Ritsumeikan University Graduate AY2024Entrance Examination

Master's Program

Graduate School of Information Science and Engineering

Advanced Information Science and Engineering Major

Admissions	Course	Examination	Major Subjects (Common Subjects・Specialized Subjects)	
			Page	Notes
Regular Admissions (English-based Program)	Information Science and Engineering	August	P.1～	
		February	P.22～	
		February (September 2025 Enrollment)	P.22～	
International Student Admissions (English-based Program)		August		
		November		
In-University Advancement Admissions (English-based Program)		July		
		February (September 2025 Enrollment)		
Accelerated Learners (Grade Skippers) (English-based Program)		February	P.22～	

【How to read the front cover page】
×…Those for which the entrance examination questions were not created due to reasons such as the entrance examination not being conducted, or those for which the examination questions are not disclosed.
Diagonal line…The test designed by each couse(a written test) has not been conducted.

Ritsumeikan University Graduate School

AY2024Entrance Examination

Doctoral Program

Graduate School of Information Science and Engineering

Advanced Information Science and Engineering Major

Written Examination is not conducted for the Doctoral Program.

August 2024 Admissions

AY2025 Examination Questions for the Graduate School of Information Science and Engineering, Ritsumeikan University (Master's Program)

Major in Information Science and Engineering
Information Science and Engineering Course

【How to answer questions】

Please follow the instructions below and answer the questions.

1) Choose two questions from question ①~③ for Common Subjects.
2) Choose either the Computer Science section or the Human Information Science section for Specialized Subjects.
   - In case choosing the Computer Science section, answer three questions from question ④~⑨.
   - In case choosing the Human Information Science section, choose one question either ⑩or⑪.

   *There will be two blank answer sheets in case choosing the Human Information Science section.

Examination Subjects and Questions			Allocation of Points		Remarks
Common Subjects		①Linear Algebra	100 points	Total 200 points	Choose 2 out of the 3 questions
		②Probability and statistics	100 points		
		③Data structure and algorithms	100 points		
Specialized Subjects	Computer Science	④Computer Architecture	-	Total 100 points	Choose 3 out of the 6 questions
		⑤Operating System	-		
		⑥Software Engineering	-		
		⑦Computer Networks	-		
		⑧Databases	-		
		⑨Artificial Intelligence	-		
	Human Information Science	⑩Image processing	100 points	Total 100 points	Choose 1 out of the 2 questions
		⑪Artificial Intelligence	100 points		

【Examination time】

9:30-11:30 (120minutes)

※Leaving the examination venue is not allowed during the examination time.

※In case you feel sick or need to go to the bathroom, let examination supervisors know by raising your hand.

【Notes】

(1) Use one answer sheet for one question.
(2) Fill out your examination number and name for all the answer sheets. Also, make sure to fill out all the other necessary sections such as the questions number column.
(3) Do not remove the staple of your answer sheets.
(4) Answer sheets with no names will be invalid and the score will be 0 points.
(5) Do not take the question sheets and answer sheets with you after the examination.

Common Subjects

①Linear Algebra
②Probability and Statistics
③Data Structure and Algorithms

Choose two questions from the above.

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Common Subjects① Linear Algebra

Answer all the questions below with the derivation process.

Question 1. Determine whether the set of vectors $\left\{\begin{pmatrix}0\\1\\4\end{pmatrix}, \begin{pmatrix}2\\-1\\0\end{pmatrix}, \begin{pmatrix}1\\0\\2\end{pmatrix}\right\}$ is linearly independent or linearly dependent.

Question 2. Given the point $\mathrm{A}(7,1,-3)$ and the plane $\beta: x+2y-3z+10=0$, answer the following.

(1) Find the line l passing through the point A and perpendicular to the plane β.

(2) When the intersection of the plane β and the line l is point P, find the length of AP.

Question 3. Given the matrix $C=\begin{pmatrix}2 & -1\\3 & 6\end{pmatrix}$, answer the following.

(1) Find the eigenvalues and eigenvectors of matrix C.

(2) Find C^n.

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Common Subjects② Probability and Statistics

Answer all of the following questions with all calculation processes and ideas.

Question 1. Suppose the random variables X and Y follow the joint probability density function:

$$f(x, y) = Ce^{-2x^2-y^2+x-2y}$$

Answer the following questions:

(1) Determine the constant C.
(2) Calculate the means of X and Y.
(3) Determine the covariance matrix for X and Y.
(4) Discuss whether X and Y are independent and whether they are uncorrelated, providing reasons.

Question 2. A coin, which has an equal probability of landing heads or tails ($1/2$ each), is tossed. If it lands heads, add $+1$ to x; if it lands tails, subtract -1 from x. Starting from $x = 0$, and after tossing the coin n times, answer the following questions about x_n (the value of x after n tosses):

(1) Calculate the expected mean of x_n.
(2) Calculate the expected mean of $(x_n)^2$.

Question 3. For a log-normal distribution with parameters μ and σ (where $x > 0$):

$$P(x) = \frac{1}{x\sigma\sqrt{2\pi}} e^{-\frac{(\log x-\mu)^2}{2\sigma^2}}$$

answer the following questions:

(1) Calculate the mean of the log-normal distribution.
(2) Determine the mode of the log-normal distribution.
(3) Find the median of the log-normal distribution.
(4) Assume that a population following the log-normal distribution provides ten independent samples $X_1, X_2, \cdots, X_{10}$. Express the log-likelihood function $L(\mu, \sigma)$ using $X_1, X_2, \cdots, X_{10}$.
(5) Determine the values of μ and σ that maximize the log-likelihood function $L(\mu, \sigma)$ calculated in part (4).

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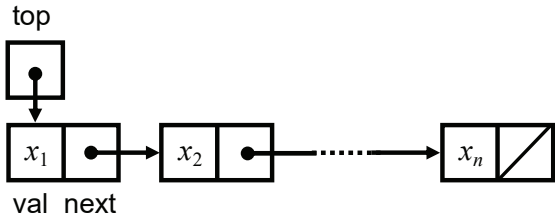
Common Subjects③ Data Structure and Algorithm

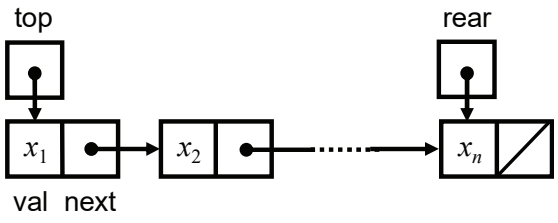
This question consists of 2 pages. Answer all the questions below.

Question 1. Consider the behavior of a linked list consisting of n elements $x_1, x_2, \ldots, x_n$ when implemented using the following implementation methods A and B. Answer the following questions.

Implementation method A: The 'top' in the figure holds the address of the first element.



Implementation method B: The 'top' in the figure holds the address of the first element, and the 'rear' in the figure holds the address of the last element.



(1) Answer one applicable classification from the options in (a) that corresponds to a linked list implemented using the method B, which has the functionality of adding new elements to the end and removing elements from the beginning.

Options (a):
① queue ② stack ③ singly linked list ④ doubly linked list ⑤ circular linked list

(2) For implementation methods A and B, answer the worst-case time complexity required to search for the last element in order notation, using the number of elements n if necessary.

(3) Assume that a linked list containing the elements {7, 5, 3} in order from the top, with the address of the top element held in 'list1', and a linked list containing the elements {6, 4} in order from the top, with the address of the top element held in 'list2' are given to the function of the pseudocode shown in Figure 1. Give all the elements of the linked list returned by the function in order from top to bottom. Note that both given linked lists are realized by implementation method A.

(4) Give the worst-case time complexity in order notation when the function of the pseudocode shown in Figure 1 is applied to two linked lists realized by implementation method A, where the address of the first elements is held by 'list1' and 'list2', respectively, using the number of elements n in the linked list 'list1' and the number of elements m in 'list2'.

```
 1: function searchTwoList(list1, list2) {
 2:     if (list1 == NULL) return list2
 3:     if (list2 == NULL) return list1
 4:     if (list1.val >= list2.val) {
 5:         list1.next = searchTwoList(list1.next, list2)
 6:         return list1
 7:     } else {
 8:         list2.next = searchTwoList(list1, list2.next)
 9:         return list2
10:     }
11: }
```

Figure 1: pseudocode for the two linked lists.

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Question 2. If the number of elements in an array to be sorted is n, select all the names of sorting algorithms from the options in (b) that satisfy each of the conditions (1) to (3) below. Note that a sorting algorithm is stable if, when sorting an array with two or more elements with the same value, the order of those elements does not change before and after sorting.

(1) A stable algorithm with a worst-case time complexity of O(n log n)
(2) An unstable algorithm with a worst-case time complexity of O(n^2)
(3) A stable algorithm with a worst-case time complexity of O(n^2)

Options (b):
① bubble sort ② selection sort ③ insertion sort ④ heap sort ⑤ merge sort ⑥ quick sort

Question 3. Hashing is a data search algorithm that maps the values of n elements $x_1, x_2, \ldots, x_n$ in the search target to indexes using a hash function to store data in an array. Answer the following questions.

(1) Using a hash function that calculates the remainder of each element's value a from the data $S = \{10, 5, 6, 4, 2, 7, 3\}$ divided by 3 (i.e., mod(a, 3)), give which element's value causes the first collision when processing from the beginning of the data.
(2) Give the worst-case time complexity in order notation for searching when the hash function does not cause collisions in the data.

Specialized Subjects

Computer Science

④Computer Architecture
⑤Operating System
⑥Software Engineering
⑦Computer Networks
⑧Databases
⑨Artificial Intelligence

In case choosing the Computer Science section, answer three questions from question ④～⑨

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Computer Science④ Computer Architecture

Answer all the questions below.

Question 1.

Fill in the blanks [A] through [P] in the following sentences regarding pipeline processing of processor instructions with the appropriate word(s). Assume the same word is filled in the blanks with the same symbol.

Pipeline processing processes multiple [A]s in parallel by slightly overlapping the execution of successive instructions. Figure 1 shows pipeline processing in a processor where the number of [A]s is 5. The [A]s marked with an * in Figure 1 are [A]s to perform [B]. Pipeline processing does not aim to improve the time from the start to the end of execution of an instruction, in other words, [C], but rather the number of instructions processed in a given amount of time, in other words, [D].

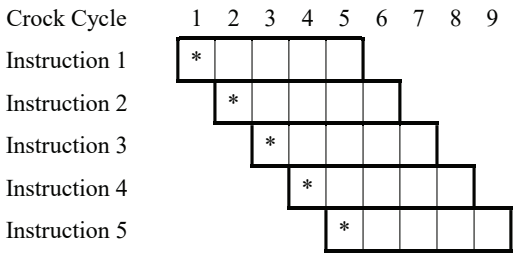

Figure 1

Ideally, the processing of each instruction would progress to the next [A] every clock cycle, but events can occur where this is not possible. These events are called [E]. [E]s are broadly classified into [F], [G], and [H]. [F] occurs when the subsequent instruction depends on the result of the preceding instruction. [G] arises when the execution of a subsequent instruction depends on whether the preceding branch instruction is taken. [H] occurs due to contention for hardware resources. For example, [H] occurs in a processor design that cannot simultaneously perform memory access to perform [B] and memory access to read or write operands.

When a [E] occurs, it is common to temporarily stop part of the pipeline, which is called [I]. To maximize the effectiveness of pipeline processing, it is important to reduce the frequency of [I].

To resolve [F], the result of the calculation obtained by the preceding instruction is sent to the [A] of the subsequent instruction that requires it, which is called [J]. To eliminate [G], a branch instruction is introduced that always executes the immediately following instruction regardless of whether the branch is taken or not. This type of branch instruction is called [K]. [L] is introduced as a method to reduce the probability of [I] caused by [G]. In addition, [M], which combines multiple iterations of a repetitive process into one to reduce the number of iterations, can also contribute to a reduction in [G] because it reduces the number of times branch instructions are executed.

Instruction set architectures must be carefully designed to implement pipeline processing efficiently. For example, it is not desirable for the number of memory accesses required for [B] to vary depending on the instruction so it is expected to set [N] to be the same for all instructions.

So far, we have discussed basic pipeline processing, which can only issue one instruction at a time. Still, more advanced architectures aim to improve [D] by simultaneously issuing multiple instructions. This can be broadly divided into static multiple issue and dynamic multiple issue. The former is an architecture that assumes that the compiler generates a large instruction that combines multiple instructions that do not result in [E] when issued simultaneously. It is often referred to by its four-letter abbreviation [O]. The latter dynamically determines whether [E] will occur across multiple instructions in an instruction sequence and executes them in parallel as much as possible. It is referred to as [P].

Question 2.

When processor A executes a program, 75% of the time is taken up by calculation processing, and the remaining 25% is taken up by I/O processing. Discuss the limit of performance improvement that can be expected when executing the same program on processor B, which has significantly better calculation processing performance, citing the name of a well-known law. Assume that the time required for I/O processing is the same for processors A and B.

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Computer Science⑤ Operating Systems

Answer all the questions below.

There are two execution programs, "non-semaphore" and "semaphore", which handle a shared variable initialized to 0 with two threads. One thread increments the shared variable by 1 a total of 10 million times, while the other thread decrements it by 1 the same number of times. The "non-semaphore" program executes without mutual exclusion control over the shared variable, while the "semaphore" program executes with mutual exclusion control. As a result, the value of the shared variable in the "non-semaphore" program will not necessarily be 0 at the end of execution. When the execution time for both programs was measured using the "time" command, the following results were displayed.

```
% time ./non-semaphore

./non-semaphore  0.11s user 0.00s system 197% cpu 0.056 total

% time ./semaphore

./semaphore  0.84s user 0.27s system 182% cpu 0.604 total
```

Among the items displayed in the execution results, **`user`**, **`system`**, **`cpu`**, and **`total`**, the **`total`** represents the actual number of seconds the program took from start to finish, and the **`cpu`** indicates the CPU utilization rate during program execution. Additionally, **`user`** and **`system`** represent the time the processor was active, with system specifically indicating the time spent on system calls, i.e., calling the OS. The reason the **`cpu`** value exceeds 100% for both programs is that the processor in this execution environment had two processor cores running. Answer the following questions considering process state transition.

(1) Explain what it means that the **`cpu`** value for both execution programs is slightly less than 200%.
(2) Explain why the **`cpu`** value for the non-semaphore program is closer to 200% than for the semaphore program.
(3) In the semaphore execution program, the actual time the processor was used is the sum of **`user`** and **`system`**, which is just over 1 second. However, since there are two processor cores, it is actually just over 0.5 seconds, which is shorter than the total of 0.604 seconds. Write the equation that holds among **`user`**, **`system`**, **`cpu`**, and **`total`** in this case. Note that in the execution of the above program, various factors may affect the measured values, so the equation does not have to match the measured values exactly, and an error of about 1% is acceptable.
(4) Explain why the **`user`** time is longer in the semaphore execution program.

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Computer Science⑥ Software Engineering

Answer all the questions below.

Question1.

Identify and explain one reason why it is difficult to reflect customer and user requirements in the specification accurately.

Question2.

Describe one advantage of a development process that involves prototyping.

Question3.

Describe how the objectives of testing and debugging are different.

Question4.

Explain the purpose and process of refactoring.

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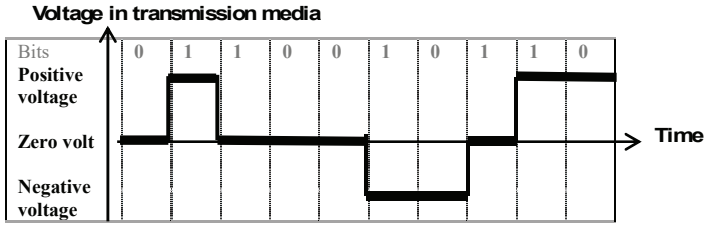
Computer Science⑦ Computer Networks

This question consists of 2 pages. Answer all the questions below.

Q1. Answer the following two sub-questions regarding line codes that use positive and negative voltages as physical quantities.
(1) Describe the two line codes:
(1a) a non-return-to-zero level (NRZ(L)) line code.
(1b) Manchester code (or phase encoding).
(2) Illustrate changes in physical quantities of transmission media such as voltage for bit sequence "0110010110" for each of the two line codes:
(2a) non-return-to-zero level line code and (2b) Manchester code. The following is the example of another line code for illustrating changes of voltage for reference.



The example to illustrate changes of voltage for MLT-3 (Multi-Level Transmit).
The line code is the bold line part. The vertical dotted lines indicate the transmission clock rise time.

Q2. For the descriptions regarding computer networks from (1) to (7), complete each description by selecting the correct answers from the options inside the boxes. You may answer by writing appropriate keywords or phrases if you find no suitable options. Assume that the same option should be assigned to the boxes with the same question identification.

(1) The acronym of an industry-driven interest group that was founded in 1993, which provides specifications for a complete set of protocols for wireless infrared communications, is [Q(a) ① ITU ② IETF ③ IEEE ④ IrDA] and the name [Q(a)] also refers to that set of protocols.

(2) In the [Q(b) ① ALOHA ② CSMA ③ FDDI ④ IEEE 802.5] protocol, which is a bus or media access control algorithm, each node does not sense whether another node's signal is on the bus or not, and starts to transmit packets as soon as they are ready.

(3) In the Open Systems Interconnection model, or OSI model, the [Q(c) ① physical ② data link ③ network ④ transport] layer is responsible for packet forwarding, including routing through intermediate routers and networks. In a LAN, a device that relays frames in the middle of a transmission path to extend the transmission distance and only transfers them at the data link layer of the OSI model is called [Q(d) ① a repeater ② a router ③ a network bridge ④ an ONU] .

(4) A host with an IPv4 (Internet Protocol version 4) address in dotted decimal notation (or dot-decimal notation) 192.168.25.254 belongs to class [Q(e) ① A ② B ③ C ④ D ⑤ E] networks. If we change the subnet mask of the network to 255.255.255.192 in dot-decimal notation, the maximum number of unique host IP addresses is [Q(f) ① 62 ② 168 ③ 192 ④ 254] .

(5) The first four bits of the IP header indicate the version number of the IP, and the binary [Q(g) ① 0001 ② 0100 ③ 0110 ④ 1001] indicates that IPv6 (Internet Protocol version 6) is being used. The Internet Header Length field, which indicates the size of the protocol header, is [Q(h) ① in the IPv4 header only ② in the IPv6 header only ③ both in the IPv4 header and in the IPv6 header] .

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(6) Regarding TCP and UDP on IPv4, Q(i) ① only TCP has ② only UDP has ③ both TCP and UDP have the source port number field on each header.

(7) The Q(j) ① RIP ② OSPF ③ BGP-4 ④ CIDR is a dynamic routing protocol that automatically determines the shortest path using the number of routers to go through as a distance metric. It is difficult to apply it in large networks for reasons such as the inability to inform neighboring routers of the subnet mask information.

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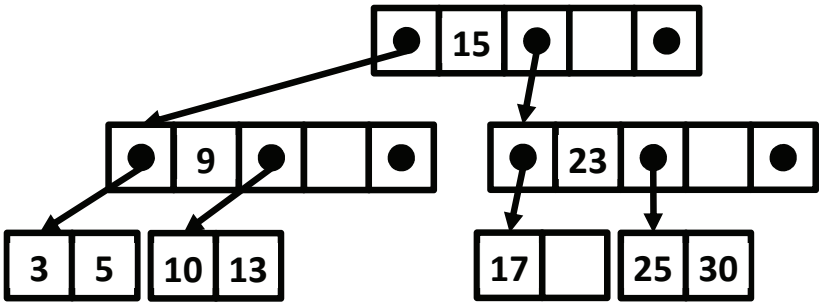
Computer Science⑧ Databases

Answer all the questions, 1, 2, and 3, below.

Question 1. For the following 2-3 B-tree, draw the result of B-tree after performing operations (1), (2), (3) and (4) on the B-tree using the same notation as the figure.

(1) Insert a record with key value 19 into the following B-tree.
(2) Insert a record with key value 21 into the result of (1).
(3) Insert a record with key value 33 into the result of (2).
(4) Insert a record with key value 14 into the result of (3).



Question 2. Rewrite the following second normal form "order" in the third order form. Here, the underlined parts show the primary keys.
order (order_num, product_num, product_name, quantity)

Question 3. For the following student relation, please fill appropriate terms in the blanks [A] through [F] of the (1) – (3) SQL queries.

stu_NO	name	gender	GPA	birthday	dep_num
100111	Hiromi Yasuda	female	3.3	1993-12-9	3
100115	Katsumi Kimura	male	4.1	1981-7-21	2
100143	Kei Irie	male	1.9	1982-4-30	3
100222	Noriko Ichikawa	female	3.6	1992-9-8	2
100233	Shinichi Tamura	male	2.6	1982-1-11	1
100262	Yumi Kuroki	female	4.5	1980-12-11	3

(1) Output stu_NO, name, and GPA of students belonging to department number 3 in the order of highest GPA.

SELECT stu_NO, name, GPA FROM student WHERE dep_num = 3 [A] GPA [B] ;

(2) For male students, output dep_num and minimum GPA for each department.

SELECT dep_no, [C] FROM student WHERE gender ='male' [D] dep_num;

(3) Output all data for students whose GPA is higher than the maximum GPA for students born after January 1, 1982.

SELECT * FROM student WHERE GPA > [E] (SELECT GPA FROM student WHERE birthday [F] '1982-1-1');

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Computer Science⑨ Artificial Intelligence

This question consists of 2 pages. Answer all the questions below.

Question：For the following explanations of Artificial Intelligence (AI) from (i) to (v), choose the most suitable word or number for the boxes (1) to (15) from the options shown below each explanation and answer with alphabetical symbols a through h. Note that some unrelated options are included. Assume that the same word is enclosed in the box with the same number.

(i) In the graph G_1 in Fig.1, the numbers along edges are actual costs and ones in parentheses are estimated costs. For the graph G_1, when finding the path from node S to G using the A* algorithm, the third node to be marked as "visited" (explored) is [(1)], and the total cost of the obtained path from node S to G is [(2)]. Note that the first node to be marked as "visited" (explored) is node S. Also, this obtained path and the path obtained using the best-first search algorithm are [(3)].

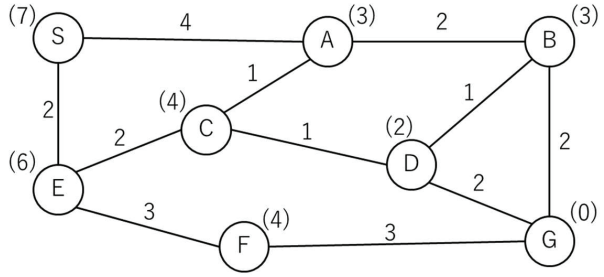

Fig.1 Graph G_1 (The numbers along edges are actual costs and ones in parentheses are estimated costs)

【Options for (i)】

a	E	b	B	c	C	d	same
e	7	f	8	g	9	h	different

(ii) Consider a normal form game represented by the payoff matrix in Table 1. In the payoff matrix, the left value of each cell is the payoff of Player A, and the right one is the payoff of Player B. Assume that each player acts rationally. When α in Table 1 is $\alpha = 1$, regardless of the other's action, Player A and Player B take actions [(4)] respectively. Also, when α in Table 1 satisfies [(5)], a dominant strategy equilibrium does not exist, but a Nash equilibrium does. In this Nash equilibrium, Player A and Player B take actions [(6)] respectively.

Table 1 Payoff matrix

		Player B	
		b_1	b_2
Player A	a_1	(3, 2)	(α, 1)
	a_2	(5, 4)	(4, 3)

【Options for (ii)】

a	$\alpha < 1$	b	$4 < \alpha$	c	(a_1, b_1)	d	(a_1, b_2)
e	$\alpha < 3$	f	$2 < \alpha < 4$	g	(a_2, b_1)	h	(a_2, b_2)

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(iii) The particle filter, a self-localization technique, is an approximation method of the [(7)] . In the particle filter, [(8)] is used, where a sample set generated from the probability distribution serves as a substitute for the probability distribution. Additionally, the [(9)] method, which involves extracting sample points from the probability distribution and resampling them with weights, is employed. This allows for the estimation of self-location from a finite set of sample points.

【Options for (iii)】

a	Q-learning	b	Bayesian filter	c	Kalman filter	d	SIR
e	Monte Carlo approximation	f	SLAM	g	Boltzmann exploration policy	h	LSTM

(iv) In supervised learning, problems are broadly divided into classification problems and regression problems. [(10)] are a method used to solve classification problems, while [(11)] are used to solve regression problems. In regression problems, the most fundamental method to solve them is to optimize the parameters θ of the learning model so as to minimize the evaluation function of the prediction error $E(\theta)$. The method that optimizes the parameters θ based on the partial derivatives of $E(\theta)$with respect to θ is called the [(12)] .

【Options for (iv)】

a	steepest descent method	b	least squares method	c	general linear model	d	k-means clustering
e	maximum likelihood estimation	f	BERD	g	random forest	h	representation learning

(v) To perform morphological analysis, [(13)] is used, where candidate words are represented as nodes, and the connections between words are represented as edges. To obtain the results of morphological analysis with [(13)] , one should find the path that [(14)] the total cost, assigning higher costs to less likely word connections. A statistical approach to determining the cost of the edges in the [(13)] is called the [(15)] , which considers the generation probability of a word conditioned on the previous n-1 words.

【Options for (v)】

a	maximizes	b	minimizes	c	Bag-of-Word representation	d	n-gram model
e	semantic analysis	f	mixture model	g	syntactic tree	h	word lattice

Specialized Subjects

Human Information Science

⑩Image Processing
⑪Artificial Intelligence

In case choosing the Human Information Science section, choose one question either ⑩ or ⑪

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Human Information Science⑩ Image Processing

This section consists of 3 pages. Answer all the questions below.

Question 1.

(1) When a 3x3 pixel median filter is applied to the input image in Figure 1, what is the output value corresponding to the pixel within the bold border? Select one of the solutions from the options.

124	128	133	137	135
132	137	123	76	123
131	125	**128**	121	134
121	180	132	121	123
120	122	136	123	137

Figure 1

【Options】

(a) 76 (b) 121 (c) 125 (d) 127 (e) 180

(2) A filter was applied to the image in Figure 2 to obtain the image in Figure 3. Which filter listed in the options was applied? The pixel value ranges from 0 to 255. If the result of applying the filter is less than 0 (negative value), the absolute value is used as the pixel value, and if the result is greater than 255, 255 is used as the pixel value, respectively.

Figure 2

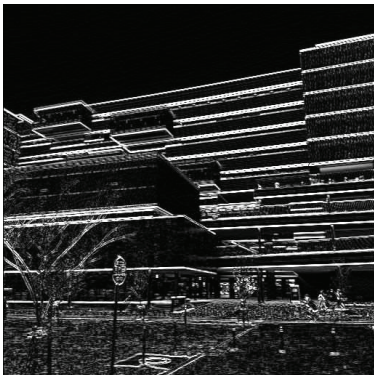

Figure 3

【Options】

a)

0	1	0
1	-4	1
0	1	0

b)

0	-1	0
-1	4	-1
0	-1	0

c)

-1	-2	-1
0	0	0
1	2	1

d)

-1	0	1
-2	0	2
-1	0	1

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Question 2.

The histogram of pixel values of Figure 4 is shown in Figure 5, and Figure 6 is obtained by applying an intensity transformation to Figure 4. Select the appropriate histogram of Figure 6 from the options.

Figure 4

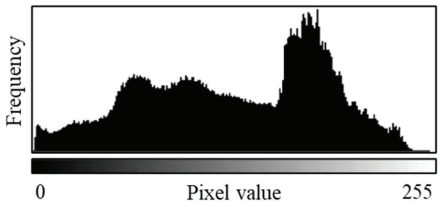
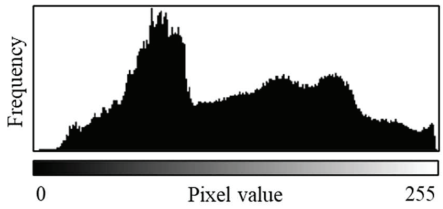


Figure 5

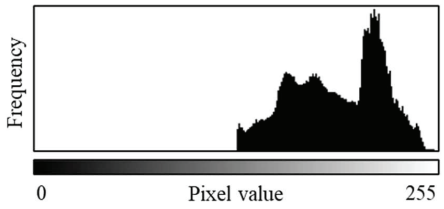
Figure 6

【Options】

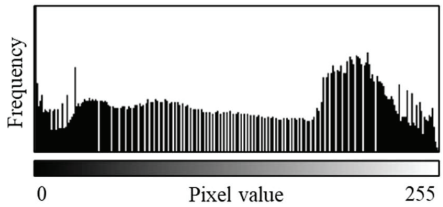
a)



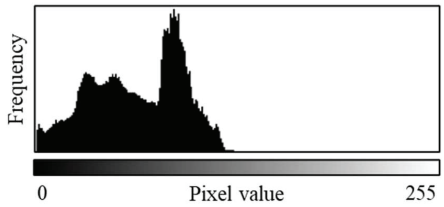
b)



c)



d)



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Question 3.

The image in Figure 7 was rotated and translated to obtain that in Figure 8. This coordinate transformation is described by the following formulation. Answer the values of a, b, c, d, e, f. Note that the coordinate (0, 0) in Figure 7 was moved to (150, 0) in Figure 8 by this transformation.

$$\begin{bmatrix} x' \\ y' \end{bmatrix} = \begin{bmatrix} a & b \\ c & d \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix} + \begin{bmatrix} e \\ f \end{bmatrix}$$

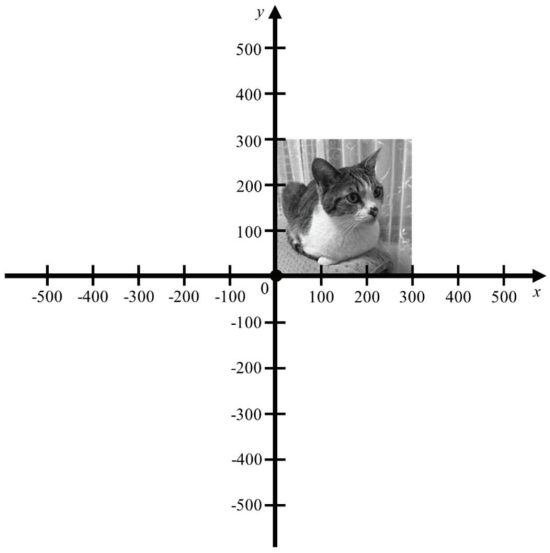

Figure 7

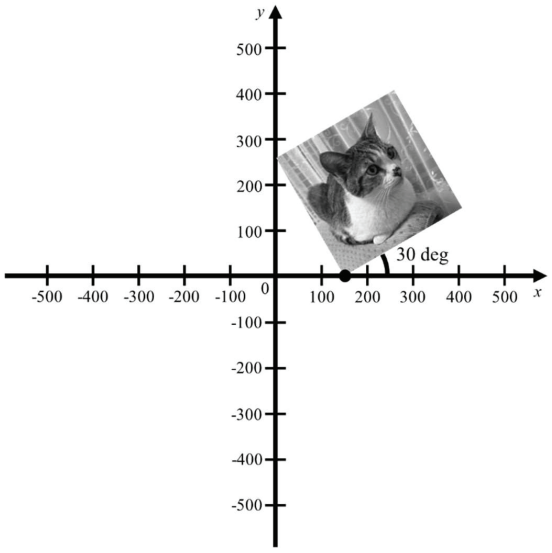

Figure 8

Question 4.

In the image $f(x, y)$, the pixel values at coordinates $(1, 1)$, $(2, 1)$, $(1, 2)$, $(2, 2)$ are $f(1, 1) = 20$, $f(2, 1) = 120$, $f(1, 2) = 20$, $f(2, 2) = 170$, respectively. Calculate the values of $f(1.4, 1.7)$ using the nearest neighbor and bilinear interpolation methods. If the result is not an integer value, answer with an integer value, rounding down the result to the nearest integer.

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Human Informatiuon Science⑪ Artificial Intelligence

This question consists of 2 pages. Give the answers to the following blanks （a） ～ （j） .

Optimal Search

The method for ensuring the discovery of the optimal path that minimizes the sum of costs without using heuristic knowledge (predicted evaluation values) is called optimal search.

Optimal Search Algorithm

1. Add the initial state with the cost value of 0 to the open list. Initialize the closed list as empty.
2. **while** (a) is not empty. **do**
3. Take out the first element s from (b). Add s into (c).
4. If s is (d), a solution is found, and terminate the search.
5. Add all the states connected to s that have not been explored yet to the open list. Recalculate the estimated cumulative cost $\hat{g}(s)$ of the states in the open list, and **reorder them in (e) order of the estimated cumulative cost.**
6. **end while**

Q-learning

The type of learning that realizes reinforcement learning by estimating the Q-values of the optimal action-value function $Q^*(s, a)$ is called Q-learning, where s and a represent a state and an action, respectively. In Q-learning, a table is prepared to record the values of $Q(s, a)$. The goal is to gradually update these values to approach the true Q-values, $Q^*(s, a)$.

Q-learning Algorithm

1. Initialize the Q-values.
2. **for** $i = 1$ to L **do**
3. Set the time to $t = 1$ and observe s_0.
4. **repeat**
5. Select action a_t according to policy π, and perform the action.
6. Observe (f) and (g) from the environment.
7. Update the value of (h) according to the Q-learning update formula.
8. Set time $t \leftarrow t + 1$.
9. **until** Reach the goal. Or, meet the termination condition.
10. **end for**

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Bayes Filter

The most basic method to estimate one's own position s_t from one's own observations (sensor information) $o_{1:t}$ and the actions $a_{1:t}$ one has taken is the Bayesian filter. The initial value of $F_0(s_0)$ is assumed to exist with equal probability in all places. T is the maximum number of steps.

Bayes Filter Algorithm

1. Initialize $F_0(s_0)$. $F_0(s_0) = P(s_0)$
2. **for** $t = 1$ to T **do**
3. Move with a_{t-1} and observe o_t.
4. Calculate the following G_t for all s_t.

$$G_t(s_t) \leftarrow P(o_t|s_t) \sum_{s_{t-1}} \boxed{\text{(i)}} F_{t-1}(s_{t-1})$$

5. $F_t(s_t) \leftarrow \boxed{\text{(j)}} / \sum_s G_t(s)$
6. **end for**

February 2025 Admissions

AY2025 Examination Questions for the Graduate School of Information Science and Engineering, Ritsumeikan University (Master's Program)

Major in Information Science and Engineering
Information Science and Engineering Course

【How to answer questions】

Please follow the instructions below and answer the questions.

1) Choose two questions from question ①~③ for Common Subjects.
2) Choose either the Computer Science section or the Human Information Science section for Specialized Subjects.
   - In case choosing the Computer Science section, answer three questions from question ④~⑨.
   - In case choosing the Human Information Science section, choose one question either ⑩or⑪.

   *There will be two blank answer sheets in case choosing the Human Information Science section.

Examination Subjects and Questions			Allocation of Points		Remarks
Common Subjects		①Linear Algebra	100 points	Total 200 points	Choose 2 out of the 3 questions
		②Probability and statistics	100 points		
		③Data structure and algorithms	100 points		
Specialized Subjects	Computer Science	④Computer Architecture	-	Total 100 points	Choose 3 out of the 6 questions
		⑤Operating System	-		
		⑥Software Engineering	-		
		⑦Computer Networks	-		
		⑧Databases	-		
		⑨Artificial Intelligence	-		
	Human Information Science	⑩Image processing	100 points	Total 100 points	Choose 1 out of the 2 questions
		⑪Artificial Intelligence	100 points		

【Examination time】

9:30-11:30 (120minutes)

※Leaving the examination venue is not allowed during the examination time.

※In case you feel sick or need to go to the bathroom, let examination supervisors know by raising your hand.

【Notes】

(1) Use one answer sheet for one question.
(2) Fill out your examination number and name for all the answer sheets. Also, make sure to fill out all the other necessary sections such as the questions number column.
(3) Do not remove the staple of your answer sheets.
(4) Answer sheets with no names will be invalid and the score will be 0 points.
(5) Do not take the question sheets and answer sheets with you after the examination.

Common Subjects

①Linear Algebra
②Probability and Statistics
③Data Structure and Algorithms

Choose two questions from the above.

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Common Subjects① Linear Algebra

Answer all the questions below.

Question 1.

Calculate the product of the following matrix **P** and matrix **A**, and denote the resulting matrix as **A'**.

$$P = \begin{pmatrix} 0 & 0 & 1 \\ 0 & 1 & 0 \\ 1 & 0 & 0 \end{pmatrix}$$

$$A = \begin{pmatrix} 6 & 8 & 1 \\ 2 & 4 & 9 \\ \alpha & 5 & 7 \end{pmatrix}$$

Question 2.

Find the value of α such that at least one eigenvalue of the matrix **A'**, obtained in Question 1, is equal to 0.

Question 3.

Determine rank(**A'**) for the matrix **A'** obtained in Question 1, assuming α is the value found in Question 2.

Question 4.

Determine all eigenvalues of the matrix **A'** obtained in Question 1, assuming α is the value found in Question 2.

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Common Subjects② Probability and Statistics

Answer all of the following questions with all calculation processes and reasonings.

Question 1.

Consider the relationship between the days when trains are delayed (Event A) and the days when 20% or more of the students are late to class (Event B). The following information is provided:

- The probability of a train delay, $P(A)$, is 0.2.
- The probability of 20% or more students being late to class, $P(B)$ is 0.15.
- The probability of 20% or more students being late to class given a train delay, $P(B|A)$, is 0.75.

Answer the following questions, providing all calculations and reasoning:

(1) Find the joint probability of Events A and B, $P(A,B)$.
(2) Determine whether Events A and B are independent, with reasoning.
(3) Find the conditional probability of Event A given Event B, $P(A|B)$.

Question 2.

Given 4 pairs of data $\{(x_i, y_i)\} = \{(1,3),(2,5),(3,5),(4,7)\}$, answer the following questions:

(1) Calculate the variance of X and the variance of Y.
(2) Calculate the covariance between X and Y.
(3) Calculate the Pearson correlation coefficient between X and Y.
(4) Based on the data, construct a linear regression model and estimate the value of y when $x_5 = 5$.

Question 3.

For an exponential distribution with a parameter λ(where $\lambda > 0$):

$$P(T)dT = \lambda e^{-\lambda T} dT$$

Answer the following questions:

(1) Calculate the mean of the exponential distribution.
(2) Determine the mode of the exponential distribution.
(3) Find the median of the exponential distribution.
(4) Given 10 independent samples from the exponential distribution $X_1, X_2, \cdots, X_{10}$, express the log-likelihood function $L(\lambda)$ using λ and $X_1, X_2, \cdots, X_{10}$.
(5) Determine the value of λ that maximizes the log-likelihood function $L(\lambda)$.

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Common Subjects③ Data Structure and Algorithm

Answer all the questions below.

Question1.

For the following explanations on bubble sort, answer the most appropriate numbers or words for blanks ① to ⑤. If there are options inside the blanks, select the most appropriate one and answer with their letter.

Consider an array A with initial values $\{5,2,7,1\}$ from the beginning, where the i-th element in the array is denoted as $A[i]$ $(0 \leq i \leq 3)$. If the elements of the array A are sorted in ascending order by a bubble sort, the first swap occurs between 5 and 2, and the second swap occurs between [①] and [②]. In total, [③] swaps will be performed before the sort is complete. If we want to express the time complexity of bubble sort using the number of elements n in given array A, the best-case time complexity is [④ (a) $O(1)$, (b) $O(\log n)$, (c) $O(n)$, (d) $O(n \log n)$, and (e) $O(n^2)$], and the worst-case time complexity is [⑤ (a) $O(1)$, (b) $O(\log n)$, (c) $O(n)$, (d) $O(n \log n)$, and (e) $O(n^2)$].

Question 2.

Binary search is an algorithm that repeatedly divides the search spaces in half. Figures 1 and 2 are pseudocodes for searching the value key using the binary search from array A, which stores the values of n elements in ascending order without duplicates. Let $A[i]$ represent the i-th element in array A $(0 \leq i \leq n-1)$. The function $length$ in Figure 1 returns the length n of the given array A. The floor function $\lfloor x \rfloor$ in Figures 1 and 2 returns the largest integer less than or equal to a real number x. Answer the following questions about these binary searches.

```
Algorithm BinarySearch1 (A, key)
    start ← 0;
    end ← length(A) − 1;
    while (start <= end)
        mid ← ⌊(start + end)/2⌋;
        if (key = A[mid]) then
            return mid;
        else if ( ① ) then
            ② ;
        else
            start ← mid + 1;
    return −1;
```

Figure 1: Non-recursive implementation

```
Algorithm BinarySearch2(A, start, end, key)
    mid ← ⌊(start + end)/2⌋
    if (key = A[mid]) then
        return mid;
    else if ( ① and ③ ) then
        return BinarySearch2(A, start, mid − 1, key);
    else if ( ④ and mid < end) then
        return BinarySearch2( ⑤ );
    else
        return −1;
```

Figure 2: Recursive implementation

(1) Fill in the blanks ① to ⑤ in the pseudocodes shown in Figures 1 and 2. Note that the same pseudocode will be used for the same blank numbers.

(2) Answer the return value when BinarySearch1$(A, 5)$ is executed using BinarySearch1 in Figure 1 for array $A = \{1,2,5,7\}$.

(3) In which case does the BinarySearch1 algorithm in Figure 1 return -1?

(4) Answer the best-case and worst-case time complexities of the binary search in Figure 1 by choosing $O(1)$, $O(\log n)$, $O(n)$, $O(n \log n)$, and $O(n^2)$.

(5) Answer the number of times the function BinarySearch2 is called when preforming BinarySearch2$(A, 0, 3, 5)$ in Figure 2 for array $A = \{1,2,5,7\}$, counting one call to BinarySearch2$(A, 0, 3, 5)$.

(6) The execution time is shorter for a program that does not use recursive calls, such as BinarySearch1 in Figure 2, than for a program that includes recursive calls, such as BinarySearch2 in Figure 2. Briefly explain the reason for this.

Specialized Subjects

Computer Science

④Computer Architecture
⑤Operating System
⑥Software Engineering
⑦Computer Networks
⑧Databases
⑨Artificial Intelligence

In case choosing the Computer Science section, answer three questions from question ④～⑨

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Computer Science④ Computer Architecture

Answer all the questions below.

Question 1.

Answer the number of tag, index, and offset bits for the following three caches when the size of the address space is 2^{32} bytes, the cache memory size is 128K bytes, and the cache block size is 64 bytes. Also, show the calculation process.

A. A direct-mapped cache
B. A fully associative cache
C. A 4-way set associative cache

Question 2.

Explain what "pipeline stall due to control hazards" is in pipeline processing. Additionally, describe how the efficiency of pipeline processing changes when comparing the case in which branch prediction is not used and a branch is taken for the following two cases: (1) when the prediction succeeds, and (2) when the prediction does not succeed.

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Computer Science⑤ Operating System

This question consists of 2 pages. Answer all the questions below.

Program 1

```
1 PROCEDURE 1
2 LOCK(X)
3 PROCEDURE 2
4 LOCK(Y)
5 PROCEDURE 3
6 UNLOCK(Y)
7 UNLOCK(X)
8 PROCEDURE 4
```

Program 2

```
1 PROCEDURE A
2 LOCK(Y)
3 PROCEDURE B
4 LOCK(X)
5 PROCEDURE C
6 UNLOCK(X)
7 UNLOCK(Y)
8 PROCEDURE D
```

Suppose we have two programs 1 and 2 shown in the figure that use shared variables X and Y stored in shared memory regions. The number at the beginning of a line is the line number. Here, PROCEDURE 2 writes data only to variable X, PROCEDURE B writes data only to variable Y, and PROCEDURE 3 and PROCEDURE C write data both to variable X and variable Y. PROCEDURE 1, PROCUDURE 4, PROCEDURE A, and PROCEDURE D write data neither to variable X nor to variable Y. In addition, a shared variable can have either of the two states *available* and *in-use*. For a shared variable V, LOCK(V) and UNLOCK(V) behave as follows depending on the state of V.

Behavior of LOCK(V):

1. If the state of V is *available*, change the state of V to *in-use* and proceed to the next line.
2. If the state of V is *in-use*, wait until the state of V changes to *available*. After the state of V has changed to *available*, change it to *in-use* and proceed to the next line.

Behavior of UNLOCK(V):

1. If the state of V is *available*, do nothing and proceed to the next line.
2. If the state of V is *in-use*, change it to *available* and proceed to the next line.

Answer all the questions below about these programs.

Question 1.

These programs may be suspended permanently during their execution even before finishing when they are executed concurrently. Answer the name of such a phenomenon. Also, answer the line numbers at which each program is suspended when this phenomenon happens.

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Question 2.

Fix either or both of Program 1 and Program 2 by reordering the lines so that the phenomenon answered in Question 1 never happens even when they are executed concurrently. The line numbers may be omitted. The orders of PROCEDURE 1 through PROCEDURE 2 and PROCEDURE A through PROCEDURE D must be preserved (for example, executing PROCEDURE 2 before PROCEDURE 1 is not allowed). In addition, LOCK(V) can be applied only to a single variable at the same time. In other words, for two shared variables V_1 and V_2, you cannot make them *in-use* at the same time by something like LOCK(V_1, V_2).

Question 3.

Explain how LOCK(V) can be implemented using an instruction that is generally called Test and Set. Clarify how Test and Set works and why your implementation works correctly regardless of the timing of context switches.

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Computer Science⑥ Software Engineering

Answer all the questions below.

Question 1.
Explain why incremental development is more effective than development using the waterfall model.

Question 2.
Consider developing software for a ticket-issuing system running on the web.
Describe one example of the non-functional requirements.

Question 3.
Explain the advantages of the adoption of client-server architecture in developing software systems.

Question 4.
Explain software re-engineering.

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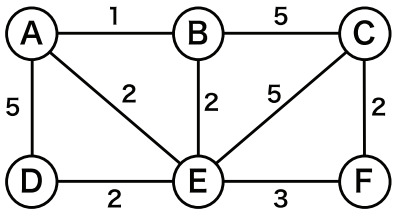
Computer Science⑦ Computer Networks



Answer all the questions below.

Question 1.

The figure on the right side shows a network. The circles denote nodes, and alphabet inside each circle denote the node's name. The line between two nodes denotes a link between them. The number near the link denotes the distance (or the cost to pass) for that link.

(1) Describe Dijkstra's algorithm by demonstrating all procedures on the network for determining all the shortest distances from node "A" to all nodes. Skipping any step or omitting the explanation of each step is not allowed. Point out unreachable nodes if they exist.

(2) Show the order of nodes where the shortest distance is determined by Dijkstra's algorithm in the sub-problem (1). You can omit the unreachable nodes from your answer. The order should be denoted as a list of node names separated by comma ",". For example, if you wish to answer that only the nodes A, D, C, and B are determined, and in that order, answer that the order of determination is A, D, C, B.

Also, show all shortest paths from node "A" to all nodes in this setting. The shortest path should be denoted as a list of node names separated by dashes "-", preceded by the destination node name and colon ":" followed by a colon and the distance. For example, if you wish to answer that the path from node "A" via node G to node E is at a distance of 10, denote it as E:A-G-E:10. Note that the shortest distance from node "A" to node "A" is determined to be zero at the beginning the steps of the Dijkstra's algorithm, so A:A-A:0 is self-evident. However, you should also clearly state it in your answer without omission.

Question 2.

For the following descriptions (1) to (8) related to computer networks, fill in the most appropriate string in the boxed parts Q(a) to Q(j). If there are options in the box, enter one of the option symbols. If there is no suitable option, enter the appropriate term.

(1) The organization that formulates standards for technologies used on the Internet and stores and publishes technical specifications in a format called RFCs (Request for Comments) is abbreviated in English as
Q(a) ① ITU ② IETF ③ IEEE ④ IrDA .

(2) The maximum throughput of the media access control method ALOHA (or Pure ALOHA) can be written using the natural logarithm of the base (or Napier's constant) e as Q(b) .

(3) In the OSI Basic Reference Model (or OSI Reference Model), the layer that transfers bits using a transmission medium such as electrical signals or light is the Q(c) layer. On the other hand, the session layer performs, for example,
Q(d) ① administrating session check-pointing and recovery ② converting from abstract syntax data to transfer syntax ones ③ definitions of standard specs for optical fibers ④ routing control .

(4) In a LAN (Local Area Network), a device that relays frames in the middle of a transmission path to extend the transmission distance and performs only data link layer transfers is called Q(e) ① a repeater ② a router ③ a bridge ④ an ONU .

(5) For the IPv4 (Internet Protocol version 4) address 10.11.23.58 shown in dotted decimal notation, this IP network is a class Q(f) ① A ② B ③ C ④ D ⑤ E . If the subnet mask is also in a dotted decimal notation 255.255.255.192, the broadcast address used in this IP network is
Q(g) ① 10.255.255.255 ② 10.11.255.255 ③ 10.11.23.63 ④ 10.11.23.255 .

(6) In the IP headers of IPv4 and IPv6 (Internet Protocol version 6), the header length field indicating the size of the header is present in Q(h) ① IPv4 only ② IPv6 only ③ both IPv4 and IPv6 .

(7) For IP, TCP and UDP in IPv4, the headers with a fixed length are Q(i) ① only TCP ② only UDP ③ only TCP and UDP ④ only IP ⑤ only IP and TCP ⑥ only IP and UDP ⑦ all three headers .

(8) Q(j) ① Return-to-zero ② NRZ(L) ③ Manchester code ④ MLT-3 is a line code where each data bit is encoded with either of two transitions "high to low" or "low to high" at equal intervals, and was used for Ethernet standards such as 10BASE-T.

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Computer Science⑧ Databases

Answer all the questions below.

Question 1.

Relation schema "sales" in the first normal form is as shown below, and the primary key is {slip_num, product_code}.

sales (slip_num, store_ID, store_name, sales_date, product_code, product_name, unit_price, quantity, subtotal)

In this relationship, the following partial functional dependencies exist.

{slip_num}→{store_ID, store_name, sales_date}

{product_code}→{product_name, unit_price}

Show the normalization results of this relation into second normal form and underline key attributes.

Question 2.

Calculate the vector similarity (cosine similarity) between the following document vectors A, B, and C, and find the pair of documents with the highest similarity. Show all calculation processes and results.

$$\text{docA} = \begin{bmatrix}0\\2\\1\\2\end{bmatrix} \quad \text{docB} = \begin{bmatrix}2\\2\\1\\0\end{bmatrix} \quad \text{docC} = \begin{bmatrix}1\\2\\0\\2\end{bmatrix}$$

Question 3.

A user searches for a book by entering a keyword into a book management system that has 1,000 books registered. As a result, 12 books have been retrieved and 9 of them were correct. However, 6 books are not retrieved with the keyword. Calculate the recall and precision of this search.

Question 4.

Describe the result of the join operation $P \bowtie_{B<C} Q$ and $P \bowtie_{B=D} Q$ for the two relations P and Q below.

P

A	B
1	1
0	3
1	2

Q

C	D	E
2	3	1
4	1	4
3	1	4

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Computer Science⑨ Artificial Intelligence

This question consists of 2 pages. Answer all the questions below.

Question1.

For the following explanations of Artificial Intelligence (AI) from (i) to (v), choose the most suitable word or number for boxes (1) to (15) from the options shown below each explanation and answer with the symbols shown in alphabetic letters. Note that some unrelated options are included. Assume that the same word is enclosed in the box with the same number.

(1) A certain image classifier outputs "dog" with a probability of 0.6 and "cat" with a probability of 0.4 when presented with an image of a dog. For an image of a cat, it outputs "dog" with a probability of 0.2 and "cat" with a probability of 0.8. Additionally, 70% of the input images are dog images, and 30% are cat images. Given this, calculate the following probabilities. Note that the options are presented to three decimal places.

(a) The probability that a cat image is input and the classifier outputs "cat" is [(1)] .

(b) The probability that the input image is classified as "dog" is [(2)] .

(c) Given that the classifier outputs "dog," the probability that the input image is actually a dog is [(3)] .

【Options for (1)】

A	0.240	b	0.300	c	0.420	d	0.480
E	0.600	f	0.625	g	0.800	h	0.875

(2) Fig.1 shows the game tree of a game where two players make decisions in turn, with □ nodes representing the board of the first mover and ○ nodes representing the board of the second mover. The alphabet in each node is the name of each board, and the numbers under the leaf nodes denote the evaluation values of the nodes. The strategy in which the first mover selects moves to maximize their possible payoff assuming that the second mover chooses moves to minimize the first mover's payoff is called the [(4)] . If the first mover takes the [(4)] , the evaluation value of node A is [(5)] . When the $\alpha\beta$ method is applied to avoid unnecessary search where the board evaluates proceeds from left to right in the game tree shown in Fig.1, the set of nodes to be pruned by β-cut is [(6)] .

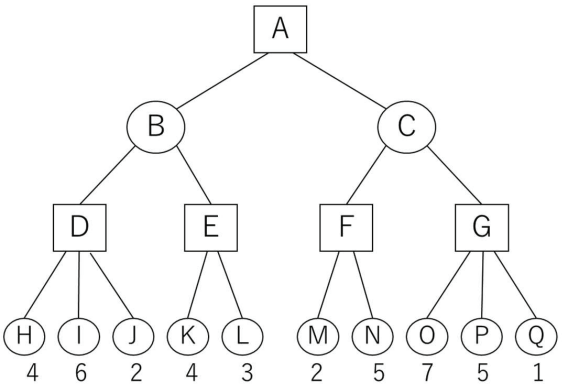

Fig.1 Game tree

【Options for (2)】

a	4	b	5	c	6	d	{P, Q}
e	{L, P, Q}	f	{J, L, Q}	g	minimax strategy	h	dominant strategy

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(3) The k-means method is a clustering technique that iteratively assigns each data point to the nearest representative point and then updates the coordinates of the representative points to the (7) of the assigned data points. Consider applying the k-means method with k=2 to the 2-dimensional data set {(1,1), (2,0), (2,3), (3,2), (4,4)}. Suppose the coordinates of the representative points A and B are A(1,2) and B(4,3), respectively. In this case, the data point a=(2,3) is assigned to the representative point (8) , and the coordinates of the representative point assigned to a are updated to (9) .

【Options for (3)】

a	A	b	maximum value	c	centroid value	d	expected value
e	B	f	(3 , 3)	g	$\left(\frac{5}{3}, \frac{4}{3}\right)$	h	$\left(2, \frac{3}{2}\right)$

(4) In supervised learning, a regression problem involves learning a continuous functional relationship that returns a (10) of output given an input vector. The fundamental approach to solving regression problems is to find the optimal parameters of the model such that the prediction error is minimized. Among these methods, using the sum of squared errors as an evaluation function to represent prediction error is called the (11) , and the technique of adjusting parameters based on the partial derivatives of the evaluation function, according to the gradient, is known as the (12) .

【Options for (4)】

a	Ward's method	b	kernel method	c	least squares method	d	error back propagation algorithm
e	steepest descent method	f	real value	g	expected value	h	binary value

(5) The following shows the process of converting the logical formula $(A \to B) \to C$ into its conjunctive normal form. The rule used for each transformation is noted to the right of the formula. Choose the most suitable options for the boxes (13) to (15).

$$
\begin{aligned}
& (A \to B) \to C && \\
\Leftrightarrow\ & \boxed{(13)} \vee C && \text{Elimination of implication} \\
\Leftrightarrow\ & (A \wedge \neg B) \vee C && \boxed{(14)} \\
\Leftrightarrow\ & \boxed{(15)} && \text{Distributive law}
\end{aligned}
$$

【Options for (5)】

a	De Morgan's laws	b	Elimination of equivalence	c	associative law	d	$\neg(\neg A \wedge B)$
e	$\neg(\neg A \vee B)$	f	$(A \wedge C) \vee (\neg B \wedge C)$	g	$(A \vee C) \wedge (\neg B \vee C)$	h	$(A \vee \neg B \vee C)$

Specialized Subjects

Human Information Science

⑩Image Processing
⑪Artificial Intelligence

In case choosing the Human Information Science section, choose one question either ⑩ or ⑪

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Human Information Science⑩ Image Processing

Answer all the questions below.

Question1.

100	**60**
50	**40**

is a 2 by 2 image, where the coordinates of the 4 pixels are (0,0), (1,0), (0,1), (1,1) and their pixel values are I (0,0) =100, I (1,0) =60, I (0,1) =50, I (1,1) =40. Determine the subpixel value I (0.8,0.3) by bilinear interpolation.

Question2.

$G(x,y) = A\exp\left(-\frac{x^2+y^2}{2}\right)$, $A > 0$ is a 2D Gaussian function. We are to design a digital filter representing this function, where each point has an integer value of 8 bits ranging from 0 to 255, and the result of filtering is to be normalized by dividing the convolution by the total sum of all the filter values.

(1) Determine the coordinates x, y at which G (x, y) has the maximal value and determine G (x, y) at that point.

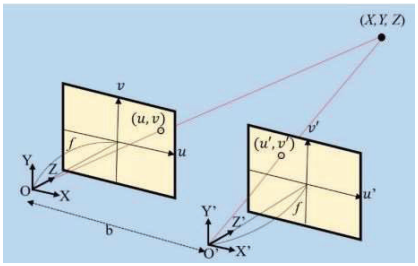
(2) Determine A as an integer to maximally utilize the 8 bits.

(3) Determine U as an integer where (2U+1)×(2U+1) is the filter size.

For your convenience, exp(-1/2)≒0.6, exp(-2)≒0.135 , exp(-4.5)≒0.0111, exp(-8)≒0.0003.

Question3.

The figure shows a parallel stereo, where the distance between the two cameras is 300mm, and the point on the left image (u, v) = (400 pixels,300 pixels) corresponds to the point on the right image (u', v') = (200 pixels,300 pixels). Determine X, Y and Z. It is known that in parallel stereo, axis u and axis u' are collinear and parallel to axis X, and axis v and axis v' are parallel to axis Y. The origin of (u, v) is on the Z axis, and two cameras have exactly the same intrinsic parameters and f =1000 pixels.

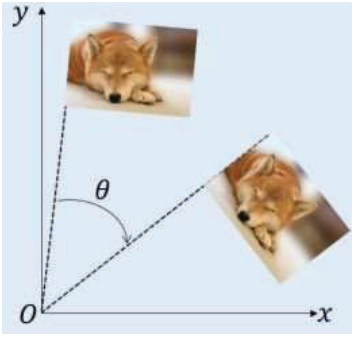


Question4.

As shown in the figure, after rotating the image clockwise by 45 degrees, it is further translated by 50 in horizontal direction and -20 in the vertical direction. The new coordinates can be expressed by

$$\begin{bmatrix} x' \\ y' \end{bmatrix} = \begin{bmatrix} a & b \\ c & d \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix} + \begin{bmatrix} e \\ f \end{bmatrix}$$

where (x', y') are the coordinates after the rotation and translation, and (x, y) are the coordinates before the rotation and translation. Determine a, b, c, d, e and f.



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Human Information Science⑪ Artificial Intelligence

Give the answers to the following blanks (a) ～ (j) .

Best-First Search

Best-first search progresses by relying on estimated evaluation values as heuristic knowledge.

Algorithm for Best-First Search

1. Add the initial state assigned with a cost value of 0 to (a). Initialize (b) as empty.
2. **while** the open list is not empty, **do**
3. Remove the first element s from the open list. Add s to the closed list.
4. If s is the goal state, terminate the search as the solution has been found.
5. Add all states (c) from s and not yet explored to the open list. Rearrange the states in the open list in **ascending order of the estimated evaluation value** $\hat{h}(s)$.
6. **end while** Terminate the search.

Policy

Representative policies π in Q-learning are described below.

Greedy Method Always selects the action with the (d) Q-value.

Random Method Selects actions with equal (e).

ϵ-Greedy Method Chooses an action randomly with a probability of (f) and chooses an action using the greedy method with a probability of (g).

Boltzmann Exploration Policy Creates a policy by constructing a probability distribution called the (h) distribution using the action-value function.

Particle Filter

The particle filter is an approximation method of the Bayesian filter, realized by introducing (i) approximation and Sampling Importance Resampling (SIR) into the update equations of the Bayesian filter. After moving each particle according to the (j) probabilities, the algorithm is extremely simple: assign weights to each particle based on observation probabilities and perform resampling.