functions.

Q3-50 c)

Combination of keys in public key cryptography

Public key cryptography forms a pair of keys: a public key and a private key, and shares public keys with multiple senders. The private key is kept confidential by the recipient. While data is encrypted with the public key, the encrypted data is decoded with the private key.

In this question, when the shop receives orders over a network, customers use a public key, and the shop uses the private key. This method is safe because even if wiretapping is performed by a third party, only the party (shop) that has the private key can decode the data. Therefore, c) is the correct combination.



Typical public key cryptography: RSA (Rivest Shamir Adleman)

Q3-51 a)

Purposes of using digital signature for communication

In a digital signature, the sender attaches a signature created by signing with plain text (refers to unencrypted data), which allows the recipient verify the sender. A signature is an encrypted message digest created from the plain text, and therefore, if the plain text differs, the message digest also differs.

There are two purposes of using a digital signature.

- Personal authentication function: The sender encrypts the data with his or her own private key (signing key), and if the recipient can decode it with the public key of the sender, the recipient can verify the sender. Only the sender, who creates the pair of public key and private key, can encrypt so that the encrypted data can be decoded with the public key of the sender.

- Message authentication function: If the message is altered, the message digest created from it is different from the signed message digest. Therefore, it can be checked whether the message has been altered or not after the signature is added (for the purpose of preventing the message from falsification).

Therefore, a) is the correct answer.

- b) From the mechanism of the Internet, neither wiretapping of the message itself can be detected, nor can it be prevented. Therefore, it is not possible to check whether someone else read the message or not.
- c) Although a digital signature's objective is user authentication, it is not used for checking the ID of the sender.
- d) As the sender is required to confidentially preserve the private key, it is not possible for the recipient to check whether to return it or not.

Q3-52 d)

Handling keys in public key cryptography

In public key cryptography, the encryption key and the decryption key are different, and data is kept confidential only with the decryption key. Thus, it is common to publish the encryption algorithm. Therefore, d) is the appropriate description.

Moreover, as public key cryptography ensures that data is safe from code-breaking, the key is large at about 500 bits, and therefore the encryption and decryption speeds are much slower compared with secret key cryptography. However, it has the advantage that when only one person is required to receive the communication among n number of unspecified users, this can be easily achieved with one decryption key (private key).

Q3-53 d)

Protocol for enhancing the confidentiality of e-mails

Protocols for enhancing the confidentiality of e-mail content by encrypting the e-mails before they are sent include PGP (Pretty Good Privacy) and S/MIME (Secure Multipurpose Internet Mail Extensions). Therefore, d) is the correct answer. However, just like normal e-mails, SMTP and POP are used for sending and receiving e-mails that are encrypted with PGP or S/MIME.

The meanings of the other terms are as follows:

- a) IMAP4 (Internet Message Access Protocol version 4) – This is a protocol that is used for receiving e-mails stored in the mailbox of the mail server.
- b) POP3 (Post Office Protocol version 3) – Like IMAP4, it is a protocol for receiving e-mails stored in the mailbox of the mail server. In POP and IMAP, the method of management for the received e-mails is different. In other words, in POP, all e-mails are downloaded to the client, and therefore e-mails are managed by the client. However, in IMAP, e-mails are not downloaded on the client; rather they can be managed by the server.
- c) SMTP (Simple Mail Transfer Protocol) – The protocol for sending e-mails from the mail client to the mail server, and exchanging e-mails between mail servers in the TCP/IP network.

Q3-54 a)

Purpose of using message digest

This question concerns a message digest.

The concept of a message digest is slightly different from what is generally called a digest. A completely different digest value is generated even if one bit is different, and it is used for checking in the case of falsification. Therefore, the description of a) is about a message digest. MD5 and SHA-1 are two famous algorithms for this, and in MD5, a digest value of 16 octets is generated, while in SHA-1, a digest value of 20 octets is generated.

As a message digest is widely used in combination with encryption technology for secured communication, it is often confused as an encryption technology. However, it should be remembered that “encryption is for hiding” and “message digest is for detecting falsification.”

- b) This describes negotiation. Prior to the communication stage, adjusting both ends for encryption technology and encoding method is called negotiation. In SSL (Secure Sockets Layer), negotiation of encryption specifications is performed, while in IP phones, negotiation of the CODEC is performed before actual communication.
- c) This describes what is commonly known as a digest.
- d) This describes encryption, and it is not related to the prevention of falsification.

Q3-55 c)

Authentication between two communication entities

In Procedure (1), *Y* does not know whether the receiver is *X* itself or not.

In Procedure (2), *X* does not know whether the character string sent is from *Y* or not. However, *X* generates a new character string based on the rule decided with *Y* beforehand, and returns it to *Y*. *Y* already knows the rules that enable *Y* to read this newly generated character string.

In Procedure (3), *Y* decodes the returned character string based on the rule decided with *X* beforehand, and checks that the contents are correct. If the contents are correct, it means that *X* is the genuine other party with whom the rules were decided beforehand and therefore *Y* can authenticate *X*.

In this case, it is important that the “rule decided between *X* and *Y*” is not known to a third party. Therefore, *X* usually has a private key available only to *X*, and *Y* has a key (public key, or private key) that can decode information that is encrypted by *X*.

In this procedure, *X* merely receives “character strings including random information” from *Y*, and does not receive any other information about *Y*. In other words, *X* cannot authenticate *Y*.

Therefore, “c) *Y* authenticates *X*” is the correct answer.

Q3-56 d)

Authentication methods for remote access

Internal systems can be remotely accessed from outside with different methods such as using public lines like analog telephones and ISDN, and accessing over the Internet. In either of these methods, there is a threat of unauthorized access by spoofing. Therefore, authentication is performed to check that genuine user is accessing the system.

The most basic authentication method is authentication with user ID and password. User ID and password are registered in an internal system beforehand, and authentication is performed at the time of remote access. In the usual authentication that is based on fixed passwords, leakage or theft of a password may result in unauthorized access by spoofing using this password. Therefore, as a measure for strengthening the password authentication method, a one-time password method where password can be used only once, was designed. As the authentication information circulating on the channel is of the use-and-throw type, it cannot be reused even if it is intercepted. For generating authentication information, there is the challenge response method that uses a random number, and there is the synchronization method that synchronizes counter data, which creates authentication information. A one-time password can be effectively used on public lines as well as the Internet. Therefore, d) is the correct answer.

- a) Registration of the IP address of permitted PCs in advance, and allowing communication from only registered addresses while denying any communication from other devices is effective for the enhancement of security. However, it does not result in enhanced authentication of PC users if their PCs are fraudulently acquired.
- b) In call back, during remote access over a public line, an internal system disconnects the communication at once, and then reconnects by making a call to the number of the remote device registered in the server. Although it strengthens communication, it is not applicable to remote access over the Internet.
- c) This does not result in enhanced authentication because there is a possibility of obtaining the user ID by illegitimate means that lead to unauthorized access by spoofing.

Q3-57 b)

Characteristic of security protocol SSL

SSL (Secure Sockets Layer) is a security protocol developed by Netscape Communications Corporation of the United States for ensuring safe HTML communication. Nowadays it is implemented in major Web browsers and Web servers as a standard function, and SSL is easily available for use. In a Web server using SSL, by embedding the digital certificate in its own FQDN (Fully Qualified Domain Name, complete URL), it can be checked to determine if it matches the URL requested by the Web browser. Therefore, b) is the correct answer.

- a) In TCP/IP, SSL exists in the application layer, while in the OSI basic reference model it exists in the session layer. In addition to Web servers, it is also implemented in FTP and TELNET.
- c) The certificate used in SSL can be stored in the file format by exporting it in a Web browser. For example, in Internet Explorer, this can be done by exporting the certificate in the Contents tab under the Internet Options menu. Moreover, by importing this file, it can also be used in other computers.
- d) SSL is an industry-standard security protocol on a global scale, and there is no restriction that 128 bits can be used only by governmental institutions.

Q3-58 d)

Act corresponding to social engineering

Social engineering refers to the act of using physical means to obtain the required ID and password for unauthorized access to network systems. It also includes the acts of impersonation and obtaining important information about a company or an organization from paper waste. Therefore, d) is the correct answer.

- a) Examples of types of attacks on a security hole in an OS (security flaws and vulnerabilities arising from software design error) include DoS attack (attacking the devices constituting the network, for interrupting the provision of services, and it is also known as denial of service attack and suspension of service attack) for system shutdown and taking control of privileges by command injection (Administrative rights are obtained by entering from the security hole of an OS. All resources can be accessed).
- b) The creation of a virus has nothing to do with social engineering.
- c) In a dictionary attack, character strings listed in a dictionary are encrypted with the same method as that used when a password file is created. After the dictionary entry which fully matches with these results is found, the original password is identified by looking for items that match these results.

Q3-59 d)

Phishing

Phishing is a fraudulent act of illegitimately obtaining personal information by using a fake e-mail that appears to be that of a real financial institution or online shopping Web site. With the URL noted in an e-mail sent to multiple unspecified recipients, recipients are tricked into visiting a fake Web site that looks exactly like the Web site of the actual company. If the user does not notice that the Web site is fake and enters his or her personal information such as login ID, password, name, address, and credit card number, this information is sent to the phishing source. Therefore, d) is the correct answer.

- a) This refers to cross-site scripting. Script not allowed by a user is automatically executed, resulting in the risk of leakage of cookies.
- b) This is unauthorized access through a backdoor. The backdoor itself is a window for unauthorized access, and it may be automatically set up due to virus information, or it may be created through manual operation by a cracker (an intruder).
- c) This refers to spyware. It is software that runs in the background without the user's knowledge, and collects personal information and the computer usage pattern of a user and then sends them to a marketing company or the person who developed the spyware. Generally, it is embedded when some kind of application software is installed. Usually, the user's permission for installation is obtained at that point in time, so it is not necessarily illegal. However, as there are few users who carefully read terms and conditions, this itself is regarded as a problem.

Q3-60 b)

Pattern matching method of antivirus software

Pattern matching methods of antivirus software compare and check the program with known viruses to detect the presence of a virus. A signature code refers to the fingerprint of a computer virus, and it is a unique code that exists in specific computer virus. Therefore, antivirus software can identify and detect viruses from these signature codes. Therefore, b) is the appropriate answer.

- a) A virus cannot be detected just by a comparison of files before and after infection to check if any changes were made.
- c) A method for the detection of a virus by monitoring abnormal phenomena attributable to the virus is not a pattern matching method. Moreover, antivirus measures fall behind the curve in this method.
- d) Matching with the checksum of a file is one of the methods known as generic detection, and it is used as a means for the detection of suspicious programs and unknown viruses. Therefore, it is different from the pattern matching that can specifically identify known viruses, and it is not generally used as antivirus software like option b).

Q3-61 d)

Role of risk analysis in security measures

Risk means “possibility of occurrence of event that interferes with the performance of corporate activities and the results of such interference.” In risk analysis, the possibility of occurrence of a security failure and its impact on information assets is evaluated. In other words, the extent of the loss is obtained as an outcome of risk analysis along with the frequency of occurrence. Therefore, d) is the correct answer.

- a) Vulnerabilities are obtained as an outcome of the security process.
- b) Implemented security controls are obtained as an outcome during the implementation of security measures.
- c) Security specifications are obtained as an outcome of the formulation of a plan for security measures.

Q3-62 d)

Steps of implementing security management system of JIS Q27001:2006

JIS Q 27001:2006 describes the requirements to be satisfied when information security management system (ISMS) is implemented in the organization. In this, it is mentioned that to build the system, an organization should follow the six main steps described below.

(1) Define the ISMS policy of the organization.

(2) Define the scope of ISMS.

(Note: Scope is a concept that includes applicable range and objectives)

(3) Risk assessment (evaluation)

(4) Risk management

(Note: Management here refers to the act of identifying potential risks that may arise and their resolutions)

(5) Select the controls to be incorporated and describe the target of these controls in detail.

(Note: Controls indicate methods and means of regulation)

(6) Prepare a Statement of Applicability (SOA).

Option d) describes this sequence, and therefore d) is the correct answer.

Q3-63 b)

Information security policy in ISMS conformity assessment scheme

In the ISMS certification standards (Ver. 2.0) used in the ISMS conformity assessment scheme, under the basic policy of information security in the annex “Detailed Controls,” the control objective described is “To provide management direction and support for information security.”

This basic policy of information security is also called information security policy, and therefore b) is the appropriate description.

- a) Information security measures should be implemented company side, and its basic policy (security policy) should be informed everyone in the organization.
- c) ISMS should be built, implemented, and maintained as a management system, and it should be continuously improved. Basic policy (security policy) should also be periodically reviewed, and it should be continuously improved for optimizing its contents in accordance with changes in business environment and technologies.
- d) Information security policy sets the overall direction and principle concerning information security in the organization, and it is not a detailed description of a particular system.

Q3-64 d)

Response procedure in the event of occurrence of security failure

In case of detection of unauthorized access to a Web server from an external location, in order to prevent the damage from spreading, it is necessary to promptly disconnect the Web server from the network. A description of this is provided in (3).

Next, a survey should be conducted to determine the extent of damage. In concrete terms, each log of the server, IDS (Intrusion Detection System), and firewall should be analyzed, and the intrusion path and method as well as the range of the unauthorized access should be identified. This is noted in (1).

Next, the damaged area that was identified should be reinforced, and the network reconstructed. Especially, the intrusion path is the area that does not have adequate security, so it is necessary to take adequate measures henceforth. In concrete terms, the latest patches and security setting information that are revised based on the damage should be applied. With regard to the Web server also, falsified content and the damaged area should be restored. This is mentioned in (2).

As per the aforementioned procedure, the network should be reconstructed, and the Web server that is now safe should be connected to the network. Since the intruder may attempt unauthorized access again if security is not adequate, temporary monitoring should be strengthened and the situation should be closely watched. This is noted in (4). Therefore, d) is the correct answer.

Q3-65 a)

Human act of wrongfully obtaining the confidential information

Instead of using electronic methods, the act of illegitimately obtaining a password or other confidential information using administrative deficiencies attributable to human behavior, or deficiencies in physical security is called a) social engineering. For example, it includes acts such as, feigning the identity of the user and making the request to the system administrator such as “I forgot my password so please tell me it because I am working on something very urgent” to obtain the password, or pretending to be the system administrator and asking the user to give his or her password. In addition, shoulder surfing, which means covertly looking over someone’s shoulder when he or she is entering his or her password with a keyboard, and scavenging, which means obtaining important information by recovering the discarded forms and other material from a dust bin are also social engineering.

- b) A Trojan horse is a form of computer virus. Although it may appear normal from the outside, it is an unauthorized program that executes a malicious code that functions as a backdoor and damages the system or leaks information. Like a worm, it does not self-diffuse, and it exists as an independent program without infecting other programs.
- c) Password crack refers to illegitimately analyzing a password with electronic methods such as a dictionary attack or a brute force attack.
- d) In the stepping-stone attack, instead of directly attacking the target, the attacker indirectly attacks through a network by using another site that has vulnerabilities. It attempts to hide the identity of the attacker.

Q3-66 d)

Measures for preventing theft of registered password

A hash value is a value of fixed length determined from the data assigned by a certain algorithm. The characteristics of the hash values are “If the original data differs, hash value derived from it usually differs, and the hash value is rarely the same,” and “even if the hash value and the hash function are known, the source data cannot be identified.” Therefore, if a password is converted into a hash value, the original password cannot be recovered from the hash value even if the password file is stolen, and hence d) is the correct answer.

- a) Covering a user ID with the hash function has nothing to do with password theft prevention.
- b), c) If the entire password file is stolen, fraudulent use of stolen passwords cannot be prevented, and unauthorized users cannot be kept out.

Q3-67 d)

Management approach for preventing falsification and destruction of data

In order to maintain the convenience for users whereby they can continue sharing a program, setting access restrictions for data processed by the program is an effective management approach for preventing falsification and destruction of the data. Therefore, “d) Setting of access rights for files” is the appropriate preventive measure.

- a) Taking an access log is certainly useful to ascertain whether unauthorized execution of a program occurred based on access records, and also for the recovery of damaged data with the update journal, but it cannot prevent damage to the data.
- b) As the program itself may be altered and it may be executed illegitimately, “Comparison of the source program and the executed program” is helpful in ascertaining the cause of damage, but it cannot prevent damage.
- c) Storing source programs in multiple locations certainly acts as an antitheft measure for the source programs, but it cannot prevent damage.

Q3-68 d)

Explanation of Web beacon

Web beacon refers to an image embedded in e-mails of HTML format or webpages to collect the access information of users. Therefore, d) is the correct answer. Usually, it is a very small image which is not noticed by users. If users access the Web site or e-mail where a Web beacon is embedded, a server is accessed to fetch that image data. The server records this access information, and secretly collects the access pattern of users.

Beacon actually means “indicator”. Since it is a very small image, it is also called a Web bug in many cases. This Web beacon is the subject of heavy recent criticism, and some e-mail programs can be set so that image files do not open during e-mail preview.

Q3-69 c)

Connection restrictions in a wireless LAN

In a wireless LAN, MAC address filtering restricts access by terminals not registered at the access point beforehand. A MAC address is a fixed physical address assigned to the NIC (Network Interface Card) of the terminal. Therefore, by registering the MAC address of the permitted terminal at the access point beforehand, the connection of unregistered devices can be restricted. Therefore, c) is the correct answer.

- a) AES (Advanced Encryption Standard) – This is an encryption algorithm that uses common key cryptography.
- b) IEEE 802.11b – It is a communication standard for a wireless LAN that uses the 2.4GHz band. There is no access restriction for each terminal.
- d) TKIP (Temporal Key Integrity Protocol) – It is a protocol that enables encrypted communication and detects the falsification of frames in a wireless LAN.

Section 4

Development Technology

Q4-1 c)

Software requirements





Software requirements (also called functional requirements) are for the fulfillment of business requirements. In other words, software requirements are for the implementation of business processes in a business system. The definition of data is an important software requirement. Therefore, c) is the correct answer.

- a) The disk capacity of the development environment is a necessary system requirement for system operation. It is not a software requirement, and is defined as a non-functional requirement.
- b) The objectives of computerization are specified at the planning phase of the system.
- d) Database design is performed at the external design phase.

Q4-2 a)

Identifying notation

The notation used in the question is a) DFD (Data Flow Diagram). A DFD primarily describes functions (processes) and the flow of data among these functions. The symbols used are shown below.

Process	
Data store (file)	
Source (origin) or sink (destination) of data	
Flow of data among components (data flow)	

- b) A state transition diagram is a diagram for representing the events that cause changes in state, and their accompanying changes in state, for objects that can take one of several different states depending on the occurrence of events.
- c) A flowchart uses flowchart symbols to represent the flow of data and control.
- d) A Petri net represents the synchronization among functions that operate in parallel. The generation of water through the reaction of oxygen and hydrogen is shown below as an example.

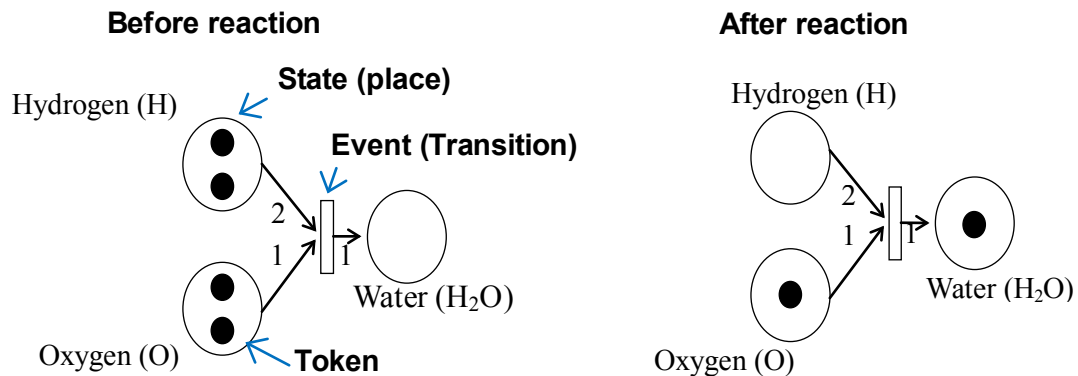


Fig. A Petri net model of the generation of water through the reaction of oxygen and hydrogen

Q4-3 c)

Code design for business systems

Appending a check digit to code allows the strengthening of code input checking. Therefore, c) is an appropriate statement.

- a) Actual assignment of code is generally performed by system users.
- b) The attributes and number of digits in a code must be designed with consideration of not only the internal processing efficiency of the computer, but also other factors, such as ease of use from a user perspective, commonality, systematization, and expandability.
- d) It is difficult to change the scheme of code once the code begins to be used. Therefore, it is necessary to fully consider maintainability and expandability at the time of design.

Q4-4 a)

UML standardized by OMG?

UML (Unified Modeling Language) is a modeling language that is based on an object-oriented approach. It is used in software development and was standardized by a body called the OMG (Object Management Group). Therefore, a) is the correct answer. In order to describe the details of analysis and design, UML has various diagrams such as use case diagrams, class diagrams, sequence diagrams, and state chart diagrams.

- b) This is a description concerning IDL (Interface Definition Language).
- c) This is a description concerning SQL (Structured Query Language).
- d) This is a description concerning SGML (Standard Generalized Markup Language).

Q4-5 d)

Target for modeling with use cases

As described in the question, a use case is “a technique that clearly describes the functional requirements of a system and defines interactions between a user (actor) and the system.” In UML, interactions between an actor and a system is modeled and expressed with use case diagrams. Use cases, which are constituent elements of a use case diagram, are used to signify operations performed by the system for providing services to the actor, and in a broad sense, use cases can be considered as a unit of function that is provided by the system. Recently, as UML has gained popularity, use cases have become common as constituent elements of a use case diagram. However, as described in the question, use cases are also known as a method or technique for clearly specifying the functional requirements of a system. In either case, use cases are used for the specification of the functional requirements of a system, and if the option that is related to the function of a system is chosen, the obvious choice is d). On the other hand, a) and b) are not implemented with a function of an information system, and c) is a processing method. Therefore, none of these choices are appropriate.

Q4-6 d)

Explanation of encapsulation in object-oriented approach

Encapsulation refers to unifying data and procedures related to it, and then concealing it inside an object. By encapsulation, only operations (methods) performed on the object are shown externally. Therefore, d) is the appropriate answer.

- a) Abstraction of multiple objects with common characteristics is called generalization (the opposite of which is specialization).
- b) Making the subclass (child class) inherit the characteristics of a base class (parent class, super class) is called inheritance.
- c) “Abstracting common characteristics between classes and creating a base class” is a description of generalization.

Q4-7 c)

Method for transmitting information with the weakest module coupling

Module coupling is a measure of interdependence between modules, and it is categorized into six types. Generally, the weaker the coupling, the better it is considered to be. Arranging in the sequence from strong to weak gives the following result. “No direct coupling” (7) means that there is no interdependence between modules, and it is the ideal form of relationship. However, this is very rare in practice, and therefore coupling is usually categorized into the following six types from (1) to (6).

- (1) Content coupling
- (2) Common coupling
- (3) External coupling
- (4) Control coupling
- (5) Stamp coupling
- (6) Data coupling
- (7) No direct coupling

Among these, in “data coupling” (6), which has the weakest module coupling, “only data items are passed as arguments between modules,” so the correct answer is c). In “stamp coupling” (5), when the pointer of a structure is passed as an argument, the receiving side will become aware of this data structure and use the required data.

- a) “Data defined in a common area is referenced by the relevant modules” corresponds to “common coupling” (2).
- b) “Control parameters are passed as arguments, and the execution sequence of modules is controlled” corresponds to “control coupling” (4). In this form, awareness of the internal logic of other modules is necessary, so module coupling strengthens.
- d) “Required data is shared through external declaration” corresponds to “external coupling” (3).

Q4-8 c)

Module having the highest module strength

Module strength is a measure of the strength of the connection between instructions in a module, and the stronger the connection (high strength), the better it is considered to be. “Functional strength” is required for a module to perform its unique function. In other words, all instructions are required to perform this one function. As the module with the highest “functional strength” is considered to be the best, c) is the correct answer.

As mentioned above, module strength is a measure of strength of the connection between instructions in a module. The objective of considering this measure is to increase the maintainability of a module. When one module has multiple functions, and if the connection between these functions is not strong, maintenance of the module becomes difficult (for example, the modification of one instruction may affect multiple functions). Therefore, modules that have a “single function” (functional strength) with a high strength are considered to be better.

With regard to other options in the answer group, a) includes multiple functions for identical data, so it is called “communicational strength.” As for d), it includes multiple functions performed simultaneously at a specific point in time, and it is called “classical strength.” Moreover, with regard to b), it is difficult to determine the strength from the description. However, data processing from different media means that the module has multiple functions, and therefore it cannot be said that its strength is higher than module c), which has a single function.

Incidentally, in addition to three types of strengths (functional strength, communicational strength, and classical strength) described above, there are four other types of module strengths. Each of them corresponds to the following modules.

- Coincidental strength: The function of a module cannot be defined. A large program is simply partitioned into modules with number of lines or another parameter as a guide.
- Logical strength: A module has multiple functions, and a function is executed in a selective manner according to the details of the function parameters.
- Procedural strength: A module that contains multiple functions defined in functional specifications.
- Informational strength: A module into which multiple functions that handle the same data are combined, and which has separate entry point names for each function (module name is separate for each function).

These seven strengths can be arranged in the decreasing order of strength (strong, desirable) as follows: functional strength, informational strength, communicational strength, procedural strength, classical strength, logical strength, and coincidental strength. Therefore, module partitioning that results in modules with functional strength and informational strength is desired.

Q4-9 a)

Review method of a design document

In system development, work is divided and assigned to multiple people, and these people work in parallel. If work is performed by the person in-charge only, assumptions or mistakes may cause incorrect results or deliverables. In order to prevent this, upon completion of each process, the person in-charge and other relevant persons get together and conduct a review to check the content of the work. A series of activities conducted by relevant persons reviewing the document or work in order to detect design errors as early as possible is called a) walkthrough. Furthermore, a review conducted under the guidance of a dedicated facilitator (called a moderator) to identify and analyze problems and consider measures for such problems is called an inspection.

- b) Desk checking: A debugging method where the developer himself traces instructions one by one with the assumed test data without running the program. Errors may be overlooked due to perceived notions.
- c) Top-down testing: A method for an integration test, where modules are integrated and tested in sequence from the upper level to the lower level.
- d) Parallel simulation: In a system audit conducted using a computer, an auditor prepares a test program for the audit with respect to a specific application, and performs verifications by comparing the simulation results obtained using the actual input data with the actual results generated by the production program.

Q4-10 a)

Situation that can be anticipated from bug control chart

As all three curves in the bug control chart given in the question remained at the same levels, the chart indicates that all three activities of test execution (number of test items not executed), bug detection (number of bugs detected), and bug resolution (number of unresolved bugs) have halted, and the test is not progressing. There could be multiple reasons for this, such as all members of the test team caught a cold or went on a company outing. However, if a selection is made from the answer group, as mentioned in a), it can be thought that the test team have discovered a bug that is difficult to resolve. For example, a functional bug that is related to all test cases not yet executed (remaining) has occurred, and unless this bug is resolved, testing cannot move forward, which leads to the situation described in the question.

In the typical form of the software reliability growth curve, the rate of bug detection is low immediately after the test starts. This is usually because tests have come across a critical bug that affects other tests. As is the case in this question, testing cannot move forward.

- b) Rather than the detection of many bugs, the reason that the execution of test items is not processed further could be that the number of unresolved bugs is not decreasing.
- c) The number of test items not executed is flat but it is not approaching zero. Therefore, it cannot be said that test is close to being completed.
- d) The fact that the number of bugs detected becomes equal to that of test items executed has no relation with the resolution of bugs.

Q4-11 b)

Black box test

The method for the design of test cases is divided into a white box test and a black box test.

A black box test is a test to check whether the program satisfies the functions in the design document without focusing on the internal logic of the program. It can also be said that this test is conducted from the viewpoint of a user. Equivalence partitioning and boundary value analysis are used for preparing test data. In this case, since focus is not on the internal logic of the program, even if there is unnecessary description (redundant code) in the program, it cannot be detected unless processing results are abnormal. Therefore, b) is the appropriate description.

On the other hand, a white box test is a test conducted based on the internal specifications of a program, and test data is prepared in consideration of the coverage of instructions, conditional decisions/branches, path combinations, and other factors. Description of a), c), and d) corresponds to the white box test.

Q4-12 c)

Combining test data of equivalence partitioning technique

This question is related to design methods for test data in a black box test. A black box test is a test that checks whether functions are executed correctly based on the external specifications without examining the internal specifications of a program.

For test data, equivalence partitioning, which is a design method for test data, uses the representative values of a valid equivalence class (which is valid data) and the representative values of an invalid equivalence class (which is invalid data). Here, since minimum test data is determined by taking one representative value from the invalid equivalence class of -2 to 0 , the valid equivalence class of 1 to 5 , and the invalid equivalence class of 6 to 8 . This means that a total of three representative values are selected as test data.

Therefore, c) $-1, 3, 6$, which satisfies this, is the appropriate answer.

Q4-13 c)

Verification test

In system modification during the maintenance phase, modifications that are made often adversely affect other functioning sections, and functions that were working normally before modification stop working correctly. Therefore, for the testing conducted after system modification, in addition to testing the modified section, it is necessary to check that functions that were working normally before the modification still work correctly. A test that verifies that such modifications do not lead to new errors in functions that were working correctly is called c) regression test.

- a) A function test is a test for verification that a system satisfies all the functions required by its specifications.
- b) An integration test is conducted after a unit test of each module is completed, and it verifies that modules are processed correctly when they are integrated.
- d) An exception test is a test for verification that when data other than the predefined data is processed, such data is processed as per specifications without abnormal termination.

Q4-14 b)

Test of interface verification

During the course of system development, tests are conducted in the sequence of unit test → integration test → system test → operational test. In b) integration test, programs are combined and verification of whether interfaces between modules and between subsystems, such as procedure and format of transferring data, are functioning correctly is performed.

- a) An operational test is a test where a user department takes the center stage and a test is conducted using the same system and data as the production environment. An operational test checks whether the new system can be effectively used for business operations.
- c) A system test is a test that verifies from several angles whether all programs for which an integration test is completed functions correctly as per the design document. For the entire system, function test, load test, performance test, and operability test are conducted.
- d) A unit test is conducted for individual modules. A unit test verifies whether a particular module is functioning properly and whether the logical structure of the program is correct.

Q4-15 c)

Substitute test module for a lower level module

In top-down testing, when a lower level module is not yet integrated (because it is not complete or not in the scope of test), a test module that is used as a substitute for such a lower level module is called a stub. Therefore, c) is the correct answer.

- a) An emulator is a mechanism that allows a computer to execute the program of another computer that has a different instruction format. It is normally implemented as software.
- b) Simulator refers to software or hardware that simulates all or a part of a computer system.
- d) In a bottom-up system, a driver is a test module used as a substitute of an upper level module not yet integrated.

Q4-16 a)

Tests conducted in system test process

- In software development based on the waterfall model, testing is conducted in the sequence of unit (module) test, integration test, system test, and operational test. a) Load test is conducted in the system test phase. In a load test, a load that is equivalent to or higher than the data processing volume at the peak time of operation is applied in order to verify that a system operates normally.
- b) Conducted in the integration test phase.
 - c) Conducted in the unit test phase.
 - d) A regression test is a test for checking whether modification of a program adversely affects any other parts than the corresponding function, and it is conducted in the maintenance phase.

Q4-17 a)

Test data to be prepared for system qualification test

A system qualification test, sometimes simply called as a system test, is conducted after a system developer has conducted a unit test and an integration test. Therefore, when it is required, users also participate in this test to check that the entire system is working as per the specifications. A system qualification test includes a function test to check whether all the required functions are included or not, a performance test to check the processing capacity (throughput) and response time, an exception processing test for error and data failure, and a load test to check that the system can handle large volume of data processing. The data used in actual operations and the data handled by exception processing are also required, so a) is the correct answer. In addition, a system qualification test also includes an operability test to check usability for users. Also, the term “system qualification test” is one of the processes of Common Frame 2007 (SLCP-JCF2007), and was previously called a “system test.”

- b) A test concerning the interface between software units is called an integration test, and is conducted before a system test. A system is tested for errors using data not defined in the interfaces between software units.
- c) and d) Data that covers all branches and executes all instructions within a software unit one or more times is used in a unit test conducted as per the white box test method. A unit test verifies whether each software unit satisfies the relevant functions in the program specifications, and it checks if there are any logical errors inside a software unit. Moreover, in the terminology of testing techniques, c) is the test data that is used in a decision condition (or branch) coverage, while d) is the test data that is used in statement coverage.

Q4-18 a)

Objective of system migration test

A migration test is a test to check that after a new system is developed, changeover (migration) from the old system to the new system can be performed smoothly. A migration test is not a test of the new system itself. Since it is also conducted to check the process for system changeover in advance from the viewpoint of safety and efficiency, a) is the correct answer.

b), c), and d) are correct in terms of description concerning the test and performance verification conducted prior to migration test. However, these are not the main objectives of migration test.

Q4-19 a)

Test process quality control chart

From the quality control chart of the testing phase that is provided here, it is obvious that the number of test items not executed is more than expected, and that the number of errors detected is also more than expected.

Since the increase in the number of errors detected is large in comparison with the decline in the number of test items not executed, there are quality problems, and it is highly possible that several elementary errors are present in the stage prior to starting the current test. Therefore, in addition to investigating the areas that have many defects and taking the necessary measures, the previous phases should be reviewed as required. Accordingly, a) is the appropriate description.

- b) As the number of test items not executed is higher than the expected number, deficiencies in the test environment and a lack of development personnel may be the issues. However, since the number of errors detected is higher than the expected number, it is highly possible that there are many elementary errors. It is incorrect to assume that there are no quality problems.
- c) The number of test items not executed is higher than the expected number, and therefore it is incorrect to say that execution of test items is fast.
- d) There can be two ways of looking at a situation where error detection is progressing better than expected. First, the quality of test items is high, and with fewer test items, more errors are detected than the expectation, in other words, testing is progressing efficiently. Second, the quality of software is poorer than expected, and therefore many unexpected elementary errors have occurred. Even if it is the former, it should be verified that this is actually the case, rather than just thinking optimistically as attention is not required immediately. Moreover, as a result of verification, if it is found that testing is progressing efficiently, “keeping track of the progress of error resolution is necessary so that unsolved bugs do not remain unaddressed for a long time” is appropriate.

Q4-20 d)

Relationship between scale and workload in software development

For the relationship between the development scale and workload (i.e., person-hours) in software development, it is known that an increase in development scale will generally increase the person-hours of development exponentially; that is, as the development scale increases, the increase in person-hours of development is dramatically huge. Therefore, the graph shown in d) is correct.

In addition, a) is incorrect because an increase in person-hours of development has slowed down at the middle point, while b) and c) are incorrect because the increase in person-hours of development is slowing down as the development scale increases.

Q4-21 a)

CMMI

CMMI (Capability Maturity Model Integration) is essentially a model developed by adding an interface with hardware development to CMM (process maturity model), which is for software development. None of the answers describes the details entirely. However, description of a) is an explanation of CMM, which forms the basis of CMMI. As none of the answers from b) through d) are related to CMMI, the correct answer is a). In addition, CMM is a process evaluation method defined by Software Engineering Institute of Carnegie Mellon University of the United States. Like CMM, in CMMI also, maturity of development process is evaluated with the following 5-stage evaluation criteria.

- Level 1: The initial stage where no processes are established.
 - Level 2: Although individual processes are managed, they are not organized.
 - Level 3: The experience of each individual is collected and documented, and a consistent standard processes are established for the organization.
 - Level 4: Standardized processes are quantitatively measured and analyzed.
 - Level 5: Standardized processes are optimized and improved according to the difference in technology and requirements of the environment.
- b) “Process model for software development” refers to a model like the waterfall model and growth model, where the method for proceeding with development work is modeled.
- c) “Common frame for software-based system development and transactions” stipulates the mechanism of a common software lifecycle process for clear specification development and transactions. At present, the revised SLCP-JCF 2007 is the latest version.
- d) No such model exists.

Q4-22 a)

Buyer's responsibilities in software transactions of JIS X 0160

JIS X 0160 was formed by the JIS standardization of international standards (ISO/IEC 12207) concerning software lifecycle process. SLCP-JCF98 (common frame) was formed by adding definitions of work items to JIS X 0160 after consideration of local circumstances in Japan.

As in the description in the question, both JIS X 0160 and SLCP-JCF98 stipulate supplier's responsibilities as well as a buyer's responsibilities. Some of the main responsibilities of a buyer are "defining and documenting requirements," "definition of acceptance criteria and conditions," "monitoring suppliers, such as joint review and cooperation with the supplier" and so on. Therefore, a) is the correct answer.

Answers b) through d) are not defined as buyer's responsibilities.

- b) Depending on the contract, a supplier's responsibility may include operations up to system operations.
- c) In simple terms, "product defect" refers to a bug. Even if the responsibility of correcting this defect lies with the supplier, it is clear that it will not be the buyer's responsibility in most cases.
- d) An internal quality audit is conducted on the supplier side, and its responsibility lies with the supplier, not the buyer.

Q4-23 c)

Extracting program specifications and desing from code

The technique of extracting information about the design and specifications of a program by analysis of the source code or the object code is called reverse engineering. Therefore, c) is the correct answer.

- a) Reengineering refers to revision of the existing organization structure and rules, and redesign of the business flow and job duties, management mechanism, or information systems for corporate restructuring from the viewpoint of processes.
- b) In Japan, restructuring is generally considered to be a reduction of the workforce. In correct terms, it not only means a reduction of the workforce, but also includes transforming the management structure by rearranging the business structure.
- d) Refactoring refers to a manual modification of source code so that it does not affect or change the execution results of the program.

Q4-24 a)

Specifications of componentization of a Java program

“JavaBeans” refers to the specifications of software components that can be used from a Java program. Individual software components are called Beans. Just as coffee is made from many beans, this originated from the concept of creating a Java program using components (JavaBeans) that can be reused. Therefore, a) is the correct answer.

- b) JavaScript is a scripting language developed based on Java. It is a different language to Java.
- c) Java application refers to a program developed in Java.
- d) Java applet refers to a small program written in Java. It is downloaded from the server and then executed on the client side. Applet is a composite word of application and –let, and it means a “small application.”

Q4-25 c)

Maintenance of development environment of embedded system

The most important point to be considered concerning maintenance of a development environment after product development is the consideration of reuse during the product maintenance phase, and maintenance of the development environment as it is in the development phase so that it can be used without any delay when required. Therefore, conducting periodic operation checks is important. Accordingly, c) is the correct answer.

- a) Updating the development environment after product development to the latest condition may lead to a situation where the environment for generating the same modules as during development cannot be maintained.
- b) This is not appropriate in consideration of the product maintenance phase and the possibility of the subsequent development of similar products.
- d) It is difficult to assume this situation because it depends on contract terms and conditions with the rental company, including duration.

Section 5

Project Management

Q5-1 c)

Explanation of project organization

Project organization implies “a temporary and flexible organization that is formed for a set period and for a set goal and is composed of specialists from various departments, in order to handle a specific issue.” Therefore, c) is the appropriate description.

- a) “An organization in which members belong to both a specific functional department and another department that is involved in a specific business” is referred to as a matrix organization.
- b) “An organization that is composed of departments based on the nature of work, such as purchase, production, sales, and finance” is referred to as a functional organization, because such an organization can be divided based on the function of each department.
- d) “An organization that can perform self-contained management activities” is referred to as a divisional organization. Such a business unit in which the development and implementation of a strategy are linked directly is also called an SBU (Strategic Business Unit).

Q5-2 a)

Constraints to be considered by a project manager

An international standard concerning project management is PMBOK (Project Management Body of Knowledge), which is used widely at present. According to the current version of PMBOK, examples of constraints that must be considered by a project manager include scope, quality, schedule, budget, resources, and risk. Scope indicates the range of deliverables and activities in a project, which also includes the quality conditions. Among these, the most basic constraints are “scope” including quality, “schedule” including delivery date, and “budget,” which were once called the three constraints. Therefore, a) is appropriate.

Q5-3 a)

Effect of using a WBS

A WBS (Work Breakdown Structure) is a chart in which the activities to be performed in a project are broken down hierarchically and illustrated as elements with a focus on the deliverables. As a result of using a WBS, “The details and scope of each activity can be organized systematically, so it becomes easier to grasp an overview of all activities.” Therefore, a) is the appropriate effect.

- b) System components are not defined in a WBS.
- c) The project structure is reviewed by using a WBS.
- d) A WBS is used to review the assignment of activities to staff members, but the appropriate assignment of activities cannot be understood directly from the WBS.

Q5-4 d)

Purpose of using a WBS

A WBS (Work Breakdown Structure) examines the activities necessary for achieving the objective in a top-down approach, and illustrates their relationship in a hierarchical structure.

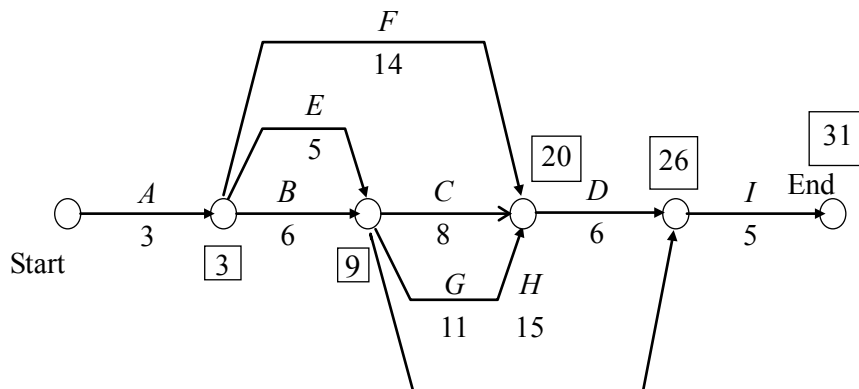
It is used when a project is planned, and each activity of the project is broken into smaller activities to be arranged as manageable components. Therefore, d) is appropriate.

- a) When there is a trade-off relationship between the number of days and the cost that are required for development, total cost optimization is achieved by examining the cost effectiveness (ROI: Return on Investment).
- b) This is the intended use of an arrow diagram.
- c) This is the intended use of a Gantt chart.

Q5-5 d)

Minimum number of days required until the completion of a project

In order to determine the minimum number of days required until the completion of a project, each of the earliest node times is calculated (as a numeric value shown in). The result is that the minimum number of days until the completion of the project is d) 31 days.



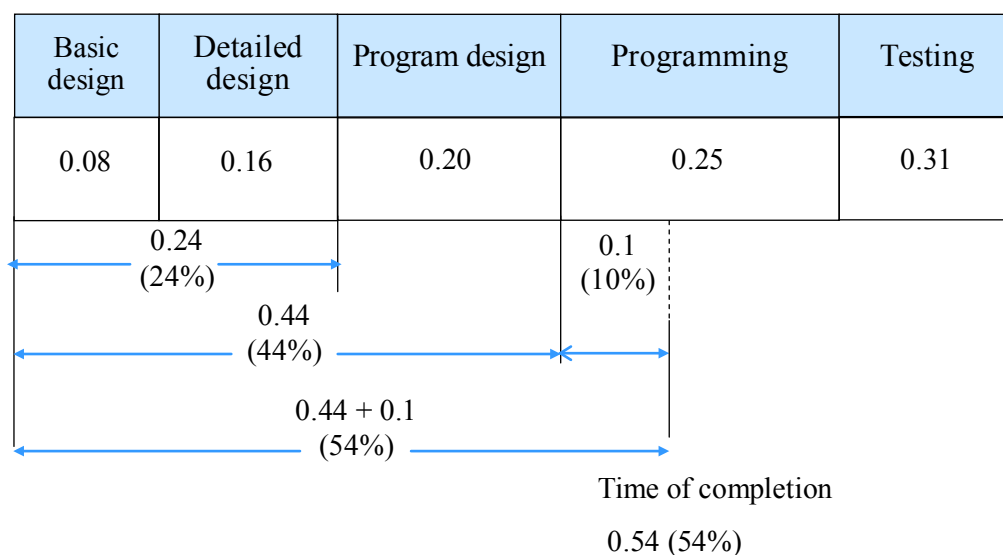
Q5-6 c)

Calculating the degree of progress of a project

44% of the entire project, from the basic design up to the program design, is completed. Since the number of programs created in the programming stage is somewhat large, the size and complexity vary equally, and the person-days required for creation is also expected to vary similarly, and therefore, the degree of progress can be represented by the percentage of programs that have been created.

1,200 of the 3,000 programs are complete in the programming stage, and this ratio of $1,200/3,000$ of completed programs is multiplied by 0.25, which is the percentage of person-hours of the entire project, to find out the extent of progress from the viewpoint of the entire project.

$$0.25 \times (1,200 / 3,000) = 0.1 = 10(\%)$$



Therefore, the current level of progress of the entire project is $44 + 10 = 55(\%)$, which means that c) is the correct answer.

Q5-7 c)

Critical path of an arrow diagram

The critical path is the path among all of the possible paths which has the largest sum total of the number of days required for each activity. It is called a critical path, because any delay in this path affects the entire schedule. When the number of required days is calculated for the options, the result is as given below:

a) 42, b) 40, c) 45, d) 42

Also, other paths not given in the options include $A-C-E-H-K-N$ (43) and $A-D-F-J-M$ (42). If the numbers of required days for all paths given above are compared, the maximum number of days is 45. Therefore, c) is the correct answer.

Q5-8 c)

Characteristics of a Gantt chart

A Gantt chart is a chart in which the vertical axis represents the work items and the horizontal axis is time measured in months or days, and the planned schedule and the actual result are noted using lines. As described in c), it clarifies the planned schedule and the actual result of the start and finish dates of each activity, as well as the work items in progress (Fig. 1).

- The important points for process management are called milestones, and the chart used for managing milestones is called a milestone chart.
- In a Gantt chart, which is created for each activity, the relationship between activities and the order of activities cannot be clarified. A chart that is suitable for such details is an arrow diagram, which enables the calculation of the number of days required for the workplace as well as the float (or slack) time (Fig. 2).
- A chart that is suitable for showing time-based changes is a line graph or a Z graph.

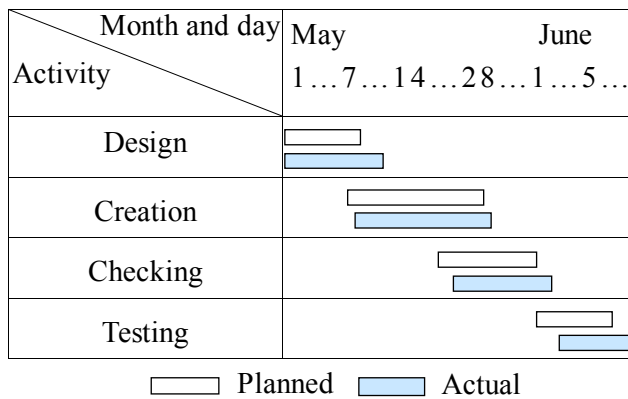


Fig. 1 Example of a Gantt chart

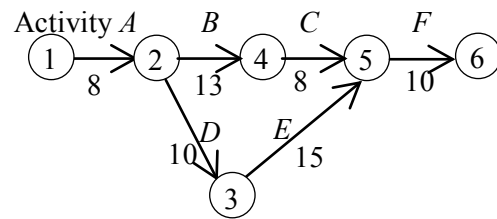


Fig. 2 Example of an arrow diagram

Q5-9 b)

Estimating with the FP (Function Point) method

The FP (Function Point) method, which is a method for estimating the development scale of a system, was advocated by Albrecht and is used to estimate development scale based on the number of functions necessary in the system to be developed.

Specifically, the number of functions is determined based on the number of external inputs, number of external outputs, number of master files, number of external interfaces, and number of screens, and then the function point is determined by adding the complexity of the processing to the number of functions. Therefore, the correct answer is “Number of screens” as described in b).

- a) Number of developers: This is determined after the system development scale is clear.
- c) Number of program steps: This was used for estimating the scale before the Function Point method was devised. However, this number depends on the programming language and the development technique. Since the Function Point method is independent of these, an objective estimate can be made independently of specific development tools and programming languages.
- d) Number of users: Although this affects the functions of a system, it is not used for estimating the development scale of a system.

Q5-10 a)

Calculating the number of function points

The Function Point method is used to estimate the person-hours of development based on the number of functions for a program. Specifically, the number of function points is calculated with the procedures described below, which form the basis of estimating person-hours.

- (1) “The value of weighting factor × the number of functions” for each function type is summed up as the total number of functions.
- (2) The number of function points is calculated as “the total number of functions × the correction coefficient of complexity”.

The number of function points is calculated by substituting values in procedures (1) and (2).

- (1) Calculation of the total number of functions

External input	$1 \times 4 = 4$	} Total number of functions $= 4 + 10 + 10 + 0 + 0 = 24$
External output	$2 \times 5 = 10$	
Internal logical file	$1 \times 10 = 10$	
External interface file	$0 \times 7 = 0$	
External inquiry	$0 \times 4 = 0$	

- (2) Calculation of the number of function points in view of the complexity

Number of function points = Total number of functions × Complexity = $24 \times 0.75 = 18$

Therefore, a) 18 is the correct answer.

Q5-11 a)

Estimating the person-hours for system development

COCOMO (CONstructive COSt MOdel) proposed by Boehm in 1981 is a method for estimating the person-hours and time period from factors that represent the development scale (number of source codes) and development characteristics. The adjustment coefficient (effort coefficient) is assigned depending on influencing factors such as the scope and complexity, computer constraints, employee conditions, and conditions for tools used. When COCOMO is to be applied to an actual company, the coefficients must be selected based on past experience and performance data of a company, and collection of productivity data is indispensable. Therefore, a) is appropriate.

- b) Since the skills of the development staff vary, it is important to evaluate skill level, which further necessitates the collection of actual person-hour data. Past data should be considered as an important reference.
- c) The accuracy of the estimated person-hours varies greatly depending on the implementation quality of software. When the actual number of person-hours is different from the estimated value (planned value), in most cases, this implies that there are various problems concerning quality management for which identification in the planning stage was not possible, and therefore the description “not related to quality management” does not hold true.
- d) The Function Point method does not use the number of program steps as an indicator of the scale, but estimates the person-hours based on the functions seen from the user side.

Q5-12 b)

Personnel plan for project development

For a project in which the estimated development workload of the entire development project is 88 person-months, a total of 40 person-months of work are completed by the end of May. Therefore, the remaining work is equivalent to 48 person-months. In order to complete the project in the three months to the end of August, the number of additional staff members required is to be determined.

The point to be noted first is the work efficiency of the staff. In the period of the five months from January to May, when 10 members worked each month (in other words a total of 50 persons were involved during this period), only 40 person-months of work could be completed. Therefore, the work efficiency is $40 \div 50 = 0.8$, implying that each member performs only 0.8 person-month of work in one month.

In order to complete 48 person-months of work in three months, 16 person-months of work must be performed every month. As the work efficiency of all members is the same up to May, in order to perform 16 person-months of work in one month, $16 \text{ (persons/month)} \div 0.8 \text{ (months)} = 20$ persons are needed every month.

Finally, it should be noted that the “number of additional staff” is to be determined. Currently, the work is being performed by 10 members. Therefore, the number of staff members to be added is $20 - 10 = 10$ members, which means that b) is the correct answer.

Q5-13 a)

Development of waterfall-type software

When an error is detected in the external design and internal design phases, redesigning must be performed and the subsequent development activities must be performed again from the beginning. Therefore, as described in a), the cost of fixing the error becomes very high. For a coding error, only the program needs to be coded again, and therefore, the cost of fixing the coding error is less in comparison with a design error.

- b) The expression becomes correct if “coding” and “requirement definition” are interchanged.
- c) If there is an error in a test case, the test case is corrected and executed again, and then if necessary, the program is also corrected. However, the cost of fixing the error is low in comparison with a defect in the external design or internal design.
- d) Errors in the requirements definition phase are often detected in the last phase of a project, which increases the cost of fixing these errors.

Q5-14 a)

Evaluating the cumulative total of bugs in the test process

Generally, the passage of time and the cumulative total of bugs show a reliability growth curve. In the initial stage, because of unfamiliarity with the test and detection of fatal bugs, testing progresses very slowly, which makes the increase in the cumulative total of bugs small. In the intermediate stage, as familiarity with the test increases, bugs are detected smoothly, which leads to a rise in the upward tendency of the curve. In the final stage, the detected bugs also start to converge, and the curve almost flattens out. When the quality of development software is estimated, the focus is on the detection status of bugs in the latter half of the graph. When almost all of the resident bugs have been detected and removed, the detection of new bugs decreases, and a stable curve as shown in the option a) is achieved. Therefore, the subsystem with the best quality is a).

- b) As the same number of bugs is detected at all times and there is no indication of convergence, the system quality does not seem to have stabilized at the moment.
- c), d) The curve has a sharp upward rise even immediately before the end of testing. This indicates that the detection of bugs has not converged, which is far from high quality.

Q5-15 c)

Transferring a system from the development department to the operation department

When the development department and operation department of a system are organized separately, the operation activities of the system are taken on by the operation department when full operation begins. Therefore, the handover of system specifications and operating methods for business operations, and installation training must be performed before the transition to full operation. In order to enable a smooth and effective transition of business operations, both the departments must provide support from the development stage. Therefore, c) is the appropriate description.

- a) The operational test is performed by operation of the system in the production environment, and is mainly performed by the operation department. Therefore, the development department must explain the system specifications and operating methods to the operation department before the execution of the test.
- b) Since the bugs and problems detected during the operational test must be corrected, the participation and support of the development department is also necessary.
- d) During an operational test, the system is operated based on an operation manual, and undesirable locations are detected. Therefore, the first operation manual must be created before the execution of the operational test. Furthermore, even when the first operation manual is created, it is not only the development department that performs the task, but the support of the operation department is also necessary.

Q5-16 d)

Risk management framework

Concerning risk management, a department or staff member in a position with the appropriate authority is assigned, and a department or position must be established to take executive responsibility of the entire situation. Therefore, d) is appropriate.

- a) Rather than the execution of all activities by the risk management director, the appropriate authority and responsibility must be assigned to staff members who are involved in risk management, and importance must be given to management of such a situation.
- b) Based on whether confidential information is handled or not, the risk management director is required to select an appropriate person in charge in each case. Therefore, a policy where departments other than those specializing in risk management cannot participate at all in risk management because of the inclusion of confidential information is not correct.
- c) Unlike the risk transfer (insurance) and risk retention that are related to a finance department, risk reduction and risk avoidance must be performed primarily by the engineering department and management department.

Q5-17 a)

Main purpose of the ISO 9000 series

The ISO 9000 series are standards concerning quality assurance established by ISO. Based on these standards, it is possible to set up a quality management system (an organization and rules that can ensure quality assurance), and provide stable products and services to customers. Thus, a) is the correct answer.

It is a set of international standards used as an index for the evaluation of reliability in international business transactions. Specifically, it includes the standards shown below.

- ISO9000:2000: This standard indicates the fundamentals and vocabulary of a quality management system.
- ISO9001:2000: This standard indicates the requirements of a quality management system.
- ISO9004:2000: This standard indicates guidelines for performance improvement in a quality management system.

In connection with the ISO series, it is worth understanding the titles of the standards shown below.

- ISO/IEC27001: Security management implementation criteria for the information system of organizations such as companies
- ISO/IEC15408: Security evaluation criteria for products related to the information system
- ISO10006: Guidelines for quality management in projects
- ISO19011: Guidelines for quality and/or environmental management systems auditing

Section 6

Service Management

Q6-1 d)

ISO standard based on ITIL

As regards the standards concerning IT service management, BS15000 was standardized as a mechanism of management based on ITIL that was created in England. Later, ISO/IEC 20000 was established in 2006 based on BS15000. It is composed of “Information technology – Service management – Part 1: Specification” 20000-1 and “Information technology – Service management – Part 2: Code for practice” 20000-2. The corresponding JIS standards JIS Q 20000-1 and JIS Q 20000-2 were established in April 2007. Therefore, d) is the correct answer.

- a) ISO 9001 is a standard for quality management systems (QMS).
- b) ISO 14001 is a standard for environmental management systems (EMS).
- c) ISO/IEC 15408 is a standard indicating the evaluation criteria for IT security (JIS X 5070 is the corresponding JIS standard).

Q6-2 a)

Content to be described in an SLA

An SLA (Service Level Agreement) is a written agreement concerning the service content mutually agreed upon between a customer and a service provider (IT service provider). According to “ISO/IEC 20000 (JIS Q 20000) Information technology – Service management,” explanation of the service, effective period and SLA change management, emergency procedures, service provision time, responsibilities of the customer, responsibilities and duties of the service provider, escalation and notification process, complaint settlement procedures, service objectives, agreed number of users and workload, and measures to be taken during service disruption are some of the items that must be included in the SLA. As this can be understood from these details, the objectives and scope of responsibilities for the service must be included in the SLA. Therefore, a) indicates the appropriate content.

- b) If it is assumed that the service provider manages the service desk and the IT support department is an organization at the customer’s side, then the distribution of roles between the service desk and the IT support department may be described in the SLA. However, the definition of the service desk and the IT support department is ambiguous if based only on the description of b), and this is not the content that must definitely be included.
- c) The SLA need not necessarily include all the services that the service provider provides.
- d) The SLA describes service content that is agreed upon. The operational requirements from the users are described in the RFP (Request for Proposal) concerning the IT service.

Q6-3 d)

SLA

An SLA (Service Level Agreement) is an agreement between the user of an information communications system and a service provider, which clearly stipulates the level of the provided services mainly by using numeric values, and assures that a fixed criterion is followed. Generally, the service level is defined in a document for each item, which also stipulates that if this assurance cannot be achieved, the charges will be reduced. This system has been installed by major telecommunications houses in the USA, and is being adopted by providers and software houses in Japan as well.

In future, from the viewpoint of providing services suitable to the cost awareness and needs of the user department through the clarification of the service standards and billing, the concept of an SLA will be incorporated in in-house information systems as well. Therefore, d) is the appropriate description.

Q6-4 a)

Considerations for the update activity of an application system

When an application system is changed, not only the corrected locations, but the other parts are also affected, which may lead to a failure. If a failure occurs after the change activity, the details of the change activity must be checked in order to find the cause of the failure. Therefore, a) is the correct answer.

- b) The system operations department is not free to decide the priority order, such as performing the change activity in the order of arrival of requests, but is informed about the emergency from the user department in which system changes are needed, and then decides the priority order.
- c) The scope of impact caused by the change activity must be specified by the system specification and operation regulations. Based on this, it is also important to determine the employees who might be affected by the changes.
- d) If changes to a particular part do not have any impact on the user, the change activity need not necessarily be performed late at night, but can also be performed during the daylight hours when the user is using the system. Furthermore, if a change is to be implemented immediately, it is necessary to stop the system temporarily.

Q6-5 c)

Incident management

An incident in IT service management indicates an “event that causes an interruption to normal service usage and operations, or a reduction in service quality.” Therefore, the option that corresponds to such an event is c), which is the correct answer.

Incident management is a process of recording, investigating, analyzing, and recovering such an incident.

- a) A training request to a new hire is not a cause of interruption to service usage and operations, or a reduction in service quality, and therefore, does not require incident management.
- b) If an inquiry about the system includes details such as the inability to use the system, it might require incident management. However, in the question, the inquiry concerns the functions or usage method of a system, and since it does not directly lead to the cause of interruption of service usage and operations, or a reduction in service quality, it does not require incident management.
- d) A request for the provision of an IT service to a new sales office is not a cause of interruption of service usage and operations, or a reduction in service quality, and therefore, does not require incident management.

Q6-6 a)

Configuration management in service support

IT service management is composed of IT service support that supports daily service and IT service delivery that manages mid-to-long term operation plans. Among these two, IT service support is composed of the five processes and one function described below.

- Incident management: A process that analyzes incidents (failures and accidents) so as to recover the service promptly
- Problem management: A process that analyzes the root cause of an incident, and executes permanent recurrence prevention measures
- Configuration management: A process that manages the configuration of IT assets (such as hardware and data)
- Change management: A process that appropriately manages the changes in IT assets
- Release management: A process that ensures that changes approved by change management are executed
- Service desk: A function that provides a single point of contact to the service user

Therefore, a) is the correct answer.

- b) This is an explanation of incident management.
- c) This is a necessary activity for providing the functions of service desk.
- d) This is an explanation of release management.

Q6-7 c)

Explanation of a distributed system

The point to be noted during the operations of a distributed system is that the distribution of system resources does not imply that the management load is reduced. Common resources such as the database are the most important, and require a specialized administrator to be deployed in the same way as in a centralized system. Therefore, c) is the appropriate description.

- a) If operations are assigned to the users, the management method might fall apart, which is inappropriate. An administrator must also be deployed in each distributed site.
- b) The distribution of information resources, on the other hand, allows malicious network intrusions to be performed easily. And, it must be taken into consideration that as a matter of fact the security management load increases.
- d) In comparison with a centralized system, the network configuration of each distributed site can be changed flexibly, but the user cannot change it as he or she wants. Configuration management by the network administrator is necessary.

Q6-8 b)

Concept of hardware maintenance activities

This question deals with the concept for performing hardware maintenance activities. First of all, the maintenance management of information equipment does not stop at hardware, but is an extremely important activity from the viewpoint of operations, with its aim being to promote normal operations of the information equipment. This requires constitutive recording (documentation) of the installation status and daily usage status of hardware and software in the departments, and also of the history of functional expansion, and the existence and aspect of failure occurrence, as well as continuous management to enable checking at all times. Even if no hardware malfunction is seen to occur during periodic maintenance inspection, the operations must be ensured, and efforts must be made to discover “hidden malfunctions” that are not visible by the user. Therefore, b) is the appropriate concept.

- a) As described above, maintenance activities must also be performed in cases other than a malfunction.
- c) When the user senses any problem as a result of feeling that something is different from normal usage, maintenance activities must be performed immediately without waiting for the periodic inspection.
- d) In order to fulfill the purpose of performing hardware maintenance activities, the maintenance activities must not be performed only on the printer and storage associated with the mechanical operation. For example, maintenance activities must be performed even for semiconductor devices that do not have a drive part, such as the CPU and memory.

Q6-9 d)

Changes in the network configuration after the start of operation

Generally, after a network is installed, its configuration is changed relatively frequently. To accurately perform such configuration change, it must be possible to correctly understand the current status of network configuration at all times. Therefore, the description provided in d) that in order to enable changing the network configuration whenever changes are required, the equipment management register and network drawings must be updated in a timely manner, is the most appropriate.

The other descriptions include expressions that lack appropriateness as shown below:

- a) As the network configuration becomes more complex, the execution of management by network management software results in fewer errors in comparison to the manual management. In addition, it is desired that an experienced person in charge changes the configuration based on the correct management information.
- b) When the network configuration is changed, the activities must not be hindered as far as possible. Furthermore, achieving network security and stopping business applications is not related directly to this issue.
- c) Since the network changes made after the start of operation are executed relatively frequently, it is necessary to examine during the network design stage if changes can be made easily.

Q6-10 b)

Operations and maintenance of an application program

When an application program is operated and maintained, knowledge of the application program can prove to be useful for appropriately handling the problems that occur, however it is difficult to expect all persons in charge of the operations to possess such ability. Thus, an operations manual that can be referenced when required must be prepared beforehand for the persons in charge. Therefore, b) is the appropriate concept.

- a) Additional codes used for error log extraction and trace that are created and used in the development stage and become unnecessary after the start of operations must be removed if they cause a decline in the processing efficiency, but need not be removed if they do not affect the processing efficiency at all. This is also because some problem might actually occur as a result of unnecessary removal.
- c) In many cases, correcting an error in an easy manner creates new errors. As a result, the maintenance task (correction of errors) of an application program must be performed by the department in charge of development, as far as possible. Therefore, when an error occurs during operations, the operations manager immediately contacts the department in charge of development and takes action as described in the operations manual. After this, the department in charge of development corrects the error.
- d) Although it is important to conduct a confirmation test using the test data created for the development of the source program, it is not sufficient by itself. It is necessary to create new test data that can be used to test the changed portion, and then perform the confirmation test.

Q6-11 c)

Procedure for implementing IT service management

When IT service management is implemented, the first step is “Having a clear vision” described in *C*, followed by “Understanding the current status” of *B*, and then specifically “Setting the objectives” of *F*. Next, “Reviewing the methods for accomplishing the objectives” of *E* is performed, which is followed by “Reviewing the methods for understanding the objectives accomplishment status” of *D*. Finally, “Reviewing the methods for continuous improvement” of *A* is performed to circulate the PDCA cycle. Therefore, c) is the correct answer.

In such questions dealing with procedures, focusing on several elements with a clear context, and then selecting the corresponding elements is effective. For example, if “objectives” is focused on, “setting the objectives” would be the first task, followed by “reviewing the methods for accomplishing the objectives,” which would obviously be followed by “reviewing the methods for understanding the objectives accomplishment status.” c) is the only option in which $F \rightarrow E \rightarrow D$ are arranged in a sequence, which makes it easy to identify the correct answer.

Q6-12 c)

Explanation of the degraded operation as a failure measure

Degraded operation is one of the measures that is taken when a failure occurs in the information system. Degraded operation refers to continuation of system operation by isolating the failed portion to prevent the failure from having an effect on other normally operating portions, when it is determined that the failure is not temporary. The main point here is isolating the failed portion and continuing the operation even when the system efficiency is lowered. Therefore, c) is appropriate.

- a) This is the description of changes in the execution schedule of a job during operation. The purpose of degraded operation is a measure against failures rather than a reduction of operation time.
- b) This is the description of abnormal termination of a program in an operating system.
- d) This is the procedure for stopping the system as a measure for a general hardware failure.

Q6-13 a)

Scope of facility management

Facility management of the information system means appropriately installing and maintaining facilities including incidental facilities such as the power supply, air conditioning, and security equipment necessary for the operation of the information system. Here, the main point is “incidental facilities of the information system.” Therefore, option a) that describes monitoring and improvement of IT-related facilities, which are synonymous with the incidental facilities of the information system, is the correct answer. The other options are explanations concerning the information system.

- b) This is an explanation of CAM (Computer Aided Manufacturing) in which computers are used to control the production line of a plant.
- c) This is an explanation of CRM (Customer Relationship Management) in which companies establish a long-term relationship with their customers by making use of the information system.
- d) This is an explanation concerning an ERP (Enterprise Resource Planning) package, which is integrated software for improving the efficiency of management by performing integrated management of the entire company from the viewpoint of effective utilization of management resources.

Q6-14 d)

Auditability of an information system

Auditability means the possibility of performing an audit. If control functions effectively and appropriately, then the reliability, safety, and efficiency of the information system can be ensured retrospectively and in continuation. This is the significance of auditability of an information system. The existence of control and audit evidence (including the audit trail) constitutes auditability. Option d) deals with designing and operating a system that enables the audit and review of the correctness of a process indicated by the audit evidence (audit trail), and the internal control indicating the existence of control. Therefore, it is the appropriate description.

- a) The existence of control is a mandatory constituent of auditability, and the existence of audit evidence alone is insufficient. Furthermore, the completeness of audit reports is not directly related to the existence of control.
- b) Recognition by a company and cooperation of the departments to be audited is a factor for proceeding smoothly with audits, but does not correspond to the content of auditability.
- c) This refers to the necessary ability of the system auditor, but does not correspond to the content of auditability.

Q6-15 b)

Independence of a system auditor

“II. Purpose of the system audit” in the System Audit Standards is as described below:

“The purpose of system audit is to contribute to the achievement of IT governance by having an independent and specialized system auditor provide assurance or advice through verification and evaluation of whether or not the control of risks concerning the information system of an organization is maintained and operated based on risk assessment.”

In this way, the independence of the auditor is a requirement for system audit. A system auditor of an auditing firm does not participate in the development of a company’s business system, and is therefore an independent third party. Therefore, b) is the correct answer.

- a) Since the staff members of the sales department are the concerned party, they are not positioned as an independent third party.
- c) Since the staff members of the systems department are concerned with the development of the system, they are not positioned as an independent third party.
- d) Since the audit department of an IT vendor is concerned with the business system operations, it is not positioned as an independent third party.

Q6-16 d)

Operations of a quality management system based on JIS Q 9001

As the name “Quality Management Systems – Requirements” suggests, JIS Q 9001 (ISO 9001) is a standard stipulating the requirements of a quality management system. The characteristics of the standard include process approach, customer focus, and continuous improvement. Process approach refers to the clarification of each activity (task) for proceeding with the business of an organization, its identification as a process, understanding of the mutual relationship between each process, and the execution of operational management. Based on this fundamental concept, the content of each option should be examined, and the answer determined.

- a) “Several activities” refers to processes such as purchase and manufacturing, and if the content of these processes is different, the quality objectives naturally differ. In fact, this standard stipulates that the quality objectives are set for an organization and each hierarchy. Therefore, this option is not valid.
- b), c), d) Although the manuals, execution status, procedures, and the terminology used are different, ultimately the possibility of revising and changing these is needed for the operations of the quality management system. As described earlier, a characteristic of this standard is continuous improvement, and based on this viewpoint, the continued use of manuals that cannot actually be followed, as described in b), does not deal with several problems, and the continuation of operations regardless of the implementation status of processes as described in c) seems to be inappropriate. Additionally, according to d), continuous improvements amounting to changes are performed when there is a problem. Therefore, d) is the correct answer. When a process is to be changed, it must be done through the regular procedure.

Q6-17 d)

Third-party audit according to JIS Q 9000:2000

According to JIS Q 9000: 2000, an audit is classified into internal audit and external audit, where an external audit generally includes second-party audits and third-party audits.

A second-party audit and a third-party audit are defined as follows:

“A second-party audit is performed by a group or an agent that has interest in an organization, such as a customer. A third-party audit is performed by an external, independent organization. Such an organization performs authentication of conformity to requirements such as JIS Q 9001 and JIS Q 14001, or certification and registration. ”

Therefore, d) is the correct answer.

- a), b) These correspond to third-party audits.
- c) This corresponds to an internal audit.

Q6-18 d)

Data integrity

This question deals with data integrity; that is, the strength of data safety with respect to the invalid input of data is asked in the question.

As regards the entry of data, the roles of the information systems department and the user department must be divided appropriately so as to achieve effective functioning of checks and balances, as well as integrity of data. Therefore, d) is the correct answer.

- a) If the information systems department develops a data entry system and performs data entry, checks and balances do not function properly, and invalid data processing may be performed.
- b) If staff members are assigned to the same department for a long period of time, it becomes difficult to detect illegal actions. Job rotation must be performed at appropriate intervals.
- c) After staff members move to another department, they need not prepare to deal with system-related emergencies by carrying along the materials used at the old workplace in an attempt to achieve proper functioning of checks and balances.

Q6-19 c)

Software management according to System Management Standards

In the System Management Standards, Chapter 6 (Software Management) of Section IV (Operation Activities) indicates nine criteria for software management concerning operations, of which the sixth criterion stipulates that “Measures must be taken to prevent illegal handling and protection of confidentiality during storage, copying, and disposal of software.” Illegal copies of a program lead to invalid usage of software, and the training for preventing this is stipulated as the content of software management. Therefore, c) is the correct answer.

- a) Recording the usage status of output information and analyzing it periodically correspond to the content of Chapter 5 (Output Management) of Section IV (Operation Activities) of the System Management Standards.
- b) Effective functioning of access control to data corresponds to the content of Chapter 4 (Data Management) of Section IV (Operation Activities) of the System Management Standards.
- d) Assessing, recording, and storing the test results of a program correspond to the content of Chapter 4 (Programming) of Section III (Development Activities) of the System Management Standards.

Q6-20 b)

Explanation of IT governance

IT governance indicates the organizational capability that enables the maximum effective use of IT, which can be seen during the installation of an information system, when a structure that helps an organization achieve the best results is established within the organization, by appropriately setting and analyzing beforehand the purpose of installing the information system and the IT strategies to be developed, and also evaluating the merits and demerits that come along with the information system. Therefore, b) is the correct answer.

- a) This is a description concerning ITIL. ITIL (Information Technology Infrastructure Library) provides guidelines that introduce the best practices concerning IT service management and system operations management formulated by CCTA (Central Computer and Telecommunications Agency), a UK Government agency. ITIL is composed of service support, which is the operational procedure of daily IT services, and service delivery, which is a mid-to-long term system operations plan and management as seen from the user's side.
- c) This is a description concerning an RFP. An RFP (Request for Proposal) is a document created by the user to be presented to a system vendor when an information system is installed, and includes the purpose and overview of the information system expected to be installed, the system requirements, the necessary functions, and the procurement conditions.
- d) This is a description concerning an SLA. An SLA (Service Level Agreement) is an agreement concluded between the customer and the vendor providing a service that guarantees the quality of the provided service during the operations of the information system.

Q6-21 b)

Detective control as a part of IT control

Generally, internal control performed in companies includes control performed with the aim of prevention and control performed with the aim of detection.

The former is called preventive control while the latter is called detective control. Preventive control is used to prevent errors and inaccuracies that may occur during the course of business, and detective control is a retrospective control activity for detecting errors and inaccuracies that have already occurred.

Collating the output form and the input form after the entry of data in order to rule out any errors is a posteriori measure corresponding to detective control. Therefore, b) is the correct answer. This can easily be answered by determining whether the provided option is a measure taken before the entry of data or after the entry of data.

- a) Designing the input screen in such a way that an operational error does not occur easily is a preventive control measure.
- c) Limiting the number of persons entering the data and assignment of access right is a preventive control measure.
- d) Creation of manuals and training for data entry is a preventive control measure.

Q6-22 a)

Term associated with internal control

The term associated with the organizational capability of a company to guide the development and implementation of its IT strategy in the desired direction in order to establish competitive superiority is a) IT governance. Governance means to control and rule.

- a) IT service is a collective term for various services that can be provided in connection with IT, such as system installation, migration, operations, monitoring, and helpdesk.
- c) IT skill is the ability to perform IT-related services, such as system development and operations and management, negotiations with customers, and problem-solving ability.
- d) IT literacy is the basic ability to take advantage of and make use of IT (Information Technology).

Section 7

System Strategy

Q7-1 b)

Items to be considered when corporate information strategy is developed

Information strategy is developed for the purpose of achieving management strategy. As a key element of management strategy, information strategy has come to be developed in an integrated way. Therefore, b) is the correct answer.

- a) Immediately implementing information technology simply due to its advancement does not necessarily solve the problems of the organization. The preparation and understanding of the entire organization that uses the technology is necessary.
- c) When management strategy changes, items no longer needed in existing systems must be removed, and newly required items must be added. The organization should carefully examine what is actually needed and develop its information strategy, without regard to existing systems.
- d) The purpose of information strategy is, in the end, to achieve the company's management strategy. For purposes of the company's competitiveness it may at times be necessary to also consider the information strategies of competitors, but this is not the highest priority consideration.

Q7-2 c)

Graph of declining metered rate

"Declining" refers to the gradual decrease of a volume or amount. Therefore, c), in which the monetary value per unit of usage becomes smaller as usage increases, is the correct answer.

- a) In this graph, overall usage fee decreases with increasing use. (A high fee charged for zero usage is a practical impossibility.)
- b) In this method, fees are charged in proportion to usage up to a certain volume, after which a flat rate is charged.
- d) In this method, fees are charged according to usage, but the fee per unit of usage increases with increasing usage.

Q7-3 c)

Knowledge concerning Enterprise Architecture

Enterprise architecture (EA) is a methodology that describes and analyzes, by using comprehensive and strict techniques, the structure and functions of the processes, information systems, personnel, divisions, and so on of a corporate, government, or other organization. It provides directions for overall optimizations so that the organization will function in accordance with its strategic objectives. Therefore, c) is the correct answer.

The organizational structural elements handled by Enterprise Architecture are composed of the following four architectures.

- (1) Business architecture including business objectives and business processes
- (2) Data architecture that indicates the content and relevance of information (i.e., data in

- systems) used in business operations and systems
- (3) Application architecture that systematically indicates the form of information systems that are optimal for business processing
 - (4) Technology architecture that indicates the various technological components and security platforms used in actual construction of systems
 - a) This is a description of system analysis and design techniques based on UML (Unified Modeling Language).
 - b) This is a description of data modeling based on an E-R (Entity-Relationship) diagram.
 - d) This is a description of design techniques based on a DFD (Data Flow Diagram).

Q7-4 a)**Deliverables of business architecture**

Enterprise Architecture (EA) is a methodology for the overall optimization of information systems. It defines the structure of information systems by using the four frameworks of business architecture, data architecture, application architecture, and technology architecture. When business architecture is developed, the deliverables include Data Flow Diagrams (DFD) and Work flow diagrams (also referred to as WFA (Work Flow Architecture)). Therefore, a) is the correct answer.

- b) The Entity-Relationship Diagram (ERD) is a deliverable of the development of data architecture.
- c) The information system relationship diagram is a deliverable of the development of application architecture.
- d) The software configuration diagram is a deliverable of the development of technology architecture.

Q7-5 b)

Application architecture

Enterprise Architecture (EA) is the methodology for activities aimed at the optimization of an overall organization, by sorting out the business operations and information systems of a large organization according to hierarchies to clarify mutual relationships, and by enabling visualization of the “As-Is” current situation versus the “To-Be” ideal. The hierarchies and the content defined for each are as follows:

- Business Architecture (BA): Defines work content and workflow
- Data Architecture (DA): Defines content and relevancy of information
- Application Architecture (AA): Defines the system form for handling information, as well as packages and other applications
- Technology Architecture (TA): Defines the technologies for use of services

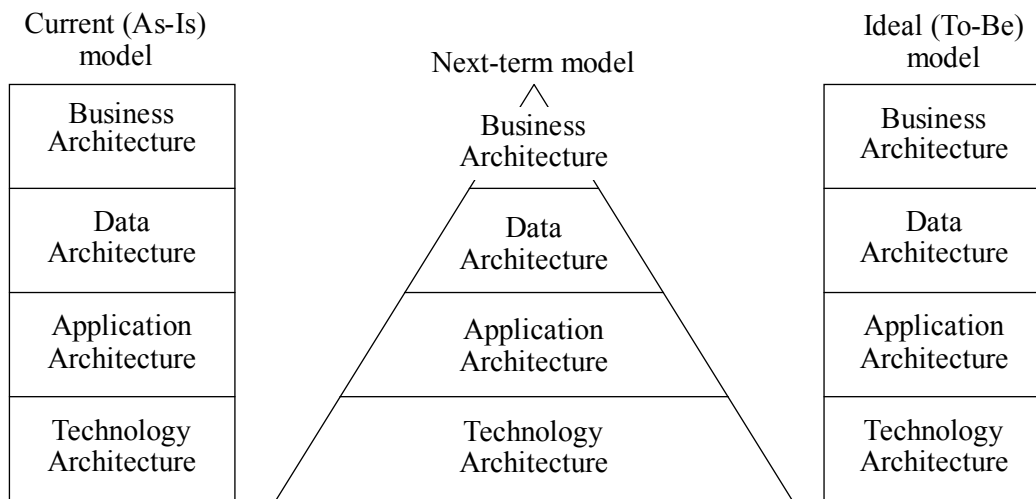


Fig. Partial modification of “Regarding Enterprise Architecture” (Ministry of Economy, Trade and Industry)

As per the above, application architecture indicates the functions and structure of business processes (i.e. systems to support business architecture), so b) is the correct answer.

- This is a description of Data Architecture.
- This is a description of Technology Architecture.
- This is a description of Business Architecture.

Q7-6 d)

ERP package-based reconstruction of mission-critical business systems

An ERP (Enterprise Resource Planning) package is a software package for the real-time understanding and effective use of an organization's overall management resources. It is developed based on standard business processes and, with reference to the business model of the package, is often used for reviewing the company's business processes themselves. As it is necessary to conduct a review and redesign of the business processes of the entire company at that time, d) is the correct answer.

- a) Making adjustments as required while ERP is installed in steps, as opposed to implementing it across all business systems at once, is one advisable method for firmly establishing ERP in business operations.
- b) While it is important to put importance on users' opinions, users may oppose installation simply on the grounds that it differs from familiar existing methods. Thus, there should be no fixation on existing business processes.
- c) Installing an accounting system first does not necessarily mean that system reconstruction will proceed effectively. In general, installation often starts from sales force automation.

Q7-7 a)

SFA

SFA (Sales Force Automation) improves sales productivity through installation of information systems in the sales organization, and creates a customer-oriented corporate operations system. Therefore, a) is the correct answer.

- b) This is a description of ERP (Enterprise Resource Planning).
- c) This is a description of RSS (Retail Support Systems).
- d) This is a description of EC (Electronic Commerce).

Q7-8 a)

Breakdown of business improvement process

In general, the following steps are involved in undertaking business improvement in a corporation.

- (1) Confirmation of improvement objectives: Step to decide upon the areas and targeted scope for improvement activities
- (2) Understanding of problems: Step to understand and analyze the current state of problems that should be improved
- (3) Setting of improvement objectives: Step to consider and set as a target the future post-improvement form with respect to problems.
- (4) Creation of improvement proposals: Step to create several concrete improvement proposals for achieving the set objectives
- (5) Evaluation of improvement proposals: Step to evaluate the multiple improvement proposals that were created and select the proposal that should be executed
- (6) Implementation and confirmation of effectiveness: Step to migrate to execution of the improvement proposals and to confirm their effectiveness after implementation

Therefore, “Creation of improvement proposals” corresponds to *C* in the diagram, and a) is the correct answer.

Q7-9 c)

Business model development

In the planning of information systems, it is important to draft an ideal business model while at the same time sorting out the current business model and, based on this, to develop a feasible business model. For the purpose of developing an ideal business model in this process, it is necessary to build the business model based on essential needs without being constrained by the current status. Therefore, c) is the correct answer.

- a) The starting point and end point for each activity should be indicated in a business model.
- b) While business functions should always be subject to modification, what should be performed for that very purpose is the drafting of an ideal business model and the development of a realistic business model, as described above.
- d) Consideration of how business is conducted is an activity to be performed in the development of a business model. When analysis of business functions is performed, the analysis focuses more on the objectives of business functions than on the matter of “how.”
- e) A business model should be developed on the scale of the entire company, and in units of the activities required to accomplish certain objectives.

Q7-10 c)

Effectiveness of sales force automation implementation

First, the total working time is calculated for the case in which the number of customer calls is set to six and the customer call preparation time is shortened. As the customer call time is currently 5 hours for 5 calls, it is understood that the time is 1 hour per call. Therefore, when the number of customer calls is six, the time required will be $1 \text{ hour} \times 6 \text{ calls} = 6 \text{ hours}$. At the same time, the customer call preparation time was 1.5 hours for 5 calls, and thus 0.3 hours per call. However, as SFA enables the shortening of this by 0.1 hours per call, the preparation time per call will be shortened to $0.3 - 0.1 = 0.2 \text{ hours}$. Therefore, when the number of customer calls is set to six, the customer call preparation time will be $0.2 \text{ hours} \times 6 \text{ calls} = 1.2 \text{ hours}$. The time required for other jobs is 1.5 hours, and thus without any change, the total working time will be $6 + 1.2 + 1.5 = 8.7 \text{ hours}$. As the current total working time is 8.0 hours, the time required for other jobs must be reduced by 0.7 hours. Therefore, c) is the correct answer.

Q7-11 b)

Description of solution business

The solution business is a business which investigates customer issues and customer demands with regard to systems, then proposes solutions and provides support for resolution of the issues. In the case of ASP (Application Service Provider) and SaaS (Software as a Solution), the solution service provider provides systems over the Internet for resolving issues, so users need only the ability to connect to the Internet, and initial costs are generally low and maintenance cost is also lower than that of running the systems in-house. Therefore, b) is appropriate.

- a) As ASPs can be used via connection to the Internet, installation can be performed simply. The business operator performs operations management of the servers and applications.
- c) SaaS is a form of service by which users access applications on a business operator's servers via the Internet. Therefore, it is generally able to adapt to sudden increases or decreases in users.
- d) SOA (Service Oriented Architecture) provides services through business processes paired with IT infrastructure. Under this concept, the user can freely combine business processes to configure the system.

Q7-12 c)

Services provided by MSPs

An MSP (Managed Services Provider) is a business operator that contracts for the operations, monitoring, maintenance, etc. of a company's servers and networks. An MSP service is a service that performs system operations management, system operations monitoring, etc. for a company over a network. Therefore, c) is the correct answer.

- a) This is a description of housing service.
- b) This is a description of BPO (Business Process Outsourcing). BPO refers to the outsourcing of a company's business operations themselves.
- d) This is a description of ASP (Application Service Provider).

Q7-13 a)

Software usage

Software usage by which users do not construct and install applications as independent systems, but rather select from among necessary functions provided as services, is known as SaaS (Software as a Service). This typically takes the form of constructing the system environment and running applications at the vendor site providing the service, and thus multiple users connecting over the Internet can use the software as a service. Therefore, a) is the correct answer.

- b) SAN (Storage Area Network) is a dedicated high-speed network connecting servers and mass storage devices, such as hard disks, via fiber channel switches.
- c) SOA (Service Oriented Architecture) refers to the concept of constructing systems as a collection of services. Through interfaces conforming to message exchange protocols, SOA enables cooperation among systems in which one system uses another as a service.
- d) SLA (Service Level Agreement) refers to the contract or agreement between a service provider and a user regarding system operations management.

Q7-14 d)

Overview of housing service

Housing service is a service by which a user installs its communications equipment or servers in facilities equipped with communication line facilities and maintained by the business providing the service. Provision of the installation location, high-speed communication lines, stable power supply, and so forth forms the primary content of the service, and there are cases where some providers may contract for maintenance and inspection of the installed servers. Therefore, d) is the correct answer.

- a) This describes ASP (Application Service Provider) and SaaS (Software as a Service). ASP places business and other software on servers, and provides this to client users as a service over the Internet. SaaS refers to a form of software usage by which users download only needed functions over a network, or use only specific functions of server-based software online.
- b) This is a description of SI (System Integration), which provides system development and operation services.
- c) This is a description of rental servers or hosting services.

Q7-15 d)

Uses for embedded systems

Embedded systems are computer systems installed in home electrical appliances, industrial machinery, and other devices to control the devices or to implement their functional capabilities. This is in contrast to PCs, servers, host computers, and other computer systems that can be used for general purposes by changing the executed programs. Answers a) through c) refer to computer systems installed inside devices for the purpose of achieving functionality specific to the devices, and thus correspond to embedded systems. On the other hand, answer d), “manage train seat reservations,” refers to a host system; it is not installed in a device, and thus is not an embedded system. Therefore, d) is the correct answer.

Q7-16 b)

System usage promotion and improvement measures

A data warehouse is a company-wide collection of data for the purpose of supporting decision-making through data analysis, and has the characteristics “purpose-specific,” “integrated,” “time series,” and “not updated.” The problem concerns improvement measures for the low skill level of the users of a data warehouse, which include educating users and devising methods to make use easier.

- a) Even if administrators send out notices to promote usage, this does not directly lead to the improvement of skill levels, and cannot be expected to be effective.
- b) A template is an item prepared with processing methods, etc., made into patterns. Users search for a template close to their needs, and make simple changes to achieve their goals. Templates allow trouble-free usage even with low skill levels, and can be expected to promote usage. Thus, this is the correct statement.
- c), d) The cause behind lack of usage is the low skill level of users. Even if the timing and accuracy of data provision is improved as per c), or information thought to be requested is added per d), this will not improve skills, and thus cannot be expected to be effective.

Q7-17 d)

Items for consideration in computerization planning

Computerization planning is a task conducted in the basic planning that is performed at the start of system development. As information-based society advances, the differences among companies' information technologies and information systems have come to greatly impact the development and decline of companies; as such, the importance of information strategy continues to expand. For this reason, companies' investments in information systems continue to grow, and the efficacy, investment effect, and efficiency of systems is rigorously questioned. In computerization planning, the effectiveness and investment effect of information systems must be made clear. Therefore, d) is the appropriate answer.

- a) Whether to perform development in-house through the company's own employees or whether to outsource development is something considered within computerization planning. However, for reasons of system scale, development period, development cost, employees' skills, and so on, in-house development by the company's own employees is not necessarily best. Furthermore, from the perspective of operations (i.e., actual use of the system), outsourcing development may be acceptable through active participation by actual users from the initial stages of design, and through the thorough creation of operation manuals when the system is put into operation.
- b) In the setting of business objectives, there is a technique (known as benchmarking) that attempts to set the company's best practices by qualitatively and quantitatively surveying the products, services, and practices of the most powerful competitors or other advanced companies. However, the purpose is to use other companies as reference, with no need to implement the same systems. The company should strive to achieve the systems that best suit itself.
- c) The conception of computerization should be indicated in the basic plan, yet operations manuals and failure measures cannot be specifically indicated at least until system design is complete.

Q7-18 d)

Business models developed at the time of overall planning

The procedures for business model development are 1) definition of business processes, 2) definition of data classes, and 3) associating business processes with data classes. Business processes are the grouping of diverse business activities and decision-making activities in a company, based on the purpose and type of activity. Data classes are the grouping of data used in the execution of business processes, from the perspective of information to be used by the user. Therefore, d) is the correct answer.

- a) Definition of functions and data items is performed in the external design phase.
- b) Business processes are not drawn from existing information systems.
- c) Organizational functions are not business processes. Moreover, it is important to organize the data represented in forms, rather than the forms themselves.

Q7-19 b)

Tasks included in the requirements definition process

This question concerns the tasks included in the requirements definition process within the software life cycle process. Multiple companies and teams will often collaborate in unitary system development. However, consistency can be lost as each pursues development by its own methods, with the result of major obstacles to the progress of work. To prevent this from happening, and to clarify the respective division of roles and work content for the system outsourcer and the developers, standard development and operations processes have been standardized under Japan Common Frame 2007. Japan Common Frame 2007 divides the software life cycle process into five (5) stages: the planning process, requirements definition process, development process, operations process, and maintenance process. In the requirements definition process, determination of the functions required by the system and the organization of system user needs are performed in order to define requirements regarding the mechanisms to be realized. Therefore, d) is the correct answer.

- a), c) These tasks are included in the planning process.
- b) This task is included in the development process.

Q7-20 a)

Work procedures in the procurement process

Procurement refers to the acquisition of needed items, and in system development refers to the external outsourcing of all or part of the work. As such, work procedures in the procurement process can be called the flow of outsourcing work to external development vendors.

The outsourcing of work to development vendors begins with the collection of information on development methods and technology trends. When the prospective procurer requests information from development vendors, an RFI (Request For Information) indicating the purpose and work overview of the computerization is created and distributed. Next, based on the above, an RFP (Request For Proposal) indicating an overview of the system to be implemented, items requested in the proposal, procurement requirements, and so on is created and is distributed to development vendors. The development vendors return proposals leveraging their respective characteristics, and thus deciding on the source of procurement calls for selection standards and proposal evaluation methods based on the company's business strategy. However, as work procedures, these can be completed by the end of proposal evaluation. As such, the question text defines the start of work procedures as "determination of proposal evaluation methods." From there, the development vendors' proposals are evaluated, the procurement source is decided, an agreement is formed, and procurement ends. Putting together this flow in line with the question yields the following.

- (1) Determination of proposal evaluation methods
- (2) A: Issuance of RFP: c)
- (3) B: Evaluation of proposals d)
- (4) C: Selection of procurement source a)
- (5) D: Implementation of procurement b)

"Selection of procurement source" is inserted into blank C, therefore a) is the correct answer.

Q7-21 c)

Explanation of RFI

The RFI (Request For Information), which comes before creation of the RFP (Request For Proposal), is a document by which the prospective procurer of products or services requests that vendors provide information that is required to determine the scope of procurement and to organize requirements definitions. In the procurement of information systems, information is requested on the usable technologies to achieve the requirements, as well as implementation methods, vendor experiences, vendor products, and so on. Therefore, c) is the correct answer.

- a) This is a description of an SLA (Service Level Agreement).
- b) This is a description of an RFP (Request For Proposals).
- d) This is a description of basic design specifications.

Section 8**Business Strategy****Q8-1 c)***Characteristics of the niche strategy*

Competitive strategy is a concept advocated by Michael Porter, an American business scholar, in the 1980s. It explains that there are three basic strategies for a company to overcome its competitors, namely the cost leadership strategy, the differentiation strategy, and the niche strategy, and any one of these must be selected.

An overview of each strategy is as follows:

- Cost leadership strategy: Provision of products at a cost lower than that of the competitors.
- Differentiation strategy: The advertising of differences with competitors, such as same-day service and high quality.
- Niche strategy (focus strategy): The targeting of a gap in a niche market (a market in which not many competitors participate), dealing with a narrow range of customers, but achieving high profitability.

If the content of each option is compared, c) is the correct answer.

- a) This is the explanation of a strategy with which the differentiation strategy is combined by a low-rank company in order to compete with a high-rank company, and is called a challenger strategy.
- b) This is considered an extension of the cost leadership strategy and differentiation strategy. It does not correspond to the niche strategy that targets a niche market.
- d) This is an explanation of the cost leadership strategy.

Q8-2 a)

Explanation of the management principle

A management principle indicates the basic concept for the working of a company. If there is no management principle, it becomes unclear as to what a company is trying to achieve, and based on what standard must decisions (decision-making) be taken. It also becomes impossible to determine the significance of existence of the company and employees. The management principle clarifies the purpose of a company, as well as the significance of its existence and the sense of values. Therefore, a) is the correct answer.

- b) Competitive superiority is the superiority in the competition for customers that occurs in the market, with other companies of the same industry. The resources of a company include human resources, material resources, financial resources, and information resources, and some companies even consider time and brand as resources.
- c) This is the content of a management plan. Although there is no clear stipulation of the time period, generally, the planning is based on the consideration of 3 to 5 years or more as a long term, 3 to 5 years or less as a midterm, and 1 year or less as a short term.
- d) This concerns corporate culture. Although a school tradition similar to this is seen in schools, because of the replacement of pupils and students in 3 to 4 years, the school tradition changes with time. However, since one works for as long as 40 years after joining a company, the corporate culture established over years and months does not change majorly in a short period of time.

Q8-3 b)

Merit of M&A

Merger and Acquisition implies the “merger and acquisition of companies.” One of the corporate strategies is the acquisition of management resources of another company in order to strengthen the management foundation or to supplement the weak points of a company. Foray into new fields, and expansion and reorganization of business are considered corporate strategies. Merger refers to mutual agreement through a contract, whereas acquisition refers to gaining a company through money. Through M&A, the acquisition of technologies and know-how that one’s company does not possess also leads to the accomplishment of new businesses in a short period of time. Therefore, b) is the correct answer.

- a) M&A essentially refers to the expansion of a company and is not a means for proceeding with function-specific division of labor. Therefore, this is not an appropriate merit of M&A. On the contrary, in many cases, division of labor is promoted by a spin-out. Note that once a company has executed M&A, it increases its specialization through function-specific division of labor. Therefore, this is not completely a wrong answer. However, because of the presence of option b), it cannot be claimed to be the most appropriate answer.
- c) Since autonomy is lost as a result of mergers and acquisitions, this is not an appropriate merit of M&A.
- d) This option indicates that a company considers a department system and subsidiary system for the division of labor in its business, which is a policy opposite to that of M&A that indicates integration. Therefore, this is not an appropriate merit of M&A.

Q8-4 a)

Risk that can be expected to be reduced as a result of an alliance

An alliance refers to a business tie-up between companies according to which a partner company with whom a tie-up is thought appropriate is sought, and business management is performed through collaboration while a business tie-up between the two companies is established. This includes forms such as a capital tie-up and sales tie-up, and generally, partnership is sought with another company that has corporate strength in an area different from the prime business of the company in question. As a result, even the cost necessary for the expansion of business can be shared with the business partner, and as a result, a reduction in the business investment risk can be expected. Therefore, a) is the most appropriate.

b), c), d) A reduction in all of these risks cannot be expected directly as a result of an alliance, and on the contrary, an increase in the concerned persons of a corporate activity can most probably lead to an increase in risk.

Q8-5 d)

Purpose of focusing on stakeholders

The word stakeholder is used to indicate all concerned parties of a company, such as the shareholders and customers. Particularly according to the latest trend, an improvement in the satisfaction level of the stakeholders has become indispensable for the continuous growth and expansion of a company. Therefore, d) is the correct answer.

- a) This is an explanation of compliance management.
- b) This is an explanation of core competence management.
- c) This is an explanation of corporate governance.

Q8-6 c)

Explanation of benchmarking used in business administration

Benchmarking intends to reform a company's business administration, and implies the investigation of other companies, the selection of the one that achieves the highest-level results, and setting improvement targets for the company in reference to the best practices. Therefore, c) is the correct answer. As far as the origin of the word benchmark is concerned, it is a level point used in measurements, and while the performance comparison criterion is referred to as a benchmark in computers, the term used in management is differentiated by adding an "ing" to become "benchmarking."

- a) This is an explanation of ERP (Enterprise Resource Planning).
- b) This is an explanation of BPR (Business Process Re-engineering).
- d) This is an explanation of CSF (Critical Success Factor).

Q8-7 b)

Purpose of analysis based on portfolio categorization

A technique of positioning and analyzing the business based on a matrix that combines the market growth rate and market share is called the PPM (Product Portfolio Management) analysis technique, and is frequently used for creating a product strategy. The purpose of performing such portfolio analysis is to identify the prioritized areas and areas that need to be withdrawn from, allocate the management resources selectively to the areas whose growth can be expected, and pull out management resources from areas that need to be withdrawn from in order to achieve efficient resource allocation in the company as a whole. Therefore, b) is the correct answer.

- a) The promotional effect is not represented directly by such a matrix.
- c) The quality of a product is not represented directly by such a matrix.
- d) Seasonal fluctuation factors and geographical distribution are not represented directly by such a matrix.

Q8-8 a)

Business policy as seen from a graph

In this question, the business policy is considered from the viewpoint of the actual annual sales amount and the projected annual purchase amount of each customer.

A customer in area *A* has a small amount of actual annual sales, and a large amount of projected annual purchase, as described in the explanation, so the customer is a potential large-volume customer, and reinforcing sales efforts towards the customer is worthwhile. Therefore, the description of a) is appropriate.

- b) A customer in area *B* can be regarded as a regular customer because of large amounts of both the actual annual sales and the projected annual purchase. Therefore, the sales efforts towards the customer must continue as before.
- c) A customer in area *C* has a small amount of both the actual annual sales and the projected annual purchase, so it cannot be said that the customer has the potential to become a prospective regular customer. Therefore, this option is incorrect.
- d) A customer in area *D* has a large amount of actual annual sales, but a small amount of projected annual purchase. Therefore, it cannot be said that the customer can be expected to increase the amount of purchases, as described in the explanation.

Q8-9 c)

Explanation of marketing mix

The objective of a company is to provide feedback to the company as well as the shareholders and employees about the profits earned by providing products and services to consumers, and to ensure continuance of activities by them. Ensuring the semi-permanent persistence of a business organization in this way is called a going concern. However, these activities might increase, decrease, or even stop (bankruptcy or discontinuance of business) in some sales of products. Therefore, in order to achieve a going concern, methods for expanding marketing (business activities from production to sales) are extremely important, and marketing mix is focused upon as a means for satisfying the market needs.

This is a keyword that collectively represents the business activities developed for the sale of a product, such as the brand strategy and service, transport of the product, and inventory control and advertising, and effective marketing development can be achieved by fully elaborating on the sales strategy after all these are taken into consideration at the time of development of the product. As shown in the table below, in marketing mix, appropriate examination is performed in each stage of the viewpoint of the buyer (4C) and the viewpoint of the supplier (4P). Therefore, c) is the correct answer.

4C and 4P in marketing mix

Element	4C (viewpoint of the buyer)	4P (viewpoint of the supplier)
Product	Consumer's value (value for the buyer)	Product (quality and attractiveness of the product)
Price	Consumer's cost (cost borne by the buyer)	Price (price of the product)
Distribution	Consumer's convenience (ease of the buying method)	Place (sales method)
Promotion	Communication (information transmittance)	Promotion (advertising)

- a) This is a psychology process model seen in consumption behavior that is called the AIDMA law according to which the psychology of the consumer from the understanding of the existence of a product until its purchase is explained based on five stages, namely attention, interest, desire, memory, and action.
- b) The division of a market by grouping the consumers demanding diversified products and marketing mix is called market segmentation, and the elements used for this include the geographic variables, demographic variables, psychographic variables, and behavioral variables. This method defines the target market and is utilized in the target market through target marketing, which is a marketing process in which the marketing mix of the company has been applied.
- d) This is a product life cycle model according to which the series of processes of sales of the product and transition in profit from the time the product is introduced in the market until it gradually stops selling and disappears from the market is explained based on the four stages of the introduction stage, growth stage, maturity stage, and decline stage.

Q8-10 a)

Explanation of BSC (Balanced Score Card)

BSC (Balanced Score Card) is a performance management technique that was developed by Robert S. Kaplan and David P. Norton in the U.S. in the early 1990s, and thereafter was widely accepted by the manufacturing industry and the service industry of the U.S. It captures corporate activities based on the four perspectives of the “perspective of learning and growth,” the “perspective of customer,” the “perspective of internal business processes,” and the “financial perspective,” and aims to control the performance of the company while maintaining a balance between these perspectives. By stipulating the basic strategic objectives for each of these four perspectives, promoting activities for achieving the objectives, and periodically evaluating their attainment level, the realization of the business strategy can be aimed at. Therefore, a) is the correct answer.

- b) This is an explanation of SWOT analysis. SWOT represents the Strength-Weakness of the internal environment of a company, and the Opportunity-Threat of the company’s external environment.
- c) This is the explanation of the product lifecycle strategy technique.
- d) This is the explanation of the PPM (Product Portfolio Management) technique.

Q8-11 c)

CRM

As described in option c), CRM (Customer Relationship Management) is a corporate strategy for improving customer satisfaction thus leading to better business performance. For example, the consumption trend and preferences of the customer are analyzed based on a customer database such as past ordering history. As a result, CRM aims to improve customer satisfaction and convenience by corresponding to the customer needs in detail, and thereby attempting an improvement in profitability by capturing customers as regular customers. Therefore, (c) is the correct answer.

- a) This is an explanation of MRP (Material Requirements Planning).
- b) This is an explanation of ERP (Enterprise Resource Planning).
- d) This is an explanation of SCM (Supply Chain Management).

Q8-12 d)

Effect of implementing CRM

CRM (Customer Relationship Management) is a technique for increasing earning power through an improvement in customer satisfaction by sharing across an entire company a database in which overall customer information, such as the purchase pattern of the customer and the complaint history, as well as maintenance service history and likes and tastes are accumulated, and also by providing intricate services. Thus, the objective of CRM is to acquire customer loyalty (which means ensuring that a person becomes a long-term patron of the products of the company), and to achieve an increase in customer lifetime value (which means securing the lifetime demands of the customer through the products of one's company). Therefore, d) is the correct answer.

- a) In the sales management system and the accounts receivable management system, payment status corresponding to the business details of the customer can be understood. This is used for customer analysis by integration with CRM.
- b) This is a description of QR (Quick Response) or SCM (Supply Chain Management). QR is a business management technique that aims to reduce the time required between the order of a product and its delivery (lead time), by working towards the elimination of wastage and loss underlying the distribution processes ranging from manufacture of the product until it is passed on to the customer, under the assumption of a state in which the maximum efficiency is achieved, and with the objective of achieving such a state. Furthermore, SCM is a technique for performing integrated management of materials flow from acceptance and ordering of material until inventory control and delivery. It aims at the reduction of the lead time by sharing information through all processes of procurement, production, and "supply chain" of sales among several departments and companies, and focuses on the total optimization of the business process, and at the same time, aims at cost reduction and increase in earning power.
- c) This is a description concerning SFA (Sales Force Automation).

Q8-13 c)

Effect of supply chain management

Supply Chain Management (SCM) is a management technique of constructing an integrated logistics system (distribution system) for achieving consistency in the flow of material and information from procurement until production and sales. Therefore, c) is the correct answer.

- a) This refers to POS (Point Of Sale). POS system refers to the information system in a retail business, and implies point-of-sale management. Specifically, it is a system that enables fast processing of information concerning sales, including calculation of charges, by reading the bar code appended on the product, at the time of selling the product.
- b) This refers to a knowledge base. It is difficult to store a large amount of content in a single database, and so generally the empirical knowledge necessary for problem solving as well as the factual knowledge concerning the object itself is collected with the focus on a particular field.
- d) This refers to the help desk. Depending on the company, a different name such as a customer service center or a customer inquiry center might be adopted.

Q8-14 d)

Points to be noted prior to installing an ERP package

The objective of an ERP (Enterprise Resource Planning) package is to understand overall management resources in real time and aim for their effective use by revising mission-critical business processes. In many cases, it aims at reviewing the business activities in accordance with the business model of a package created in correspondence to a standard business process. In such a case, it becomes necessary to review and redesign the business processes of the entire company. Therefore, d) is appropriate.

- a) Installing and revising the business systems in phases as and when necessary, rather than installing all business systems simultaneously is one of the desired methods for adhering to business.
- b) While it is necessary to respect the opinions of the users, the users might be opposed to the installation of the ERP package due to the simple reason that it is different from the method they have become accustomed to. Therefore, it is not necessary to adhere to the current business processes.
- c) It cannot be said that installing the accounting system first is effective for reconstruction of the system. Generally, most examples of installation indicate starting installation from SFA (Sales Force Automation).

Q8-15 d)

Technical development for developing new products

The term indicating the fundamental research development for the development of new products is R&D (Research and Development) described in d).

- a) M&A (Mergers and Acquisitions) refers to the “merger and acquisition of companies,” and is a corporate strategy for the acquisition of management resources of another company in order to strengthen the management foundation or to supplement the weak points of one’s company.
- b) MOT (Management Of Technology) refers to management for the creation of new products and new businesses through technical development. It implies integrated management that includes not only effective technical development and product development, and pursuing production efficiency, but also marketing and intellectual property management.
- c) OEM (Original Equipment Manufacturing) refers to production of products to be sold under the company name (brand) of a partner.

Q8-16 c)

Role of an organization approved or accredited under the TLO law

The TLO (Technology Licensing Organization) law is also called the Law Promoting Technology Transfer from Universities, and its formal name is “Act promoting transfer of research results of technological research in universities to private companies.” It has been enforced since August 1998.

TLO refers to the university, technical college, or inter-university research institute that undertakes the specific business of technology transfer of the university as stipulated by this law, with its main role being to patent the research results of the technology developed by the university and the research institute, and support the creation of new businesses of the company by granting a license to the company. Furthermore, the organization returns a part of the profits to the university as a royalty (patent fee), which is assigned to a new research fund. That is, it acts as an intermediary between businesses and universities, and supports this cycle. Therefore, c) is the appropriate role.

TLOs include approved TLOs and accredited TLOs. The characteristic of an approved TLO is to handle the patents owned by individuals such as university professors, and the activities planning of such a TLO is approved by the Ministry of Economy, Trade and Industry as well as the Ministry of Education, Culture, Sports, Science and Technology based on the TLO law. The characteristic of an accredited TLO is to handle government-owned patents of national universities and research and testing institutes, and such a TLO is accredited by ministries and government offices having jurisdiction over each of these research institutions.

a), b), d) None of these is directly related to the main point of the TLO law.

Q8-17 a)

Digital divide

Divide is a term implying “to discriminate against.” Digital divide (information gap) is a term implying a gap caused by the presence or absence of the ability to master digital products and services such as PCs and communications. Therefore, a) is the correct answer.

- b) This is a description concerning an e-government.
- c) This is a description concerning a universal service.
- d) This is a description concerning a one-stop service.

Q8-18 d)

Application suitable for groupware

Groupware is software supporting collaborative work, and its main functions include e-mails and conference room reservation, file sharing, e-meetings, adjustment of meeting time, scheduling, and project management. Therefore, d) is appropriate. Groupware is suitable for activities involving sharing of information among several persons so as to improve the efficiency of the group. Therefore, the processes described in a) through c) are not applicable.

Q8-19 a)

Bar code in a POS system

A bar code printed on a product appears as follows:



Such a code is called a JAN (Japanese Article Number) code. The JAN code includes the standard type that is composed of 13 digits, and the short type that is composed of 8 digits. The short type can be used only when the product is small such that it is difficult to print the standard type. Therefore, a) is the correct answer.

- b) JAS is the Japanese Agricultural Standard. This standard is provided to achieve improvement and reformation in the quality of agricultural and forestry products, simplify and make transactions fair, and rationalize production or consumption.
- c) JIS is the Japanese Industrial Standard. It is a national standard of Japan, and was established based on the Industrial Standardization Law. Its purpose is to achieve improvement in the quality of industrial products, improvement in production efficiency, rationalization of production, simplifying and making transactions fair, and rationalizing use and consumption.
- d) The QR (Quick Response) code is the most popular code of all two-dimensional codes, and has evolved with the purpose of printing a greater amount of information than a one-dimensional code (such as the JAN code) in a small space. A QR code can handle information containing 7,000 or more numeric characters, and in addition, can also handle Japanese characters (Hiragana and Kanji). Furthermore, even if a part of the code is damaged or contaminated, it can be read correctly by including information for error correction.



Q8-20 d)

Settlement method of a debit card

A debit card is similar to an ATM card that can be used for settlement of payments through direct deduction from a savings account of a banking institution during shopping. Therefore, (d) is the correct answer.

- a) Settlement performed through a post-payment method corresponds to a credit card.
- b), c) These are pre-payment methods in which the balance amount is managed within the card, and correspond to a prepaid card.

Q8-21 b)

Mechanism for data exchange between companies

The mechanism used to digitize information concerning business transactions, and exchanging data between companies via a network is called EDI (Electronic Data Interchange) as described in b). A standard protocols and specifications are used as the agreement necessary for the exchange of data.

- a) CA (Certification Authority) This is an agency that issues and manages electronic certificates regarding the validity of the public key.
- c) SET (Secure Electronic Transaction) This is a protocol for the safe and secure settlement of a credit card over the Internet.
- d) SSL (Secure Sockets Layer) This is an industry standard protocol that is used for the safe and secure exchange of data between a Web browser and a Web server.

Q8-22 d)

B-to-C in EC

A B-to-C transaction refers to a direct transaction from a Business to a Consumer. Transactions performed over the Internet, that is, EC, include various forms such as company-to-company and company-to-individual.

A virtual mall refers to a market targeting various individuals that is established over the Internet with the aim of advertising and selling several products to unidentified consumers, and exactly suits the concept of a B-to-C transaction. Therefore, d) is the correct answer.

- a) CALS (Continuous Acquisition and Lifecycle Support) is an information standardization activity that aims for cost reduction, shortening of the delivery period, and improvement in quality of the entire lifecycle from the development and designing of a product until its manufacturing, sale, usage, and disposal. It does not represent the concept of transactions.
- b) EDI (Electronic Data Interchange) refers to electronic business transactions between companies, and a simple form of an EDI activity using the Internet is Web-EDI. This corresponds to a B-to-B transaction.
- c) A virtual company is a method of business accomplishment according to which several individuals are connected via a network to function just like a single company. It does not represent the concept of transactions.

Q8-23 b)

Agreement for performing e-commerce using EDI

In e-commerce that uses EDI (Electronic Data Interchange), a standard agreement needs to be set up at the below-mentioned four levels. Among the options, b) is the correct description of the information communication protocol.

Level	Agreement content
First level	Information communication protocol (communication protocols such as the type of the communication line and the transmission control procedure)
Second level	Information representation protocol (agreement concerning the message format and data code)
Third level	Task operation protocol (agreements concerning system operations such as the operating time of the network system and failure measures)
Fourth level	Basic transaction protocol (basic agreement concerning a transaction contract between both parties)

- a) Communication methods are included in the information communication protocol.
- c) The system operating time and failure measures are included in the task operation protocol.
- d) The information representation protocol defines the data format.

Q8-24 b)

Online checking of credit card details

CAT (Credit Authorization Terminal) is a terminal device for CAFIS (Credit and Finance Information Switching System) of NTT. A telephone line is used to connect to the CAFIS center, and the checking whether a user's credit card is valid or not as well as the credit limit can be performed online. Therefore, b) is correct.

- a) ACR (Automatic Carrier Routing) is a function for selecting the line of a common carrier with low charges, when lines of several common carriers exist between the caller and recipient of a long-distance call. The common carrier can be selected either by the adapter attached to the telephone or the selection function provided in the telephone.
- c) GPS (Global Positioning System) is composed of 24 artificial satellites launched by the Armed Forces of the United States, a terrestrial control office, and a user mobile station. Although it was originally built for military affairs, currently it is increasingly being used in the private sector for car navigation and location information services.
- d) A PDA (Personal Digital Assistant) is a small-size information device as big as the palm of the hand. Currently, products integrated with cell phones and PHS are also frequently referred to as PDAs.

Q8-25 a)

Comparison of safeguard against the counterfeiting of an IC card and a magnetic card

An IC card is a card that uses an IC (integrated circuit) for recording information. Types include one that comes equipped with only a memory using an IC, and one in which a CPU is also provided, however, both these types can store significantly large amount of information in comparison with a magnetic stripe card. A magnetic stripe card is a card in which a belt-shaped magnet using iron is pasted, which records information as a result of changes in its magnetic properties. In a magnetic stripe card, the information recorded in the magnetic stripe can be read easily by using a cheap magnetic reader, however, since the data recorded in the memory of an IC card can be encrypted, an IC card is difficult to counterfeit as compared to a magnetic card. Therefore, a) is appropriate.

- b) An IC card uses computerized data for recording information.
- c) It can be said that a magnetic card is easy to counterfeit as it uses a simple mechanism for recording and protecting information as compared to an IC card.
- d) A magnetic card uses changes in the magnetic properties for recording information.

Q8-26 d)

Characteristic of an IC tag (RFID)

An IC tag (RFID: Radio Frequency Identification) is a tag that comes with a small embedded IC chip, and can read and write the content information through information interchange based on close-range wireless communications.

The currently popular type is the passive-type IC tag in which power is not supplied to the tag itself, but by receiving and making use of the electric waves emitted by the reader/writer, an electric current is generated in the tag, which enables information processing and transmission. In comparison with the conventional bar code type, most of the information stored in an IC tag is non-contact type, and therefore, even when a non-visible area becomes dirty, an IC tag can perform reading and writing, which is its strong point. Therefore, d) is the correct answer.

- a) In GPS (Global Positioning System), location is calculated by receiving electric-wave signals from several GPS satellites, however, a GPS receiver and a display device connected with it are used for receiving and displaying the signals, and there is no relationship with an IC tag.
- b) An IC tag contains information in an IC chip, and does not use an external storage device.
- c) This is an explanation of an insert-type IC card (chip card and smart card). An IC tag does not need to be inserted in a reader.

Section 9

Corporate and Legal Affairs

Q9-1 a)

Highest decision making body of a stock company

The highest decision making body of a stock company is the stockholders' meeting (Companies Act, Part 2, Chapter 1, Article 1, Clause 1). In a stockholders' meeting decisions are made concerning fundamental aspects of a company, such as organization of the company (including changes to the articles of incorporation, and dissolution and mergers), appointments and removals of constituent members (such as directors and auditors), and dividends and other profit for shareholders. Therefore, a) is correct.

A stockholders' meeting is composed of stockholders. It is formed of regular general meetings that are held at a set time in each accounting period, and extraordinary general meetings that are held as necessary. It is not a permanent body. There is a duty to take minutes of a stockholders' meeting, and stockholders are notified of resolutions passed via a stockholder's meeting notification of resolution. Stockholders have voting rights based on the number of shares owned, and as a general rule resolutions at a stockholders' meeting are made by majority vote.

- b) A management conference is a conference that is held to discuss important topics concerning the basic policy for organizational operation and management in order to strategically handle various issues concerning corporate organization from a companywide point of view. It is also used as a venue for reports about budgets and issues, analysis of business results, confirmation of the overall situation of the company, and unification of the direction of all departments.
- c) A managing committee is a decision making body concerning projects that are important for a company. It is composed of directors equal to or higher than executive directors who take the role of presiding over the company's business by constantly assisting the representative director (CEO) in the directors of a stock company. Unlike a board of directors, there is no legal requirement to establish a managing committee, but historically, and in reality, in Japan in the majority of cases the function of a board of directors is achieved with a managing committee.
- d) A board of directors is a decision making body concerning the management of a stock company that by law must be established. One meeting must be held at least once every three months, and the execution of the business of a stock company depends on the resolutions of the board of directors. A board of directors is composed of all directors, and it monitors the execution of business of representative directors. The difference between a board of directors and a stockholders' meeting is that important decisions concerning the survival of the company are made by a stockholders' meeting and all other aspects concerning management are decided by a board of directors.

Q9-2 c)

Explanation of a BCP in corporate activities

A BCP in corporate activities refers to a Business Continuity Plan, which is a plan that is created in advance in order to continue business as far as possible in the event of a disaster or an accident. Therefore, c) is correct.

In an information system, contingency plans (an emergency plan which is similar to a BCP) are common knowledge, but a contingency plan is for after an emergency situation occurs whereas a BCP includes everyday countermeasures and focuses on the continuity of business and its recovery. Furthermore, for business continuity, as well as a proposal for a BCP, a chain of processes that comprises actual operation, training, and review and improvement is required. Management of this chain of processes is called BCM (Business Continuity Management).

- a) The social responsibility of a company in this description is called CSR (Corporate Social Responsibility). Environmental measures that are recently popular as well as the commonly heard “compliance” are also part of the measures for fulfilling CSR. Furthermore, the responsibility for explanation in this description is also part of these measures, and is also called “accountability.”
- b) This is an explanation of knowledge management. The “implicit knowledge” in knowledge management is knowledge that is based on gut feeling and experience and is difficult to represent with language. In contrast to this, knowledge that can be represented with language, a graph, or a diagram is called “formal knowledge.”
- d) This refers to risk management, and the approach in this description that is taken by an organization is called ERM (Enterprise Risk Management).

Q9-3 d)

Activity in the PLAN phase of PDCA

ISMS (Information Security Management System) is a repetition of the cycle, PLAN → DO → CHECK (check or audit) → ACT, and is an organized mechanism for the continuous maintenance and improvement of the level of security. In the PLAN phase, a specific plan and goal for information security measures are created. An assessment is a prior analysis and evaluation, and it is necessary to analyze and evaluate risks concerning information assets that are subject to management in the PLAN phase. Therefore, d) is correct.

- a) Management of operational status is information security management itself and applies to the DO phase.
- b) Implementation of measures for improvement is performed in the ACT phase.
- c) R Review of implementation status is performed in the CHECK phase.

Q9-4 d)

Project organization in the development of information systems

a) Committee organization is simple to organize and operate, but responsibilities and authorities tend to be unclear. b) Since a functional organization is organized by duties, the most appropriate personnel are selected for the most appropriate duty, and personnel assignment is efficient. c) Since task force organization assembles the personnel necessary to achieve a specific aim, decision making is generally performed swiftly. d) The description concerning matrix organization is correct.

Q9-5 c)

Maximin strategy

A maximin strategy is also called a minimax strategy, and is a strategy to maximize the minimum payoff for each strategy. In other words, it is an approach that assumes the worst case for each strategy, and attempts to minimize the loss in that case.

		Company B	
		Strategy B1	Strategy B2
Company A	Strategy A1	-15, 15	20, -20
	Strategy A2	5, -5	0, 0

In the question, Company A has strategies A1 and A2. The minimum payoff for strategy A1 is -15 and the minimum payoff for strategy A2 is 0, so the minimum payoff with the largest value (maximum value) is strategy A2. Company B has strategies B1 and B2. The minimum payoff for strategy B1 is -5 and the minimum payoff for strategy B2 is -20, so the minimum payoff with the largest value (maximum value) is strategy B1. Thus, Company A selects strategy A2 and Company B selects strategy B1. At the intersecting cell of A2 and B1, the profit of Company A is 5, so c) is correct.

Here, there is also a “maximax strategy” that maximizes the maximum profit of each strategy.

Q9-6 d)

Annual total of purchase cost, order cost, and storage cost

The annual total of the purchase cost, order cost, and storage cost can be calculated with the following expressions.

Total ordering cost

$$= \text{cost per order} \times \text{annual number of orders}$$

$$= \text{cost per order} \times (\text{annual order volume} \div \text{order quantity per order})$$

Total purchase cost

$$= \text{unit purchase cost} \times \text{annual order quantity}$$

(Here, if the order quantity of a single order is 100 units or more, there is a discount of 10%)

Total storage cost

$$= \text{average inventory quantity} \times \text{annual storage cost per unit}$$

$$= (\text{order quantity per order} \div 2) \times \text{annual storage cost per unit}$$

Here, the reason why the average inventory quantity is “the order quantity per order \div 2” is because the inventory decreases at a fixed rate, and when the inventory runs out goods are received simultaneously so the maximum value for the inventory is the order quantity per order, and the minimum value is 0, and so the average of these two values should be taken.

When these expressions are used to calculate the order quantity per order for 40 units and 100 units, the results are as shown in the table below.

	40 units	100 units
Order cost	$2 \times (400 \div 40) = 20$	$2 \times (400 \div 100) = 8$
Purchase cost	$5 \times 400 = 2,000$	$5 \times 400 \times (1 - 0.1) = 1,800$
Storage cost	$(40 \div 2) \times 1 = 20$	$(100 \div 2) \times 1 = 50$
Total	$20 + 2,000 + 20 = 2,040$	$8 + 1,800 + 50 = 1,858$

Thus, the total amount of 40 units is 1,820,000 yen more expensive, so d) is correct.

Q9-7 c)

Activities that are appropriate for an investigation with game theory

Game theory is a method where decision making is performed by the selection of the means to gain superiority over another party by predicting the decision making of the other party in a competitive environment. For example, when a strategic product is released in accordance with an internal corporate profit plan, there are competition problems such as whether or not the product is accepted by the market is affected by the sales strategy for similar products from the same vendor. The description of option c) applies to this.

- a) A decision on the number of entry gates at an event venue is an estimation problem.
- b) For analysis of the reasons behind hot-selling products, a method such as the cause and effect analysis method used for problem resolution is used.
- d) An estimate for the demand for a newly developed product is a problem for profit planning in management forecasting and is a case where no competitors exist.

Q9-8 c)

Methods for the calculation of the maximum profit under manufacturing constraints

Linear programming is an approach to secure the largest result within constraints. In this question also, the quantity of products *A*, *B*, and *C* that should be made in order to maximize profit under constraints in quantity of resources (production time, quantity of raw material) that can be allocated is calculated, so it is appropriate to solve the problem with c) linear programming.

Specifically, methods to solve this kind of problem include a solution that formulates the problem, a solution that uses a graph, and a solution that uses the simplex method. In consideration of this problem, the solution is as shown below.

For products *A*, *B*, and *C*, *x*, *y*, and *z* units are manufactured respectively.

(Constraints)

$$x \geq 0, y \geq 0, z \geq 0$$

$$2x + 3y + z \leq 240$$

$$2x + y + 2z \leq 150$$

(Target function)

$8x + 5y + 5z \rightarrow \text{Maximum}$ The values of *x*, *y*, and *z* that maximize this are the most appropriate.

- a) The moving average method is used in questions related to demand forecasting.
- b) The least squares method is used for the approximation of functions. In regression analysis for demand forecasting, it is used to calculate a regression line from observed values.
- d) In inventory management, the fixed quantity ordering method is a method for ordering a fixed quantity when the inventory decreases to a certain level.

Q9-9 b)

ABC analysis

In fields such as inventory management, in order to optimize the management method, ABC analysis is used as a method to classify products into ranks and decide products to be prioritized for management. In ABC analysis, a composite graph (Pareto chart) that is composed of a bar graph of a monetary amount and a line graph of the ratio of accumulated total for a monetary amount. The specific procedure for ABC analysis is shown below.

- (1) Arrange products in descending order of sales.
- (2) Calculate the total sales of all products
- (3) For each individual product calculate the cumulative sales and proportion of accumulation.
- (4) Classify the products into the following ranks of A, B, and C (the proportion of rank B is an example). Perform priority management for the products that are assigned to rank A in this procedure.
 - Rank A: Products with cumulative sales of up to approximately 70%
 - Rank B: Products with cumulative sales of up to approximately 70% through 90%
 - Rank C: Other products

In accordance with steps (1) to (4), the data of the question is inserted into a table and investigated. Product numbers 2 and 5 are applicable to “group A” of products.

Here, in general ABC analysis, the numbers that state rank A is 70% and rank B is 90% are only guidelines, and there are no precise rules such as “products that exceed 70%.” A comparison of the values of 62.7% of product number 2, and the 78.4% of product numbers 2 and 5 with the standard of 70% suggests that the 62.7% of product number 2 is also valid. However, there is no option for this in the answer group, so option b) containing product numbers 2 to 5 is selected.

Product number	Annual sales	Cumulative total of annual sales	Cumulative ratio	
2	2,400	2,400	62.7%	Rank A
5	600	3,000	78.4%	
8	300	3,300	86.2%	Rank B
1	220	3,520	92.0%	
4	130	3,650	95.4%	Rank C
10	50	3,700	96.7%	
3	40	3,740	97.8%	
9	40	3,780	98.8%	
6	25	3,805	99.5%	
7	20	3,825	100.0%	
Total	3,825			

Q9-10 a)

Chart showing the cause and proportion of defective products

This is a description of a Pareto chart. A Pareto chart is a bar graph that represents the number of instances for each item with the instances (values) arranged in descending order (from largest to smallest), and a line graph that shows the accumulated proportion. Therefore, a) is correct.

A Pareto chart is one of the seven tools for QC, and can reveal causes that have a high level of importance. In addition, a Pareto chart can be used with ABC analysis that classifies an overall group into three groups, and allows the importance of each item to be understood.

Q9-11 a)

Methods used to prevent operation mistakes

When appropriate countermeasures are taken in advance for failures that are assumed, the seven new tools for QC PDPC (Process Decision Program Chart) are used. A PDPC is a flow chart diagram that represents an implementation plan for the achievement of a goal as a process that includes avoidance of conceivable risks and attainment of the goal. Therefore, a) is correct.

- b) An arrow diagram is a method that is used for scheduling. Related activities are linked with an arrow and appropriate schedule management can be performed by analysis of activity paths that cause a bottleneck due to the order of activities and the number of days.
- c) The tree diagram method is one of the seven new tools for QC. It is a method for searching for guidelines to solve a problem through a chain of development from the goal to the method in order to achieve the goal.
- d) The association diagram method is also one of the seven new tools for QC. It is a diagram that uses arrows that represents cause-effect relationships that are assumed between numerous problems and their causes. It is used to clarify an entire problem where things such as cause and effect or the aim and the method are intertwined in a complex manner.

Q9-12 b)

Diagrams that are appropriate for the analysis of program errors

A scatter diagram is a graph that plots two characteristic values that are thought to have a mutual relationship on the vertical and horizontal axes. It is appropriate for an investigation of the relationship between the number of steps and number of errors in a program. Therefore, b) is correct.

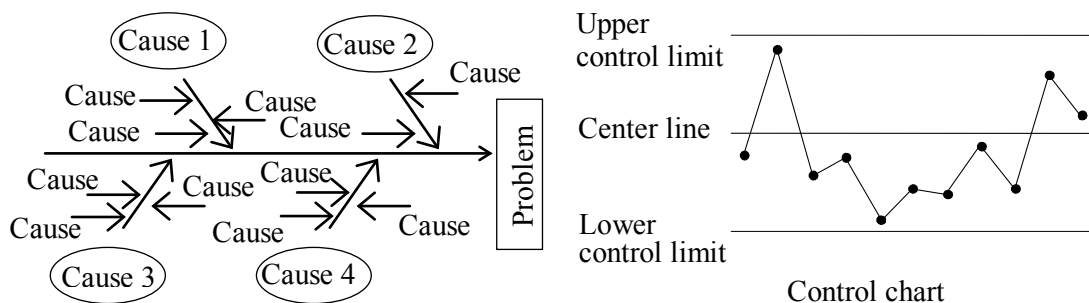
- a) A tree diagram is one of the seven new tools for QC. It is a diagram for the clarification of the process of a thorough investigation of a topic, such as methods to achieve a goal, or an effect that leads to a result.
- c) A cause and effect diagram is one of the seven tools for QC. It is a diagram that traces back and organizes causes that have an effect on an attribute, and assigns a relationship. It is shaped like the bones of a fish, so it is also called a “fish bone diagram.”
- d) A Pareto chart is one of the seven tools for QC. It arranges the frequency of occurrence of each item in descending order of magnitude on a bar graph, and shows the cumulative sum of this with a line graph. It is used in order to perform stratification in accordance with the degree of occurrence.

Q9-13 a)

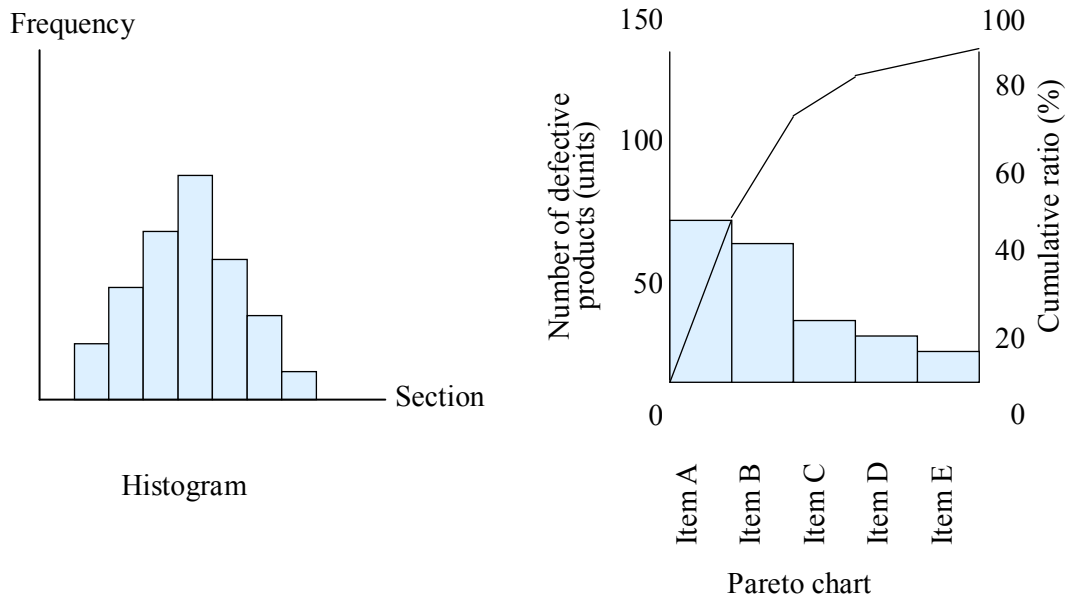
Explanation of cause and effect diagram

A cause and effect diagram is a systematic diagram that organizes the relationships between causes and effects in the shape of the bones of a fish. Therefore, a) is the appropriate description. It is one of the seven tools for quality control (Pareto chart, cause and effect diagram, scatter diagram, histogram, control chart, checklist, graph).

- b) This is an explanation of a control chart
- c) This is an explanation of a histogram. A histogram can show the shape of the distribution of all data, the average value of data, and differences in data.
- d) This is a description of a Pareto chart.



Cause and effect diagram

**Q9-14 c)**

Financial indicator

This is a question concerning the financial indicators used in management analysis where a judgment is made on whether operating results and financial situation are favorable or not through the analysis of the profitability, security, productivity, and growth potential of a company. The percentage of profit to total capital is the total capital profit ratio, and the larger the value the higher the profitability. Therefore, c) is appropriate.

- a) A fixed ratio is the percentage of fixed assets to equity capital. Generally, 100% or less is considered to be desirable.
- b) Equity to total asset is the percentage of fixed assets to total capital. The higher the value the better, but generally 50% or more is considered to be desirable.
- d) A current ratio is the percentage of current assets to current liabilities. It can be judged that the larger the value the higher the security is in the short term. Generally, 200% or more is considered to be desirable.

Q9-15 d)

Calculation of sales for a profit target

The amount remaining after the deduction of fixed costs and variable costs from total sales is profit. If the number of customers per month is x , since the total sales per customer is 500 yen, the total sales is $500x$ yen. Next, the monthly fixed cost is 300,000 yen as shown in the conditions. The variable cost is described as “100 yen variable cost in total sales for each customer,” and so is $100x$ yen.

The target profit is 100,000 yen per month, so if the following expression is used, the number of monthly customers x can be calculated.

(total sales) – (variable costs + fixed costs) = (loss or profit)

$$500x - (100x + 300,000) = 100,000$$

$$500x - 100x - 300,000 = 100,000$$

$$400x = 400,000$$

$$x = 1,000$$

Thus, 1,000 customers per month are required, and since the number of business days per month is 20, the number of customers per day is $1,000 \div 20 = 50$. Furthermore, the number of seats is 10, so the calculated number of customers required per day per seat is $50 \div 10 = 5$. Therefore, d) is correct.

Q9-16 c)

Calculation of expected profit with the expectation principle

In a plan for production facilities, the expected profit when the expectation principle is used can be found by multiplication of the desired value of each facility plan by the expected probability for each situation.

The expected profit of each facility plan is as shown in the table below (unit: million yen).

		Situation 1	Situation 2	Situation 3	Situation 4	Total
Expected probability		0.2	0.3	0.4	0.1	
Facility plan	A	8.0	3.0	0.0	-0.6	10.4
	B	1.4	5.4	4.0	-1.0	9.8
	C	1.6	5.4	4.8	-0.5	11.3
	D	0.4	1.2	4.8	3.0	9.4

If the total is calculated from the calculation results above, the value of plan C is 11.3, and it can be understood that this is the maximum expected value. Therefore, c) is correct.

Q9-17 a)

Periodic average method

This is a question concerning the evaluation procedure for sales unit price. Broadly speaking, calculation methods for sales unit price include cost methods and LCM (Lower of Cost or Market value) methods. The main cost methods are shown in the table below, and the LCM methods are methods that compare the evaluated value of one of the cost methods with the normal acquisition price at the end of a period and then use the lower price.

Cost method	Details
First-in first-out method	Items that come into stock first are first out and are used for the sales unit price.
Last-in first-out method	Items that come into stock last are first out and are used for the sales unit price.
Periodic average method	The total of the evaluated value at the beginning of the period and all acquisition prices within the period is obtained and divided by a total of all quantities. The resulting average value is the sales unit price (a).
Moving average method	When a purchase is made, the mean of the inventory cash amount and the purchase cash amount is calculated. This value is used to fix the sales unit price (c).
Simple average method	The average unit price for purchases in the period is the sales unit price.

Therefore, a) is correct.

Q9-18 c)

Break-even point

This question asks for the required unit sales in order to achieve a profit of twice the current period, or in other words a profit of 4,000,000 yen. As such, it is necessary to notice that some kind of numeric value is hidden in the question. This hidden numeric value is the sales quantity for the current period. If the sales quantity is not understood, then the variable cost divided by the sales quantity that gives the variable cost per unit cannot be understood. Since the total sales for a product with a unit cost of 5,000 yen is 10,000,000 yen, it can be understood that the number of units sold is 2,000, and that the variable cost per product is 3,000 yen. Based on this, if the sales quantity is n and an equation to calculate a profit of 4,000,000 yen is composed, the calculation is as shown below.

$$\begin{aligned} &5,000 \times n \text{ (total sales)} \\ &- 2,000,000 \text{ (fixed cost)} \\ &- 3,000 \times n \text{ (variable cost)} \\ &= 4,000,000 \text{ (target profit)} \end{aligned}$$

The result of calculation of these is as shown below.

$$\begin{aligned} 5,000n - 2,000,000 - 3,000n &= 4,000,000 \\ 2,000n &= 6,000,000 \\ n &= 3,000 \end{aligned}$$

As such, it can be understood that a profit of 4,000,000 yen is achieved when 3,000 units are sold. Therefore, c) is correct.

Q9-19 d)

Explanation of ROE

ROE (Return On Equity) is called the equity to total asset or return on stockholders' equity, and represents the proportion of profit to equity capital (capital stock). It is an index that focuses on the return of profit to a stockholder. Therefore, d) is correct.

- a) This is an explanation of ROA (Return On Asset). ROA represents the proportion of profit to total assets. It is an index that measures overall profitability by examination of how efficiently invested assets are used to obtain profit.
- b) This is an explanation of equity to total assets. Equity to total assets represents the proportion of equity capital to total capital. It is an index that shows how much equity capital that doesn't need to be paid back is present in invested funds.
- c) This is an explanation of ROI (Return On Investment). ROI represents the proportion of profit to capital. It is an index that shows the profitability of a company by an examination of whether invested capital is used efficiently or not.

Q9-20 d)

Inventory value evaluated with the first-in first-out method

This is a question that asks for the evaluated value of an inventory with the first-in first-out method. Methods of calculation for an evaluated value also include the last-in first-out method and the periodic average method.

With the first-in first-out method, cost accounting or inventory accounting is performed with a rule where products are sold in order from those purchased first. In this question, when 30 units are sold on April 5, all ten units (unit price 100 yen) from the carry-over inventory declared on April 1 and 20 units from the 40 units purchased on the April 4 are allocated. At this time, for product A, the unit price is 120 yen and there are 20 units, so the evaluated value of the inventory is 2,400 yen.

Next, when 30 units are sold on April 30, 20 units remaining of the purchase on April 4 are allocated, and for the remaining 10 units, 10 units of the 30 units purchased on April 7 with a unit price of 140 yen are allocated (remainder: 20 units).

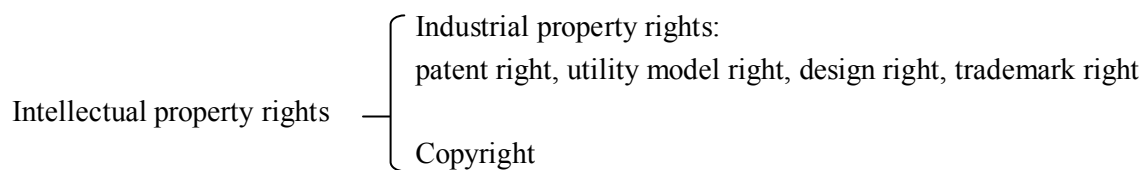
From this, the evaluated value of the inventory at the end of April is the total of the 20 remaining units purchased on April 7 for 140 yen (2,800 yen) and the 10 units purchased on April 10 with a unit price of 110 yen (1,100 yen), which gives the result of 3,900 yen. Therefore, d) is correct.

Q9-21 a)

Industrial property rights

Intellectual property rights are divided into industrial property rights and copyright. Industrial property rights include the four rights of patent rights, utility model rights, design rights, and trademark rights, whereas these are not included in copyright. Therefore, a) is correct.

The term industrial ownership rights in Japan was changed to the term “industrial property rights” in the Intellectual Property Strategy Outline decided by the Intellectual Property Strategy Headquarters by the government in July 2002.



Q9-22 d)

Descriptions concerning copyrighted works such as a computer program

Article 10 Clause 3 of the Copyright Act states “The protection granted by this Act to works provided in paragraph (1), item (ix) shall not extend to any computer programming language, rule or algorithm used for creating such work.” Therefore, d) is appropriate.

- a) The copyright of a program that is jointly developed is not decided only by the proportion of the cost of development that is borne. Furthermore, joint copyright may not be exercised without the unanimous agreement of all co-holders. (Copyright Act, Article 65)
- b) Databases which, by reason of the selection or systematic construction of information contained therein, constitute intellectual creations shall be protected as independent works. (Copyright Act, Article 12 Clause 2)
- c) As a work, the copyright of a program is protected, but know-how is not a work and its copyright is not protected.

Q9-23 d)

Copyright

Copyright is a right that is naturally held by a creator as soon as he or she creates a work. There are absolutely no procedures necessary to obtain this right (called the immethodical principle), so d) is the appropriate description.

- a) Copyright is naturally held as soon as a work is created. Rights that are not held unless an application for registration is made include patent right.
- b) The agency with jurisdiction over copyright is the Agency for Cultural Affairs. The Patent Office has jurisdiction over patent rights.
- c) The period of copyright is 50 years after the death of the creator or 50 years after publishing (the work must be published within 50 years of creation). For films, the period is 70 years after publishing.

Q9-24 b)

Software Management Guidelines

The purpose of “Software Management Guidelines” states “this is a collection of the actions that corporations and groups should implement when software is used in order to prevent the illegal duplication of software.” Therefore, b) is the appropriate description.

The composition and details of the guidelines are as below.

- (1) Basic actions that corporations and other such organizations should implement
A collection of the most basic actions that should be implemented by corporations and other such organizations in order to prevent the illegal duplication of software within the organization
- (2) Actions that the person responsible for software management should implement
A collection of the actions that should be implemented by the person who is responsible for the use of software (person responsible for software management) in corporations and other such organizations
- (3) Actions that software users should implement
A collection of actions that should be implemented by employees who use the software (software users) in the offices of corporations and other such organizations

Q9-25 d)

Standards for Measures against Unauthorized Access to Computers

The “Standards for Measures against Unauthorized Access to Computers” as defined by the Ministry of Economy, Trade and Industry is a collection of countermeasures that should be implemented by organizations and individuals of organizations concerning the prevention, discovery, and recovery of damage due to unauthorized access to computers, as well as the prevention of expansion and reoccurrence. It was released in August 1998.

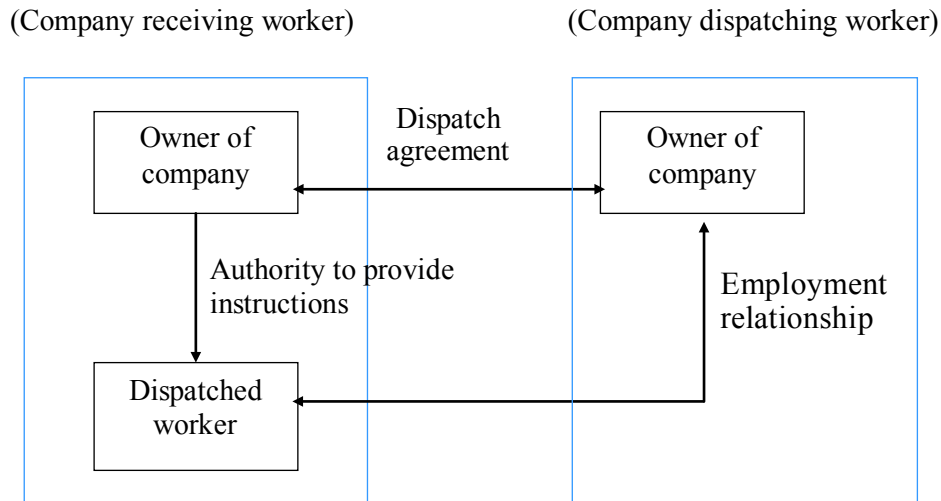
In the standards, System User Standards (5) Education and Information Collection 1. states “education should be received as necessary concerning security measures from the system administrator.” Therefore, d) is correct.

- a) System Administrator Standards (4) Facilities Management 11. states “communication paths and computers that can be accessed from external locations via a network should be minimized.” Connection of all networks to each other for efficiency of monitoring is incorrect.
- b) System User Standards (1) Password and User ID Management 1. states “a user ID should not be used for multiple system users.” As such, this is incorrect.
- c) System Administrator Standards (1) Implementation of Administration System 5. states “the privileges of a system administrator should be minimized to those necessary for business.” Thus, all privileges need not be assigned.

Q9-26 c)

Parties between which a temporary worker dispatch contract exists

The a temporary worker dispatch contract based on the Act for Securing the Proper Operation of Worker Dispatching Undertakings and Improved Working Conditions for Dispatched Workers exists between the owner of the company dispatching the worker and the owner of the company receiving the worker.



Worker dispatch is when the owner of the company dispatching the worker allows an employed worker to work for another party while maintaining the employment contract. Thus, the worker is not party to a dispatch agreement, and it is established between company owners.

The details of the agreement are stipulated in the Temporary Worker Dispatching Act Article 26 and are generally formed from the following items.

- Details of activities
- Office name
- Matters concerning the provision of instructions
- Period of agreement
- Start time and end time of work, and break time
- Matters concerning health and safety and items defined by ministerial orders (responsible person, permissible overtime work etc.)

Q9-27 b)*Actions by a company receiving a worker based on a dispatch agreement*

This is a question concerning the actions by a company receiving a worker towards the dispatched worker when there are no particular arrangements for working conditions. In order to perform a given activity, direct provision of instructions for an activity to a dispatched worker in the same way as for employees of the company is stipulated in Article 26 of the Temporary Worker Dispatching Act under “matters relating to the person who directly instructs the Dispatched Workers, in the course of their work, on behalf of the person receiving Worker Dispatching services.” Therefore, b) is the appropriate description.

- a) An application for paid vacation from a dispatched worker should be made to the company dispatching the worker. Such applications are not settled by direct application and approval between the dispatched worker and the company receiving the worker.
- c) The product liability stipulated in the PL Act (Product Liability Act) is “liability of the manufacturer, etc. for damages for injury to life, body, or property which is caused by a defect in the product.” Thus, even if a product defect occurs due to an error in an activity, no “product liability” is placed on the dispatched worker or the company dispatching the worker. Furthermore, for defect liability also, no questions can be raised in the case of a dispatch agreement.
- d) In the Temporary Worker Dispatching Act, as long as there are no stipulations in the work rules concerning overtime work at the time a contract is concluded, it is defined that the dispatched worker does not need to do overtime work. Thus, instructions for overtime work to a dispatched worker are not appropriate.

Q9-28 b)*Contracts when system development is performed by an external vendor*

This is a question concerning contracts when system development is performed by an external vendor. When a system is developed with a service contract and when there are no specific stipulations in the contract, the copyright for the program belongs to the party receiving the order, so b) is the appropriate description.

- a) In a mandate contract, there is no responsibility for the completion of work, and it is not necessary to provide deliverables. The authority to provide instructions is not with the party placing the order, but with the party receiving the order under the responsibility of the party receiving the order.
- c) With an underpinning contract, the responsibility for the completion of work is with the party receiving the order, but with a dispatch agreement the party receiving the order is not responsible for the completion of work and so this is incorrect. Concerning service contracts, Article 632 of Civil Law states “An employment contract shall become effective when one of the parties promises to the other party that he/she will engage in work and the other party promises to pay remuneration for the same.”
- d) Even if a serious defect occurs in the developed program because of a dispatched worker, the company dispatching the worker has no defect liability, so this is incorrect. For an underpinning contract, there is defect liability.

Q9-29 c)

Illegal counterfeit of electromagnetic records

Article 7 Clause 2 of the Penal Code contains the following definition of electromagnetic records.

[The term “electromagnetic record” as used in this Code shall mean any record which is produced by electronic, magnetic or any other means unrecognizable by natural perceptive functions and is used for data-processing by a computer.]

Therefore, the option that does not include electromagnetic records is c).

Q9-30 d)

Physical security measures for the protection of personal information

In relation to Clause 20 of the Act on the Protection of Personal Information (Security Control Measures), the Ministry of Economy, Trade and Industry’s guidelines categorizes security measures into the following four categories and describes desirable actions for these.

1. Organizational security control measures

Clear definition of responsibilities concerning security control and privileges of employees, the development and implementation of rules and procedures for security control, and confirmation of the implementation status of these

2. Human security control measures

For employees, the signing of non-disclosure agreements for personal information specified as confidential in terms of business, and education and training

3. Physical security control measures

Measures for management of access to a building or room, and the prevention of theft of personal data etc.

4. Technical security control measures

Technical security measures for individual data such as access control for an individual’s data itself and information systems that handle this data, countermeasures for unauthorized software, and monitoring of information systems

Physical security measures include the three items of implementation of management for access to a building or room, prevention of theft, and physical protection of devices and peripherals. In these items, as an item that is desirable in terms of the implementation of management of access to a building or room, “installation in rooms with information systems that handle personal data that are physically protected by the management of access” is described. Therefore, d) is correct.

- a) This is an item that applies to human security control measures.
- b) This is an item that applies to organizational security control measures.
- c) This is an item that applies to technical security control measures.

Q9-31 c)

Personal information that is subject to the Act on the Protection of Personal Information

Clause 2 of the Act on the Protection of Personal Information states “The term ‘personal information’ as used in this Act shall mean information about a living individual which can

identify the specific individual by name, date of birth or other description contained in such information (including such information as will allow easy reference to other information and will thereby enable the identification of the specific individual).”

As described, the act is limited to information of living individuals, so c) is correct.

- a) Not only information concerning customers, information about individuals other than customers that is registered by a private company (employees etc.) is covered by the act.
- b) Information that is not especially confidential is also protected.
- d) There are no stipulations concerning nationality.

Q9-32 d)

Stipulations in an information representation protocol for EDI

In order to implement EDI (Electronic Data Interchange), the items defined in the information representation protocol are the message format and are more exclusive than EC (Electronic Commerce). At the beginning in the 1970s, the Ministry of International Trade and Industry (now the Minister of Economy, Trade and Industry) defined EDI as “a message for transactions between different organizations exchanged between computers (including terminals) using a standard protocol (as far as possible various widely agreed protocols) via a communication network.” As can be determined by this definition, it is intended for transactions at the corporate level between two or more computers. The Japanese EDI standard is a CII syntax rule, but currently in the finance and distribution industries that use EDI, most organizations don’t use the CII standard format and use the Japanese Bankers format or the JCA format.

When EDI is to be used in this way, if the format is not converted for each organization, EDI cannot be used. Therefore, d) is correct.

Q9-33 a)

Explanation of character codes used by a computer

The ASCII character set is a code set defined by ANSI (a standards group equivalent to the Japanese JIS), and is a 7-bit character code for the representation of alphabetical characters and numerical characters, etc. It does not include Kanji. Therefore, a) is the appropriate description.

- b) EUC (Extended UNIX Code) includes a Kanji code. EUC is a code system of two or more bytes that handles characters from all countries in a unified way on UNIX systems. Kanji code is represented with two bytes, but the JIS auxiliary Kanji is represented with three bytes including control characters.
- c) Unicode is a character code that handles all characters in existence in a unified manner. All characters are assigned either a 2-byte code or a 4-byte code. The description concerns JIS code.
- d) The Shift JIS code set is a coding system that converts JIS Kanji code. To ensure that the first byte does not overlap with ASCII code, it is shifted and then allocated, and thus can be differentiated even if it is mixed with ASCII code. The description concerns EUC.

Q9-34 a)

Explanation of information barrier-free

Barrier-free generally means “no obstacles (barriers) to disabled and elderly people going about their daily life, or products or buildings designed not to have obstacles.” In line with this approach, information barrier-free means an environment where even in the case of a disability information devices can be manipulated and taken advantage of. Therefore, a) is applicable.

- b) This is a description of mobile communication.
- c) This is a description of SOHO (Small Office Home Office).
- d) In English, “seamless” means that there is no connection point, but in the world of computing, it is used to mean no matter which computer service a user receives, there is no uncomfortable feeling, no obstacles, and it feels as if they are always using the same computer. “Can be used without obstacles” has a different meaning to information barrier-free.

Section 10

Selected Questions (Computer System)

Q10-1 Execution of hardware instructions

[Answers]

[Subquestion] A-a), B-f), C-g), D-a)

[Explanation]

This question deals with the contents of registers associated with the execution of hardware instructions. An instruction is described in hexadecimal notation, and therefore, the instruction part may be referenced as is in hexadecimal from Table 2 of the question, and since the contents of registers include logical operations as well, they may be converted to binary numbers.

[Subquestion]

Based on the question, the contents of the registers are as described below. The right side of the figure shows the binary notation.

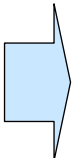
(Register number)	Contents		Binary notation
1	1234		0001 0010 0011 0100
2	8361		1000 0011 0110 0001
3	5F2A		0101 1111 0010 1010
4	C38B		1100 0011 1000 1011
5	0010		0000 0000 0001 0000

Fig. 4 Contents of registers 1 through 5

- Blank A: Based on the question, specify the contents of register 2 after the instruction 3021 has been executed. If instruction 3021 is applied to Fig. 1 of the question, it results in the table below:

Instruction part	Register r	Register v
30	2	1

When the instruction part is 30, Table 2 of the question states “Obtain the logical sum of the register r and register v contents, and set the results in register r .” Therefore, the logical sum of the contents of register 2 and register 1 may be obtained and set in register 2.

Register 2 1000 0011 0110 0001
 Register 1 0001 0010 0011 0100
 Logical sum 1001 0011 0111 0101 → Set in register 2
 Hexadecimal 9 3 7 5

Based on the figure above, if the value set in register 2 is described in hexadecimal notation, it becomes 9375. Therefore, a) is the correct answer.

- Blanks B and C: Based on the question, specify the contents of registers after 4 instructions have been executed. Execute instructions 1034 4038 5048 3043 in an order.

(i) If instruction 1034 is applied to Fig. 1 of the question, it results in the table below:

Instruction part	Register r	Register v
10	3	4

When the instruction part is 10, Table 2 of the question states “Set the contents of register v in register r .” Therefore, the contents of register 4 may be set in register 3.

Thus, the contents of registers change from Fig. A as shown below.


(Register number)	Contents		Binary notation
1	1234		0001 0010 0011 0100
2	8361		1000 0011 0110 0001
3	C38B		1100 0011 1000 1011
4	C38B		1100 0011 1000 1011
5	0010		0000 0000 0001 0000

Fig. B Contents of registers after the instruction 1034 is executed

(ii) If instruction 4038 is applied to Fig. 1 of the question, it results in the table below:

Instruction part	Register r	Register v
40	3	8

When the instruction part is 40, Table 2 of the question states “Shift the contents of register r to the left by the number of bits specified by the constant v , and set “0” in empty bit positions resulting from the shift.” Therefore, the contents of register 3 may be shifted 8 bits to the left.

Register 3 1100 0011 1000 1011



Register 3 1000 1011 0000 0000

Thus, the contents of registers change from Fig. B as shown below.

(Register number)	Contents		Binary notation
1	1234		0001 0010 0011 0100
2	8361		1000 0011 0110 0001
3	8B00		1000 1011 0000 0000
4	C38B		1100 0011 1000 1011
5	0010		0000 0000 0001 0000

Fig. C Contents of registers after the instruction 4038 is executed

(iii) If instruction 5048 is applied to Fig. 1 of the question, it results in the table below:

Instruction part	Register r	Register v
50	4	8

When the instruction part is 50, Table 2 of the question states “Shift the contents of register r to the right by the number of bits specified by the constant v , and set “0” in empty bit positions resulting from the shift.” Therefore, the contents of register 4 may be shifted 8 bits to the right.

Register 4 1100 0011 1000 1011

Register 4 0000 0000 1100 0011

Thus, the contents of registers change from Fig. C as shown below

(Register number)	Contents		Binary notation
1	1234		0001 0010 0011 0100
2	8361		1000 0011 0110 0001
3	8B00		1000 1011 0000 0000
4	00C3		0000 0000 1100 0011
5	0010		0000 0000 0001 0000

Fig. D Contents of registers after the instruction 5048 is executed

(iv) If instruction 3043 is applied to Fig. 1 of the question, it results in the table below:

Instruction part	Register r	Register v
30	4	3

When the instruction part is 30, Table 2 of the question states “Obtain the logical sum of the register r and register v contents, and set the results in register r .” Therefore, the logical sum of the contents of register 4 and register 3 may be obtained and set in register 4.

Register 4 0000 0000 1100 0011
 Register 3 1000 1011 0000 0000
 Logical sum 1000 1011 1100 0011 → Set in register 4
 Hexadecimal 8 B C 3

Thus, the contents of registers change from Fig. *D* as shown below.

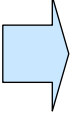
(Register number)	Contents		Binary notation
1	1234		0001 0010 0011 0100
2	8361		1000 0011 0110 0001
3	8B00		1000 1011 0000 0000
4	8BC3		1000 1011 1100 0011
5	0010		0000 0000 0001 0000

Fig. E Contents of registers after the instruction 3043 is executed

Therefore, the correct answer for the blank B is f), and the correct answer for the blank C is g).

- Blank D: Based on the question, it is understood that the hardware instructions are such that after the 4 instructions have been executed in an order, the contents of register 5 is multiplied by 10.

Execute instructions 1065 4063 40?? 2056 in an order.

(i) If instruction 1065 is applied to Fig. 1 of the question, it results in the table below:

Instruction part	Register <i>r</i>	Register <i>v</i>
10	6	5

When the instruction part is 10, Table 2 of the question states “Set the contents of register *v* in register *r*.” Therefore, the contents of register 5 may be set in register 6.

Thus, the contents of registers change from Fig. *A* as shown below.

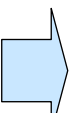
(Register number)	Contents		Binary notation
1	1234		0001 0010 0011 0100
2	8361		1000 0011 0110 0001
3	5F2A		0101 1111 0010 1010
4	C38B		1100 0011 1000 1011
5	0010		0000 0000 0001 0000
6	0010		0000 0000 0001 0000

Fig. F Contents of registers after the instruction 1065 is executed

(ii) If instruction 4063 is applied to Fig. 1 of the question, it results in the table below:

Instruction part	Register r	Register v
40	6	3

When the instruction part is 40, Table 2 of the question states “Shift the contents of register r to the right by the number of bits specified by the constant v , and set “0” in empty bit positions resulting from the shift.” Therefore, the contents of register 6 may be shifted 3 bits to the left.

Register 6 0000 0000 0001 0000



Register 6 0000 0000 1000 0000

Hexadecimal 0 080

Thus, the contents of registers change from Fig. F in the manner below:

(Register number)	Contents		Binary notation
1	1234		0001 0010 0011 0100
2	8361		1000 0011 0110 0001
3	5F2A		0101 1111 0010 1010
4	C38B		1100 0011 1000 1011
5	0010		0000 0000 0001 0000
6	0080		0000 0000 1000 0000

Fig. G Contents of registers after the instruction 4063 is executed

(iii) Next, if instruction 40?? is applied to Fig. 1 of the question, it results in the table below:

Instruction part	Register r	Register v
40	?	?

When the instruction part is 40, Table 2 of the question states “Shift the contents of register r to the right by the number of bits specified by the constant v , and set “0” in empty bit positions resulting from the shift.” Therefore, the contents of register r may be shifted to the left by v bits.

Here, the original value is multiplied by 10, but it must be noted that if the bits are shifted to the left, the value is doubled each time a bit is shifted. That is, the value doubles with a 1-bit shift to the left. The value is multiplied by 4 with a 2-bit shift. And based on the condition that the value is multiplied by 8 with a 3-bit shift, an n -bit shift to the left results in the value being multiplied by 2^n .

However 2^n does not equate to a multiplication of 10. Thus, in order to multiply the value by 10, the result obtained by doubling the original value and the result obtained by multiplying the value by 8 are aggregated.

Example: If 5 is to be multiplied by 10, then

$$5 \times 2 = 10$$

$$\underline{5 \times 8 = 40}$$

$$\text{Sum} \quad 50$$

In the earlier process, the contents of the register have already been shifted 3 bits to the left. A 3-bit shift to the left means that the original value has been multiplied by $2^3 = 8$.

Additionally, because the last process is 2056, if it is applied to Fig. 1 of the question, it results in the table below:

Instruction part	Register r	Register v
20	5	6

When the instruction part is 20, Table 2 of the question states “Obtain the sum of the register r and register v contents, and set the results in register r .” Therefore, the sum of the contents of register 5 and register 6 is obtained and set in register 5.

Thus, the process performed here may be doubled, which results in the table below:

Instruction part	Register r	Register v
40	5	1

Thus, this indicates the hardware instruction 4051. Therefore, the correct answer for the blank D is a).

Q10-2 Floating point number**[Answers]**

[Subquestion] A-b), B-d), C-f), D-g)

[Explanation]

The floating point number is an expression technique used when a computer handles numeric values. Floating point numbers include single-precision real numbers represented in 32 bits and double-precision real numbers represented in 64 bits.

In a floating point number, because the position of the decimal point is not fixed, the computation speed is slower as compared to a fixed point number in which the position of the decimal point is fixed. However, a floating point number is suitable for scientific and technological calculations because of the wide range of numeric values that can be represented.

There are several standards for floating point numbers. Here the single-precision representation in the IEEE 754 standard is focused upon.

[Subquestion]

This question deals with the extraction of the integer part of a numeric value saved in a 32-bit floating point number, and its conversion to a 32-bit integer.

As shown in Fig. 1, a 32-bit floating point number is composed of a sign part (1 bit), an exponent part (8 bits), and a mantissa part (23 bits), from the high-order bit.

Sign part		Exponent part								Mantissa part																						
0	1	0	0	0	0	0	1	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
31	30								23	22																				0		

Fig. 1 Bit position

The sign part indicates either 0 or a positive number when it is 0, and a negative number when it is 1.

The exponent part represents the power of 2, however, in order to represent a negative power as well, the almost middle value 127 of the values that can be represented in 8 bits (0 to 255) is taken as the reference, and while a value lesser than 127 represents a negative power, 127 or a higher value represents 0 or a positive power. That is, 2^0 is represented by 127, 2^3 is represented $127 + 3 = 130$, and 2^{-4} is represented by $127 - 4 = 123$ (such an expression is called “biased representation” or “excess expression”).

The mantissa part is adjusted so that the integer part of the mantissa becomes 1, and only its decimal fraction part is saved. That is, for the value 100.101, which can be represented as 1.00101×2^2 , 00101 is saved in the mantissa part and $127 + 2 = 129$ is saved in the exponent part. Furthermore, for the value 0.00101, which can be represented as 1.01×2^{-3} , 01 is saved in the mantissa part and $127 - 3 = 124$ is saved in the exponent part.

- Blank A: The value saved in the exponent part is represented as the power of 2.

0	1 0 0 0 0 1 0 1	0 0 1 1 0 1 0 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0
---	-----------------	---

Fig. 2 Exponent part

As shown in Fig. 2, the value saved in the exponent part is 10000101. When radix conversion to decimal number is performed for this value, it becomes 133.

Because 127 is taken as the reference for the exponent part, $133 - 127 = 6$, which implies 2^6 . Therefore, b) is the correct answer.

- Blank B: This is a process for conversion from the mantissa part to an integer.

As shown in Fig. 3, if only the mantissa part is extracted, the value becomes 001101011000000000000000 ((ii) of Fig. 3). Because this is the value after the decimal point next to the adjustments made to insert 1 in the integer part, 1 is added to the integer part, and 1.001101011000000000000000 is saved ((iii) of Fig. 3).

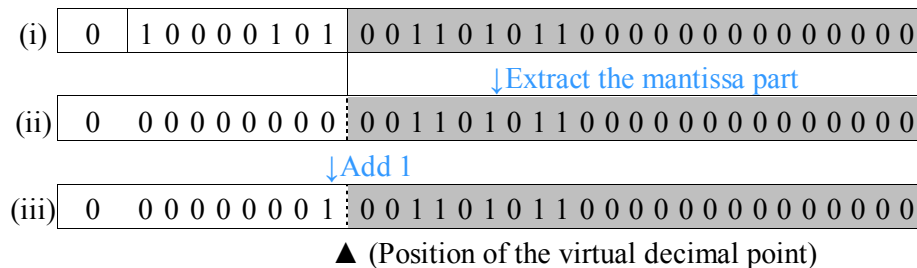


Fig. 3 Mantissa part

The exponent part becomes the 6th power of 2, and therefore, the numeric value becomes $1.001101011000000000000000 \times 2^6$. As a result, the 1001101.0110000000000000 obtained by shifting the position of the virtual decimal point to the right by 6 bits, which is the power of 2, becomes the original numeric value ((i) of Fig. 4).

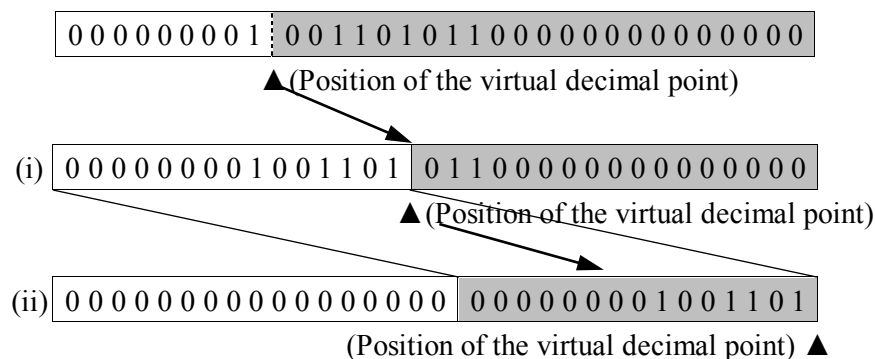


Fig. 4 Conversion to an integer (integer value)

In order to convert the value indicated by (i) in Fig. 4 to an integer, the position of the virtual decimal point is moved to the right end since the value after the decimal point is not necessary ((ii) of Fig. 4). To achieve this, the entire bit may be shifted to the right by as many bits as the number obtained by subtracting the value of the exponent part from the number of columns of the mantissa part. That is,

Mantissa part (23 bits) – Value of the exponent part (6 bits) = 17 bits.

Therefore, d) is the correct answer.

- Blank C: Returning to the original value by shifting the position of the virtual decimal point of the mantissa part to the right by as many bits as specified in the exponent part is as described in the explanation of the blank B ((i) of Fig. 4). However, there is a limit up to which the position of the virtual decimal point may be moved to the right.

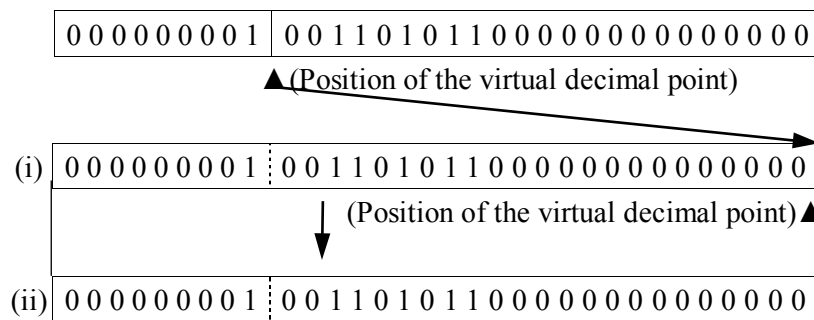


Fig. 5 Moving the position of the virtual decimal point

That is, since the mantissa part is only 23 bits, the position of the virtual decimal point will be extreme right when 2 is raised to the power of 23 (2^{23}) ((i) of Fig. 5). In such a case, when the value is to be converted to an integer, it can be used as is without shifting the position of the decimal since there is already no value after the decimal point ((ii) of Fig. 5).

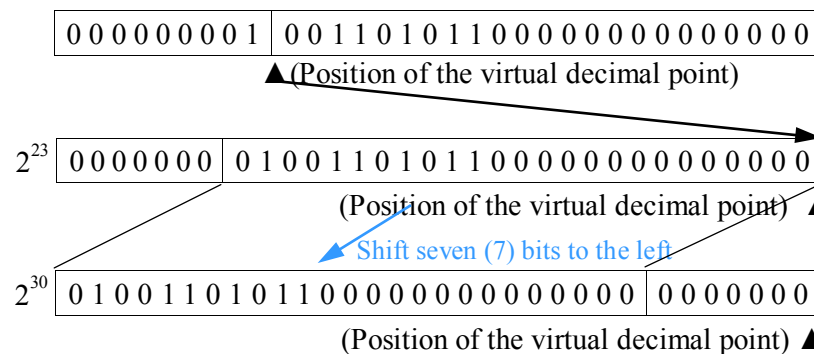


Fig. 6 For 2^{30}

Based on the above, since it is no longer necessary to further shift the position of the virtual decimal point to the right when the 23rd power of 2 is exceeded, all bits must be shifted to the left (Fig. 6). Therefore, f) is the correct answer.

- Blank D: When the virtual decimal point is taken into consideration, the bit 23 that corresponds to the integer part is always 1. Furthermore, because bit 31 is a sign bit, the numeric value 1 at bit 23 can be moved to the left only up to bit 30. This implies that only up to 7 bits can be shifted to the left.

That is, because the power exceeds 30, which is the value obtained by adding the 23 bits that can be shifted to the right to the 7 bits that can be shifted to the left, the range that can be represented by a 32-bit integer value is also exceeded. For example, as shown in Fig. 7, in the case of 2^{31} , an 8-bit shift to the left occurs, and as a result, the sign bit gets removed.

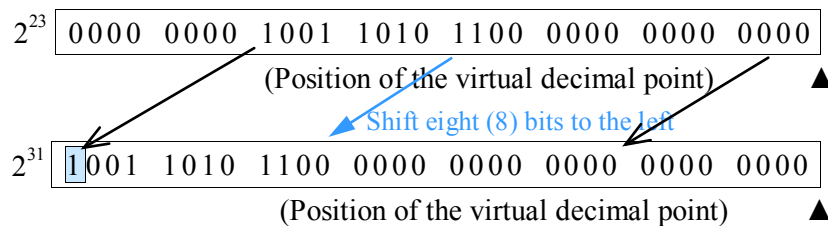


Fig. 7 For 2^{31}

Therefore, g) is the correct answer.

Q10-3 Overlay**[Answers]**

[Subquestion 1] d)

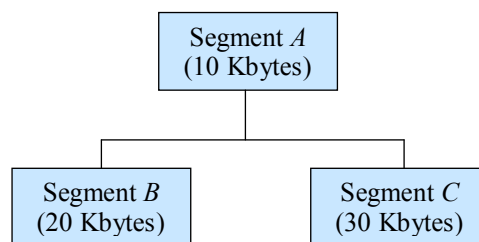
[Subquestion 2] A-b), B-g), C-d)

[Explanation]

This question is concerned with overlay. The concept is described in the question, and an accurate solution is to be found by ensuring that no calculation errors are made. In order to execute a lower segment, an upper segment controlling the same must be imported in to the main memory area. Whether or not this concept is understood is the key to solving the problem. The degree of difficulty is normal.

In order to execute a program in the limited main memory area, the concept of virtual memory is put to use. A virtual memory enables the creation of a program without being pinned down by the restrictions of the main memory area, by acting as a large storage capacity. Overlay can also be referred to as a type of a virtual memory, but because there is a control relationship between an upper segment and a lower segment, the programmer creates it by taking into consideration the constituent segments.

In order to explain the concept of overlay in a simple manner, a program composed of segments *A* through *C* as shown below is considered:

**Fig. A Overlay program configuration**

If this entire program were to be imported into the main memory area, an area of $10 + 20 + 30 = 60$ Kbytes would be needed. However, by residing the upper segment *A* on the main memory area, importing segment *B* at the time of executing segment *B*, and importing and executing segment *C* in the area where segment *B* is stored at the time of executing segment *C*, only 40 Kbytes (area of *A* + *C*) of allocation capacity would be needed in the minimum required main memory area. That is, by importing the program saved on the auxiliary storage device in the segment unit, the program can be executed within the limited capacity of the main memory area. A program that has such a program structure is called an overlay structure.

In Fig. *A*, segment *A* is called the root segment, and segments *B* and *C* are called exclusive segments.

[Subquestion 1]

The overlay structure shown in Fig. 3 is composed of segments P0 through P3, and P1, P2, and P3 are imported into spaces starting at the same address in the main memory area. That is, when P1 is executed, P0 and P1 must be imported. In the same way, when P2 is executed, P0 and P2 must be imported, and when P3 is executed, P0 and P3 must be imported.

The module contents configuring segments P0 through P3 are also shown in Fig. 3, and the value obtained by calculating the sum total of the size of each module is the size of the segment.

Module	A	B	C	D	E	F	G	H	I	J
Size (Mbytes)	10	8	6	5	6	4	6	2	3	15

$P0 = 10$ $P1 = 14$ $P2 = 26$ $P3 = 15$

Therefore, the size required for execution is 36 Mbytes, as shown below, and d) is the correct answer. Here, MAX is used to find out the maximum value within ().

$$10 + \text{MAX}(14, 26, 15) = 10 + 26 = 36 \text{ Mbytes}$$

[Subquestion 2]

This subquestion deals with the amount of the main memory area that can be reduced during the execution of the program, by reviewing the overlay structure and segments. When the amount of the main memory required during the execution of the program in the overlay structure shown in Fig. 4 and Fig. 5 is calculated by taking note of the hierarchical structure, it results in the list below.

1. Plan 1 for the overlay structure and segments (Fig. 4)

- (1) Execution of Q1: Q0 and Q1 are required $\rightarrow A(10) + B(8) + C(6) = 24$
- (2) Execution of Q3: Q0 and Q2, Q3 are required $\rightarrow A(10) + D(5) + E(6) + F(4) = 25$
- (3) Execution of Q4: Q0 and Q2, Q4 are required $\rightarrow A(10) + D(5) + G(6) + H(2) + I(3) = 26$
- (4) Execution of Q5: Q0 and Q5 are required $\rightarrow A(10) + J(15) = 25$

The minimum area required for executing the program may be determined from the maximum value of these values, that is, MAX(24, 25, 26, 25), which equals 26 Mbytes.

2. Plan 2 for the overlay structure and segments (Fig. 5)

- (1) Execution of R1: R0 and R1 are required $\rightarrow A(10) + B(8) + C(6) = 24$
- (2) Execution of R3: R0 and R2, R3 are required $\rightarrow A(10) + D(5) + E(6) = 21$
- (3) Execution of R4: R0 and R2, R4 are required $\rightarrow A(10) + D(5) + F(4) = 19$
- (4) Execution of R6: R0 and R2, R5, R6 are required $\rightarrow A(10) + D(5) + G(6) + H(2) = 23$
- (5) Execution of R7: R0 and R2, R5, R7 are required $\rightarrow A(10) + D(5) + G(6) + I(3) = 24$
- (6) Execution of R8: R0 and R8 are required $\rightarrow A(10) + J(15) = 25$

As in plan 1 earlier, the minimum area required for executing the program is determined from the maximum value of these values, that is, MAX(24, 21, 19, 23, 24, 25), which equals 25 Mbytes.

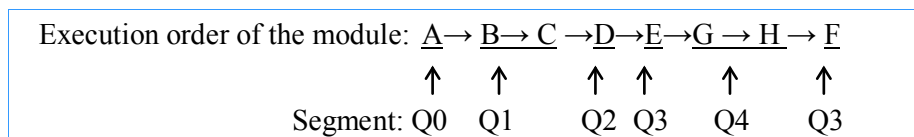
- Blank A: The required main memory area in the overlay structure of P0, P1, P2, and P3 of Fig. 3 is 36 Mbytes.

According to plan 1, in comparison with Fig. 3, the memory area can be reduced by $36 - 26 = 10$ (Mbytes).

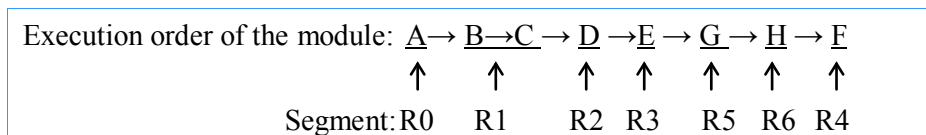
According to plan 2, in comparison with Fig. 3, the memory area can be reduced by $36 - 25 = 11$ (Mbytes).

Therefore, b) is the correct answer.

- Blank B: If the number of times a segment is imported into the main memory area by the time the execution of module F located at position α in Fig. 2 is complete is calculated according to plan 1, it results as shown below, which matches the 6 times described in the question:



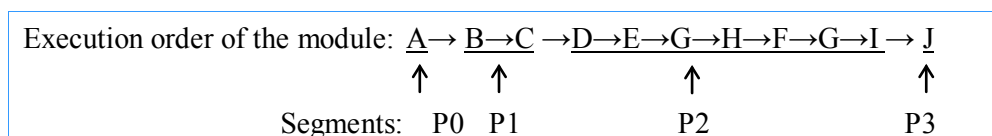
In the same way, the answer is 7 times according to plan 2, as shown below:



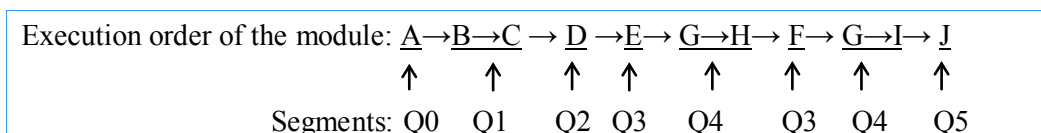
Thus, the blank B will be 7 times, which is g).

- Blank C: The number of times a segment is imported into the main memory area by the time the execution of the program is complete is taken into consideration.

In the case of Fig. 3, the answer is 4 times, as shown below:



In the case of plan 1, the answer is 8 times, as shown below:



From the above, it is understood that the number of times increases by $8 - 4 = 4$ (times). Therefore, d) is the correct answer for the blank C.

For reference purpose, if the number of times the program is executed according to plan 2 is indicated, it becomes 10 times, as shown below.

Execution order of the module: $\underline{A} \rightarrow \underline{B} \rightarrow \underline{C} \rightarrow \underline{D} \rightarrow \underline{E} \rightarrow \underline{G} \rightarrow \underline{H} \rightarrow \underline{F} \rightarrow \underline{G} \rightarrow \underline{I} \rightarrow \underline{J}$									
	↑	↑	↑	↑	↑	↑	↑	↑	↑
Segments:	R0	R1	R2	R3	R5	R6	R4	R5	R7 R8

Q10-4 Task control

[Answers]

[Subquestion 1] A-a), B-c), C-b), D-b), E-b)

[Subquestion 2] F-a)

[Subquestion 3] G-b), H-e)

[Explanation]

This question is concerned with the state transition and scheduling method of a task. The explanation is provided for each of these, and therefore, even in the case of lack of detailed knowledge, the answer can be provided for blanks except blanks A through C. The blanks A through C require knowledge of interrupts. Although subquestions 1 and 2 are somewhat easy, subquestion 3 requires a larger amount of time, which makes the overall degree of difficulty standard. Task control is a subject that is covered in the Morning Exam as well. Therefore, it must be understood well.

[Subquestion 1]

- Blanks A through C These are questions concerning interrupts. An interrupt is a signal for switching the state of a running task when an event occurs. An input/output processing request, input/output processing termination, and expiry of a timer are events. Interrupts are classified into external interrupts that occur regardless of the instructions of a running program, and internal interrupts that occur as a result of execution of instructions of the program.

External interrupts

- Timer interrupt: An interrupt by a timer (CPU clock) at a predetermined time, such as when a timeout period has expired
- I/O interrupt: An interrupt that provides notification of the termination of the input/output processing
- Machine check interrupt: An interrupt that provides notification of a hardware malfunctioning

Internal interrupts

- SVC interrupt: An interrupt that provides notification of the execution of an SVC (supervisor call) instruction, such as an input/output processing request
- Program interrupt: An interrupt that provides notification of an error that has occurred during the execution of a program, such as division by zero

Therefore, the correct answer for the blank A is a), for the blank B is c), and that for the blank C is b).

- Blank D: According to the round robin method, a fixed CPU time (time slice) is assigned sequentially to the tasks in the ready state. Here, an example in which a task *A* with a long CPU processing time, and a task *B* with a short CPU processing time operate simultaneously, is taken into consideration. If the time slice is large, the time for which task *B* is made to wait becomes long, and if the time slice is small, this time is shortened. Also, because the CPU processing time of task *B* is short even when the time slice is small, it terminates with a lower CPU allocation frequency. Therefore, b) is the correct answer. However, if the time slice is too small, the overheads for switching the task increase, resulting in a decline in the overall throughput.
- Blank E: The example of Fig. 2 of subquestion 3 is taken into consideration. As compared to the input/output processing time, the CPU processing time of task T1 is short, and the CPU processing time of task T3 is long. Here, if the priority order of task T3 is raised, task T3 occupies the CPU for a long time, which hinders the progress of T1. On the other hand, even if the priority order of task T1 is raised, task T1 enters the input/output processing immediately after the CPU is used, and does not occupy the CPU for long. Therefore, the progress of task T3 is not hindered, and the overall throughput improves. Therefore, b) is the correct answer.

[Subquestion 2]

The state in which the CPU is assigned to a task and the task is using the CPU is the running state. Because there is only 1 CPU in a single processor, the maximum number of tasks in the running state is 1. On the other hand, the state in which a task is waiting for the CPU to be assigned is the ready state. There may be several tasks in the ready state.

Under the condition when 3 tasks are operating, if no task is in the waiting state (waiting for the termination of input/output), the number of tasks in the running state will be 1 and the number of tasks in the ready state will be 2, at the most. All 3 tasks cannot be in the ready state. If the input/output processing is being performed for 1 task, and the other 2 tasks are waiting the input/output processing, the number of tasks in the running state and the number of tasks in the ready state are both 0, which is the minimum value. Therefore, a) is the correct answer.

[Subquestion 3]

This question is solved by drawing a diagram as shown in Fig. A. The diagram should be drawn properly taking care to avoid any mistakes. In the figure, the CPU row indicates the usage time of the tasks using the CPU. The rows T1 (I/O), T2 (I/O), and T3 (I/O) indicate the time of usage of the I/O device by each task.

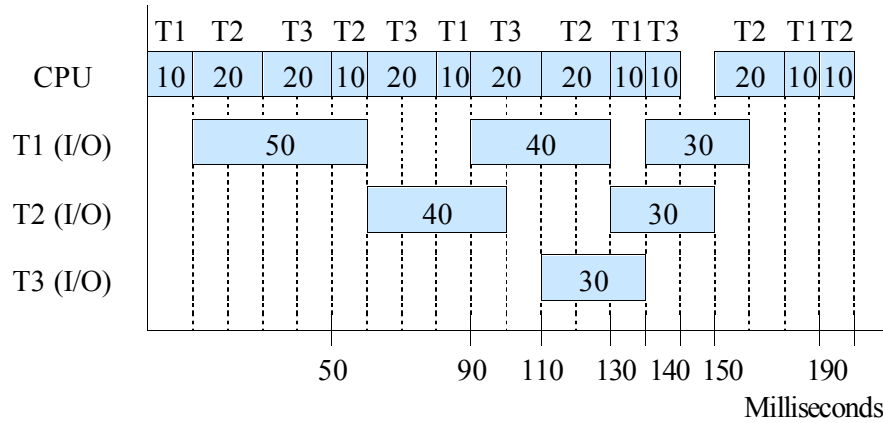


Fig. A Execution order of tasks according to the round robin method

During the time period after 50 milliseconds in Fig. A, the input/output processing is being performed for task T1, and therefore, after task T3, task T2 uses the CPU. In the same way, during the time period after 90 milliseconds, the input/output processing is being performed for task T2, and therefore, after task T1, task T3 will use the CPU. The state transition is the same during the time period after 110 milliseconds, 130 milliseconds, and 140 milliseconds. Although task T3 terminates during the time period after 150 milliseconds, the input/output processing is being performed for both task T1 and task T2. Therefore, the CPU is in an idle state up to the time period after 160 milliseconds when the input/output processing of task T2 terminates. Thus, task T2 terminates in the end after 200 milliseconds. Therefore, the correct answer for the blank G is b) and that for the blank H is e).

For reference purpose, Fig. B shows the execution order of tasks when the priority order of tasks T1, T2, and T3 is $T1 > T2 > T3$.

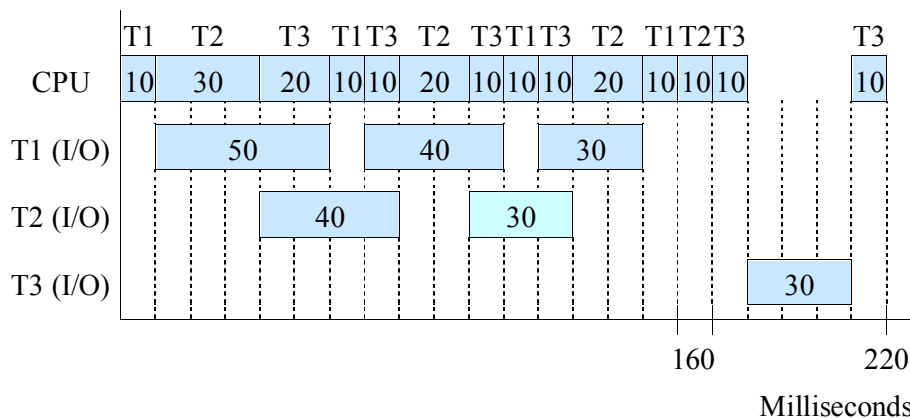


Fig. B Execution order of tasks according to the priority scheduling method

In the case of the priority scheduling method, first of all, the diagram of task T1 should be drawn with the highest priority order. After this, the diagram of task T2 should be drawn with the next highest priority order. Finally, the diagram of task T3 with the lowest priority order should be drawn.

Q10-5 Relational database for managing distribution centers

[Answers]

[Subquestion 1] b)

[Subquestion 2] A-d), B-e), C-f)

[Subquestion 3] d)

[Explanation]

This is a basic question concerning the SQL required for operating a relational database. The example of the transportation company explained as the business theme in the question has a deep relationship to our daily lives. As the business contents are simple, and the SQL statements used to determine the answers also have comparatively basic contents, this is classified as an easier database question.

[Subquestion 1]

In this question, the number of branch offices managed by the distribution center A01 is to be determined. The Branch Office Table possesses the relationship between a distribution center and a branch office. From this Branch Office Table, the number of branch offices with the distribution center code A01 may be determined. The point is “COUNT (Branch_office_code)” (counting the number of branch offices) and the condition after WHERE is “Distribution_center_code = 'A01'” (condition of the matching distribution center code). Therefore, b) is the correct answer.

- a) The subquestion is answered from the viewpoint that the number of branch office codes in the Branch Office Table is counted by COUNT (Branch_office_code) FROM Branch_Office_Table after the SELECT clause. However, because the condition after WHERE is Distribution_center_code NOT IN ('A01'), distribution center codes other than A01 are selected, which is an incorrect answer.
- c) Same as a), the subquestion is answered from the viewpoint that the number of branch office codes in the Branch Office Table is counted by COUNT (Branch_office_code) FROM Branch_Office_Table after the SELECT clause. However, the condition after WHERE is not the distribution center code, but Branch_office_code = 'A01', and therefore, the branch office with the branch office code A01 is selected (Because the branch office code is a 3-character value that begins with the letter S, nothing is selected), which is an incorrect answer.
- d) Because the option states SELECT Branch_office_code, the branch office codes that matches the distribution center code A01 are listed from the Branch Office Table based on WHERE Distribution_center_code = 'A01', and the number of branch offices is not determined, which is an incorrect answer.
- e) This option is used to select distribution center codes from the Branch Office Table based on

`Branch_office_code = 'A01' ORDER BY Distribution_center_code`, by arranging those distribution center codes in an ascending order that have the branch office code A01, which is an incorrect answer. Similar to c), in reality, nothing is extracted by this SQL statement.

[Subquestion 2]

“The delivery destinations for parcels delivered directly by the branch office S11 from among the parcels accepted by that branch office thus far” indicates that first of all, the accepting branch office code of the Parcel Table is S11, and the District of the branch office S11 in the Delivery Area Table matches the Destination district of the Parcel Table. In such a case, the Sender district is also matching.

- Blank A: Here, the table that acts as the extraction source is being questioned. The point that needs to be focused here is that in the `SELECT` clause, the destination district, destination address, and destination name are to be extracted. The table that possesses these items is the Parcel Table. Therefore, d) is the correct answer.
- Blank B: Here, the condition shown after the `WHERE` clause is that the accepting branch office code is S11. Since the condition “The delivery destinations for parcels delivered directly by the branch office” of the question is still not solved, a conjunction such as `AND` or `OR` is expected to be entered in the conditional expression. As described earlier, both the conditions must be fulfilled, which implies that `AND` will be used here. Therefore, e) is the correct answer.
- Blank C: Here, it is necessary to select the Destination district corresponding to the district extracted in the sub query, and therefore, `IN` is appropriate. Therefore, f) is the correct answer.

[Subquestion 3]

The SQL statement provided here is almost the same as Subquestion 2 until before `AND`. This means that until then, the passed date and time, passed branch office or distribution center code, and in/out status code of the data matching the receipt number '0000004' is selected from the Transfer History Table.

After `AND`, an additional condition to be added to this condition is described. Within the parentheses (), of the data matching the receipt number '0000004', the data with the `MAX` (maximum) passed date and time is selected. The maximum passed date and time indicates the most recent date and time of the exit and entry of the parcel at the collection and distribution location. The selection of the passed date and time, passed branch office or distribution code, and in/out status code with the receipt number '0000004' which has the most recent passed date and time indicates “The most recent collection and distribution location and the date and time” as described in d).

Q10-6 Design and SQLs of a relational database**[Answers]**

[Subquestion 1] A-e), B-d), C-g), D-f)

[Subquestion 2] (1) d), (2) b)

[Subquestion 3] E-f), F-d)

[Explanation]

This is a question concerning E-R (Entity - Relationship) diagram that is the basis for designing a relational database, and SQL statements that use GROUP BY phrase. First of all, the note in the diagram must be checked properly. Subquestion 1 deals with filling in the attribute names in the blanks, and the solid underline for the primary key and broken underline for the external key need to be focused upon. Subquestion 2 deals with the relationship (corresponding relationship) between entities, however, since there are no connecting lines for both (1) and (2), analogical inference must be drawn from the description of the question and the relationship between the primary key and external key. Subquestion 3 checks the basic items of SQL statement associated with GROUP BY phrase.

[Subquestion 1]

From the answer group, select the appropriate attribute name to be inserted in blanks A through D of the E-R diagram.

- Blank A: This attribute is common to “Transportation cost” and “Receipt of order”. It is the primary key under “Transportation cost”, and also performs the role of an external key. It is the external key under “Receipt of order”. Therefore, the option e) Distributor code is the correct answer. In terms of the relationship between entities, there is a corresponding relationship with one primary key and many (or one) external keys. “One or many” are also called multiplicity for association.
- Blank B: This attribute is common to “Transportation cost” and “Stock allocation”. It is the primary key under “Transportation cost”, and also performs the role of an external key. It is the external key under “Stock allocation”. Therefore, the option d) Warehouse code is the correct answer. The primary keys of “Transportation cost” are the pair of {Distributor code, Warehouse code}, and each of these are external keys referencing the primary key of the “Distributor” and “Warehouse”.
- Blank C: This attribute is common to “Stock” and “Stock allocation”. It is the primary key under “Stock”, and also performs the role of an external key. It is the external key under “Stock allocation”. Because “Stock” has a many-to-one corresponding relationship with “Component”, g) Component number is the correct answer. The external keys of “Stock allocation” are the pair of {Warehouse code, Component number} and they refer to the same pair of primary keys of “Stock”.
- Blank D: Because it is a singular attribute of “Stock allocation”, f) Allocated quantity is the correct answer.

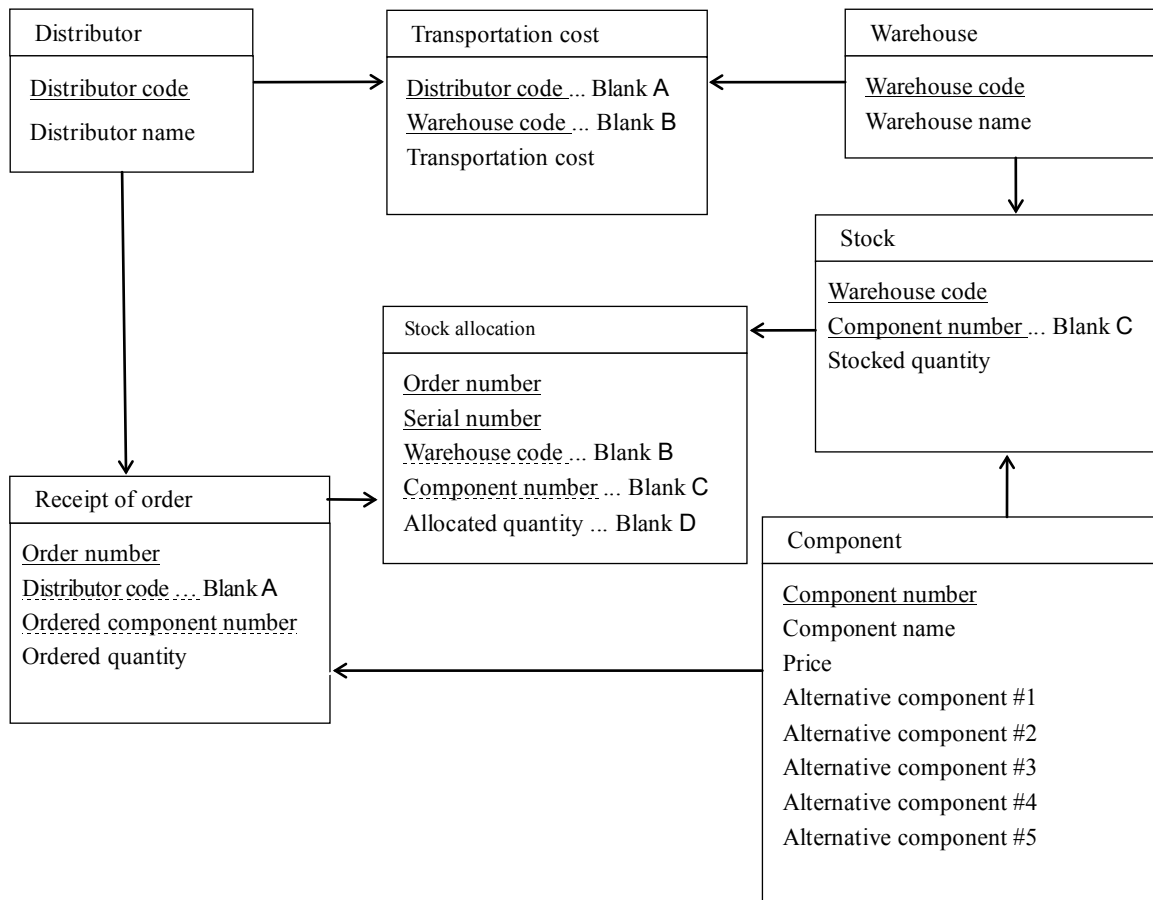


Fig. E-R diagram of the order-receiving system

[Subquestion 2]

From the answer group, select the relationship between each of the pair of entities Warehouse - Component, and Distributor - Receipt of order.

- (1) According to the E-R diagram, both “Warehouse” and “Component” have a separate one-to-many relationship with “Stock”. The question states that “The electric components are stocked in multiple warehouses, and as a principle, delivery is made to each distributor from the warehouse with the least transportation cost.” Based on this, it is obvious that there are several components in a warehouse, thus implying that the “Warehouse” and “Component” have a many-to-many relationship. Therefore, d) is the correct answer.

An entity like “Stock” positioned in such a way that a many-to-many relationship is divided into two one-to-many relationships is called an association entity.

- (2) “Distributor” and “Receipt of order” have a one-to-many relationship since a single distributor can place multiple orders. This is also clear from the primary key of “Distributor” (Distributor code) and the external key of “Receipt of order” (Distributor code) as answered in Subquestion 1. Therefore, b) is the correct answer.

[Subquestion 3]

From the answer group, select the appropriate terms to be inserted in blanks E and F in the SELECT clause.

- Blank E: When the GROUP BY clause is present, the column names that can be written in the SELECT clause is restricted to either column names or set functions described in the GROUP BY clause. In other words, the column names that can be written in the SELECT clause are only values that represent the group. In this Subquestion, the column names of the GROUP BY clause (Receipt_of_order.Order_number, Ordered_component_number, Ordered_quantity) are provided. Therefore, Ordered_component_number described in the option f) is the correct answer.
- Blank F: Because brackets () are present immediately after the blank, it indicates a set function. The ordered quantity and the allocated quantity are compared with the HAVING clause, however, to find the allocated quantity, the allocated quantity of the consecutively numbered "Stock allocation" must be added up. To achieve this, grouping is performed based on Receipt_of_order.Order_number, Ordered_component_number, and as for the set function, the SUM function described in d) that is used to find the total within the group is the correct answer. As described in the answer group, the other set functions of SQL include the AVG function (average), COUNT function (line count), MAX function (maximum value), and MIN function (minimum value). The COUNT function enables to find out the total number of lines of the table with COUNT(*) .

Q10-7 IP address**[Answers]**

[Subquestion 1] A-e), B-d), C-d), D-c)

[Subquestion 2] E-c)

[Explanation]

This question is concerned with the IP address (IPv4). Although similar questions were set several times in the past, as regards a network system making use of the Internet, a knowledge of the IP address used to identify the connected devices (such as computers) is mandatory. The meaning of the components of the IP address, that is, the network address and the host address, must be understood perfectly. Furthermore, the concept of the subnet mask is also important.

Recently, from the viewpoint of practicality, the representation of the subnet mask in the CIDR (Classless Inter-Domain Routing) method has been seen in many cases. This is because in the context of the fast-spreading Internet, while the number of users is increasing on one hand, an effective allocation and management of IP addresses is required. However, there is a limitation on the number of addresses in the 32-bit format, and the practical application of IPv6 in which addresses have a length of 128 bits is also being examined.

An IP address (IPv4) composed of 32 bits is divided into classes *A* through *E*, and while class *A* is positioned for use with large networks (the bit count of the host part is large), class *B* is used for mid-size networks, and class *C* is used for small-size networks (the bit count of the host part is small). Besides these, class *D* and class *E* are also available, of which class *D* is used for multicasting a specific group, and class *E* is reserved for future expansion. Each class is identified by the first bit of the IP address.

Class <i>A</i>	0	Network part (7 bits)	Host part (24 bits)
Class <i>B</i>	1	0	Network part (14 bits) Host part (16 bits)
Class <i>C</i>	1	1	0 Network part (21 bits) Host part (8 bits)
Class <i>D</i>	1	1	1 0 Multicast address (28 bits)
Class <i>E</i>	1	1	1 1 Reserved for future use (28 bits)

A bit array showing partitioning between the network part and the host part is called a subnet mask. In the case of class *B*, because the first 16 bits constitute the network address, the value of the subnet mask in decimal notation is “255.255.0.0”, but if the first 8 bits of the original host part are also to be used as the network address, the subnet mask may be set as “255.255.255.0”. The method of using the portion that was originally in the host part as a network address is called subnet, and the excess bit portion extended as the network address is called the subnet address. By using this, several subnets in a single network address can be identified.

Thus, the CIDR method was proposed to enable flexible (free) setting of the subnet mask.

If the logical product of each bit of the subnet mask and IP address is taken, the network address can also be extracted.

[Subquestion 1]

- Blank A: As shown in the explanation, the pattern of the starting bits of the network part is predetermined in order to identify the bit array of each class. Class *C* begins with 110. Therefore, e) is the correct answer. a) and b) represent class *A*, c) and d) represent class *B*, and f) represents class *D*.
- Blank B: The theoretical value that can be represented by the 8 bits of the host part of class *C* is $2^8=256$. However, IP addresses with all bits of the host part as either “0” or “1” cannot be used as the host address. Therefore, $256 - 2 = 254$ is the number of bits that can be allocated. d) is the correct answer.
- Blanks C and D: When the maximum number of hosts is 30, the required number of host addresses will be $30 + 2 = 32$ when cases with all bits of the host part as “0” and “1” are included. Therefore, the minimum number of required bits is $2^5 = 32$, which is 5 bits. Therefore, if the remaining bits are considered as the network address, the subnet mask would be:

255	. 255	. 255	.224	← Decimal notation
11111111	11111111	11111111	11100000	

Five (5) bits indicate the host address

Because the first 27 bits ($32 - 5 = 27$) represent the network address, when the prefix is represented according to the CIDR method, it will be “/27”. Therefore, the correct answers for blanks C and D are d) and c), respectively.

[Subquestion 2]

The question states that “in terms of class *A*, a real problem is that it is difficult to assume that a number of hosts close to the theoretical value exist at all times. Also, in class *C*, if the number of hosts becomes more than $2^8 - 2$, the addresses become insufficient.” That is, when the IP address is managed or used based on classes, bit patterns that cannot be assigned might occur since the bit count of the network part and the host part has been stipulated. In order to effectively use an IP address that is restricted to 32 bits, deciding the network part and the host part based on the bit unit can eliminate wastage. Therefore, c) is the correct answer.

The mistakes in the other options are as follows:

- a) Since this is predetermined each time, both the network part and the host part can be recognized immediately.
- b) According to the method based on classes, since the differentiation between the network part and the host part can be determined only from the IP address, management is convenient. On the other hand, according to the CIDR method, since the bit length of the IP address and the subnet mask must also be managed as address information, the management is cumbersome.

- d) If the network address is not clear, further relaying will not be possible. The method based on classes and the CIDR method are different only terms of representation, and the path information must be set in the router for both the methods.

Q10-8 Data transmission and data encoding

[Answers]

[Subquestion 1] b)

[Subquestion 2] A-b), B-h), C-d)

[Subquestion 3] D-b)

[Explanation]

This question is concerned with the transmission method of values measured by a sensor. Because sensing is performed at a frequency of 100 times per second, it may be considered in terms of transmission of data with high real time, such as for automobile control, however, since there is no specific description in the question, a general theory is taken into consideration. However, in the case of transmission of data with a high real time, depending on the volume of data put together and sent, the processing time for header transmission, and the volume of transmitted data changes. Therefore, this question focuses on this point as well. Even when the data size of this question is taken as the basis, for example, when the values measured through sensing are sent one by one, the header becomes 150 bytes and the payload becomes 4 bytes, and almost the entire area of the transmission data constitutes the header. Therefore, the efficiency is extremely poor.

[Subquestion 1]

As described above, Subquestion 1 deals with how the overheads caused by the transmission of the header part will change depending on how many measurement values are collected together and sent. As the number of measurement values stored in a packet increases, the total volume of the header decreases. As a result, the transmission volume per unit time decreases. Therefore, b) is the correct answer.

[Subquestion 2]

Fundamentally, this Subquestion deals with the same point as Subquestion 1, however, a specific calculation expression is implicated.

- Blank A: First of all, consideration should be given to the maximum number of measurement values that can be stored in a single packet. This can be calculated if the maximum payload size of a packet, the size per single measurement value, and the number of measurement values per second is known. First of all, the maximum payload size should be calculated. Since the maximum size of a packet is 1478 bytes and the header size is 150 bytes, the maximum payload size can be determined through subtraction, which is 1328. Next, the size per single measurement value is to be calculated. It is understood from the question that the size per single measurement value is 4 bytes. Furthermore, it is also understood from the question that the number of measurement values per second is 100. Thus, by dividing the maximum payload size by the size per single measurement value, the maximum number of measurement values

that can be stored in 1 packet can be known:

$$1,328 \div 4 = 332$$

Next, in order to calculate the number of seconds in which these measurement values are measured, the maximum number of measurement values is divided by 100, which is the number of measurement values per second:

$$332 \div 100 = 3.32$$

Therefore, b) is the correct answer.

- Blanks B and C: Here, if it is understood beforehand as to what part of the equation represents which value, the answer can be determined with ease.

$$w = \boxed{B} \times \underbrace{8 \times (150 + \boxed{C})}_{\text{Number of bytes per packet}} \text{ bits/second}$$

Number of bits per packet

The blank C is the part concerning the “number of bytes per 1 packet,” however, since the 150 on its left is the byte length of the “header”, the byte length of the “array of measurement values” will be entered in the blank C. Here, the number of measurement values stored in 1 packet is n , and the number of bytes per 1 measurement value is 4, which means that the value to be entered is $4n$. Therefore, d) is the correct answer for the blank C.

Next, the blank B is taken into consideration. From the above calculation for the “number of bits per 1 packet,” the size of 1 packet is known, however, how many packets would be sent in 1 second corresponds to the blank B. First of all, from the question, it is understood that 100 measurement values are feasible in 1 second, however, entering 100 in the blank B would be wrong. This is because n number of measurement values are stored in 1 packet. Therefore, h) is the correct answer for the blank B.

[Subquestion 3]

Although the name of the theory is not mentioned in this Subquestion, it focuses on the fact that most of the measurement values are not very different from the immediately preceding measurement value, and deals with the subject of reduction in the data transmission volume through encoding by applying the Huffman coding theory. According to the Huffman coding theory, by expressing data with a high frequency of appearance in a small number of bits, the overall data is represented by a short bit length.

Because the expected value of the bit length is determined after the main point is understood, each bit length and the appearance frequency of the data expressed by that bit length may be multiplied and added up. Thus, the calculation expression below is obtained:

$$9 \times 0.7 + 18 \times 0.25 + 27 \times 0.04 + 35 \times 0.01 = 6.3 + 4.5 + 1.08 + 0.35 = 12.23 \text{ bits}$$

Therefore, b) is the correct answer for the blank D.

Section 10

Selected Questions (Information Security)

Q10-9 Packet Filtering

[Answers]

[Subquestion 1] A-d), B-b), C-d), D-d)

[Subquestion 2] c), d)

[Explanation]

This is a basic question concerning packet filtering, services and protocols, and port numbers of a firewall included as a part of network security. As a prerequisite, the basic services of the Web and email and their operation must be understood precisely from the viewpoint of security. Subquestion 2 deals with the threats to the information system and the protection offered by the firewall, however, the meaning of “security risks that can be prevented with packet filtering” must be understood correctly, and the measures that can be taken through packet filtering, and the specific measures against each threat must be grasped.

[Subquestion 1]

- Blanks A and B: In firewall *A*, the services allowed to pass to the DMZ from outside the company include the Internet and transfer of e-mails, and the settings of rule 1 (Web server) and rule 2 (Mail server) described in Table 2 correspond to these respectively. When information is published on the Web site, an HTTP (80) request to the Web server from any sender (source) on the Internet may be allowed to pass through, however, with regard to transfer of e-mails, bi-directional communication (SMTP) between the company and the outside must be allowed to pass. As regards the filtering settings of firewall *A*, only a unidirectional (reception) setting from the Internet to the mail server is clear. Also, as regards the settings of the last rule 4, by default, the source, destination, and the port number are all denied for any service, and all service other than those described in the earlier 3 rules are denied. Point (2) of the text explains that the “Mail server sends and receives e-mails to and from external entities.” Therefore, in the blanks A and B, settings for e-mail transfer (transmission) from the mail server to the Internet will be entered. It can be confirmed from Table 1 that the port number for e-mail transfer is 25, and therefore, the correct answer for the blank A is d) and that for the blank B is b).

- Blanks C and D In firewall *B*, the services allowed to pass to the corporate LAN from the DMZ include DB access (DB dedicated protocol) from the Web server and mail server (rule 1 and rule 2 of Table 3). Furthermore, based on the explanation that “From the management PC connected to the corporate LAN, it is possible to login to each server using SSH, and send and receive e-mails to and from external entities via Mail server,” the services that are allowed to pass through the firewall *B* from the corporate LAN must include (SSH (22), rule 4 and rule 7 of Table 3) for logging on to the mail server and Web server, (SMTP (25), rule 5) for transmission to the mail server on DMZ, as well as (POP3 (110), rule 3) for reception. Because “it is possible to access the corporate Web server from the management PC,” (HTTP (80), rule 6) is also necessary. SMTP is used in the same way as a mail server for sending e-mails via a PC, however, the use of POP3 for receiving e-mails must be noted. From the above communication, it is understood that POP3 (110) that is used for receiving e-mails will be inserted in the blanks C and D concerning filtering settings for firewall *B*. Therefore, d) is the correct answer for the blank C, d) for the blank D.

[Subquestion 2]

This Subquestion deals with the selection of the 2 risks that can be protected against through packet filtering. Attacks concerning the security of the Web server and those concerning the security of database applications cannot be prevented through packet filtering by the firewall. Information leakage through e-mails may be caused by external factors such as viruses and bots, or by human factors concerning operation, and measures need to be taken for each of these.

- a) A method of encoding communications between the server and the client by using the SSL (Secure Socket Layer) protocol (port number 443) is used as a measure for Web server security concerning loss and modification of data exchanged with the Website. Furthermore, a session information management mechanism on the server side that makes use of cookies is used for session management to ensure continuity of a series of processes. Although session management can also be performed in methods using query strings and hidden fields, there is a possibility of being recorded in the log or being stolen, leading to the risk of tampering, so its use should be avoided.
- c) SQL injection attacks on the Web site are performed by setting up SQL statements using the entered items. Its measures include performing the escape processing for special characters (such as &, <, >, “, and ') included in the input items used in the SQL statement for DB access, or using a binding mechanism (generally, each of the statements of prepare and execute) prepared in the program language used.
- e) As a measure against leakage of files via e-mails, corporate rules for e-mail usage must be established as a prerequisite, and e-mails that are feared will result in leakage of attached files must either be isolated or their transmission may be stopped by a relay server having the audit function for closely investigating the main body and attached files of e-mails. Furthermore, as a measure to prevent leakage through viruses and bots, in addition to the introduction of antivirus software and antispam system, providing security training to inculcate the habit of not opening any suspicious e-mails is also important.

The above security risks cannot be prevented through packet filtering.

The 2 risks listed below can be prevented by packet filtering performed by the firewall.

- c) As described, the services that are allowed to establish a connection via the Internet are only Web services using the port number 80 (rule 1 of Table 2) and transfer of e-mails using the port number 25 (rule 2 of Table 2). Other services (ports) are not allowed to establish a connection from the Internet to the server on DMZ as these are denied by default (rule 4 of Table 2).
- d) Direct access from the Internet to the corporate LAN is generally denied by the firewall, by default. When the filtering is performed between the DMZ and the corporate LAN is set appropriately by limiting access to only the minimum required services, illegal access to the corporate LAN caused by buffer overflow via the server on DMZ can be prevented. According to the settings of firewall *B*, only the access to the DB server (rule 1 and rule 2 of Table 3) is allowed, and access to all other corporate LANs is denied by default (rule 8 of Table 3).

Therefore, c) and d) are the correct answers.

Q10-10 Server certificate

[Answers]

[Subquestion 1] A-d), B-b), C-a), D-b)

[Subquestion 2] E-a), F-d) (E and F may be in any order)

[Explanation]

This is a question concerning encryption and certificates used in SSL (Secure Sockets Layer) communication. In this question, the basic items of public key cryptography (private key and public key) and common key cryptography (common key and hash value) are explained for SSL communication. Although the question text might be a little difficult to understand in the beginning, if one becomes accustomed to the names of the keys and algorithms used with each encryption method, it is not too difficult to understand the contents, and answering the question also becomes easy.

[Subquestion 1]

The main processing contents of each phase between the client and the server are as follows:

- Phase 1: Arrangement of encryption communication
- Phase 2: Sending the server certificate and the certificate of the certificate authority to the client
- Phase 3: Checking the appropriateness of the server certificate, extracting the public key of the server, and sharing the common key

- Blank A: In the initial negotiation (arrangement of the communication method) stage of SSL communication, the root certificate authority sends a chain of all certificates including the root certificate signed by the root certificate authority, and the intermediate certificate signed by the intermediate certificate authority, or the certificate issued by the intermediate certificate authority itself, from the server to the client.

When attention is focused on the part “all certificates up to the certificate by A” of the point no. (iii) under [Overview of processing], it becomes clear that several certificates are sent from the server. Also, because the location where the second blank A is present states that “finally, the certificate of the A is always sent,” it implies that the root certificate authority indicating the highest order among the certificate authorities will be inserted in the blank A, and therefore, d) Root certificate authority is the correct answer. This question can also be answered easily because the fact that words indicating the answer are used in the explanation of the verification method of appropriateness of the root certificate in the text of the question.

- Blank B: From the explanation of (vi) under [Overview of processing], it is understood that the client uses a key that is to be inserted in the blank B, and sends the encrypted data to the server. Based on the description “The server encrypts the received encryption data with its own private key” provided in (vii), it is understood that the server uses the private key and the client uses the public key, and therefore, b) Public key is the correct answer.
- Blank C: As described in [Verification of the certificate], “The client and the server generate a common key from the premaster secret, and start the encryption communication (SSL) with this key,” a) Common key is the correct answer.
- Blank D: In public key cryptography, the encrypted hash value of data by a private key is used as a signature. In this Subquestion, the certificate of the certificate authority corresponds to data, and the contents of the certificate, whose hash value is encrypted by using the private key of the certificate authority, correspond to the signature put in the certificate so b) hash value is the correct answer. MD5 (Message Digest5) is the name of a typical hash function along with SHA-1 (Secure Hash Algorithm-1) and SHA-2 (Secure Hash Algorithm-2).

The client at the receiving end uses the hash function determined in phase 1, and decrypts the main text of the certificate received from the server with the public key of the server, and compares the obtained hash value and the signature of the certificate authority (that is, data corresponding to the contents of the certificate whose hash value is encrypted by the private key of the certificate authority).

Items to be issued
Common Name (CN)
Organization (O)
Department (OU)
Serial number
Issued by
Common Name (CN)
Organization (O)
Department (OU)
Effective period of the certificate
Date of issue
Effective period
Certificate fingerprints
SHA1 fingerprints
MD5 fingerprints

Fig. SSL server certificate

[Subquestion 2]

During SSL communication, the pre-processing of the actual encryption processing includes arrangement of the encryption procedure (Client Hello, Server Hello), transmission of the server certificate (Server Certificate) and confirmation of its appropriateness, and transmission and sharing of the premaster secret (Client Key Exchange) that forms the basis of the common key. Confirmation of appropriateness can be performed by comparing the received root certificate with the root certificate already installed in the browser and PC. Public key cryptography is used up to this stage. During the actual encryption communication, both the server and the client generate a different common key for each session from the premaster secret, and perform encryption communication using these common keys. Common key cryptography with a lighter encryption and decryption process is used as the encryption method.

Therefore, a) and e) are the correct answers (in any order). The contents of the other options do not hold true because of the description below:

- b) Checking the appropriateness of the server certificate is a pre-process for the actual encryption communication, and makes use of public key cryptography rather than common key cryptography.
- c) The signature provided in the server certificate is data corresponding to the contents of the certificate whose hash value is encrypted by the private key of the certificate authority.

Section 10

Multiple-choice Questions (Software design)

Q10-11 Updating the master file**[Answers]**

[Subquestion 1] A-b), B-c)

[Subquestion 2] C-e), D-b)

[Subquestion 3] E-a), F-d), G-d)

[Explanation]

This question is about program design for updating a master file of member information. This question is based on the subject concerning a matching process that creates a new master file using the contents of a transaction file in which the updated contents are written at the end of the month. Generally, it is necessary to frequently update the information according to the status of operations and services. Therefore, this question is perhaps based on the precondition of using the member information on a monthly basis.

The question passage is comprised of [File Description], [Process Description], “Fig. 1 Flow of update program,” and Subquestions 1 through 3. Basically, examinees read the question in sequence from the beginning. However, in the Afternoon examination, because it is possible that examinees may run out of time, it is better to use innovative techniques for answering such as, skimming the question at first and then reading it over again when answering the subquestions.

With regard to [File Description] and [Process Description], it is important to understand the meaning of file formats and the meaning of processes. For “Fig. 1 Flow of update program,” it is necessary to understand it in conjunction with the flow of processes.

Upon looking at “Fig. 1 Flow of update program,” it is clear that “M input process” (reading the next record from master file) and “T input process” (reading the next record from transaction file) are used as modules. After the first records of the master file and the transaction file are read, the records are matched until the last record is reached, and while the necessary change process is performed, a new master file is created. The important point here is to understand the meaning of comparing K_M and K_T , and “ $M' \leftarrow M$ ” in the “M input process” module.

“ $M' \leftarrow M$ ” in the “M input process” means that the record of the master file being read currently is copied to the storage area called M' for work. Unless this is understood, it will not be possible to understand the meaning of “Copy non-blank items in T to the corresponding items in M' ” and “Output M' to new master file” described in “Fig. 1 Flow of update program.”

In addition, with regard to the comparison of K_M and K_T , " $K_M < K_T$ " indicates that there is no transaction record whose member number is identical to the member number in the current master record. Therefore, the record read from the master file is written to a new master file. As " $K_M = K_T$ " indicates that there is a transaction record whose member number is identical to the member number in the current master record (it is ready to change information of already registered member), the master record is written to a new master file after the incorporation of non-blank items from the transaction record. As " $K_M > K_T$ " indicates that there is no master record whose member number is identical to the member number in the current transaction record, the record read from the transaction file is written to a new master file.

Before the subquestions are answered, it is recommended that this kind of detail be understood.

[Subquestion 1]

With regards to blanks A and B in the module process in "Fig. 1 Flow of update program," it is necessary to examine this figure closely and consider the answers while the options provided in the answer group are compared.

- Blank A: Attention should be paid to the fact that the area covered by the dotted line is inside the loop that will repeat the matching process unless " $K_M = \text{Maximum value}(99999)$ and $K_T = \text{Maximum value}(99999)$." Therefore, processes that increase K_M and K_T are needed. Moreover, it should also be kept in mind that only modules defined in Fig. 1 here are "M input process" and "T input process." Therefore, only one of these choices can be the correct answer.

In "Fig. 1 Flow of update program," it is clear that when " $K_M = K_T$," there is a transaction record whose member number is identical to the member number in the current master record. Therefore, records of the master file updated with non-blank data of records in the transaction file are written to a new master file. In this case, after the process "Copy non-blank items in T to the corresponding items in M" is performed, the process "Output M' to new master file" is performed. This means that records of the master file are modified appropriately, and written to a new master file. Furthermore, when " $K_M < K_T$," there is no transaction record whose member number is identical to the member number in the current master record. Therefore, records read from the master file are written to a new master file. In this case, it means that there are no changes in records in the master file, and therefore, the process "Output M' to new master file" is performed and the corresponding records are written to the new master file.

From the above, it is clear that after modifying the record read from the master file when necessary and output it in a new master file, the process in this blank should read the next record in the master file. Therefore, b) M input process is the correct answer. This module increases K_M and leads to conditional decision that continues the loop.

- Blank B: As previously mentioned, when " $K_M > K_T$," there is no master record whose member number is identical to the member number in the current transaction record. Therefore, the record that is read from the transaction file is written to a new master file. After this process, it is necessary to read the next record from the transaction file. Therefore, c) T input process is the correct answer.

[Subquestion 2]

The only update processes that appear in the question so far are "new registration" and "to change information of already registered member." Subquestion 2 is about a program change that adds a "deletion process" for member information. The modifications (1) through (5) are made.

- (1) Add an item called type of transaction to the record format of the transaction file.
So far, the precondition is that formats of the master file and the transaction file are same. However, the transaction file will now have one additional item.
- (2) When the type of transaction is "U," it refers to a new registration and change. "D" will refer to deletion.
This means that the attribute value of the item "type of transaction" added to the transaction file will be "U" or "D."
- (3) Change the processes α and β in Fig. 1 so that they support the changes made to the record format in (1).
This means that because the number of items of the transaction file is increased by one, in the case of "Copy non-blank items in T to the corresponding items in M' ", the process to discard the information of type of transaction without copying it is added, and in the case of "Output T to new master file," the process to discard the information of type of transaction without copying it is added.
- (4) Change the main process to that shown in Fig. 2.
Change the program so that it satisfies "Fig. 2 Flow of update program after change."
- (5) For T input process, add a process to set "U" in the type of transaction when reading of the file is complete.
If K_M is not 99999 when K_T reaches 99999, a process for branch selection to increase K_M is required.

- Blank C: By comparing the contents of Process (2) and conditional branching of the type of transaction in “Fig. 2 Flow of update program after change”, it is possible to decide the contents of Condition X1, Condition X2, and Condition X3. Since Condition X1 corresponds to the process of “Fig. 1 Flow of update program,” this is a case of new registration and change, in other words the condition should be type of transaction = “U”. If Condition X2 and Condition X3 are compared, it is clear that Condition X2 processes an error in the type of transaction, and it reads the next record in the transaction file. On the other hand, since Condition X3 includes a process for writing to a new master file, it is most likely the procedure for the “deletion process” that needs to be added. Therefore, it can be determined that in Condition X2, Type of transaction is neither “U” nor “D”, while Condition X3 is Type of Transaction=“D”.

Based on the above, the correct answer is e).

- Blank D: Error process 2 is the display process when $K_M > K_T$ in the case of Type of transaction=“D”. $K_M > K_T$ in the deletion process means that there is no record to be deleted in the master file, and hence the deletion process cannot be performed. Accordingly, there is no record which has the member number to be deleted in the master file, and therefore the correct answer is b).

[Subquestion 3]

This subquestion is also about program enhancement. One of the preconditions of the program is that neither the master file nor the transaction file has multiple records with the same member number. Here, the program is modified so that multiple records with the same member number are allowed in the transaction file. When there are multiple records, they are processed in the sequence of occurrence of records.

The following two changes are made:

- (1) A new item named Date and time occurred is added to the transaction file record format.
- (2) In addition to the update program in Fig. 2, a sort program and a record aggregation program are added to the transaction process to generate a new transaction file.

In other words, a new item named Date and time occurred is added to the transaction file, and a program for sorting in the case of multiple records with the same member number and performing record aggregation is added.

Also, this question asks about the sorting key of the sort program, and the execution order of the update program, sort program, and record aggregation program. First, the execution order of programs is discussed below.

The sort program is the most likely process that is performed when there are multiple records with the same member number. It can be determined that when there are multiple records with the same member number, the record aggregation program performs the process of summarizing records with the same member number into a single record. The update program has the precondition that neither the master file nor the transaction file has multiple records with the same member number. Based on these, it is clear that the sort program and record aggregation program need to be executed before the update program is executed. Furthermore, with regard to the sort program and the record aggregation program, if the record aggregation program is executed before the sort program, records with multiple dates and times of occurrence will be overwritten without sorting, and sorting will have two keys, namely Key 1 and Key 2. This contradicts to the assumption.

Based on the above, it can be concluded that the execution order is Sort program -> Record aggregation program -> Update program.

Furthermore, with regard to the sorting key of the sort program, since it is mentioned that “when there are multiple records, they are processed in the sequence of occurrence of records,” it is clear that records are first sorted by member number so that records with the same member number are sorted in the sequence of their occurrence, the first sorting key is “Member number,” and the second sorting key is “Date and time occurred.”

Based on the above, correct answers for blanks E, F, and G are a), d), and d) respectively.

Q10-12 Music download system**[Answers]**

[Subquestion 1] A-a), B-e)

[Subquestion 2] C-b), D-b)

[Subquestion 3] E-b), F-d)

[Explanation]

This question is based on the subject of music download systems that have rapidly become popular on the Internet in recent years. The content of the question is quite similar to past questions concerning topics such as a module structure diagram and file processing. Examinees should be able to answer the subquestions by thoroughly understanding the question passage.

[Subquestion 1]

This subquestion is about a procedure for determining the download count for that day for a logged in member. This question is considered by focusing on Fig. 3 “The record format of the download result file.”

- Blank A: This question is about the key required for searching the download record file in order to determine the “download count” for “that day” for the “logged in member.” The part corresponding to “that day” uses the “current date” that is obtained from the system. In order to identify the “logged in member,” the “member number” is required. By using the “current date” and the “member number” as search keys, the number of records where both these keys match is listed. Therefore, a) member number is the correct answer.
Moreover, there are 3 key items in the download result file, namely, “Member number,” “Download date,” and “Download time;” however, there is no restriction where all 3 must be specified when a search is performed. Key items of Fig. 3 are primary keys, they are for uniquely indentifying a record.
- Blank B: This question is about the timing for performing the process to determine the download count for that day. Because the subquestion contains “if the date has changed between login and download,” it is clear that this process must be performed just before the downloading process and not at the time of login. Therefore, e) Download music is the correct answer.

[Subquestion 2]

This subquestion is about a function for adding the last download date of music to the items displayed on the music selection screen. This question is considered by focusing on Fig. 3 “The record format of the download result file” and Fig. 5 “Module structure of the system.”

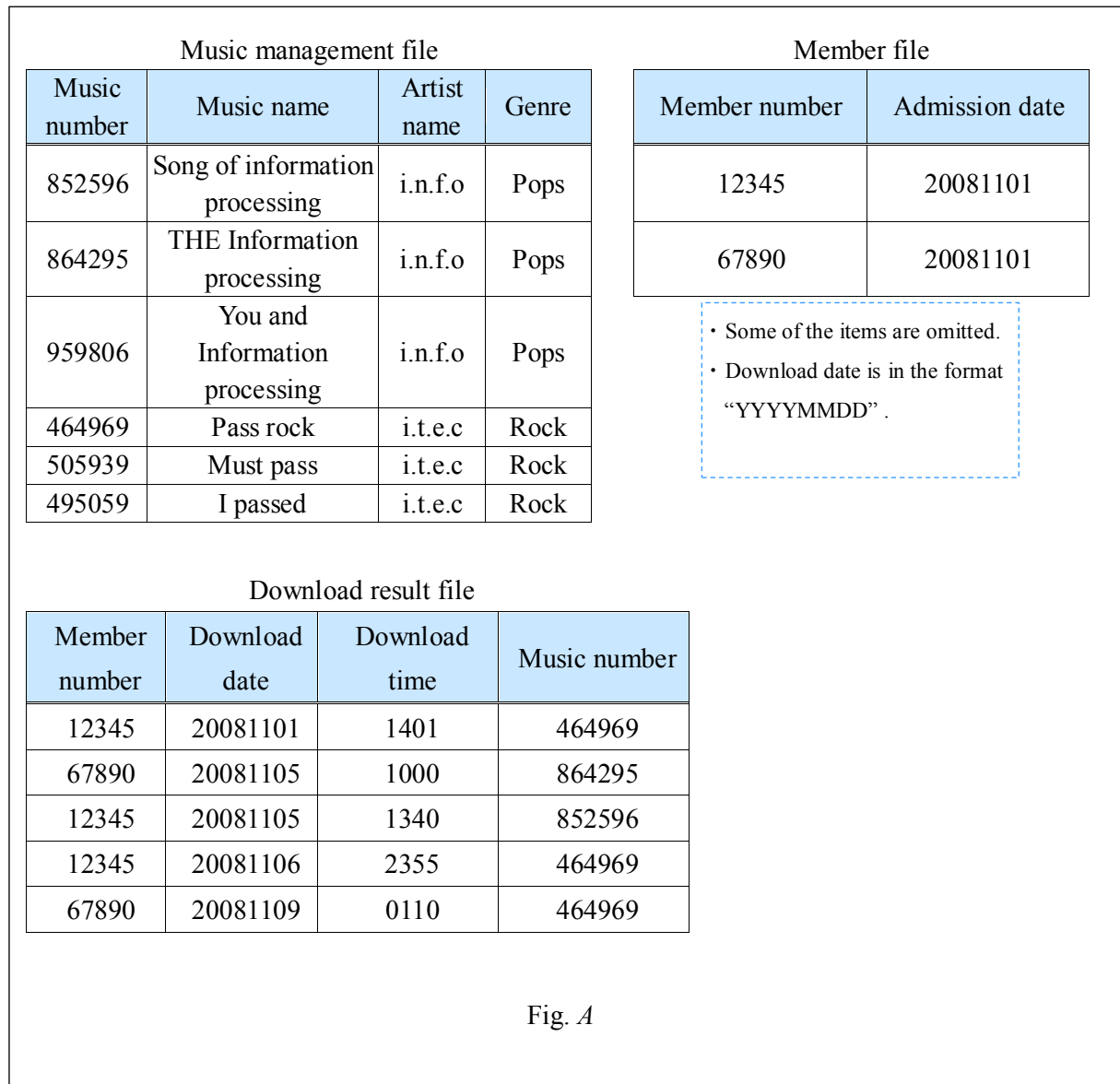
- Blank C: Whether or not the extracted records are those that are “already downloaded music numbers” by the logged in “member” can be checked by searching the download result file with the “Member number” and “Music number.” Therefore, b) Member number and Music number is the correct answer.
- Blank D: Once the music is downloaded, one record is added to the download result file during the “Add record to download result file” process shown in Fig. 5. In other words, the number of records created in the download result file is same as the number of downloads. As a result of searching the download result file with “Member number” and “Music number,” if there are no corresponding records, it means that the corresponding music is not yet downloaded. If the search result is 1 or more records, it indicates that the corresponding music is already downloaded. Furthermore, if the music is downloaded multiple times, there will be multiple records. Therefore, b) 0 or more is the correct answer.

In addition, in the question passage there is no mention of any restriction where a member can only download one music number once. Therefore, c) 0 or 1 is not the correct answer.

[Subquestion 3]

This subquestion is about the process for the creation of “List of download counts by genre” for all members during the first week after they have joined. This is achieved by combining basic file processes like Matching, Sorting, and Counting. It is necessary to think about this subquestion while a complete image of details of the respective process is created.

Processes 1 through 3 are explained on the assumption that data shown in Fig. A is stored in the respective files.



Process 1: “Match the records in files *X* and *Y* using member number as a key.” In other words, it is necessary for Files *X* and *Y* to have a member number as a parameter. Furthermore, the note in Fig. 7 says, “Each of the files *X* and *Y* represents one of three files; the music management file, member file, and download result file.” Although the music management file does not have member numbers, the member file and download result file have member numbers. Therefore, files *X* and *Y* will be a member file and download result file respectively. In Process 1, records in the member file and the download result file are matched with a member number as a key. When the key matches and download date is within a week of the member joining, the music number is extracted and downloaded.

When the contents of the respective files are as shown in Fig. 4, the following file is generated by Process 1.

File generated by Process 1

Member number	Download date	Download time	Music number
12345	20081101	1401	464969
67890	20081105	1000	864295
12345	20081105	1340	852596
12345	20081106	2355	464969

Process 2: Reads the file generated in Process 1, sorts it with the music number as a key, and then returns this file.

Process 3: Reads the file generated in Process 2. Counts the number of records (control break) with music number as a control key, and then writes the music numbers and the counted number of records.

Files generated by Process 3

Music number	Number of records
464969	2
864295	1
852596	1

- Blank E: As described above, up to Process 3, an intermediate file is generated based on the items extracted and created from the member file and the download result file. On the other hand, Process 6 “counts the number of records by genre.” Since genre is not extracted up until Process 3, it is necessary to extract the genre in Process 4 or Process 5. Because Process 5 is a sorting process, it is necessary to extract the genre in Process 4. As genre details are in the music management file, the intermediate file generated in Process 3 and the music management file are matched with music number as a key, and the music number and genre are returned. Therefore, b) Music management file is the correct answer.
- Blank F: Process 5 sorts the records. As sorting is required for the subsequent process, the sorting key should be considered based on the content of the subsequent process. As Process 6 “counts the number of records by genre,” it is clear that the genre is used as a control key for aggregation (control break) process. Therefore, Process 5 sorts the records with genre as a key and writes the results. Accordingly, d) Genre is the correct answer.

Q10-13 Business system of a distribution center

(810424)

[Answers]

[Subquestion 1] A-c)

[Subquestion 2] B-d), C-b)

[Subquestion 3] D-h), E-e), F-g), G-f), H-b), I-d), J-c)

[Explanation]

This question is about identifying problems that are likely to occur in a distribution center’s delivery operations that are conducted based on the processing of slips, and system design for improving the situation. At the beginning, Subquestion 1 checks whether the examinee has thoroughly understood the problems. Here, it is necessary to read the question passage and keep in mind the manual activities and the problems to be overcome by system based automation. Subquestion 2 and subsequent subquestions test the details of the examinee’s understanding of writing class diagrams and sequence diagrams in UML.

[Subquestion 1]

It can be understood from the question passage that Company *A* is facing the problem of “significant delays in deliveries.” By reading [Details of current operations] while keeping this problem in mind, it comes to light that in the series of operations “Receipt in warehouse from large trucks -> Storage in rack -> Dispatch using small trucks,” the manual handover of slips is widely practiced in general cases as well. However, it is difficult to think of any hidden problem here. Moreover, since the problem is delayed delivery, it is unlikely that the management of destination address and consignee in the mission-critical system is the root cause of the problem. On the other hand, a manual search through delivery slips that correspond to the delivery area of a truck from a delivery slip box is likely to result in many omissions. If delivery slips are left out at this stage, it will lead to delayed delivery, and therefore this is likely to be the root of problem faced by Company *A*. This also appears in the question passage, “Based on an analysis of the current situation, it comes to light that the problem lies in the manual search of delivery slips at the time of retrieval and dispatch of consignments.” Therefore, c) is the correct answer.

[Subquestion 2]

Here, cardinality between classes is examined. As cardinality is a relation of numbers, this subquestion should be answered while imaging the kind of real world numerical structure of entities expressed by each class.

- Blank B: The cardinality between bar code reader and terminal control is examined here. Since handheld terminals are equipped with bar code reader, it can be concluded that there is a one-to-one relationship. Therefore, d) is the correct answer.
- Blank C: Cardinality between terminal control and warehouse management server is examined here. Based on the description of the number of delivery staff members in each distribution center and the fact that every delivery staff member has a handheld terminal, it is clear that there are multiple handheld control units for one warehouse server. Therefore, b) is the correct answer.

[Subquestion 3]

In this subquestion, the examinee is required to provide terms and phrases to fill the sequence diagrams for receipt and dispatch from warehouse. Therefore, it is necessary to answer this subquestion while referring to the description of [New system] in the question passage and definition of operations in the class diagram.

- Blanks D, E: The process performed by terminal control on the terminal screen after the power supply of the bar code reader is turned on should be considered here. Because [New system] states “bar code readers read the bar codes that are printed on slips and that indicate consignment codes. Next, bar codes that are affixed to the storage racks and that indicate rack numbers are read.” From this, the sequence in which bar codes of consignment and rack are read can be understood. Next, below blanks D and E, it is stated that bar code input is performed from bar code readers. Therefore, it can be concluded that a display requiring bar code input will appear on the terminal screen as a preceding step. Since the arrow is bidirectional, if the operations of the terminal screen class in class diagram are checked, it is clear that “Consignment bar code input instruction display” and “Rack bar code input instruction display” are the appropriate choices for blanks D and E respectively. Therefore, h) is the correct answer for blank D, and e) is the correct answer for blank E.
- Blank F: This question is about the operations of the warehouse management server that is called by terminal control. Based on the operations of the warehouse management server in the class diagram, and the response (receiving complete) to terminal control from the warehouse management server corresponding to the blank F in the sequence diagram, it is clear that the receipt process is the appropriate choice. Therefore, g) is the correct answer.
- Blank G: This question is about the operations of rack that are called by the warehouse management server. Based on the operations of racks in the class diagram, and the response (receiving complete) to the warehouse management server from the rack corresponding to blank G in the sequence diagram, it is clear that receipt is the correct answer. Therefore, f) is the correct answer.
- Blank H: The process performed by terminal control on the terminal screen after power supply of the bar code reader is turned on should be considered here. Because the description of [New system] states “the bar code reader on the handheld terminal of the delivery staff reads the TR bar code (indicating the truck number) carried by the truck driver.” Next, below blank H it is mentioned that “bar code input” is performed from the bar code reader. Therefore, it can be concluded that a display requiring bar code input will appear on the terminal screen as a preceding step. Here, since the TR bar code needs to be read, “TR bar code input instruction display” is the appropriate choice. Therefore, b) is the correct answer.

- Blank I: This question is about operations of the warehouse management server for calling terminal controls. Based on the operations of the warehouse management server in the class diagram, and the response (dispatch complete) to terminal control from the warehouse management server corresponding to blank I in the sequence diagram, it is clear that the dispatch process is the appropriate choice. Therefore, d) is the correct answer.
- Blank J: This question is about the operations of the rack that are called by the warehouse management server. Based on the operation of the rack in the class diagram, and the response (dispatch complete) to the warehouse management server from the rack corresponding to blank J in the sequence diagram, it is clear that dispatch process is the appropriate choice. Therefore, c) is the correct answer.

Section 10

Multiple Choice Questions (Management)

Q10-14 Risk management for a project**[Answers]**

[Subquestion 1] A-c)

[Subquestion 2] d)

[Subquestion 3] (1) b), (2) B-d), C-a), (3) a)

[Subquestion 4] D-b)

[Explanation]

This question is based on a subject concerning risk management for a project, and it uses the example of a system development project for a sales management system.

[Subquestion 1]

-Blank A: The risk value is calculated as the product of probability of occurrence and impact. Therefore, “c) Probability of occurrence” is correct. Higher risk values are regarded as having higher priority.

[Subquestion 2]

This question requires that the examinee provides an appropriate term or phrase that corresponds to the underlined section (i). The underlined section (i) concerns risks “that require no special measures.” Acceptance of a risk without taking any special measures is called “risk acceptance.” Therefore, d) is correct.

- a) Risk transfer is the transfer of the impact of when a risk occurs to another party.
- b) Risk avoidance is a measure that avoids the occurrence of a risk.
- c) Risk reduction is a measure that is implemented to reduce the risk.

[Subquestion 3]

- (1) For the risk “after the conclusion of the contract, the number of screens and forms that are included in the development scope increases,” this question asks the examinee which of “risk avoidance,” “risk reduction,” “risk acceptance,” and “risk transfer” the risk response “before the conclusion of the contract, negotiate to finalize the number of screens and forms” equates to. The meaning of each of the options is as explained in Subquestion 2. If the number of screens and forms is finalized before the conclusion of the contract, the risk “after the conclusion of the contract, the number of screens and forms that are included in the development scope increases” will not occur. Because this is a measure that avoids the occurrence of the risk, “b) Risk avoidance” is correct.

(2)

- Blank B: For the risk “after the conclusion of the contract, the number of screens and forms that are included in the development scope increases,” the risk response “before the conclusion of the contract, negotiate to finalize the number of screens and forms” is tried first, but this question requires the examinee to provide an answer for the kinds of risk countermeasures that are possible in the event that the risk materializes.

The fact that the number of screens and forms could not be finalized before the conclusion of the contract means that the project started before a service contract for phases after the external design phase without fixing the number of screens and forms. As mentioned in the risks, there is a possibility that the number of screens and forms will increase as the project progresses, so measures must be taken for this increase. However, because there are restrictions in terms of budget and deadline, unlimited measures cannot be taken.

Thus, to take realistic measures, it is necessary to set a maximum number of screens and forms as well as a deadline for the finalization of the specifications. Company *E* and Company *L* only have an agreement about the cost and schedule based on an estimate for the development scope that is currently set. Thus, if an increase in the number of screens and forms will have an impact on the cost or schedule, then it is necessary to create a new estimate and take measures in accordance with result of this estimate. Therefore, d) is correct.

- a) Only a subset of the screens and forms are not finalized, so it is not necessary to perform requirements definition again from the beginning.
 - b) Although a decision about the specifications with prototyping also concerns the finalization of screens and forms, this does not guarantee that the number of screens and forms will be kept to a certain value or less.
 - c) Even if there are areas that are not finalized, it is problematic to go ahead with the project without an agreement about the development scope.
- Blank C: For the risk “there are no members of staff who sufficiently understand the business of Company *L*,” this question requires that the examinee mentions a risk countermeasure other than “implement training concerning Company *L*’s business.” Because the implementation of training does not guarantee an increase in proficiency in a short time, there is a danger that the necessary deadline will not be met. As such, the support of a person who sufficiently understands the business is desired, but because there is no such person at Company *E*, the remaining countermeasure is to receive support from a person at Company *L*. Therefore, a) is correct.
 - b) Without a sufficient understanding of Company *L*’s business, external design is limited. As such, the plan will be incomplete so although this is a temporary solution it is not a solution to the problem.
 - c) Concerning this answer, if a problem occurs in terms of the contract, even if there is an escalation to a superior manager at Company *L* it involves dealing with the risk on the spot and cannot be called a risk countermeasure that should be considered in advance.

- d) The fact that there are no staff members who are familiar with the business is the problem, not the number of people, so even if the number of staff members is increased, the problem is not solved.
- (3) If the risk response “(iii) secure staff familiar with SOA” is adopted, a problem may occur where the cost of securing staff exceeds the assumed cost. This means that through the use of a risk response, a new risk occurs. A risk that occurs through the implementation of a risk response is called a secondary risk. Therefore, “a) Occurrence of secondary risks” is correct.

[Subquestion 4]

- Blank D: The countermeasure for the actual occurrence of a risk is inserted here. A plan that is made for countermeasures that should be implemented if a risk occurs is called a contingency plan. Therefore, b) is correct.
 - a) A circumvention measure is a countermeasure to ensure that a risk does not occur. It is not a countermeasure for when a risk occurs.
 - c) A business continuation plan is a plan for when a phenomenon that stops business occurs and enables the swift restart and continuation of business. This question concerns risk response in system development, so business continuity is not applicable.
 - d) A risk assessment refers to the actual activity of analysis and evaluation of a risk. It is not a measure against risks.

Q10-15 Creation of a plan for system development

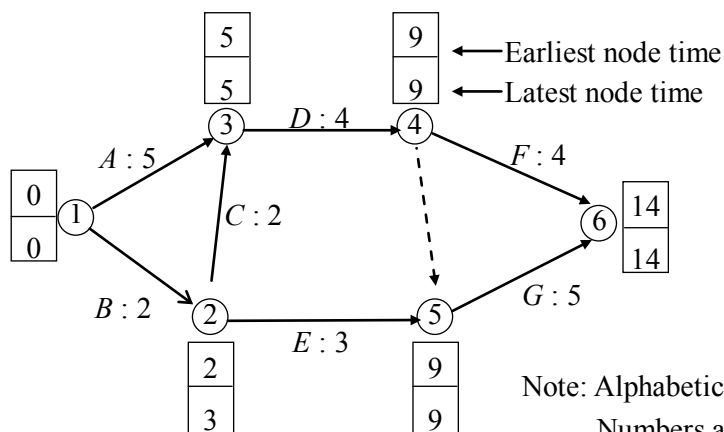
[Answers]

[Subquestion 1] b), e)

[Subquestion 2] A-a), B-f), C-a)

[Explanation]

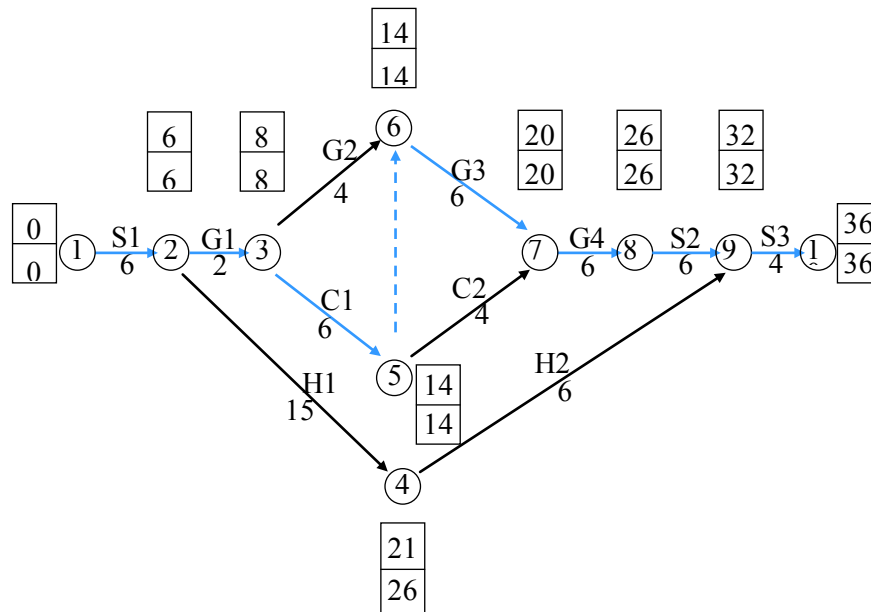
An arrow diagram is a diagram that is used for scheduling (an arrow diagram is sometimes called a PERT diagram). The activities of a project include activities that are performed in parallel and activities that cannot be started until another activity is completed. With an arrow diagram, the relationships between these activities can be graphically represented. In an arrow diagram, activities are represented with an arrow, and the preceding and subsequent activities are connected with a node (as in the diagram below).



Note: Alphabetic characters are activity names
 Numbers are the number of days of an activity
 A dashed line is a dummy activity

- Dummy activity: An activity with an activity time of 0 that represents the relationship between preceeding and subsequent activities (no actual activity occurs).
- Earliest node time: The earliest time that an activity which starts at that node can start. For each node, in order for the next activity to start, each of the activities that merge at that node must be completed. For this reason, time is calculated in the order of smallest node number first. If multiple activities merge at a node, the merge time with the largest value is the earliest node time. For example, activities *A* and *C* merge at node (3). Activity *A* finishes in 5 days and activity *C* finishes in 4 days (activity *B* + activity *C* = 2 + 2 = 4), so the larger value of 5 days is the earliest node time.
- Latest node time: The latest time by which the activity must be started, or all activities will be delayed. In contrast to the earliest node time, time is calculated from the largest node number first. If multiple activities start from that node, the time with the lowest value is chosen as the latest node time. For example, at node (4), activities *F* and *G* are started (activity *G* is started via a dummy activity). Activity *F* finishes in 4 days, so the activity *F* should be started on day 10 (= 14 – 4). However, because activity *G* takes 5 days, in order to complete all activities in 14 days it is necessary for activity *G* to be started on day 9 (= 14 – 5), so the smaller value of 9 days is the latest node time.
- Critical path: this represents an activity route that has no leeway and both the earliest node time and latest node time are the same. If an activity on the critical path is delayed, then the overall project will be delayed. In the diagram, the route of the critical path is (1)→(3)→(4)→(5)→(6).

[Subquestion 1]



A verification of the answer group based on the arrow diagram is as below:

- (G3) can start if each of the activities (S1), (G1), (G2), and (C1) are completed (a dummy activity (5)→(6) exists, so the completion of (C1) is also necessary), and it can be started without considering the activity (C2). As such, this is incorrect.
- (G4) cannot be started if (C2) does not finish and merge. Therefore, this is correct.
- Because there is a dummy activity from (5) to (6), (G3) cannot be started unless (G2) and (C1) are completed. Both (G2) and (C1) start after activities (S1) and (G1) finish. (G2) takes 4 days to complete, but because (C1) takes 6 days, (G3) cannot be started even if (G2) is finished. As such, this is incorrect.
- (G4) is an activity that can be performed in parallel with hardware procurement and building the hardware environment, and it can be started without real computing environment. As such, this is incorrect.
- (H1) is an activity that can be started after the completion of (S1). Therefore, this is correct.

[Subquestion 2]

The number of days necessary for all activities is as below:

- a) $(1) \rightarrow (2) \rightarrow (3) \rightarrow (5) \rightarrow (6) \rightarrow (7) \rightarrow (8) \rightarrow (9) \rightarrow (10) = 6 + 2 + 6 + 6 + 6 + 6 + 4 = 36$ days
 - b) $(1) \rightarrow (2) \rightarrow (3) \rightarrow (5) \rightarrow (7) \rightarrow (8) \rightarrow (9) \rightarrow (10) = 6 + 2 + 6 + 4 + 6 + 6 + 4 = 34$ days
 - c) $(1) \rightarrow (2) \rightarrow (3) \rightarrow (6) \rightarrow (7) \rightarrow (8) \rightarrow (9) \rightarrow (10) = 6 + 2 + 4 + 6 + 6 + 6 + 4 = 34$ days
 - d) $(1) \rightarrow (2) \rightarrow (4) \rightarrow (9) \rightarrow (10) = 6 + 15 + 6 + 4 = 31$ days
- Blank A: $(1) \rightarrow (2) \rightarrow (3) \rightarrow (5) \rightarrow (6) \rightarrow (7) \rightarrow (8) \rightarrow (9) \rightarrow (10)$ is the critical path (arrow on blue line). Therefore, a) is correct.
 - Blank B: The smallest number of days necessary is 36. Therefore, f) is correct.
 - Blank C: In order to shorten the overall development period, the activities on the critical path must be shortened. The activity in the answer group that is on the critical path is (C1). Therefore, a) is correct.

Q10-16 Fault management

[Answers]

[Subquestion 1] A-e), B-g)

[Subquestion 2] C-f), D-f), E-d), F-d), G-d)

[Explanation]

This question centers on a calculation problem. In a calculation problem, it is important to thoroughly check for “condition omissions.” When the question is answered, if the problem was solved smoothly or if the result of the calculation is not present in the answer group, then there is a possibility that the key condition was overlooked. As such, a check for omission of conditions should be performed again. The difficulty of the question is “medium” and it has an answer time of 15 minutes.

[Subquestion 1]

- Blank A, B: The key to this subquestion is that work on all 100 PCs for data entry stops if the business server stops. This should be reflected in the answer.

For the business server, the time for each stoppage from a failure is 4 hours, and the number of failures is 2, so the total stoppage time for the business server is 8 hours. If the business server stops, the 100 PCs for data entry cannot be used, so the total stoppage time for the PCs for data entry is 800 hours. Because the lost cash amount if a PC for data entry stops for 1 hour is 10,000 yen, the total lost cash amount is 8,000,000 yen. Therefore, e) is correct for blank A and g) is correct for blank B.

[Subquestion 2]

The key to this subquestion is that Table 2 shows the cost of countermeasures for proposal *A* per month and for proposal *B* by year. This difference should be reflected in the answer.

- Blank C: Based on the description of Table 2, spare PCs for data entry are installed at a ratio of 20 to 1 in proposal *A*, so for 100 PCs 5 spare PCs are required. The cost of countermeasures for each spare PC is 20,000 yen per month, so the annual cost of countermeasures is 1,200,000 yen. Therefore, f) is correct.
- Blank D: Because the stoppage time of the business server for each failure changes from 4 hours to 1 hour, the avoidable total stoppage time for the business server is 6 hours. Because the total stoppage time of the PCs for data entry is calculated, the result is 6 (hours) \times 100 (PCs) = 600 (hours). Therefore, f) is correct.
- Blank E: Because the lost cash amount if a PC for data entry stops for 1 hour is 10,000 yen, the avoidable lost cash amount is 6,000,000 yen. Therefore, d) is correct.
- Blank F: If the amount after deduction of the cost of countermeasures from the avoidable lost cash amount is considered as the effect of countermeasures, the result is as shown in the table below. Because the proposals that have a positive effect are used, only proposal *B* is used. Therefore, d) is correct.

Proposal for countermeasure	Avoidable total stoppage time (hours)	Avoidable lost cash amount (thousands of yen)	Annual cost of countermeasures (k yen)	Effect of countermeasures (k yen)
Proposal <i>A</i>	100	1,000	1,200	-200
Proposal <i>B</i>	600	6,000	2,000	4,000

- Blank G: The management aim of each ITIL service support is as follows:
 - Incident management: To swiftly recover a service from a system failure
 - Problem management: To identify and eliminate the root cause of a failure
 - Change management: To perform centralized control of changes to service
 - Release management: To implement things such as changed systems into the production environment
 - Configuration management: To perform centralized management of information concerning the components of IT services such as hardware and software
 The question asks for the activity to identify and eliminate the root cause of a failure, so d) is correct.

Q10-17 Incident and problem management**[Answers]**

[Subquestion 1] A-e), B-d), C-c), D-a), E-d), F-a)

[Explanation]

In the ITIL (IT Infrastructure Library), a computer system is handled as an IT service, and the aims are (1) to provide an appropriate service in response to a request, and (2) to continuously improve IT services in order to maintain a high return on investment. From this point of view, ITIL IT services are divided into support services that provide support to enable the use of services needed by users on a daily basis, and service delivery that improves services in the long term in order to maintain a high return on investment.

For the relationship between incident management, problem management, and change management that is asked about in this question, examples are used for the explanation.

- (1) Incidents that are received by the service desk are initially dealt with incident management.
- (2) In incident management, the history of past incidents is searched (in this question, a fault management database). If the incident is in the history, the recovery measures written in this history are implemented.
- (3) If the incident is not in the history, an escalation to problem management (handled incrementally) is performed. Specifically, the “problem,” which is an error for which the root cause is not identified, is taken over by problem management from incident management in order to create corrective measures and identify the cause.
- (4) In problem management, corrective measures are investigated and instructions are given for the implementation of recovery measures for incident management.
- (5) In incident management, recovery measures are taken and efforts to restore IT services are made.
- (6) In problem management, if the root cause of an incident is understood, a “problem” is treated as an “existing error,” and a solution is created.
- (7) In problem management, solutions are compiled in an RFC (Request For Change), and passed to change management.

These activities are actually performed in parallel. The key points of incident management and problem management are shown below:

The aim of incident management is to swiftly restore an IT service.

The aims of problem management are the reactive activity of prevention of recurrence of an incident and the proactive activity of incident prevention. Also, the reactive activity of prevention of recurrence includes problem control, which reveals the root cause of an incident and makes a “problem” an “existing error,” and error control, which eliminates existing errors through change management of root causes.

Below is an explanation based on this specialist knowledge. Because this question tests knowledge concerning ITIL, it has a slightly higher level of difficulty.

[Subquestion]

- Blank A: From the contents of Table 2, it can be understood that an item related to “level” is inserted in to blank A. The description states that at level 1 notification is not given to any party outside the systems department, and at level 3 board members and affiliate companies are notified and a post is made on the internal Web site. Based on this, if keywords associated to “level” are searched for in the answer group, e) “Impact of the fault” is applicable, and it can be thought that if the impact is small then notification is not given to any party outside the systems department, and if it is large then board members and affiliate companies are also notified. Therefore, e) is correct.
- Blank B: Description immediately after blank B states “information about the recovery action and recovery status, which were formerly recorded on a whiteboard at the time of a critical fault, is recorded in the DB so that the current status can be shared by the staff of the systems department”. Based on this, it is understood that an item concerning “recovery action and recovery status” is inserted into blank B. A search of the answer group reveals that d) “Details of recovery action (append type)” is similar in content. Therefore, d) is correct.
- Blank C: Description immediately after blank C states “the problem management committee follows up on the status of problem resolution on a weekly basis by using this item as a criterion,” and it can be understood that an item to become a criterion is inserted into blank C. Furthermore, Table 3 states “(i) The problem management committee checks weekly whether the problems to be resolved in that week have been resolved” in “Improvement (outline).” As such, it can be understood that “an item to become a criterion” is inserted in blank C. In the answer group, “c) Planned resolution date and time” is similar in content to this. Therefore, c) is correct.
- Blank D: Of the unsolved problems, the problem that remains for a long time and can be handled as complete based on stipulated procedures is chosen from the answer group.
 - a) This is a problem for which the cause cannot be identified and which does not reoccur. If valid procedures are used, such as treating it as complete at a problem management committee, it can be considered not to be a problem. Therefore, a) is correct.
 - b) If a solution is not possible with internal skills, a request for resolution should be made to an external party such as the manufacturer, and efforts should be made to prevent reoccurrence of the incident.
 - c) If the incident reoccurs, efforts should be made for the prevention of reoccurrence. If there is no large obstruction to business, an RFC with a low priority level should be created and it should be taken on by change management.
 - d) “Problems for which the system cannot be changed because of an insufficient budget” means that this is an “existing error” for which a solution has been created. This is because it can be considered that the budget is set based on the solutions. However, before blank D, the description states “of those problems that remain unresolved,” so these must be “problems” not “existing errors.” Therefore, this option is not appropriate. Note, it is considered that a decision about whether work for system change can be implemented or not is made in change management after problem management, and thus can be judged to be inappropriate.

- Blank E: This is a fill-in-the-blank question that tests knowledge. In problem management, solutions are compiled in an RFC (Request For Change), and passed to change management. Therefore, d) is correct.
- Blank F: Focus should be placed on the description after the relevant section that states “so that unresolved problems are displayed in order of importance.” The description before the relevant section that states “displayed in the descending order of fault control numbers” applies to “In order of importance.” Thus, blank F must be an item which allows the fact that it is an “unresolved problem” to be understood. Furthermore, based on the part of the description that states “the problems whose F field is blank”, if blank F is in unfilled, it is clear that it can be determined to be an “unresolved problem.” A search for a description related to this reveals that in management problems of item No. 2 in Table 1 states “The DB has many records whose resolution date and time fields are blank; a blank resolution date and time field indicates that the incident process was completed but the problem has not been resolved,” so it can be understood that “a) Resolution date and time” is inserted. Therefore, a) is correct.

Section 10

Multiple-choice Questions (Strategy)

Q10-18 Sales analysis of a department store**[Correct answers]**

[Subquestion 1] A-b), B-a), C-e), D-c), E-e)

[Subquestion 2] F-d), G-b)

[Subquestion 3] H-c), I-e), J-a), K-c), L-c)

[Explanation]

This question is about sales analysis of a department store. You should be able to answer the subquestions if you are able to understand the scatter diagram and the line chart provided in the question statement. Difficulty level of this question is average, and it can be easily solved. Information required for answering all the subquestions is provided in the question statement, respective subquestions, tables and diagrams, and the key is to quickly find this information in a limited time.

[Subquestion 1]

Key point is the method of reading Fig. 1. Correctly understand the kind of nuances that can be read from the information provided in Fig. 1. Especially, it is important to correctly understand the relative positions with auxiliary line γ as a reference, which shows that sales revenue before and after the reshuffle are equal.

- Blank A: With regard to comparison of the brands that experienced a growth in sales revenue for the 1-year period after the reshuffle and the brands that experienced a decline in sales revenue for the 1-year period after the reshuffle, comparison can be made by checking whether the brands are located in the upper side or the lower side of the auxiliary line γ . If you count the number of brands appearing in the upper side of the auxiliary line γ after removing 2 brands that are on the line γ , there are 23 brands that appear in the upper side of the auxiliary line γ . Against this, there are 15 brands on the lower side of the auxiliary line γ . From this, it is clear that “there are more brands that experienced an increase in sales revenue.” Therefore, b) is the correct answer.
- Blank B: Among the brands that satisfied the conditions for reshuffling to preferred shop, let us compare the brands that were actually reshuffled (\circ) with the brands that were not reshuffled (\bullet). With regard to sales revenue of the respective brand for the 1-year period before and after the reshuffle, among the brands that were actually reshuffled, there were 8 brands where sales revenue increased (there was 1 brand where sales revenue declined), while in the brands that were not reshuffled, 1 brand experienced an increase in sales revenue (there were 3 brands that experienced a decline). From this, it can be concluded that brands that were reshuffled experienced an increase in sales revenue. Therefore, a) is the correct answer.

- Blank C: Brand *X* is one of the brands that satisfied the conditions for reshuffling to the preferred shops, and that were actually reshuffled. As shown in Fig. 1, it is the only brand where sales revenue actually declined (Brand *X* appears in the lower side of the auxiliary line γ). Therefore, e) is the correct answer.
- Blank D: Out of the brands that met the conditions for reshuffling to the non-preferred shops (\square and \blacksquare), with regard to sales revenue for the 1-year period before and after the reshuffle, there are 2 brands that experienced an increase in sales revenue (appears in the upper part of the auxiliary line γ). Unlike the conditions for blank C, this subquestion asks about the number of brands that met the conditions for reshuffling to non-preferred shops irrespective of whether they were actually reshuffled or not. Therefore, please pay attention to careless mistakes such as misreading the question. Accordingly, c) is the correct answer.
- Blank E: Among the brand that were reshuffled to the non-preferred shops, Brand *Y* is the only brand where sales revenue increased when compared with the sales revenue before the reshuffle (Brand *Y* appears in the upper side of the auxiliary line γ). Therefore, e) is the correct answer.

[Subquestion 2]

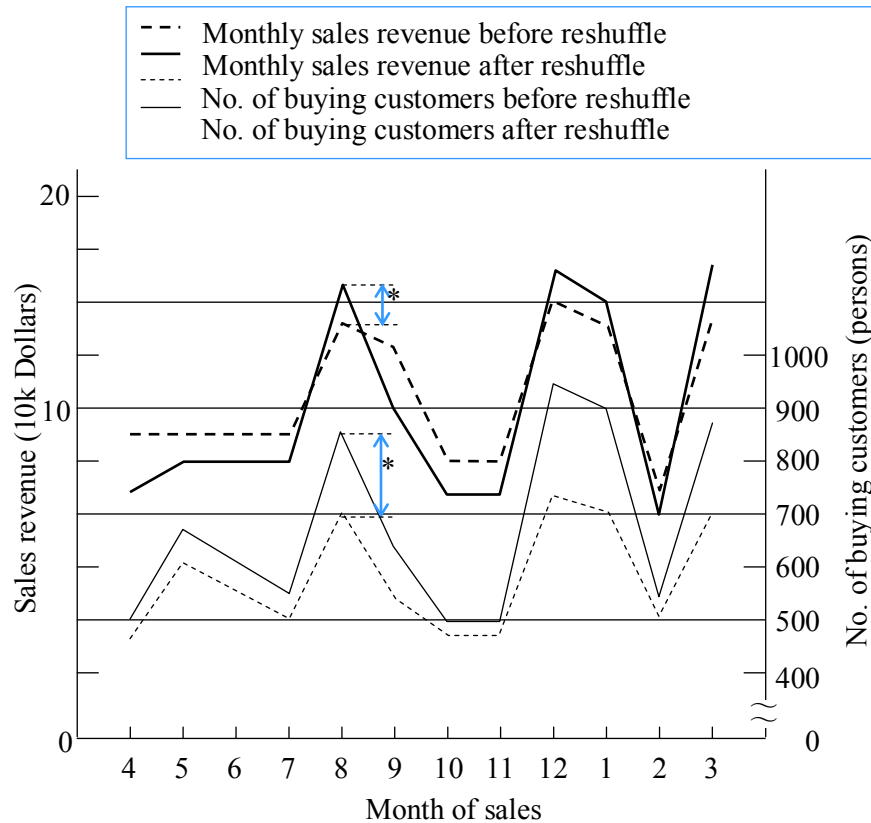
This subquestion calls for filling the blanks in the analysis of changes in sales revenue for the 1-year period before and after the reshuffle for Brand *X*. In this subquestion, Fig. 2 containing the line graph of changes in monthly sales revenue and the number of buying customers for Brand *X*, and Table 2 providing comparison of monthly average customer spend for the 1-year period before and after the reshuffle are provided. We will read the required information from Fig. 2 and Table 2, and answer the subquestions.

- Blank F: This blank appears in the comparison results of December and January in Table 2. A quick look at Fig. 2 shows that there is a relationship between an increase or a decline in sales revenue and rise or fall in the number of buying customers. Moreover, when thinking about blank F, it is necessary to take a standpoint of making a relative comparison of changes in the places that offer cues, and changes in the places that are asked in the subquestion. Here, results of comparing “monthly average customer spending” is asked, and this can be inferred from the correspondence relationship of “sales revenue” and “the number of buying customers.”

To begin with, with regard to Table 2, information that provides hint is given in August and September data. By taking a look at this data, it is clear that average customer spend has declined after the reshuffle for both August and September. On the other hand, if you check the corresponding places in Fig. 2, it is clear that sales revenue and the number of buying customers has increased in August when compared with that before the reshuffle. In other words, while sales revenue itself has grown and exceeded 160k Dollars, the number of buying customers has simultaneously exceeded 800 persons. Status for the month of August in Table 2 shows that the average customer spend has declined after the reshuffle when compared with that prior to the reshuffle.

Given that, if you look at December, it is clear that while sales revenue has grown close to 180k Dollars, the number of buying customer has increased and it has exceeded 900 persons. However, if you compare the growth in sales revenue before and after the reshuffle for December with the growth in sales revenue for August, despite the growth is almost same (about 10k Dollars) in both the cases, growth in the number of buying customers is much more in December than August (by close to 200 people more in December). Therefore, it can be concluded that the real average customer spend has clearly declined compared with the average customer spend before the reshuffle.

Moreover, let us investigate January data in the same manner. Although sales revenue has declined over December, variation in sales revenue after and before the reshuffle (about 5k Dollars) for January is not same as that for December (about 10k Dollars). On the other hand, with regard to the number of buying customers, there is hardly any variation before and after the reshuffle. In other words, from the standpoint of the preceding month, decline in the number of buying customers is lesser than decline in sales revenue (variation is small). As a result, it is clear that monthly average customer spend for January has declined. Therefore, d) is the correct answer. For comparison, although rough values that can be read from Fig. 2 are shown in this explanation, it is important to understand the relative variation relationship when actually answering the subquestion. It is not necessary to emphasize the actual values themselves, and it is very much possible to answer this subquestion without the actual values. In order to study the sales revenue of Brand *X* in detail, trend of monthly sales revenue and the number of buying customers for Brand *X* is shown in the graph below.



*: As the number of customers is also increasing compared with sales revenue, the average customer spend is declining.
(Same for December and January).

Trend of monthly net sales and the number of buying customers for Brand X

- Blank G: Here the reason why sales revenue of Brand X for the 1-year period after the reshuffle is lower than that before the reshuffle is asked. Looking at the answer group, it is clear that you are required to select the applicable option, (1) through (3), mentioned in the subquestion. Therefore, verifying which option conforms to the information provided in these options should suffice. First, with regard to (1) and (3), according to Fig. 2, it is very clear that for Brand X, the number of buying customers for all months is higher than that before the reshuffle. Therefore, both of them are not suitable reasons. With regard to the remaining option (2), in the annual column of comparison results in Table 2 showing the monthly average customer spend for the 1-year period before and after the reshuffle, if the average customer spend after reshuffle has declined compared to that before reshuffle, it is shown as (↓). Therefore, reasons described in (2) are appropriate. Accordingly, b) is the correct answer.

[Subquestion 3]

This subquestion calls for filling the blanks in the description about analysis of brands that were reshuffled to non-preferred shops. In this subquestion, Fig. 3 comparing the average customer-spend for the 1-year period before and after the reshuffle, and Table 3 comparing the average number of buying customer and the average number of articles bought per person for each brand for the 1-year period before and after the reshuffle are provided. We will answer the questions by reading the required information from Fig. 3 and Table 3. As complicated thinking is not required, you should attempt this subquestion in a very calm and easy manner.

- Blank H: This asks about the item that has grown for each of the brands *I*, *II*, *III*, and *Y*. In Table 3, the average number of articles bought per person and the average number of buying customers are compared. Although there is a mention of the average number of buying customers in the subquestion, there is no mention of the average number of articles bought. With that, by looking at the answer group, it is clear that there is no option of the average number of articles bought, and therefore this is not what is asked here. Next, if you look at Fig. 3, which shows comparison of the average customer spend for the 1-year period before and after the reshuffle for each brand, it is clear that for all brand except Brand *IV*, the average customer-spend has grown. In other words, that is exactly what is asked here, and therefore c) is the correct answer.
- Blank I: For a certain brand, it is mentioned “growth in the number of articles purchased by customers contributed to the sales revenue.” Before the blank, it is mentioned “From Fig. 3 and Table 3,” therefore, you may tend to answer this question based on Fig. 3 and Table 3 only. However, in the final subquestions of the afternoon exam, questions are often designed such that they cover the entire question statement. Therefore, you should pay attention as not to get trapped into narrow perspective. In this case, with “Fig. 3 and Table 3” only, it is clear that “growth in the number of articles purchased by customers” happened, but it is not clear whether it has “contributed to the sales revenue.” Therefore, it is necessary to refer to Fig. 1. We will refer to Fig. 1 after verifying in Table 3 that “growth in the number of articles purchased by customers” for Brands *III*, *IV*, and *Y* where the average number of articles bought per person has also increased. “Contributed to sales revenue” essentially indicates that sales revenue after the reshuffle grew when compared with that prior to the reshuffle. Based on this, it is possible to identify Brand *Y*, which is the only brand where sales revenue after reshuffle has grown. Therefore, e) is the correct answer.
- Blank J: From Fig. 1, it is clear that Brand *I* had almost same revenue for the 1-year period after reshuffle as Brand *Y*. Therefore, a) is the correct answer.
- Blank K: Sales revenue of Brand *I* for the 1-year period after reshuffle (under 1,300k Dollars from Fig. 1) is less than its sales revenue for the 1-year period before reshuffle (more than 1,300k Dollars from Fig. 1). Therefore, c) is the correct answer.

- Blank L: Just before the blank there is “unit price of articles;” however, do not confuse this with average customer spend. You should calculate this by making a rough estimate, compare both of them, and then answer the question. To begin with, in sales revenue of Brand *Y* for the 1-year period after the reshuffle, determine the unit price of articles sold by making a rough estimate. In Fig. 3, the average customer spend for Brand *Y* after the reshuffle exceeds 160 Dollars (temporarily you will take this as 168 Dollars), and in Table 3, the average number of articles bought per person for Brand *Y* after the reshuffle is 1.8 (number of clothes). Calculating the unit price per article based on this gives $168 \text{ (Dollars)} \div 1.8 \text{ (number of clothes)} \approx 93 \text{ (Dollars)}$. On the other hand, in Fig. 3, the average customer spend for Brand *I* after the reshuffle exceeds 130 Dollars (temporarily you will take this as 132 Dollars), and in Table 3, the average number of articles bought per person for Brand *I* is 1.3 (number of clothes). Calculating the unit price per article based on this gives $132 \text{ (Dollars)} \div 1.3 \text{ (number of clothes)} \approx 102 \text{ (Dollars)}$. Therefore, in sales revenue of Brand *Y* for the 1-year period after the reshuffle, the “unit price of articles” is below the “unit price of articles” sold for Brand *I*. Therefore, c) is the correct answer.

Q10-19 Arranging customer information

[Correct answers]

[Subquestion 1] A-c), B-b), C-f)

[Subquestion 2] D-c), E-f), F-d)

[Subquestion 3] G-b), H-f)

[Explanation]

This question is about arranging customer information. Using a tool, customer information in three separate systems is arranged. As functions of the tool are described in the question statement, you need to understand these functions and arrange customer data in a table. As an illustration of data arranged with the tool is also provided, the question itself is not that difficult to understand, and you should definitely score in this question.

[Subquestion 1]

Table 3 shows the results when customer information in Table 2 is processed with the cleaning function of the reference tool.

- Blank A: As cleaning function unifies (1) notation of company names, from “Japan ABCD Co. Ltd.”, “Co. Ltd.” will be removed and will result in “Japan ABCD”. Therefore, c) is the correct answer.
- Blank B: As cleaning function unifies (2) notation of addresses, in “Chiba Inzai-shi Oguradai 5 chome 3-2”, “chome” is converted into “-” and space will be deleted. This will give “Chiba, Inzai-shi, Oguradai 5-3-2”, and therefore b) is the correct answer.

- Blank C: Out of total 13 records in Table 3, first and second records (Company name: Japan ABCD), fourth and fifth records (Company name: IPA), seventh and eighth records (Company name: Hamaya, Address: Saitama, Ageo-shi, Komon 2-3-6), and tenth and twelfth records (Company name: Senbei, Address: Niigata, Kashiwazaki-shi, Nishiyasuda 3-2-3) are considered as identical records, and counting based on this will give total 9 separate records. Therefore, f) is the correct answer.

[Subquestion 2]

In this subquestion, you are required to think about the scores assigned in the matching function.

- Blank D: Let us think about Threshold II. As per the matching function described in Table 1:

Threshold I: Total value of scores when automatically screening the identical customer.

Threshold II: Total value of scores when manually screening the identical customer.

Concerning the conditions of Threshold II, Subquestion 2 says, “records with matching company names and either a matching address or telephone number are treated as the records where a manual decision is required.”

The following two conditions can be identified for Threshold II.

Table Scores assigned in matching

	Company	Score	Address	Score	Telephone number	Score	Total score
Condition 1	○	50 points	○	25 points	×	0 point	75 points
Condition 2	○	50 points	×	0 point	○	25 points	75 points

○: Matching ×: Not matching

Therefore, the correct answer is 75, which is c).

Next, let us think about Table 4, which shows the “cleaned customer information after adding telephone number and sales revenue of March,” and Table 5, which gives the “score list of matching results based on Table 4.”

- Blank E: Let us consider score and rating of the original data number 4 and the comparison data number 5. If we compare data number 4 and 5 in Table 4, company name and address are matching, but telephone number is not matching. This falls under Condition 1 of score table in matching, and therefore the score is 75 points. Moreover, in the statement of Subquestion 2, it is mentioned, “‘Δ’ is printed if the total value of scores is equal to or greater than Threshold II but less than Threshold I.” Therefore, rating will be Δ.

Accordingly f)

75	Δ
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 is the correct answer.

- Blank F: Compare Table 4 and Table 5, and look for the records that have the same company name but that have not been compared. Doing this exercise shows that data number 5 and 6 are not compared, and therefore the correct answer is d)

5	6
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[Subquestion 3]

Based on the matching list of Table 5, assign new customer codes, and calculate the sales revenue of March for each of the new customer code. Result of this is the correspondence table of new customer codes shown in Table 6. The table below is prepared by inserting the original data numbers and by calculating the respective items based on Table 4 and Table 5.

Original data number	New customer code	Customer code in System α	Customer code in System β	Customer code in System γ	Sales revenue of March (10k Dollars)	Calculation of sales revenue of March
1, 2	M00001	1111	CD2311		5	2+3
3	M00002			G-1123	5	
4, 5	M00003	1256	ER3256		12	4+8
6	M00004			H-3321	2	4+3+5
7, 8, 9	M00005	3233	GH1324	J-4231	12	
10	M00006			I-2234	7	

- Blanks G and H: From this table, it can be determined that sales revenue of March for M00003, which is the correct answer for blank G is “1256 of α , ER3256 of β , and 120k Dollars,” and therefore b) is the correct answer. In addition, sales revenue of March for M00005 will be “3233 of α , GH1324 of β , J-4231 of γ , and 120k Dollars,” and therefore f) is the correct answer for blank H.

Q10-20 Product portfolio management analysis

[Correct answers]

[Subquestion 1] A-c), B-b), C-f), D-e)

[Subquestion 2] E-d), F-g), G-b), H-c), I-d)

[Subquestion 3] J-a)

[Explanation]

This question is about product portfolio management. In the product portfolio management analysis (hereinafter called PPM analysis), competitiveness of products in the market is analyzed to study how much investment should be made in which product. From the market growth rate (it is an indicator of the extent of overall market growth by product) and the percentage of market share (it is an indicator of relative strength in the market against competition), position of the respective product in the market is made clear, and it is analyzed what kind of investment allocation can maximize the sales revenue and profits. Portfolio chart is created during analysis, and positioning of products is represented by categorizing into 4 areas of star products, harvest products (cash cows), problem child products, and dog products.

[Subquestion 1]

- Blanks A through D: This subquestion calls for filling the corresponding blanks. As mentioned earlier, in PPM analysis, products are divided into 4 areas based on whether the market growth rate is high/low, and whether the percentage of market share is high/low. In order to understand the positioning of each product, a portfolio chart is created, and then further analysis is conducted based on that.

Blank A is about high market growth rate and high percentage of market share, therefore c) Star products is the correct answer. These products are market leaders, and they are expected to become profit source of the company in medium to long term.

Cash cows in the blank B are the products having low market growth rate but high percentage of market share, therefore b) Harvest products (cash cows) is the correct answer. Harvest products are not the target for aggressive investment; however, as they form the core of the company's income, it is appropriate to allocate the profits generated through these products for investing into star products or problem child products.

Blank C refers to the products having high market growth rate but low percentage of market share, therefore f) Problem child products is the correct answer. As future growth can be expected in problem child products, large investments are made in the immediate future for accelerating the growth. Although these are potential candidate for future star products, if they fail to capture the percentage of market share, they may end up becoming dog products.

As the blank D refers to the products having low market growth rate and low percentage of market share, e) Dog product is the correct answer. Due to severe market competition and low attractiveness of the market itself, it is necessary to explore the possibility of pulling out from the market.

[Subquestion 2]

This subquestion is concerning calculations to be performed for mapping to the portfolio chart of [Case example of analysis conducted at Company *M*], and determining the areas to which the respective products correspond to. Calculate the market growth rate and the percentage market share from Table 1, and then determine mapping to 4 areas of the portfolio chart from the calculation results.

- Blanks E and F: Calculate the market growth rate from "Last year's market size" and "Current year's market size" provided in Table 1. In the question statement, since it is mentioned as "an indicator of the extent of overall market growth by product," we can infer the calculation formula $(\text{Current year's market size} - \text{Last year's market size}) \div \text{Last year's market size}$.

From Table 1,

Market growth rate of *X* product group is $(10,800\text{M Dollars} - 12,000\text{M Dollars}) \div 12,000\text{M Dollars} = -0.1 \times 100 = -10\%$

Market growth rate of *Y* product group is $(900\text{M Dollars} - 200\text{M Dollars}) \div 200\text{M Dollars} = 3.5 \times 100 = +350\%$

Therefore, d) is the correct answer for blank E, and g) is the correct answer for blank F.

- Blanks G through I: In [Case study of analysis conducted at Company *M*], since there is a condition that boundary value for determining whether the market growth rate is high or low is taken as “0%,” and boundary value for determining whether the percentage market share is high or low is taken as “50%,” it can be determined that *X* product group has low market growth rate, but high percentage of market share. Similarly, *Y* product group has high market growth rate, but low percentage of market share. For *Z* product group, it can be determined that it has high market growth rate as well as high percentage of market share. Therefore, b) Product 2 is the correct answer for blank G, c) Product 3 is the correct answer for blank H, and d) Product 4 is the correct answer for blank I.

[Subquestion 3]

This subquestion is about the results of PPM analysis for Company *M*. In the previous subquestion, it was determined that *X* product group is harvest products (cash cow) business, *Y* product group is problem child products business, and *Z* product group is dog products business. You should answer this subquestion by properly thinking about their meaning. In [Issues with Company *M*'s products], it is mentioned that “securing the future sources of profits is a major challenge.” In other words, there are no product groups that fall under star products business. Therefore, it can be determined that sources of profits in medium-to-long term are not available. Accordingly, “a) Because there is no product that corresponds to Product 1, a medium-to-long term profit source is absent” is the correct answer.

Q10-21 Balanced Score Card

[Correct answers]

[Subquestion 1] A-a), B-c), C-a), D-b), E-e)

[Subquestion 2] F-d), G-b), H-f), I-e), J-h)

[Explanation]

This question is about assigning cause-effect relationship of critical success factors and their indicators in the Balanced Score Card (BSC). Companies must adopt the most suitable management strategy according to changes in the environment in order to survive the business competition. It is necessary to keep a big-picture in mind when adopting this management strategy. Balanced Score Card provides 4 different standpoints for this. In addition to enumerating the critical success factors for each standpoint, relation between goal and means is established.

This question discusses a case example of applying the Balanced Score Card to a specialized trading company dealing in electric materials. At present, trading companies and wholesalers are pressed for tackling the trend that manufacturers do direct business not through trading companies or wholesalers, and how they can provide value addition has become the main requirement for survival.

[Subquestion 1]

This question can be easily answered by carefully reading [Description of Company A].

To begin with, blank A in the standpoint of finance will be a factor contributing to increasing the profit, a) Increasing sales revenue is appropriate.

From the description of Company A, the following 3 points can be identified concerning management policies for customers:

- Provide information about appropriate materials in a real time manner
- Prompt response to sudden requests
- As a part of SCM, trading company should be included in the SCM system

Management policies for suppliers includes “introduction of new customers.” Common point for both customers and suppliers is “to provide added value through distribution processing.”

Although the means for “introduction of new customers” are not clearly mentioned in the description of Company A, it is mentioned that it is necessary to improve employees’ “understanding of the type of material required by different electronics manufacturers.”

Next, let us consider the means for “to provide added value through distribution processing.” For this, [Description of Company A] says, “by working in close collaboration with customers, Company A needs to pursue and realize their potential for distribution processing as a trading company. Therefore, it is necessary to improve technical and creative capabilities of employees concerning distribution processing.” “Close collaboration with customers” falls under the standpoint of business process, and “to improve technical and creative capabilities of employees concerning distribution processing” falls under the standpoint of “Learning and growth.”

Finally, let us consider the management policies for customers. Although the means for “to provide real-time information about appropriate materials to customers” are not clearly mentioned in the [Description of Company A], it can be said that “Improved employees’ knowledge of electrical materials” is appropriate in terms of cause-effect relationship. Moreover, this falls under the standpoint of “Learning and growth.” Therefore, e) is the appropriate answer for blank E.

Next, in the [Description of Company A], it is mentioned, “Company A must manage very detailed information about suppliers, and create an internal mechanism to enable a prompt response to unexpected requests from customers.” Therefore, means “to swiftly meet unexpected requests” is “Managing very detailed information about suppliers.” Accordingly, c) is the correct answer for blank B.

With regard to means for “As a part of SCM, Company A should be included in the SCM system,” in the [Description of Company A], it is mentioned that “In addition to modifying their own systems so that that they interface with customer’s SCM, Company A is also required to develop features that can provide new value-added data to customers.” Therefore, a) is the correct answer for blank C, while b) is the correct answer for blank D.

[Subquestion 2]

In this subquestion, as indicators are reflecting the critical success factors as it is, answers should be easily found. In other words, the relation is as follows:

- Blank F: Providing real-time information about materials
→ Number of instances of providing information about materials d)
- Blank G: Swift handling of sudden requests
→ Number of cases of handling sudden requests b)
- Blank H: Practicing knowledge management
→ Number of knowledge items registered f)
- Blank I: Introducing new customers
→ Number of instances where a new customer was introduced e)
- Blank J: Achieving distribution processing as a product company
→ Number of instances of proposing distribution processing h)

Section 11

Mandatory Questions (Data Structure and Algorithm)

Q11-1 Tabulation of a questionnaire

[Answers]

[Subquestion] A-c), B-g), C-d), D-c), E-c)

[Explanation]

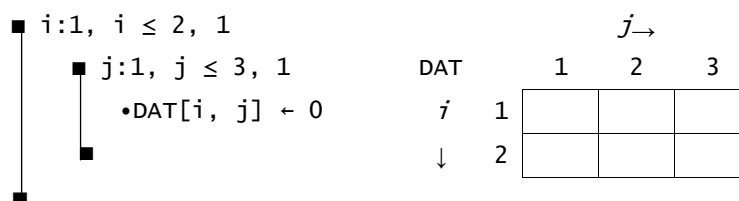
This question is about a program that tabulates and prints questionnaire responses. There are 3 items to be tabulated, namely, number of people for each selection choice for each question in the questionnaire (hereinafter called response results), number of respondents by age group who selected “Highly satisfied” or “Satisfied” for the respective question (hereinafter called satisfaction level by age group), and number of males and females by age group (hereinafter called number of males and females by age group). For tabulation process, two-dimensional arrays are used. The key point for correctly answering this question is to understand how the respective array is used in the program.

Before an investigation of the processing taking place in the blanks, the program flow and role of the arrays used should be understood.

By looking at the program, it can be understood that there are 3 processes that are happening.

- (1) Line number 1 to 14: Initialization process for reading records from a file and initializing arrays
- (2) Line number 15 to 30: Tabulation process for tabulating response results, satisfaction level by age group, and number of males and females by age group from questionnaire responses
- (3) Line number 31 to 59: Printing process for printing tabulation results table

As all these processes use two-dimensional arrays, and they have a double-loop structure. Let's see how the double-loop structure works using the following example below that initializes all elements of the two-dimensional array DAT to 0.



i	j	Process
1	1	DAT[1, 1] \leftarrow 0
	2	DAT[1, 2] \leftarrow 0
	3	DAT[1, 3] \leftarrow 0
2	1	DAT[2, 1] \leftarrow 0
	2	DAT[2, 2] \leftarrow 0
	3	DAT[2, 3] \leftarrow 0

Next, the role of arrays is considered. Usage of the respective array can be understood from the program comments (sections marked with “/* ~ */”), and linkage between the print process section of the program and the print format in paragraph (3) in the [Program Description].

[One-dimensional array]

integer_type: Age[1000]

Stores age of all respondents read from AFile.

	1	2	...	Cnt	...	1000
Age	29	33	...	49	...	

*Cnt($1 \leq \text{Cnt} \leq 1000$) is the number of input records from the file (number of respondents)

character_type: Gender[1000]

Stores gender of all respondents read from AFile.

	1	2	...	Cnt	...	1000
Gender	F	F	...	M	...	

character_type: Response[1000]

Stores responses (numerical string) of all respondents read from AFile.

	1	2	...	Cnt	...	1000
Response	42345	33432	...	54554	...	

*When the number of questions N ($1 \leq N \leq 50$) = 5

[Two-dimensional array]

character_type: QCnt[50, 5]

For tabulating the number of persons for each selection choice in each questions (response results)

QCnt	1	2	3	4	5
1	Q1: Unsatisfied	Q1: Somewhat satisfied	Q1: Neutral	Q1: Satisfied	Q1: Highly satisfied
2	Q2: Unsatisfied	Q2: Somewhat unsatisfied	Q2: Neutral	Q2: Satisfied	Q2: Highly satisfied
⋮					
<i>N</i>	Q <i>N</i> : Unsatisfied	Q <i>N</i> : Somewhat unsatisfied	Q <i>N</i> : Neutral	Q <i>N</i> : Satisfied	Q <i>N</i> : Highly satisfied
⋮					
50					

*For usage of QCnt, it is necessary to understand the iteration process from line number 18 up to 24.

Refer to the explanation of blanks B and C.

integer_type: MCnt[50, 5]

For tabulation of the number of respondents by age group who selected “Highly satisfied” or “Satisfied” for the respective question.

MCnt	1	2	3	4	5
1	Q1: 20s	Q1: 30s	Q1: 40s	Q1: 50s	Q1: 60s
2	Q2: 20s	Q2: 30s	Q2: 40s	Q2: 50s	Q2: 60s
⋮			⋮		
<i>N</i>	Q <i>N</i> : 20s	Q <i>N</i> : 30s	Q <i>N</i> : 40s	Q <i>N</i> : 50s	Q <i>N</i> : 60s
⋮					
50					

character_type: SCnt[5, 2]

For tabulations of the number of males and females by age group (number of males and females by age group)

SCnt	1	2
1	Males in 20s	Females in 20s
2	Males in 30s	Females in 30s
3	Males in 40s	Females in 40s
4	Males in 50s	Females in 50s
5	Males in 60s	Females in 60s

[Subquestion]

- Blank A: As is obvious from the answer group, blank A is the process for determining the value of variable A . The role of A is to decide the index of the two-dimensional array `SCnt` from line number 26 or 28. As mentioned earlier in the explanation of arrays, array `SCnt` is for tabulating number of males and females by age group, and in `SCnt[Row, Column]`, `Row` indicates age group and `Column` indicates gender. A is the index of row indicating the age group. For example, in the case of a 28 year old male, 1 must be added to `SCnt[1, 1]` ($A = 1$) in line number 26; while in the case of a 36 year old female, 1 must be added to `SCnt[2, 2]` ($A = 2$) in line number 28. As age group is determined from age of the respondent, we should select the formula that gives $A = 1$ when `Age[i]` (age of the i -th respondent) = 28, and $A = 2$ when `Age[i]` = 36. When each formula in b), c), and d) is calculated for `Age[i]` = 28, b) results in $A = 8$, c) results in $A = 1$, and d) results in $A = 20$. Therefore, c) is the correct answer. In addition, a) does not use age of respondents and calculation is performed without initial value of A . Therefore, it is not considered for the calculation above.
- Blanks B and C: From the answer group it is clear that it is performing the process of adding 1 to the arrays `MCnt` and `QCnt`. In line number 19, 1 letter at the j -th position from the start of `Response` (numerical array of responses to questions 1 to N) is fetched and converted into an integer that is set to κ . In line number 18, as j is increased from 1 to N in the increments of 1, it is clear that j is the question number and κ is the response number for the respective question. As mentioned in the explanation of array earlier, `MCnt` stores the number of respondents by age group who selected “Highly satisfied (5)” or “Satisfied (4)” for the respective questions, and `QCnt` stores the number of people for each selection choice in each subquestion. From the conditional expression of line number 21, it is clear that blank C is a process concerning `MCnt`, and blank B is a process concerning `QCnt`. First, the process in blank C should be considered. In `MCnt[Row, Column]`, `Row` is the question number and `Column` is the age group. From blank A, it is already known that j shows the question number and A is the index of the age group. Therefore, the process can be performed correctly by expressing as `MCnt[j, A]`. On the other hand, for blank B it is necessary that rows are question numbers and the columns are selection numbers, and therefore it can be expressed as `QCnt[j, κ]`. However, it should be kept in mind that unlike the sequence of printing, 1 corresponds to “Unsatisfied”, 2 corresponds to “Somewhat unsatisfied”,, and 5 corresponds to “Highly satisfied”. Therefore, g) is the correct answer for blank B and d) is the correct answer for blank C.
- Blank D: Blank D is the iteration process as a part of print process for response results. For printing the contents of `QCnt[i, j]` in line number 38, blank D needs to decide how to change variable j . In the print format of the tabulation results table in paragraph (3) under [Program description], printing is done in the sequence of Highly satisfied, Satisfied,, Unsatisfied. However, in the array, 1 corresponds to “Unsatisfied”, 2 corresponds to “Somewhat unsatisfied”,, and 5 corresponds to “Highly satisfied”, which is opposite to the order of printing. Therefore, instead of starting the initial value of j from 1 (Unsatisfied), it is necessary to change it from 5 (Highly satisfied) to 1 (Unsatisfied). Therefore, c) is the correct answer.

- Blank E: Blank E is for printing “s ” in the processing of line number 54, and age group (20s, 30s,..., 60s), which is also clear from the printing format of the tabulation results table (number of males and females by age group). To change i from 1 to 5, and to change from 20(s) to 60(s) in the order of 10 with i , the value obtained by adding 1 to i should be multiplied by 10. Therefore, c) is the correct answer.

Q11-2 Sorting program by using merge/sort

[Correct answers]

[Subquestion 1] A-c), B-d), C-a), D-b)

[Subquestion 2] E-c), F-g), G-i)

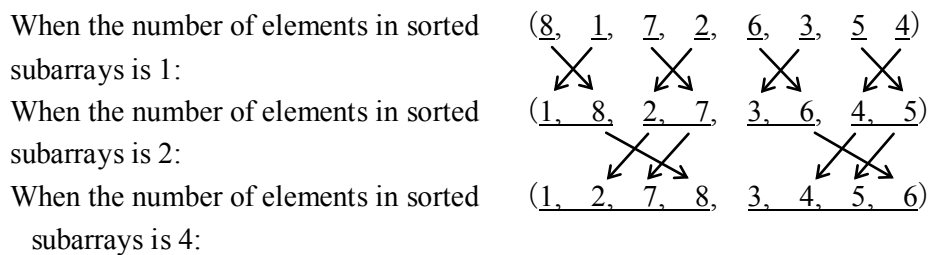
[Subquestion 3] H-c), I-f), J-f)

[Explanation]

[Subquestion 1]

This question focuses on tracing the intermediate steps of a sorting process. When the number of elements in array B is 8, if the number of elements in subarrays each of which has sorted elements is 4, it means that the first half and the second half of array B are sorted separately, and now the process is at the final stage of merging the entire array.

As explained in the question statement, in the beginning, this subprogram considers that the relevant array elements are sorted subarrays with 1 element each, and from these, sorted subarrays with 2 elements each are created, and then they are merged to create subarrays of 4 elements each. This flow is shown below:



Therefore, blank A is c) 7, blank B is d) 8, blank C is a) 3, and blank D is b) 4.

[Subquestion 2]

First, let us summarize the details of arguments of the subprogram `Merge` and local variables (variables used in `Merge`) in Table 1 and Table 2.

Table 1 Arguments of Merge

Variable	Input/Output	Meaning
A	Input/Output	One-dimensional array to be sorted
N	Input	Number of elements of Array A

Table 2 Local variables

Variable	Description
X, Y	One-dimensional arrays that store subarrays
Max	Sentinel element (Stores the value of 9999 that is higher than any element of array A)
J	Number of elements in the sorted subarray (initial value is 1)
K	Final element number of the merged section (initial value is 0)
L, M	Control variable of iteration process
P, Q	Element numbers of array X and Y

Next, a clear description of the process outline of the subprogram **Merge**. Generally, the structure of the program is comprised of a process for fetching subarrays from the array X and Y and a process for merging while the arrays X and Y are sorted, and the entire array is sorted by repeating these processes. Fig. 1 shows the outline of the overall process.

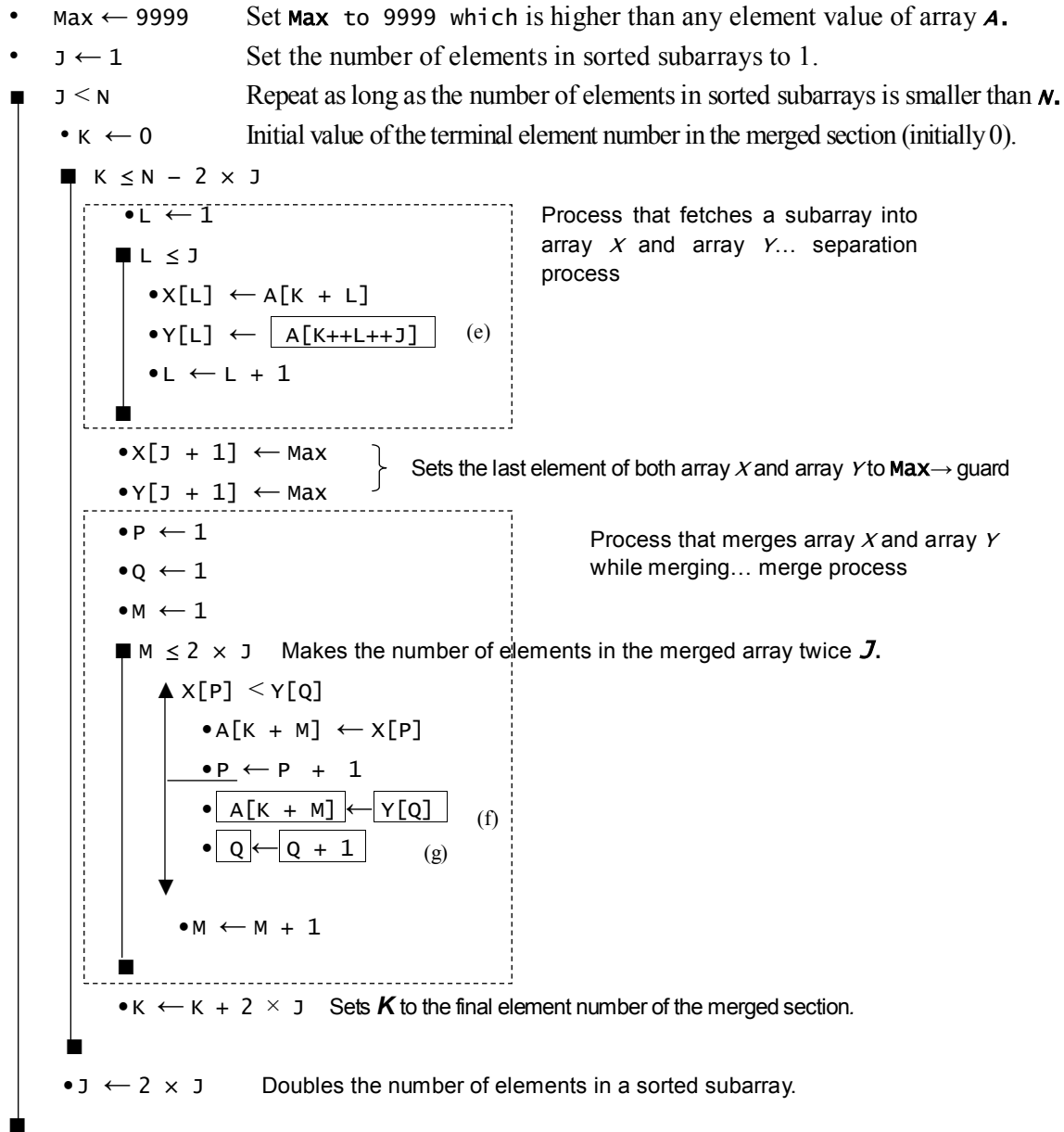
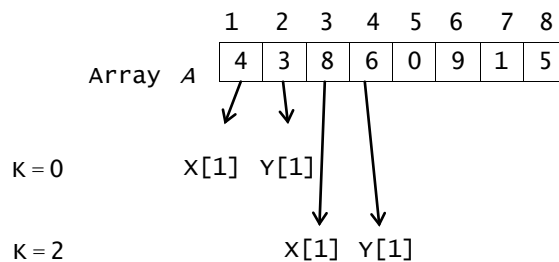


Fig. 1 Outline of the overall process

- Blank E: This blank is in the middle of the process for fetching subarrays in the array x and y (separation process). Here, correctly understanding the roles of variables J and K is the key point for arriving at the correct answer. To start with, variable J shows the number of elements in a sorted subarray, and it is set to 1 in the beginning. Moreover, when a certain number of sorted subarrays are merged, variable K shows the element of the array A up to which the merging process is completed. The condition of the iterative process " $K \leq N - 2 \times J$ " shows that the separation process is repeated until the variable K reaches the position where the final pair of subarrays remains $(N - 2 \times J)$. For example, when $N = 8$ and $J = 1$, the separation process is repeated as long as " $K \leq 6$ ", and $A[1]$ and $A[2]$ are fetched at the start, and in the end $A[7]$ and $A[8]$ are fetched. As a result, all array elements become processed.

Immediately after the subprogram Merge is started, variable J is 1, and because the merging process is not yet performed, variable K is 0. At this stage, it is necessary to fetch $A[1]$ ($= 4$) in $x[1]$, and $A[2]$ ($= 3$) in $y[1]$. After that, when these are merged, the merging process is completed up to element number 2 of the array A , and variable K becomes 2. Next, $A[3]$ is fetched into $x[1]$ and $A[4]$ is fetched into $y[1]$. When the number of elements in a sorted subarray is 1, elements of the array A are fetched in $x[1]$ and $y[1]$ only.



At this point, with variable J that shows the number of elements in a sorted subarray and variable K that shows the final element number of a merged subarray, elements fetched in $x[1]$ and $y[1]$ can be expressed as follows:

$$x[1] \leftarrow A[K + 1]$$

$$y[1] \leftarrow A[K + 1 + J]$$

This shows the separation process when the number of elements in a sorted subarray is 1. However, as it is considered that the number of elements can be more than 1, variable L is used to show where the number of elements becomes 1, and with the iterative process, part of the array A is sequentially fetched into $x[L]$ and $y[L]$ ($L = 1, 2, \dots, J$). For example, as mentioned in (2)(i) under [Program description], the figures below show when $K = 0$ and $J = 2$.

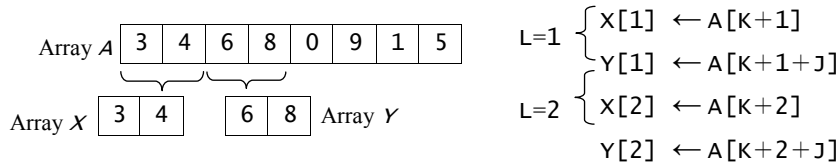


Fig. 3 Separation process when $K = 0$ and $J = 2$

Therefore, the process of fetching in $x[L]$ and $y[L]$ ($L = 1, 2, \dots, J$) can be expressed as,

$$x[L] \leftarrow A[K + L]$$

$$y[L] \leftarrow A[K + L + J]$$

and blank E is c) $A[K + L + J]$.

- Blanks F and G: After the separation process, sentinel ($\text{max} = 9999$) is set at the last element of the array x and the array y respectively. Although this is related to the Subquestion 3 as well, when merging is on going, if elements remain in either array x or y only, by comparing with a large value that actually does not exist as data, the remaining portion of the array x or y can be written to the array A . When the number of elements in a sorted subarray is 1, and when a portion of the array A is fetched into $x[1]$ and $y[1]$, $x[2]$ and $y[2]$ become sentinels.

Blanks F and G are in the middle of a process that sorts while arrays x and y are merged (merging process). The roles played by variables J and K are as described in the explanation of blank E. Moreover, variable P is the element index of the array x , and variable Q is the element number of the array y . In addition, variable M is used as a position with the array A . $x[P]$ and $y[Q]$ are compared, and if $x[P]$ is smaller than $y[Q]$, $x[P]$ is written to the array A and variable P is increased by 1. Otherwise, $y[Q]$ is written to the array A , and variable Q is increased by 1. If blanks F and G are considered based on the writing process of $x[P]$ above, blank F is g) $A[K + M] \leftarrow y[Q]$, and blank G is i) $Q \leftarrow Q + 1$. The merging process moves forward in this manner, and when elements remain in either array x or y , a comparison is made with sentinel of the other array, and the remaining elements are written to the array A .

Although there are no more blanks from here onwards in this subquestion, a check about updating the values of variables κ and \mathcal{J} should be made in the last section. As variable κ shows the element of array A up to which the merging process is complete, when 1 merging process is complete, the length of the merged subarray ($= 2 \times \mathcal{J}$) is added as $\kappa \leftarrow \kappa + 2 \times \mathcal{J}$, and the position represented by variable κ is advanced. Moreover, as variable \mathcal{J} indicates the number of elements in a sorted subarray, once the merging of all sorted subarrays consisting a certain number of elements is completed, the value of \mathcal{J} is updated as $\mathcal{J} \leftarrow 2 \times \mathcal{J}$,

[Subquestion 3]

This subquestion is about the method for using sentinels. Reasons for assigning a sentinel are mentioned in the subquestion. In (2)(ii) under [Program description], the number of elements in a sorted subarray is 2 ($\mathcal{J} = 2$), and parts of array A are fetched into both array x and array y up to element number 2 of each array. Moreover, in setting the values of sentinels after the merging process, the sentinels are set as $x[\mathcal{J} + 1]$ and $y[\mathcal{J} + 1]$. Therefore, if $\mathcal{J} = 2$, the sentinels are $x[3]$ and $y[3]$. Therefore, blank H is c) $x[3]$, and blank I is f) $y[3]$. After the merging process is started, when $x[2]$ ($= 9$) remains at the end, a comparison is made with $y[3]$ ($= 9999$), which is the sentinel of array y , and $x[2]$ (the smaller one) is written to the array A . Therefore, the correct answer for blank J is f) $y[3]$.

Q11-3 Algorithm that determines the shortest distance

[Correct answers]

[Subquestion 1] A-d), B-c)

[Subquestion 2] C-d), D-c), E-a), F-d)

[Explanation]

This question is about an algorithm that determines the shortest distance between the starting point and other points in a graph comprised of N ($N > 1$) points. In this question, instead of a pseudo-language program of the overall process, we are required to answer the results of tracing the process steps according to the description of algorithm. We should be able to solve this question by tracing as per the details provided in description of the algorithm with the graph provided in the figure. The difficulty level of this question is easy when compare with the conventional questions where the examinee is required to read the program flow and fill in the blanks.

Here, the method to determine the shortest distance in graph in Fig. 1 according to [Description of the algorithm] is determined.

As per paragraph (1) in [Description of the algorithm], in a graph, a circle shows a point, the direction of an arrow shows the direction of movement, and the number attached to the arrow shows the distance between the points. In case of Fig. 1, it is possible to go to Points 2, 4, and 5 from Point 1, and distance between Point 1 and Points 2, 4, and 5 is 10, 20, and 30 respectively. Other points should also be looked into this manner.

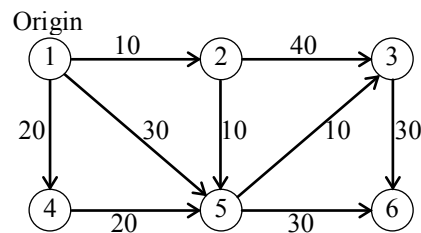


Fig. 1 Example of a graph (Number of points $N=6$)

As per paragraph (2) in [Description of the algorithm], the arrays used are as follows:

Dt: An array that stores the distance from Point i to Point j , and is shown as $Dt[i][j]$. The distance from Point 1 to Point 2 is $Dt[1][2]=10$. When there is no direct path from Point i to Point j , such as from Point 1 to Point 3, or when the direction of movement is opposite, such as from Point 2 to Point 1, or in the case of the same 2 points $Dt[i][i]$, ∞ (constant indicating the maximum value) is stored as distance.

		$\rightarrow j$					
	Dt	1	2	3	4	5	6
	1	∞	10	∞	20	30	∞
	2	∞	∞	40	∞	10	∞
\downarrow	3	∞	∞	∞	∞	∞	30
i	4	∞	∞	∞	∞	20	∞
	5	∞	∞	10	∞	∞	30
	6	∞	∞	∞	∞	∞	∞

Sd: An array that stores the provisional shortest distance (hereinafter called temporary shortest distance) from Point 1 which is the starting point, to Point i . In the initial state, ∞ is stored in all the elements. When all points are processed, the shortest distances are confirmed. Moreover, the index of the array corresponds to point number. For example, the shortest distance between Point 1 and Point 6 is stored in $Sd[6]$.

	1	2	3	4	5	6
Sd	∞	∞	∞	∞	∞	∞

Pe: An array for identifying the points that are already processed during the course of determining the shortest distances. The initial value is set to **false** for all elements. When **Pe[i]** is set to **true**, it means that the shortest distance from Point 1 to Point *i* is determined and stored in **Sd[i]**. When all elements become **true**, it means that the process is complete. Like **Sd**, index of **Pe** also shows point number.

	1	2	3	4	5	6
Pe	false	false	false	false	false	false

Next, the process of determining the shortest distance from paragraph (3) in [Description of the algorithm] shall be examined.

[Step (i)]

As Point 1 is the starting point, **Pe[1]** is set to **true**.

	1	2	3	4	5	6
Pe	true	false	false	false	false	false

Distances **Dt[1][2]**, **Dt[1][4]**, and **Dt[1][5]** that respectively indicate the distance from Point 1 to the directly connected Point 2, Point 4 and Point 5, are stored in **Sd[2]**, **Sd[4]**, and **Sd[5]**.

	1	2	3	4	5	6
Sd	∞	10	∞	20	30	∞

[Step (ii)]

From the unprocessed points (points where an element of the Array **Pe** is **false**), Point 2, which has the shortest temporary distance (distances are managed by Array **Sd**) from Point 1, is selected and **Pe[2]** is set to **true**. At this point, it is now confirmed that the shortest distance between Point 1 and Point 2 is **Sd[2] = 10**. With regard to Points 4 and 5 that do not have the shortest distances, as it is possible that they may be closer via other points, **Pe[4]** and **Pe[5]** are not set to **true**.

	1	2	3	4	5	6
Pe	true	true	false	false	false	false

	1	2	3	4	5	6
Sd	∞	10	∞	20	30	∞

Next, the temporary shortest distances $Sd[3]$ and $Sd[5]$ of Point 3 and Point 5 that are directly accessible from Point 2 are updated. In the case of Point 3, the distance before update (current distance) is ∞ , and distance via Point 2 is 50. As 50 is smaller than ∞ , the temporary shortest distance ($Sd[3]$) after update it is 50. Similarly, in the case of Point 5 the distance before update is 30, however, the distance through Point 2 is 30. Therefore, the temporary shortest distance ($Sd[5]$) after update is 20, which is the smaller of the two distances.

Before update (current distance)	Distance when going via Point 2	After update
$Sd[3] = \infty$	$Sd[2] + Dt[2][3] = 50$	$Sd[3] = 50$
$Sd[5] = 30$	$Sd[2] + Dt[2][5] = 20$	$Sd[5] = 20$

* $Sd[2]$ shows the final distance from Point 1 to Point 2, and $Dt[2][3]$ and $Dt[2][5]$ shows the distance from Point 2 to Point 3 and Point 2 to Point 5 respectively.

	1	2	3	4	5	6
Sd	∞	10	50	20	20	∞

[Step (iii)]

Among the unprocessed points, Point 4 ($Sd[4] = 20$) and Point 5 ($Sd[5] = 20$) have the shortest temporary shortest distance. However, when there are multiple points like this, Point 4, which has the smaller element number, is selected and considered as the processed point. At this stage, the shortest distance ($Sd[4]$) up to Point 4 is finalized.

	1	2	3	4	5	6
Pe	True	true	false	true	false	false

	1	2	3	4	5	6
Sd	∞	10	50	20	20	∞

Next, the shortest temporary distance of Point 5 that is directly accessible from Point 4 is updated. In this case, current distance ($Sd[5]$) is 20, while the distance via Point 4 ($Sd[4] + Dt[4][5]$) is 40. As going through Point 4 increases the distance, $Sd[5]$ is not updated.

	1	2	3	4	5	6
Sd	∞	10	50	20	20	∞

[Step (iv)]

From the unprocessed points, Point 5, which has the shortest temporary shortest distance, is selected and marked as a processed point. At this stage, $Sd[5]$ is the final shortest distance from Point 1 to Point 5.

	1	2	3	4	5	6
Pe	true	true	false	true	true	false

	1	2	3	4	5	6
Sd	∞	10	50	20	20	∞

Next, the temporary shortest distance of Point 3 and Point 6, which are directly accessible from Point 5, are updated. As the current shortest distance of Point 3 is 50, and the distance $(Sd[5] + Dt[5][3])$ via Point 5 is 30, it is updated as $Sd[3]=30$. Similarly, the current distance of Point 6 is ∞ , and distance $(Sd[5] + Dt[5][6])$ via Point 5 is 50, it is updated as $Sd[6]=50$.

	1	2	3	4	5	6
Sd	∞	10	30	20	20	50

[Step (v)]

From the unprocessed points, Point 3, which has the shortest temporary shortest distance, is selected and marked as a processed point. At this stage, $Sd[3]$ is the final shortest distance from Point 1 through Point 3.

	1	2	3	4	5	6
Pe	true	true	true	true	true	false

	1	2	3	4	5	6
Sd	∞	10	30	20	20	50

Next, the temporary shortest distance of Point 6, which is directly accessible from Point 3, is updated. The current shortest distance of Point 6 is 50, and the distance $(Sd[3] + Dt[3][6])$ via Point 3 is 60. Therefore, $Sd[6]$ remains at 50, which is the shorter of the 2 distances.

	1	2	3	4	5	6
Sd	∞	10	30	20	20	50

[Step (vi)]

From the unprocessed points, Point 6, which has the shortest temporary shortest distance, is selected and marked as a processed point. At this stage, $Sd[6]$ is the final shortest distance from Point 1 to Point 6. As all the points become processed points, the program ends.

	1	2	3	4	5	6
Pe	true	true	true	true	true	true

	1	2	3	4	5	6
Sd	∞	10	30	20	20	50

In this manner, to determine the shortest distance to the respective points, distances to the points that are directly accessible from the starting point are determined first, and the closest point that has the shortest distance is marked as processed. After that, the temporary shortest distance up to the point that can be directly accessed from the newly processed point, and distance via the processed point are compared, and shorter distance is selected as temporary shortest distance. From the unprocessed points, the point with the shortest temporary shortest distance is marked as processed, and this process is repeated until all points are marked as processed.

[Subquestion 1]

- Blank A: As described earlier, when the temporary shortest distance of Point 3 is updated for example, the current temporary shortest distance $Sd[3]$ is compared with the distance obtained by adding the distance $Dt[2][3]$ from Point 2 to Point 3 to the shortest distance $Sd[2]$ from the starting point to Point 2, which is the connecting point, and the smaller of these two distances is selected. When this is applied to " $Sd[i] \leftarrow \min(Sd[i],$

A

 $]$ ", i becomes the update point and k is the connecting point. Therefore, the current temporary shortest distance of Point i can be expressed as $Sd[i]$, and distance from Point k to Point i can be expressed as $Dt[k][i]$. The distance to be inserted in blank A is the distance via Point k , and therefore d) is the correct answer.
- Blank B: As previously shown, based on the results of Steps (iv), (v), and (vi), $Sd[6]$ is 50. Therefore, c) is the correct answer.

[Subquestion 2]

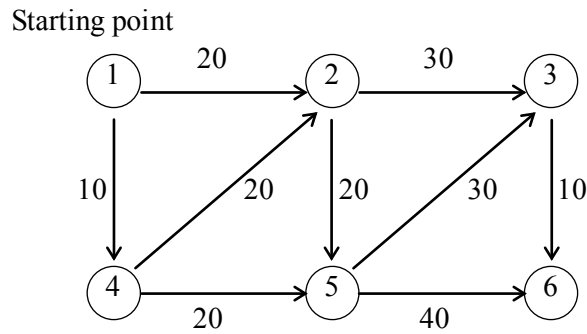


Fig. 8 Graph

Tracing the graph in Fig. 8 as per the process for determining the shortest distance gives the following results.

Dt	1	2	3	4	5	6
1	∞	20	∞	10	∞	∞
2	∞	∞	30	∞	20	∞
3	∞	∞	∞	∞	∞	10
4	∞	20	∞	∞	20	∞
5	∞	∞	30	∞	∞	40
6	∞	∞	∞	∞	∞	∞

Sd	1	2	3	4	5	6
	∞	∞	∞	∞	∞	∞

Pe	1	2	3	4	5	6
	false	false	false	false	false	false

As Point 1 is the starting point, the status of Point 1 is changed to processed.

Pe	1	2	3	4	5	6
	true	false	false	false	false	false

(1)

Processed sequence

Distances up to Point 2 and Point 4 that are directly connected to Point 1 are set as temporary shortest distances. As a result, $Sd[2]=20$ and $Sd[4] = 10$, and Point 4, which has the shortest distance from Point 1, is marked as a processed point.

Sd	1	2	3	4	5	6
	∞	20	∞	10	∞	∞

	1	2	3	4	5	6
Pe	true	false	false	true	false	false
	(1)			(2)		

Next, from the unprocessed points, determine the temporary shortest distance of the directly connected Point 2 and Point 5 to Point 4. The current distance of Point 2 is $Sd[2] = 20$, while the distance via Point 4 is $Sd[4] + Dt[4][2] = 10 + 20 = 30$. Therefore, $Sd[2]$ remains unchanged at 20. Similarly, current distance of Point 5 is $Sd[5] = \infty$, and distance via Point 4 is $Sd[4] + Dt[4][5] = 10 + 20 = 30$. Therefore, it is updated as $Sd[5] = 30$. As a result, 2 points that have the shortest temporary distance re marked as processed.

	1	2	3	4	5	6
Sd	∞	20	∞	10	30	∞
Pe	true	true	false	true	false	false
	(1)	(3)		(2)		

Similarly, determining the temporary shortest distance of the directly connected Point 3 and Point 5 to Point 2 gives 50 for Point 3 and 30 for Point 5. As Point 5 has the shortest temporary shortest distance, it is marked as processed.

	1	2	3	4	5	6
Sd	∞	20	50	10	30	∞
Pe	true	true	false	true	true	false
	(1)	(3)		(2)	(4)	

Similarly, determining the temporary shortest distance of the directly connected Point 3 and Point 6 to Point 5 gives 50 for Point 3 and 70 for Point 6. As Point 3 has the shortest temporary shortest distance, it is marked as processed.

	1	2	3	4	5	6
Sd	∞	20	50	10	30	70
Pe	true	true	true	true	true	false
	(1)	(3)	(5)	(2)	(4)	

Finally, determining the temporary shortest distance of Point 6, which is directly connected to Point 3, gives 60 for Point 6. Point 6, which has the shortest temporary shortest distance, is marked as processed. With this, shortest distances up to all points are finalized.

	1	2	3	4	5	6
Sd	∞	20	50	10	30	60

	1	2	3	4	5	6
Pe	true	true	true	true	true	true
	(1)	(3)	(5)	(2)	(4)	(6)

As it is clear from the processed sequence supplementary to the array **Pe**, the sequence for finalization of the shortest distance is Point 1, Point 4, Point 2, Point 5, Point 3, and Point 6. Therefore, d) is the correct answer for blank C. Moreover, if the array **Sd** that stores the shortest distance up to each point is checked, it can be seen that $Sd[3] = 50$, $Sd[5] = 30$, and $Sd[6] = 60$. Therefore, c) is the correct answer for blank D, a) is the correct answer for blank E, and d) is the correct answer for blank F.

Q11-4 Compression and decompression of a character string

[Correct answers]

[Subquestion 1] A-b), B-g), C-c)

[Subquestion 2] D-b), E-b), F-d)

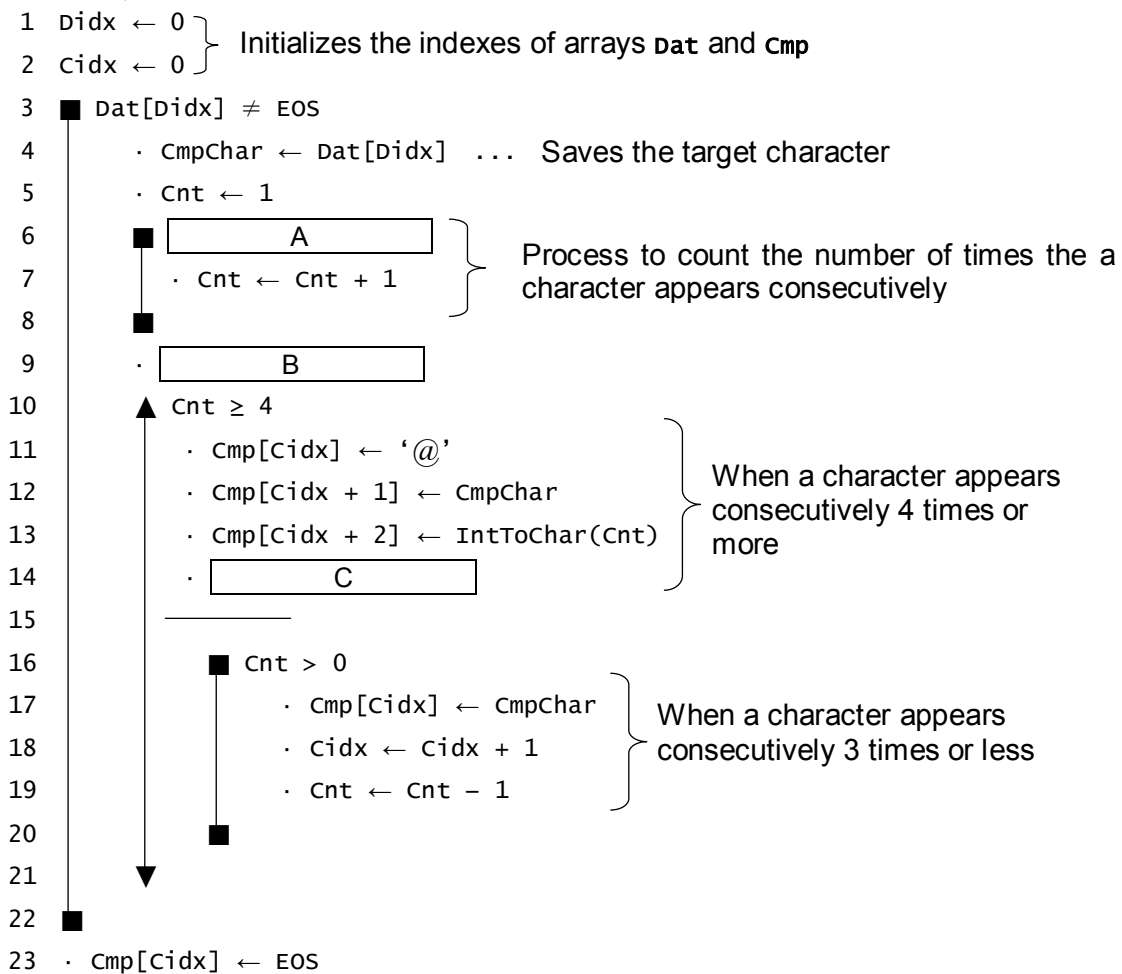
[Explanation]

This question is about a program that compresses and decompresses a character string. In Subquestion 1, when the same character appears 4 or more times consecutively, those characters are compressed by substitution with a 3 letter character string starting with '@', and the 3 letter character string is then stored in a character type array. The reason for storing an unmodified character string when the same character appears continuously 3 or less times is quite obvious. In the case of 3 characters, the number of characters after conversion remains same, and in the case of 2 characters, the number of characters after conversion increases, which lowers the efficiency of compression. In Subquestion 2, the character string compressed by the program of Subquestion 1 is decompressed. When '@' appears in a character string, the character after '@' is expanded by the number of times it appeared consecutively, and in other cases, it is stored unmodified in the character type array.

[Subquestion 1]

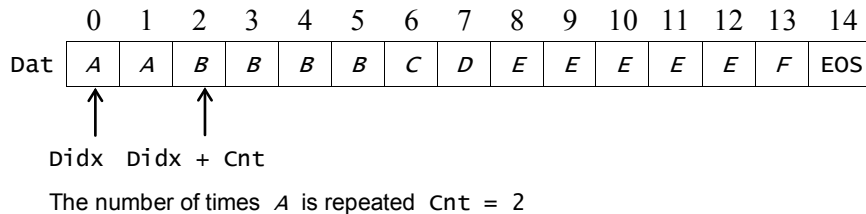
When the same character consecutively appears for 4 or more times in the array `dat`, Program 1 converts those characters into a 3-letter character string starting with '@' and stores the 3-letter character string in the array `cmp`. For this, the program requires a process that counts the number of times the same character appears consecutively, and a process that determines whether this number is equal or more than 4. If the number is equal or more than 4, the program converts those characters into a 3-letter character string and stores it in the array `cmp` instead of those characters. If the number is 3 or less, the program stores those characters unmodified in the array `cmp`.

(Line number)

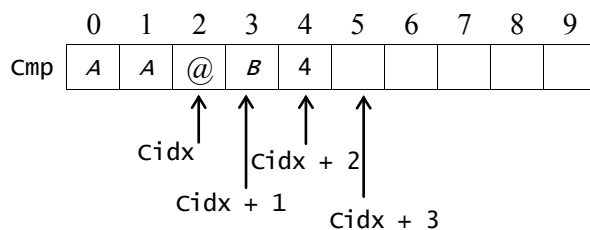


- Blank A: Blank A is a conditional expression for iteration, and as long as this conditional expression is satisfied, **cnt** is increased by 1 at a time. After the iteration process is completed, the line number 10 determines whether **cnt** is more than or equal to 4. If **cnt** is more than or equal to 4, the string is converted into a 3 character string starting with '@' and stored in the array **Cmp**. Because of this, it is clear that iteration of line numbers 6 through 8 is the process to count the number of times the same character appears consecutively. Character to be counted is stored in the variable **CmpChar** in line number 4. If the next character is same as **CmpChar**, **cnt** is increased by 1. In order to check whether the next character is same or not, it is necessary to shift elements of the array **Dat** one by one in the rear side. However, the process to add 1 to **Didx**, which is index of **Dat**, is not present in the iteration. Therefore, this should be taken care of in the conditional expression of the iteration. To increase **cnt** by 1, if the character is the same as **CmpChar**, the option for selection is either a) or b). However, in the case of a), as **Didx** is not updated, it always points at the same element. On the other hand, in the case of b), **cnt** starts with 1 and increases in increments of 1 in the iteration process. Therefore, even if **Didx** is not updated, the target element is shifted back one by one. Accordingly, b) is the correct answer.

- Blank B: By taking a look at the overall program, it can be understood that there is no process for updating `didx`, which is the index of the array `dat`. Therefore, it can be considered that blank B performs this process. In the iteration process in line numbers 6 through 8, because only `cnt` is increased by the number of times the same character appears consecutively, by adding `cnt` to `didx`, it is possible to shift the index up to position of the next target character. Therefore, g) is the correct answer.



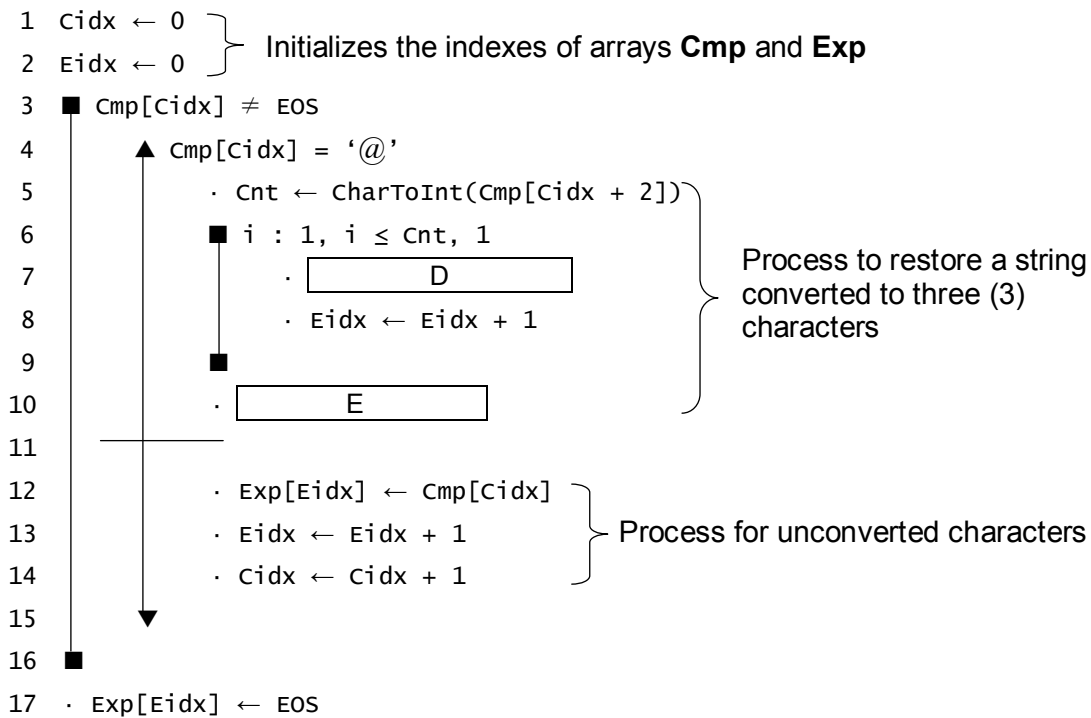
- Blank C: In the processing of line numbers 12 and 13, for the index of the array `cmp`, although it is mentioned that `cidx + 1`, `cidx + 2`, because this not actually updating the value of `cidx`, it is necessary to update `cidx` in blank C. Line numbers 11 through 13 describe the processing when the same character appears consecutively 4 or more times and is converted into a 3 character string starting with '@' and stored in the array `cmp`. Therefore, `cidx` is advanced by 3 characters. Accordingly, c) is the correct answer.



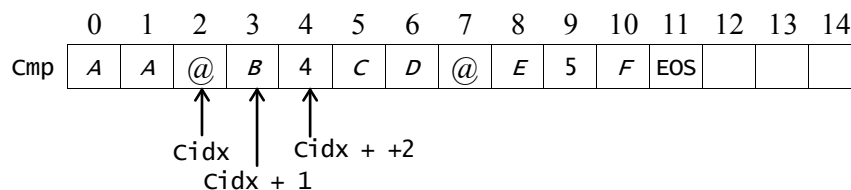
[Subquestion 2]

When '@' appears in the array `cmp`, it is necessary to decompress the character string by printing the subsequent character for the number of times it appears consecutively. Therefore, program 2 determines whether the target element is '@', and if it is '@', the subsequent character is expanded and stored. If is not '@', it is stored unmodified in the array `Exp`.

(Line number)



- Blank D: Blank D is the iteration process when '@' appears in the array Cmp. In line number 5, the number of times the same character appears consecutively is converted into a value and stored in Cnt, and processing of line numbers 6 through 9 is repeated cnt times. '@' is an identifier indicating the converted character string when the same character appears consecutively 4 or more times. Moreover, as blank D is repeated cnt times, it is clear that a consecutively appearing character needs to be stored in the array Exp. As Cmp[Cidx] is '@', consecutive character can be expressed as Cmp[Cidx + 1]. Therefore, b) is the correct answer.



- Blank E: Blank E is the process after the consecutively appearing character is decompressed in the array Exp. In the iteration process of line number 6 through 9, there is no process for updating Cidx, which is the index of the array Cmp. Therefore, this needs to be performed in blank E. Character string starting with '@' has 3 characters, and for moving to the next character, it is necessary to advance the index by 3 characters. Therefore, b) is the correct answer.

	0	1	2	3	4	5	6	7	8	9	1	1	1	1	1
											0	1	2	3	4
Cm	A	A	@	B	4	C	D	@	E	5	F	EO			
p											S				

↑
↑
cidx
cidx + 3

- Blank F: In the array `cnum`, '0' is stored in `cnum[0]`, '1' is stored in `cnum[1]`, '2' is stored in `cnum[2]`, ..., '8' is stored in `cnum[8]`, '9' is stored in `cnum[9]`, and `EOS` is stored in `cnum[10]`. The function `charToInt` is a function for the conversion of a character into an integer, for example, the character '6' into the figure 6. The relation between the character '6' and figure 6 is expressed with elements and index of the array `cnum`. Therefore, the place (index) where '6' is stored needs to be returned. In the program, *i* (index of `cnum`) at the time the iteration process ends is returned. Therefore, *i* at the stage where element of `cnum` matches with the argument `chr` is returned. Blank F is a conditional expression for iteration, and iteration continues as long as the element of `cnum` does not match with `chr`. Therefore, d) is the correct answer.

Moreover, the initial value of *i* starts with 4 only when there are 4 or more consecutive characters, and in this case, the function `charToInt` is called.

Section 11**Mandatory Questions (Data Structure and Algorithm)****Q11-5 Merge sort****[Correct answers]**

[Subquestion 1] A-d), B-h)

[Subquestion 2] C-c), D-b), E-c)

[Explanation]

This is a pseudo-language program for merge-sort, which is one of the practical sorting methods. However, this program applies the concept of a merge process, which is generally positioned as external sorting, to internal sorting. External sorting refers to reading each record from two or more sorted files (data) located on the external (auxiliary) memory device, and integrating these records in a single file (sorted). On the other hand, internal sorting refers to high-speed sorting of data located on the memory with arrays. The former sorting technique is used when data volume is large, while the later one is used when the volume of data is relatively small.

As merge sort or quicksort repeats the same process (operation), it is generally implemented with recursive processing. However, in this question, recursive processing is not used, rather it is implemented with iterative processing with a one-dimensional array. As a practical sorting method, questions on quicksort also appeared in the past examinations, and in future examinations, other practical sorting methods like shell sort, shaker sort, and heap sort may also appear.

As the program in this question uses several variables, even if we understand the concept of merge sort itself, many may struggle in tracing the program. Although this is a kind of program where the level of difficulty can be increased for different blanks; fortunately, the contents are not that difficult. It is important to grasp the concept and understand the application of each of the key variables without rushing. Blank E can be solved by understanding the use of `write_idx`, however, it is easy to misunderstand its contents. As far as the level of difficulty is concerned, this question is somewhat difficult because we are required to understand the meaning of several variables used in the program.

Based on the 8 data items shown in the figure, application of the respective variable is explained in detail. Data for sorting is stored into the array `output` from the array `input`.

	[0]	[1]	[2]	[3]	[4]	[5]	[6]	[7]
output	47	33	68	55	74	89	25	10

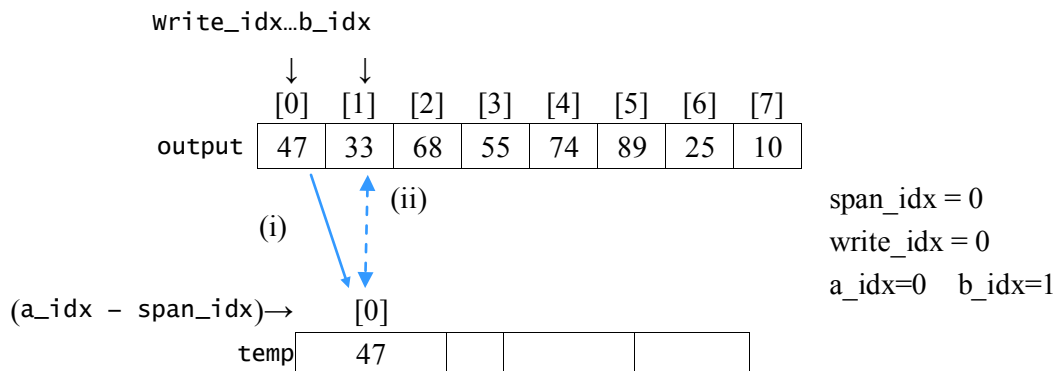
As you can understand from [1-st merging] in the figure, data is first divided into 4 groups of 2 elements each, and for each 2 elements of the relevant group, data arranged in ascending order is created. On the other hand, the indexes of the first group are 0th and 1st, the indexes of the next group are 2nd and 3rd, and the same for the last group are 6th and 7th. Keeping this in mind, consideration shall be given here to the program provided in the question. In the program, because the sorted contents are copied unmodified in the array `output`, the data in the first half of the group is first copied in the array `temp`. The application of the respective variable for achieving this task is as follows:

Variable	Application
<code>span_size</code>	Indicates the number of elements in a group to be sorted (2 elements in the beginning).
<code>span_idx</code>	Index showing the initial position of data in a group to be sorted.
<code>a_idx</code>	Index showing the position of data in the first half of a group to be sorted that is stored in the array <code>temp</code> . It is combined with <code>span_idx</code> .
<code>b_idx</code>	Index showing the position of data in the later half of a group to be sorted.
<code>write_idx</code>	Index showing the position of storing the sorted data where the order of data is finalized.
<code>a_yet</code>	Indicates whether there is any unprocessed data in the first half of the group.
<code>b_yet</code>	Indicates whether there is any unprocessed data in the later half of the group.

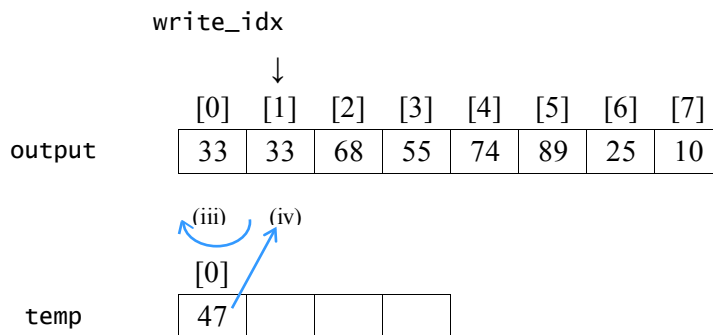
Note `a_yet`, `b_yet`: `true` shows that there is unprocessed data, while `false` shows that there is no unprocessed data.

1. 1st merging (Details of sorting 4 groups of 2 elements each)

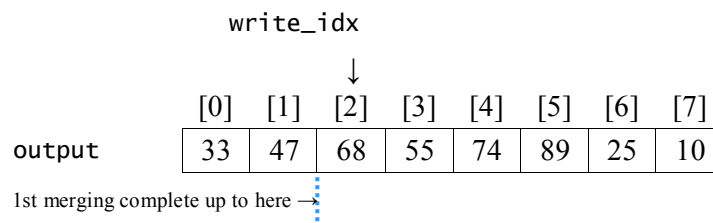
(1) Details of the sorting of the 1st group (Indexes are 0th and 1st)



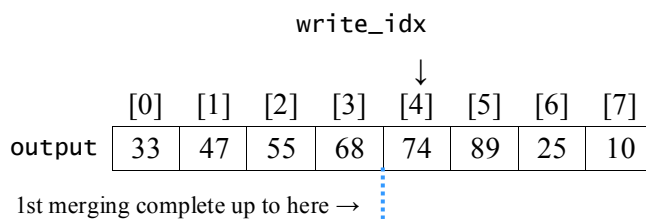
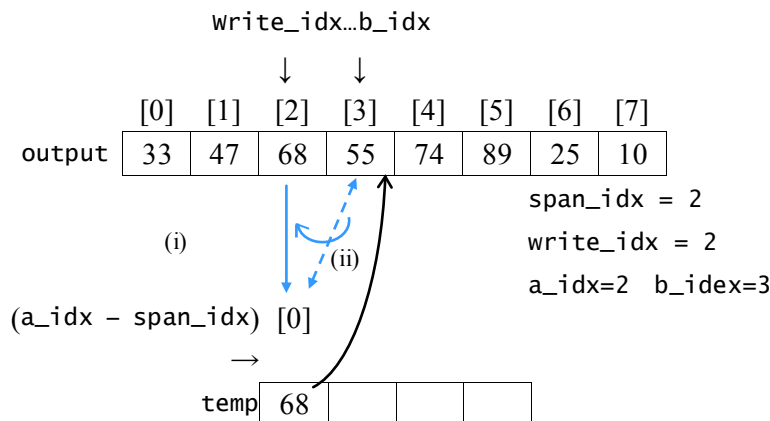
- (i) Data element 47 located in the first half is copied into temp.
- (ii) temp[a_idx - span_idx] = temp[0] = 47 and output[b_idx] = output[1] = 33 are compared, and the smaller one is stored in output[write_idx] = output[0].
- (iii) In this case, as 33 is the smaller one, it is stored in output[0]. For advancing the index of the copied data by 1, "b_idx ← b_idx + 1" is done. However, as there is no data for comparing with the later half of the group [b_idx(= 2) ≥ span_idx(= 0) + span_size(= 2)], the boolean variable b_yet is changed to false. Moreover, the index write_idx showing the next storing position is also advanced by 1.
- (iv) When there is no more data to be sorted in the later half (b_yet = false), the remaining data in temp is stored in output.



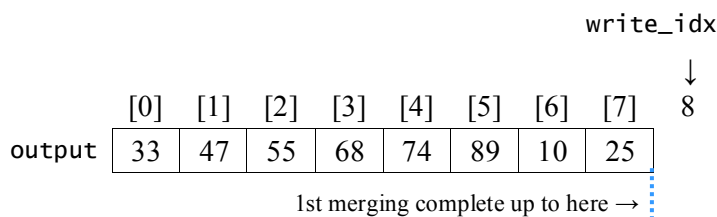
- (v) The following figure shows the state where sorting of the 1st group is completed.



(2) Details of the sorting of the 2nd group (Indexes are 2nd and 3rd)



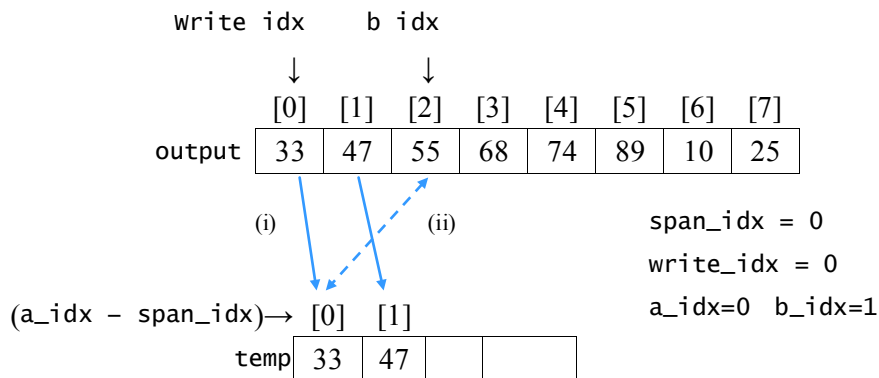
(3) Repeating the same procedure for 3rd and 4th group as follows completes the 1st merging for all groups. In the 3rd group, as the value 74 stored in temp is the smaller one, data in the first half is stored first, and a_yet is turned to false. Value 89 in the later half is stored at the same position. The figure below shows the state where 1st merging is completed for all groups.



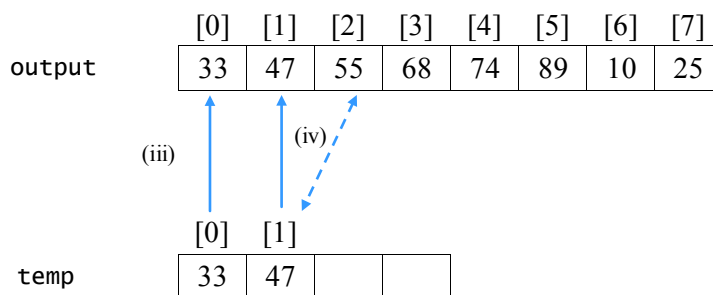
2. 2nd merging (Details of sorting 2 groups with 4 elements each)

In this case, a similar process is repeated for 2 groups. span_idx showing the initial position of data in a group becomes 4 from 0 because span_size is doubled by the process γ .

- (1) Details of the sorting of the 1st group (indexes are 0th to 3rd)

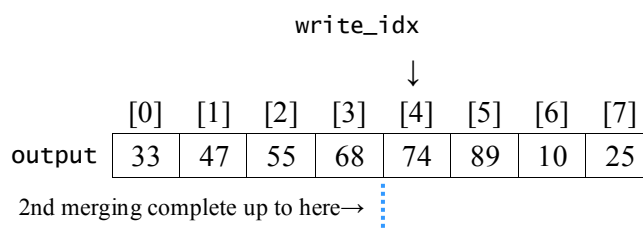


- (i) Data elements 33 and 47 in the first half are stored in **temp**.
- (ii) **temp[a_idx - span_idx] = temp[0] = 33** and **output[b_idx] = output[2] = 55** are compared, and the smaller one is stored in **output[write_idx] = output[0]**.
- (iii) In this case, as 33 is the smaller one, it is stored in **output[0]**. To advance the index of **temp** by 1 where data is copied, "**a_idx ← a_idx + 1**" is performed, and value becomes 1 from 0. The value of **write_idx** showing the storing position is also advanced by 1. However, as data for a comparison with the first half of the group still exists [**a_idx(= 1) < span_idx(= 0) + span_size ÷ 2(= 2)**], the boolean variable **a_yet** showing completion status of the process is kept unchanged as **true**.
- (iv) Next, values of **temp[a_idx - span_idx] = temp[1] = 47** and **output[b_idx] = output[2] = 55** are compared, and as 47 is the smaller one, 47 is stored in **output[write_idx] = output[1]**.



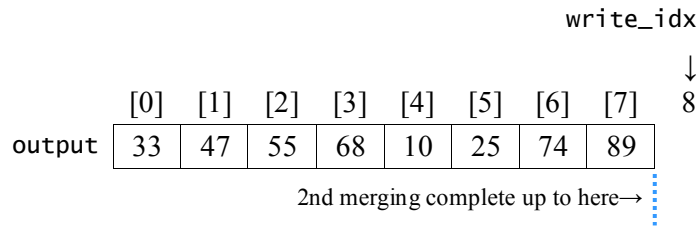
At this stage, there is no more data left in **temp**, and **a_yet** becomes **false**. Therefore, data elements 55 and 68 in the later half are stored unmodified.

- (v) The figure below shows the state where sorting of the 1st group is completed.



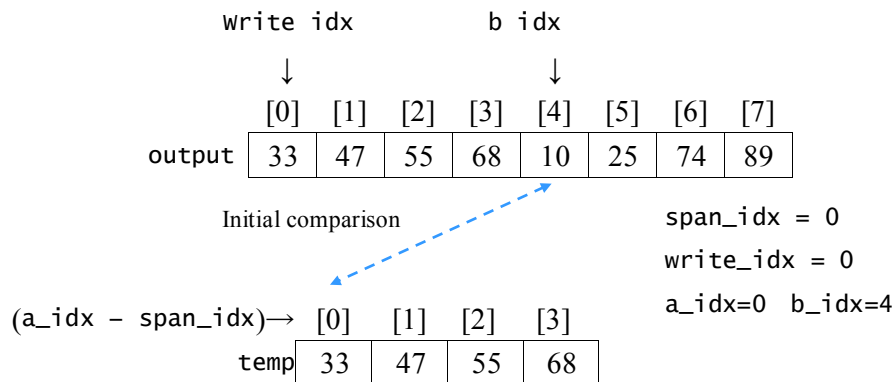
(2) Details of the sorting of the 2nd group (indexes are from 4th to 7th)

The 2nd group is also sorted with the same method. The sequence of the data stored in the array output is 10, 25, 74, 89. The figure below shows the state where 2nd merging is complete.



3. 3rd merging (details of the sorting of 1 group that has 8 elements)

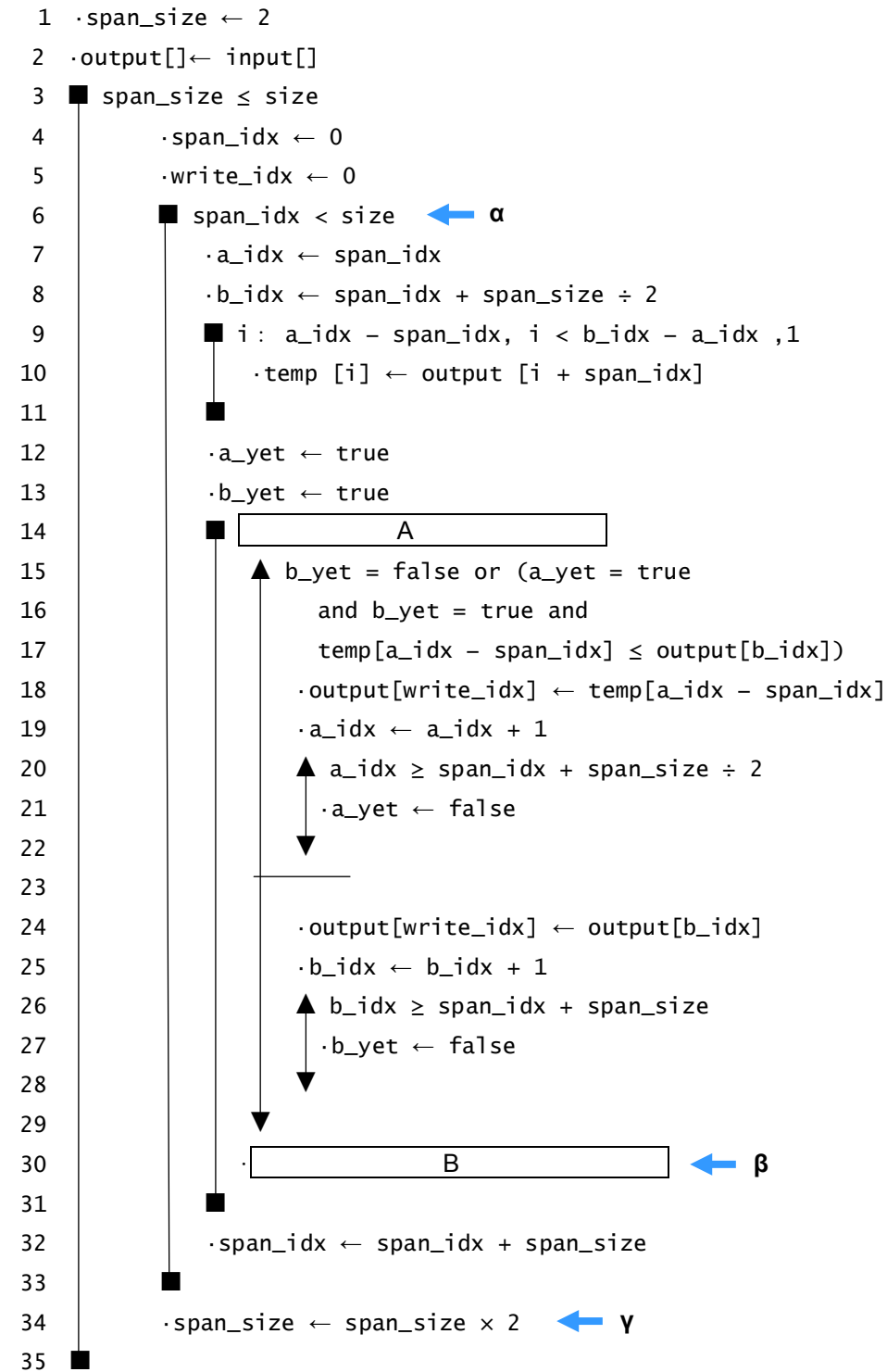
Finally, the same process is repeated for 1 group (indexes are from 0th to 7th). Data stored in temp is shown below. No more processing is investigated here so, any further investigation must be performed by yourself.



The storage sequence of the data is 10, 25, 33, 47, 55, 68, 74, 89, and therefore sorting is completed.

The procedure for sorting should now be understood, so next the program given in the question is shown below, followed by explanation of the subquestions.

(Line number)

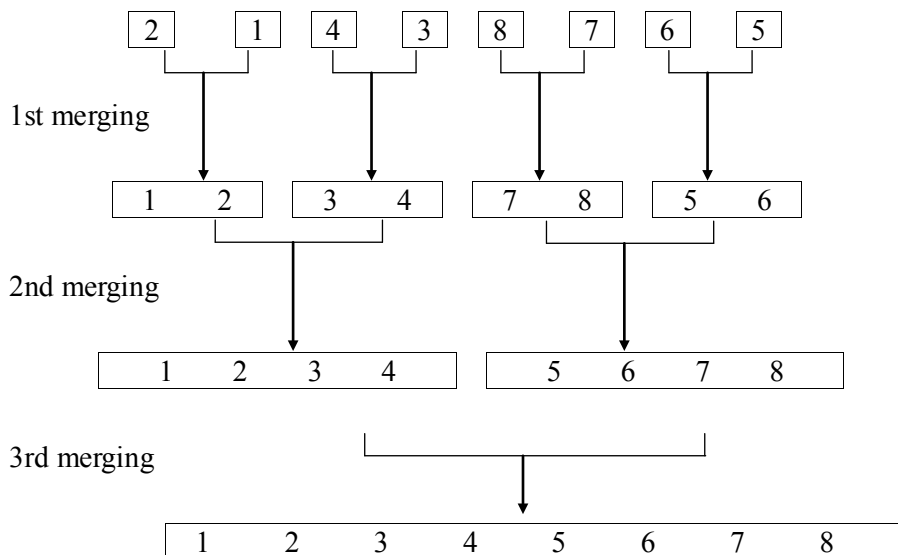


[Subquestion 1]

- Blank A: As already explained earlier, this iteration process is a merging process for data in each group. Eventually, data in the group needs to be stored in sequence starting from the smaller value. However, in this program, when all data in the first half of the group (data copied into the array `temp`) and in the later half of the group is processed, processing of 1 group is concluded. As variables indicating whether any data to be processed exists or not, `a_yet` is used for the first half of the group, while `b_yet` is used for the later half. This decision is done by selection processes in line numbers 20 and 26. Loop is ended when processing of data in the first half and the later half is completed, and at that stage, both `a_yet` and `b_yet` become false. Therefore, condition for continuation of processing is “`a_yet = true or b_yet = true`”, and therefore d) is the correct answer for blank A. Moreover, there are cases either of the first half or the later half is completed first, c) is incorrect.
- Blank B: In the iteration process between line numbers 14 and 31, data is stored in the array `output` starting from the smaller value. The index showing the storing position is `write_idx`. This can also be inferred from statements in line numbers 18 and 24. After one value is stored, it is necessary to add 1 to the value of `write_idx` in order to advance the storing position. However, this process is not performed anywhere. In the selection process between line numbers 15 and 29, at least one value is stored. Therefore, storing position can be advanced in the end of loop, in other words, after the selection process is performed. Therefore, the correct answer is h).

[Subquestion 2]

- Blanks C and D: This can be solved by tracing the merge process for the data in the subquestion.



As it is clear from this, data is actually sorted in ascending order after 2nd merging. However, in the current program, merging is performed even after that. Therefore, the correct answer for blank C is c) 3, and the correct answer for blank D is b) 2.

- Blank E: The ordered in Change 1 is a Boolean flag showing whether sorting is completed or not. It is used in the same way as `a_yet` and `b_yet`. The process of γ is for setting `span_size` for going into the next new group. Therefore, at this stage it is decided whether to proceed to the next merging process.

In the additional process in Change 3, when `ordered` is `true`, the value of `size` is set in `span_size`. Therefore, in the next process of γ , it is possible to end the outer loop (between line numbers 3 and 35). In other words, if `ordered` is `true`, the sorting process is complete. Therefore, unless the sorting process is complete, `ordered` is set to `false`, and this is the condition in blank E. If the sorting is completed, data is stored in ascending order, and therefore, between a value which is stored using `write_idx` and its preceding value, “`output[write_idx - 1] ≤ output[write_idx]`” is always satisfied, where `write_idx` shows the storing position. This should also apply to the end of a group (between the last data in a group and the first data in the next group). Therefore, the correct answer for blank E is c), which is the opposite of this condition.

Q11-6 Repainting a graphic

[Answers]

[Subquestion] A-b), B-c), C-b), D-b), E-a), F-e)

[Explanation]

This question is about a program that specifies one pixel from an area comprised of 64 (8×8) pixels, and then repaints the area with the same color as the pixel with the specified color. The Subquestions concern the behavior of the program.

Because of changes in the examination structure, scope of the Fundamental Information Technology Engineer (FE) Examination has expanded to cover non-technical engineers. Because of this, the afternoon exam has become a multiple choice exam. However, algorithm question is a mandatory question, so all examinees are required to answer this question. Because this question is about tracking the flow of processes and thinking about the meaning of processes, this is somewhat difficult for non-technical examinees. Here the key point is whether examinees are able to read the flow of processes and their meanings from program descriptions and hints provided in the comments.

[Program]

(Line number)

```

1  ○ unsigned 8-bit integer: Image[10, 10]    /* Color of pixels */
2  ○ Integer: VS, HS                          /* Starting point is Image[VS, HS] */
3  ○ unsigned 8-bit integer: CC, NC /* Repaint area with color CC using color NC */
4  ○ Integer: More                            /* Number of pixels waiting for process */
5  ○ Integer: VPos[64], HPos[64] /* Positions of pixels waiting for process */
6
7  ○ Program: Main

```

```

8  o Integer: V, H                      /* Indices for vertical (V) and horizontal (H) directions */
9  o Unsigned 8-bit integer: wall /* Value to be stored in the periphery of display area */
10
11  .CC ← Image[VS, HS]                  /* Get current-color of starting point */
12  ▲ CC = NC
13  .Return                               /* End of processing */
14  ▼
15  . wall ← 0
16  ■ V : 1, V ≤ 8, 1                    /* Set value for periphery(V=1,2..8) */
17  .Image[V, 0] ← wall
18  .Image[V, 9] ← wall
19  ■
20  ■ H : 1, H ≤ 8, 1                    /* Set value for periphery (H = 1, 2,...8) */
21  .Image[0, H] ← wall
22  .Image[9, H] ← wall
23  ■
24  .More ← 0
25  .CheckAndStack(VS, HS) /* Register starting point as the pixel waiting for process */
26  ■ More > 0                          /* Repeat the following steps while More > 0 */
27  .V ← VPos[More]
28  .H ← HPos[More]
29  .More ← More - 1
30  .CheckAndStack(V - 1, H)
31  .CheckAndStack(V, H - 1)
32  .CheckAndStack(V + 1, H)
33  .CheckAndStack(V, H + 1)
34  ■
35  .Return                               /* End of processing */
36
37  o Subprogram: CheckAndStack(Integer: Vt, Integer: Ht)
38  ▲ Image[Vt, Ht] = CC                /* Within the area of same color? */
39  .Image[Vt, Ht] ← NC
40  .More ← More + 1
41  .VPos[More] ← Vt
42  .HPos[More] ← Ht
43  ▼
44  .Return                               /* Return to the caller */

```

As you can understand from the [Program description], this program specifies one pixel (starting point) in the display area, and repaints the same-colored area containing that pixel with the specified color. For determining the same-colored area, the original color of the starting point and the colors of the upper, lower, left, or right adjacent pixels are compared. When the color of the adjacent pixel is the same, it is considered that the pixel is within the same-colored area. Next, the same procedure is also performed for each adjacent pixel determined to be within the same-colored area to find out the same-colored pixels from upper, lower, left, or right of that adjacent pixel. Subsequently, by repeating the same test, the area is gradually expanded. As the processing is performed by checking the colors of the upper, lower, left, or right adjacent pixels from the starting point, same-colored pixels stretching out from the start point can be repainted with the specified color, but non-adjacent same-colored pixels are not repainted.

For a given pixel, if its upper, lower, left, or right adjacent pixels have the same color, those pixels are determined to be within the same-colored area.

- Line numbers 11 to 14: The current color of the starting point is obtained, and if its color is same as the specified color, the program is ended.
- Line numbers 15 to 23: Surround the display area with 0s, which is not used in the repainting process. However, although the range of indexes in the vertical and horizontal directions of the two-dimensional array `Image` is 0-9, variables `v` and `h` that represent the index of vertical and horizontal direction respectively in this process changes between 1 and 8, 0s are not set for 4 corners (`Image[0, 0]`, `Image[0, 9]`, `Image[9, 0]`, `Image[9, 9]`).

	0	1	2	3	4	5	6	7	8	9
0		0	0	0	0	0	0	0	0	
1	0									0
2	0									0
3	0									0
4	0									0
5	0									0
6	0									0
7	0									0
8	0									0
9		0	0	0	0	0	0	0	0	

●In the actual array, the grey portion has the value of 2, and the white portion has the value of 3.

- Line numbers 24 to 35: In line number 25, position of the starting point is passed to the subprogram `checkAndStack`, and the pixel is repainted. In `checkAndStack`, the repainted pixel registers its position information as the pixel waiting for process in the arrays `vPos` and `hPos`, and therefore position of the starting point is registered in `vPos` and `hPos`. In this case, the variable `more` that is index of `vPos` and `hPos` is increased by 1 (Line number 40), resulting in `more=1`. Once the subprogram `checkAndStack` is executed, process returns to the Main program, and line number 26 is executed. Because `more > 0`, the process is repeated, and position information of the pixel waiting for process (starting point in the beginning) is fetched (line numbers 27 and 28), and it is determined whether pixel adjacent to its upper

pixel (line number 30), left pixel (line number 31), lower pixel (line number 32), or right pixel (line number 33) are within the same-colored area or not. If they are of same color, pixels are repainted and their position information is registered with `checkAndStack`. As `more` is increased by 1 before the registration of the position information of the pixel waiting for process, and it is decreased by 1 after the fetch of the position information of the pixel waiting for process, it indicates the number of pixels waiting for processing. Therefore, line numbers 26 to 34 are repeated as long as there are pixels waiting for process (`more > 0`).

- Line numbers 37 to 44 (Subprogram `checkAndStack`): It is determined whether color of pixel to be processed is same as the original color of pixel of starting point (line number 38), and the color is same, it is repainted with the specified color (line number 39). After that, variable `more`, which is index of arrays `vPos` and `hPos`, and which indicates the number of pixels waiting for process is increased by 1 (line number 40), and position information of the repainted pixel is registered as the pixel waiting for process (line numbers 41 and 42).

[Subquestion]

- Blank A: During the execution of `checkAndStack` in line number 25, the pixel of the starting point is repainted and its position information is registered. Once the position information is registered, `more` is increased by 1 and the process returns to the main program. When line number 26 is executed, because `more > 0`, repeated processing of line numbers 27 to 33 takes place. During repeated processing, position information of the pixel waiting for process (starting point in the beginning) is fetched with line numbers 27 and 28. With the execution of `checkAndStack` in line numbers 30 to 33, it is determined in sequence whether colors of upper, left, lower, or right pixels are the same as original color of the starting point. If the color is same, process of repainting with the specified color and process for registering the position information of pixels in `vPos` and `hPos` is performed. In case there is any pixel waiting for process after checking of upper, lower, left, and right pixels is done, `more > 0` and the program once again goes into iteration process for repeating the same process.

When data of Fig. 1 is provided, upper pixel (`Image[4, 3]`) and left pixel (`Image[5, 2]`) to the starting point (`Image[5, 3]`) become the same-colored area, and the color of these 2 pixels is repainted and position information are registered. At this stage, it is necessary to think whether the pixel to process next is either the upper pixel or the left pixel. Therefore, changes in the variable `more`, which is the index of `vPos` and `hPos` needs to be checked. `more` is increased by 1 just before a value is stored in the array (line number 40), while it is reduced by 1 right after a value is fetched from the array (line number 29). Because of this, `more` always specifies the tail of `vPos` and `hPos`. Therefore, it is clear that `vPos` and `hPos` are stacks that first fetch the last stored value (last-in first-out). Because of this, pixel processed after the start point is the left pixel `Image[5, 2]` that is stored at last in `vPos` and `hPos`. Therefore, the adjacent pixels around `Image[5, 2]` are searched in the sequence of the upper, left, lower, and right in the next iteration. For `Image[5, 2]`, upper (`Image[4, 2]`) and lower (`Image[6, 2]`) pixels are repainted in sequence, and their position information is registered. Based on this understanding, sequence of the first 5 repainted pixels is `Image[5, 3]`, `Image[4, 3]`, `Image[5, 2]`, `Image[4, 2]`, and `Image[6, 2]`, and therefore b) is the correct answer.

Initial reference point

	0	1	2	3	4	5	6	7	8	9
0		0	0	0	0	0	0	0	0	
1	0									0
2	0									0
3	0									0
4	0			U						0
5	0		L	×	R					0
6	0			D						0
7	0									0
8	0									0
9		0	0	0	0	0	0	0	0	

Second reference point

	0	1	2	3	4	5	6	7	8	9
0		0	0	0	0	0	0	0	0	
1	0									0
2	0									0
3	0									0
4	0		U							0
5	0	L	×	R						0
6	0		D							0
7	0									0
8	0									0
9		0	0	0	0	0	0	0	0	

* × represents the starting pixel

- Blank B: During the processing of line numbers 16 to 23, 0s are set in the periphery of the array `Image` excluding 4 corners. As 0 is a different value to the three colors used in processing (Black: 1, Grey: 2, White: 3), based on the decision of line number 38, it can be identified that these pixels are not in the scope of repainting. In this manner, by setting a special value for pixels that show the periphery, it is possible to distinguish between pixels to be processed and the periphery. As a result, it is possible to omit the process for checking the range of indexes (0 to 9) of the array `Image`. Therefore, c) is the correct answer.

If this process is not present, in the processing of line numbers 27 and 28, it is necessary to determine whether upper, lower, left, and right positions to the values stored in the variables `v` and `h` (position of pixels to be processed) are within the range of indexes of the array `Image`.

- Blank C: During the processing of line numbers 15 to 23, 0s are set to elements of the array of the periphery. However, while the range of vertical and horizontal indexes of the array `Image` is 0 through 9, vertical and horizontal indexes `v` and `h` can be changed from 1 to 8 only with processing. Therefore, the 4 corners (`Image[0, 0]`, `Image[0, 9]`, `Image[9, 0]`, `Image[9, 9]`) are excluded from the processing of the periphery. Accordingly, in the case of 8×8 pixels of Fig. 1, the number of pixels of periphery that is processed is 8×2 (left edge and right edge) in the vertical direction, and 8×2 (upper edge and lower edge) in the horizontal direction. In other words, it is the number of vertical pixels $\times 2$ + the number of horizontal pixels $\times 2$. Applying this to $m \times n$ pixels, as the number of vertical pixels is m and the number of horizontal pixels is n , this becomes $m \times 2 + n \times 2 = 2(m + n)$. Based on the above, b) is the correct answer.
- Blank D: This program omits the checking of the range of each index of the array `Image` by establishing a periphery. Therefore, in order to distinguish between the pixels to be processed and the periphery, it is necessary to assign a special color (value) to periphery that is not used in processing. However, using all of 0 through 255 expressed with an unsigned 8-bit integer does not leave any special value for showing the periphery. Therefore, a value between 0 and 255, which is not used for color conversion, should be used as a value for the periphery.

Verification of each selection option is given below:

- a) Value of `cc` shows the color of starting point pixel. Setting the same color in periphery as the starting point does not allow to identify pixels of the area to be repainted, and as the process does not end even after the periphery is reached, the program runs over the edge. Therefore, this selection option is incorrect.
- b) The value of `nc` shows the color to be repainted. When `nc` is different to the color of the starting point, the color of the area to be repainted and color of periphery differ, and therefore it is possible to identify the periphery. Moreover, even if `nc` and color of the starting point is same, condition of line number 12 becomes true, and process can be correctly ended. Therefore, this is correct.
- c) Depending on the value of `cc`, the process may or may not be performed correctly. For example, when `cc = 128`, `wall = 128` and as the starting point and periphery have the same color, the periphery cannot be determined. Moreover, when `cc = 0`, `wall = 256`, but `wall` is an unsigned 8-bit integer, and therefore it is overflowing in terms of its type. Accordingly, this is incorrect.
- d) Depending on the value of `nc`, the process may or may not be performed correctly. For example, when `255-nc(wall)` is same as the value of `cc`, color of the starting point and periphery are the same, and therefore the periphery cannot be determined. Accordingly, this is incorrect.

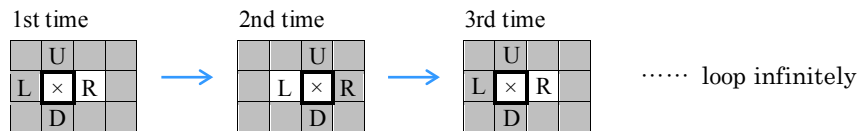
Based on the above, b) is the correct answer.

- Blank E: Repainting is done in the sequence of pixel of the starting point, upper, left, lower, and right pixel to the starting point. In the case of (1) in Fig. 2, when `checkAndStack` in line number 25 is executed, the pixel of the starting point is repainted with the same color, and then with the execution of `checkAndStack` in line numbers 30 to 33, the upper, left, lower, and right pixels to the starting point are checked. (1) in Fig. 2 is the area comprised of 1 pixel, and as the colors of the upper, lower, left, and right pixels are different from the color of the pixel of the starting point, conditions in line number 38 are not satisfied. Therefore, the value of the variable `more` remains 0 after execution of line number 29, the program is ended after the first iteration process of line numbers 26 to 34. In this manner, case (1) in Fig. 2 is correctly ended after repaint with the same color as per specifications, and therefore a) is the correct answer.



- Blank F: In the case of (2) in Fig. 2, thinking along the same lines as (1) in Fig. 2, after repaint of the starting point pixel, the condition in line number 38 is satisfied with the pixel on the right of the starting point, and therefore it is repainted with the same color. Position information of the repainted pixel is registered as a pixel waiting for processing, and therefore position information of the pixel on the right of the starting point is registered in `VPos` and `HPos` as a pixel waiting for processing. At this stage, variable `more` is increased by 1, because of which `more > 0`, and the iteration process in line numbers 26 to 34 is performed once again. The next reference pixel is the pixel on the right whose position was registered in `VPos` and `HPos` earlier. Upper, lower, left, and right pixels to this pixel are checked and repainted. However,

as they are repainted with the same color, the starting point (pixel located on left of the pixel to be processed), which is already repainted becomes a target for processing once again, and subsequently the same process is repeated. As the variable `more` is repeatedly increased and decreased, it does not exceed a certain value. However, since repainting is done with the same color, the processed pixels are treated as target pixels infinitely, and the process enters an endless loop. Therefore, e) is the correct answer.



* `x` represents the starting

Q11-7 Converting a base M character sequence to a base N character sequence

[Correct answers]

[Subquestion] A-c), B-e), C-a), D-h), E-b)

[Explanation]

This is a pseudo-language program that shows an algorithm for radix conversion of a base M digit string to a base N digit string. Because radix conversion is a mandatory topic in the morning examination, this is a relatively easy problem to solve. Although several functions are used, understanding the role of each function and tracing the process by applying appropriate data make the contents easy to understand. As far as the level of difficulty is concerned, it is normal.

The overall structure of the program and processing details can be generally understood as follows:

- (1) Radix of source digit string (`Frdx`), source digit string (`Fnum`), and the radix of the converted digit string (`Trdx`) are passed to the function `RadixConv`. The return value is a converted base `Trdx` digit string.
- (2) In the beginning, with the function `MtoInt`, a base M digit string is converted to an integer. The radix of source digit string is $M = Rdx$. In this case, to convert the source digit string (characters) into an integer, the function `ToInt` is used. The return value is the converted integer value `val`.
- (3) Integer value (`val`) converted in (2) above is converted into the converted digit string (`Tmp`) with the function `IntToN`. Return value is the converted base Rdx digit string stored in `Tmp`.

For example, running the program with $M = 10$, `Fnum` = "12", and $N = 2$ gives the following result. Moreover, the character type variable `Tmp` is cleared beforehand, and it is ""(null character).

- (i) Digit string "12" as characters is converted to an integer value $\rightarrow val = 12$
- (ii) The integer value `Val` = `Quo` = 12 is converted into the digit string "1100" as characters with radix $N = 2$. Conversion is the process of determining remainder by dividing an integer value with radix, where it is sequentially stored in the character type variable `Tmp`.

Quo	Rdx	Division process	Rem	Tmp
12	2	1st $12\%2 \rightarrow$	0	"0"
6	2	2nd $6\%2 \rightarrow$	0	"00"
3	2	3rd $3\%2 \rightarrow$	1	"100"
1				
Division process is ended when Quo = 1 < Rdx = 2, and Quo = 1 is stored in Tmp.				
				"1100"

Next, the correct answers for the blanks are explained while an outline of the program in question is provided. Moreover, (1) through (19) are program line numbers that are used in the explanation.

<Function MToInt(integer_type: Rdx, character_type: Num)>

```

(1)  · val ← 0
(2)  ■ Idx: 1, Idx ≤ Length(Num), 1
      |
(3)  · val ← A + ToInt(Substr(Num, Idx, 1))
(4)  ■
(5)  · return val

```

<Function IntToN(integer_type: val, integer_type: Rdx)>

```

(6)  · B
(7)  · Tmp ← ""
(8)  ■ Quo ≥ Rdx
      |
(9)  · Rem ← Quo % Rdx
(10) · Tmp ← Tostr(Rem) + Tmp
(11) · C
(12) ■
(13) · D
(14) · return Tmp

```

<Function ToInt(character_type: P)>

```

(15) · Idx ← 0
(16) ■ E
      |
(17) · Idx ← Idx + 1
(18) ■
(19) · return Idx

```

[Subquestion]

- Blank A: This is based on the contents of the function `MtoInt`. Here, a base `m` digit string is converted to an integer value. The radix of the source is passed with `Rdx` and the source digit string is passed with `Num`.

Tracing with the example in the explanation gives the following results.

Rdx	Num	val	Idx	Length(Num)	ToInt(Substr(Num,Idx,1))
10	"12"	0	1	2	1 ← 1st character of Num
		1			
			2		2 ← 2nd character of Num
		12			
			3	←End at Idx = 3	

The digit string "12" as characters should become the integer value 12 when considered as a decimal value. Iteration process in line numbers (2) to (4) determines this value. This value is determined in `val`, however, as explained in the function `Substr`, the character fetched at the beginning is "1". Conversion of this into an integer number with the function `ToInt` gives 1, and after adding the value of blank A, this results in `val = 1`. Next, as shown in tracing, the integer value 2 is obtained from the character "2". `val = 12` should be determinable as a result. However, to do this, we should think in terms of shifting the digit. In the case of a decimal number, for moving to a higher order digit, it must be multiplied by 10. This can be achieved by multiplying the radix `Rdx` to `val`. Therefore, c) is the correct answer for blank A. For a radix other than 10 also, this relationship of shift holds.

- Blanks B through D: These concern the details of the function `IntToN`. Here, the value converted into an integer value with the function `MtoInt` is converted into a base `n` digit string. Regarding the arguments, `val` contains the converted integer value and `Rdx` contains radix `n`. The return value is `Tmp`.

From line numbers (8) to (12), it can be inferred that the variable `quo` contains an integer value to be converted. This is because in line number (9), `rem` determines the remainder value obtained by dividing `quo` with the radix `Rdx`. For this, it is necessary to assign the value of `val` into `quo` in line number (6). Therefore, e) is the correct answer for blank B.

The variable `tmp` holds a character string; however, as shown in the explanation, the remainder obtained by dividing the integer value `quo` by the radix `Rdx` is converted into a character, and then it is concatenated to `tmp`. Line numbers (8) to (12) does this. In this process, the remainder is determined repeatedly, but when the next remainder is determined, it is necessary to keep replacing the value of `quo` with the quotient. Therefore, a) is the correct answer for blank C.

Moreover, the termination condition of line number (8) is `quo < Rdx`. Therefore, the final remainder still remains in `quo`, and it is necessary to concatenate this to `tmp`. This is what blank D does, and therefore the correct answer is h). i) is incorrect because it concatenates the remainder `rem` determined at the last iteration.

- Blank E: This is the question concerning the function `toInt`. Here, the character `p` given by the argument is converted into an integer value. As each character is stored in the array `code` in 16 types, it is checked in sequence whether they match, and the corresponding character can be determined. At that time, as the index for the array operation corresponds to the integer value of that character, the index when it matches can be returned as a return value. From line number (15) it is clear that the index for the array operation is `idx`, and therefore blank E should contain the condition for that. The 0th character is the smallest character, and as value continuously increases, this process should be repeated as long as `p > code[idx]`. Therefore, b) is the correct answer for blank E.

The condition for ending this iteration is `p ≤ code[idx]`. However, it only means that `p` and `code[idx]` are equal.

Section 12

Software Development(C)

Q12-1 Control of a drawing marker (C)**[Answers]**

[Subquestion] A-a), B-c), C-a), D-h), E-e), F-f), G-c)

[Explanation]

This question concerns a program that controls a marker that draws according to instructions stored within a structure array. The processing structure of the program is easy to understand. In addition, because the roles of the structures and variables used (with the exception of `dx` and `dy`) are explained in the question text and in program list comments, the question allows focus on deciphering the content of the processing.

In this program, the roles of the data structure and the variables used are complicated, with complexities including the use of a structure array. Such a program should be considered in the following order: sort the roles of the structure array and variables → sort out the processing structure → decipher the processing content. In addition, when the processing content is deciphered, the sample data presented in the question text is to be used. The program listing of the function `execute()` section is given again below, with the line numbers, auxiliary lines, block numbers, and memos needed for deciphering.

```

1  void execute(){
2
3      STACK stack[STACKSIZE];
4      int opno = 0; /*Element number of insts, the instruction array to be
executed */
5      int spt = -1; /*Stack pointer      */
6      int dx, dy;
7
8      paintMarker( mark );
9
10     while( insts[opno].code != '\0' ) {
11         switch( insts[opno].code ) {
12             case '{':
13                 stack[  ].opno = opno;
14                 (1) stack[spt].rest = insts[opno].val;
15                 break;
16             case 't':
17                 mark.dir = ;
18                 (2) break;
19             case 'f':
20                 eraseMarker( mark ) ;
21                 dx = ( mark.dir % 2 == 0 ) ? ;
22                 dy = ( mark.dir % 2 == 0 ) ? ;
23                 drawLine( mark.x, mark.y,
24                 (3) mark.x + dx, mark.y + dy );
25                 mark.x += dx;
26                 mark.y += dy;
27                 paintMarker( mark );
28                 break;
29             case ' } ':
30                 if ( stack[spt].rest  ){
31                     opno = stack[spt].opno;
32                     stack[spt].rest--;
33                 (4) } else {
34                     ;
35                 }
36                 break;
37         } ← end switch
38          ;
39     } ← end while
40 }

```

Program listing of the function execute() section

(Sorting the structure array and variables)

When the program listing is read through Line 6 using the question text and comments as hints, the following can be understood with regard to the roles and content of the structure array and the variables.

Variable **opno**: The element number of the structure array **insts** in which instructions are stored, with 0 assigned as the initial value in Line 4. Because this is an element number (that is, an index), it can be predicted that the increment processing to investigate in order the instructions stored in the structure array **insts** is located somewhere.

Variable **spt**: The element number (that is, an index) of the structure array **stack**, with -1 assigned as the initial value in Line 5. Details regarding the use of the structure array **stack** remain unclear at this phase, but from the comment in the line defining the **stack** type, it can be predicted that it is used to control the number of iterations. Furthermore, as the initial value of the index **spt** is -1, it can be predicted that, when something is assigned to the array **stack**, **spt** is incremented prior to the assignment. Also, because it is a stack, it can be predicted that a corresponding decrementing is performed at some location.

Structure **mark**: As the elements **x** and **y** are the **x** coordinate and the **y** coordinate of the marker, it can be predicted that they are used for drawing when the instruction code is 'f', and that, after drawing, they are updated to the coordinates of the marker's destination. Also, as the element **dir** is the direction of travel of the marker, it can be predicted that it is used for drawing when the instruction code is 'f', and that it is updated when the instruction code is 't'.

The variables **dx**, **dy**: The roles of these are unclear at this phase. From their variable names, it can be predicted that they are used for drawing when the instruction code is 'f', but details will be considered when the processing content is deciphered.

When sorted, the above can be depicted as in Fig. 1. Note that the structure array **insts** is shown in horizontal orientation in the question text, but is shown in vertical orientation in Fig. 1 to make the actions of the index **opno** easy to chart.

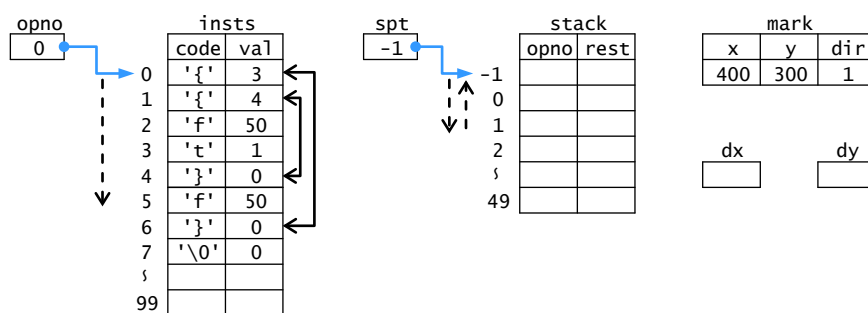


Fig. 1 Roles and content of structure array and variables

(Sorting the processing structure)

The main processing of the function `execute` is performed within the `while-do` loop that continues while the content of `insts[opno].code` is not `'\0'` (which indicates termination). Furthermore, within this `while-do` loop are a `switch-case` block that branches into 4 cases according to the content of `insts[opno].code`, and blank G. Within the `switch-case` block are Blocks (1), (2), (3), and (4), for which processing for each instruction code is described. Because the blank G is outside of the `switch-case` block, it will be executed when 1 element of the instructions stored in the structure array is handled. From this, it can be predicted that a process which increments the index `opno` of the structure array `insts` is inserted into blank G. Verification of this shall be performed when the processing content is deciphered.

The process structure of the function `execute` is easy to understand. However, to reduce mistakes and misunderstanding, the reader is advised to add auxiliary lines and memos of the sort in the program listing that was given again. For example, it is advisable to make clear that the blank G is outside of the `switch-case` block. By doing this, the answer to be placed in the blank G should be obvious.

(Deciphering of the process content)

Because sorting of the structure array and the variables, and sorting of the processing structure, have been completed, the blanks can be filled in while the processing content is deciphered with the sample data presented in the question text. Note that the order of deciphering depends on the order that the sample data is handled. As the code of the element number 0 in the sample data is `'{'`, deciphering starts from Block (1), which contains the blank A.

* Blank A: The blank A corresponds to the index of the structure array `stack`. As can be understood from the comment attached to the variable `spt` in Line 5 and from the line after this blank, the index of the structure array `stack` is the variable `spt`. However, as the initial value of the variable `spt` is `-1`, it cannot be used as is. It must be incremented before the value of `opno`, an element of `stack`, can be found. Therefore, answer a), `++spt`, is inserted into the blank.

Here, Fig. 2 depicts the processed state of the `'{'` of element number 0 in the sample data, through Line 14.

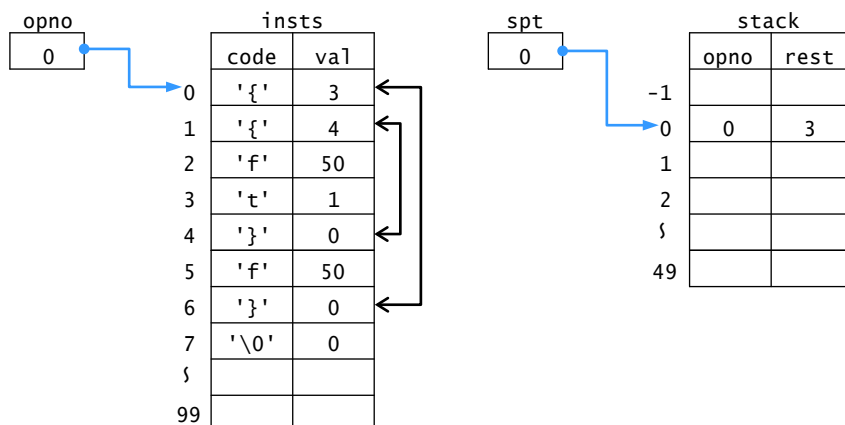


Fig. 2 Processed state of the `'{'` of element number 0 in the sample data, through Line 14

After Line 2, processing breaks at Line 15, exits the `switch` subroutine, and jumps to Line 38, which holds the blank G.

- * Blank G: It is understood that, at the phase of sorting the processing structure, the blank G will be executed after one instruction stored within the structure array `inst` is handled, and it was predictable that this corresponds to the incrementing of the index `opno`. This will be verified below using sample data.

The state just prior to executing the blank G is, as an example, the state shown in Fig. 2. When processing jumps to Line 10 and Line 11 with no action taken in blank G, the value of the index `opno` remains 0, and thus the '{' of element number 0, which has already been handled, is handled again. However, in actuality the '{' of element number 1 should be processed. In other words, the index `opno` should be incremented in blank G. As such, it can be confirmed that the answer `opno++` is inserted into blank G. Therefore, c) is inserted into the blank.

Here, Fig. 3 depicts the state in which the '{' of element number 1 has been processed through Line 38, and the index `opno` has been set to 2.

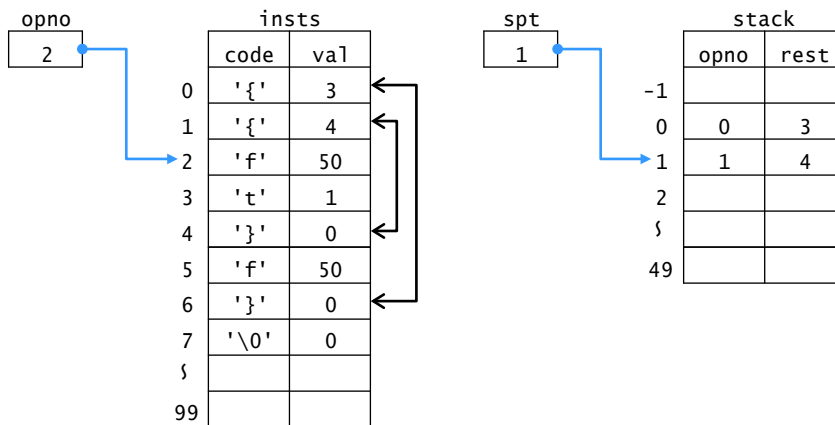


Fig. 3 State in which the '{' of element number 1 has been processed through Line 38, and the index `opno` has been set to 2

As the content of `insts[opno].code` is 'f' when processing jumps to Line 11 in the Fig. 3 state, Block (3), which contains blanks C and D, is executed. As the lines containing the blanks C and D are similar to each other, they should be considered in a similar manner. First, consideration will focus on blank C, and using that as reference, blank D will be deciphered.

- * Blank C: In Line 21, which contains blank C, the return value of an expression using the conditional operator "?" is assigned in the variable `dx`. First, the role of the variable `dx` will be considered.

The variable `dx` is used in Line 24 and Line 25. In Line 24, it is used as part of the expression for obtaining the terminal x coordinate, as an argument of the function `drawLine` that draws lines. Moreover, in Line 25, its value is added to `mark.x`, but as a mark is drawn using the function `paintMarker` in Line 27, it can be understood that the addition is for the purpose of updating the x coordinate with the value of the move destination. From this, it is understood that the distance (difference) between the x coordinate of the move origin and the x coordinate of the move destination is assigned to the variable `dx`. In other words, the variable `dx` expresses the distance moved in the horizontal direction. This is shown as a figure below.

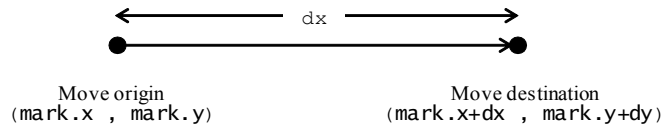


Fig. 4 Role of the variable `dx` (No. 1)

However, according to the question text, the distance moved is stored within `insts[opno].val`. This means that the x coordinate of the move destination can be obtained from “`mark.x + insts[opno].val`”. Considering this further, it can be understood that when the direction of travel is to the left, the value of `insts[opno].val` must be subtracted from `mark.x`. In other words, the negative value of `insts[opno].val` must be assigned to the variable `dx`. This is shown as a figure below.

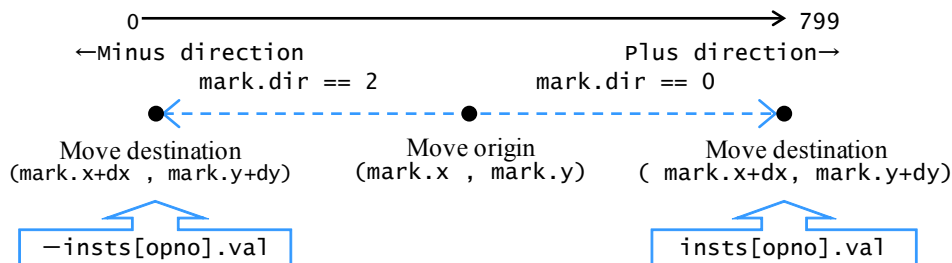


Fig. 5 Role of the variable `dx` (No. 2)

Based on the outcome of the above considerations, the expression for obtaining the value to be assigned to the variable `dx` will be considered.

The conditional operator “?” is used in the expression for obtaining the value to be assigned to the variable `dx`. The conditional operator “?” is used in the form “Expression 1 ? Expression 2 : Expression 3,” and returns Expression 2 if Expression 1 is TRUE, and returns Expression 3 if Expression 1 is FALSE. “`mark.dir % 2 == 0`”, which corresponds to Expression 1, is TRUE when the value of `mark.dir` is 0 (left) or 2 (right). Therefore, the result of Expression 2 is assigned to the variable `dx` when the direction of travel of the marker is left or right, and the result of Expression 3 is assigned to the variable `dx` when the direction of travel of the marker is up or down.

As the distance along the horizontal direction is stored within the variable `dx`, 0 is inserted into the blank when the direction of movement is up or down. From this, the choices can be narrowed down to a) through d) and to j), for which Expression 3 is 0. From among these choices, the choices for which the result of Expression 2 is “+`insts[opno].val`” when the direction of travel of the marker is right (`mark.dir` is 0), and for which the result of Expression 2 is “-`insts[opno].val`” when the direction of travel of the marker is left (`mark.dir` is 2), can be selected. Corresponding to this is $(1 - \text{mark.dir}) * \text{insts[opno].val} : 0$, which becomes “1 * `insts[opno].val`” when `mark.dir` is 0 (right), and “-1 * `insts[opno].val`” when `mark.dir` is 2 (left). Therefore, a) is inserted into blank C.

As the explanation has become lengthy, it is summarized below. This summary can be used when considering blank D.

The variable `dx` is the distance moved in the horizontal direction. It is assigned the value +`insts[opno].val` when `mark.dir` is 0 (right direction of travel), the value -`insts[opno].val` when `mark.dir` is 2 (left direction of travel), and the value 0 when `mark.dir` is 1 or 3 (up or down direction of travel). As such, the following expression is appropriate.

`dx = (mark.dir % 2 == 0) ? (1 - mark.dir) * insts[opno].val : 0`

* Blank D: This will be considered with application of the summary for blank C.

The variable `dy` is the distance moved in the vertical direction. It is assigned the value 0 when `mark.dir` is 0 or 2 (right or left), the value -`insts[opno].val` when `mark.dir` is 1 (up), and the value +`insts[opno].val` when `mark.dir` is 3 (down).

In other words, the result of Expression 2 of the conditional operator must be made 0. This means that the choices are narrowed down to e) through i). Further, Expression 3 should return “-1 * `insts[opno].val`” when `mark.dir` is 1 (up), or “1 * `insts[opno].val`” when `mark.dir` is 3 (down). In other words, the following expressions are appropriate.

`dy = (mark.dir % 2 == 0) ? 0 : (mark.dir - 2) * insts[opno].val`

Therefore, h) is inserted into the blank.

In Block (3), after 'f' in element number 2 is handled, the variable `opno` is incremented in Line 38 and becomes 3. As the content of `insts[opno].code` subsequently becomes 't', Block (2), which contains blank B, is executed next.

* Blank B: According to the question text, when the content of `insts[opno].code` is 't', the direction of travel of the marker changes by only $90 \text{ degrees} \times \text{val}$, counterclockwise. In other words, an expression that calculates the value that expresses the direction of travel after change is inserted into blank B. As the value that expresses the direction of travel is limited to an integer value from 0 to 3, an expression for which the calculation result is a value from 0 to 3 should be chosen from the answer group. The only corresponding answer in the group is $(\text{mark.dir} + \text{insts}[\text{opno}].\text{val}) \% 4$. Therefore, c) is inserted into the blank.

Incidentally, g) is inappropriate. For example, if `mark.dir` is 3 and `insts[opno].val` is 5, then $3 + 5 \% 4 = 3 + 1 = 4$, which is inappropriate as a value for the direction of travel.

Here, Fig. 6 depicts the state in which 't' of element number 3 in Block (2) has been handled, and the index `opno` has been incremented in Line 38 and has become 4.

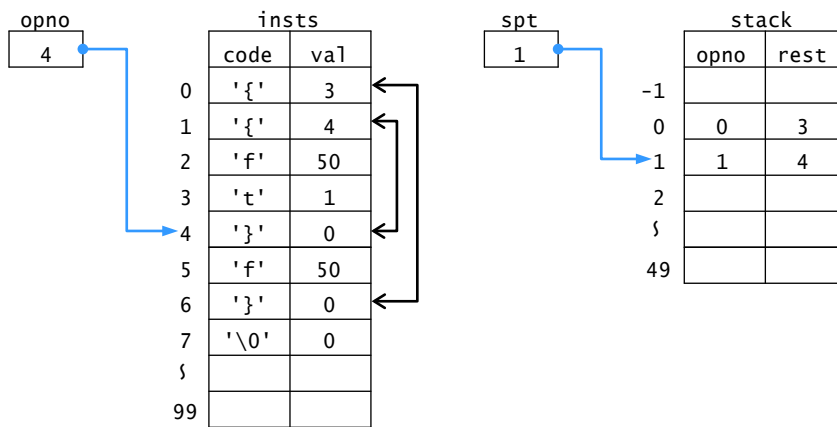


Fig. 6 State in which the index `opno` has been incremented in Line 38 and has become 4

As the content of `inst[opno].code` is '}' in this state, Block (4), which contains blank E and blank F, is executed next.

* Blank E: As Block (4), which contains this blank, performs processing when the content of `inst[opno].code` is '}', it can be thought of as performing processing for the purpose of repeating the instructions enclosed within the '{' and '}'. This can also be confirmed from the content of the processing in Line 31 and Line 32. As an example, when Line 31 is executed in the state shown in Fig. 6, the value of the index `opno` is changed from 4 to 1, and becomes the element number of the '{' corresponding to the '}' indicated currently by the index `opno`. The index `opno` is used to retrieve instructions stored within the array `inst`, and is normally incremented by 1 in Line 38 each time it handles one instruction, handling instructions in order. Therefore, updating the index `opno` to a specified value is a branching point to instructions stored within the location indicated by the value. In other words, the instructions enclosed in "{" and "}" are handled again (iterated). In addition, when Line 32 is handled, the value of the element `rest` in the structure `stack`, which is explained in the comment as "the number of repetitions remaining," is decremented.

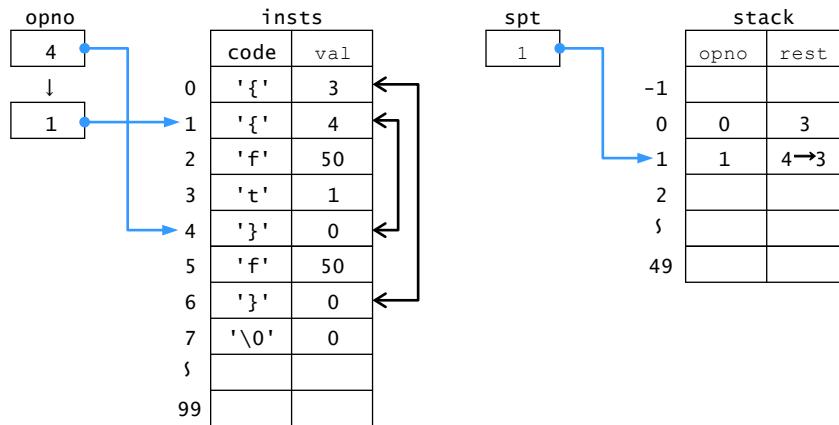


Fig. 7 State after Line 31 has been handled

In this way, as Line 31 and Line 32 are handled in the case of repetitions, the if statement in Line 30, which contains blank E, can be deemed equivalent to a conditional expression that continues repetition. Therefore, in order to fill in blank A, it is sufficient to consider what value of `stack[stp].rest` will terminate the repetition, and select a choice that results in the opposite conditional expression.

The initial value of `stack[stp].rest` is 4, and is decremented by 1 in Line 32. As was considered above, after executing this section, the next repetition is begun. Specifically considering 4 repetitions, the value changes from 4 to 3 when the first repetition has been completed and the second repetition is begun. It becomes 2 when the third repetition is begun, and becomes 1 when the fourth repetition is begun. In other words, the value is 1 when the last, fourth repetition has been completed. At this time, Line 34 should be handled, without repetition performed.

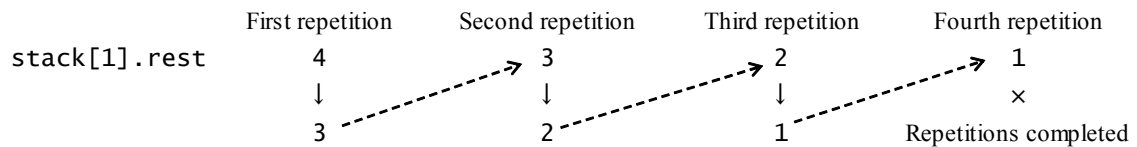


Fig. 8

Expressing this in a reverse manner, blank E should be filled so that the conditional expression is TRUE when the value of `stack[stp].rest` exceeds 1, and Line 31 and Line 32 are handled. Therefore, answer e), > 1 , is inserted into blank E.

- * Blank F: This handles the case in which the content of `insts[opno].code` is `'}'` and `stack[spt].rest` is 1 – in other words, when repetitions have completed. As an example, when blank F in Line 34 is handled after 4 repetitions of the instructions enclosed within the `'{'` of element number 1 and the `'}'` of element number 4, the content of the structure arrays `insts` and `stack`, and of the indexes, should be as follows:

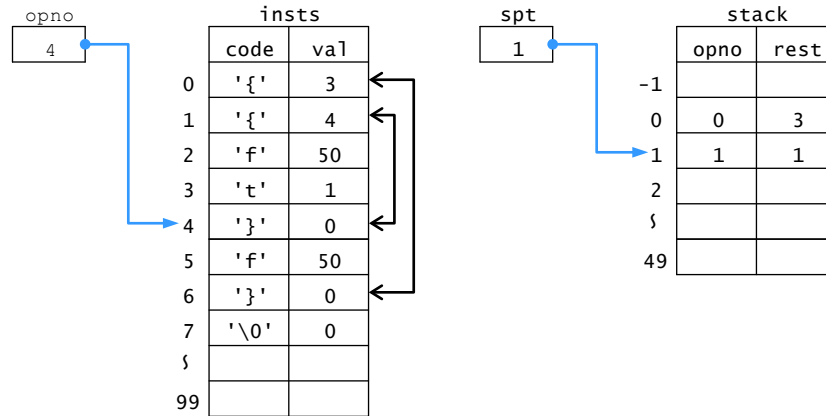
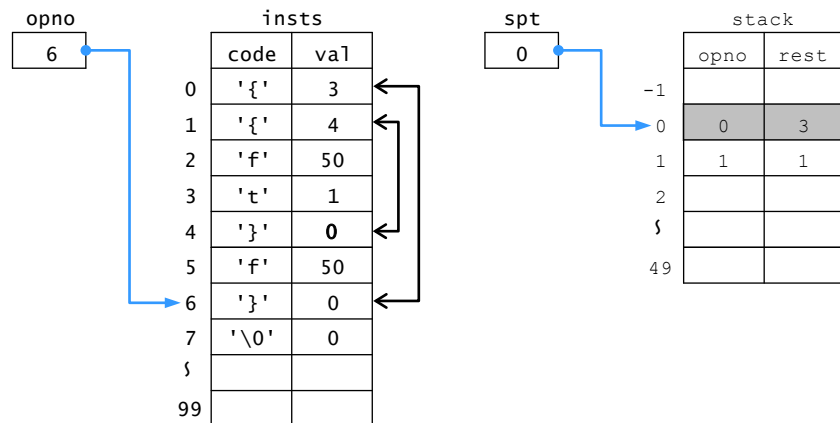


Fig. 9 The content of the structure arrays `inst` and `stack` and the indexes

To fill in blank F, it is sufficient to find failures that occur when handling is continued with no action taken in the blank, and to consider the handling needed to avoid those failures.

When handling moves from the state of Fig. 9 to the next handling without any action, first the index `opno` is incremented from 4 to 5 in Line 38, and thus `insts[opno].code` becomes `'f'`, and Block (3) is handled. No particular failure occurs when Block (3) is handled. When the handling of Block (3) is completed, `opno` is incremented from 5 to 6 in Line 38. Because `insts[opno].code` is `'}'`, Block (4) is handled. At this time, a failure occurs when the value of the index `spt` of the structure array `stack` remains 1. This is because the repetitions enclosed within element numbers 1 and 4 have terminated, and therefore must be removed (popped) from the stack. In other words, the index `spt` must be set to 0. This is shown as a figure below.

Fig. 10 The index `spt`

In order for the Fig. 10 state to result when the index `opno` is 6, the index `spt` must be decremented after the instructions enclosed within the `'{'` of element number 1 and the `'}'` of element number 4 have been repeated 4 times. Therefore, answer f), `spt--`, is inserted into blank F. The value is not actually removed from the stack, but as the position of `++spt` is overwritten when `'{'` is next handled, a problem does not occur.

Note that as blank F does not include handling which decrements the stack pointer `spt`, it can be filled even if the corresponding position is sought. As the timing by which the stack pointer `spt` should be decremented is after the function of one `stack[spt].rest` has been completed, blank F can be deemed appropriate as the position.

Q12-2 Program to output customer information of a credit card company (C)

[Answers]

[Subquestion 1] A-e), B-f), C-g)

[Subquestion 2] D-f)

[Subquestion 3] E-c), F-a)

[Explanation]

The program reads in data from files and stores the data in a binary search tree. As questions concerning file input/output and securing dynamic memory have become more prevalent, their syntax and methods of use should be understood. In particular, methods of representation when pointers to structures are used need to be understood in detail to solve such problems. The following will focus on the movement of the pointer as it is moved and traced.

[Subquestion 1]

This question concerns filling in the blanks in Program 1. The function `init` section, which reads from files, contains no blanks, and requires consideration of the function `regist` that registers data in the binary search tree, and the function `writeMember` that outputs to a file. The problem will be addressed after reviewing the whole to ascertain what must be done.

* The function `init`

This function reads in two files, and calculates total usage amounts. Moreover, after the calculation has been completed it calls up the function `regist` and performs registration for each item of data. At this time, on the assumption that both files are sorted in ascending order of member ID, it continues processing until all data from the member files have been read.

* The function `regist`

This function registers data. The locations in which it registers data are the positions for which the magnitude relationships of the data are correct in the binary search tree.

* The function `writeTree`

This is the section that outputs data. It opens the output file and outputs data. In the section that actually performs output, it uses `writeMember`, which is a recursive function.

* The function `writeMember`

This function uses recursion to write items of data one by one to a file. Using recursive calls, it performs output in the following order (in-order): left subtree → node data → right subtree.

* Blanks A, B: This is the section that registers new data in the binary search tree. In the function `regist`, area for the new data is secured and values are assigned in the following section:

```
p = (struct MEMBER *)malloc(sizeof(struct MEMBER))
```

After this, in the next section, the program searches for an appropriate location where new data should be registered.

```
while ( ptr != NULL )
    pre = ptr;
    if ( amount < ptr->amount ) ptr = ptr->left;
    else                        ptr = ptr->right;
}
```

Here, one data item previous is stored in pre as 0 XXX

At the start of the while loop, the value of the variable `ptr` is `root`, and the loop is terminated if `ptr` becomes `NULL`. In other words, the search proceeds from root in order, using the variable `ptr`, and if `NULL` is detected at the start, that is the location at which registration should be performed. Moreover, the pointer to the parent data of the data to be newly registered is assigned to the variable `pre` as `pre = ptr`, before the next data is searched. After this, in the next section, the location to register `p` is decided.

```
if ( amount < pre->amount )
else
```

A
B

In the earlier `while` statement, it was understood that `pre` is the parent of `p`, but as it is not known whether `p` is the right or left child, it is determined with this conditional statement. In the case that `amount < pre->amount`, as `p` retains a smaller value than `pre`, `p` is registered in the left subtree of `pre`. Therefore, A is `pre->left = p`, and e) is the correct answer. If the preceding is not the case, then as `p` is registered in the right subtree of `pre`, B is `pre->right = p`, and f) is the correct answer.

- * Blank C: The format when a list of usage amounts is written to a file will be considered. C is the section that sets variables in accordance with the format written by `fprintf`. The variable `p` that points to the `MEMBER` structure indicates the starting address for each item of member data.

Per Fig. 1, the output consists of member ID, member name, prefecture, and total usage amount. Among the output, looking at the `MEMBER` structure, member ID and total usage amount are integer values, and member name and prefecture are character strings. These can be used as reference. To reference the members of the structure using the pointer variable, it is defined in the syntax that `p` alone can be used instead of `*p` as with normal pointer variables, and that `p->no` can be used instead of `(*p).no`.

Therefore, as member ID and total usage amount are integer values, their content is referenced as is, and are `p->no` and `p->amount`, respectively. Furthermore, member name and prefecture are character strings, and, when character strings are written with a `fprintf` statement, specify pointers to the starting sections, or in other words, the array names themselves. Therefore, reference is performed by the specification of `p->name`, `p->area` are referenced. For this reason, the content of C is `p->no`, `p->name`, `p->area`, `p->amount`, and the correct answer is g).

[Subquestion 2]

The output order of the usage amount list will be considered. When the usage amount list is written with the function `writeMember`, recursion is used in the function and `writeMember` is called again. At this time, execution takes place in the order shown below; the head writes `p->left`, or in other words, the left subtree of `p`.

```
writeMember(p->left, fp);
fprintf(fp, "%5d %-20s %-10s %8d\n", C );
writeMember(p->right, fp);
```

Next, the data referenced with `p` is written, and after that, `p->right` (or in other words, the right subtree of `p`) is written. This is read as a binary tree, and is read in-order priority scheduling by depth from the root node (left subtree – self – right subtree). In the case of a binary search tree, when read in this way, the sorted data is placed in ascending order. Therefore, the answers are narrowed down to e) and f).

The order of sorting will be further considered here. As was noted in Subquestion 1, the location in which data is registered is determined with the pointer variable `pre` of the function `regist`. The location of registration at this time is the left subtree if the following section applies, and the right subtree if not.

```
if ( amount < pre->amount )
```

Considering this in more detail, first, if the total usage amount (`amount`) of the data to be registered is less than the parent `pre`, it is registered in the left subtree. If the total usage amount is the same as the parent `pre`, the condition does not apply, and thus the data is registered in the right subtree.

Considering the reading order in the function `init`, when registering data in the binary search tree, the data is read in in the order of member ID. In other words, as low member IDs are registered first in the binary search tree, high member IDs coming in later are registered in the right subtree. Therefore, when the total usage amount is the same as the parent `pre`, member IDs with lower values are written first, and the correct answer is f).

[Subquestion 3]

This question considers the output order of the function `writeMember`. As total usage amount was written in order of lowest to highest value in Subquestion 2, the problem can be addressed by modification of that section.

* Blanks E, F: For total usage amount to be written in order of lowest to highest value, it can be written in-order (left subtree – self – right subtree) recursively, per the function `writeMember` in Program 1. In order to write in the order of highest to lowest, the order of output can simply be reversed (right subtree – self – left subtree). This is because in recursion the same rules apply even in subtrees, and when output is reversed, the order of output follows the same rules (right subtree – self – left subtree) even within subtrees, and the order of output can be completely reversed. Therefore, as `writeMember(p->right, fp)`, which writes the right subtree, should be executed in E, c) is the correct answer; and as `writeMember(p->left, fp)`, which writes the left subtree, should be executed in F, a) is the correct answer.

After things are sorted as per Fig. 1, blank B can easily be filled. (See the explanation of blank B.)

From the declarations section of “Program” it can be understood that the array `student`, a `STUDENT` type structure, reflects the information in the `student` file. This is shown as a figure below to clarify the correspondence with Fig. 2.

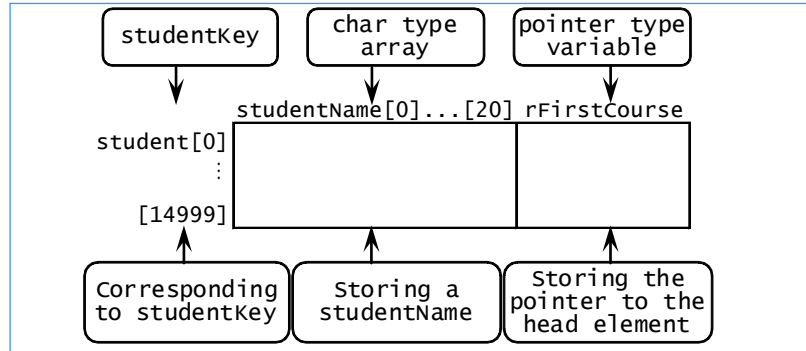


Fig. 2 Array student of STUDENT type structures corresponding to a student key

The difference from Fig. 3 of the question is that the pointer (address) to the head element of the list that represents grade information is stored in the member `rFirstCourse`. The pointer type variable that stores the pointer (address) to the head element of the list is called “list header,” and the member `rFirstCourse` corresponds to this header.

According to (3) in “Program Description” the information in the grade information file is represented as a list structure of the structure `RECORD`. In addition, it can be understood from (4) and (5) in “Program Description” that the structure `RECORD`, which is a list element, is created by the `malloc` function. The state in which 2 items of grade information are registered is shown as a figure below, with the member `rFirstCourse` of the structure `STUDENT` as the header, and the structure `RECORD` simplified to a data portion and a pointer portion.

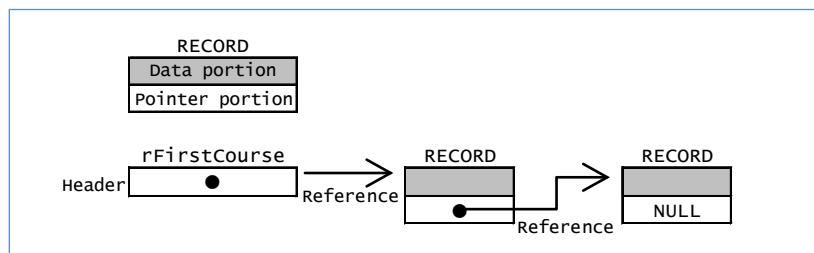


Fig. 3 List structure with two items of grade information registered

In this explanation, simplified figures such as Fig. 3 will be used when pointer operations in the list structure are explained.

[Subquestion 1]

This subquestion concerns filling in blanks in “Program.” For each of the blanks, looking at the answer group should immediately make clear what the intended processing is. What remains is simply to select the choices with syntactically appropriate code. Syntactic knowledge is advantageous in selecting the appropriate choices, but even without such knowledge, selection should be possible by referring to other sections of “Program.”

* Blank A: Blank A asks what should be assigned to `student[studentKey].rFirstCourse`, which corresponds to the list header. Looking at the handling prior to blank A, after the pointer (address) to the structure `RECORD` that was obtained by the function `malloc` is assigned to the pointer type variable `p`, the pointer (address) retained by `student[studentKey].rFirstCourse` is assigned to the member `rNextCourse` of the structure indicated by the pointer type variable `p`. `p->rNextCourse = student[studentKey].rFirstCourse` is shown as a figure below.

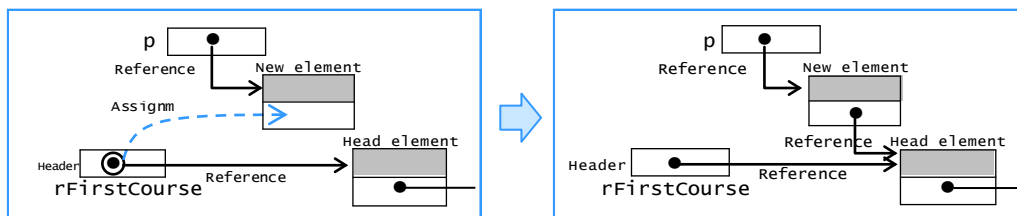


Fig. 4 `p->rNextCourse = student[studentKey].rFirstCourse`

In other words, an attempt is made to register the element that was just obtained by the function `malloc`, in the head of the list. This means that, in the line containing blank A, the pointer (address) of the new element that was stored in the pointer type variable `p` should be assigned to `student[studentKey].rFirstCourse`, which corresponds to the header, and the state should be made as follows.

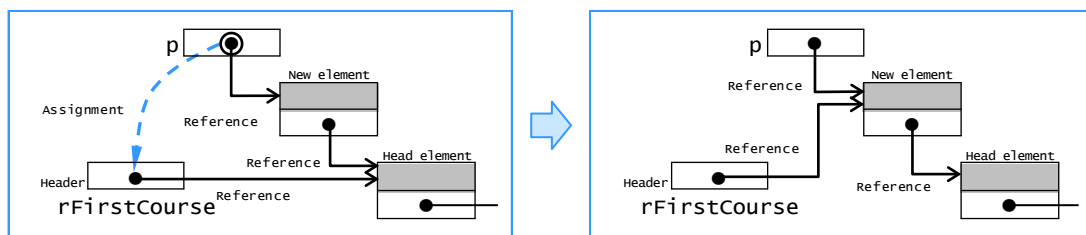


Fig. 5 `student[studentKey].rFirstCourse = p`

Therefore, the `p` of option d) is inserted into the blank.

Students should confirm for themselves that consistency is maintained even if there is no element in the list and `NULL` is stored in `student[studentKey].rFirstCourse`.

- * Blank B: Blank B asks what is stored in the member `courseName` of the structure `RECORD` that was obtained by the function `malloc`. It is explained in (3) of “Program Description” that “a pointer to the course name (is stored in) the member `courseName` (of the structure `RECORD`).” The pointer (address) to the course name is, as was explained before beginning the explanation of the subquestion, `courseName[courseKey]`. Therefore, d) is inserted into the blank.

For blank B, The problem is extremely simple if it is understood that `courseName[courseKey]` is a pointer (address) with the same meaning as `&courseName[courseKey][0]`. However, even if this is not understood, if it is realized that `courseName[courseKey]` is used as the argument of the function `fscanf` which must specify a pointer in the sixth line of the function `init`, then it will be understood that `courseName[courseKey]` is a pointer (address). Moreover, because `&courseName[courseKey]`, which is easily mistaken as the correct answer, is not among the choices, simply selecting d) results in the correct answer.

- Blank C: Blank C corresponds to an argument that specifies the content to be written with the function `fprintf`. Looking at the answer group, it is clear that it specifies the course name and scores, and thus, the question is which statement is appropriate as an argument of the function `fprintf`. The question will be considered with reference to the line that writes student keys and student names, using the function `fprintf` in the same manner.

As course names are character strings, the statement method used when student names (which are also character strings) are written can be used as reference. When student names are written, the statement uses `student[i].studentName`, which is a pointer to character strings that store student names. Therefore, `p->courseName`, a pointer to character strings that store character strings in which course names are stored, can also be used as-is in statements when course names are written, with no need to append the dereference operator `*` or the address operator `&`. In addition, looking at the statement method used when the variable `i` is written, which corresponds to the course key, it can be understood that there is also no need to append the above to `p->score`, the variable that corresponds to scores. Therefore, g) is inserted into the blank.

The problem can also be considered syntactically, as follows.

A variable or value is generally specified for the arguments that specify the content to be written by the function `fprintf`. However, when `%` is used to specify formatting in a character string, it is necessary to specify a pointer. Looking at the format specification that precedes blank C, the format for course names, which is the content that forms the first output, is “%-24s”. Therefore, it is necessary to specify a pointer for course names. Moreover, as `p->courseName` is a pointer to course names, it can be used as-is in statements, with no need to append the dereference operator `*` or the address operator `&`. At the same time, the format specification for scores is “%3d”. Therefore, score need only specify a variable. As `p->score` is a variable, it can be used as-is in statements.

[Subquestion 2]

The subquestion concerns the order of output of course names in a list of grades for credited courses. Course names are written repetitively in the `while` loop of the function `writeCourses`. Moreover, `p = p->rNextCourse`, which is inside the `while` loop, is a process for the purpose of referencing elements in the list in order using the pointer type variable `p`. This is shown as a figure below.

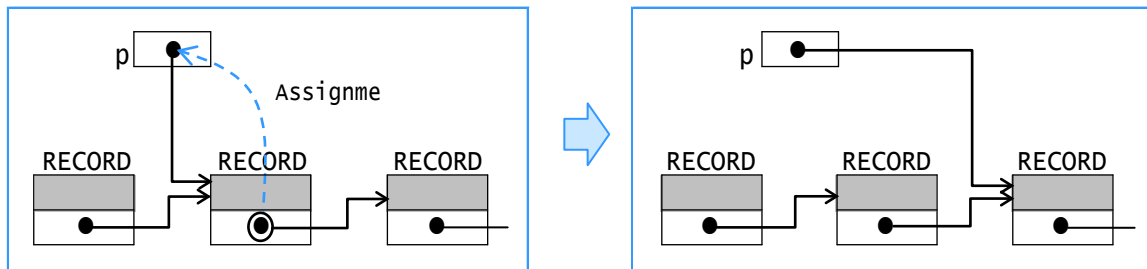


Fig. 6 `p = p->rNextCourse`

In other words, course names are written in the order of the list. In addition, as was considered for blank A, in the function `regist`, elements obtained by the function `malloc` are registered at the head of the list. This means that the elements registered first are placed at the end of the list. Therefore, the elements registered first are printed later. In other words, d) is the correct answer.

[Subquestion 3]

This question involves modifying the α and β sections of the function `regist` so as to write scores in descending order. As was considered in Subquestion 2, scores are written in the order of the list in the function `writeCourses`. Therefore, to write list elements in descending order of scores, how to modify the α and β sections of the function `regist` will be considered.

For purposes of explanation, the program listing of `regist`, with the modified α and β sections, is described with line numbers, auxiliary lines, and block numbers. The answer is in blank A.

```

1 void regist(int courseKey, int studentKey, short s){
2     struct RECORD *p; ← α
3     struct RECORD *q;
4     if ((p = (struct RECORD *)malloc(sizeof(struct RECORD)))
5         == NULL){
6         printf("Memory error\n");
7         exit(-1);
8     }
9     q = student[studentKey].rFirstCourse;
10    (1) if ( [ D ] ){
11        p->rNextCourse = q;
12        student[studentKey].rFirstCourse = p ← β
13    (2) } else {
14        (3) while ( [ E ] ){
15            q = q->rNextCourse;
16        }
17        (4) p->rNextCourse = q->rNextCourse;
18            q->rNextCourse = p
19        }
20    p->courseName = courseName[courseKey];
21    p->score = s;
22 }

```

regist function with modified α and β sections

α corresponds to the variable declarations section, with the modification being the addition of a declaration for the pointer type variable q .

β corresponds to a section that swaps pointers for the purpose of registering elements, and is structured so as to assign `student[studentKey].rFirstCourse` (in other words, a pointer (address) to the head element) to the pointer type variable q in Line 9, and then to execute either Block (1), which contains blank D, or Block (2), which contains blank E.

Blank D: Blank D corresponds to an execution conditional expression of Block (1). Here, what is being done in Block (1) will be considered. In Line 11, the pointer (address) stored in the pointer type variable q is assigned to the new element member `rNextCourse`, which is indicated by the pointer type variable p . As `student[studentKey].rFirstCourse` is assigned to the pointer type variable q in Line 9, the handling in Line 11 is identical to the following.

```
p->rNextCourse = student[studentKey].rFirstCourse;
```

This is the same handling as that of Line 1 in β prior to modification. Furthermore, Line 12 is identical to Line 2 in β prior to modification. In other words, elements are registered in the head of the list in Block (1). Therefore, the conditions for registering elements in the head of the list are inserted into blank D.

As the list elements will be put in descending order of scores, registering elements in the head of the list occurs when there is no head element (in other words, NULL is stored in the header), or when the score of the new element to be registered is the largest score (in other words, when the score of the new element is larger than the score of the head element). The pointer (address) to the head element is stored within the header `student[studentKey].rFirstCourse`, but in Line 9 is assigned to the pointer type variable `q`. Therefore, the choice that appropriately represents the conditions is c), or “`q == NULL || q->score < s`”.

- * Blank E: As the registration of elements at the head of the list was performed in Block (1), in-progress or final registration of the list can be considered as occurring in Block (2). For that purpose, registration of a new element must be performed after a search is performed for an appropriate position that puts the list in descending order.

Searching for the appropriate position can be considered as occurring in the `while` loop of Block (3), for which blank E is a continuation condition. This is because `q = q->rNextCourse`, which is in the `while` loop, is a process for referencing elements in the list in order, using the pointer type variable `q` (see the explanation for Subquestion 2). In other words, the conditions for continuation of the process for referencing list elements in order (search processing) are inserted into blank E. Deducing the continuation conditions requires consideration of the state in which an appropriate position for registration is not found. However, it is easier to consider the state in which the above is found. As such, the continuation conditions will be deduced by considering the found state – that is, the termination conditions for search processing – and then considering the reverse.

Here, the relationship between the pointer type variable `q` used for searching, and the registration position of new elements, will be confirmed. Registration of new elements is performed in Block (4), and from `q->rNextCourse = p` in Line 18, it can be understood that new elements indicated by the pointer type variable `p` are registered behind elements indicated by the pointer type variable `q`. Based on the fact that new elements are registered behind the pointer type variable `q`, the state in which searching should terminate can be depicted per the figure below. Note that the “large” and “small” in the data portion indicate the results of comparison with the score of the new element. (If the compared scores are equal, registration can be performed either before or after the element, and thus this case is not considered.) In addition, “ignored” indicates that either a pointer (address) or NULL is fine.

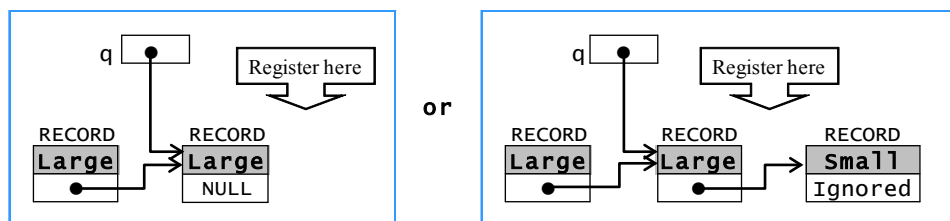


Fig. 7 State in which searching should be terminated

From Fig. 7, it can be understood that searching terminates when there is no element following the element indicated by the pointer type variable q , or when the score of the element following the element indicated by the pointer type variable q is smaller than the score of the new element. This can be expressed as an expression: $rNextCourse = NULL \ || \ q \rightarrow rNextCourse \rightarrow score$ As this is a termination condition, $q \rightarrow rNextCourse \neq NULL \ \&\& \ q \rightarrow rNextCourse \rightarrow score > s$ is the continuation condition. Thus, f) is inserted into the blank.

Incidentally, searching is terminated in the case of $q \rightarrow rNextCourse \rightarrow score = s$, and thus in the event that the scores are equal, registration occurs prior to the element with equal scores. The state in which the registration position that is the continuation condition is not found is shown as a figure below.

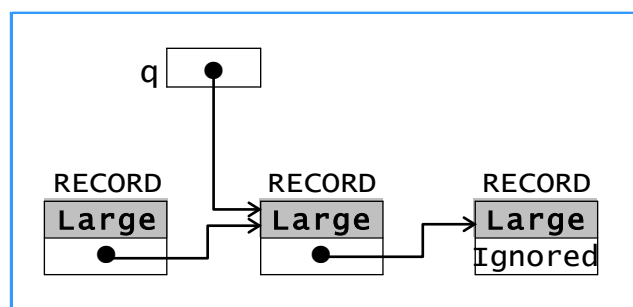


Fig. 8 State in which searching should be continued

Once familiar with the handling of the list structure, the student can note that there is an element ($\neq NULL$) and ($\&\&$) that it is larger ($> s$) than the score of the new element, and can limit the choices to b) and f). In addition, the student can note that the registration position is behind the element indicated by the pointer type variable q , can deduce that $q \rightarrow rNextCourse \neq NULL$, and can quickly arrive at the correct answer f).

Section 12

Software Development(COBOL)

Q12-4 Creation of a grade ranking file (COBOL)**[Answers]**

[Subquestion 1] A-d), B-b), C-e), D-g), E-d)

[Subquestion 2] F-d)

[Explanation]

This program creates a grade ranking file to which per-course ranking is appended from the grade file. The question addresses record sorting functions (the `SORT` statement), single-level control break processing, and table manipulation. In the test for the spring term of 2009 (when the test system was revised), a program using two `SORT` statements was given as a question. Questions are often given concerning the record sorting function itself, but a question involving multiple `SORT` statements had not appeared for some time. This question also involves two `SORT` statements, but it is not difficult if the program overall is understood. Examinees who have trouble with the `SORT` statement should take this opportunity to review it thoroughly.

The overall structure of the program is as follows.

- (1) Records read from the grade file (`IN-FILE`) are divided into records on a per-course basis, and are passed to a record sorting file (`SORT-FILE`). The category code expressing each course is a numeral value 1 to 3, but the ranking column of the sorted file has no meaning.
- (2) Records are sorted in descending order of score on a per-course basis, and are passed to a work file (`TEMP-FILE`). Regarding specification of the record sorting key, the 1st key is the category code (ascending order) that expresses the course, and the 2nd key is score (descending order).
- (3) Records read from the work file are ranked in descending order of score on a per-course basis, and are again passed to the record sorting file.
- (4) To arrange records on a per-examinee basis, records are sorted in ascending order of examinee ID.
- (5) Records are read from the record sorting file, collected as records on a per-examinee basis, and written to the grade ranking file.

The usage of the `SORT` statement will be explained simply.

```

SORT      Specification of the record sorting work file name
           Specification of ascending or descending order (ASCENDING or DESCENDING)
           Specification of the record sorting key (starting with the 1st key if more than one)
           Input procedure section statements ... (A) or (B)
           Output procedure section statements ... (C) or (D)

```

- (A) `USING` input file name (file targeted for record sorting)

This is the statement format when input procedures are not needed and input files are passed to the record sorting work file on a per-file basis.

(B) INPUT PROCEDURE input procedure name

This is the statement format when records are passed to the record sorting work file on a per-record basis and input procedures are needed. It uses the `RELEASE` statement when passing.

(C) GIVING Output file name (file to be sorted)

When output procedures are not needed, records are read from the record sorting work file to the output file on a per-file basis.

(D) OUTPUT PROCEDURE output procedure name

This is the statement format when records are read from the record sorting work file on a per-record basis and input procedures are needed. It uses the `RETURN` statement when reading.

[Subquestion 1]

The overall structure of the program is shown in the explanation, but points to note in answering the question are as follows. Data for the 3 courses is collected in the records of the grade file. Ranking on a per-course basis can be performed by defining a table, but as there is no such table definition, the ordering is to be performed on a per-record basis. For this purpose, the records must be divided on a per-course basis. If the records are divided on a per-course basis, then to perform ranking by high scores, it is necessary to sort the records in descending order of score (the first `SORT` statement). After this, ranking can be performed and written, but in order to again gather the records on a per-course basis, the records are again passed to the record sorting file and sorted according to examinee ID (the second `SORT` statement). Finally, based on examinee ID, the records in the record sorting file can be gathered into a single record and written.

* Blank A: This is a specification of the record sorting key in the first `SORT` statement. From Line 49 and Line 50 of the procedure `IN1-SYORI`, it can be understood that the variable `I` is a category code indicating course (1: Japanese; 2: Mathematics; 3: English). Because record sorting requires records to be sorted on a per-course basis, the first key is category code (`SD-KBN`). Either ascending or descending order is fine, but ranking of the records gathered on a per-course basis cannot be performed if records are not sorted by score. Therefore, specification of the second key is necessary. The correct answer is narrowed down to c), d), or g). The specified order of the record sorting keys is not correct in g), and both category codes and scores are specified as ascending order in c). When scores are sorted in ascending order, it is possible to rank them by reducing the rank from the total number of data. However, as such summing of the total number of data is not found in the procedure `IN1-SYORI`, the correct answer is d), in which scores are specified as descending order. Note that this is made clear within the contents of procedure `IN2-SYORI`.

* Blank B: This is the specified contents of the record sorting key in the second `SORT` statement. As this is for the purpose of reorganizing the records on a per-course basis into the records on a per-examinee basis, so examinee ID is inserted into the blank. Either ascending or descending order is possible, but as the order is ascending by the description (2) (ii), the correct answer is b). Note that f) specifies descending order and is thus incorrect.

- * Blanks C, D: These can be considered together here. The procedure `IN2-SYORI` should be understood as the process that performs ranking. From Line 73, it can be understood that `WK-JUNI` expresses the order calculated. What should be noted with respect to ranking is that, as in the example in the description, the rank is the same when the scores are the same, and when the same rank continues, the next rank increases by that amount. When records are considered to be sorted in descending order of score, they become as follows:

Record input order	Score	Ranking
1st	100	1
2nd	98	2
3rd	98	2
4th	97	4
:	:	:

In other words, the new rank in the event that the same score continues corresponds to the number of input records. In Line 76, as `WK-CNT` performs a count every time a record is read, `WK-CNT` can be understood as a variable expressing the number of input records. Realizing this should make solving the problem faster.

As initial values are not set in the DATA portion of either `WK-JUNI` or `WK-CNT`, these must be set. As long as `WK-JUNI`, which expresses rank, is not increased by 1 and then written, its initial value must be 1. In addition, after the input of the first record in Line 60, and after the input of the second record in Line 75, `WK-CNT` must have the value 2 in the next line. From the above, the correct answer for blank C is e). With the initialize statement in c), 0 is set, and as correct processing is not possible with either of `WK-JUNI` or `WK-CNT` as in d) and f), those are also incorrect.

In addition, blank D is inside the `IF` statement that starts in Line 69. Looking at the conditions, this is executed when the record score that was read is smaller than `WK-TEN`. Considering this from the other viewpoint, it is escaped when they are equal (or more accurately, \geq). In that case, as the value of `WK-JUNI` in Line 73 gets set as-is, blank D can be understood as processing that updates the content of `WK-JUNI` with a new rank. As this needs only move the content of `WK-CNT`, the correct answer for blank D is g). At this time, as in Line 71, the current score must also be updated for the purpose of comparison with the next score.

Note that correct rank is not calculated with a simple count as in a), and thus this is an incorrect answer.

* Blank E: This is contained within the last output procedure, `OUT-SYORI`. Here, handling is needed that takes the records divided on a per-course basis and gathers them into one. Looking at the `PERFORM` code beginning in Line 86, the same handling is performed three times. As there are three courses, this can be deemed the handling that performs the gathering. What should be noted is that the order is set as from Japanese to English, but as record sorting in blank B only sorts the records by examinee ID, the record order of each course is indefinite. It might be thought that the variable `I` can be made to match as-is and set in order, but that is not the case. Sorting unsorted records into correct order requires use of the category code. Therefore, the correct answer is d). Note that the increase and decrease in b) and c) have no meaning and thus these are incorrect answers.

[Subquestion 2]

This content modifies the program to enable output of the total scores for the three courses and their order as well. As is clear from the addition of the modification to the program in the table, blank F asks about the location for inserting statements that pass the total score for the three courses and its category code (4) to the record sorting file. This must be performed before the next new record is read. In addition, c) is incorrect because within the `PERFORM` code in Lines 49 to 53 it is executed three times.

The locations between Lines 48 and 49, between Lines 53 and 54, and between Lines 54 and 55 can be considered candidates, but from among the choices the correct answer is d).

Note that with a), handling is correct from the 2nd record onward, but the first record is prior to input and thus is not handled correctly. With b), examinee ID is not set. e) is after all input file records have read, and thus is meaningless and incorrect.

Q12-5 Summation of number of users of an interval between train stations (COBOL)

[Answers]

[Subquestion 1] A-b), B-f), C-f), D-a)

[Subquestion 2] E-c), F-e)

[Explanation]

This program sums and prints the number of passengers of each segment between stations on a train line that connects stations *A* through *J*. As the program is somewhat long and uses many variables, it must be traced with patience. A two-dimensional array is used in the handling, and it is first important to understand the array's structure. Afterward, the contents of the question can be understood by creating appropriate data and tracing the program. Subquestion 2 tests whether or not the meaning of the array (table) defined for the purpose of modification has been understood, but the fact that there are 9 defined data items can be used in guessing. The key point in resolving the problem is understanding the method for using the two-dimensional array defined by the first program, and the summing of the number of passengers for segments between stations in both directions (inbound and outbound). In consideration of the time required to answer the question, it is fairly difficult.

First, the following is an explanation of the structure of the 18-row, 9-column, two-dimensional array used in the program. There are 10 stations from *A* to *J*, with columns corresponding to the segments between stations. Each station opens at 6 A.M. and closes at 12 A.M.; thus, each of the 18 rows should be understandable as indicating an hour-long time slot. In addition, judging from the data names, UP-TABLE is for the inbound train and DOWN-TABLE is for the outbound train.

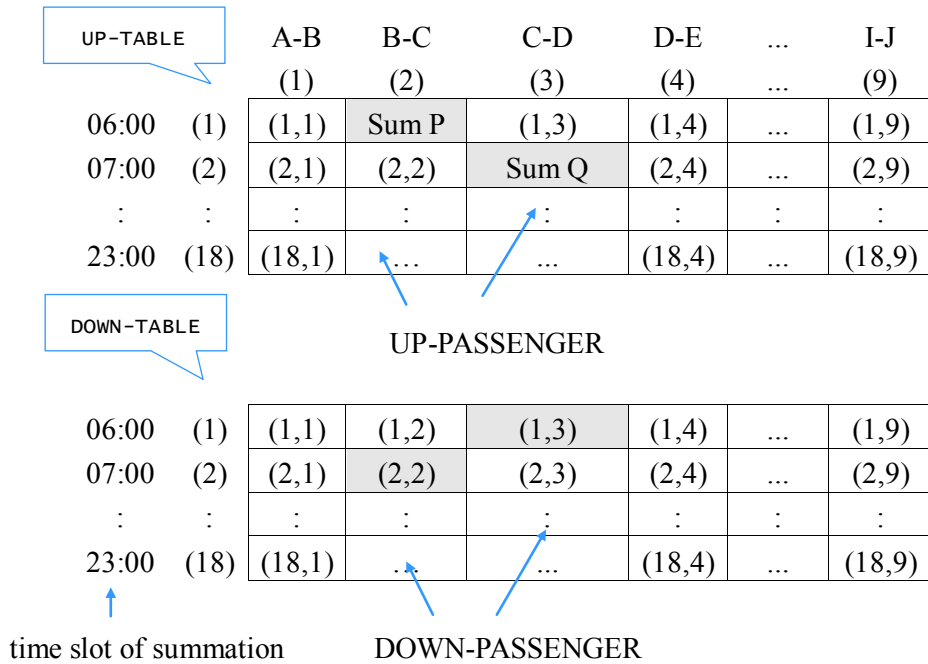


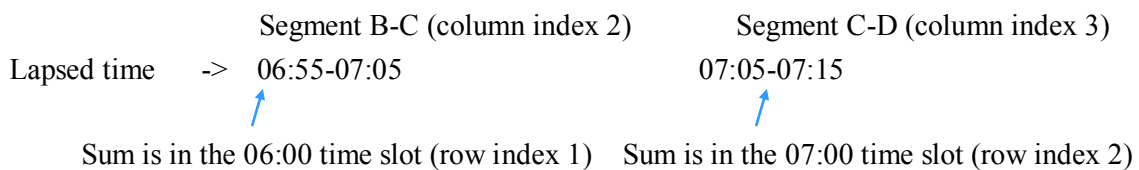
Fig. A Structure and meaning of two-dimensional array

As per the question description, upon entering from Station *B* at 6:55 and exiting from Station *D*, the content of the record is as follows:

Starting station: <i>B</i>	Ending station: <i>D</i>	Time of entry
02	04	0655

Fig. B Input record data example 1

As the section of the array in which this data is summed is explained in (2) (iv), the correspondence relationship must be thoroughly understood. With the travel time between each pair of stations being 10 minutes, and taking note that ridership from 07:00 to 07:59 is summed in the 07:00 row, the following holds.



Therefore, for the data in Fig. B, 1 is added to the shaded sections of the UP-TABLE (Sum P and

Sum Q). In other words, first of all, the row index corresponds to the time slot of entry into the station, and the column index corresponds to the numeric value of the station entered. And then, the counting is done for each segment up to the ending station, while calculating lapsed time. However, it must be noted that as the travel time for each segment is 10 minutes, when lapsed time transitions to the next summation time slot, the row index is increased by 1.

Condition names (level 88) are used in the program, but as these have appeared in many past questions, the Subquestion will be explained under the assumption that syntactic matters are understood.

[Subquestion 1]

Lines 44 to 49 are the main PERFORM statement that repeats the summing. The procedure COUNT-PASSENGER is repeated every time that a record is read. This can be understood as a procedure that sums the number of passengers for the segments. Line 50 can be understood as the output process of the number of passengers for each segment summed in the array; as such, the overall structure of the program is simple. Regarding the details of each procedure, data examples will be used to perform tracing.

* Blank A: This is the content of the first IF statement in the procedure COUNT-PASSENGER. If the condition is TRUE, then the condition name UP-WAY becomes TRUE, and thus the content of the data name WAY becomes 1 at this time. If the condition is FALSE, then conversely, the content of WAY becomes -1. As this WAY acts to make the increment +1 or -1 in the PERFORM statement in Line 61, it can be thought of as determining inbound or outbound. Per the question description, considering the value of the numbers indicating the stations, inbound is the direction “A→J,” with the number of starting station < the number of ending station, and with +1 as the direction. Outbound is the direction “J→A,” with the number of starting station > the number of ending station, and with -1 as the direction. Therefore, the correct answer for blank A is b), “starting station (IN-STATION) < ending station (OUT-STATION)”.

* Blank B: This appears inside the PERFORM statement starting in Line 61. This PERFORM statement is repeated up through the ending station, taking the value of the starting station as the initial value of the variable SECT-IDX. This can be understood as repetition that sums the number of passengers for segments. The content of the IF statement (Lines 63 to 67) will be examined, using the input record data example 1 indicated in Fig. B.

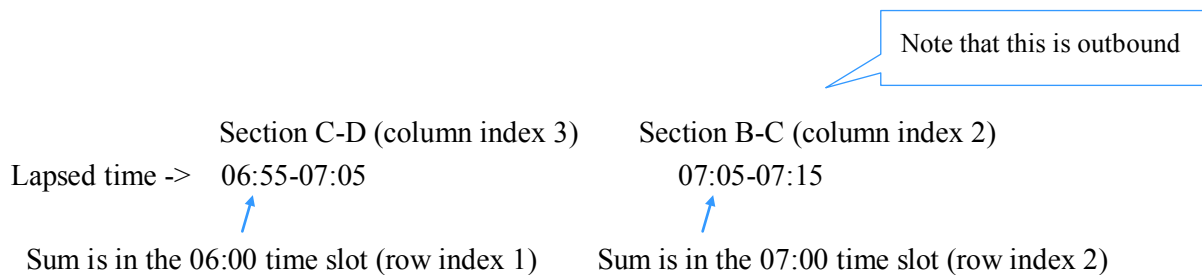
First, in Line 54, IN-STATION(02) < OUT-STATION(04), which indicates UP-WAY (inbound). When the condition (UP-WAY) in Line 63 is TRUE, 1 is added to the element of the array (TIME-IDX, SECT-IDX). TIME-IDX is calculated in Line 59; applying data, its value is as follows.

$$\text{TIME-IDX} = \text{IN-HH} - 5 = 06 - 5 = 1$$

This is the row index for performing summation. In addition, initial value is set to SECT-IDX in Line 61; as this is the value of the starting station, it is 2. Therefore, it can be confirmed that 1 is added to the element of Sum P. At the same time, when the condition is FALSE, outbound is indicated, and Line 66 is executed. At this time, it is necessary to assume outbound data. The reverse of the previous data example will be considered next.

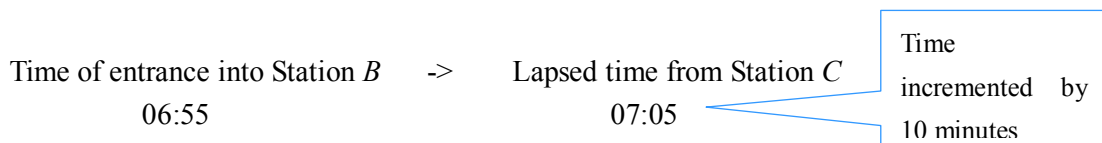
Starting station: <i>D</i>	Ending station: <i>B</i>	Time of entry
04	02	0655

Fig. C Input record data example 2



If the locations of summation at this time are considered as indexes, the first is (1, 3) and the next is (2, 2) (the shaded portions of DOWN-TABLE in Fig. A). There is no change in the time slot row, and the value of the column corresponding to segment is different. In other words, it can be understood that “the value of starting station - 1” can be made the initial value of the column, and summation need only continue subtracting 1. Therefore, the correct answer for blank B is f), which uses “SECT-IDX - 1”. Note that, as indicated in Fig. A, summation proceeds separately for inbound and outbound, and thus attention must be paid to the data names.

- * Blank C: This is the condition for the IF statement starting in Line 69. When this condition is TRUE, TIME-IDX and TIME-CNT are calculated. TIME-IDX can be understood as indicating “hours,” and, from Lines 60 and 68, TIME-CNT can be understood as indicating “minutes.” In Lines 63 to 67, after summation (+1) is performed for the first time slot, 10 is added to TIME-CNT in Line 68, which can thus be understood as a calculation of lapsed time to the next station (as lapsed time between stations is 10 minutes for all segments). As Line 70 adds 1 to TIME-IDX (hours) and line 71 subtracts 60 from TIME-CNT (minutes), this can be understood as adjusting the time slot. Using the data example from Fig. B, the calculation is as follows.



Simply adding 10 to TIME-CNT results in 65, but as this exceeds 60 minutes, the time slot must advance to the next time slot. For that purpose, it must be determined whether the value has become 60 or greater. Either “TIME-CNT > 59” or “TIME-CNT >= 60” can be considered, but from the available choices, f) is the correct answer. What should be noted is the process when the value is exactly 60 minutes. An explanation is given in the question description (2) (i),

which advances the time slot to the next time slot. For example, when the time of entry is 06:50, the next station is reached at $50+10=60$ minutes (i.e., 10 minutes later); however, this is 07:00, and summation takes place in the next time slot. Note that in e), adjustment occurs only at exactly 60 minutes, not when the value exceeds 60 minutes, and thus this answer is incorrect. Moreover, it is meaningless in determining the data name `TIME-IDX` (hour).

- * Blank D: This is contained within `PRINT-DATA`, which is an output procedure that comes after passengers for a segment are summed. Here, only output of the summed number of passengers needs to be performed. The output print format is indicated in question description (2), with inbound and outbound passengers printed as a set for each time slot. In order to do so, the summation results are repeatedly printed row by row (with columns repeated for each fixed row). Blank D is the content that is common to the `PERFORM` statements in Lines 81 to 85 and Lines 89 to 93, but looking at the data names used in the array, it can be understood that the former handles inbound data and the latter handles outbound data. As either one repeats the same process 9 times, they share the same method of use, and judging from the fact that the process occurs 9 times, it can be understood that they are column elements. Moreover, as the `PERFORM` statement that controls the whole is in Line 76, and as this repeats `TIME-IDX` from the initial value 1 through 18, it functions as control of time slots. As the `PERFORM` statements in Lines 81 and 89 are repeated within that, this is the content of the element (column) for each station. Therefore, when this is considered in the form of indexes, it is handled by `SECT-IDX`, and the correct answer is a). Note that `PR-PASSENGER`, which is a storage location for details, is a one-dimensional array, and thus there being a single index also provides a hint for evaluating choices.

[Subquestion 2]

This concerns a modification of specifications to more accurately sum the number of passengers for segments. A table (array) holds the travel time between stations in units of minutes. Understanding the meaning of the table is the key to solving the problem.

- * Blanks E, F: The structure of `TIME-TABLE`, which provides additional definition of the specification modifications, is as follows.

	A-B	B-C	C-D	D-E	E-F	F-G	G-H	H-I	I-J
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
SECT-MM	08	06	11	07	10	09	08	10	13

TIME-DATA

As there are 9 elements, it can be surmised that these correspond to the segments between stations. What do the values of the elements mean? Judging from the fact that the numeric values are close to 10, it can be guessed that these are the lapsed time between stations. As the contents of the specification modifications include the calculation of `TIME-CNT`, it should be possible to relate this to calculation of “minutes.” In other words, while calculation was handled so far simply using increments of 10 minutes, this is for the purpose of calculating accurate lapsed time and performing summation according to the lapsed time slots between stations. As the lapsed time to the next station cannot be calculated when Line 68 is deleted,

the formula is added immediately after Lines 64 and 66. The former is for inbound and the latter for outbound, but using the sample data in Fig. B, 06 should be added initially, and using the sample data in Fig. C, 11 should be added initially (note that this is in the reverse direction). The value of the station entered can be used as the index, but as was explained for blank B, it must be noted that in the case of outbound, the index should be decremented by 1. Therefore, the correct answer for blank E is c), which uses `SECT-IDX` (station entered), and the correct answer for blank F is e), which uses `"SECT-IDX - 1"`. Note that other choices are incorrect as they are contradictory and do not allow correct calculation of lapsed time (minutes).

Q12-6 Creation of a caregiver list (COBOL)

[Answers]

[Subquestion 1] A-a), B-e), C-d), D-a)

[Subquestion 2] b)

[Explanation]

This is a question to create a caregiver list for an elementary school. The contents concern file matching, which is a fundamental processing in COBOL. Matching is often easy to solve if the logic is understood, but as this question uses many condition-name conditions, it can be expected to cause some confusion. However, it is not difficult if the three processing sections are looked at and traced while their meanings are considered. The difficulty level is average.

From the specifications of the question description, the following three record creation types can be envisioned.

1. Records created only from the list of caregivers (of existing students) from the last academic year (duplication)

This is data for caregivers of existing students, who do not have new students (i.e., siblings of the existing students). For this case, the academic year simply needs to be advanced 1 year. However, students who graduate should not be included in the output.

2. Records that are created from the list of caregivers (of existing students) from the last academic year and caregivers of new students (updating)

This is for caregivers of existing students, who also have new students (i.e., siblings of the existing students). The existing students (with academic year updated) and new students (with academic year set to 1) are to be gathered and written as a single record. In the event of multiple existing students, these are to be recorded in ascending order of academic year and left-justified, with care taken to set blanks in the area remaining. In this case, too, there may be students graduating, who are not among the targets for recording (storage).

3. Records created only from the caregiver list for new students (appending)

This is for the case of caregivers who have only children who enter as new students. In this case, these are appended to the current caregiver list. The academic year should be set to 1 in the Grade field.

In the files storing the last academic year's caregivers and new students' caregivers, it is a necessary condition that there not be multiple records in each containing the same caregiver name and telephone number. This is posed as a condition that can be understood naturally when considered theoretically. In addition, it is assumed that there are caregivers with the same first name and last name; however, as matching keys, including telephone number, are set, these can be distinguished. Thus considered, the matching will be 1:1, with basic logic as follows.

The matching key for the old master file and the matching key for the transaction file are termed master-key and transaction-key, respectively. The 1:1 concept is as shown below.

- o Repeat the following compare operation
 - until master-key = HIGH-VALUE and transaction-key = HIGH-VALUE
- o Compare master-key : transaction-key
 - Case 1: Do when master-key < transaction-key
 - o Write new master file
 - o Read old master file
 - Case 2: Do when master-key = transaction-key
 - o Update process
 - o Read old master file
 - o Read transaction file
 - Case 3: Do when master-key > transaction-key
 - o Append process (or error handling process)
 - o Read transaction file

Fig. 1. 1:1 general processing flow

(Case 1) If the master-key is less than the transaction-key

As there are no changes in records having this key, the content of the old master file is duplicated as-is to the new master file, and the next old master file is read.

(Case 2) If the master-key and transaction-key are equal

The content of the old master file is to be updated with the content of the transaction file. As multiple records of the same key do not exist, after update process, the old master file and transaction file are read and key matching is performed again.

(Case 3) If the master-key is greater than the transaction-key

This is the case in which a record with a transaction key which is not found in the master file appears in the transaction file. Error handling or appending process is performed and the next transaction file is read. The content of the process here varies somewhat with the conditions of the question. When appending process is performed as per the question, the record should be newly written, and read the next transaction record. Moreover, even when error handling is performed, read the next transaction record afterward.

(*) Conditions by which all processing ends

When there are no longer records requiring input, the maximum value (HIGH-VALUE) is entered into the matching key. As processing ends when no records remain in either file, the values will be “master-key = HIGH-VALUE and transaction-key = HIGH-VALUE”.

In this question, caution is required as there are conditions on the updating of academic year, the determination of graduation (process of removal from the list), the storing order of existing students, etc. But as the basic concepts are unchanged, tracing of the question can be performed while considering the three processes according to key comparing operation. In solving the question, caution will be paid to the data names and condition names used in the program, and their correspondence relationships. In other words, the question is which name is related to the old master file and which name is related to the transaction file. A mistake here will reverse the direction of the sign of inequality, possibly resulting in an error.

The correspondence relationships among the files used by the program are as follows.

Old master file : last academic year's caregiver list (OLD-FILE)

Transaction file : new students' caregiver list (ENT-FILE)

New master file : current academic year's caregiver list (NEW-FILE)

Master-key : (OLD-ID) contained in working area of last academic year's caregiver list (W-OLD-REC)

Transaction-key : (NEW-ID) contained in working area of new students' caregiver list (W-NEW-REC)

Moreover, the meanings of the condition names that control input of the input files are as follows.

Content of READ-FLG	Condition name	Corresponding input file process
“B”	READ-BOTH	Read both last academic year's caregiver list and new students' caregiver list
“O”	READ-OLD-FILE	Read last academic year's caregiver list
“E”	READ-ENT-FILE	Read new students' caregiver list

The procedure CREATE-PROC from Line 58 corresponds to the logic portion that performs matching. If this is understood and the procedures NUM-UP-PROC and ENT-ADD-PROC are traced, the question should be solvable. Subquestions will be explained as follows on the assumption that condition-name conditions are understood.

[Subquestion 1]

* Blank A: The `PERFORM` statement in Lines 41 to 55 can be understood as content that concerns record input process. All processing ends when the conditions in Line 41 are satisfied and when both of the matching keys of the input files are at maximum value (`HIGH-VALUE`). As matching begins after the first records are read from the two input files, it is clear that this can be achieved by the `IF` statement in Lines 42 to 51. From here, the procedure `CREATE-PROC` is executed and the process begins via the `IF` statement in Line 52. Therefore, for blank A, the condition that will execute this procedure should be considered. The `IF` statement in Lines 42 to 46 controls input into the previous academic year's caregiver list, and the `IF` statement in Lines 47 to 51 controls input into the new students' caregiver list, but when no input record exists, the maximum value (`HIGH-VALUE`) is set. In other words, although the file eventually ends, in the event that the procedure `CREATE-PROC` does not have to be executed, all handling ends. Restated, the condition for executing the procedure `CREATE-PROC` is the condition for blank A. This is the case in which records still exist in either of the input files. An answer which agrees with this condition should be selected. The name of the condition is "`NOT OLD-EOF OR NOT ENT-EOF`". Considering the choices a) and b) leads to the following.

(a): `NOT(OLD-EOF AND ENT-EOF)` is equivalent to `NOT OLD-EOF OR NOT ENT-EOF`.

(b): `NOT(OLD-EOF OR ENT-EOF)` is equivalent to `NOT OLD-EOF AND NOT ENT-EOF`.

In the case of such conditions, De Morgan's laws can be used. Expressing A and B as logical variables,

$$\text{NOT}(A \text{ AND } B) = \text{NOT } A \text{ OR } \text{NOT } B$$

$$\text{NOT}(A \text{ OR } B) = \text{NOT } A \text{ AND } \text{NOT } B$$

hold true. Therefore, the correct answer is a).

* Blanks B-D: The `EVALUATE` statement in Lines 60 to 80 must first be understood. From the conditions in Lines 61, 65, and 76, the meaning of the process in each is as follows.

(1) Lines 62 to 64

This is the case when the process uses only the last academic year's caregiver list. Consideration should focus on the flow by which the current academic year's caregiver list is created by way of the procedure `NUM-UP-PROC` and blank B. In terms of basic logic, this corresponds to duplication.

(2) Lines 66 to 75

This is the process that creates the current year's caregiver list from the last year's caregiver list and the new students' caregiver list. It is achieved by executing the two processes `NUM-UP-PROC` and `ENT-ADD-PROC`. In terms of basic logic, this corresponds to updating.

(3) Lines 77 to 79

This is the case when the process uses only the new students' caregiver list. Note that the procedure `ENT-ADD-PROC` is executed. In terms of basic logic, this corresponds to appending.

With (1)-(3) above having been understood, the section (1) will be further considered. This section first executes NUM-UP-PROC. Looking at the condition in Line 87, whether an existing student's grade is less than 6 is determined, and if so, blank D is set in the existing student area, whereas if not (i.e., if the grade is 6), a blank is set in the existing student area. In other words, this can be understood as the process of graduation. This means that, when grade is less than 6, process of grade advancement (advancing academic year by 1) is necessary. Blank D should carry that meaning, with the only corresponding answer being a).

As the flow in (1) creates the current year's caregiver list from only the last year's caregiver list, the content can be written out after processing of grade advancement and graduation has been completed. As Line 64 is the set of conditions for connecting this to input of the next record, blank B is the content written to the new master file (the current year's caregiver list). However, as that output is performed in the IF statement in Lines 81 to 83, here only the setting of the data need be performed. As the data area of the last year's caregiver list is W-OLD-REC and the data area of the current year's caregiver list is W-NEW-REC, the correct answer for blank B is e).

(2) is the content of the updating. The procedure NUM-UP-PROC is executed first; this can be understood as the process of grade advancement and graduation. The next statement is the setting of the matching key. After that, the procedure ENT-ADD-PROC is performed. Looking at procedure ENT-ADD-PROC, it can be understood from Lines 96 and 97 that the setting of new students is performed. The reason why this is performed through repetition is the assumption that multiple entry into the school is possible, which can be imagined as cases involving twins (or even the unlikely case of triplets or more, etc.). The reason for first process new students is that, as per the program specifications, these are stored left-justified (ascending order of academic grade). Therefore, the next process is that of existing students. Lines 69 to 74 correspond to this. ENT-CNT is the index when new students are stored in the student area. This indicates the next empty area in the existing student data space for the current year's caregiver list. Existing students can be set from this value. As the index for the student field in the last year's caregiver list is OLD-CNT and is 1, the index for the student field in the current year's caregiver list is NEW-CNT and has the value of ENT-CNT; therefore, the correct answer for blank C is d). It is easy to mistake c) as the answer, but understanding the meaning of the index should make clear that this is incorrect. It is also meaningless by virtue of not being counted up.

While the above covers the answers that go into the blanks, a final supplementary explanation is given here for the `IF` statement starting in Line 81. Whether duplication, updating, or appending is performed, this `IF` statement is evaluated. At this time, in the case of updating or appending, there must be one or more existing students. However, in the case of duplication, when the process of grade advancement and graduation is performed on the last year's caregiver list data, caregivers who have only children in grade 6 are not written. Only the process of grade advancement and graduation is performed in the procedure `NUM-UP-PROC`. Following this, after updated values are set in the area for creating the current year's caregiver list, this `IF` statement is executed. At this time, as the student area on which the process of graduation was performed is blank, caregivers with only graduating child will not be written to the current year's caregiver list. Considering this in the opposite way, if there is at least one existing student, the caregiver will be written, and thus through such evaluation (i.e., determination of whether the first element is blank), the process will be performed correctly.

[Subquestion 2]

This concerns modification of the program to display the names and telephone numbers of caregivers who have been removed from the caregiver list. As was discussed at the end of Subquestion 1, this targets caregivers who only have children who will graduate. As this is determined by the `IF` statement from Line 81, b) is the correct answer. The possible mistakes in the remaining choices are as follows.

- a): The `IF` statement in Line 52 determines whether matching will be performed, and if the conditions in blank A do not hold, this means all processing has ended. This is meaningless, and as long as the procedure `CREATE-PROC` is not executed, determination of graduation and the handling of blanks cannot be performed.
- c): The procedure `NUM-UP-PROC` is the process of grade advancement and graduation. At this point, even in the case of students who will graduate, if there are other siblings then the caregiver must be written to the current year's caregiver list. The display at this point can not handle everything correctly.
- d): As with c), this has no meaning. With this timing, caregivers who have only non-graduating children will also be included.

Section 12

Software Development (Java)

Q12-7 Program for a one-person card game (Java)

[Answers]

[Subquestion] A-d), B-b), C-b), D-b), E-d)

[Explanation]

This is a program for playing a one-person card game. The rules of the game, as stated in the question text, are: From among the cards lined-up on the ground, when cards of the same rank are adjacent vertically, horizontally, or diagonally, the pair is removed from the ground. This is repeated. If all cards are removed, the game is won. In the program, the objects representing cards are manipulated by a list, which is a relatively simple method. However, treatment of the relative vertical, horizontal, and diagonal positions calls for some care. Syntactically, `private` constructors and `static` initializers are taken up for the first time, but overall the difficulty is a bit low.

[Program Description]

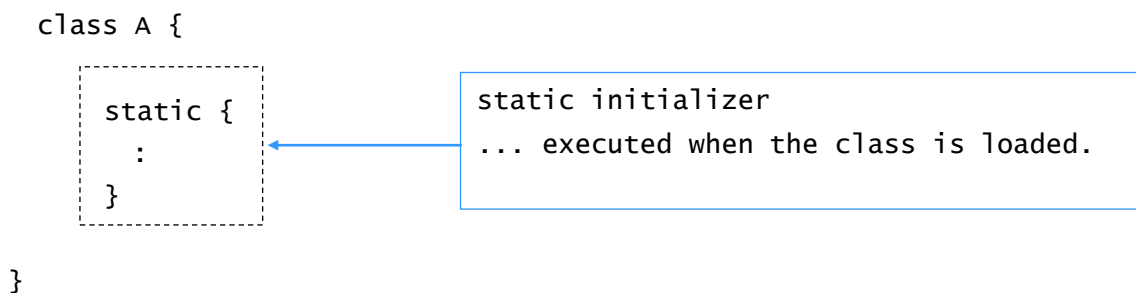
First, in the `Card` class, the constructor is specified as `private` and thus this class's constructor cannot be called from outside the `Card` class. Therefore, `Card` objects cannot be created from outside the `Card` class. However, creation of objects is possible with `static` methods, etc., defined in the `Card` class.

The `private` declaration of constructors is usually used when it is desirable to limit the number of objects created. For example, the `java.lang.Math` class is composed of a group of `static` methods for mathematical functions, but as there is no need to create objects, the constructor is declared as `private`, and objects cannot be created. In the `Card` class, the number of created objects is sufficient at $13 * 4 = 52$, and to prevent the creation of unnecessary objects from outside the class, the constructor is declared as `private` and therefore, cannot be called from outside of the `Card` class. The created objects are stored in the `static` array variable `cards`, and an array with the objects randomly shuffled is returned by the `static` method `newDeck`.

* Blank A: This concerns the object creation block in the `Card` class. As per the above, `Card` objects can only be created in the `Card` class. In such cases, preparing a `static` method within the class and creating objects inside that `static` method is a commonly used technique. As `static` methods can be used without creating objects, this is convenient for creating the limited number of objects.

Within the `Card` class is the `static` method called `newDeck`, which is called at the start of the `main` method and thus can be thought of as creating objects. For example, if `init()` had been called within the `newDeck` method, the correct answer for blank A could have been b), “`private static void init(){}`”. However, as there is no call to `init()`, this is inappropriate. In addition, creation of objects is not performed in this method, nor are there other `static` method calls.

What can be considered as the correct answer for blank A is d), “`static {}`”. Known as a *static initializer*, this is a special block executed at the time when the class is loaded into the Java Virtual Machines (JVM), and is mainly used for the initialization of `static` variables.

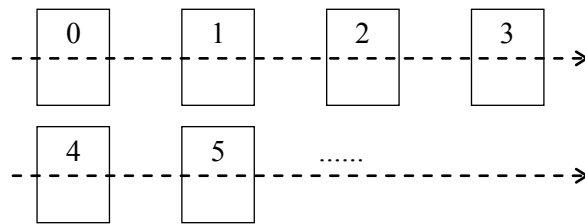


As for the other choices, a), b), and c), their specified method names are not called by other portions of the program. As such, they cannot create `Card` objects, and are inappropriate. Meanwhile, `synchronized` in e) is a keyword that creates a block for synchronizing threads within a method; it is unnecessary and thus inappropriate. f) only creates a meaningless block, and is inappropriate.

- * Blank B: This concerns the index of the array `cards` for storing `Card` objects created inside the `static` initializer. The blank in question is inside a double `for` loop, with the variable `i` in the outer `for` statement varying within the range 0 (SPADES) through 3 (CLUBS), and the variable `j` in the inner `for` statement varying within the range 1 to 13. Next, `Card` objects are created with the variables `i` and `j` as arguments, and are stored in appropriate positions in the array `cards`. The size of the storage destination, the array `cards`, is $13 * 4 = 52$, and thus an expression that uses the variables `i` and `j` to calculate numbers in the range 0 to 51 without duplication should be selected. Therefore, the correct answer is b), “`i * 13 + j - 1`”.

The program starts from the `main` method defined in the `Game` class. In the `main` method, the `newDeck` method is first called, and the array of randomly shuffled `Card` objects is acquired. Each element in the acquired array is, one by one, added to a list (an `ArrayList` object), and each time, receives handling by the `checkAndRemove` method. In the `checkAndRemove` method, the `currentIndex` variable (the index value of the card currently in focus) is used, the elements of the argument `list` (`Card` objects) are checked one by one, and handling is performed so that `Card` objects satisfying conditions including blank D are removed from `list`.

Here, as addition and removal of `Card` objects are performed, `list` can be surmised to be the object representing the ground. Also, `Card` objects are stored in one-dimensional order in `list`, and logically can be considered to be stored in the following order.



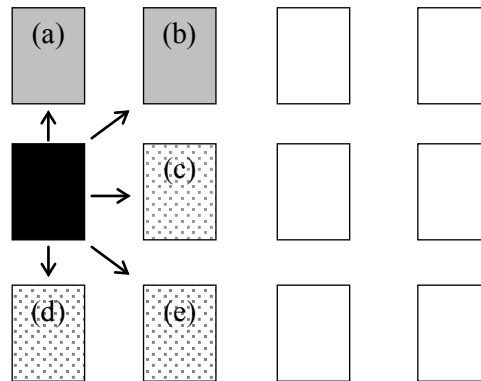
In the `for` statement containing blanks C-E, the elements of the row corresponding to “`currentIndex % 4`” (this section is also a one-dimensional array) are taken out from the two-dimensional array defined at the head of the `Game` class and put into the array `diffList`, and the elements are handled one by one. In other words, the core of this section is the values of the array `diffList` taken out from the two-dimensional array `indexDiff`, and thus it is first necessary to understand what role is played by the two-dimensional array `indexDiff`.

The definitions section of `indexDiff` contains the comment “relative index from the card currently in focus.” In addition, the section with blank C contains the comment “`adjacentIndex` is the index value to adjacent card.” The items in the answer group all calculate values through calculations using the value of `currentIndex` and the value of the array `diffList`, and set the result in `adjacentIndex`, which is the index value of the adjacent card. Furthermore, the rank of the `adjacentIndex`-th element in `list` is compared with `currentRank`. In other words, the value of `diffIndex` (`indexDiff`) is used to calculate the position of the adjacent card that is to be checked, with respect to the card currently in focus (the card indicated by `currentIndex`). However, even noting the values of elements such as {1, 4, 5} and {1, 3, 4, 5}, the meaning is difficult to understand. Thus, conversely, the positions of the cards that are adjacent to the card in the position indicated by `currentIndex`, will be considered.

As explained earlier, the value of the row corresponding to “`currentIndex % 4`” within the two-dimensional array `indexDiff` is set in the one-dimensional array `diffIndex`. The meaning of this “`currentIndex % 4`” will first be considered. `currentIndex` is an index that indicates the card within `list` that is currently in focus. Moreover, `list` is an object expressing the ground, but as it is a linear list it does not incorporate the concept of 4-card rows as used in the actual ground. For this reason, by calculating the remainder after dividing by 4, the position within the row of the card indicated by `currentIndex` is checked. In other words, the value “`currentIndex % 4`” indicates the positions of the cards as 0, 1, 2, and 3, with 0 being the leftmost position. The four (4) cases for the value of “`currentIndex % 4`”, from 0 to 3, will be considered.

(1) `currentIndex % 4 == 0`

This means that the card is in the leftmost position. In the following diagram, the cards (a)-(e) are adjacent cards. However, within the program, only the 3 values {1, 4, 5} are defined for `IndexDiff`. The repetition due to the `for` statement is also only for these 3 values, so that too will be considered.



Note that this checking is performed in order, starting with the card at the head of the `list`. In other words, the checking against cards in positions prior to that of the card currently in focus was performed when each of those cards was the card currently in focus. For that reason, even though a card is adjacent to the card currently in focus, the aforementioned checking is unnecessary if it is a card in a prior position. Considered that way, checking is to be performed for the 3 cards (c)-(e), with the position of each card within the list as follows.

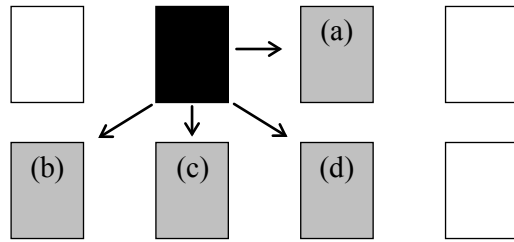
Position of (c): `currentIndex + 1`

Position of (d): `currentIndex + 4`

Position of (e): `currentIndex + 5`

Keeping in mind that cards with a position prior to that of the card currently in focus do not need to be checked, sorting out the targets for checking results in (2)-(4).

(2) $\text{currentIndex} \% 4 == 1$



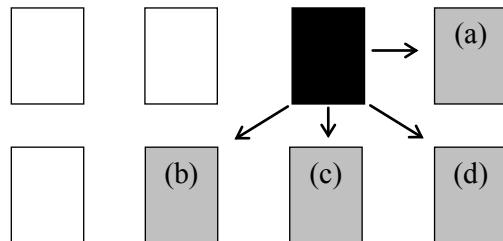
Position of (a): $\text{currentIndex} + 1$

Position of (b): $\text{currentIndex} + 3$

Position of (c): $\text{currentIndex} + 4$

Position of (d): $\text{currentIndex} + 5$

(3) $\text{currentIndex} \% 4 == 2$



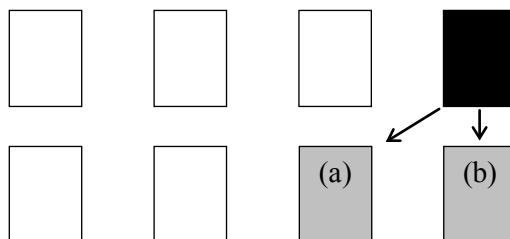
Position of (a): $\text{currentIndex} + 1$

Position of (b): $\text{currentIndex} + 3$

Position of (c): $\text{currentIndex} + 4$

Position of (d): $\text{currentIndex} + 5$

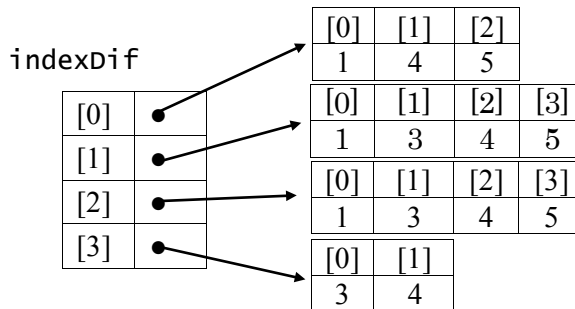
(4) $\text{currentIndex} \% 4 == 3$



Position of (a): $\text{currentIndex} + 3$

Position of (b): $\text{currentIndex} + 4$

The relative index of these from `currentIndex` match the content declared as the two-dimensional array `indexDiff` in the `Game` class, and depending upon `indexDiff[currentIndex % 4]`, can acquire the array of the relative index that corresponds to the card currently in focus. This is because a two-dimensional array in Java is constructed as follows, with each element of the first dimension in `indexDiff` referencing a different array.



The acquired arrays are stored in `diffList`, and only the number of elements in `diffList` have the possibility of an existing adjacent card.

- * Blank C: This is the location for assigning the index of the adjacent card to the variable `adjacentIndex`. As per the above explanation, the relative indexes of the cards adjacent to `currentIndex` are stored in `diffList`, and their values can be added up as-is. Therefore, the correct answer is b).
- * Blank D: This is the condition for removing the adjacent card from `list`, which represents the ground. The condition that the cards are of the same rank has already been stated. Looking at the answer group, the comparison condition for `adjacentIndex` and `list.size()` is described, and it can be understood that the condition code for checking whether the acquired index exists in the list should be put into the blank. As the index in the list is 0 through `list.size()-1`, this is the condition in b), that “`adjacentIndex < list.size()`” be in the list. Therefore, the correct answer is b).
- * Blank E: This is the argument specified for `list.remove`. It can be understood that in the previous line, the card in the position of the index of the adjacent card, `adjacentIndex`, was removed. As the card currently in focus and the adjacent card need to be removed as a pair, the index of the card currently in focus must go into blank E. Therefore, the correct answer is `currentIndex`, or d).

Q12-8 Inheritance, interface implementation, and sort logic (Java)**[Answers]**

[Subquestion 1] A-c), B-a), C-c), D-d)

[Subquestion 2] E-a)

[Explanation]

In a program defining the methods required for interfaces and using classes that implement these interfaces, handling can be described with only the methods defined in interfaces, without awareness of the specific implementation of the methods. Moreover, in a program implementing interfaces, classes can be described so as to implement interfaces. For both items using the classes and used by the classes, unawareness of each other's implementations is extremely important for raising the independence and maintainability of the program. In Java, this is achieved through interfaces. Skillful use of interfaces is a key point in Java system development.

[Subquestion 1]

* Blank A: Both Program 3 and Program 4 implement Program 2, which is an interface. When an interface is implemented, the methods defined in the interface must be implemented. The method `getProjectMemberId` and the method `biggerId` in Program 3 and Program 4 are both implemented methods.

The methods defined in the interface are all abstract methods. These methods have the characteristic of being treated implicitly as `public abstract`, even if not made explicit.

In addition, overriding is subject to the following restrictions.

	Override method
Argument list	Must not be modified.
Return value types	Must not be modified. Covariant return types are allowed.
Access restrictions	Restrictions cannot be made stricter. Restrictions can be made less strict.
Exceptions	Only the same exception or its subclass can throw. Exceptions that throw can be reduced. A new exception or an exception with wide range cannot be thrown.

The text calls for selecting one of the access modifiers. As the interface methods are implicit and `public`, if the override conditions are followed, access restrictions cannot be made stricter than `public`. The access modifiers are as follows, from most restrictive to least.

`private` < no access modifier < `protected` < `public`

Therefore, when interface (abstract) methods are implemented, access modifiers must be made `public` or a compiler error will result. Therefore, c) is the correct answer.

* Blanks B, C: Employee IDs at Company A consist of a 2-digit number and a 5-digit number,

connected by a hyphen (for example, 21-19436). To convert this to a project member ID, a procedure is necessary to first append the fixed value “A00” to the head of the employee ID, and then to remove the hyphen, “-”.

(Line number)

```
1: StringBuffer sb = new StringBuffer("A00");
2:  ;
3: int i =  ;
4: sb.deleteCharAt(i);
5: return sb.toString();
```

These will be considered in conjunction with the problem program. First, in Line 1, the fixed value “A00” is made the variable `sb`, and made a `StringBuffer` object.

The i -th character of `sb` is deleted in Line 4, and return is performed on the string representation in `sb` in Line 5. Thus, it can be surmised that `sb` is a variable consisting of “A00” joined with the employee ID, with the i -th character, the hyphen “-”, then removed. Therefore, it can be surmised that the Company *A* employee ID is appended to the variable `sb` in Line 2, and that which character position in `sb` contains the hyphen “-” is calculated in Line 3. As the method that calculates the Company *A* employee ID is `getMemberId`, it can be understood that a) is inserted in blank B. At first glance c) also appears possible, but in the case of c), employee ID will be inserted into the 0th character of `sb` – that is, the head – and thus the order will be reversed, as in 21-19436A00.

Moreover, as the method that calculates the location of specified characters in the `StringBuffer` object is `indexOf`, it can be understood that c) is inserted in blank C.

- * Blank D: The location that contains blank D is a loop that sorts project member IDs in ascending order. The content of the sort makes clear that it is a bubble sort. Therefore, it can be understood that the content of blank D is a condition that compares `pi[j]` and `pi[j+1]`, and if `pi[j+1]` is larger or equal, replaces it with `pi[j]`. As `pi[j]` and `pi[j+1]` are of `String` type, simple comparison of the value sizes is not possible, and rather their context must be checked lexically. Therefore, it can be understood that a) and b) are incorrect.

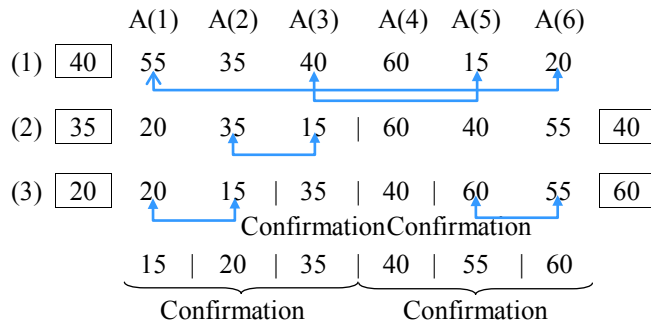
The `biggerId` method in c) and d) is implemented in Program 2 and Program 3. This method returns a value acquired through

```
getProjectMemmberId().compareTo(pi.getProjectMemmberId())
```

In the case of `a.compareTo(b)`, `a` and `b` are compared lexically. If `a` and `b` are equal, 0 is returned; if `b` comes after `a` lexically (i.e., is bigger), a negative value is returned; and if `b` comes before `a` lexically (i.e., is smaller), a positive value is returned. Therefore, c) is the correct answer.

[Subquestion 2]

Quick sort will be explained simply.



- (1) 40 is taken out as the central data. 55 is swapped with 20 and 40 is swapped with 15, and the data is divided into a small group and a large group, with 40 as the boundary value.
- (2) The same handling is performed on the former group and on the latter group. The former will be looked at. 35 is taken out, 35 and 15 are swapped, and separation is performed. The position of 35 is confirmed.
- (3) Next, 20 is taken out, 20 and 15 are swapped and separated, and the locations of 15 and 20 are also confirmed.

Fig. Quick sort

The program logic can be considered as follows. In the main text, the values stored in the array are sorted, and thus the value positioned in the center of the array is made the central value (standard value). First, the data is separated, with data equal to or lower than the standard value on the left, and data exceeding the standard value on the right. Specifically, data equal to or greater than the standard value is sought from the left of the standard value, data equal to or less than the standard value is sought from the right, and both are swapped.

At the point of completion, values equal to or smaller than the standard value are stored on the left, and values exceeding the standard value are stored on the right. However, neither the right side nor the left side is sorted yet.

Next, for the left side, a center value (standard value) is newly chosen, and the same activity is performed. The handling is repeated until the data cannot be separated any more.

Repetition of the separation is achieved through recursive calls. In other words, through logic that separates an area into 2, the separated areas can be further separated in serial fashion by recursive calls. The structure of the program is as follows.

1. The argument-specified area is separated into sections smaller than and larger than the central value (standard value).
2. The program calls itself, using the smaller section as an argument.
3. The program calls itself, using the larger section as an argument.

Separation is continued recursively via the above handling, and sorting ends.

- * Blank E: After separation into values larger and smaller than the standard value has completed, the program calls itself recursively. Therefore, as long as the index in the head of the array is smaller than the variable `i`, further separation is repeated. Moreover, as long as the index in the head of the array is larger than the variable `j`, further separation is repeated. Therefore, a) is the correct answer.

Q12-9 Matching of strings (Java)

[Answers]

[Subquestion 1] A-c), B-c), C-b), D-g), E-d)

[Subquestion 2] b)

[Explanation]

This program addresses the way that the use of an interface allows classes to be uniformly treated as the same type, even when the classes used differ.

Which classes to use must be determined based on the handling, the data, and so on, but control of the classes can be achieved through the skillful use of interfaces. In actual practice, the roles and usage of interfaces and classes, as well as methods that should be defined, must be understood and used correctly.

This question involves the handling of pattern matching of strings, using implementation of an interface. By implementing each pattern element with the same interface, the program is able to treat any pattern elements as the same type when performing character matching. To solve the problem, it is important to understand the ideal form for each pattern element, and how the process that converts and adds analyzed patterns to a list is read and represented by the program.

The degree of difficulty is average, and if the problem is read unhurriedly, getting the entire problem correct is not difficult.

[Subquestion 1]

- * Blank A: [Program 2] implements [Program 1], which is an interface. The location of the Subquestion is the implementation section of the overridden method `matches`. [Program 2] includes the comment “When the character at position `index` in the given string `str` and one character represented by this pattern element match, return `true`; otherwise return `false`”. Therefore, the method `matches` must use logic that can determine whether the `index-th` character of the string `str` matches the pattern element `ch`. `true` is returned if they match, and `false` is returned otherwise; therefore, blank A must be a “matching” condition. The `index-th` character of the string `str` can be found with “`str.charAt(index)`”. The matching of this with the pattern element `ch` can be made a condition, and thus “`str.charAt(index) == ch`” is inserted into blank A. Therefore, c) is the correct answer.

Note that “`str.length() > index`” comes before blank A using an and condition. This is a measure to handle the case in which the value is specified by `index` exceeds the string length of the string `str`. As the *index-th* character of the string `str` does not exist in such a case, `false` is returned at that time. If that condition is not inserted, then in the case that the value of `index` exceeds the string length of the string `str`, “`str.charAt(index)`” will throw an exception (`StringIndexOutOfBoundsException`). This line forms the text of the condition that the string length of the string `str` is larger than the value of `index` (which represents position), and that the *index-th* character of the string `str` matches the pattern element `ch`.

- * Blank B: As with [Program 2], the problem in [Program 3] concerns the overridden method `matches` from [Program 1]. [Program 3] includes the comment, “When there are one or more characters from position `index` in the given string `str`, return `true`; otherwise return `false`.” To satisfy this condition, any character in `str` should exist in the position of `index`. That is, it is necessary that the value of the position `index` be smaller than the string length of the string `str`. If so, then (although this is not implemented in the program) characters can be acquired with “`str.charAt(index)`” (the same approach as for the blank A subquestion). What about the case in which the string length of the string `str` is equal to the value of `index`? For example, in the case of a 10- string (meaning string length is 10), the head character is counted as the 0th character, the next character as the 1st, and so on, with the last character the 9th. That is, the `index` can only take a value up to the “string length -1”-th character. Therefore, “`str.length() > index`”, or c), is inserted in the blank.
- * Blanks C, D: In the `compile` method of [Program 6], a given pattern is analyzed one character at a time, and a class suitable for the matching of each is generated. The patterns are of the 4 types `'.'`, `'^'`, `'$'`, and other characters, and each pattern is handled separately. As in the question text, the pattern `'.'` represents matching with any 1 character. Moreover, it is understood that when the pattern is neither `'.'`, `'^'`, nor `'$'` – that is, the blank D case – it represents those characters. The explanation of the classes implementing the interface `PatternElement` in the question text states “(2) Class `AnyChar` is a pattern element that indicates any one character,” and “(1) Class `OneChar` is a pattern element that indicates one literal character.” As such, “`AnyChar()`”, or b) is inserted in blank C, and “`OneChar(c)`”, or g), is inserted in blank D.

* Blank E: Blank E is contained within a construction called an enhanced `for` statement. This `for` statement, introduced in Java 5.0, functions to sequentially loop string arrays or collections. An expanded `for` statement, unlike conventional `for` statements, does not specify the number of repetitions.

In the case of this problem, it can be understood that elements are taken from the string array `data` one by one, are assigned to the variable `str`, and handling is performed on this `str`. Immediately before the `for` statement, `"ho.e$"` is given as a pattern, and thus it can be surmised that how the string `str` is matched with the pattern is performed within the `for` statement. In actuality, if the condition in blank E is `true`, `"matches"` is printed, and if not, `"doesn't match"` is printed. Therefore, a condition to determine whether the string `str` matches the pattern is inserted into blank E. The choices use the method of the instance `pattern`. The instance `pattern` is an object of the `Pattern` class, and thus uses methods implemented in the `Pattern` class. The method directly described in the program is `matches`, but the `Pattern` class also inherits the method `equals` defined in the `Object` class. However, in the case of a) and c), which use the `equals` method, the target for comparison evaluates whether instance `pattern` itself and the string `str` are the same. Therefore, it can be understood that these choices are incorrect. If b) or d), the method `matches` that contains the instance `pattern` is called. `matches` matches the string `str` to the pattern, and returns `true` if matching. Therefore, d), `"pattern.matches(str)"`, is inserted in the blank.

[Subquestion 2]

In Line α , `"{ else if (c == '^') {"}` is treated as a metacharacter with the meaning "matches the head of the string". However, if modified to `"{ else if (c == '^' && i == 0) {"}` per the Subquestion, then only if `c` is `'^'` and the value of `i` is 0, will it be treated as a metacharacter. From the `for` statement condition, it can be understood that the value of `i` can only range from 0 to less than the string length of the variable `pattern`. `i` thus represents the element number of the string `pattern`. From this, `"i == 0"` means that it is at the start of `pattern`. Therefore, it can be understood that if Line α is modified per the Subquestion, the character `'^'` is treated as a metacharacter only when it is at the start of the argument `pattern`. Moreover, in other cases, evaluation by the next condition (`c == 's'`) with an `else if` statement occurs, but as this too is `false`, the next `else` statement is evaluated, and handling concludes there. As noted in the explanation for blank D, here it is treated as a pattern element representing 1 literal character. Therefore, the correct answer is "Character `'^'` is treated as a metacharacter only at the beginning of argument `pattern`. Otherwise, it is treated as a literal character," or b).

Section 12

Software Development (Assembler)

Q12-10 Summation of BCD code

[Answers]

[Subquestion 1] A-b)

[Subquestion 2] B-b), C-c)

[Subquestion 3] D-a), E-d)

[Explanation]

BCD encoding expresses each digit of a decimal value in 4-bit binary format. From the main program, BCDADD in Subprogram 1 receives the 2 integers a and b , expressed in BCD encoding, in GR1 and GR2, and calculates the BCD-encoded sum of a and b in GR1. As in Table 1, the sum of GR1 and GR2 is calculated in BCD encoding in GR1, but in the end, GR0 is set to the carry information from addition of the thousands place, either 1 or 0, and the program terminates. As the argument information for GR1 and GR2 and the return value information for GR1 and GR0 are important in solving Subquestions 1 through 3, they should be understood.

Table 1 Example of execution when GR1=#3205 and GR2=#7148

		Carry from thousands place	thousands place	hundreds place	tens place	units place
(argument)	GR1	—	3	2	0	5
	GR2	—	7	1	4	8
(return value)	GR1	—	0	3	5	3
	GR0	1	—	—	—	—

[Subprogram 1]

(Line number)

```

1  BCDADD START
   :
6      ST    GR1,A      ; BCD code a is stored in the A address
7      ST    GR2,B      ; BCD code b is stored in the B address
8      LD    GR3,=0      ; initializes shift count
9      LD    GR5,=0      ; initializes the result area
10 LOOP1 AND    GR1,=#000F ; identifies 4 bits from integer a
11      AND    GR2,=#000F ; identifies 4 bits from integer b
12      LD    GR0,=0      ; initializes carry information area
13      ADDA   GR1,GR2     ; 4-bit addition
14      CPA    GR1,=10     ; result ≥ 10?
15      

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16      SUBA   GR1,=10     ; subtracts 10 from result
17      LD    GR0,=1      ; sets carry
18 NOTOVR SLL    GR1,0,GR3 ; puts result of 4-bit addition into original bit
position
19      OR     GR1,GR5     ; merges into interim result
20      ADDA   GR3,=4      ; increments the shift count by 4
21      CPA    GR3,=16     ; all digits are completed?
22      JZE    FIN1       ; terminates with 12-bit shift
23 NEXT1 LD     GR5,GR1    ; stores interim result
24      LD     GR1,A      ; resets integer a in GR1
25      SRL    GR1,0,GR3   ; moves next 4 bits of integer a to right end
26      LD     GR2,B      ; resets integer b in GR1
27      SRL    GR2,0,GR3   ; moves next 4 bits of integer b to right end
28      ADDA   GR1,GR0     ; adds carry
29      JUMP   LOOP1
30 FIN1 LD     GR2,B
31      LD     GR3,A
   :
36      RET
37 A      DS    1
38 B      DS    1
39      END

```

[Subquestion 1]

* Blank A: The BCD code from Table 1, with GR1=#3205 and GR2=#7148, will be traced as an example. First, in Line 6, the BCD encoded integer *a* (#3205) is stored in the A address with “ST GR1,A”, and in Line 7, the BCD encoded integer *b* (#7148) is stored in the B address with “ST GR1,B”. Next, with “AND GR1,#000F” in Line 10, the 5 from the bottom 4 bits (the units place) is identified in integer *a* (#3205), and in the same way, with “AND GR2,#000F” in Line 11, the 8 from the bottom 4 bits is identified in integer *b* (#7148). Next, “ADDA GR1,GR2” in Line 13 is used to sum the units place of both numbers, but with decimal summation performed for every 4 bits. As such, nothing need be done if GR1, the sum, is 9 (#0009) or less. However, if GR1 is 10 (#000A) or greater, then 10 must be subtracted in Line 16 with “SUBA GR1,=10”, and the carry information in GR0 must be set to 1 with “LD GR0,=1” in Line 17. In this case, as GR1=13 (#000D), then GR0 must processed to be 1 and GR1 must processed to be 3 (#0003). The sum is compared with 10 with “CPA GR1,=10” in Line 14, but what should be inserted in blank A is handling which, if GR1 is less than 10, skips the subtraction of 10 (“SUBA GR1,=10”) in Line 16 and the setting of carry information (“LD GR0,=1”) in Line 17. Therefore, the correct answer is b), “JMI NOTOVR”.

[Subquestion 2]

* Blanks B, C: Looking at its role, GR3 is used as the number of shifts to move all places (from the units place to the thousands place) of the integer *a* and the integer *b*, to the units place, through logical right shifts. By varying the number of shifts according to 0→4→8→12, the summation of GR1 and GR2 is performed. After completion of the summation, the original bit positions are restored through logical left shifts.

Table 2 Number of shifts for each place to reach the units place

	thousands place	hundreds place	tens place	units place
Number of shifts	12	8	4	0

Line 18, “NOTOVR SLL GR1,0,GR3”, contains the comment “puts result of 4-bit addition into original bit position,” but as the initial value of GR3 is 0, the number of logical left shifts is 0 following the first summation of units places. However, as summation of the tens places is performed after a 4-bit logical right shift of the original integers *a* and *b*, they are then restored using 4-bit logical left shifts. This is repeated through the thousands places. The interim result is merged using “OR GR1,GR5” of Line 19 and “LD GR5,GR1” of Line 23. The termination condition is the number of shifts (GR3) reaching 16. After integer *a* is reset in GR1 with “LD GR1,A” in Line 24, and integer *b* is reset in GR2 with “LD GR2,B” in Line 26, the previous place's carry information is appended with “ADDA GR1,GR0” in Line 28. When the number of shifts (GR3) repeated between “LOOP1” in Line 10 and “JUMP LOOP1” in Line 29 reaches 16 in Line 29, the program jumps to termination in FIN1. As a result, at the time of termination GR1 is set to the summation result, and GR0 is set to the carry information for the thousands place.

Table 3 Summation results for GR1 and GR2

Before execution, GR1=0101 0010 1001 1000 (#5298), and GR2=0100 1000 0101 0011 (#4853)

		Carry from thousands place	thousands place	hundreds place	tens place	units place
Before execution	GR1	—	5	2	9	8
	GR2	—	4	8	5	3
After execution	GR1	—	0	1	5	1
	GR0	1	—	—	—	—

Therefore, the correct answer for blank B is b), “0000 0000 0000 0001”, and the correct answer for blank C is c), “0000 0001 0101 0001”.

[Subquestion 3]

2 strings m and n , entered as 4-digit numerical strings, are treated as integers and converted to BCD encoding, after which they are summed using BCDADD in Subprogram 1. After this, they are entered into BCDIN in Subprogram 2, which converts the sum to a 5-digit numerical string (string). The relationship between input and output of BCDIN in Subprogram 2 are as follows.

Table 4 Summation of m and n

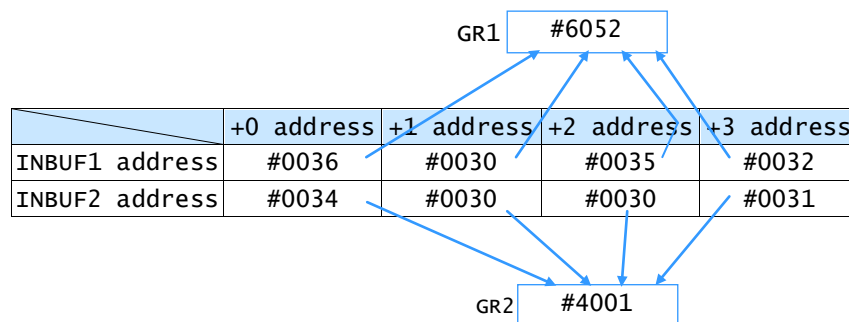
m	n	Output string
‘6052’	‘4001’	‘10053’

Table 5 INBUF1, INBUF2, and OUTBUF table

	+0 address	+1 address	+2 address	+3 address	+4 address
INBUF1 address	‘6’	‘0’	‘5’	‘2’	
INBUF2 address	‘4’	‘0’	‘0’	‘1’	
OUTBUF address	‘1’	‘0’	‘0’	‘5’	‘3’

The number of characters input is 4, and thus the head addresses of the INBUF1 table and INBUF2 table are the thousands place. What calls for caution is the fact that the number of characters in the output is 5, and thus the head address of the OUTBUF table used in “OUTBUF,OUTLEN” in Line 89 is the ten thousands place. Below, the +1 address is the thousands place, the +2 address is the hundreds place, and so on. In order to use BCDADD of Subprogram 1, the INBUF1 numerical string and the INBUF2 numerical string must be converted to BCD encoding and stored in GR1 and GR2, respectively.

Fig. Conversion of BCD encoding to numerical strings



[Subprogram 2]

(Line number)

```

51 BCDIN START
52     RPUSH
53     IN     INBUF1,INLEN    ; inputs m
54     IN     INBUF2,INLEN    ; inputs n
55     LD     GR1,=0          ; initiates BCD encoding register
56     LD     GR2,=0          ; same as above
57     LD     GR6,=0          ; initializes shift count
58     LD     GR7,=3          ; initializes loop counter
59 LOOP2 LD     GR4,INBUF1,GR7 ; retrieves 1 character from m
60     AND    GR4,=#000F      ; converts to numeric value
61     SLL    GR4,0,GR6
62     OR     GR1,GR4         ; merges BCD encoding
63     LD     GR5,INBUF2,GR7  ; retrieves 1 character from n
64     AND    GR5,=#000F      ; converts to numeric value
65     SLL    GR5,0,GR6
66     OR     GR2,GR5         ; merges BCD encoding
67     

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68     SUBL   GR7,=1
69     JMI    NEXT           ; end of loop?
70     JUMP   LOOP2
71 NEXT  CALL BCDADD
72     LD     GR6,=0          ; initializes the shift count
73     LD     GR7,=4          ; initializes the output area counter
74 LOOP3 LD     GR5,GR1       ; Copies BCD encoding into GR1
75     SRL    GR5,0,GR6
76     AND    GR5,=#000F
77     OR     GR5,=#0030      ; converts to characters
78     ST     GR5,OUTBUF,GR7  ; stores characters in output area
79     SUBL   GR7,=1
80     ADDL   GR6,=4          ; increments the shift count
81     CPL    GR6,=16
82     JMI    LOOP3
83     

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| E |
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84     OR     GR7,=#0030      ; converts numeric values to characters
85     ST     GR7,OUTBUF
86     ST     GR1,ANS
87     ST     GR2,N
88     ST     GR3,M
89     OUT    OUTBUF,OUTLEN
90     RPOP
91     RET

```

92	INBUF1	DS	4
93	INBUF2	DS	4
94	INLEN DC	4	
95	M	DS	1
96	N	DS	1
97	ANS	DS	1
98	OUTBUF	DS	5
99	OUTLEN	DC	5
100		END	

- * Blank D: The number of shifts is initialized as 0 with “LD GR6,=0” in Line 57. So as to be usable as the index of the INBUF1 table and the INBUF2 table with “LD GR7,=3” in Line 58, GR7 is initialized as 3 and is also used as a loop counter. With “LOOP2 LD GR4,INBUF1,GR7” in Line 59, first #0032, which is the units place in the INBUF1 table, is put into GR4, and is converted to a numerical value (GR4 = #0002) with “AND GR4,=#000F” in Line 60. With “SLL GR4,0,GR6” in Line 61, the number of logical left shifts (0 bits at first) equal to GR6 is performed on GR4, for the purpose of merging it with GR1. Merging of the BCD code (GR1=#0002) is performed with “OR GR1,GR4” in Line 62. Through a similar procedure, GR2 is set to #0001, instead of the #0031 in the INBUF2+3 address. GR7 is decreased by 1, the target characters are moved to the INBUF1+2 address and INBUF2+2 address, and the target characters are shifted forward while looping. What else is needed within the Line 59 and Line 67 loop is for the number of left shifts in GR6 to be incremented by 4 with each loop. Therefore, a), “ADDA GR6,=4”, is the correct answer.
- * Blank E: When GR1 is set to the integer m and GR2 is set to the integer n , and BCDADD in Subprogram 1 is executed with “NEXT CALL BCDADD” in Line 71, GR1 is set to the summation result, GR2 is set to the integer n , GR3 is set to the integer m , and GR0 is set to the carry information, and handling returns to the main program.

Table 6 OUTBUF table handling in Lines 73 through 82

	ten thousands place	thousands place	hundreds place	tens place	units place
	+0 address	+1 address	+2 address	+3 address	+4 address
OUTBUF address	'1'	'0'	'0'	'5'	'3'

The code from “LD GR7,=4” in Line 73 to “JMI LOOP3” in Line 82 is handling to store the sum of m and n (which is in GR1 per Table 6) in the OUTBUF address from the units place to the thousands place, while converting it to a numerical string. “OR GR7,=#0030” in Line 84 and “ST GR7,OUTBUF” in Line 85 appear after blank E. Unquestionably, this changes the numerical values to strings and stores them in the ten thousands place. From this, it is clear that in blank E, the carry information in GR0 should be copied into GR7. Therefore, d), “LD GR7, GR0” is the correct answer.

Q12-11 Vertical and horizontal parity setting (assembler)

[Answers]

[Subquestion 1] A-f), B-f)

[Subquestion 2] c)

[Explanation]

The subprogram SETPAR sets the parity bit in the head of each word stored in a continuous N -word block, and also sets a one-word horizontal parity immediately after the block. It is an orthodox process which, rather than counting bits, checks whether the head bit (bit number 15) of the result of logical shift left operations is 0 or 1, and each time changes the parity bit using an exclusive OR (XOR) instruction. While horizontal parity setting in the problem is not so difficult, it should be noted that interpretation can take time when the problem is read too much.

[Subquestion 1]

* Blank A: The 1 word stored in GR1 is logically shifted to the left one bit at a time by the SLL instruction in Line 8. With attention paid to this instruction, the branch condition for parity checking will be considered. As the initial value of the starting bit of the 1 word stored in GR1 is 0, the following 3 branch conditions can be considered.

Branch condition (1)

As the result of the logical left shift, the starting bit of GR1 becomes 1 (in which case, SF becomes 1 and a branch results according to the JMI instruction).

Branch condition (2)

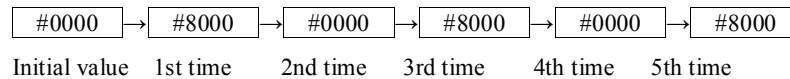
As the result of the logical left shift, the starting bit of GR1 becomes 0, and furthermore, at least 1 other bit contains 1 (in which case, both SF and ZF become 0 and a branch results according to the JPL instruction).

Branch condition (3)

As the result of the logical left shift, all bits of GR1 become 0 (in which case, SF becomes 0 and ZF becomes 1, and a branch results according to the JZE instruction).

In the JZE instruction in Line 9, handling proceeds to branch condition (3) and jumps to the CONT address, after which the parity bit and the 1 word in the block are merged via the OR instruction. Furthermore, if the initial value of GR7 is set to #8000, then each time the XOR instruction in Line 11 is executed, the starting bit of GR1, and only that bit, is repeatedly switched between the values 1 and 0.

Changes to GR7 following the execution of Line 11



In the handling here, while the 1 word in GR1 is logically shifted left 1 bit at a time, every time a sign bit of 1 is detected the starting bit of GR7 is changed by the exclusive OR (XOR) instruction between it and #8000, and GR7 is set to even parity regardless of when the shift operation terminates with the JZE instruction in Line 9. Therefore, it can be understood that this is branch condition (1), in which the starting bit is 1. From the above, blank A can be seen as the handling for branch condition (2), in which the starting bit is 0. In concrete terms, if the starting bit of GR1 becomes 1 as the result of the logical left shift, the parity bit is updated; if GR1 becomes #0000, handling of 1 word terminates; and if both SF and ZF are 0, the JPL instruction is executed and thus handling returns to the LP2 address, and the starting bit determination handling is repeated. Therefore, the correct answer is f).

A more detailed explanation is provided by the following table of exclusive OR truth values.

A	B	A XOR B
0	0	0
1	0	1
0	1	1
1	1	0

Note the bottom 2 rows of the truth value table. If B=1 and A=0, then A XOR B=1; and if A=1, then A XOR B=0. In either case, it can be understood that the value of A is reversed as the result of the operation. In this way, when the exclusive logical sum of a given bit and 1 is taken, the original bit will be reversed.

- * Blank B: Because GR4 is used as the adjustment register for the horizontal parity bit with the LAD instruction in Line 5, it is initialized as the decimal 0=#0000. After the one-word parity bit is set in Line 13 and stored in GR7, in Line 14 the value of the 1 word appended with the even parity bit is restored to its original location. In Line 15, blank B has the comment “Adjust horizontal parity.” Here, if the exclusive logical sum instruction is sequentially repeated between GR4, which was initialized as #0000, and the 1 word appended with the even parity in GR7, then GR4 will be set to the horizontal parity (also even parity) of the words already processed to that point. As such, blank B must contain “XOR GR4, GR7”. Therefore, the correct answer is f).

This will be considered using the conditions below.

An example using N=3 and initialized status as follows will be traced:

(1) Initialized status

Bit number	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
word 0	0	0	0	1	0	1	0	1	0	1	0	1	0	1	0	1
word 1	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	1
word 2	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Horizontal parity	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GR4	0000 0000 0000 0000 (initial value)															



(2) At time of termination of handling of word 0 (following execution of XOR instruction in

Line 5)

Bit number	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
GR7 = word 0	1	0	0	1	0	1	0	1	0	1	0	1	0	1	0	1
word 1	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	1
word 2	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Horizontal parity	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GR4	1001 0101 0101 0101															



(3) At time of termination of handling of word 1 (following execution of XOR instruction in

Line 15)

Bit number	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
GR7 = word 0	1	0	0	1	0	1	0	1	0	1	0	1	0	1	0	1
word 1	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	1
word 2	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Horizontal parity	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GR4	1000 0100 0100 0100															



(4) At time of termination of handling of word 2 (following execution of XOR instruction in

Line 15 and the ST instruction in Line 19)

Bit number		15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
GR7 = Horizontal parity	word 0	1	0	0	1	0	1	0	1	0	1	0	1	0	1	0	1
	word 1	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	1
	word 2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Horizontal parity	0	1	1	1	1	0	1	1	1	0	1	1	1	0	1	1
GR4		0111 1011 1011 1011															

[Subquestion 2]

As was explained for Subquestion 1, the value of GR7 switches between #0000 and #8000 due to the XOR instruction in Line 11. The text states, “The program is to be changed so that 0 is set as the parity bit value when the number of bits that are 1 in bit numbers 0 to 14 of each word is odd, or 1 when even.” As such, the Subquestion can be understood as changing the handling from the even parity method to the odd parity method.

The difference between setting even parity and setting odd parity is simply a matter of whether the number of 1s within the entire bit string, including the parity bit, is odd or even.

- (1) Parity bit set by the even parity method is 1

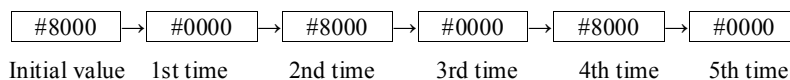
As this is the case in which there are odd number of bits that are 1 in bit numbers 0 through 14, if the handling is changed to the odd parity method, the parity bit to be set is 0.

- (2) Parity bit set by the even parity method is 0

As this is the case in which there are even number of bits that are 1 in bit numbers 0 through 14, if the handling is changed to the odd parity method, the parity bit to be set is 1.

Therefore, if the changing of the value of GR7 that is repeated by the XOR instruction in Line 11 is shifted by one repetition, the odd parity method results. This can be achieved by changing the initial value of GR7 from #0000 to #8000.

Changes to GR7 following the execution of Line 11



Therefore, the correct answer for Subquestion 2 is c), or #8000.

The below is a supplement to understanding the overall structure of the program.

(Line number)

```

1  SETPER START
2      RPUSH
3      LD    GR6,GR2      ; sets GR6 to starting address
4      ADDL  GR6,GR1      ; stores horizontal parity bit at the end of the
                          ; block
5      LAD   GR4,GR0      ; initializes horizontal parity
6 LP1   LD    GR1,0,GR2   ; ←
7      LAD   GR7,GR0      ; initializes vertical parity
8 LP2   SLL   GR1,1
9      JZE   CONT        ; If the results of logical left shifts are all
                          ; 0, go to CONT
10      

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11      XOR   GR7,=#8000  ; adjusts parity bit
12      JUMP  LP2
13 CONT  OR    GR7,0,GR2  ; appends even parity bit by OR instruction
14      ST    GR7,0,GR2   ; sets even parity bit
15      

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 ; adjusts horizontal parity
16      LAD   GR2,1,GR2   ; sets address+1 through repetition
17      CPL   GR2,GR6     ; end of block?
18      JNZ   LP1        ; are the target address and GR6 the same?
19      ST    GR4,0,GR6   ; sets horizontal parity
20      RPOP
21      RET
22      END

```

As GR2 is set to the starting address of the block for the first iteration, GR1 is set to the starting 1 word with the LD instruction in Line 6. However, as the target address is counted up by 1 when the LAD instruction in Line 16 is executed, every time the loop with Line 18 is run, words are taken out by GR1 in the order 0 word, 1 word, 2 word, and so on.

As GR4 is used as the adjustment register when horizontal parity is set, it is initialized as #0000. After the even parity bit of 1 word is set, the value with even parity bit appended is saved in GR7. If the exclusive or instruction (XOR) is sequentially repeated between GR4, which is used for horizontal parity, and the 1 word appended with the even parity bit in GR7, then GR4 will always be set to the horizontal parity bit up to the 1 word. This section likely presented the greatest difficulty. In horizontal parity adjustment, when all the 16 bits of each word are the target of exclusive or operations but the exclusive or instruction is 1, the original bit is reversed, but 0 has no effect on the original bit. Therefore, if the bit is reversed only in locations where 1 bit was detected, the necessary and sufficient condition for parity adjustment is satisfied.

Q12-12 Bit string replacement problem (assembler)**[Answers]**

[Subquestion 1] A-b), B-c), C-a), D-d)

[Subquestion 2] c)

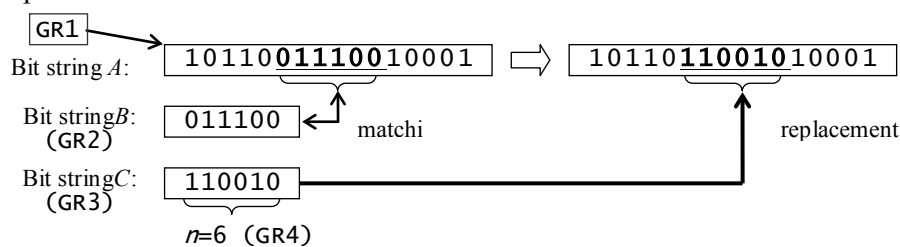
[Explanation]

This problem concerns subprogram BREP, which performs pattern matching and replacement on bit strings, and subprogram ROTSL, which cyclically shifts bit strings. The problem may appear difficult due to the use of many registers, but the handling is simple. Reading the comments in the program allows the handling to be easily surmised. If the shift operation instructions and logical operation instructions necessary for the bit string operations are understood, and if attention is paid to the values stored in registers, the correct answer can be found.

[Subquestion 1]

Subprogram BREP is a program that does the following: if a 16-bit string A contains substrings that are identical to an n -bit string B , the program replaces the string with an n -bit string C .

Example



The contents of the registers at the time Subprogram BREP is called are as follows.

GR1: address of the word where the bit string A is stored

GR2: bit string B (set left-aligned, and the remaining bits are filled with 0s)

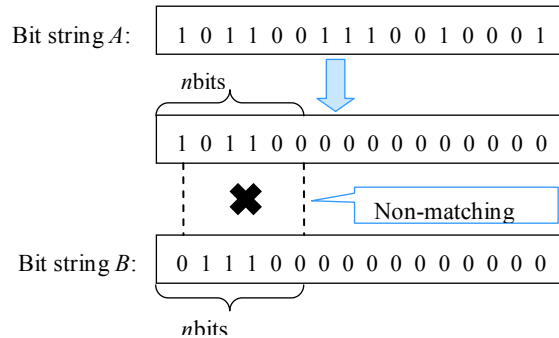
GR3: bit string C (set left-aligned, and the remaining bits are filled with 0s)

GR4: n ($1 \leq n \leq 16$)

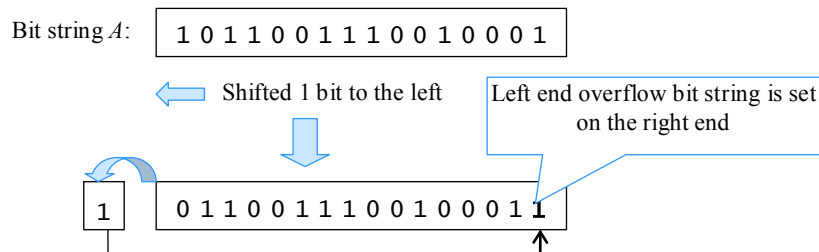
The program will be examined to see what methods are used in BREP to search bit string B . (Hereinafter, text within quotes represents program comments.) As shown in the program's comments, it “compares the n leftmost bits and the bit string B ,” and if these do not match, sets the “number of bits to be cyclically shifted to the left” (which here is 1), and branches at the label CONT to call ROTSL. Following this, when there are unchecked bits, it returns to the label LOOP and repeats the comparison handling. The bit string B (GR2) does not perform shift operations. From these things, it can be understood that the search moves the compared substrings of bit string A to the left end of the bit string, and performs comparison with bit string B .

Example

- (1) The n leftmost bits of bit string A are compared to bit string B .



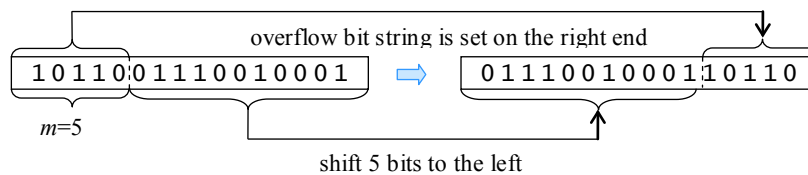
- (2) If the compared items do not match, bit string A is cyclically shifted 1 bit to the left.



- (3) The comparison of the leftmost n bits of bit string B and bit string A is repeated.

Here, the specifications of subprogram ROTSL, which cyclically shifts bit strings, are checked. Subprogram ROTSL cycles the 16-bit bit string to the left by only m bits.

Example



The contents of the registers at the time subprogram ROTSL is called as follows.

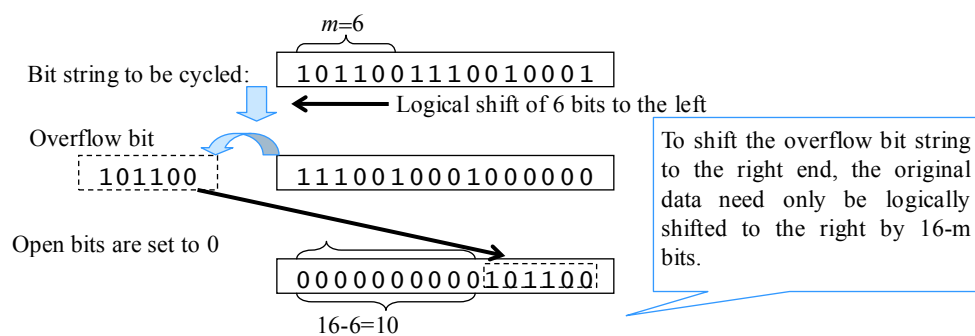
GR0: m ($1 \leq m \leq 16$)

GR1: address of the word where the bit string is stored

- * Blank A: The comment accompanying blank A reads, “sets all bits, except the n leftmost bits, to 0.” The answer group consists of AND and OR logical operation instructions, but because making the bit string 0 requires taking the logical product of 0, the AND instruction applies. Next, confirmation of the register reveals that the next instruction after blank A compares GR7 and GR2, but because GR2 is set to bit string B , the result of the logical product is stored in GR7. Immediately before blank A, GR7 is set to bit string A . Within the answer group, the registers with which logical product is performed are GR3, or a); and GR6, or b). However, GR3 is set to bit string C , and GR6 is set to a mask. As 0 is set in all bits in bit string C except for the leftmost n bits, taking the logical product achieves the goal of setting all bits except the leftmost n bits to 0. However, as the leftmost n bits may change the value of bit string A , GR3 is incorrect. A mask is set for GR6 before the label LOOP. As the content of the mask arithmetically right shifts #8000 by $n-1$ bits, 1 is set in the leftmost n bits, with a remainder of 0. If the logical product is taken with GR7, all bits except for the leftmost n bits are set to 0, and moreover, the original values of the leftmost n bits are preserved. The correct answer is b), “AND GR7, GR6”.
- * Blank B: Because blank B is handling that follows the label MATCH, it is executed when the leftmost n bits of bit string A match bit string B . The comment accompanying blank B reads “sets the n leftmost bits to the bit string C .” Looking at the handling preceding and following blank B, GR7 is set to bit string A before the blank, and the leftmost n bits are set to 0. After the blank is the comment “rewrite the original area,” with GR7 stored in the bit string A area. From these things, it can be surmised that in blank B, the leftmost n bits of bit string A , which is stored in GR7, are set to bit string C . In order to set the locations of the 0s set in the leftmost n bits of bit string A to the value of bit string C , the logical sum, or OR instruction, in the answer group can be used. Within the answer group, the registers with which logical sum is performed are GR3, or c); and GR6, or d). However, as GR3 is set to bit string C , the correct answer is c), or “OR GR7, GR3”.
- * Blank C: Because the comment accompanying blank C reads “If less than n , finish,” a termination condition is evaluated here. The previous instruction compared GR5 and GR4; GR5 is set to the number of unchecked bits, and GR4 is set to n . The initial value of the number of unchecked bits is 16. The numerical value is changed after ROTSL is called by label CONT, and the number of bits cyclically shifted left (GR0) by ROTSL is subtracted. When bit string B and the starting n bits of bit string A do not match, 1 bit is cyclically shifted left and thus 1 is subtracted. When bit string B and the starting n bits of bit string A do match, n bits are cyclically shifted left and thus n bits are subtracted. Therefore, if the number of unchecked bits is n or more, re-checking is necessary, and processing ends when the number becomes less than n . When $GR5 < GR4$ with the CPA instruction, SF of FR (flag register) becomes 1, and thus the corresponding branch instruction is JMI, and the correct answer is a), or “JMI FIN”.

* Blank D: Blank d is handling within ROTSL, with an accompanying comment that reads “Bit string overflow.” Prior to blank D, the bit string set to GR5 is logically shifted m bits to the left. After blank D, the logical sum of GR5 and GR6 is taken, with accompanying comment “Set the overflow bit string at the right end.” From this, it can be surmised that in blank D, the overflow bit string is set at the right end of GR6. Before blank D is executed, GR6 is set to the data before cycling. The answer group consists of SLL instructions and SRL instructions, but as the bit string is set at the right end, the SRL instruction, which performs a right shift, is the corresponding instruction. The number of bits shifted is either c), GR3; or d), GR4. GR3 is set to m , and GR4 is set to $16-m$. As overflow bits are left behind, GR4, or $16-m$, is the correct value.

(Example: $m=6$)



The correct answer is d), “SRL GR6, 0, GR4”.

[Subquestion 2]

This question concerns the number of times the subprogram ROTSL is called. The bit strings passed by the caller are as follows.

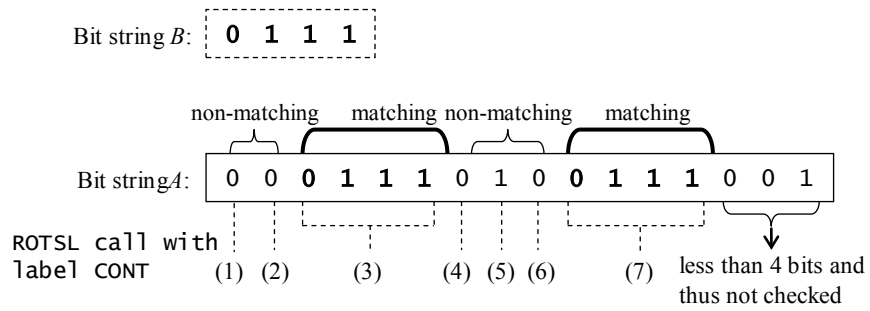
Bit string A: 0001110100111001

Bit string B: 0111

Bit string C: 1001

n : 4

The locations where ROTSL is called are the label CONT and before the return to the caller. The call with the label CONT occurs when the bit strings match and are cycled by n bits, and when they do not match and are cycled by 1 bit. The passed bit strings' calls in CONT are as follows.



The number of times it is called with `CONT` is 7. To this, the first time it is called before returning to the caller is also added, and thus the number of times called is 8, and c) is the correct answer.

Section 12

Software Development (Spreadsheet)

Q12-13 Investment effect of new system installation**[Answers]**

[Subquestion 1] A-e), B-d), C-b), D-c), E-d)

[Subquestion 2] d)

[Explanation]

This question addresses the comprehensive considerations of when implementation of a new system is decided upon. Considerations include the initial investment cost, maintenance cost, and expected economic benefit due to implementation. These considerations represent important knowledge for the activities performed by a system administrator within a company. The typically complicated calculation of the various values is made efficient through the use of spreadsheet software. As a question concerning spreadsheet software, the number of answers required is not many and they are of a simple level, which means that this question poses no particular difficulties.

[Subquestion 1]

The form of the subquestion calls for filling in 5 blanks among a fairly large amount of text. Thoroughly perusing the entire text runs the risk of using up considerable time. It is best to answer the questions efficiently using minimal information contained around the blanks as hints, and making reference to relevant areas in the worksheet and the question text as necessary.

* Blank A: The key word here is “equipment maintenance cost,” a term that can be found within the text in “(2) Maintenance cost (i) Equipment maintenance cost.” What calls for caution is the statement “In years 2 through 4, 10% of equipment acquisition cost will occur as an annual maintenance cost, and in year 5 and onward, 20% of equipment acquisition cost will occur as an annual maintenance cost” – in other words, the need for conditional branching depending on the number of years lapsed. For that reason, the choices can easily be narrowed to e) or f); however, as shown in Table 1, the equipment acquisition cost consists of both the IP phone equipment acquisition cost and the LAN equipment acquisition cost, and referencing the worksheet shows that the values for these are entered into C3 and C4, respectively. Moreover, cell D7 references the number of years lapsed, and when consideration is given to the logical expression contained within the IF function to calculate 10% for years 2 through 4 and 20% for year 5 and later, this is “ $D7 \geq 5$ ” or “ $D7 < 5$ ”. When “ $D7 \geq 5$ ” is TRUE, the calculation is “ $(\$C3 + \$C4) * 0.2$ ”, and when “ $D7 < 5$ ” is TRUE, the calculation is “ $(\$C3 + \$C4) * 0.1$ ”. The choice that satisfies these conditions is “ $\text{IF}(D7 \geq 5, (\$C3 + \$C4) * 0.2, (\$C3 + \$C4) * 0.1)$ ”. Therefore, e) is the correct answer.

- * Blank B: Software maintenance cost, according to “(2) Maintenance cost (ii) Software maintenance cost,” equates to 12% of the software purchase cost annually, and thus to the product of cell C5, which references software maintenance cost, and 0.12. However, there is the condition that this calculation is duplicated in cells D9 through H9, and as C5 is a value that must not be changed (because the software maintenance cost is unchanged every year), this becomes \$C5, an absolute reference with respect to the horizontal direction. Therefore, d) is the correct answer.
- * Blank C: In “(3) Expected economic benefit (i) Communication cost reductions,” the communication cost expected for year 2 is described: “As the unit cost of communications is falling, a reduction of 10% over the previous year is expected every year, even without implementation of the IPC system.” Thus, cell C11, the value for the previous year used in the relevant expression in cell D11, is inserted in blank C. Furthermore, this expression is duplicated in cells E11 through H11, but as the value for the previous year must be referenced for each year lapsed, the column name must use a relative reference. Therefore, b) is the correct answer.
- * Blank D: This expression calculates the cumulative total of the incremental cash flow for year 2 in cell D17. For year 2 and later, this is the cumulative total through the previous year plus the value for the current year, and thus according to the cells corresponding to each, the expression is “C17+D16”. This expression is further duplicated in cells E17-H17, but for each year lapsed the value of the incremental cash flow for the year and the value from that year's previous year must be referenced, and thus the column name must be referenced relatively. Therefore, c) is the correct answer.
- * Blank E: The correct way to answer this question is to read through (5) in Subquestion 1 while contrasting each item of its content with the worksheet. However, it is also acceptable to answer immediately after reading the single sentence in which blank E is contained. Blank E is “the expression to calculate the amortization cost for software for year 1, entered in cell C23”, with the corresponding information found in Table 2 (or in B5:F5 in the worksheet). In other words, from Table 2, the expression is “amortization cost = unamortized balance × amortization rate,” which yields “C5*F5”, but there is the condition that this expression is duplicated in cells D23:G23. In addition, the cell addresses that these reference are “software purchase cost” and “amortization rate by straight-line method,” and as these are values that cannot be changed (software amortization cost is calculated by the straight-line method, and thus is the same every year), the references are absolute in the horizontal direction, and thus “\$C5*\$F5”. Therefore, d) is the correct answer.

[Subquestion 2]

This question concerns making a determination based on the worksheet that was completed by answering Subquestion 1. The answer group contains choices that require Subquestion 1 to have been answered correctly beforehand in order to narrow down the choices of this Subquestion. Therefore, this question involves a high degree of relatedness between the Subquestions.

From the choices, it can be understood that the key point in question is whether 2 values, the payback period determination value and the profitability determination value, satisfy specified criteria. At this point, what these 2 keywords indicate and by what methods they are calculated can be picked up from the question text. Through this process, it can be understood that the value and calculation method of each, and the investment determination criteria according to those values, are described in (4) “Investment determination criteria.”

First, with regard to the payback period determination value, sorting out the description for this yields “incremental cash flow = annual economic benefit - annual maintenance cost,” and “payback period determination value = cumulative incremental cash flow – initial investment cost.” When the expression that should be entered into cell C16 is hypothetically considered, an application of the cell addresses that correspond to each item in the expression yields “C15–C10”. Moreover, as a cell to calculate total initial investment cost has not been set in advance anywhere, with the assumption that this is “SUM(\$C3:\$C5)”, the expression “C17–SUM(\$C3:\$C5)” can be considered. Note that as the payback period determination value of “-14,410” for the first year is displayed in C18 from the start, this value should be used to verify the validity of the expression.

The profitability determination value is described in “(4) Investment determination criteria.” Sorting out the description here yields “profitability determination value = incremental cash flow – total amortization cost of the investment.” When the expression that should be entered into cell C25 is hypothetically considered, an application of the cell addresses that correspond to each item in the expression yields “C16 – C24”.

For each of the fiscal years 1 through 6, the payback period determination value and profitability determination value calculated by these methods are placed into the table below.

Fiscal years lapsed	1	2	3	4	5	6
Payback period determination value	-14,410	-10,464	-6,648	-2,948	-853	1,147
Profitability determination value	596	63	723	1,172	-27	1,171

What can be determined from the above is that the payback period determination value turns positive from fiscal year 6, which satisfies the investment determination criterion of “within 6 years after the IPC system goes into operation.” Moreover, it is clear that the investment determination criterion of “positive by the end of year 6 after the IPC system goes into operation” is not satisfied. Therefore, d) is the correct answer.

Q12-14 Analysis of selling and sales at a catalog retailer (spreadsheet)**[Answers]**

[Subquestion 1] A-a),B-c)

[Subquestion 2] C-a), D-c), E-d), F-a)

[Subquestion 3] a)

[Subquestion 4] c)

[Explanation]

This question concerns selling and sales at a catalog retailer. The size of the question and the composition of the questions are standard-level, and the difficulty level is moderate. The Subquestions include analysis of sales performance using spreadsheet software, but the expressions and functions used in the spreadsheet are all fundamental, and should present no difficulties if the conditions and procedures presented in the text are read carefully.

[Subquestion 1]

Subquestion 1 concerns the expression necessary to create a sales performance table for use in assessing sales performance for the past three years. Creation of the specific expression is not problematic if the explanation in [Procedure 1] is read thoroughly, but the subsequent setting of the reference methods during cell duplication is important.

* Blank A: The seasonal index for April is calculated in this block. A seasonal index, according to (3) under [Procedure 1], is “the 3-year total sales for the month in question, as a percentage of 3-year monthly average sales.” Setting aside the reference method, the choices in the answer group all involve E2, which is the monthly total for April for the past 3 years. In order for this value to act as the “3-year monthly average sales,” which is a condition for the seasonal index, the appropriate value for the denominator must be set as the total for 3 years, just as the numerator is the total for 3 years. For that reason, the denominator must be divided by 12 in order to turn the 3-year sales total (fiscal year totals of monthly totals) into a monthly value. The 3-year sales total is entered in E14, and the expression in the blank is duplicated into cells H3 through H13 (i.e., across rows). Thus E2, which is the numerator that references the monthly total for each month, must use a relative reference, and H14, which references the fiscal year total of monthly averages, must use an absolute reference, in order for references to be correct. The expression is therefore “E2/(\$E\$14/12)*100”, and a) is the correct answer.

* Blank B: The Determination for April is calculated in this blank. As per (4) in [Procedure 1], the Determination column displays “○○” for months in which the seasonal index exceeds 150%; “○” for months in which the seasonal index exceeds 120% and is less than 150%; “●” for months in which the seasonal index exceeds 90% and is less than 120%; and “▲” for months in which the seasonal index is 90% or less.” The choices in the answer group all use the IF function, and do not require comparison determinations to be made regarding cell references. In order to achieve 4-way branching in the result, the differences among the choices, which are inside 3 nested IF functions, inequality signs and values to be compared in the formula are concerned. If the choices are examined while the first condition is focused on, it can be seen that ““○○” for months in which the seasonal index exceeds 150%,” c) is the only choice that correctly represents H2 which contains the seasonal index for April, as exceeding 150% ($H2 > 150$). In c), a TRUE result is represented by “○○”, and it can be confirmed that the respective results of the 2nd and 3rd formulas are also represented appropriately. Therefore, the expression is “IF($H2 > 150$, '○○', IF($H2 > 120$, '○', IF($H2 > 90$, '●', '▲'))),” and c) is the correct answer.

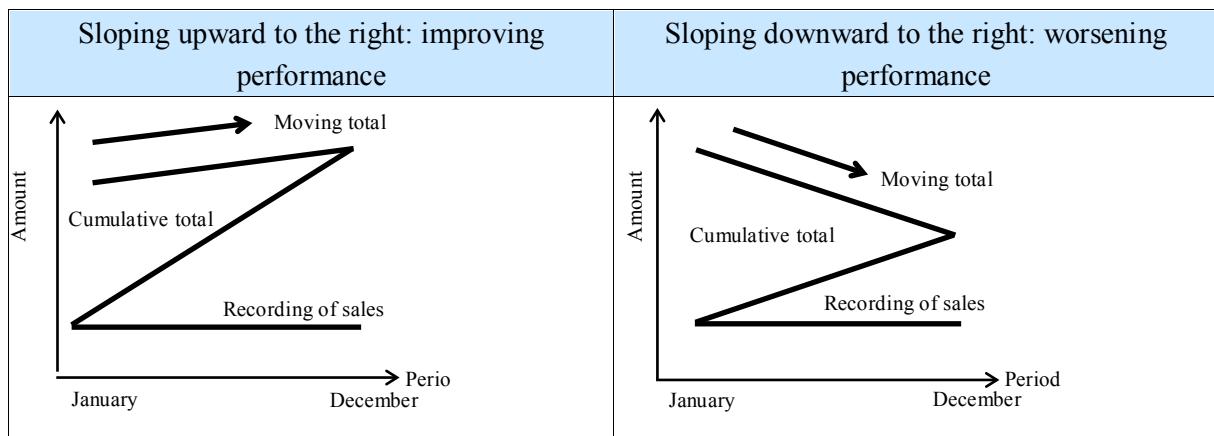
For reference, the worksheet that displays seasonal indexes and Determination values is as follows:

	A	B	C	D	E	F	G	H	I
1		FY 2005	FY 2006	FY 2007	Monthly total	Monthly average	Composition ratio	Seasonal index	Determination
2	April	5,608	5,553	5,441	16,602	5,534	7.6%	91	●
3	May	5,599	5,544	5,433	16,576	5,525	7.6%	91	●
4	June	5,111	5,061	4,959	15,131	5,044	6.9%	83	▲
5	July	6,138	6,078	5,956	18,172	6,057	8.3%	100	●
6	August	7,659	7,584	7,432	22,675	7,558	10.4%	124	○
7	September	4,926	4,878	4,780	14,584	4,861	6.7%	80	▲
8	October	5,484	5,430	5,321	16,235	5,412	7.4%	89	▲
9	November	6,469	6,405	6,276	19,150	6,383	8.7%	105	●
10	December	4,190	4,149	4,066	12,405	4,135	5.7%	68	▲
11	January	3,669	3,633	3,560	10,862	3,621	5.0%	60	▲
12	February	9,805	9,708	9,513	29,026	9,675	13.3%	159	○○
13	March	9,274	9,183	8,999	27,456	9,152	12.5%	151	○○
14	FY total	73,932	73,206	71,736	218,874	72,958	100.0%		

[Subquestion 2]

This Subquestion concerns the expressions and procedures for organizing cumulative performance, moving average, and moving total in the worksheet, based on totaled sales performance. Specifically, the question is one of calculating the various elements used to create a Z graph to be used in analyzing the status of the company's sales. Because all of the blanks call into question the reference methods for cells, the direction of duplication after expressions are entered into cells should be approached with care.

Here a Z-chart is a graph that allows changes in monthly performance and cumulative totals, and 1-year moving totals, to be summarized and compared. Moreover, the slope of the moving total line, which expresses month-by-month cumulative performance for the past year, is able to represent the status of business performance. The Z-chart itself is not addressed in this question, but Z-charts do appear frequently in questions in the test. Because they are not complicated, this opportunity will be taken to review them.



* Blank C: This concerns an expression to calculate cumulative performance for April 2005. At this time, the value of M2, in which sales performance for the month in question is entered will be displayed as is. Thus, among the answer group, a), b), and d) are all potentially correct. However, as (2) in the Subquestion states “cells N2 through N13 is duplicated in cells N14 through N25 and in cells N26 through N37,” the expressions after duplication must use relative references so that N14, which calculates cumulative performance for April 2006, is M14; and so that N26, which calculates cumulative performance for April 2007, is M26. Therefore, b) and d), which use absolute cell references either across rows or across both rows and columns, are inappropriate, and a) is the correct answer.

* Blank D: This concerns an expression to calculate the cumulative total for May 2005 in cell N3, for which the expression “April sales performance + May sales performance” could be considered. However, April sales performance is calculated in cell N2. Further, according to (2) in the Subquestion, after duplication, the expression “is duplicated in cells N4 through N13.” When this is performed, N4, for example, must be “N3 (cumulative sales performance through May) + M4 (sales performance for June)”. For that reason, the expression must use relative references in both directions, with “N2 (cumulative performance through the previous month) + M3 (the current month's sales performance)” being appropriate for the expression, and c) the correct answer.

- * Blank E: The method for calculating the moving average sought for this blank is explained in (2) of [Procedure 2] as a calculation of the average sales performance for the past 1 year (12 months). Because this is the moving average as of April 2006, the expression calculates the average sales performance value from May 2005 to April 2006, for which AVERAGE(M3:M14) is appropriate. Moreover, after this is duplicated in cells O15 through O37, the expression in O15, as an example, must be AVERAGE(M4:M15). For this reason, the cell range must use relative references, and d) is the correct answer.
- * Blank F: The method for calculating the moving total sought for this blank is explained in (3) of [Procedure 2] as a calculation of the total sales performance for the past 1 year (12 months). Because this is the moving total as of April 2006, the expression calculates the total sales performance value from May 2005 to April 2006, for which SUM(M3:M14) is appropriate. Moreover, after this is duplicated in cells P15 through P37, the expression in P15, as an example, must be AVERAGE(M4:M15). For this reason, the cell range must use relative references, and a) is the correct answer.

As reference, the worksheet displaying moving averages and moving totals is as follows:

	K	L	M	N	O	P
1	FY	Month	Sales performance	Cumulative performance	Moving average	Moving total
2	FY2005	April	5,608	5,608		
3		May	5,599	11,207		
4		June	5,111	16,318		
5		July	6,138	22,456		
6		August	7,659	30,115		
7		September	4,926	35,041		
8		October	5,484	40,525		
9		November	6,469	46,994		
10		December	4,190	51,184		
11		January	3,669	54,853		
12		February	9,805	64,658		
13		March	9,274	73,932		
14	FY2006	April	5,553	5,553	6,156	73,877
15		May	5,544	11,097	6,152	73,822
16		June	5,061	16,158	6,148	73,772
17		July	6,078	22,236	6,143	73,712
18		August	7,584	29,820	6,136	73,637
19		September	4,878	34,698	6,132	73,589
20		October	5,430	40,128	6,128	73,535
21		November	6,405	46,533	6,123	73,471
22		December	4,149	50,682	6,119	73,430
23		January	3,633	54,315	6,116	73,394
24		February	9,708	64,023	6,108	73,297
25		March	9,183	73,206	6,101	73,206

26	FY2007	April	5,441	5,441	6,091	73,094
27		May	5,433	10,874	6,082	72,983
28		June	4,959	15,833	6,073	72,881
29		July	5,956	21,789	6,063	72,759
30		August	7,432	29,221	6,051	72,607
31		September	4,780	34,001	6,042	72,509
32		October	5,321	39,322	6,033	72,400
33		November	6,276	45,598	6,023	72,271
34		December	4,066	49,664	6,016	72,188
35		January	3,560	53,224	6,010	72,115
36		February	9,513	62,737	5,993	71,920
37		March	8,999	71,736	5,978	71,736

Note: Cells O14 through O37, which are values for moving averages, are rounded to the nearest integer.

[Subquestion 3]

Subquestions 3 and 4 concern appropriate measures to resolve current problems in the company, based on the results of hearings with the sales department and customer management department. As a step prior to resolving problems in work activities, appropriate assessment and analysis of current workflows is indispensable. Several of the points considered problematic are covered in the hearings, and thus reading through these spots while making annotations for clarity should enable efficient solving of the question.

Subquestion 3 concerns sales promotion proposals to improve the company's repeat order rate and response rate to its pamphlet, with the use of DM and e-mail under consideration as measures.

In order to increase the repeat order rate, the customer management department accepts orders for consumables and regularly replaced parts, but (2) in [Results of hearings with the customer management department] notes that “the order volume for such products is extremely low compared to the sales volume of the main products that use the consumables and parts. The department would like to see orders increase.” As such, it can be assumed that the company has expectations for the effects of actively suggesting consumables and regularly replaced parts, using DM and e-mail to target customers with a purchase history for its main products. At the same time, to increase the response rate to the pamphlet, the company must consider how to narrow down, from the various data it possesses, the information it will provide to customers, and how to provide this information in timely fashion. Moreover, selection of customer groups as appropriate targets for information should seek more efficient methods than the past method, by which the targets for the pamphlet mailing were determined solely on the basis of value of products purchased. Specifically, there is a need to confirm agreement between customer attributes and special products, with provision of information concentrated on those customer groups for which special products and customer needs match. Therefore, a) is the correct answer. Here, the other choices are incorrect due to the following.

- b) The minimal level of information provided should be uniform, but the status of customers' ordering varies widely. Rather than the monolithic response of b), the company ideally should respond as flexibly as possible to each customer. Already, the product catalog is mailed to all customers registered in the system, and the pamphlet is mailed only to customers who have made product purchases of a certain value or higher in the past year. However, the number of customers making repeated orders for regular products has barely increased in recent years, and the repeat order rate per customer is on a downward trend. Furthermore, the pamphlet response rate is almost the same as that for regular products. The goal of Subquestion 3 is to resolve the problems behind the current stagnation, and the method of b) is doubtful from a cost-performance perspective.
- c) Creating a web-based shopping site for product purchases and increasing the opportunities for use by customers is a commonplace method today. However, as such a plan is not described anywhere in the question, and as even the Subquestion text limits methods of "using DM and e-mail," this is incorrect. Moreover, because it is easy to imagine that stopping the use of paper media and thus DM would alienate customers who do not shop in the online environment, this is not an appropriate method.

[Subquestion 4]

This concerns functional improvements to the system in order to respond promptly to inquiries and complaints from customers. In (3) of [Results of hearings with the customer management department], a cause of current problems is identified as "Requests or complaints concerning the same product may come from multiple customers, but even in cases concerning the same content, the current system requires a search with a full-text search function" so therefore the method that solves this should be selected as an answer. In other words, a function that categorizes and organizes past results of Company N's customer responses by product, content of claims, etc., and that enables search by any keyword, would seem to be essential. Therefore, c) is the correct answer. In addition, the other choices are incorrect due to the following.

- a) The suggestion is to stop response by phone and FAX, which are considered responsive methods, and instead accept all inquiries and complaints only through online methods such as e-mail and the Web site. In general, whether this strategy leads to prompt responses depends largely in part on the equipment and systems in place on the customer response side. From the description in the question text, it cannot be determined that this will have a sure effect.
- b) As the question concerns improvements to systems, answer b), which suggests the employment and assignment of apt human resources, is irrelevant.
- d) On screens introducing specific products, offering easy search and display of information on related products would enable the provision of effective advice in response to product inquiries from customers. However, this cannot be said to be an appropriate method for speeding responses to complaints.

Q12-15 Class placement test (spreadsheet)**[Answers]**

[Subquestion 1] A-d), B-c)

[Subquestion 2] C-c), D-g), E-d)

[Subquestion 3] F-c), G-a), H-b), I-e)

[Subquestion 4] J-b), K-e), L-b), M-a)

[Explanation]

This question concerns a class placement test for applicants of a course for the acquisition of qualifications. The currently used classification method, based on a score drawn from the number of correct answers, is analyzed, and a new classification method, based on probabilities calculated from accuracy in answering the questions, is considered. The subquestions involving data references across worksheets and reference relationships when duplicating cells are relatively easy, but the Subquestions involving the expressions to display classes based on score, or the expressions to calculate probability corresponding to each class from the applicants' accuracy, are somewhat difficult. Those with basic knowledge of probability will find the content easy to understand, but even those without that knowledge should not find answering the questions impossible.

[Subquestion 1]

Using the current class placement method, this subquestion calls for calculating the class into which applicants with 65 correct answers are sorted, and the minimum number of correct answers for placement into Class 5. The expression for score is described in the question text. Calculation of the score, number of correct answers, etc. can be performed by assigning values for averages, standard deviation, and so on in the expression. Incidentally, the score used here, derived from the number of correct answers, is a numerical value corresponding to statistical standard value.

- * Blank A: Assigning the applicant's number of correct answers (65), the number of correct answers for all applicants (60), and the standard deviation (10) to the relevant expression for score in the question yields $(65 - 60) / 10$, for a score of 0.5. Checking this score against the table "Criteria for class placement according to score" yields Class 4. It should carefully be noted that a score of 0.5 is on the border of Class 3 and Class 4, but falls under Class 4 as that class specifies 0.5 or more while Class 3 specifies less than 0.5. Therefore, d) is the correct answer.
- * Blank B: As Class 5 specifies a score of 1.5 or more, assigning score (1.5), average (60), and standard deviation (10) to the expression for score to derive the number of correct answers yields $1.5 = (\text{number of correct answers} - 60) / 10$, or 75 as the number of correct answers. Therefore, an applicant with 75 or more correct answers is placed in Class 5, and c) is the correct answer.

[Subquestion 2]

This subquestion concerns expressions for summing the number of correct answers given by applicants and deriving the average and standard deviation in the worksheet “Grading”, based on data in the worksheet “Accuracy”, which contains the grading results for tests from 1,000 persons. The question concerns data referencing across worksheets, with “sheet_name!cell” as the specified format to be followed.

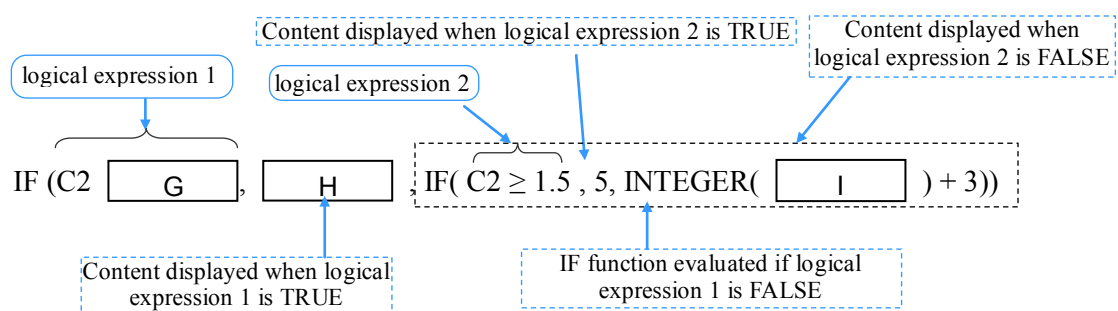
- * Blank C: An expression to sum the grading results in worksheet “Accuracy” and calculate applicants' number of correct answers is entered in cell B2, and is duplicated in cells B3 through B1001. As data in another worksheet is referenced, the functions in the expression must specify cells in the worksheet “Accuracy”. In worksheet “Accuracy”, the status of accuracy for 100 questions is entered in columns B through CW, using “1” for a correct answer and “0” for an incorrect answer. Therefore, calculating the sum for Column B through Column CW for each row yields the number of correct answers for each applicant. From the above, the expression to be entered into cell B2 in the worksheet “Grading” is, with the sheet name “Accuracy” specified, “SUM(Accuracy!B2:Accuracy!CW2)”. Moreover, when the expression is duplicated in cells B3 through B1001, the number of correct answers for 1,000 applicants is displayed. Therefore, c) is the correct answer. Here, the answer group does not call the direction of references into question, and thus in the duplication it is not necessary to consider absolute versus relative references.
- * Blanks D, E: These calculate average and standard deviation based on the number of correct answers of 1,000 applicants in the worksheet “Grading”. The number of correct answers given by applicants is calculated in the worksheet “Grading” from the expression in blank C, and there is no need to reference data in another worksheet. Moreover, the number of correct answers for the 1,000 applicants is entered in Column B, from rows 2 through 1001. Therefore, blanks D and E are “AVERAGE(B2:B1001)” and “STANDARDDEVIATION(B2:B1001)”, respectively, making g) the correct answer for blank D and d) the correct answer for blank E. Here, “AVERAGE” and “STANDARDDEVIATION” are standard functions listed under “Spreadsheet Software Functions and Terminology” at the end of the question booklet.

[Subquestion 3]

The score is calculated for each applicant, and the corresponding class is displayed. It is important to understand the mechanism by which class is displayed according to “criteria for class placement according to score” and the expressions set in the blanks in the Subquestion.

* Blank F: The expression to calculate the first person's score is entered in cell C2, and is duplicated in cells C3 through C1001. First, the expression for the score of the first person that is entered into cell C2, will be considered. Taking cell B2, which is the number of correct answers for the first applicant; cell F1, which is the average number of correct answers for all applicants so far; and cell H1, which is the standard deviation of the correct answers for all applicants so far; and applying these to the question's expression for score yield $(B2-F1)/H1$. Next, the reference relationships when this expression is duplicated across rows will be considered. When the expression is duplicated, the number of correct answers for applicants is applied to the second person (cell B3), the third person (cell B4), and so on, and thus relative references must be specified. However, the average number of correct answers for all applicants so far (cell F1) and the standard deviation of correct answers for all applicants so far (cell H1) are applied equally to the second person onward, and thus absolute references must be specified. Therefore, the expression to be entered into cell B2 is $(B2-F\$1)/H\1 , and c) is the correct answer. Moreover, as B2 is not duplicated across columns, there is no need to consider the reference relationship in that direction.

* Blanks G through I: The expressions that are inserted into the blanks are for the purpose of displaying class in cell D2, and thus the resulting displayed content is the class – that is, an integer from 1 to 5. If this is considered simply, 4 nested IF functions could be used to display the class that corresponds to the value in C2. However, the expression in the question uses two nested IF functions, and thus the answer is not so simple. As the expression is all blanks, sorting out the expression according to the IF function format yields the following.



First, regarding the “`IF(C2 ≥ 1.5, 5`” portion that is not a blank, this displays “5” when the value of C2 is 1.5 or more, and is clearly the determination and display of Class 5. On the other hand, blank H is the content that is displayed when logical expression 1 (C2 and blank G) is TRUE. The answers for blank G are all comparisons with 1.5 or −1.5. However, a section displaying Class 5, distinguished by comparison with 1.5, already exists, and thus it can be assumed (if not known for sure) that blank G is a section that displays Class 1 through comparison with −1.5. Subsequently, it can be predicted that “`INTEGER([blank I]) + 3`”

is a section displaying Class 2 through Class 4. Moreover, from the content of the answer group for blank I, either C2 or C2 adjusted by a constant goes into blank I. At this stage, these are no more than predictions, but the question can be considered concretely by using these as clues.

For example, as $C2 = -1.5$ yields Class 2, the answer group for blank I can be searched for content that yields the value 2 for “INTEGER() + 3”. The answer e), “C2 + 0.5”, corresponds to this. Moreover, applying this to blank I and looking at “INTEGER(C2 + 0.5) + 3”, the expression yields “3” when $C2 = -0.5$, and yields “4” when $C2 = 0.5$, confirming that Class 2 through Class 4 are correctly displayed according to the value of C2. Based on this result, applying candidate answer to each blank yields the following.

$$\text{IF}(C2 < -1.5, 1, \text{IF}(C2 \geq 1.5, 5, \text{INTEGER}(C2 + 0.5) + 3))$$

An analysis of the content of this shows that the content displayed is “1” when logical expression 1 ($C2 < -1.5$) is TRUE, and is “5” when logical expression 2 ($C2 \geq 1.5$) is TRUE. Otherwise ($-1.5 \leq C2 < 1.5$), a value from “2” to “4” is displayed according to the value of “INTEGER(C2 + 0.5) + 3”. As the content of this matches the class sorting conditions in the table, the predictions made so far can be considered confirmed, and can be settled on as answers. Therefore, the correct answers are a) for blank G, b) for blank H, and e) for blank I.

[Subquestion 4]

This question concerns a new class placement method. As there are blanks in the description indicating the specific procedures, answers should be considered while reading the descriptions of the relevant locations, with reference to Fig. 4 and Fig. 5.

* Blank J: This concerns the probability that a person in Class 1 will answer Q5 correctly and Q25 incorrectly. In general, the probability that two incidents (phenomena) will occur simultaneously is calculated as the product of the two probabilities. Thus, the correct answer is the product of the probability of answering Q5 correctly (0.1) and the probability of answering Q5 incorrectly ($0.8 = 1 - 0.2$), which yields 0.08, or b). It should be carefully noted that the probability for Q25 is not that of a correct answer, but that of an incorrect answer.

Incidentally, the calculation of the probability of two phenomena occurring simultaneously by taking the product as per the above is conditional upon the two phenomena being independent (i.e., unrelated, and both coincidental). As accuracy in answering test questions is dependent upon the knowledge of the applicant, strictly speaking, they cannot be called independent. Examinees with the knowledge to answer Q5 correctly should, in comparison with persons without that knowledge, have a higher probability of answering Q25 correctly. For this reason, persons with knowledge of probability and statistics may have been troubled by the question. However, as no conditions regarding such relationships are described in the question, there is nothing to do but use simple products in the calculation. Moreover, care should also be taken to note that only persons in Class 1 are considered. If all applicants were under consideration, a knowledge bias could be considered, and it would be fairly doubtful that there is no dependent relationship between the probabilities of answering Q5 and Q25

correctly. However, as the premise concerns persons in Class 1 only – that is, persons with roughly the same level of knowledge – the relatedness can be assumed to be low.

- * Blank K: If this blank is the probability that a person in Class 1 will obtain the result in cell B2 (i.e., answer Q5 correctly), then the content of cell B3 can simply be displayed here as is. However, as the content is also duplicated in cells B8 through K12, it is not that simple. For example, in the duplication destination cell C9, the value of the corresponding cell C4 displays not 0.36, but 0.64. Considering that the logical meaning of the duplication destination cell C9 is the probability of a person in Class 2 obtaining the result in cell C2 (answering Q25 incorrectly), the value is that of 1 minus the probability of answering correctly which is entered in cell C4 (with matching content displayed). In other words, if the accuracy (the second row) of that column is “1”, and the value of the corresponding cell in the third to seventh rows in the same column is “0”, the value is 1 minus the value of the corresponding cell. The answer corresponding to this should be searched from among the answer group. An analysis of each expression shows that a) through d) and g) each takes the form of a product, and depending on the value of B\$2 (C\$2 through K\$2 at the duplication destination), is 0 regardless of B3 (B3 through K7), and thus is incorrect. Moreover, in f), when the value in the second row is “1”, the value becomes 1 minus the value of the relevant cell $(1 - B3)$, and thus this too is incorrect. Therefore, “ $B\$2 * B3 + (1 - B\$2) * (1 - B3)$ ”, or e), is the correct answer. It should be confirmed that this content yields the value of the relevant cell (B3) when the second row is “1”, and the value of 1 minus the value of the relevant cell $(1 - B3)$ when the second row is “0”.
- * Blank L: This is the expression input into cell L8 and duplicated in cells L9 through L12. However, the content actually displayed is shaded out, and furthermore, the meaning of what it calculates is not directly described. A search for a hint reveals that all that can be understood from the description in (4) and (5) is that class is decided by this value; any more than that is unclear. If the description text is read again for further hints, it can be seen that just before (1) is: “Mr U decided to apply the method for calculating the probabilities for these 2 questions to the selected 10 questions, and to perform class placement using the method shown below.” Furthermore, as the “method for calculating the probabilities for these 2 questions” – that is, blank J – was one that calculates the product of probabilities, the product in b) is the correct answer.
- * Blank M: The purpose of the selected 10 questions is to perform efficient class placement. In other words, the selected questions must include characteristics for the purpose of performing class placement. Keeping this in mind, and considering the content of the answer group, it can be understood that “large differences in the correct answer ratio,” as per a), is an appropriate answer. “Small differences in the correct answer ratio,” as per b), means that classes have little in the way of characteristics. As for “difficult” as per c) and “easy” as per d), there is no guarantee that these are reflected as is in the correct answer ratio. Moreover, with “randomly-chosen,” any characteristic will change each time.

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