Programming and Artificial Intelligence

An Introduction to Information and Communication Technology For First Year of Secondary School

2025 – 2026

CONTENTS

1-1 Information and Media

Point!

1 Data, Information, Knowledge

(1) ([1]**Data**) : Facts or matters represented using numbers, characters, or symbols.

(2) ([2]**Information**) : Something that holds meaning or value for the recipient and serves as a basis for decision-making. Unlike objects, information has no form.

- Information has the following characteristics.

[1] ([3]**Persistence**) : Information, once created, cannot be completely erased.

[2] ([4]**Reproducibility**) : Information can be easily copied in large quantities.

[3] ([5]**Propagation**) : Information is easy to convey and spread.
Information can easily spread through ([6]**mass media**) such as newspapers and television, as well as the internet.

(3) ([7]**Knowledge**) : Information that has been analyzed and systematized to aid in problem-solving.

(4) Primary information and secondary information

[1] ([8]**Primary information**) : Information obtained through direct personal experience or acquired through research and experiments.
<Examples> Experimental reports, survey results, tabulations of questionnaire results, etc.

[2] ([9]**Secondary information**) : Information not obtained directly by oneself, but acquired through a third party.
<Example> Books, newspapers, television, etc.

- Secondary information can sometimes differ from the original information or have interpretations added to it. In other words, it is necessary to compare the obtained information from multiple perspectives with other information to determine the degree of its accuracy and reliability. This is called ([10]**cross-checking**).

2 Media

(1) ([11]**Media**) : Media for conveying information to people.

(2) Types of media

Name	Content	Example
([12]**Expression media**)	Media used as a means of expressing information.	Text, images, audio, video
([13]**Propagation/ Transmission media**)	Media used as an intermediary for the transmission and communication of information.	Television, radio, newspapers, books, telephone, internet
([14]**Recording media**)	Media used for recording and storing information.	Paper, USB drives, DVDs, cloud storage

(3) ([15]**Media literacy**) : The ability to accurately interpret information obtained from media.

Warm Up

Answer the following questions.

(1) [1] For the following items a to c, answer whether they are related to: **1)** Data, **2)** Information, or **3)** Knowledge. Write "1," "2," or "3" as your answer.

a Temperature and humidity values

b Analysis results of temperature and humidity over the past 10 years

c Weather forecast

[2] Choose one statement that is not suitable as a characteristic of information from the options **A** to **D**, and answer using the letters.

A It has a form just like an object.

B The meaning or value changes depending on the recipient.

C It has the characteristic of persistence.

D It has the characteristic of propagation.

[3] Choose the content related to the following sentences a to c from the group of words labeled **A** to **C** below, and answer using the letters.

a Even if you purchase a commercially available music CD, you are not allowed to make copies to distribute to friends.

b Emails can be sent instantly overseas.

c Rumors about people and false information can persist indefinitely.

[Word group] **A** Persistence **B** Reproducibility **C** Propagation

(2) [1] For the following media from a to f, answer whether they are classified as **1)** Expression media, **2)** Propagation/Transmission media, or **3)** Recording media. Write "**1**," "**2**," or "**3**" as your answer.

a Television b Cloud storage c Photograph

d Internet e Text character f Book

[2] What is the term for the ability to accurately interpret information obtained from media?

Explanation

(1) [1] a: **1** b: **2** c: **3**

[2] Unlike objects, information does not have form. Therefore, **A**

[3] a: The characteristic of being easily copied is reproducibility. **B**

b: The characteristic of being able to be sent instantaneously is propagation. **C**

c: The characteristic of information, once created, that never disappears is persistence. **A**

(2) [1] a: **2** b: **3** c: **1** d: **2** e: **1** f: **2**

[2] Media literacy

Try

1 Answer the following questions.

(1) What is the term for the representation of facts or matters using numbers, characters, or symbols?

(2) For the following items a to c, answer whether they are related to: **1)** Data, **2)** Information, or **3)** Knowledge. Write "**1**," "**2**," or "**3**" as your answer.

a Results on mock exam b Analysis results for admission to the desired school c Scores on mock exam

(3) Choose the characteristic of information that is appropriate from the options **A** to **D** below, and answer using the letters.

A Information does not have the characteristic of reproducibility.
B The meaning or value of the information does not change depending on the recipient.
C Information has form like an object.
D Information that has been disseminated cannot be easily deleted.

(4) Choose the content related to the following sentences [1] to [3] from the group of words labeled **A** to **C** below, and answer using the letters.

[1] It is possible to copy commercially available music and movies in large quantities without any degradation.
[2] Rumors about people persist and never completely disappear.
[3] Information published on the internet spreads widely in a short period of time.
[Word group] **A** Persistence **B** Reproducibility **C** Propagation

(5) What is the term for information obtained through personal experience or from investigations and experiments that were personally conducted?

2 Answer the following questions.

(1) What is the term for the medium used to convey information to people?

(2) Choose all the media corresponding to the following a to c from the options **A** to **F**, and answer using the letters.

a Expression media b Propagation/Transmission media c Recording media
A USB drive **B** Radio **C** Telephone **D** DVD **E** Video **F** Audio

(3) Choose the explanation of media literacy that is appropriate from the options **A** to **D** below, and answer using the letters.

A The ability to accept information disseminated by the media without question
B The ability to understand the meaning and characteristics of media and to accurately interpret information
C The ability to capture content for media distribution
D The ability to use media to edit information in accordance with the intent of the sender

Exercise

1 Read the following passage and answer each question.

> We obtain (a) such as weather forecasts from sources such as newspapers and television, and use it as a basis for deciding on our actions. Weather forecasts organize (b) such as weather conditions, precipitation, and atmospheric pressure patterns, and add meaning and value to them. Additionally, this can be generalized to accumulate (c), such as "it often rains in May and June every year."

(1) For each of the following options **A** to **C**, use the corresponding letter to indicate which blank, (a) to (c), it is related to.

A Temperature graph **B** Temperature **C** Analysis results of the lowest temperatures over the past 20 years

(2) Choose the content related to the following sentences [1] to [3] from the group of words labeled **A** to **C** below, and answer using the letters.

[1] False information once disseminated on the internet can persist indefinitely.
[2] Not only mass media, but also individuals are now able to disseminate large amounts of information throughout the world.
[3] A person copied a commercially available music CD and distributed it to their friends.

A Persistence **B** Reproducibility **C** Propagation

(3) For the following statements about information, mark "○" if the statement is correct, and "×" if it is incorrect.

[1] Primary information refers to information obtained through surveys or investigations conducted by the person themselves.
[2] The statistical data published on the Statistics Bureau's website is considered primary information.
[3] Information found by a person on a website is considered primary information.
[4] Information obtained through a third party is considered secondary information.

2 Answer the following questions.

(1) Choose all of the following media from **A** to **F** that qualify as Propagation/Transmission media.

A Internet **B** Text character **C** USB drive
D Audio **E** Radio **F** Book

(2) What is the term for the ability to understand the meaning and characteristics of media and to accurately interpret information?

1-2 Information Ethics

Point!

1 Information Ethics

(1) ([1]**Information ethics**) : The foundational concepts and attitudes necessary for conducting appropriate activities in the information society.
This is regardless of the presence or absence of ([2]**laws**).

(2) Points to consider when disseminating information

[1] Characteristics of Information on the internet : Information is easily ([3]**spread**) and, once disseminated, it tends ([4]**not to disappear**) easily.

[2] Infringement of Others' Rights

- You must not publicly share images or videos for which others hold the ([5]**copyright**) without permission.
- You must not leak the ([6]**personal information**) of another person on the internet.
- You must not infringe upon others' ([7]**privacy**).
- You must not post comments that slander or defame others or engage in ([8]**online bullying**).

[3] ([9]**Geotag (Geotagging)**) : Information that includes latitude and longitude embedded in photos and videos taken with smartphones and mobile phones. There is a risk of being identified, such as having your home pinpointed based on the location where the photo was taken.

[4] ([10]**Disinformation and rumors**) : False information that is deliberately spread or baseless rumors.

2 Problems that occur with smartphones and social media

(1) ([11]**Social media**) : Services that provide platforms where individuals can connect with each other on the internet.

(2) Problems that occur with smartphones and social media

[1] ([12]**Internet addiction**) : A state where one becomes excessively immersed in the internet to the extent of interfering with daily life.

[2] ([13]**Using smartphone while walking**) : The act of using a smartphone while walking.

[3] ([14]**Cybercrime**) : The misuse of computers and networks for criminal activities.

[4] ([15]**Identity theft**) : The act of a third party pretending to be a certain individual or organization to steal IDs or passwords.

[5] ([16] **Leakage of personal information**) : When personal information that should remain confidential is disclosed to a third party.

Warm Up

Answer the following questions.

(1) What is the term for the foundational concepts and attitudes necessary for conducting appropriate activities in the information society?

(2) For the following statements **A** to **D**, mark "○" if the statement is correct, and "×" if it is incorrect.

A Social media is nothing more than a dangerous tool that causes trouble.

B There is a risk that your home address could be identified from geotags embedded in photos and videos.

C You can write whatever you want on an anonymous bulletin board because no one can ever know who wrote it.

D Be mindful that there are real people on the other side of the internet, and try to share information with consideration for their perspective.

Explanation

(1) Information ethics

(2) **A** Social media is a convenient tool on the internet that allows individuals to connect with each other. However, social media can be a dangerous tool if not used properly. Therefore, ×

B ○

C Never post defamatory content, disinformation, or rumors, even anonymously. Therefore, ×

D ○

Try

1 Answer the following questions.

(1) Fill in the blanks with the appropriate words.

[1] (　　) is the term for the foundational concepts and attitudes necessary for conducting appropriate activities in the information society.

[2] (　　) is the term for false information that is deliberately spread or baseless rumors.

[3] (　　) is the collective term for crimes involving the misuse of computers and networks.

(2) Choose the phrases that best fit into the blanks [1] to [3] from the options **A** to **D** below.

> When transmitting information on the internet, you must be very careful with handling others' ([1]) and with images or videos in which others have ([2]). Additionally, photos and videos taken with a smartphone have a feature that can add information such as the latitude and longitude of the location where they were taken, which is referred to as ([3]). ([3]) is convenient because it enables the confirmation or search of the location where a photo was taken, but caution is needed as there is a risk of having your home address identified.

A Copyright　**B** Personal Information　**C** Industrial Property Rights　**D** Geotag

(3) From the following options **A** to **D**, choose the one that is a general term for services that provide platforms for individuals to connect with each other on the internet. Answer by writing the corresponding letter.

A Social engineering　**B** Social marketing

C Social networking service　**D** Social network system

(4) The following statements **A** to **D** describe information ethics. Mark "○" if the statement is appropriate, and "×" if it is inappropriate.

A You can write freely on an anonymous bulletin board because no one can know who wrote it.

B Websites are legally required to always provide accurate information.

C You must be careful not only with your own personal information, but also with how you handle the personal information of others.

D For any content, it is better to use a bulletin board for information dissemination as it can reach a larger audience.

(5) Choose one statement that is appropriate as etiquette when using a smartphone from the options **A** to **D** below.

A I operated on a smartphone while driving my car.

B I turned off the smartphone at places like movie theaters or art museums.

C I posted negative comments about others on the internet.

D I sent my photo to a stranger I met online.

Exercise

1 Answer the following questions.

(1) Fill in the blanks with the appropriate words.

[1] (　　) is the term for a state in which a person prioritizes internet usage over aspects of life such as studies, work, physical and mental health, and is unable to control the time spent or the manner of internet usage.

[2] (　　) is the collective term for services that facilitate the building of relationships over the internet.

[3] (　　) is the term for location information that can be added to various media such as photos and videos.

(2) From the following options **A** to **H,** choose the phrases that best fit into the blanks [1] to [4].

([1]) is the term for the foundational concepts and attitudes necessary for conducting appropriate activities in the information society. Even if something is not prohibited by ([2]), you should still refrain from engaging in inappropriate behavior. Furthermore, information on the internet is easily ([3]) and, once disseminated, it tends ([4]). With all of this in mind, we must be careful not to become involved in internet-related crimes or problematic behavior.

A	Information etiquette	**B**	Information ethics	**C**	Spread	**D**	Online backlash
E	To Disappear	**F**	Not To Disappear	**G**	Laws	**H**	System

(3) The following statements **A** to **D** describe information ethics. Mark "○" if the statement is appropriate, and "×" if it is inappropriate.

A When interacting through a network, it is important to communicate appropriately to avoid misunderstandings.

B You can write freely on an anonymous bulletin board because no one can ever know who wrote it.

C Websites are legally required to always provide accurate information.

D Since a celebrity was at a nearby shopping mall, I took a photo and shared it on social media. I assumed that this is OK since the photo was taken in a public place.

(4) Choose one correct statement regarding the use of the internet and social media from the options **A** to **D** below.

A It is acceptable to copy a commercially available CD and post it on social media without permission.

B Social media is nothing more than a dangerous tool that causes trouble.

C If you live a life disconnected from the internet, you won't be a victim of cybercrime.

D When disseminating information, ensure that it does not infringe on the privacy of others.

2-1 Personal Information

Point!

1 Personal Information

(1) ([1]**Personal information**) : Any data or information related to a natural person who can be identified directly or indirectly by linking it with other data.
<Example> name, address, date of birth, gender, phone number, national ID number, passport number, driving license, or any data that identifies psychological, health, economic identity.

- Among the different types of personal information, name, address, date of birth, and gender are referred to as the ([2]**Four Basic Items**), while numbers such as those on passports, driver's licenses, or National IDs are known as ([3]**Personal Identification Codes**).
- Information that requires careful handling to prevent prejudice and other disadvantages (for example, race, creed, social status, medical history, and criminal record) is referred to as ([4]**Special Care-Required Personal Information**).

(2) ([5]**Act on the Protection of Personal Information**) : A law that stipulates the proper handling of personal information.

(3) Provision of Personal Information to Third Parties

- The Act on the Protection of Personal Information states that one cannot provide the personal information of an individual to a third party without the individual's consent. However, in the following cases, it is permissible to provide personal information without obtaining the individual's consent.
  - [1] When provision is based on laws and regulations.
  - [2] When necessary for the protection of national security or public interest.
  - [3] When necessary for the protection of human life, body, or property.
  - [4] When especially necessary for public health or the healthy development of children.
  - [5] When cooperating with national or local governments, etc.

2 Protection of Privacy and Image Rights

(1) ([6]**Right to Privacy**) : The right of an individual to protect personal information that the individual does not want others to know.

(2) ([7]**Image Rights**) : The right of an individual to prevent others from photographing or using their face or appearance without permission.

(3) ([8]**Publicity Rights**) : A right that protects the economic interests of celebrities in their likeness, among other things.

*These rights are recognized not by law but through court ([9]**precedents**).

3 Protection of Personal Information in Corporations and Organizations

(1) ([10]**Privacy policy**) : A policy that stipulates how companies and organizations manage personal information.

(2) ([11]**Personal Data Protection Center License**) : the license obtained by companies from the regulatory authority (Personal Data Protection Center) to ensure compliance with the law.

(3) ([12]**Prior Approval System**) : A method in which a provider does not collect user data or offer a service to a user unless prior consent is given.

(4) ([13]**Opjection System**) : A method in which a service provider continues to offer a service to the user until the user requests the provider to discontinue the service.

Warm Up

Answer the following questions.

(1) Choose all the items from **A** to **D** that can be considered personal information as defined by the Act on the Protection of Personal Information.

A Email address **B** Fingerprint data **C** Address of a deceased person

D Passport number

(2) The following statements **A** to **D** describe personal information and privacy. Mark "○" if the statement is appropriate, and "×" if it is inappropriate.

A If everyone in a photo is your family member, you can upload group photos to social media without permission.

B Posting information such as the economic status or health status of a person on social media without his premession, thinking it might aid the investigation, is not a violation of the Act on the Protection of Personal Information.

C Although a driver's license number or a National ID Number consists merely of a sequence of digits, it can be considered personal information because it allows for the identification of an individual when combined with other information.

D It is acceptable to print a photo of your favorite celebrity on a T-shirt yourself and sell the T-shirt online.

Explanation

(1) Personal information refers to information concerning a living individual. Information about deceased individuals is not considered to be personal information. Therefore, **A**, **B**, and **D**

(2) **A** Uploading a person's photo to the internet or social media without their permission constitutes a violation of image rights. Therefore, ×

B Past criminal records and medical histories are referred to as special care-required personal information. As a general rule, they should not be provided to third parties without the individual's consent. Therefore, ×

C Personal information refers to data related to a living individual and includes information that can be used to identify an individual when combined with other information. Therefore, ○

D The likeness of famous people (such as celebrities or athletes) holds economic value, and one should not sell that likeness for profit without permission. Therefore, ×

Try

1 Answer the following questions.

(1) What is the term for information related to living individuals?

(2) From among (1), what is the term for the collective reference to name, address, date of birth, and gender?

(3) From among (1), what is the term for the numerical information found in items like passports, driver's licenses, and My Number cards?

(4) Since the likenesses of celebrities hold economic value, celebrities possess rights recognized to protect the economic benefits arising from their popularity. What is the term for these rights?

(5) What is the term used for the licenses granted to companies or organizations that implement appropriate protection measures for personal information?

(6) Choose the appropriate terms for [1] and [2] to complete the following sentence.

> When providing services to users, the system where services are not provided without prior consent is called the ([1]) system, while the system where services continue to be provided until the user requests the provider to stop is called the ([2]) system.

2 Answer the following questions.

(1) Choose one correct statement regarding personal information from the options **A** to **C** below.

A Personal information is protected until 50 years after the individual's death.

B Although your passport, driver's license, and National ID Number information are merely sequences of numbers, they still constitute personal information.

C The names, addresses, dates of birth, and gender of individuals that have already been published in newspapers or on the internet do not constitute personal information.

(2) Choose one correct statement regarding image rights from the options **A** to **D** below.

A The right of an individual to protect personal information that the individual does not want others to know.

B The right to protect economic benefits arises from the fact that the likeness of a celebrity possesses economic value.

C The right of an individual to prevent others from photographing or using their face or appearance without permission.

D The individual's right to the protection of literary, artistic, and scientific works.

(3) The following statements **A** to **D** describe personal information and privacy. Mark "○" if the statement is appropriate, and "×" if it is inappropriate.

A Taking a photo of a portrait of a famous person that you drew yourself and saving it on your smartphone does not violate the Act on the Protection of Personal Information.

B If a person is your friend, you can upload a photo of their face to social media without permission.

C The transfer of personal information of an individual to third parties without the consent of the individual is prohibited.

D It's permissible to sell fan merchandise of your favorite celebrity if you create it personally.

Exercise

1 From the following options **A** to **L**, choose the phrases that best fit into the blanks [1] to [6].

In the context of the Act on the Protection of Personal Information, ([1]) refers to information that can identify a living individual. Among these, important pieces of information that are also used for identity verification are referred to as the four basic items, which include ([2]), ([3]), ([4]), and ([5]). Furthermore, information that can identify an individual when combined with other information is also considered to be ([1]). Examples include ([6]), which refers to number-based information such as driver's license numbers and My Number.

A	Name	**B**	Address	**C**	Date of birth	**D**	Age
E	Gender	**F**	Telephone number	**G**	Email address	**H**	Anonymized information
I	Personal Identification Code	**J**	Special Care-Required Personal Information	**K**	Personal information	**L**	Privacy

2 Answer the following questions.

(1) Choose all the items from **A** to **D** that can be considered personal information as defined by the Act on the Protection of Personal Information.

- **A** A nickname for use on social media made from letters and numbers
- **B** Information such as the names and addresses of foreigners residing in foreign countries
- **C** Information such as weather conditions and air tempreture.
- **D** Biometric data such as iris and fingerprints.

(2) Choose one correct statement regarding publicity rights from the options **A** to **D** below.

- **A** The right of an individual to protect personal information that the individual does not want others to know.
- **B** A right that protects the economic interests of celebrities in their likeness, among other things.
- **C** The right of an individual to prevent others from photographing or using their face or appearance without permission.
- **D** The right to protect one's thoughts and feelings as expressed in the form of a work.

(3) The following statements **A** to **D** describe behavior related to personal information and privacy. Mark "○" if the statement is appropriate, and "×" if it is inappropriate.

- **A** I received an email asking to verify my personal information from an unknown email address, so I replied to the contact provided in the email.
- **B** I shared widely on social media the personal information of an individual rumored to be the perpetrator in a crime. I thought my action would aid in the criminal investigation.
- **C** After paying the admission fee and entering the concert, I took a photo of the singer with my smartphone and posted it on social media.
- **D** After destroying the list of final test scores with a shredder, I discarded of the shredded documents as combustible waste.

2-2 Intellectual Property Rights

Point!

1 Intellectual Property Rights

([1]**Intellectual Property Rights**) : Rights that protect creations and ideas generated by human intellectual activities. These rights are mainly divided into Industrial Property Rights and Copyrights.

2 Industrial Property Rights

(1) ([2]**Industrial Property Rights**) : Rights primarily related to the manufacturing of industrial or commercial products. This follows the principle in which rights come into effect once an application is filed with and registered by the ([3]**Egypt Patent Office**). This is known as the ([4]**Formality**) Principle.

(2) Types of Industrial Property Rights

Name	Subject of Rights	Protection Period
([5]**Patent Rights**)	Rights to advanced technological ideas and inventions.	20 years from the application
([6]**Utility Model Rights**)	Rights to the shape or structure of a product.	7 years from the application
([7]**Design Rights**)	Rights to a design, such as the shape and patterns of a product.	10 years from the application (to be renewed once every 5 years)
([8]**Trademark Rights**)	Rights related to items such as product names, logos, text, and sound.	10 years from the registration (Updated)

3 Copyrights

(1) ([9]**Copyrights**) : Rights related to creative activities in the arts and cover works such as novels, movies, paintings, photographs, music, and computer programs. It follows the ([10]**Non-Formality**) Principle, under which rights are established at the moment a copyrighted work is created, regardless of whether the creator is an amateur or a minor.

(2) ([11]**Copyright Act**) : A law that protects the rights of creators.

<Rights of Creators>

[1] ([12]**Moral rights of creator**) : Rights that protect the personal interests of the creator.

[2] ([13]**Copyrights (property rights)**) : Rights that protect the economic interests of the creator.

(3) ([14]**Neighboring Rights**) : Rights that arise for individuals or entities who communicate or transmit copyrighted works. Granted to performers such as singers, directors, and actors, as well as record companies and broadcasting organizations.

(4) Copyright protection period : The lifetime of the creator plus ([15]**50**) years after their death.

(5) Copyright infringement : As a general rule, when reproducing someone else's copyrighted work or using it on a website, it is necessary to obtain ([16]**permission**) from the creator. Using a work without permission would constitute a ([17]**copyright infringement**).

Warm Up

Answer the following questions.

(1) Insert the appropriate terms for [1] to [6] to complete the following sentence.

> The rights granted to a creator when they produce something through intellectual activity are called ([1]). ([1]) are primarily composed of ([2]), which contribute to the development of industry, and ([3]), which contribute to the development of culture. ([2]) are established under the ([5]) in which rights are granted upon approval after filing a notification with ([4]). On the other hand, ([3]) do not require reporting or registration, and the rights are granted at the time of creation. Furthermore, the protection period for ([3]) is ([6]) years after the death of the creator.

(2) For the following statements concerning the laws and rights of information society, mark "○" if the statement is appropriate, and "×" if it is incorrect.

[1] Posting Taha Hussein's novel "The Days" on your website without permission does not constitute copyright infringement.

[2] Downloading music or videos that are for sale while knowing that they have been illegally uploaded constitutes copyright infringement.

[3] Posting the audio data of Beethoven's Symphony No. 5 "Fate" played exceptionally well by someone else on social media does not constitute copyright infringement.

[4] Trademark rights conclude 10 years after registration with the Patent Office, but the rights can be maintained through renewal procedures.

Explanation

(1) [1] Intellectual Property Rights [2] Industrial Property Rights [3] copyrights
[4] Egypt Patent Office [5] Formality Principle [6] 50

(2) [1] Novelists like Taha Hussein can be used copyright-free as over 50 years have passed since their death. Therefore, ○

[2] Downloading music or movies while knowing they have been illegally uploaded constitutes copyright infringement. Therefore, ○

[3] Musical compositions by Beethoven, Mozart, and similar composers are no longer under copyright protection, as more than 50 years have passed since their death. However, performers and record companies have neighboring rights, so it is necessary to verify the usage permissions. Therefore, ×

[4] Trademark rights conclude 10 years after registration with the Patent Office, but the rights can be maintained for an additional 10 years through renewal procedures. Therefore, ○

Try

1 Answer the following questions.

(1) From the following terms **A** to **H**, choose the terms that best fit into the blanks [1] to [4].

> Rights related to creations resulting from human intellectual activity are collectively referred to as ([1]). ([1]) can be largely divided into Industrial Property Rights and ([2]).
> A copyrighted work is something created through academic or artistic creative activity. Copyrighted Works include novels, scripts, ([3]), musical compositions, works of art, buildings, photographs, computer programs, etc. Illustrations or web pages that you create yourself are also considered copyrighted works. In principle, to use someone else's copyrighted work, you are required to obtain permission from the creator. Using a work without permission will be considered ([4]) and may be subject to penalties.

A	Copyrights	**B**	Intellectual Property Rights	**C**	Patent Rights	**D**	Utility Model Rights
E	Movies	**F**	Ideas	**G**	Copyright Infringement	**H**	Patent Infringement

(2) From the following terms **A** to **H**, choose the terms that best fit into the blanks [1] to [3].

> Industrial property rights include rights such as ([1]) rights, which protect designs like those of automobiles, and ([2]) rights, which protect inventions such as ideas for shapes that improve water drainage in washing machines. To receive protection as an industrial property right, it is ([3]) to file an application.

A	Utility model	**B**	Trademark	**C**	Creative works	**D**	Design
E	Patent	**F**	Unnecessary	**G**	Necessary		
H	Necessary when obtaining rights for commercial purposes						

2 Read the following passage and answer the questions.

> As a general rule, it is necessary to obtain permission from the creator when reproducing someone else's copyrighted work or publishing it on a website. Using the work without permission constitutes (A)copyright infringement. However, under certain conditions, it is possible to freely use a copyrighted work without obtaining permission from the creator. For example, works that have passed more than (B) years after the death of the creator fall under this category.

(1) For the underlined section A, choose all statements that apply as copyright infringement, and answer using the letters.

A I recorded a movie broadcast on television and distributed it.
B I posted Taha Hussein's novel "The Days" on my website without permission.
C I copied an illustration that was distributed for free and sold the copies at a low price.
D Even though I knew that a video was illegally uploaded, I downloaded it solely for personal use.

(2) Answer by writing the appropriate number in blank B.

Exercise

1 Answer the following questions.

(1) Among intellectual property rights, what is the term for the rights that pertain to the manufacturing of industrial and manufactured products?

(2) Out of the following statements **A** to **D**, choose all statements that are incorrect in relation to copyrights.

A Copyrights are granted through recognition upon application to the Patent Office.

B Copyrights are related to the quality of a work.

C Copyrights are maintained for 50 years after the death of the creator.

D Copyrights arise even if the creator is a minor.

(3) What is the term for the rights that protect the marks used to distinguish goods and services?

(4) What is the term for the rights that protect inventions of things or methods?

(5) For the following statements concerning the laws and rights of information society, mark "○" if the statement is appropriate, and "×" if it is incorrect.

[1] A design right is recognized for ideas related to the technical aspects of a product's shape or structure that can be immediately implemented.

[2] Copyrights tend to be recognized less frequently for creations by amateurs or children, as copyrights are often related to the quality of the work.

[3] Recording a movie broadcast on television and then distributing that movie constitutes a copyright infringement.

[4] The protection period for a patent right is 20 years from the date of application.

[5] There is no problem with posting the full text of Sadeq Elrafaey's "The Pen Inspiration" on one's blog without obtaining permission if you are very fond of its prose.

2 Read the following passage and answer the questions.

There are four types of Industrial Property Rights: Patent Rights, Utility Model Rights, Design Rights, and (A) Rights. Among these, Utility Model Rights are rights pertaining to ([1]). Additionally, (A) rights refer to the rights concerning product names or logos, and the protection period is (B) years from the date of registration.

(1) Answer by filling in blank A with the appropriate term.

(2) Answer by filling in blank B with the appropriate number.

(3) Choose the most appropriate phrase to fill in blank [1] from the options **A** to **D** below, and answer using the letters.

A Reproduction or sale of products

B Conveyors of products

C Product design

D Ideas for the structure and shape of a product

2-3 Utilization and Disclosure of Information

Point!

Utilization and Disclosure of Information

(1) Purpose of Copyright
A copyright aims to contribute to cultural development by ensuring the ([1]**fair use**) of copyrighted works and the ([2]**protection of rights**).

(2) Exceptions
Under the purpose of copyright, there are exceptions where the copyright can be limited to allow use without obtaining permission from the copyright holder.
<Example> Reproduction for private use, reproduction within educational institutions, non-profit performances, etc.

(3) ([3]**Quotation**) : The act of using a portion of another person's copyrighted work in your own copyrighted work.
If certain requirements are met, portions of a copyrighted work can be quoted without obtaining permission from the author.
<Quotation Methods and Rules>
[1] Your own copyrighted work takes precedence, while the quoted work is subordinate.
(Your own copyrighted work is the subject.)
[2] There must be a necessity to engage in quotation.
[3] Ensure that the quoted material is clearly identifiable by enclosing it in quotation marks.
[4] The source is clearly specified.
[5] Do not alter the quoted material.

(4) Setting the duration of protection : The economic rights of the author expire ([4]**50**) years after the death of the creator.

(5) ([5]**Creative Commons License**) (CC License) : A mark indicating the conditions for using copyrighted works.
<Types of Creative Commons Licenses>

Mark	Condition	Content
	([6]**Credit to creator**) (BY)	Display the title of the work and name of the creator.
	([7]**Non-commercial**) (NC)	Do not use for ([8]**commercial**) purposes.
	([9]**No derivatives**) (ND)	Do not alter the original copyrighted work.
	([10]**Same terms for adaptations**) (SA)	Publish under the same combination of licenses as the original work.

Warm Up

Answer the following questions.

(1) Choose all statements that allow for the use of copyrighted works without permission as an exception from the options **A** to **D** below, and answer using the letters.

A I copied the materials and distributed them to students in my social studies class.

B I copied commercially available music CDs and distributed them to friends.

C We charged an admission fee and performed a K-pop medley at our band's regular concert.

D I quoted a section of a book when writing a report.

(2) Choose all statements that correctly describe the method and rules of quotations from the options **A** to **D** below, and answer using the letters.

A Even when quoting, it is always necessary to obtain permission from the creator.

B There is a necessity to quote, and the portion being cited is subordinate.

C Clearly indicate the quoted material by enclosing it in quotation marks.

D Regardless of the reason, you must not modify the material you are quoting.

(3) When publishing a photo you took on a web page, you want to allow others to use it on the conditions that "the name of the photographer and the title of the work are displayed" and "the work is not altered." At this time, choose all the Creative Commons licenses that should be displayed in combination from the options **A** to **D** below, and answer using the letters.

A 

B 

C 

D 

Explanation

(1) **A** The use of copyrighted works in the course of teaching falls under reproduction in educational institutions and works can therefore be utilized without obtaining permission from the copyright holder.

B Copying commercially available CDs and distributing them to friends does not qualify as reproduction for personal use and constitutes copyright infringement.

C Since an admission fee is charged and the usage does not fall under the condition of a performance not for profit, this usage constitutes a copyright infringement.

D In the case of quotation, a copyrighted work can be used in one's own creation without obtaining permission from the creator of the other work.

Therefore, **A** and **D**

(2) **B**, **C**, **D**

(3) **A** represents display, **B** represents non-commercial, **C** represents no derivative works, and **D** represents same terms for adaptations.

Therefore, **A** and **C**

Try

Answer the following questions.

(1) Insert the appropriate terms in blanks [1] and [2] to complete the following sentence.

> A copyright aims to contribute to cultural development by ensuring the ([1]) of copyrighted works and the ([2]) .

(2) For each of the following statements **A** to **D**, mark "○" if the statement does not constitute copyright infringement, and "×" if it is infringement.

A The sheet music for a regular concert was copied and distributed to all members of the wind orchestra.

B At a school cultural festival, the drama club performed a play using a script selected from a collection of commercially-available scripts.

C A Spanish work written by a Spanish person was translated into Arabic and published without obtaining permission from the copyright holder, as the languages were different.

D In a report assigned for class, a student cited a portion of statistical data from a web page.

(3) Choose all statements that correctly describe the method and rules of quotations from the options **A** to **D** below, and answer using the letters.

A Even in the case of a quotation, permission from the copyright holder must always be obtained.

B Clearly indicate quotes through measures such as enclosing the quoted materials in quotation marks.

C If the quoted material is clearly distinguished, it is not necessary cite the source from which the quoted material was taken.

D Quoted texts must not be altered, regardless of one's own argument.

(4) The following table is a summary of Creative Commons licenses. Complete the table by filling in the blanks [1] to [4] with the appropriate terms.

Mark	Condition	Content
	([1])	Display the title of the work and name of the creator.
	Non-commercial	Do not use for ([2]) purposes.
	([3])	Do not alter the original copyrighted work.
	([4])	Publish under the same combination of licenses as the original work.

(5) Choose one statement that correctly represents the conditions indicated by the Creative Commons license shown on the right from the options **A** to **D** below. Answer using the letters.

A Display the name of the creator and do not use the work for commercial purposes.

B Display the name of the creator and do not alter the original work.

C Do not use the work for commercial purposes and do not alter the original work.

D Do not use the work for commercial purposes. Also, if you modify the work, publish it under the same license as the original work.

Exercise

1 Answer the following questions.

(1) Choose the term that best fit into the blanks [1] to [3] from the options **A** to **D** below, and answer using the letters.

> If you want to use another person's copyrighted work, you must clarify the purpose and method of use, as well as the place where it will be published, and obtain permission from the copyright holder. However, usage is permitted without obtaining permission in cases such as ([1]) in educational institutions, reproduction for ([2]) use, and ([3]) from texts.

A Quotation **B** For-profit **C** Personal **D** Classes

(2) Choose the one that does not constitute copyright infringement from the options **A** to **D** below, and answer using the letters.

A I made a copy of a commercially purchased music CD and gave it to a friend.
B I listen to music by recording commercial music CDs that I have purchased onto my smartphone.
C I shared and disseminated on social media the audio data of a popular artist's song.
D I copied an illustration that is distributed for free and sold the copies at a low price.

(3) Choose all statements that correctly describe the method and rules of quotations from the options **A** to **D** below, and answer using the letters.

A There is a necessity to engage in quotation.
B You cannot quote without obtaining permission from the copyright holder.
C Do not alter quoted material without permission.
D The source is clearly specified.

(4) The following table is a summary of Creative Commons licenses. Complete the table by filling in the blanks [1] to [4] with the appropriate terms.

Mark	Condition	Content
	([1])	Display the title of the work and name of the creator.
	([2])	Do not use for commercial purposes.
	([3])	Do not alter the original copyrighted work.
	([4])	Publish under the same combination of licenses as the original work.

(5) When publishing a photo you took on a web page, you want to allow others to use it on the conditions that "the name of the photographer is displayed" and "the work is not used for commercial purposes." At this time, choose all the Creative Commons licenses that should be displayed in combination from the options **A** to **D** below, and answer using the letters.

A  **B**  **C**  **D** 

3-1 Threats and Countermeasures in Information Security [1]

Point!

1 Information Security

(1) ([1]**Information security**) : The act of properly managing information and keeping it safe.

(2) The three essential elements of information security

[1] ([2]**Confidentiality**) : A state in which only authorized individuals can access the information.

[2] ([3]**Integrity**) : A state in which the information is not destroyed, tampered with, or erased.

[3] ([4]**Availability**) : A state in which information can be accessed at any time when needed.

2 Various threats to information security

(1) ([5]**Unauthorized access**) : When someone without permission gains access to a computer system.

(2) ([6]**Cracking**) : The act of unlawfully accessing a system to tamper with, erase, or steal data. A person who commits such acts is called a ([7]**cracker**).

(3) ([8]**Malware**) : A general term for malicious programs designed to harm computers. Infection can occur through websites, email attachments, USB drives, or networks.

[1] ([9]**Computer virus**) : A program designed to intentionally cause harm, such as destroying data or programs.

[2] ([10]**Trojan horse**) : A program disguised as a legitimate one that infiltrates a system and quietly initiates attacks.

[3] ([11]**Worm**) : A program that replicates itself and spreads across the internet like a worm, expanding the infection.

[4] ([12]**Spyware**) : A program that collects personal information without the user's knowledge and sends it to third parties.

- ([13]**Keylogger**) : Software that monitors and records keystrokes.
- ([14]**Adware**) : A program that displays unwanted advertisements without the user's consent.

[5] ([15]**Ransomware**) : A program that renders data inaccessible and demands a ransom to restore access.

(4) ([16]**Cybercrime**) : Criminal acts committed over computer networks.

[1] ([17]**Violation of the Unauthorized Computer Access Law**) : Illegally accessing a computer using someone else's user ID or password.

[2] Crimes involving computer or electronic records : Crimes involving tampering with stored data or unauthorized manipulation of devices.

[3] Network-based crimes : Crimes committed using networks, such as fraud, defamation, or copyright infringement.

Warm Up

Answer the following questions.

(1) Choose the one in which availability is compromised in terms of information security from the options **A** to **C** below.

A A cyberattack caused a website to go down.

B Incorrect data was entered due to a keyboard typing error.

C Personal information was leaked due to a malware infection on the computer.

(2) Choose all actions that constitute a violation of the Unauthorized Computer Access Law from the options **A** to **D** below.

A Illegally used another person's user ID and password to access a computer.

B Stored a password that was obtained illegally on a computer.

C Shared a friend's user ID and password with someone else without the friend's permission.

D Published a website selling quasi-legal drugs or containing unlawful and inappropriate content.

Explanation

(1) Information security consists of three elements: integrity, confidentiality, and availability.

A When information becomes unavailable, availability is compromised.

B When information is no longer accurate, integrity is compromised.

C When unauthorized individuals can view the information, confidentiality is compromised.

Therefore, the correct answer is **A**.

(2) **A** Using a computer without having access rights constitutes unauthorized access and is prohibited under the Unauthorized Computer Access Law.

B Storing a password obtained illegally for the purpose of unauthorized access is prohibited under the Unauthorized Computer Access Law.

C Sharing someone else's password with a third party without valid reason or permission promotes unauthorized access and is also prohibited by law.

D Publishing illegal content may fall under network-related crimes.

Therefore, the correct answers are **A**, **B**, and **C**.

Try

1 There are three elements of information security: Integrity, Confidentiality, and Availability. For each of these elements, choose the one most appropriate measure from the following options **A** to **E**.

(1) Integrity (2) Confidentiality (3) Availability

A Report your arrival at work to the network administrator.

B Handle special data such as personal ID numbers in a room where only authorized personnel are allowed to enter.

C Keep logs of data access and modifications to enable traceability.

D Install backup power supplies for all devices related to critical information systems in preparation for power outages.

E Run malware in order to always have access to important information.

2 Choose the terms that best fit into the blanks [1] to [5] from the options **A** to **H** below, and answer using the letters.

When a third party without network access rights uses someone else's ID and password to illegally enter a computer system, it is called ([1]). Incidents have occurred in which individuals known as hackers or ([2]) have destroyed systems.

Programs that destroy internal computer data or cause abnormal operations are called ([3]). Among these are ([4]), which disguise themselves as legitimate programs and silently infiltrate systems to carry out attacks, and ([5]), which replicate themselves and spread across the internet like worms to increase infections.

A Worm **B** Cracker **C** Unauthorized access
D Trojan horse **E** Computer virus **F** Adware
G Keylogger **H** Impersonation

3 Answer the following questions.

(1) Choose all items from **A** to **D** that present a risk of computer virus infection.

A An email attachment sent from a computer infected with a virus.

B Connecting to a network infected with a virus.

C A USB memory stick that was used on a computer infected with a virus.

D A movie DVD played on a computer infected with a virus.

(2) Choose one act from **A** to **D** that constitutes a violation of the Unauthorized Computer Access Law.

A Provided personal information to a third party without the individual's consent.

B Took a photo of a magazine page with a smartphone and uploaded it to social media.

C Acquired a computer virus capable of automatically infiltrating networks.

D Used another person's user ID and password without permission to purchase products through online shopping.

Exercise

1 For each of the three elements of information security, select:

- The most appropriate description from Group A (**A**–**C**), one per element
- All applicable potential damages from Group B (a–f) that may occur if that element is not ensured

(1) Confidentiality (2) Integrity (3) Availability

<Group A>

A Ensuring uninterrupted access to information when needed.

B Ensuring that only authorized individuals can access the information.

C Ensuring that information has not been destroyed, tampered with, or deleted.

<Group B>

a Eavesdropping on the network

b Service interruptions such as system downtime

c Password leakage

d Tampering with or destruction of information

e Information leakage

f Unauthorized use of computers or networks

2 Answer the following questions.

(1) Choose the most suitable option for the blank from the options **A** to **G** below, and answer using the letters.

[1] A virus that displays advertisements the user did not intend to see is called ( ).

[2] The act of illegally infiltrating a computer to tamper with, erase, or steal data is called ( ).

[3] Software that leaks data stored on a computer to the outside is called ( ).

[4] Malicious software including computer viruses and Trojan horses is collectively referred to as ( ).

A Malware **B** Keylogger **C** Adware **D** Cracking

E Hacking **F** Phishing **G** Spyware

(2) Choose the one correct statement from **A** to **D** regarding computer virus infection.

A As long as the computer is connected to a network, there is always a risk of infection by a computer virus.

B If you do not connect to a computer or network and only transfer data using a USB memory stick, infection will not occur.

C If you avoid accessing harmful or illegal websites, you will not get infected.

D As long as you do not open emails, you are safe from infection, so being cautious with emails is sufficient.

3-2 Threats and Countermeasures in Information Security [2]

Point!

1 Passwords and Authentication

(1) Password: A string of characters used to verify that the user of a given user ID is the legitimate account holder.

(2) Guidelines for creating passwords:
- Use a string that is as ([1]**long**) as possible.
- ([2]**Combine**) uppercase letters, lowercase letters, numbers, and symbols.
- Do not use personal information such as your birthday, email address, or user ID.
- Do not reuse passwords used for other services.

(3) ([3]**One-time-password**) : A password that changes at regular intervals and can only be used once.

(4) ([4]**Authentification**) : The process of verifying the identity of a user on a computer or network.

(5) Types of authentication:

Name	Method	Examples
[1] ([5]Knowledge-based authentication)	Authentication using information known only to the individual.	User ID and password, PIN code
[2] ([6]Biometric authentication (Biometrics))	Authentication using physical or behavioral characteristics of the individual.	Fingerprint, Iris, Vein pattern, Handwriting
[3] ([7]Possession-based authentication)	Authentication using an item that the individual possesses.	IC card, One-time password, SMS-based verification

[4] ([8]**Two-factor authentication**) : A method that combines two different types of factors from "knowledge," "biometrics," and "possession" to perform authentication.

[5] ([9]**Two-step authentication**) : A method that performs authentication in two steps using two pieces of information from the same type of factor.

2 Information Security Measures

(1) ([10]**Access control**) : A method of limiting access to computer systems or data so that only specific users, verified through authentication, are allowed to use them.

(2) ([11]**Firewall**) : A system installed at network entry points to prevent ([12]**unauthorized access**) from outside and to stop ([13]**data leaks**) from within.

(3) Countermeasures against computer viruses
- Install ([14]**antivirus software**) to remove or isolate viruses, and keep the virus definitions within the software up to date.
- Always keep the operating system (OS) and application software ([15]**updated**) to prevent ([16]**security holes**) (vulnerabilities) in the software.
- Regularly create ([17]**backups**) of your data.

Warm Up

Answer the following questions.

(1) Choose the one incorrect statement regarding password best practices from the options **A** to **D** below, and answer using the letter.

A Do not reuse the same password across multiple services.
B It is best to keep using the default password that was initially assigned.
C Combine letters, numbers, and symbols when creating a password.
D Avoid using easily guessable information such as your name or birthday.

(2) Choose all correct statements about one-time passwords from the options **A** to **D** below, and answer using the letters.

A If a one-time password is leaked, it can easily lead to unauthorized access.
B Using a one-time password strengthens overall security.
C A one-time password has a limited usage time and becomes invalid after expiration.
D It can prevent unauthorized access using leaked passwords.

(3) Choose the one correct example of biometric authentication from the options **A** to **D** below, and answer using the letter.

A Authentication using a user ID and password assigned to each individual
B Authentication using an SMS sent to a smartphone
C Authentication by scanning a fingerprint on a sensor
D Authentication using a one-time password

(4) If a password can use the digits 0 to 9 and lowercase letters a to z, how many different combinations are there for a 3-character password? Give your answer in the form of a^n.

Explanation

(1) If an initial password is assigned via email or memo, there is a possibility that the password has been leaked to a third party. Therefore, the initial password must be changed. The correct answer is **B**.

(2) A one-time password is a password that changes at fixed intervals and can only be used once. This strengthens security. The correct answers are **B, C,** and **D**.

(3) Biometric authentication refers to the use of an individual's physical or behavioral characteristics for verification. Examples include fingerprint, iris, vein, or handwriting-based authentication. The correct answer is **C**.
Note: A is knowledge-based authentication, B is possession-based authentication, and D is also possession-based authentication.

(4) There are 10 digits (0–9) and 26 letters (a–z), making 36 possible characters. Since each character in the password can be any of the 36, the total number of combinations for a 3-character password is 36 × 36 × 36 = **36^3 combinations**.

Try

Answer the following questions.

(1) Choose the one incorrect statement regarding password best practices from the options **A** to **D** below, and answer using the letter.

A Do not use information such as phone numbers, birthdays, email addresses, or user IDs.
B It is best to continue using the initial password without changing it.
C Do not reuse the same password across different services.
D Use a mix of uppercase and lowercase letters, numbers, and symbols.

(2) Choose the one thing that can be prevented by using a one-time password from the options **A** to **D** below, and answer using the letter.

A Password theft during transmission over a network
B Tampering with confidential files after unauthorized access
C Infection by a virus through malicious software
D Unauthorized access using a leaked password

(3) Choose the one correct example of biometric authentication from the options **A** to **D** below, and answer using the letter.

A Authentication using the shape of a fingerprint or vein pattern
B Authentication using a digital certificate
C Authentication based on whether the user can correctly read distorted text in an image
D Authentication using a one-time password

(4) Choose the terms that best fit into the blanks [1] to [4] from the options **A** to **F** below, and answer using the letters.

To protect computers and networks from threats such as unauthorized access and computer viruses, it is necessary to implement various security measures. For example, determining whether a person is authorized to access a computer or network is called ([1]). As countermeasures against computer viruses, there are the introduction of ([2]) and the ([3]) of hardware and operating systems. Furthermore, a system that hides internal LAN computers from external networks and prevents unauthorized access is called a ([4]).

A Firewall **B** Antivirus software **C** Encryption
D Authentication **E** Update **F** Security hole

(5) What is the term for restricting access so that only specific users can operate a computer system or network?

♪ (6) If a password uses 26 characters (A to Z), how many times greater is the maximum number of brute-force attempts required to crack the password when increasing the length from 4 characters to 6 characters?

Exercise

1 Answer the following questions.

(1) Choose the one incorrect statement regarding password creation from the options **A** to **D** below, and answer using the letter.

A Use the shortest possible string to make it easy to remember.
B Do not reuse passwords used for other services.
C Do not write passwords down in a notebook or on sticky notes.
D Combine uppercase and lowercase letters, numbers, and symbols.

(2) Choose the one threat that can be prevented by using a one-time password from the options **A** to **D** below, and answer using the letters.

A Theft of user ID through social engineering
B Unauthorized access through brute-force attacks
C Unauthorized access using a leaked password
D Virus infection through a security hole

(3) Choose the one correct example of biometric authentication from the options **A** to **D** below, and answer using the letter.

A Authentication using a personal ID or password
B Authentication using physical characteristics such as fingerprints or irises
C Authentication based on an individual's problem-solving ability
D Authentication using physical performance such as grip strength or flexibility

(4) Choose the terms that best fit into the blanks [1] to [5] from the options **A** to **F** below, and answer using the letters.

> System administrators must implement measures such as installing a ([1]) to prevent unauthorized access from outside the system and to minimize data tampering or leakage as much as possible. In order to deal with the constant emergence of new ([2]), it is essential to introduce ([3]) and patch ([4]).
> To prevent unauthorized access, ([5]) is useful for restricting system or network usage to specific users only.

A Firewall **B** Antivirus software **C** Security
D Access control **E** Computer virus **F** Security hole

(5) What is the name of the authentication method that combines two different elements from "knowledge," "biometric," and "possession"?

♪ (6) If a password can use the digits 0–9 and lowercase letters a–z, how many possible combinations are there for a 4-character password? Give your answer in the form of a^n.

3-3 Threats and Countermeasures in Information Security [3]

Point!

1 Fraudulent Billing

([1]**Fraudulent billing**): A scam in which a person is billed for a fictitious service they have never used, with the intent to fraudulently extract money.

([2]**One-click fraud**): A scam where clicking a URL in a website or email automatically triggers a message pretending a contract has been concluded, followed by an exorbitant payment demand.

2 Unauthorized Acquisition of Information

(1) ([3]**Phishing**) : A scam that uses fake websites disguised as financial institutions or public agencies to steal personal information such as PINs or account details.

(2) ([4]**Social engineering**) : A method of fraudulently obtaining information by exploiting human psychology, carelessness, or lack of awareness.

[1] ([5]**Impersonation**) : The act of pretending to be someone else—such as making a phone call in their name—to obtain information.

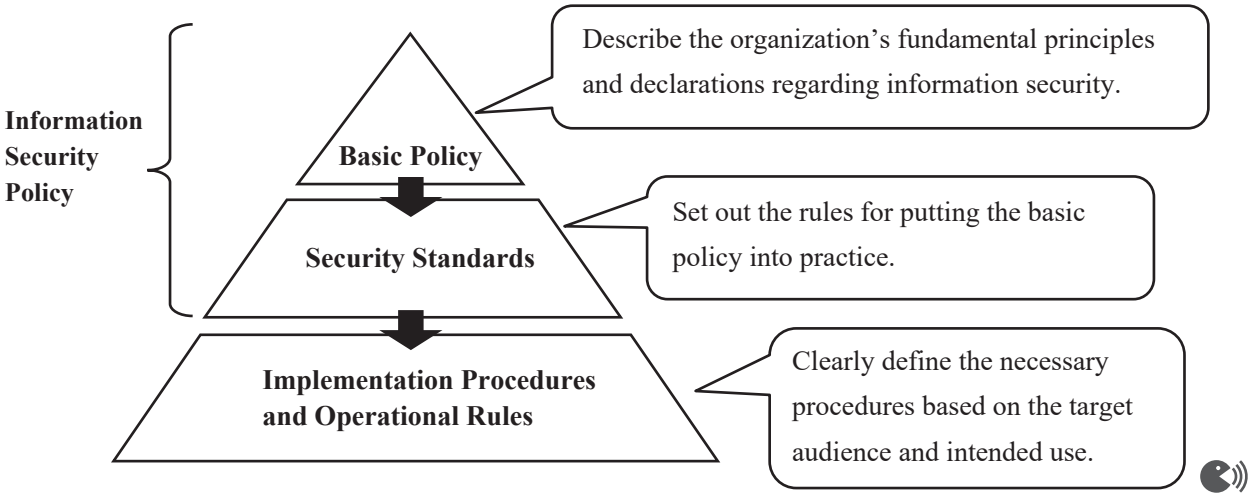
[2] ([6]**Shoulder surfing**) : The act of peeking over someone's shoulder to steal passwords or PIN codes.

[3] ([7]**Dumpster diving**) : The act of rummaging through trash to obtain discarded confidential information.

(3) ([8]**Skimming**) : The act of illegally extracting data from someone's credit or debit card and using it to create a counterfeit card.

3 Information security policy

([9]**Information Security Policy**) : A set of fundamental rules and guidelines established by a company or organization to maintain and protect information security.



Warm Up

Answer the following questions.

(1) Choose the one that correctly describes phishing from the options **A** to **D** below, and answer using the letter.

A A program that unknowingly steals personal information from inside a computer and sends it to a third party.

B Pretending to be an email from a financial institution to lure someone to a fake website and illegally obtain their PIN or credit card number.

C Clicking a URL once in a website or email triggers a false declaration of contract and a demand for a large payment.

D Being billed for a service you don't recognize and being defrauded of money.

(2) Choose *all* that correspond to social engineering from the options **A** to **D** below, and answer using the letters.

A Disabling access to data on a computer and demanding a ransom for its recovery.

B Creating a fake website posing as a bank to steal the PIN of a bank account.

C. Eavesdropping on conversations with other users.

D Rummaging through trash to obtain discarded confidential information.

Explanation

(1) A is spyware, C is one-click fraud, and D is fraudulent billing. Answer: **B**

(2) A is ransomware, B is phishing. Answers: **C, D**

Try

Read the following passage and answer the questions that follow.

As more people use the internet, cases of fraud involving the misuse of computers and smartphones are also increasing. For example, there are scams where simply clicking a URL on a website is treated as agreeing to a service contract, and a large fee is demanded ([1]), or emails pretending to be from financial institutions lead users to fake websites in order to steal PINs or credit card numbers ([2]). Various deceptive methods exist. In addition, (A)exploiting gaps in human psychology or carelessness can also lead to the unauthorized acquisition of information.

(1) Write the terms that best fit in blanks [1] and [2].
(2) What is the term used to describe the kind of activity mentioned in the underlined part A?
(3) Choose *all* that are related to the answer in (2) from the options **A** to **D** below, and answer using the letters.
- **A** Individuals can communicate with each other over the internet.
- **B** Data on a computer is made inaccessible, and a ransom is demanded for its recovery.
- **C** Eavesdropping on conversations with other users.
- **D** Peeking while someone is entering their user ID or password.

Exercise

1 Answer the question to the following.

(1) For each of the following sentences, choose the most closely related option from the options **A** to **E** below, and answer using the letters.
- [1] Being charged a usage fee simply by clicking a link, as if you had joined or signed a contract.
- [2] Pretending to be a financial institution to trick users into entering their user ID and password, which are then misused.
- [3] A basic policy established by a company or organization to maintain information security.
- [4] Illegally extracting information from someone else's credit card or bank card.

A Phishing **B** One-click fraud **C** Skimming
D Information security policy **E** Social engineering

(2) Choose *all* that fall under social engineering from the options **A** to **D** below, and answer using the letters.
- **A** Calling from outside while pretending to be an employee, in order to extract confidential internal information.
- **B** Being billed for a fictitious service you don't recognize and being defrauded of money.
- **C** Rummaging through trash to obtain discarded confidential information.
- **D** Running a program that causes malicious software to be downloaded without the user's knowledge.

3-4 Information Technology for Safety [1]

Point!

1 Encryption

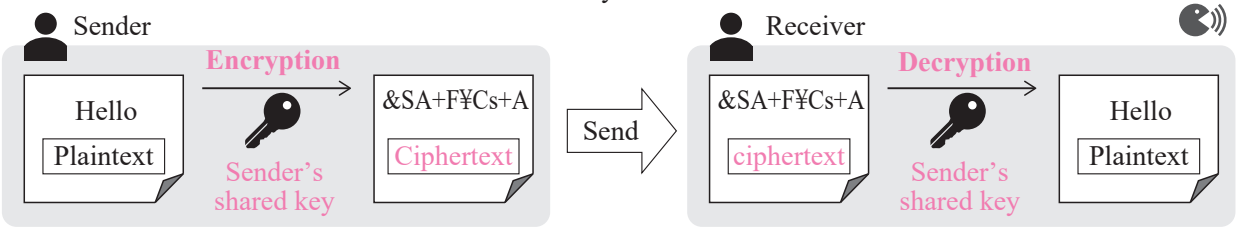
(1) ([1]**Encryption**) : A method used when sending information to prevent it from being intercepted by anyone other than the intended recipient. The encrypted text is called ([2]**ciphertext**), and the original, unencrypted text is called ([3]**plaintext**).

(2) ([4]**Decryption**) : The process of converting ciphertext back into its original plaintext form.

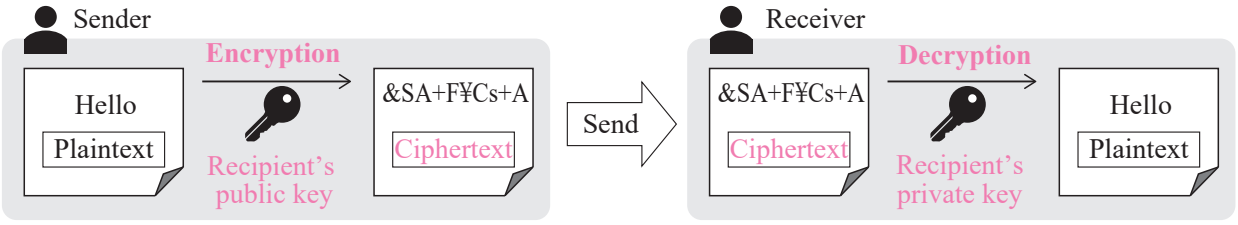
(3) ([5]**Key**) : The specific procedure or data used for encryption and decryption.

2 Types of encryption

(1) ([6]**Symmetric key encryption**) : An encryption method where the same ([7]**shared key**) is used for both encryption and decryption.
The message is encrypted using the ([8]**sender's shared key**) and decrypted using the ([9]**sender's shared key**) that was sent in advance by the sender.



(2) ([10]**Public key encryption**) : An encryption method that uses a publicly shared encryption key ([11]**public key**) and a private encryption key ([12]**private key**). The message is encrypted using the ([13]**recipient's public key**), which was sent in advance, and decrypted using the ([14]**recipient's private key**), which only the recipient possesses.



(3) Characteristics of Symmetric Key Encryption and Public Key Encryption

	Symmetric Key Encryption	Public Key Encryption
Merit	Compared to public-key encryption, encryption and decryption processing speed is ([15]**faster**).	Since data can be decrypted by anyone with the key, a different shared key is needed for each sender.
Demerit	Because the public key can be shared freely, key management is easier.	Compared to symmetric-key encryption, encryption and decryption processing speed is ([16]**slower**).

(4) ([17]**Session key method**) : An encryption method that combines symmetric key encryption and public key encryption.

Warm Up

Answer the following questions.

(1) Complete the following sentences by filling in the blanks [1] to [4] with the appropriate terms.

> When sending information, the technology used to prevent it from being leaked or tampered with by anyone other than the intended recipient is called ([1]). The original data before encryption is called ([2]), and the act of converting the ciphertext back into plaintext is called ([3]). Also, during both ([1]) and ([3]), something called a ([4]) is used.

(2) For each of the following items **A** to **D**, write "S" if the statement refers to symmetric key encryption, or "P" if it refers to public key encryption.

A The encryption key is made public, and encryption is done using the public key while decryption is done with the private key.

B Encryption uses separate keys held by the recipient — one for encryption and one for decryption.

C Compared to the other method, the encryption and decryption processing speed is faster.

D Compared to the other method, exchanging the key is more difficult.

(3) What is the name of the hybrid encryption method that combines symmetric key encryption and public key encryption?

Explanation

(1) [1] encryption [2] plaintext [3] decryption [4] key

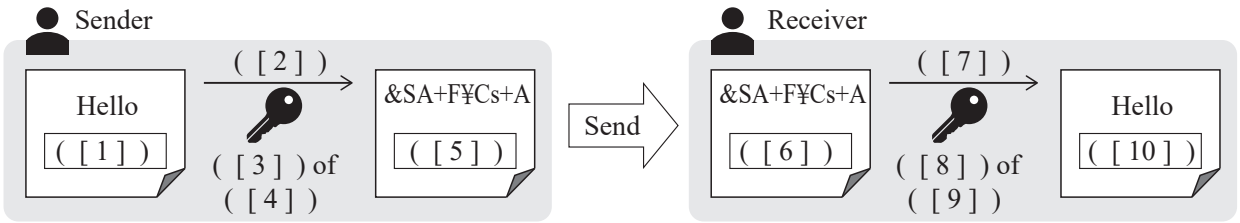
(2) **A** and **B**: The method in which encryption is performed with the recipient's public key and decryption with the recipient's private key is public key encryption.
C and **D**: Symmetric key encryption is faster than public key encryption, but since it uses the same key for both encryption and decryption, there is the issue of how to securely share the key with the recipient.
Therefore, A: **P**, B: **P**, C: **S**, D: **S**

(3) Session key method

Try

1 Answer the following question.

(1) The diagram illustrates the process flow of public key encryption. For blanks [1] to [10], choose the appropriate terms from options **A** to **J** below. Note that the same option may be used more than once.



A Plaintext **B** Ciphertext **C** Decryption **D** Encryption **E** Encoding
F Shared key **G** Public key **H** Private key **I** Sender **J** Recipient

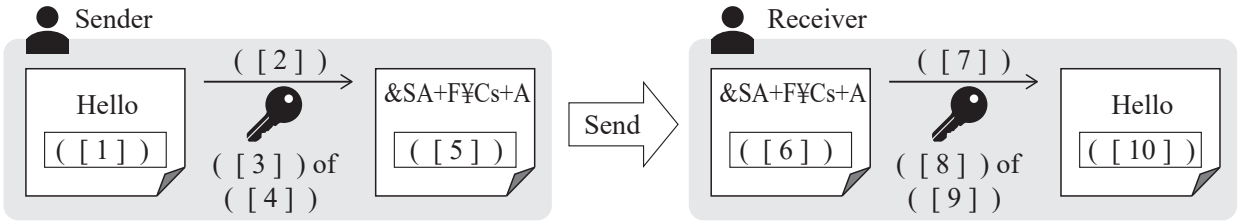
(2) For each of the following items **A** to **D**, write "S" if the statement refers to symmetric key encryption, or "P" if it refers to public key encryption.

A A separate key must be prepared for each sender.
B The same key is used by the sender for both encryption and decryption.
C Encryption and decryption are slower compared to the other method.
D Exchanging the key is easier compared to the other method.

Exercise

1 Answer the following question.

(1) The diagram shows the process flow of symmetric key encryption. For blanks [1] to [10], choose the appropriate terms from the options **A** to **J** below. The same option may be used more than once.



A Plaintext **B** Ciphertext **C** Decryption **D** Encryption **E** Encoding
F Shared key **G** Public key **H** Private key **I** Sender **J** Recipient

(2) Among the options **A** to **D** below, choose the one that best describes a characteristic of symmetric key encryption when compared to public key encryption. Answer using the corresponding letter.

A Uses different keys for encryption and decryption.
B Allows fast encryption and decryption.
C Enables safer distribution of keys.
D Makes key management easier even when communicating with many different parties.

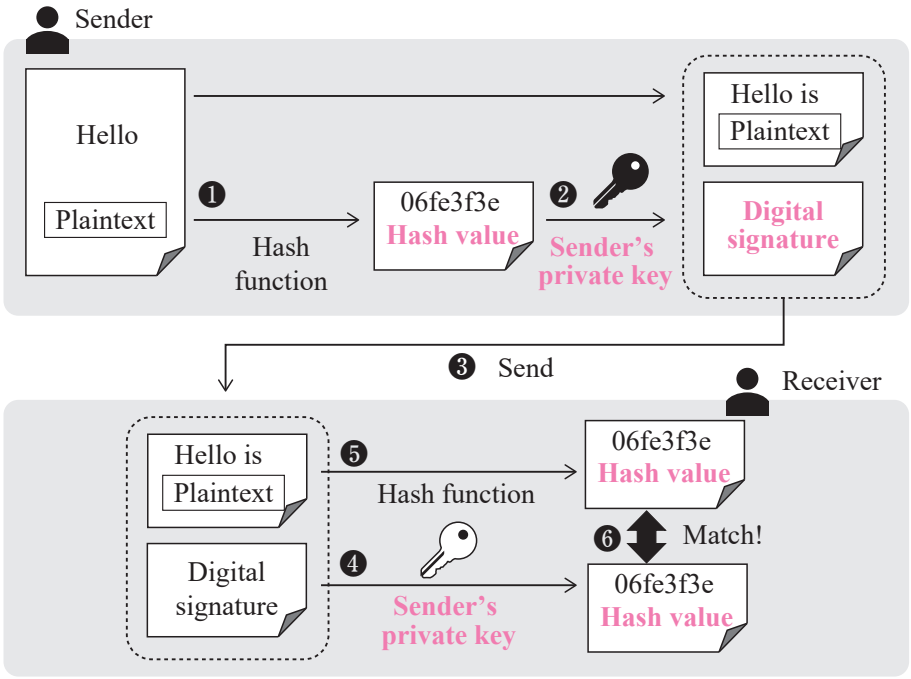
3-5 Information Technology for Safety [2]

Point!

1 Digital Signature

(1) ([1]**Hash function**) : A function that calculates a unique value based on the input data.The value generated by the hash function is called a ([2]**hash value**). It is not possible to restore the original data from the hash value.

(2) ([3]**Digital signature (Electronic signature)**) : A technology that uses public key encryption and hash values to prove that the transmitted data is from the sender and has not been tampered with.



【Sender's Procedure】

1. Use a hash function to generate a ([4]**hash value**) from the plaintext to be sent.
2. Encrypt the hash value using the ([5]**sender's private key**). This encrypted hash is called a ([6]**digital signature**).
3. Send both the plaintext and the digital signature to the recipient.

【Recipient's Procedure】

4. Use the ([7]**sender's public key**) to decrypt the received digital signature and retrieve the original hash value.
5. Use the same hash function used in step 1 to generate a new ([8]**hash value**) from the received plaintext.
6. Compare the two ([9]**hash values**) from steps 4 and 5. If they match, it proves that the message is from the sender and has not been tampered with.

(3) ([10]**Certification authority (CA)**) : A trusted third-party organization that verifies whether a public key truly belongs to its claimed owner.
It issues ([11]**digital certificates**) that include the public key and identifying information of the key owner.

2 SSL / TLS

([12]**SSL/TLS**) : A technology used to encrypt communication between a web server and a web browser. The ([13]**session key method**) is used in this encryption. The URL of an encrypted web page begins with "([14]**https**):// …".

＊TLS (Transport Layer Security) was introduced as a more secure version of the originally used SSL (Secure Sockets Layer). However, since the term "SSL" became widely recognized, the combined term SSL/TLS is often used.

Warm Up

Answer the following questions.

(1) For the following statements **A** to **D** about hash values, mark "○" if the statement is correct, or "×" if it is incorrect.

A If one character in the original data is changed, only one character in the resulting hash value will change.

B A digital signature is created by encrypting the hash value of the document to be sent with a private key.

C It is difficult to restore the original message from its hash value.

D Even if the documents being sent are different, the hash values obtained from the same hash function will always be the same.

(2) The following sentences describe the steps of creating a digital signature. Fill in the blanks [1] to [4] with the appropriate terms.

> The sender generates a ([1]) based on the data they want to send and encrypts it using their ([2]). This is called a ([3]), and the sender sends both the data and the digital signature to the recipient. The recipient decrypts the received ([3]) using the sender's ([4]) to recover the original ([1]). The recipient also generates a ([1]) from the received data using the same hash function. If the two ([1]) values match, it proves that the data is from the sender and has not been tampered with.

(3) What is the name of the technology used to encrypt communication between a web server and a web browser?

Explanation

(1) **A**. If even a single character in the original message is different, the resulting hash value becomes completely different. Therefore: ×

B ○

C ○

D If the message being sent is different, the resulting hash value will also be completely different even when using the same hash function. Therefore: ×

(2) [1] hash value [2] private key [3] digital signature (electronic signature) [4] public key

(3) SSL/TLS

Try

Answer the following question.

(1) Choose the terms that best fit into the blanks [1] to [6] from the options **A** to **J** below, and answer using the letters.

> To allow the recipient to verify that the data was created by the actual sender and was not tampered with during transmission, there is a technology called ([1]). A ([1]) is created by generating a ([2]) from the plaintext to be sent using a program, and then encrypting it with the ([3]). This is attached to the plaintext and sent to the recipient. The recipient decrypts the ([1]) using the ([4]). If the resulting ([2]) matches the ([2]) generated from the received plaintext, it proves that the data was created by the sender and has not been altered. However, this alone cannot prevent impersonation. Therefore, a third-party organization called a ([5]) issues a ([6]) to guarantee that the public key truly belongs to the sender.

A Sender's private key **B** Sender's public key **C** Sender's shared key
D Recipient's private key **E** Recipient's public key **F** Recipient's shared key
G Digital certificate **H** Digital signature **I** Hash value
J Certification Authority (CA)

(2) Choose the terms that best fit into the blanks [1] to [2] from the options **A** to **D** below, and answer using the letters.

> Regarding the hash function used in digital signatures: The same data is always converted into the same ([1]) hash value, and it is ([2]) impossible to restore the original data from the converted hash value.

A Different **B** Same **C** Possible **D** Impossible

(3) Choose the terms that best fit into the blanks [1] to [6] from the options **A** to **G** below, and answer using the letters.

> When the beginning of a web page URL is "https://", it means that encryption using ([1]) is being performed. In ([1]), encryption is carried out using a ([4]) that combines ([2]) and ([3]). In addition, ([1]) also helps prevent phishing to direct towards a fake website by attaching a ([6]) issued by a ([5]).

A Public key encryption **B** Symmetric key encryption **C** Session key method
D Digital certificate **E** Digital signature **F** SSL/TLS
G Certification Authority (CA)

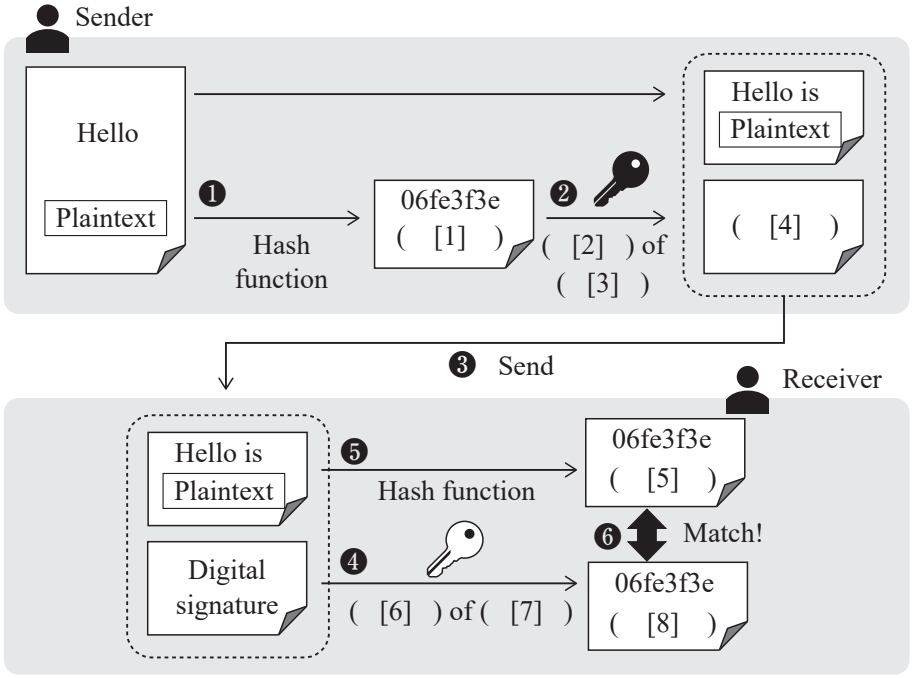
(4) Among the following options **A** to **D**, choose the one that correctly describes a function of SSL/TLS. Answer using the corresponding letter.

A Generates one-time passwords for user authentication on websites.
B Encrypts communication between the web browser and the web server.
C Filters communication to unauthorized websites.
D Detects viruses that spread through networks.

Exercise

1 Answer the following question.

(1) The diagram below illustrates the mechanism of a digital signature. For blanks [1] to [8], choose the appropriate terms from the options **A** to **H** below and answer using the corresponding letters. The same letter may be used more than once.



【Word Bank】 **A** Sender **B** Recipient **C** Shared key **D** Private key
E Public key **F** Hash value **G** Digital signature **H** Electronic authentication

(2) Among the options **A** to **D** below, choose the one that appropriately describes something related to an email with a digital signature. Answer using the corresponding letter.

A Garbled text is more likely to occur during transmission of the email.
B It allows you to confirm whether the email was sent from the correct sender.
C It prevents the contents of the email from being intercepted during transmission.
D It prevents the contents of the email from being lost.

(3) Among the options **A** to **D** below, choose *all* that correctly describe functions of SSL/TLS. Answer using the corresponding letters.

A SSL is the predecessor of TLS, and currently, TLS is the mainstream standard in use.
B It is a function that restricts access to harmful or illegal websites based on certain conditions.
C URLs that begin with “http://...” are encrypted using SSL/TLS.
D SSL/TLS encrypts communication using a session key method that combines symmetric and public key encryption methods.

4-1 Development of Information Technology

Point!

1 Advancements in Information Technology and Future Society

(1) Flow of Societal Development

Name	Explanation	Impactful Technologies and Tools
([1]Hunter-gatherer society)	• From the birth of humanity • A society where people live through hunting.	Stone axes, bows and arrows, fire-starting techniques, language, etc.
([2]Agrarian society)	• From around 13,000 BCE • A society where people lead a stable life by growing and harvesting food.	Agricultural tools, irrigation, etc.
([3]Industrialized society)	• From the mid-18th century ([4]post-industrial revolution) • A society where industrialization advanced through mass production using machinery, facilitated by the invention of the steam engine and electricity.	Steam engines, industrial machinery, printing technology, etc.
([5]Information society)	• From the latter half of the 20th century • A society where automation has been promoted by the advancement of computers.	Computers, the internet, etc.

(2) ([6]Society 5.0) : A new society where virtual space (cyberspace) and real space (physical space) are integrated to solve various social issues and achieve economic development.

2 New Information Technologies Attracting Attention

(1) ([7]Big Data) : Vast collections of data in various forms, with different characteristics and of various types. Data consists of three elements: data ([8]volume), data ([9]variety), and data ([10]generation/update frequency).

(2) ([11]AI (Artificial Intelligence)) : A technology that uses computers to artificially mimic human intellectual behavior.
<Examples> Autonomous driving, telemedicine, smart agriculture, smart homes, etc.

(3) ([12]Machine Learning) : A technology where computers learn from large amounts of data to extract rules and patterns from the data.

(4) ([13]IoT) : Technology that supports daily life by connecting household appliances and other items to the internet, thereby allowing the appliances to communicate with each other.

- ([14]Smart Home) : A residence that utilizes IoT and AI technologies to provide a more comfortable living environment.

(5) ([15]VR (Virtual Reality)) : A technology that allows users to experience an illusion of reality in a simulated environment.

(6) ([16]AR (Augmented Reality)) : A technology that uses computer processing to enhance the real-world environment perceived by human senses (vision, etc.).

3 Changes in Life Caused by Information Technology

(1) ([17]**Technostress**) : The overall term for mental and physical problems that arise from using computers.

- ([18]**Technophobia**) : A state of anxiety or fear towards using computers due to a sense of discomfort or lack of confidence in handling them.
- ([19]**Techno-Addiction**) : Excessive dependency on computers.
- ([20]**VDT Disorder**) : Shoulder stiffness and eye strain caused by prolonged computer use.

(2) ([21]**Digital Divide**) : The gap between those who can utilize information technology and those who cannot.

Warm Up

Answer the following questions.

(1) Choose the one that is the most appropriate sequence of societal development from the options A to **D** below, and answer using the letter.

A Hunter-gatherer society → Agrarian society → Industrialized society → Information society
B Agrarian society → Hunter-gatherer society → Information society → Industrialized society
C Agrarian society → Hunter-gatherer society → Industrialized society → Information society
D Hunter-gatherer society → Agrarian society → Information society → Industrialized society

(2) Choose the most closely related option for the following sentences from the options **1)** to **5)** below, and answer using the letters.

[1] Technology that connects all things (objects) to the internet.
[2] A technology in which machines analyze data to extract rules and patterns from the data.
[3] A vast amount of data that is difficult for humans to fully comprehend.
[4] A virtual space which is created by a computer and allows for experiences that feel like reality.

A Machine Learning **B** Big data **C** IoT (Internet of Things)
D Virtual Reality **E** Augmented Reality

(3) What is the term for the gap between those who can utilize information technology, such as the internet, and those who cannot?

Explanation

(1) **A**
(2) [1] **C** [2] **A** [3] **B** [4] **D**
(3) Digital Divide

Try

1 Read the following passage and answer the questions.

In ancient times, people lived by hunting animals and gathering plants. In such a ([1]) society, technologies like stone axes, bows and arrows, fire-starting techniques, and even language itself supported the community. Eventually, humanity settled on fertile land and led a life growing crops. In this kind of ([2]) society, the community was supported by technologies such as the invention of writing, agricultural tools, astronomy, and irrigation.

From the mid-18th century, when the steam engine was invented in Britain, the ([3]) Revolution occurred, leading to the formation of ([4]) society. Economic activities were stimulated by operating industrial machinery in large factories and by the mass production, transportation, and consumption of goods. Natural sciences and printing technologies supported ([4]) society.

Around the middle of the 20th century, with the development of media such as radio and television and the invention of the computer, the ([5]) society emerged. Humankind is currently aiming for a human-centered (A)new information society that harmonizes economic development with the resolution of social issues through systems that highly integrate cyberspace (virtual space) and physical space (real space).

(1) Choose the terms that best fit into the blanks [1] to [5] in the passage from the options **A** to **F**, and answer using the letters.

A Industrial **B** Hunter-gatherer **C** Information
D The internet **E** Agrarian **F** Industrialized

(2) What is the term for a society like the one referred to by the underlined section A?

2 Answer the following questions.

(1) Choose the most closely related options for the following sentences from the options **A** to **F** below, and answer using the letters.

[1] Vast amounts of data collected and accumulated from people, objects, society, and nature, which is then analyzed and utilized for problem-solving, thanks to advancements in information technology.
[2] An environment where all objects are connected to the internet and communicate with each other.
[3] Technology that enhances reality by using computers to add information to real-world environments.
[4] Residences that utilize IoT and AI technologies to achieve a more comfortable living environment.

A AI **B** Augmented Reality **C** Virtual Reality
D IoT (Internet of Things) **E** Smart Home **F** Big Data

(2) Choose the one that is not a characteristic of Big Data from the options **A** to **D**, and answer using the letter.

A The data has low versatility **B** The amount of data is enormous
C The types of data are diverse **D** The data has a high frequency of occurrence

3 Choose the term that best fits into the blank in the following text from the options **A** to **D** below, and answer using the letter.

The disparity that arises between those who can use information and communication technologies like the internet and computers and those who cannot is referred to as ( ).

A Technostress **B** Digital Divide
C VDT Disorder **D** Techno-Addiction

Exercise

1 Complete the following table by filling in the blanks [1] to [4] with the appropriate terms.

Name	Explanation
([1]) society	• From the birth of humanity • A society where people live through hunting.
([2]) society	• From around 13,000 BCE • A society where people lead a stable life by growing and harvesting food.
([3]) society	• From the mid-18th century (post-industrial revolution) • A society where industrialization advanced through mass production using machinery, facilitated by the invention of the steam engine and electricity.
([4]) society	• From the latter half of the 20th century • A society where automation has been promoted by the advancement of computers.

2 Answer the following questions.

(1) Choose the most closely related options for the following sentences from the options **A** to **D** below, and answer using the letters.

[1] An environment where all objects are connected to the internet and communicate with each other.

[2] A technology that uses computers to artificially mimic human intellectual behavior.

[3] Technology for constructing virtual environments that can be perceived by humans.

[4] A technology that adds information (still images, videos, etc.) by using computers to real-world environments.

A Virtual Reality **B** IoT (Internet of Things) **C** Augmented Reality **D** AI

(2) Choose one statement that is most inappropriate in regard to Big Data analysis from the options **A** to **D** below, and answer using the letter.

A Doctors are able to make quick and accurate diagnoses by consolidating information such as treatment progress and test results of patients.

B Monitor real-time traffic conditions, predict traffic congestion, and suggest optimal routes.

C Analyze consumer behavior patterns based on the results of group interviews.

D Analyze the large volume of posts on social media to identify trending keywords and understand current trends.

3 Choose the term that best fits into the blank in the following text from the options **A** to **D** below, and answer using the letter.

Anxiety and frustration from being unable to adapt to the operation of information devices such as computers or smartphones, as well as excessive dependency on the devices, are collectively referred to as ( ).

A Technostress **B** Digital Divide **C** VDT Disorder **D** Techno-Addiction

5-1 Development of Communication Methods

Point!

Media and Its Evolution

(1) Communication and Its Development

[1] Communication Before Telecommunications

- In ancient times, basic information was conveyed by lighting ([1]**signal fires**) or beating drums.
- After the development of writing, messages were written on ([2]**paper**) and delivered using messengers or carrier pigeons.
- The ([3]**modern postal system**) was established in 1840.

[2] The Beginning of Telecommunications

- In 1837, an American named ([4]**Morse**) invented the ([5]**Morse telegraph**) (for the transmission and reception of codes via telecommunication).
- In 1876, an American named Bell invented the ([6]**telephone**).
- In 1895, an Italian named Marconi invented the ([7]**wireless telegraph**).
- In 1946, mobile phone service ([8]**cellular phones**) began to be used in the United States.

(2) ([9]**Mass communication (Mass media)**) : A means of sending information to a large number of people at once.

<Examples> Newspapers and magazines, radio and television broadcasts, etc.

(3) The Development of Mass Communication

- In the mid-15th century, a German named ([10]**Gutenberg**) invented the ([11]**movable-type printing press**).
- In 1906, the first experimental broadcast of ([12]**radio**) was conducted in the United States.
- In 1928, the first experimental broadcast of ([13]**television**) was conducted in the United States.

(4) The Development of the Internet

- In 1969, with the support of the United States Department of Defense, an experiment was conducted on a computer network called ([14]**ARPANET**). Initially, it was mainly used by ([15]**research institutions**). However, it eventually became known as the ([16]**internet**) and began to spread among the general public.

Warm Up

Choose the terms that best fit into the blanks [1] to [4] from the options **A** to **D**.

- In the mid-15th century, Gutenberg invented the ([1]).
- In 1837, Morse invented the ([2]).
- In 1876, Bell invented the ([3]).
- In 1895, Marconi invented the ([4]).

A Wireless telegraph **B** Morse telegraph **C** Movable-type printing press **D** Telephone

Explanation

[1] **C** [2] **B** [3] **D** [4] **A**

Try

Answer the following questions.

(1) Choose the terms that best fit into the blanks [1] to [9] from the options **A** to **L**.

> In ancient times, people would convey information by lighting ([1]) or beating drums to communicate basic information to others. Eventually, letters and symbols were carried on a medium called ([2]) and delivered using messengers or carrier pigeons. In the mid-15th century, thanks to ([3]) inventing the ([4]), it became possible to easily reproduce large amounts of information as printed materials. As a result, newspapers and books could be published, thereby making it possible to convey information to a large number of people.
>
> In the 19th century, an American named ([5]) invented the ([6]), a technology for sending and receiving codes through telecommunications. Around the same time, Bell invented ([7]). Furthermore, at the end of the 19th century, an Italian named Marconi invented the ([8]), which later developed into radios, ([9]), and mobile phones.

A	Movable-type printing press	**B**	Television	**C**	Signal fires	**D**	Paper
E	Morse telegraph	**F**	Wireless telegraph	**G**	Telephone	**H**	Phonograph
I	Gutenberg	**J**	Edison	**K**	Morse	**L**	Watson

(2) Complete the following sentences by filling in the blanks [1] and [2] with the appropriate terms.

> The internet developed from ([1]), which was created by the United States Department of Defense in 1969, into a global computer network. Initially, it was mainly used by ([2]), but by the 1990s, it began to spread widely among the general public.

Exercise

1 Answer the following questions.

(1) Choose the terms that best fit into the blanks [1] to [6] from the options **A** to **F**.

> The act of exchanging information is called ([1]). Among these, the means of sending information to a large number of people at once is referred to as ([2]). Similar to ([3]) and ([4]), ([2]) primarily facilitates one-way information transmission from sender to receiver. In contrast, ([5]) and ([6]) are information communication methods that enable two-way information exchange.

A	Communication	**B**	Mass communication	**C**	Newspapers
D	Telephone	**E**	The internet	**F**	Television

(2) **A** to **D** describe events regarding communication. Place these events in chronological order, and answer using the letters.

A The telephone was invented.
B The modern postal system was established.
C Information was conveyed by lighting signal fires or beating drums.
D Cellular phones, which are a type of mobile communication service, have become widespread.

5-2 Communication and Its Forms

Point!

Communication and Its Forms

(1) ([1]**Communication**) : The process of receiving and exchanging information between people.

(2) Classification of Communication

[1] Classification by the Number of Senders and Receivers

- ([2]**One-to-one (Individual type)**) : One sender to one receiver.
  <Examples> Letters, Telephones, etc.
- ([3]**One-to-many (Mass media type)**) : One sender to multiple recipients.
  <Examples> Newspapers, Radio, Television, Web pages, etc.
- ([4]**Many-to-one (Reverse mass media type)**) : Multiple senders to one recipient.
  <Examples> Survey tabulation, Inquiries, etc.
- ([5]**Many-to-many (Conference type)**) : Multiple senders to multiple receivers.
  <Examples> Video conferencing, Group calls, Social media, etc.

[2] Classification Based on the Location Relationship Between Sender and Receiver

- ([6]**Direct communication**) : The sender and the receiver are directly face-to-face. This method enables communication while observing the other person's reactions, but there are time and location constraints.
  <Examples> Conversations, Presentations, etc.
- ([7]**Indirect communication**) : The sender and the receiver are separated. While it is not possible to directly see the other person's reactions, it can remove time and location constraints.
  <Examples> Telephones, Email, Web pages, etc.

[3] Classification by Synchronization of Communication

- ([8]**Synchronous**) : The sender and receiver share information almost simultaneously.
  <Examples> Conversation, Telephones, Presentations, Video calls, Live television broadcasts, etc.
- ([9]**Asynchronous**) : Information is sent and received at times convenient for both the sender and the receiver.
  <Examples> Letters, Email, Electronic bulletin boards, Messaging apps, Social media, etc.

Warm Up

Choose the most suitable form of communication for each of the following methods from the options **A** to **C** below, and answer using the letters.

(1) Messaging app (2) Conversation (3) Video call

A Direct and synchronous **B** Indirect and synchronous **C** Indirect and asynchronous

Explanation

(1) **C** (2) **A** (3) **B**

Try

Answer the following questions.

(1) Choose the methods that best fit into the blanks [1] to [4] in the following table from the options **A** to **D**, and answer using the letters.

	Synchronous	Asynchronous
One-to-one (Individual type)	([1])	([2])
One-to-many (Mass media type)	([3])	([4])

A Letter **B** Telephone **C** Live television broadcast **D** Social media

(2) Choose all appropriate methods from the options **A** to **F** that match the following forms of communication, and answer using the letters.

[1] Direct and synchronous [2] Indirect and synchronous [3] Indirect and asynchronous

A Telephone **B** Email **C** Conversation
D Electronic bulletin board **E** Messaging app **F** Video call

Exercise

1 Answer the following questions.

(1) Choose the most suitable method for blanks [1] and [2] in the following text from the options **A** to **D**, and answer using the letters.

> Communication methods can be classified based on the number of senders and receivers. Communication with one sender for one receiver is called the individual type. This classification includes letters and ([1]). Communication with one sender and multiple recipients is called mass media. This classification includes newspapers, ([2]), and web pages.

A Video conferencing **B** Television **C** Telephone **D** Survey tabulation

(2) Choose the most suitable form of communication for each of the following methods from the options **A** to **C** below, and answer using the letters.

[1] Email [2] Presentation [3] Video call

A Direct and synchronous **B** Indirect and synchronous **C** Indirect and asynchronous

5-3 Internet and Communication

Point!

1 Internet Communication

(1) ([1]**Email (Electronic mail)**) : A tool for sending and receiving text-based messages over the internet. Email has the feature of ([2]**broadcast capability**) that allows the user to send messages to multiple recipients.

[1] ([3]**To**) : Input the email address(es) of the recipient(s) to whom you want to send the email.

[2] ([4]**CC**) : Input the email address(es) of the recipient(s) with whom you want to share the email content.

[3] ([5]**BCC**) : Input the email address(es) of the recipient(s) with whom you want to share the email content but do not want the other recipient(s) to see. Other recipients cannot see the email addresses or the fact that BCC is being used.

(2) ([6]**Bulletin board system (BBS)**) : A tool that allows the user to post messages and write replies to other messages.

(3) ([7]**Messaging app**) : Tools that enable the exchange of text, images, and videos. This enables easy communication for individuals or groups.
<Examples> SMS (Short Message Service), LINE, etc.

(4) ([8]**Video call**) : A tool that allows real-time conversation while viewing the other person's video via the internet.

(5) ([9]**Blog**) : A word coined by combining "web" and "log." A web service that allows you to compile and publish writings such as your diary on the internet.

(6) ([10]**Social media**) : Services providing platforms where individuals can connect with each other on the internet.

(7) ([11]**Video sharing platform**) : A service that allows a wide, unspecified audience to share and watch videos posted by other unspecified users on the internet.

2 Characteristics of Communication on the Internet

(1) ([12]**Anonymity**) : Allows a user to hide information that could lead to personal identification (name, affiliation, etc.).

- Advantages: Users can express themselves freely, regardless of age or social status.
- Disadvantages:

[1] Flaming: A situation where critical comments focus on posts on social media and other platforms.

[2] Fake news: False information that is distributed and spread on social media.

(2) ([13]**Immediacy**) : Allows a user to receive an immediate response from the other party.

(3) ([14]**Convenience**) : Allows a user to communicate smoothly.

(4) ([15]**Recordability**) : Sending and receiving information on the internet leaves a record (log).

Warm Up

(1) For each of the following, choose the most appropriate explanation regarding methods of communication on the internet from the options **A** to **D**, and answer using the letters.

[1] Bulletin board system [2] Social media [3] Video sharing platform

A A tool that allows real-time conversation while viewing the other person's video via the internet.
B Services providing platforms where individuals can connect with each other on the internet.
C A tool that allows the user to post messages and write replies to other messages.
D A service that allows a wide, unspecified audience to share and watch videos posted by other unspecified users on the internet.

(2) The following **A** to **C** are explanations of services that use the internet. Mark "○" if the statement is correct, and "×" if it is incorrect.

A Since online posts can be anonymous, it is fine for users to write whatever information they like.
B When uploading videos to a video sharing platform, there is a possibility that individuals can be identified from buildings or signs visible in the video.
C In internet communication, since records of interactions are kept, it is important to be considerate and ensure that your messages do not make the recipient feel uncomfortable.

Explanation

(1) [1] **C** [2] **B** [3] **D**

(2) **A** When posting on the internet, it is important to always consider the other person's perspective and show empathy, and to strive to share accurate information. This is because there is a possibility that your words may be misunderstood in a way that you did not intend. Therefore, ×
B ○
C ○

Try

Answer the following questions.

(1) For each of the following, choose the most appropriate explanation regarding methods of communication on the internet from the options **A** to **C**, and answer using the letters.

[1] Blog [2] Social media [3] Video call

A A tool that allows real-time conversation while viewing the other person's video via the internet.

B A service that allows you to compile and publish writings such as your diary on the internet.

C Services providing platforms where individuals can connect with each other on the internet.

(2) The following sentences describe the characteristics of communication on the internet. Choose the most suitable explanation related to the sentences from the options **A** to **D**, and answer using the letters.

[1] On electronic bulletin boards and social media, it is possible to communicate while concealing information such as one's name or affiliation.

[2] Information published on the internet cannot be completely erased.

[3] You immediately receive a response from the other party.

A Convenience **B** Recordability **C** Anonymity **D** Immediacy

Exercise

1 Answer the following questions.

(1) Complete the following sentences by filling in the blanks [1] to [3] with the appropriate terms.

> Email recipients have "To," "([1])," and "([2])," all of which have the feature of ([3]) that allows the user to send emails to multiple email addresses. However, among ([1]) and ([2]), if you do not want other recipients to see the email addresses, you need to choose ([2]).

(2) Choose the most suitable explanation for each of the following sentences from the options **A** to **F** below, and answer using the letters.

[1] A tool that allows real-time conversation while viewing the other person's video via the internet.

[2] A tool that allows you to attach and send not only text, but also photos, videos, and document files.

[3] A service that allows you to compile and publish writings such as your diary on the internet.

[4] Services providing platforms where individuals can connect with each other on the internet.

A Video sharing platform **B** Messaging app **C** Email
D Blog **E** Social media **F** Video call

(3) The following **A** to **C** are explanations of services that use the internet. Mark "○" if the statement is correct, and "×" if it is incorrect.

A A person can freely disseminate information regardless of their position.

B Electronic bulletin boards are a form of communication that is primarily text-based, so misunderstandings may occur.

C It is difficult to completely erase information once it has been published on the internet.

6-1 Analog and Digital

Point!

Analog and Digital

Analog

Digital

(1) ([1]**Analog**) : Refers to quantities that can be measured continuously and with fine precision, such as mass, time, or temperature. Data represented in analog form is referred to as ([2]**analog data**).

(2) ([3]**Digital**) : Refers to quantities that continuously change and are represented numerically by segmenting at regular intervals. Data represented in digital form is referred to as ([4]**digital data**).

(3) ([5]**A/D conversion (digitization)**) : The process of converting analog data into digital data.

(4) ([6]**D/A conversion**) : Converting digital data into analog data.

(5) Advantages of Digital Data

[1] Data can be ([7]**accumulated**) or ([8]**duplicated**) without degradation.

[2] It is easy to ([9]**modify**) and ([10]**edit**) the data.

[3] It is possible to efficiently ([11]**communicate**) the information.

[4] It is possible to ([12]**combine**) various types of media.

(6) ([13]**Binary**) : A method of representing numbers using two types of digits, 0 and 1.

- In computers, all types of information, such as numbers, characters, audio, and images, are represented in ([14]**binary**).

Warm Up

For each of the following statements **A** to **D**, answer whether the statement describes analog or digital.

A A thermometer that represents a continuous quantity using the length of a mercury column.

B Accurate and highly reproducible, without any degradation due to duplication or transmission.

C A quantity that changes continuously can be represented using the numbers 0 and 1.

D All information (numbers, text, audio, images, videos, etc.) can be represented in binary.

Explanation

A: Analog

B: Digital

C: Digital

D: Digital

Try

Answer the following questions.

(1) Choose the terms that best fit into the blanks [1] to [5] from the options **A** to **F** below.

> A quantity that is commonly found in our daily lives and changes continuously, such as time or temperature, is called ([1]). In contrast, a quantity that represents a continuously changing value by dividing it into regular intervals and expressing it numerically is called ([2]). Converting analog data to digital data is called ([3]) conversion, while the reverse is called ([4]) conversion.
>
> Furthermore, when handling characters, images, audio, video, and other data on a computer, the data is represented using two numbers, 0 and 1, which is referred to as ([5]).

A Binary **B** Decimal **C** Digital **D** Analog
E A/D **F** D/A

(2) For each of the following statements **A** to **E**, answer whether the statement describes analog or digital.

A Accumulation and duplication of information can be easily achieved.
B Temperature is measured by assessing the height of the mercury column.
C Even if some distortion occurs in the electrical signal due to noise during transmission, it can be easily corrected.
D Quantities that change continuously, such as time or temperature.
E It is possible to comprehensively handle various forms of media.

Exercise

1 Answer the following questions.

(1) What is the term for quantities that can be measured continuously and with fine precision, such as mass or time?
(2) What is the term for the process of converting digital data into analog data?
(3) What is A/D conversion? Explain briefly using the terms “digital” and “analog.”
(4) What is the term for the method of representing numbers using two types of digits (0 and 1)?

2 Choose one statement that is incorrect in regard to digital data from the options **A** to **D** below, and answer using the letter.

A Accumulation and duplication of information can be easily achieved.
B It is possible to efficiently communicate the information.
C It can express quantities that change continuously, such as time and temperature.
D It is possible to combine various types of media.

6-2 Binary and Amount of Information

Point!

1 Bits and Bytes

(1) ([1]**Bit**) : The smallest unit of information, having only two possible states: "0" and "1". One bit is capable of representing two states; for example, "a switch is on or off," "voltage is high or low," "or the orientation of a magnet is north or south."

- Actual information is represented by the arrangement of bits. In general, n bits can represent ([2]2^n) different pieces of information.

<Example> 1 bit : 2 possibilities: 0 or 1
2 bits : 4 possibilities: 00, 01, 10, 11 — $2^2 = 4$ possibilities
3 bits : 8 possibilities: 000, 001, 010, 011, 100, 101, 110, 111 — $2^3 = 8$ possibilities

(2) ([3]**Byte**) : A unit consisting of 8 bits. The notation is ([4]**B**).
1 B = ([5]**8 bits**), which can represent ([6]**256**) possibilities. — $2^8 = 256$ possibilities

(3) Unit of information : The basic unit is 1 B. The unit changes every 2^{10} = ([7]**1,024**) times.
[1] 1 ([8]**KB**) = 1,024 B
[2] 1 ([9]**MB**) = 1,024 KB
[3] 1 ([10]**GB**) = 1,024 MB
[4] 1 ([11]**TB**) = 1,024 GB

2 Decimal and Binary

(1) ([12]**Decimal**) : A method of representing numbers using ten digits from "0" to "9". A number expressed in decimal notation is denoted as ([13]**decimal**).

(2) ([14]**Binary**) : A method of representing numbers using two types of digits, "0" and "1". A number represented in binary is sometimes written with a subscript (2) placed at the bottom right of the number, such as ([15]**binary number**).

(3) Conversion between Decimal and Binary
[1] Conversion from binary to decimal
Starting from the rightmost digit, multiply each digit by 1, 2^1, 2^2, 2^3, ... in order, and then sum the results.
<Example> Convert the binary number $1011_{(2)}$ into decimal form.
$1011_{(2)} = (1 \times 2^0 + 1 \times 2^1 + 0 \times 2^2 + 1 \times 2^3) = 11$

[2] Conversion from decimal to binary
Take a decimal number and keep dividing it by 2 until the quotient becomes 1, then arrange the resulting quotients and remainders in reverse order from the left.
<Example> Represent the number "6" in decimal as a number in binary.

$2)\underline{6}$
$2)\underline{3} \cdots 0$
$1 \cdots 1$

Therefore, 6 = ([17]$110_{(2)}$)

Warm Up

Answer the following questions.

(1) [1] Complete the following sentences by filling in the blanks **A** to **E** with the appropriate terms and numbers.

> The smallest unit of information is called a bit, which corresponds to (**A**) digit in binary notation. This makes it possible to represent (**B**) different types of information. Additionally, a group of (**C**) bits is called one (**D**), and is represented as 1 B. For example, 24 bits is (**E**) B.

[2] How many bits of information are required to represent all possible outcomes when throwing a set of dice (one large and one small)?

[3] How many B is 1 MB? Answer in the form of a power of 2.

[4] How many times greater is 4 bits of information compared to 2 bits of information?

(2) [1] Express the following binary numbers in decimal form.

(A) $11010_{(2)}$ (B) $101011_{(2)}$

[2] Express the following decimal number in binary.

(A) 39 (B) 120

Explanation

(1) [1] **A:** A single digit in binary can represent two different values. 1 **B:** 2 **C:** 8
D: Byte **E:** Since 8 bits = 1 B, 24 bits ÷ 8 = 3 B

[2] When you roll two dice (one large and one small), there are 6 × 6 = 36 possible combinations of outcomes.
With 5 bits, you can represent $2^5 = 32$ combinations,
and with 6 bits, you can represent $2^6 = 64$ combinations,
so the needed information is 6 bits

With n bits, it is possible to represent 2^n different pieces of information.

[3] 1 MB = 1,024 KB, and 1 KB = 1,024 B,
therefore, 1 MB = 1,024 KB = 1,024 × 1,024 B = $2^{10} \times 2^{10}$ B = 2^{20} B

[4] The amount of information that can be represented with 2 bits is $2^2 = 4$ possibilities, and the amount of information that can be represented with 4 bits is $2^4 = 16$ possibilities. Therefore, 16 ÷ 4 = 4 times

(2) [1] (A) $11010_{(2)} = 0 \times 1 + 1 \times 2^1 + 0 \times 2^2 + 1 \times 2^3 + 1 \times 2^4$
$= 0 + 2 + 0 + 8 + 16 = 26$
(B) $101011_{(2)} = 1 \times 1 + 1 \times 2^1 + 0 \times 2^2 + 1 \times 2^3 + 0 \times 2^4 + 1 \times 2^5$
$= 1 + 2 + 0 + 8 + 0 + 32 = 43$

[2] (A)
2) 39
2) 19 ⋯1
2) 9 ⋯1
2) 4 ⋯1
2) 2 ⋯0
1 ⋯0

Therefore, $100111_{(2)}$

Add (2) to the bottom right

(B)
2) 120
2) 60 ⋯0
2) 30 ⋯0
2) 15 ⋯0
2) 7 ⋯1
2) 3 ⋯1
1 ⋯1

Therefore, $1111000_{(2)}$

Try

1 Answer the following questions.

(1) Complete the following sentences by filling in the blanks [1] to [3] with the appropriate terms and numbers.

> The numbers we use in our daily lives are expressed in (　[1]　), using digits from 0 to 9. There is also (　[2]　) using the digits 0 and 1, and the information handled by computers primarily utilizes ([2]). However, because this unit is too small and difficult to understand, one byte, which consists of (　[3]　) bits, is often used to represent information.

(2) How many bits are in 5 bytes?

(3) How many different pieces of information can be represented by 1 byte?

(4) How many times is the amount of information in 5 bits compared to the amount of information in 3 bits?

(5) How many MB are in 1 GB? Also, how many B is it? Answer in the form of a power of 2.

(6) How many bits of information are needed to represent the four seasons of spring, summer, autumn, and winter?

(7) How many bits of information are needed to represent a deck of 52 playing cards, excluding the jokers?

(8) How many bits of information are needed to record all possible outcomes when tossing a coin three times?

2 Answer the following questions.

(1) Express the following binary numbers in decimal form.

[1] $110_{(2)}$　　[2] $10100_{(2)}$　　[3] $111001_{(2)}$

(2) Express the following decimal number in binary.

[1] 65　　[2] 106　　[3] 143

♪ **3** How many 4.7 GB DVDs worth of data can be stored on a 1 TB hard disk? Round your answer to the nearest whole number.

Exercise

1 Answer the following questions.

(1) Choose the number or equation that best fit into the blanks [1] to [6] from the options **A** to **J**.

> The amount of information that can be represented by 1 bit is ([1]) possibilities. Additionally, since 1 byte consists of ([2]) bits, the amount of information that can be represented by 1 byte is ([3]) possibilities. For example, 32 bits equal ([4]) bytes. Additionally, 1 KB is expressed as ([5]) B. To calculate how many bits are in 24 KB, you need to calculate the expression ([6]).

A 1	**B** 2	**C** 4	**D** 8
E 256	**F** 1,024	**G** 24 × 1,024	**H** 1,024 ÷ 24
I 24 × 1,024 × 8	**J** 24 × 1,024 ÷ 8		

(2) Choose one option that represents the correct order of the amount of information from the options **A** to **D** below.

A 1 KB < 1 MB < 1 GB < 1 TB
B 1 KB < 1 MB < 1 TB < 1 GB
C 1 TB < 1 KB < 1 MB < 1 GB
D 1 KB < 1 TB < 1 MB < 1 GB

(3) How many different combinations of designs can be created using one 100 yen coin, one 50 yen coin, and one 10 yen coin? Also, how many bits of information does this represent?

(4) How many bits of information are needed to represent 16 directions?

(5) What is the minimum number of bits needed to represent the 47 prefectures?

2 Answer the following questions.

(1) Express the following binary numbers in decimal form.

[1] $101_{(2)}$ [2] $10101_{(2)}$ [3] $101101_{(2)}$

(2) Express the following decimal number in binary.

[1] 13 [2] 128 [3] 138

3 How many photos, each with a size of 2 MB, can be stored on a 32 GB USB flash drive?

6-3 Hexadecimal

Point!

Hexadecimal

(1) ([1]**Hexadecimal**) : A method of representing numbers using the digits 0 to 9 and the alphabet letters A to F. A number represented in hexadecimal is sometimes written with a subscript (16) placed at the bottom right of the number. This is known as a ([2]**hexadecimal number**).

(2) Correspondence Between Decimal, Binary, and Hexadecimal

Decimal	Binary	Hexadecimal
0	0000	0
1	0001	1
2	0010	2
3	0011	3
4	0100	4
5	0101	5
6	0110	6
7	0111	7
8	1000	8

Decimal	Binary	Hexadecimal
9	1001	9
10	1010	([3]**A**)
11	1011	([4]**B**)
12	1100	([5]**C**)
13	1101	([6]**D**)
14	1110	([7]**E**)
15	1111	([8]**F**)
16	10000	([9]**10**)

(3) Conversion between Decimal, Binary, and Hexadecimal

[1] Conversion from binary to hexadecimal

Separate the binary number into groups of 4 digits starting from the least significant bit, convert each group into a hexadecimal value, and arrange these values in sequence.

<Example> Convert the binary number $10011010_{(2)}$ to a hexadecimal number.

Separate into groups of 4 digits starting from the least significant bit: $1001/1010_{(2)}$

$1001_{(2)}$ is $(9_{(16)})$, $1010_{(2)}$ is $(A_{(16)})$, so $10011010_{(2)} = (9A_{(16)})$

[2] Conversion from hexadecimal to binary

Convert each digit of the hexadecimal number into a 4-bit binary number, and arrange those numbers sequentially.

<Example> Express hexadecimal $A4_{(16)}$ in binary.

$A_{(16)}$ is $(1010_{(2)})$, $4_{(16)}$ is $(0100_{(2)})$, so $A4_{(16)} = (10100100_{(2)})$

[3] Conversion from hexadecimal to decimal

Convert the hexadecimal number to a binary number, and then convert that binary number to a decimal number.

<Example> Express the hexadecimal $C6_{(16)}$ in decimal format.

First, to convert the hexadecimal $C6_{(16)}$ to binary, $C_{(16)}$ is $(1100_{(2)})$,

$6_{(16)}$ is $(0110_{(2)})$, so $C6_{(16)} = (11000110_{(2)})$

Next, to convert the binary number $11000110_{(2)}$ into a decimal number,

$11000110_{(2)} = (0 \times 1 + 1 \times 2^1 + 1 \times 2^2 + 0 \times 2^3 + 0 \times 2^4 + 0 \times 2^5 + 1 \times 2^6 + 1 \times 2^7)$

$= 198$

Warm Up

Answer the following questions.

(1) Convert the following binary numbers to hexadecimal, and the hexadecimal numbers to binary.

[1] $11011011_{(2)}$ [2] $11110110_{(2)}$ [3] $9E_{(16)}$

(2) Convert the following hexadecimal numbers to decimal.

[1] $A5_{(16)}$

Explanation

(1) [1] Separate the binary number into groups of four digits starting from the least significant bit, then convert each group into a hexadecimal number and list them sequentially.
$1101_{(2)}$ is $D_{(16)}$, $1011_{(2)}$ is $B_{(16)}$, so $11011011_{(2)} = \underline{DB_{(16)}}$

[2] $1111^{(2)}$ is $F_{(16)}$, $0110_{(2)}$ is $6_{(16)}$, so $11110110_{(2)} = \underline{F6_{(16)}}$

[3] Convert each digit into a 4-bit binary number and list them sequentially.
$9_{(16)}$ is $1001_{(2)}$, $E_{(16)}$ is $1110_{(2)}$, so $9E_{(16)} = \underline{10011110_{(2)}}$

(2) Convert from hexadecimal to binary, and then to decimal.

[1] $A_{(16)}$ is $1010_{(2)}$, $5_{(16)}$ is $0101_{(2)}$, so $A5_{(16)} = 10100101_{(2)}$
Therefore, $10100101_{(2)} = 1 \times 1 + 0 \times 2^1 + 1 \times 2^2 + 0 \times 2^3 + 0 \times 2^4 + 1 \times 2^5 + 0 \times 2^6 + 1 \times 2^7 = \underline{165}$

Try

Answer the following questions.

(1) Convert the following binary numbers to hexadecimal, and the hexadecimal numbers to binary.

[1] $11010101_{(2)}$ [2] $01110110_{(2)}$ [3] $C5_{(16)}$ [4] $BB_{(16)}$

(2) Convert the following hexadecimal numbers to decimal.

[1] $31_{(16)}$ [2] $C7_{(16)}$ [3] $9F_{(16)}$ [4] $AB_{(16)}$

Exercise

1 Answer the following questions.

(1) Convert the following binary numbers to hexadecimal, and the hexadecimal numbers to binary.

[1] $01010011_{(2)}$ [2] $01101100_{(2)}$ [3] $10100111_{(2)}$ [4] $11001001_{(2)}$
[5] $2B_{(16)}$ [6] $F1_{(16)}$ [7] $EE_{(16)}$ [8] $DB_{(16)}$

(2) Convert the following hexadecimal numbers to decimal.

[1] $17_{(16)}$ [2] $C2_{(16)}$ [3] $3D_{(16)}$ [4] $AF_{(16)}$

6-4 Digital Representation of Characters

Point!

Digital Representation of Characters

(1) ([1]**Character code**) : A unique numerical value assigned to each character, symbol, etc.

(2) ([2]**Character code system**) : Summarizes the correspondence between characters and their respective character codes.

[1] ([3]**ASCII code**) : Only alphanumeric characters, symbols, and control characters (symbols used to control the computer). No Japanese characters (*kanji*, *hiragana*, or *katakana*).

		Most Significant 4 Bits								
		Binary	0000	0001	0010	0011	0100	0101	0110	0111
Least Significant 4 Bits	Binary	Hexadecimal	0	1	2	3	4	5	6	7
	0000	0	Symbols for Controlling Computers (Omission)		SP	0	@	P	`	p
	0001	1			!	1	A	Q	a	q
	0010	2			”	2	B	R	b	r
	0011	3			#	3	C	S	c	s
	0100	4			$	4	D	T	d	t
	0101	5			%	5	E	U	e	u
	0110	6			&	6	F	V	f	v
	0111	7			'	7	G	W	g	w
	1000	8			(	8	H	X	h	x
	1001	9			)	9	I	Y	i	y
	1010	A			*	:	J	Z	j	z
	1011	B			+	;	K	[	k	{
	1100	C			,	<	L	¥	l	|
	1101	D			-	=	M	]	m	}
	1110	E			.	>	N	^	n	~
	1111	F			/	?	O	_	o	DEL

<Example> Convert the string “Hello” into a binary character code and a hexadecimal character code. Combine the most significant 4 bits and the least significant 4 bits.

String	H	e	l	l	o
Character code (binary)	01001000	01100101	01101100	01101100	01101111
Character Code (hexadecimal)	48	65	6C	6C	6F

[2] ([7]**Unicode**) : A character code standard that consolidates characters from around the world into a single character code. Due to differences in code assignments, there are variations such as UTF-8 and UTF-16.

(3) ([8]**Encoding**) : Representing a string with character codes. The opposite is known as ([9]**decoding**).

(4) ([10]**Character corruption**) : A phenomenon that occurs due to mismatched encoding and decoding methods.

(5) ([11]**Font**) : The shape data of characters corresponding to character codes.
<Examples> Sans-serif, Serif, Semi-cursive, etc.

- To display characters on a computer screen or printer output, two elements are required: ([12]**character code**) and ([13]**font**).

Warm Up

Answer the following questions.

(1) Choose the numbers or terms that best fit into the blanks [1] to [5] from the options **A** to **H** below.

> Characters and symbols can also be represented by combinations of 0s and 1s. A system that maps characters and symbols to binary or hexadecimal is called a ([1]). There are several types within the ([1]), including ([2]), which accommodates the writing systems of countries around the world.
>
> Alphanumeric characters and symbols are represented by ([3]) byte, 1 byte can represent ([4]) types of characters.

A 1	**B** 2	**C** 128	**D** 256
E Character code	**F** Character corruption	**G** Unicode	**H** ASCII code

(2) Use the character code table on the right to answer the following questions.

[1] Use binary to represent the character code for "M".

[2] Use hexadecimal to represent the character code for "MILK".

[3] What is the character string corresponding to the character code "$4C6F7665_{(16)}$"?

		Most Significant 4 Bits							
		Binary	0000	0001	0010	0011	0100	0101	0110	0111
Least Significant 4 Bits	Binary	Hexadecimal	0	1	2	3	4	5	6	7
	0000	0	Symbols for Controlling Computers (Omission)		SP	0	@	P	`	p
	0001	1			!	1	A	Q	a	q
	0010	2			"	2	B	R	b	r
	0011	3			#	3	C	S	c	s
	0100	4			$	4	D	T	d	t
	0101	5			%	5	E	U	e	u
	0110	6			&	6	F	V	f	v
	0111	7			'	7	G	W	g	w
	1000	8			(	8	H	X	h	x
	1001	9			)	9	I	Y	i	y
	1010	A			*	:	J	Z	j	z
	1011	B			+	;	K	[	k	{
	1100	C			,	<	L	¥	l	|
	1101	D			-	=	M	]	m	}
	1110	E			.	>	N	^	n	~
	1111	F			/	?	O	_	o	DEL

Explanation

(1) [1] **E** [2] **G** [3] **A** [4] **B** [5] **D**

(2) [1] From the character code table, the most significant 4 bits of "M" are 0100 and the least significant 4 bits are 1101; therefore, $\underline{01001101_{(2)}}$

[2] According to the character code table, the character codes corresponding to "M, I, L, K" are 4D, 49, 4C, and 4B, respectively, in the order of most significant to least significant. Connecting these character codes results in $\underline{4D494C4B_{(16)}}$

[3] Consider the character code as separated into "4C/6F/76/65".
"4C" corresponds to the character "L" because it is located at the intersection of the most significant 4 and the least significant C.
Similarly, "6F" corresponds to "o", "76" to "v", and "65" is "e", so the resulting character string is Love

Try

1 Answer the following questions.

(1) Complete the following sentences by filling in the blanks [1] to [4] with the appropriate terms and numbers.

> The rule for how characters and symbols are represented in binary or hexadecimal is called a (　[1]　). Alphanumeric characters and symbols are represented by (　[2]　) byte. In principle, 1 byte can represent (　[4]　) types of characters, and 2 bytes can represent 65,536 types of characters.

(2) Briefly explain the characteristics of the character code system Unicode.

(3) Use the character code table below to answer the following questions.

		Most Significant 4 Bits								
		Binary	0000	0001	0010	0011	0100	0101	0110	0111
Least Significant 4 Bits	Binary	Hexadecimal	0	1	2	3	4	5	6	7
	0000	0	Symbols for Controlling Computers (Omission)		SP	0	@	P	`	p
	0001	1			!	1	A	Q	a	q
	0010	2			”	2	B	R	b	r
	0011	3			#	3	C	S	c	s
	0100	4			$	4	D	T	d	t
	0101	5			%	5	E	U	e	u
	0110	6			&	6	F	V	f	v
	0111	7			'	7	G	W	g	w
	1000	8			(	8	H	X	h	x
	1001	9			)	9	I	Y	i	y
	1010	A			*	:	J	Z	j	z
	1011	B			+	;	K	[	k	{
	1100	C			,	<	L	¥	l	|
	1101	D			-	=	M	]	m	}
	1110	E			.	>	N	^	n	~
	1111	F			/	?	O	_	o	DEL

[1] What is the character code for “a” in binary?

[2] What is the symbol corresponding to the character code “$00111110_{(2)}$”?

[3] What is the symbol corresponding to the character code “$5C_{(16)}$”?

[4] What is the character string corresponding to the character code “$486172696E657A756D69_{(16)}$”?

(4) Calculate the following data size.

[1] The data size when “Welcome” is entered.

(5) Choose the shape data of characters corresponding to character codes from the options **A** to **C** below.

A Font　　**B** Environment-dependent characters　　**C** *Emoji*

Exercise

1 Answer the following questions.

(1) Answer the following questions.

[1] What is the term for a unique numerical value assigned to each character, symbol, etc.?

[2] How many types of characters can be represented with 1 byte?

[3] What is the term for representing a string with character codes?

[4] What is the term for a design that corresponds to a character code and shares the same characteristics?

(2) Briefly explain the characteristics of the character code system ASCII.

(3) Use the character code table below to answer the following questions.

		Most Significant 4 Bits								
		Binary	0000	0001	0010	0011	0100	0101	0110	0111
Least Significant 4 Bits	Binary	Hexadecimal	0	1	2	3	4	5	6	7
	0000	0	Symbols for Controlling Computers (Omission)		SP	0	@	P	`	p
	0001	1			!	1	A	Q	a	q
	0010	2			”	2	B	R	b	r
	0011	3			#	3	C	S	c	s
	0100	4			$	4	D	T	d	t
	0101	5			%	5	E	U	e	u
	0110	6			&	6	F	V	f	v
	0111	7			'	7	G	W	g	w
	1000	8			(	8	H	X	h	x
	1001	9			)	9	I	Y	i	y
	1010	A			*	:	J	Z	j	z
	1011	B			+	;	K	[	k	{
	1100	C			,	<	L	¥	l	|
	1101	D			-	=	M	]	m	}
	1110	E			.	>	N	^	n	~
	1111	F			/	?	O	_	o	DEL

[1] What is the character code for “Y” in binary?

[2] What is the character corresponding to the character code “$01101111_{(2)}$”?

[3] What is the character corresponding to the character code “$72_{(16)}$”?

[4] What is the character string corresponding to the character code “$5468616E6B596F7521_{(16)}$”?

(4) Calculate the following data size.

[1] The data size when “HappyBirthday” is entered

6-5 Numerical Calculations [1]

Point!

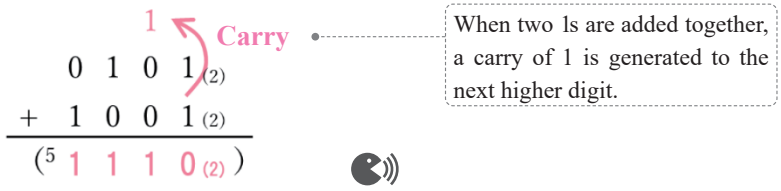
Addition and Subtraction of Binary Numbers

Addition and subtraction in binary numbers are performed digit by digit, just like in decimal numbers.

(1) Binary addition : In binary addition, the place value carries over by one position when the sum reaches 2.

$0_{(2)} + 0_{(2)} = ({}^{1}0_{(2)})$, $0_{(2)} + 1_{(2)} = ({}^{2}1_{(2)})$, $1_{(2)} + 1_{(2)} = ({}^{3}10_{(2)})$, $1_{(2)} + 1_{(2)} + 1_{(2)} = ({}^{4}11_{(2)})$

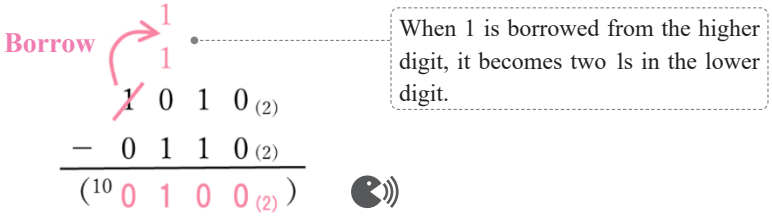
<Example> Addition of binary numbers $0101_{(2)} + 1001_{(2)}$



(2) Binary subtraction : In binary subtraction, when the minuend is insufficient, a value of 2 is borrowed from the next higher digit.

$0_{(2)} - 0_{(2)} = ({}^{6}0_{(2)})$, $1_{(2)} - 0_{(2)} = ({}^{7}1_{(2)})$, $1_{(2)} - 1_{(2)} = ({}^{8}0_{(2)})$, $10_{(2)} - 1_{(2)} = ({}^{9}1_{(2)})$

<Example> Subtraction of binary numbers $1010_{(2)}$ - $0110_{(2)}$



Warm Up

Perform the following binary calculations.

(1) $0101_{(2)} + 1010_{(2)}$

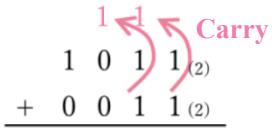
(2) $1011_{(2)} + 0011_{(2)}$

(3) $1011_{(2)} - 0101_{(2)}$

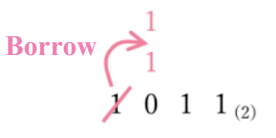
(4) $1101_{(2)} - 1010_{(2)}$

Explanation

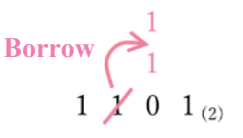
(1)
$$\begin{array}{r} 0\ 1\ 0\ 1_{(2)} \\ +\ 1\ 0\ 1\ 0_{(2)} \\ \hline 1\ 1\ 1\ 1_{(2)} \end{array}$$
Therefore, $\underline{1111_{(2)}}$

(2)


Therefore, $\underline{1110_{(2)}}$

(3)


Therefore, $\underline{0110_{(2)}}$

(4)


Therefore, $\underline{0011_{(2)}}$

Try

Perform the following binary calculations.

(1) $0101_{(2)} + 0110_{(2)}$

(2) $1101_{(2)} + 0010_{(2)}$

(3) $1101_{(2)} - 0010_{(2)}$

(4) $1010_{(2)} - 0101_{(2)}$

Exercise

1 Perform the following binary calculations.

(1) $0011_{(2)} + 1100_{(2)}$

(2) $1001_{(2)} + 0101_{(2)}$

(3) $0111_{(2)} + 0001_{(2)}$

(4) $1010_{(2)} + 0101_{(2)}$

(5) $1101_{(2)} - 1100_{(2)}$

(6) $1011_{(2)} - 0110_{(2)}$

(7) $1001_{(2)} - 0110_{(2)}$

(8) $1010_{(2)} - 1010_{(2)}$

6-6 Numerical Calculations [2]

Point!

1 Representation of Negative Numbers Using Complements

([1]**Complement**) : The smallest number which, when added to a given natural number, produces a carry to the next higher digit. Complements are used for representing negative numbers in computers.

[1] ([2]**10's complement**) : In decimal, the smallest number which, when added, produces a carry to the next higher digit.

<Examples> The 10's complement of 71 is ([3]**29**), and the 10's complement of 635 is ([4]**365**).

[2] ([5]**2's complement**) : In binary, the smallest number which, when added, produces a carry to the next higher digit.

<How to calculate the 2's complement>

For each digit of the original binary number, invert 0s to 1s and 1s to 0s, then add 1 at the end to mechanically obtain the result.

<Example> The 2's complement of $0101_{(2)}$

By inverting each digit from 0 to 1 and from 1 to 0, it becomes ([6]**$1010_{(2)}$**). Finally, by adding 1, it becomes ([7]**$1011_{(2)}$**).

2 Subtraction Using Complements

A computer uses subtraction by performing addition with complements.

<Subtraction process>

1) Find the ([8]**complement**) of the subtrahend.

2) Use the complement to perform ([9]**addition**).

3) Ignore the leading digits of the calculation result and provide the answer.

<Example 1>

Subtraction of "8 − 6" in decimal

1) The 10's complement of the decimal number 6 is ([10]**4**)

2) 8 − 6 ⇒ 8 ([11]+ 4)
= ([12]**12**)

3) Ignoring the leading digit, ([13]2)

<Example 2>

Subtraction of "$1000_{(2)}$ − $0111_{(2)}$" in binary

1) The 2's complement of the binary number $0111_{(2)}$ is ([14]$1001_{(2)}$)

2) $1000_{(2)}$ − $0111_{(2)}$ ⇒ $1000_{(2)}$ ([15]+ $1001_{(2)}$)
= ([16]$10001_{(2)}$)

3) Ignoring the leading digit, ([17]$0001_{(2)}$)

Warm Up

Answer the following questions.

(1) What is the complement of the following binary number?

[1] $1001_{(2)}$ [2] $0100_{(2)}$

(2) Use complements to perform the following binary subtractions.

[1] $1100_{(2)} - 0111_{(2)}$ [2] $1110_{(2)} - 1001_{(2)}$

Explanation

(1) [1] By inverting each digit from 0 to 1 and from 1 to 0, it becomes $0110_{(2)}$.
Finally, by adding 1, it becomes $\underline{0111}_{(2)}$.

[2] By inverting each digit from 0 to 1 and from 1 to 0, it becomes $1011_{(2)}$.
Finally, by adding 1, it becomes $\underline{1100}_{(2)}$. Adding 1 causes a place value to carry over.

(2) [1] The complement of the binary number $0111_{(2)}$ is $1001_{(2)}$, so
$1100_{(2)} - 0111_{(2)} \Rightarrow 1100_{(2)} + 1001_{(2)} = 10101_{(2)}$
By ignoring the leading digit, $\underline{0101}_{(2)}$

[2] The complement of the binary number $1001_{(2)}$ is $0111_{(2)}$, therefore,
$1110_{(2)} - 1001_{(2)} \Rightarrow 1110_{(2)} + 0111_{(2)} = 10101_{(2)}$
By ignoring the leading digit, $\underline{0101}_{(2)}$

Try

Answer the following questions.

(1) What is the complement of the following binary number?

[1] $0101_{(2)}$ [2] $1101_{(2)}$ [3] $10110001_{(2)}$ [4] $01001100_{(2)}$

(2) Use complements to perform the following binary subtractions.

[1] $1101_{(2)} - 0110_{(2)}$ [2] $1010_{(2)} - 0111_{(2)}$ [3] $1101_{(2)} - 1010_{(2)}$

Exercise

1 Answer the following questions.

(1) What is the complement of the following binary number?

[1] $0111_{(2)}$ [2] $1011_{(2)}$ [3] $10011011_{(2)}$ [4] $11000110_{(2)}$

(2) Use complements to perform the following binary subtractions.

[1] $1010_{(2)} - 0110_{(2)}$ [2] $1011_{(2)} - 1001_{(2)}$ [3] $1100_{(2)} - 0010_{(2)}$

6-7 Digitalization of Sound

Point!

1 Sound

(1) Sound : A phenomenon transmitted through the vibration of air. Waveform ([1]**analog**) data.
- For audio data on CDs, etc., sound is converted into ([2]**digital**) data.

(2) ([3]**Frequency**) : The number of waves contained in one second.
The unit is ([4]**hertz**) [Symbol: ([5]**Hz**)].

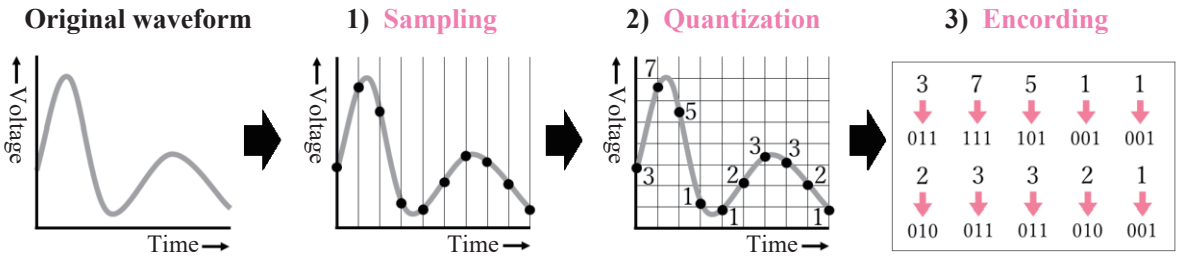
(3) ([6]**Period**) : The time it takes for one wave to propagate. The unit is ([7]**seconds**).

2 Digitalization of Sound

(1) ([8]**Pulse Code Modulation (PCM) method**) : A method for digitizing audio analog data.
Convert sound information into binary code.

<Steps for digitizing sound using the PCM method>

1) ([9]**Sampling**) : The horizontal axis (time) is divided at regular intervals, and the wave height (voltage strength) is extracted. The extracted points are referred to as ([10]**sample points**).
   - ([11]**Sampling period**) : The time interval used to divide when sampling.
   - ([12]**Sampling frequency**) : The number of samples taken per second.
2) ([13]**Quantization**) : The vertical axis (voltage) is divided at regular intervals, and the wave heights obtained from sampling are converted to the nearest values on the vertical scale.
   - ([14]**Quantization bit depth**) : This determines the number of levels into which the range is divided during quantization.
3) ([15]**Encoding**) : Express the quantized values in binary form.



(2) Digitization and Data Volume
As the sampling frequency and the quantization bit depth ([16]**increase**), the sound becomes closer to the original analog waveform. This causes the sound quality to ([17]**improve**); however, the amount of data also ([18]**increases**).

(3) ([19]**Sampling theorem**) : If the sampling frequency exceeds ([20]**twice**) the highest frequency contained in the original analog waveform, the waveform of the original analog signal can be accurately reconstructed from the digitized data.

3 Amount of Sound Data

(1) Channels : The number of signals used when transmitting sound. A method of playback using a single signal is called ([21]**monaural**), and a method of playback using two different signals is called ([22]**stereo**).

(2) How to Calculate the Amount of Audio Data
Data amount [bits] per second = ([23]**Sampling frequency × Quantization bit depth × Number of channels**)

Warm Up

Answer the following questions.

(1) Choose the one appropriate procedure for digitizing an analog sound signal from the options **A** to **D**.

A Sampling → Quantization → Encoding
B Encoding → Quantization → Sampling
C Quantization → Sampling → Encoding
D Quantization → Encoding → Sampling

(2) Calculate the data amount for 1 second in kilobytes (KB) when digitizing music at a sampling frequency of 44,100 Hz, a quantization bit depth of 16 bits, and in 2-channel stereo. However, assume that 1 KB = 1,000 B, and round off to the nearest whole number.

(3) Calculate the data amount for 1 minute in megabytes (MB) when digitizing music at a sampling frequency of 44.1 kHz, a quantization bit depth of 24 bits, and in 2-channel stereo. However, assume that 1 KB = 1,000 B, and 1 MB = 1,000 KB, and round off to the nearest whole number.

Explanation

(1) **A**

(2) Data amount [bits] per second = Sampling frequency × Quantization bit depth × Number of channels
Therefore, the amount of data per second is 44,100 [Hz] × 16 [bits] × 2 [channels] = 1,411,200 [bits].
Since 1 B = 8 bits, 1,411,200 [bits] ÷ 8 = 176,400 [B]
1 KB = 1,000 B, so 176,400 [B] ÷ 1,000 = 176.4 ≈ 176 [KB] 176 KB

(3) 44.1 kHz = 44.1 × 1,000 = 44,100 Hz, and since 2 minutes = 120 seconds, the data amount per minute is 44,100 [Hz] × 24 [bits] × 2 [channels] × 60 [seconds] = 127,008,000 [bits]
Since 1 B = 8 bits, 127,008,000 [bits] ÷ 8 = 15,876,000 [B].
1 KB = 1,000 B, 1 GB = 1,000 MB, therefore,
15,876,000 [B] ÷ 1,000 ÷ 1,000 = 15.876 [MB] ≈ 16 [MB] 16 MB

Try

1 Answer the following questions.

(1) Choose the term that best fits into the blanks [1] to [10] in the following sentences from the options **A** to **M** below, and answer using the letters.

> Sound is a phenomenon that is transmitted through the vibrations of air. The number of waves contained in one second is called ([1]) and is expressed in units of ([2]). The time it takes for one wave to propagate is called the ([3]), and it is expressed in seconds. These vibrations are ([4]) data. In contrast, sound information stored on DVDs, CDs, etc. is ([5]) data. Next, follow these steps to convert the data from ([4]) to ([5]).
>
> First, the process of dividing sound waves at regular time intervals and extracting the amplitude values (voltage) for each interval is called ([6]). Next, divide the vertical axis (voltage) at regular intervals and determine the step values. This is called ([7]), and the component that determines the quantization levels is called ([8]). Typically, with n bits, there are 2^n levels. Finally, ([9]) refers to the representation of values obtained through ([7]) in binary form. The method of converting information such as sound into binary codes by replacing numerical values in binary with two different voltage levels (high and low) is called the ([10]) method.

A	Encoding	**B**	Sampling	**C**	Quantization	**D**	Frequency	**E**	Period
F	Analog	**G**	Digital	**H**	Sampling period	**I**	Quantization bit depth		
J	PCM	**K**	MIDI	**L**	Hertz	**M**	Second		

(2) Choose the one that enables waveform restoration closest to the original analog signal when digitizing an analog audio signal from the options **A** to **D**.

A Increase the sampling frequency and increase the quantization bit depth.
B Increase the sampling frequency and decrease the quantization bit depth.
C Decrease the sampling frequency and increase the quantization bit depth.
D Decrease the sampling frequency and decrease the quantization bit depth.

2 Answer the following questions. In these questions, assume that 1 KB = 1,000 B, and 1 MB = 1,000 KB.

(1) What is the data amount for 1 second in kilobytes (KB) when digitizing music at a sampling frequency of 44,100 Hz, a quantization bit depth of 16 bits, and in 1-channel monaural? Round off to the nearest whole number in your answer.

(2) What is the data amount for 1 minute in KB when digitizing music at a sampling frequency of 192 kHz, a quantization bit depth of 24 bits, and in 2-channel stereo?

(3) What is the data amount for 3 minutes in MB when digitizing music at a sampling frequency of 44.1 kHz, a quantization bit depth of 16 bits, and in 2-channel stereo? If the length of one song is 3 minutes, approximately how many songs can be stored on a 650 MB CD? Round off to the nearest whole number in your answer.

Exercise

1 Answer the following questions.

(1) Choose the term that best fits into the blanks [1] to [6] in the following sentences from the options **A** to **I** below, and answer using the letters.

> Sound is analog data in waveforms that are transmitted through the vibration of air. The process of capturing sound waveforms on a computer begins with segmenting the waveforms at regular time intervals. This process is called ([1]). The number of partitions per second is called the ([1]) frequency. Next, convert and approximate the segmented wave heights into a continuous bar graph. This process is called ([2]). At this time, the value indicating how many levels the numbers are expressed in is called ([3]). Finally, perform ([4]), which uses 0s and 1s to express the value in binary after ([2]). This method of converting sound into digital data is called ([5]).
>
> In the case of digitizing sound, digital data converted from analog data will approximate the original waveform more closely if the ([1]) frequency is higher. Furthermore, the greater the ([3]), the more accurately the waveform can be represented numerically. However, as a result, the amount of data becomes ([6]).

A Encoding	**B** Sampling	**C** Quantization	**D** Larger	**E** Smaller
F Sampling period	**G** Quantization bit depth	**H** PCM method	**I** MIDI format	

(2) The following statements **A** to **D** are about the sampling frequency and the number of quantization levels. Mark "○" if the statement is correct, and "×" if it is incorrect.

A Sampling frequency refers to the number of times sampling occurs in one second.

B The greater the number of levels during quantization, the larger the amount of data becomes.

C If you want to approximate the original analog waveform more closely, it is effective to increase the sampling frequency and reduce the number of levels during quantization.

D If the maximum frequency of the original analog waveform is 40 Hz, you should digitize it with a sampling frequency greater than 80 Hz.

2 Answer the following questions. In these questions, assume that 1 KB = 1,000 B, and 1 MB = 1,000 KB.

(1) What is the data amount for 10 seconds in kilobytes (KB) when digitizing music at a sampling frequency of 44,100 Hz, a quantization bit depth of 16 bits, and in 1-channel monaural?

(2) What is the data amount for 1 minute in MB when digitizing music at a sampling frequency of 96 kHz, a quantization bit depth of 24 bits, and in 2-channel stereo? Round off to the nearest whole number in your answer.

6-8 Digitization of Images

Point!

1 Digitization of Images

(1) ([1]**Pixel**) : The smallest unit that composes an image.
A digital image is represented by an arrangement of pixels.

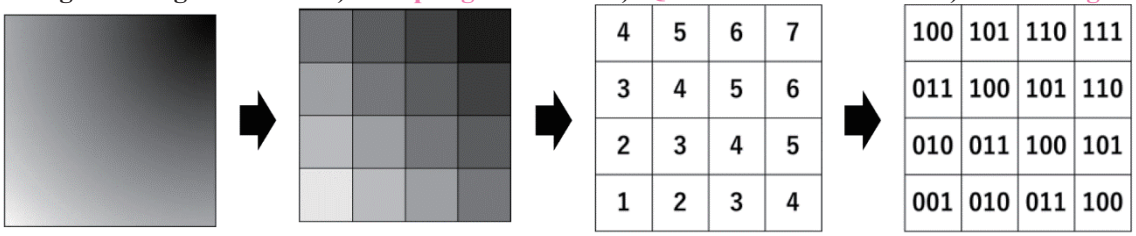
(2) Procedure for Digitization of Images
Images captured by digital cameras or image scanners are digitized and imported into a computer through the following process.

1) ([2]**Sampling**) : The image is divided into pixels, and the representative brightness is extracted.
- ([3]**Resolution**) : The degree of fineness of pixels when sampling.
The unit of resolution is ([4]**dpi**).
It is sometimes expressed as vertical pixels × horizontal pixels.

2) ([5]**Quantization**) : Converts the brightness of each pixel into numerical values divided into several levels.
- ([6]**Gradation**) : The level value that represents the intensity of color per pixel. The gradation is determined by the number of bits allocated to each pixel.
<Example> At 256 gradients (8 bits), it represents 256 levels from 0 to 255.

3) ([7] **Encoding**) : Expressing quantized values in binary numbers (0 and 1).

Original Image → **1) Sampling** → **2) Quantization** → **3) Encording**



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

100	101	110	111
011	100	101	110
010	011	100	101
001	010	011	100

(3) Digitization and Data Volume
[1] Data amount of an image [bits]
= ([8] **Number of pixels [vertical pixels × horizontal pixels) × Number of bits for color information**)
[2] The ([9]**higher**) the values of resolution and gradation, the smoother the image obtained and the image quality ([10]**improves**), but the amount of data ([11]**increases**).

(4) Raster Format and Vector Format
[1] ([12]**Raster format**) : An arrangement of pixels used to represent text or shapes. It appears jagged when enlarged (this appearance is called ([13]**jaggies**)).
Images are drawn using ([14]**painting software**).
[2] ([15]**Vector format**) : A representation that includes information about coordinates of points composing the image, as well as the angles and thickness of the lines connecting them. Images are drawn using ([16]**drawing software**).

2 Color Representation

(1) ([17]**Three primary colors of light**) : The three colors of red, green, and blue. When these colors of light are mixed, the brightness increases and approaches ([18]**white**).

(2) ([19]**Three primary colors of pigment**) : The three colors of cyan, magenta, and yellow. Mixing these colors will darken them and bring them closer to ([20]**black**).

(3) ([21]**Additive color mixing**) : A method of representing colors by combining the three primary colors of light. Used in televisions and computer displays.

(4) ([22]**Subtractive color mixing**) : A method of representing colors by combining the three primary colors of pigment. Used in color printers.

(5) ([23]**24-bit full color**) : Each color of red, green, and blue is represented in 256 levels (2^8 = 8 bits) × 3 = 24 bits.

Warm Up

Answer the following questions.

(1) Rearrange the following steps **A** to **C** in the order of converting an image into digital data.
- **A** Replace the brightness levels of each region with integer values according to a fixed rule.
- **B** Divide the image into evenly spaced grid sections.
- **C** Represent integers in binary.

(2) Choose all statements that correctly describe the digital representation of images from the options **A** to **D**, and answer using the letters.
- **A** The raster format appears as having noticeably jagged edges when the image is enlarged.
- **B** The raster format is suitable for expressing images with clear contours, such as logos.
- **C** Vector format represents images by incorporating information such as the coordinates of points and the thickness of lines.
- **D** Painting software is used to create vector graphics.

(3) What is the data amount of a 24-bit full-color image with a resolution of 1,280 × 720 pixels in megabytes? For this question, assume that 1 KB = 1,000 B and 1 MB = 1,000 KB, and round your answer to two decimal places.

Explanation

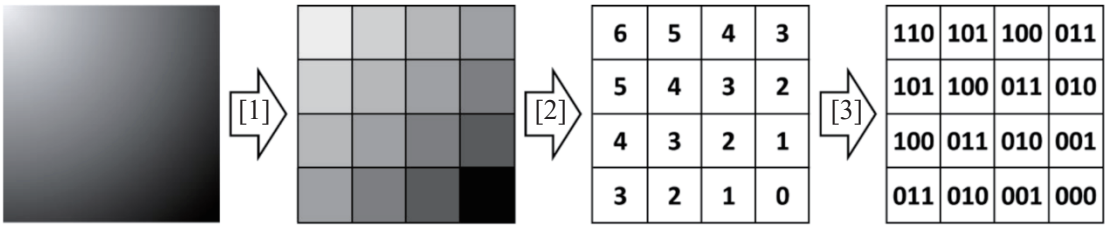
(1) **B → A → C**

(2) **A**, **C**

(3) The amount of data in the image is,
1,280 × 720 × 24 [bits] = 22,118,400 [bits]
Since 1 B equals 8 bits, 22,118,400 ÷ 8 = 2,764,800 [B].
1 KB = 1,000 B, 1 MB = 1,000 KB, therefore,
2,764,800 [B] ÷ 1,000 ÷ 1,000 = 2.7648 [MB] ≈ 2.76 [MB] 2.76 MB

Try

1 The following diagram illustrates the process of converting a monochrome image into digital data. Choose the appropriate operations for steps **[1]** to **[3]** from [Group A], and then choose the name of each operation from [Group B]. Answer using the numbers.



[Group A] **A** Replace the brightness levels of each region with integer values according to a fixed rule.
B Divide the image into evenly spaced grid sections.
C Represent integers in binary.

[Group B] **A** Quantization **B** Encoding **C** Sampling

2 Answer the following questions.

(1) Complete the following sentences by filling in the blanks [1] and [2] with the appropriate term and number.

> To represent colors, a computer display uses a combination of dots in red, green, and blue. These are known as the ([1]). The intensity of each of the primary colors is expressed in gradations. When representing one color with 8 bits, there are ([2]) gradients.

(2) Complete the following sentences by filling in the blanks [1] and [2] with the appropriate terms.

> Images processed by computers can be divided into two formats: the ([1]) format, which treats the image as a collection of tiny dots, and the ([2]) format, which uses a combination of mathematical expressions to represent the coordinates of points, lines and surfaces connecting them, and color information.

(3) Choose one statement that is incorrect as an explanation of the digital representation of images from the options **A** to **D**.

A The unit dpi represents the degree of pixel density.
B The number of gradations depends on the number of bits allocated per pixel.
C The smaller the resolution and gradation values, the smoother the image obtained.
D Gradation indicates the number of steps or levels of color or brightness.

3 Answer the following questions. In these questions, assume that 1 KB = 1,000 B, and 1 MB = 1,000 KB.

(1) What is the data amount of an image in kilobytes with a resolution of 800 × 600 pixels, where each pixel has 8 bits?

(2) What is the data amount of a 24-bit full-color image with a resolution of 720 × 480 pixels in megabytes? Round your answer to two decimal places.

(3) What is the data amount of a 24-bit full-color image with a resolution of 3,820 × 2,160 pixels in megabytes? Round your answer to two decimal places.

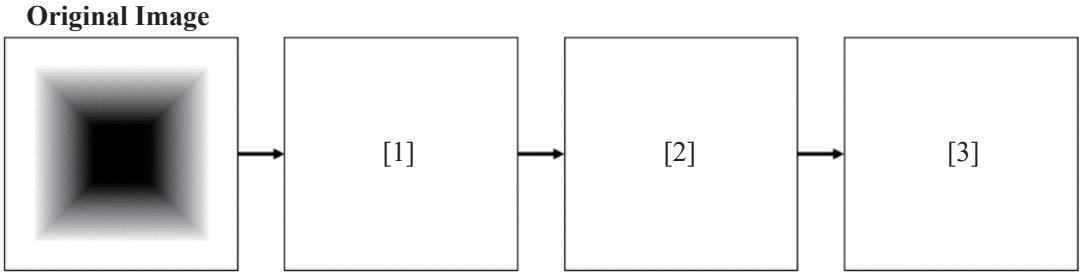
Exercise

1 Answer the following questions.

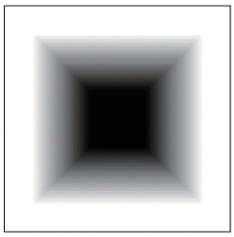
(1) Choose the correct flow for digitizing an image captured by a digital camera from the options **A** to **D**, and answer using the letter.

A Quantization → Encoding → Sampling
B Quantization → Sampling → Encoding
C Encoding → Quantization → Sampling
D Sampling → Quantization → Encoding

(2) The following diagram illustrates the process of converting the original image into digital data. Choose the diagram that best fits into the blanks [1] to [3] from the options **A** to **D**, and answer using the letters.



A



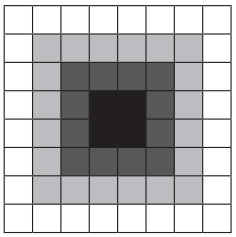
B

0	0	0	0	0	0	0	0
0	1	1	1	1	1	1	0
0	1	2	2	2	2	1	0
0	1	2	3	3	2	1	0
0	1	2	3	3	2	1	0
0	1	2	2	2	2	1	0
0	1	1	1	1	1	1	0
0	0	0	0	0	0	0	0

C

00	00	00	00	00	00	00	00
00	01	01	01	01	01	01	00
00	01	10	10	10	10	01	00
00	01	10	11	11	10	01	00
00	01	10	11	11	10	01	00
00	01	10	10	10	10	01	00
00	01	01	01	01	01	01	00
00	00	00	00	00	00	00	00

D



2 Choose the term that best fits into the blanks [1] to [3] in the following sentences from the options **A** to **D** below.

> In color printers, a variety of colors are expressed by combining the three colors of cyan, magenta, and yellow, which are the ([1]). When these colors are mixed together, they approach the color ([2]). On the other hand, computer displays represent all colors by combining red, green, and blue, which are the ([3]).

A Three primary colors of light
B Three primary colors of pigment
C White
D Black

3 Answer the following questions. In these questions, assume that 1 KB = 1,000 B, and 1 MB = 1,000 KB.

(1) What is the data amount of an image in kilobytes with a resolution of 1,080 × 720 pixels, where each pixel has 8 bits? Round your answer to the nearest whole number.

(2) What is the data amount of a 24-bit full-color image with a resolution of 320 × 480 pixels in kilobytes? Round your answer to the nearest whole number.

(3) What is the data amount of a 24-bit full-color image with a resolution of 1,920 × 1,080 pixels in megabytes? Round your answer to two decimal places.

6-9 Digital Representation and Compression Technology for Videos

Point!

1 Mechanism of Videos

(1) ([1]**Video**) : An electronic medium that creates the illusion of movement by displaying a series of still images in succession. It utilizes the ([2]**afterimage phenomenon**), which occurs due to the characteristics of human vision.

(2) ([3]**Frame**) : Each still image that composes a video.

(3) ([4]**Frame rate**) : The number of frames displayed per second. The unit is ([5]**fps**).
The ([6]**higher**) the frame rate number, the smoother the video will appear, and the ([7]**larger**) the data size will become.

(4) How to Calculate the Amount of Video Data
Amount of video data = ([8]**Amount of image data** [B] × **Frame rate**[fps] × **Time** [seconds])

2 Data Compression

(1) ([9]**Compression**) : A process of reducing the amount of data as much as possible while preserving the content of the data.

(2) ([10]**Decompression**) : A process of restoring compressed data to its original state.

(3) ([11]**Compression ratio**) : The extent to which data has been compressed.

$$\text{Compression ratio [\%]} = \frac{([12]\textbf{Amount of data after compression})}{([13]\textbf{Original amount of data})} \times 100$$

(4) Lossless Compression and Lossy Compression

[1] ([14]**Lossless compression**) : A compression method that allows for the complete restoration of the original data from the compressed data. Used for compressing information such as text or program data.

[2] ([15]**Lossy compression**) : A compression method in which the original data cannot be restored from the compressed data. Lossy compression is used for compressing audio, images, and video files in a way that humans do not perceive a significant difference, even if those files cannot be perfectly restored to their original form.

3 Main Types of Lossless Compression

(1) ([16]**Run-length encoding**) : A compression method that replaces sequences of the same consecutive symbols with a numerical value indicating the length of the sequence. It is effective when there are many consecutive identical symbols.

<Example> Before compression: "AAAAABBAAAABBBBBBBBAAAAAA" (25 characters)

↓

AAAAA (5 of "A") BB (2 of "B") AAAA (4 of "A") BBBBBBBB (8 of "B") AAAAAA (6 of "A")

After compression: ([17]**A5B2A4B8A6**) (10 characters)

The compression ratio is ([18] $\frac{10}{25} \times 100$) = ([19]**40 [%]**).

(2) ([20]**Huffman coding**) : A compression method that assigns shorter bit sequences to characters with higher frequencies of occurrence, and longer bit sequences to those with lower frequencies.

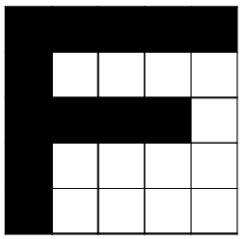
Warm Up

Answer the following questions.

(1) [1] What is the data size, in megabytes, of a 10-second uncompressed video at 30 fps, where each frame is a 24-bit full-color still image with a resolution of 500 × 200 pixels? For this question, assume that 1 KB = 1,000 B and 1 MB = 1,000 KB.

[2] Video [1] was converted into a compressed video file using a certain compression method, resulting in a file size of 30 MB. What is the compression ratio in this conversion? Round your answer to the nearest whole number and provide the answer as an integer.

(2) Consider how to represent an image using pixels. In the case of the diagram on the right, the 25 pixels in the 5 × 5 grid are read one by one from the top-left, row by row, moving to the right. If a pixel is black, write "B"; if it is white, write "W". This results in the sequence:
"BBBBBBWWWWBBBBWBWWWWBWWWW".
Next, by representing consecutive characters "B" or "W" of length n (where n is an integer of 2 or more) as "Bn" or "Wn", the sequence can be compressed to "B6W4B4WBW4BW4". Using the same method with another 5 × 5 grid, what is the alphabet letter represented by the following compressed data?



"B4WBW3B5WBW4BW4"

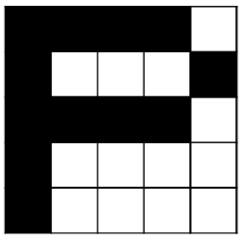
Explanation

(1) [1] The amount of data per frame is,
500 × 200 × 24 [bits] = 2,400,000 [bits]
Since 1 B = 8 bits, 2,400,000 [bits] ÷ 8 = 300,000 [B]
The amount of data of a 10-second video at 30 fps is as follows:
300,000 [B] × 30 [fps] × 10 [seconds] = 90,000,000 [B]
1 KB = 1,000 B, 1 MB = 1,000 KB, therefore,
90,000,000 [B] ÷ 1,000 ÷ 1,000 = 90 [MB] 90 MB

[2] Compression ratio [%] = $\frac{\text{Amount of data after compression}}{\text{Original amount of data}} \times 100$,

resulting in $\frac{30}{90} \times 100 = 33.3\cdots$ [%] 33%

(2) Expanding the pre-compressed data "B4WBW3B5WBW4BW4" yields "BBBBWBWWWBBBBBWBWWWWBWWWW".
If you fill in a 5 × 5 grid one pixel at a time from the top-left, row by row to the right, coloring black for "B" and white for "W", you will get the image shown on the right. Therefore, P



Try

1 Answer the following questions. For these questions, assume that 1 KB = 1,000 B and 1 MB = 1,000 KB.

(1) Complete the following sentences by filling in the blanks [1] and [5] with the appropriate terms.

> A video is a continuous display of still images. By displaying a series of gradually changing images, the phenomenon of ([1]) creates the illusion of movement for humans. The individual still images that make up a video are called ([2]), and the number of ([2]) displayed on the screen per second is referred to as the ([3]). The ([4]) the ([3]), the smoother the motion in the video appears. However, the amount of data of videos can become ([5]).

(2) What is the data size, in megabytes, of a 1-minute video at 30 fps, where each frame is a 24-bit full-color still image with a resolution of 640 × 360 pixels? Assume that the video is uncompressed. Round the amount of data to the nearest whole number and provide the answer as an integer.

2 Answer the following questions.

(1) For the following statements **A** to **D** about data compression, mark "○" if the statement is appropriate, and "×" if it is inappropriate.

A Lossless compression is a method that improves compression efficiency by allowing slight changes to the data, such as removing components that are less noticeable to humans.

B Decompression is a process of restoring compressed data to its original state.

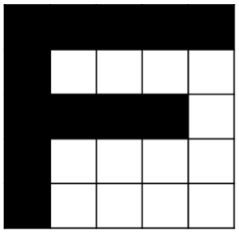
C Data compressed using lossy compression does not result in exactly the same content as the original uncompressed data.

D Data compressed using lossless compression will be exactly the same as the original data after being decompressed.

(2) When 21 MB of compressed data was decompressed, it expanded to 50 MB. What is the compression ratio of this file?

3 Answer the following questions.

(1) Consider how to represent an image using pixels. In the case of the diagram on the right, the 25 pixels in the 5 × 5 grid are read one by one from the top-left, row by row, moving to the right. If a pixel is black, write "B"; if it is white, write "W". This results in the sequence:
"BBBBBBWWWWBBBBWBWWWWBWWWW".
Next, by representing consecutive characters "B" or "W" of length n (where n is an integer of 2 or more) as "Bn" or "Wn", the sequence can be compressed to "B6W4B4WBW4BW4". Using the same method with another 5 × 5 grid, what is the alphabet letter represented by the following compressed data?
"BW3B2W3B7W3B2W3B"



(2) What is the term for the compression method that represents repeated data by listing the data and the number of consecutive occurrences, as shown in (1)? Choose one from the options **A** to **D**, and answer using the letter.

A Huffman coding **B** Codec

C Run-length encoding **D** LZ encoding

Exercise

1 Answer the following questions. For these questions, assume that 1 KB = 1,000 B and 1 MB = 1,000 KB.

(1) For the following statements **A** to **D** about video mechanisms, mark "○" if the statement is appropriate, and "×" if it is inappropriate.

A Videos create the illusion of movement by displaying a series of still images in rapid succession, leveraging the afterimage phenomenon. In reality, the images themselves are not moving.

B Each individual still image that composes a video is called a frame.

C The number of frames displayed per second is called the frame rate. The lower the frame rate, the smoother the video appears.

D When recording a video, if the resolution and frame rate settings are the same, the amount of data of a video recorded for 1 second and a video recorded for 60 seconds does not vary.

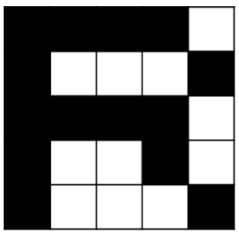
(2) What is the data size, in megabytes, of a 1-second video at 60 fps, where each frame is a 24-bit full-color still image with a resolution of 1,920 × 1,080 pixels? Assume that the video is uncompressed, and round your answer to one decimal place.

2 For the terms that fit in the blanks [1] to [3] in the following sentences, if the compression is lossless, answer with **A**; if the compression is lossy, answer with **B**.

> There are two main methods for compressing data. A compression method that allows the original data to be completely restored from the compressed data when decompressed is called ([1]). A compression method that does not allow for the complete restoration of the original data is called ([2]). For data such as images and videos, where the compressed data does not need to be perfectly restored and humans do not perceive a significant difference, ([3]) is used.

3 Answer the following questions.

(1) Consider how to represent an image using pixels. In the case of the diagram on the right, the 25 pixels in the 5 × 5 grid are read one by one from the top-left, row by row, moving to the right. If a pixel is black, write "B"; if it is white, write "W". This results in the sequence:
"BBBBWBWWWBBBBBWBWWBWBWWWB".
When "B" or "W" appears consecutively n times (where n is an integer greater than or equal to 2), they can be written as "Bn" or "Wn". Using this method, the sequence can be compressed as "B4WBW3B5WBW2BWBW3B". Using the same method with another 5 × 5 grid, what is the alphabet letter represented by the following compressed data?
"BW3BWBWBW3BW4BW4BW2"



(2) What is the term for the compression method that represents repeated data by listing the data and the number of consecutive occurrences, as shown in (1)?

6-10 Information Design

Point!

1 Information Design

(1) ([1]**Information design**) : The process of organizing and creatively expressing information according to its purpose, thereby ensuring that the intended message is correctly conveyed to the target audience.

(2) Information Design Methods

[1] ([2]**Abstraction**) : Conveying the intended information simply from within a large amount of data.

- ([3]**Pictogram**) : A pictorial symbol designed for the purpose of conveying information without using words. It is used for information signs at stations and airports.
- ([4]**Icon**) : A representation of a program's content on a computer or smartphone depicted through images or illustrations.

Pictogram

Icon

[2] ([5]**Visualization**) : Visually representing information to make it more understandable.

<Examples> Tables, graphs, etc.

[3] ([6]**Structuring**) : Organizing and expressing information clearly by arranging it according to relationships, connections, levels, stages, order, etc.

<Examples> Hierarchical menus on web pages, department store floor maps, etc.

2 Design Techniques for Ease of Understanding

(1) ([7]**User interface (UI)**) : A system for transferring information between humans and devices

<Examples> Voice input, touch panel, keyboard, etc.

[1] ([8]**CUI**) : A user interface where a device is operated by entering commands via a keyboard.

[2] ([9]**GUI**) : A user interface that allows users to issue commands in an intuitive and easy-to-understand way using icons and buttons.

(2) ([10]**User experience (UX)**) : The experience or emotional impact that users gain from interacting with a product or service.

(3) ([11]**Affordance**) : Actions or operations that can be performed on an object.

(4) ([12]**Signifier**) : Cues that prompt users to take action.

(5) ([13]**Usability**) : A measure used to indicate how easy and understandable it is for users.

(6) ([14]**Accessibility**) : The ease of access to information and services for a wide range of people.

(7) ([15]**Universal design**) : Design that is thoughtfully created with the intention that all people, regardless of age, language, nationality, or physical ability, can use it without difficulty.

3 Organizing and Classifying Information

([16]**LATCH method**) : A principle for organizing information and presenting it in a way that is easy for users to understand. Information is organized and classified according to the following five criteria.

- Location : Classification based on physical location.
- Alphabet : Classification based on alphabetical or syllabary order.
- Time : A classification based on the sequence of events in terms of time.
- Category : A classification based on the differences between things, used as a criterion to distinguish realms.
- Hierarchy : Classification based on quantitative changes such as size, level, etc.

Warm Up

Answer the following questions.

(1) Choose the most appropriate example of visualization as a method used in information design from the options **A** to **D** below, and answer using the letter.

A Pictograms for each classroom were created to guide people around the school building.

B A web page to introduce the school was created. The page was organized with menus for each hierarchy.

C The survey results were compiled into tables and graphs.

D Text summarizing multiple matters is presented in bullet points.

(2) Choose the term that best fits into the blanks [1] and [2] in the following sentences from the options **A** to **D** below, and answer using the letters.

> Current computers widely use ([1]), which allows users to manipulate graphically displayed information, such as icons, with a mouse or their finger. On the other hand, early computers used ([2]), which was a method for conveying commands by inputting characters from a keyboard.

A CUI **B** GUI **C** VUI **D** NUI

(3) What is the term for a design that is thoughtfully created in advance to allow all individuals, regardless of nationality, gender, age, or physical ability, to use it without difficulty? Choose one from the options **A** to **D** below, and answer using the letter.

A Usability **B** Universal design

C Signifier **D** User interface

Explanation

(1) **A** is an example of abstraction, **B** of structuring, **C** of visualization, and **D** of structuring.
Therefore, **C**

(2) [1]: **B** [2]: **A**

(3) **B**

Try

1 Answer the following questions.

(1) Choose the term that best fits into the blanks [1] to [3] in the following sentences from the options **A** to **E** below, and answer using the letters.

> Methods of information design include the following.
> ([1]): A method for discerning the overall picture and clearly organizing the relationships between elements.
> ([2]): A method for visually representing information.
> ([3]): A method for extracting only the necessary elements from a large amount of information.

A Specification **B** Abstraction **C** Visualization **D** Materialization **E** Structuring

(2) Choose the most appropriate example of abstraction as a method used in information design from the options **A** to **D** below, and answer using the letter.

A Pictograms for each classroom were created to guide people around the school building.
B A web page to introduce the school was created. The page was organized with menus for each hierarchy.
C The survey results were compiled into tables and graphs.
D Text summarizing multiple matters is presented in bullet points.

(3) Choose one term that represents a pictorial symbol that conveys information by abstracting the intended message without using text from the options **A** to **D** below, and answer using the letter.

A Usability **B** Affordance
C Signifier **D** Pictogram

2 Answer the following questions.

(1) Choose the term that best fits into the blanks [1] and [2] in the following sentences from the options **A** to **D** below, and answer using the letters.

> The experience that users gain through products or services is referred to as ([1]). The aim is not just to achieve ease of use, but also to achieve a sense of comfort. For that purpose, it is necessary to simplify the ([2]) that people use to operate devices and screens, choose colors with consideration for the fact that different people perceive colors differently, and add textual information.

A GUI **B** CUI **C** UX **D** UI

(2) Choose the term that best fits into the blanks [1] to [3] in the following sentences from the options **A** to **F** below, and answer using the letters.

> Regardless of the level of advancement for functions offered by a computer, those functions cannot be effectively applied in real life if they are difficult to use. The ease of use of such devices is referred to as ([1]), and ([1]) varies depending on the user. On the other hand, ease of use for a wide range of people, regardless of their abilities or conditions, is referred to as ([2]). The term ([3]) refers to design that enables ease of use for everyone, regardless of age, language, nationality, or physical ability.

A Accessibility **B** Usability **C** Affordance
D Universal design **E** User interface **F** Barrier-free

Exercise

1 Answer the following questions.

(1) Answer the following questions.

[1] Choose the most appropriate explanation of visualization as a method used in information design from the options **A** to **D** below, and answer using the letter.

A Extracting only the necessary elements from a large amount of information.

B Discerning the overall picture and clearly organizing the relationships between elements.

C Expressing the information you want to convey in a simple manner using diagrams or illustrations.

D Representing information visually.

[2] Choose all the appropriate examples of structure as a method used in information design from the options **A** to **D** below, and answer using the letters.

A A web page to introduce the school was created. The page was organized with menus for each hierarchy.

B The survey results were summarized into a graph to convey information in an easy-to-understand manner.

C Expressed a warning to the other party through illustrations without using text.

D A list was compiled to summarize the events of a particular day.

(2) What is the term for symbols used in public facilities like train stations and airports to visually convey attention or information to others, as shown in the diagram on the right?

2 Answer the following questions.

(1) Choose the term that best fits into the blanks [1] to [3] in the following sentences from the options **A** to **D** below, and answer using the letters.

(　[1]　): A system for transferring information between humans and devices.
(　[2]　): ([1]) through text. Operate everything from the keyboard.
(　[3]　): ([1]) through visuals. Intuitive operation is possible using devices like a mouse.

A GUI　　**B** CUI　　**C** UX　　**D** UI

(2) Choose the most appropriate explanation of a signifier from the options **A** to **D** below, and answer using the letter.

A A measure used to indicate how easy and understandable it is for users.

B Design that is thoughtfully created with the assumption that everyone can use it without difficulty.

C A state that is easily accessible to a wide range of people.

D Cues that prompt users to take action.

7-1 Computer Configuration

Point!

The Five Major Components of a Computer

(1) ([1]**Hardware**) : Devices such as the main computer unit and peripheral devices.

(2) Peripheral devices : Devices used by connecting them to a computer.
<Examples> Keyboard, mouse, display, printer, etc.

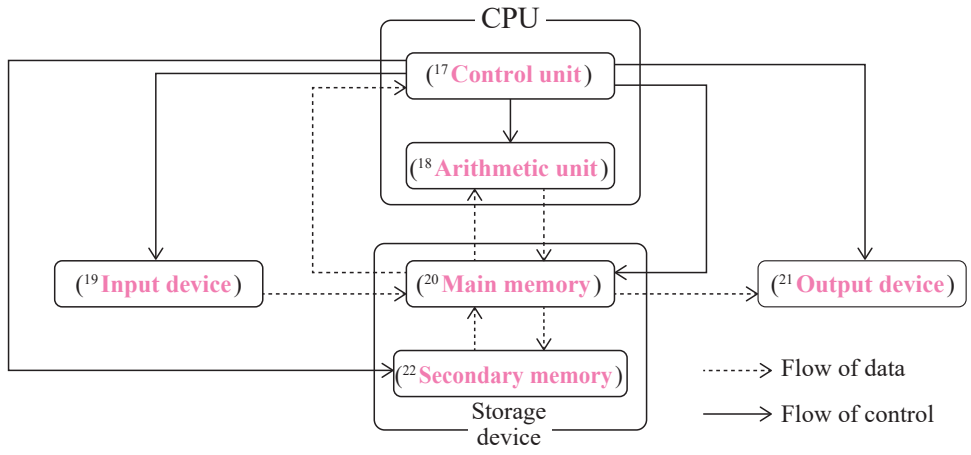
(3) The five major components of a computer : A computer is comprised of the following five components: ([2]**the control unit**), ([3]**the arithmetic unit**), ([4]**the memory unit**), ([5]**the input unit**), and ([6]**the output unit**).

- The control unit and arithmetic unit together are referred to as the ([7]**CPU (central processing unit)**).
- Storage devices are divided into ([8]**main memory**), which temporarily stores programs and data, and ([9]**secondary memory**), which is used for long-term storage.

<Roles of the Five Major Components of a Computer>

Five major components		Role	Example of major component
Control unit	CPU	Executes a computer's ([10]**instructions**) and issues ([11]**commands**) to each function.	CPU
Arithmetic unit		Performs ([12]**calculations**).	
Storage device	Main memory device (Memory)	([13]**Temporarily**) stores programs, data, etc.	Main memory
	Secondary memory (Storage)	For ([14]**long-term**) storage of programs and data.	Hard disk, SSD, USB memory
Input device		([15]**Inputs**) information from external sources.	Keyboard, mouse, scanner
Output device		([16]**Outputs**) information outside of the computer.	Display, printer

<Relationship of the Five Major Components of a Computer>



(4) ([23]**Interface**) : A component that mediates the exchange of information. It is used for connecting the main computer and peripheral devices.

[1] ([24]**USB**) : The most widely used interface for computer peripheral devices.
Compatible with printers, keyboards, and external hard drives.

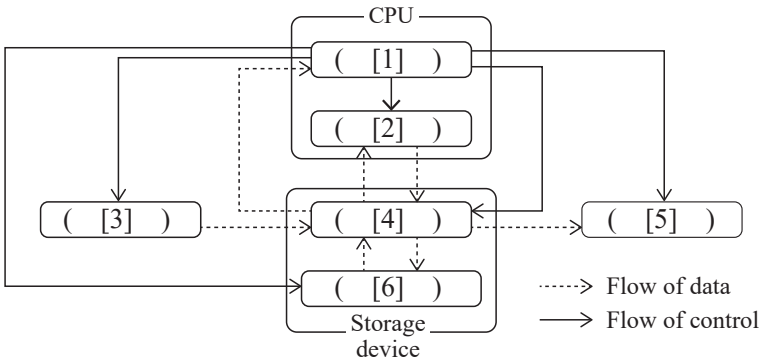
[2] ([25]**HDMI**) : A communication standard that allows video, audio, and other data to be transmitted through a single cable.
Compatible with digital televisions and audio equipment.

[3] ([26]**Ethernet**) : A communication standard used in wired LANs at home, the office, etc.
Compatible with devices such as hubs and routers.

Warm Up

Answer the following questions.

(1) The following diagram represents the relationship between computer components. Choose the appropriate device name that best fits into the blanks [1] to [6] from the options **A** to **F**, and answer using the letters.



A Input device **B** Output device **C** Control unit
D Arithmetic unit **E** Main memory device **F** Secondary memory

(2) Choose all of the following options from **A** to **H** that are output devices, and answer using the letters.

A Memory **B** Display **C** SSD **D** Mouse
E Keyboard **F** Printer **G** Hard disk **H** USB memory

Explanation

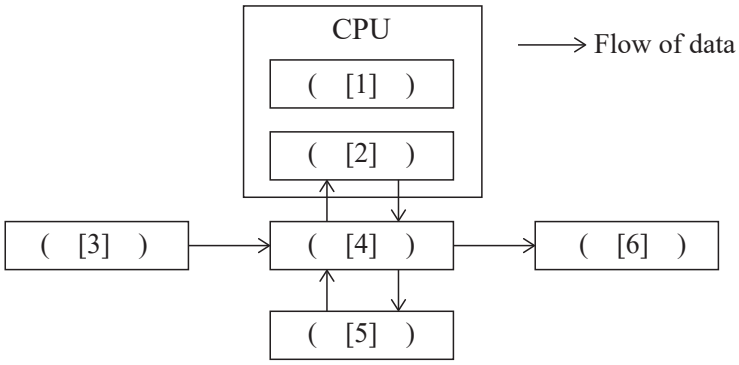
(1) [1] Control unit, because the flow of control is directed towards all devices. **C**
[2] Among the components of the CPU, [1] is the control unit; therefore, the arithmetic unit. **D**
[3] The starting point of the data flow; therefore, the input device. **A**
[4] Among storage devices, this is identified as the main memory because data flows directly into it from the input device. **E**
[5] Marks the end of the data flow; therefore, an output device. **B**
[6] Among storage devices, [4] is the main memory; therefore, the secondary memory. **F**

(2) **B, F**

Try

Answer the following questions.

(1) The following diagram represents the relationship between computer components. Choose the appropriate device name that best fits into the blanks [1] to [6] from the options **A** to **F**, and answer using the letters. Note that the order of blanks [1] and [2] does not matter.



A Input device **B** Output device **C** Control unit
D Arithmetic unit **E** Main memory device **F** Secondary memory

(2) Choose all computer components or peripheral devices corresponding to the following [1] to [5] from the options **A** to **I** below, and answer using the letters.

[1] Arithmetic unit, control unit [2] Main memory device [3] Secondary memory
[4] Input device [5] Output device

A Memory **B** Display **C** SSD
D Mouse **E** Keyboard **F** Printer
G Hard disk **H** USB memory **I** CPU

(3) Choose the term that best fits into the blanks [1] and [2] in the following sentences from the options **A** to **D** below, and answer using the letters.

([1]) is called the main memory and exchanges data directly with the CPU. ([2]) is also called secondary memory and serves the role of storing large amounts of data.

A Memory **B** Hardware
C Interface **D** Storage

(4) What is the interface described by each of the following [1] to [3]?

[1] An interface that connects devices to output video and audio through a single cable.
[2] The most commonly used interface for computer peripheral devices.
[3] Communication standard used for wired LANs in homes, offices, etc.

Exercise

1 Answer the following questions.

(1) Choose the most appropriate explanation of the control unit, which is one of the five major components of a computer from the options **A** to **D** below, and answer using the letter.

A It is a device that performs calculations.
B It is a device that executes a computer's instructions and issues commands to each function.
C It is a device for temporarily storing programs and data.
D It is a device for inputting information from external sources.

(2) Choose the names of the devices that correspond to computer devices and peripheral devices [1] to [5] from the options **A** to **E** below, and answer using the letters.

[1] Display [2] HDD [3] Keyboard
[4] CPU [5] Main memory

A Input device **B** Output device **C** Control unit, arithmetic unit
D Main memory device **E** Secondary memory

(3) Choose all the peripheral devices from the options **A** to **F**, and answer using the letters.

A Display **B** SSD **C** Memory
D CPU **E** Keyboard **F** USB memory

(4) Choose one correct statement regarding interfaces from the options **A** to **D** below, and answer using the letter.

A Devices that are not the computer itself but are used by connecting to a computer.
B Devices such as the computer itself and peripheral devices.
C Devices for temporarily storing programs and data.
D A component that mediates the exchange of information. It is used for connecting the main computer and peripheral devices.

(5) Choose the corresponding interface for each of the following peripheral devices [1] to [3] from the options **A** to **D**, and answer using the letters.

[1] Keyboard [2] Router [3] Audio equipment

A Ethernet **B** HDMI **C** SSD **D** USB

7-2 Computer Software

Point!

Hardware and Software

(1) Hardware : Devices such as the main computer unit and peripheral devices.
<Examples> CPU, memory, storage, etc.

(2) ([1]**Software**) : Programs and data that operate on hardware.

[1] ([2]**System software**) : Software necessary for operating the hardware.

[2] ([3]**Operating system (OS)**) : A type of system software responsible for the basic functions of a computer. An OS has management functions such as task management, memory management, and file management.
<Examples> Windows, macOS, Android OS, etc.

[3] ([4]**Application software**) : Software that operates on top of system software. Also known as application software.
<Examples> Word processing software, spreadsheet software, etc.

(3) ([5]**Device driver**) : A program that controls communication between a connected device and software on a computer. Also known simply as a "driver."

Warm Up

For the following statements **A** to **D** about an OS, mark "○" if the statement is appropriate, and "×" if it is inappropriate.

A Software used to perform specific tasks.
B Smartphones do not come equipped with an OS.
C A type of system software essential for operating the hardware.
D Application software cannot run without system software.

Explanation

A: An explanation about application software. Therefore, ×
B: Smartphones are equipped with an OS. For example, iPhones are equipped with iOS, while Android phones run on Android OS. Therefore, ×
C: An OS is a type of system software responsible for the basic functions of a computer. Therefore, ○
D: Application software is software that operates on top of system software. Therefore, ○

Try

Answer the following questions.

(1) Complete the following sentences by filling in the blanks [1] to [3] with the appropriate terms.

> Types of software include ([1]) software and ([2]) software. ([1]) software includes ([3]). In the case of computers, examples are Windows and macOS. Additionally, ([2]) software includes word processing software and spreadsheet software.

(2) What is the term for software that is used to control and operate devices connected to a computer?

(3) For the following statements **A** to **D**, answer with "a" if the statement is about operating systems or "b" if the statement is about application software.

A A program executed on a computer that is designed for a specific purpose.
B A program that controls software and hardware on a computer system.
C Includes word processing software and spreadsheet software.
D Included in the system software.

Exercise

1 Answer the following questions.

(1) Choose all the devices and software corresponding to the following [1] to [3] from the options **A** to **F** below, and answer using the letters.

[1] Operating system [2] Hardware [3] Application software

A Memory **B** Spreadsheet software **C** Windows
D macOS **E** CPU **F** Document processing software

(2) Choose one correct statement regarding device drivers from the options **A** to **D** below, and answer using the letter.

A A type of system software. Examples include, Windows, macOS, etc.
B Also referred to as application software.
C A program that controls communication between the devices connected to a computer and the software.
D The software necessary for operating hardware.

7-3 Logic Circuits

Point!

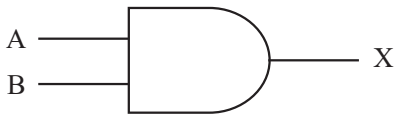
1 Logic Circuits

(1) ([1]**Logical operations**) : Operations performed using combinations of the numbers 0 and 1. In computers, "1" is processed as true and "0" as false.

(2) ([2]**Logic circuit**) : A circuit designed to perform logical operations.

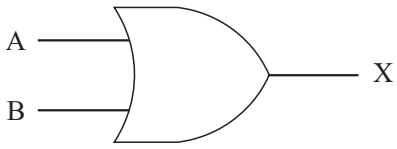
(3) ([3]**Truth table**) : A table that shows all possible combinations of inputs and outputs for a logic circuit.

(4) ([4]**AND gate (logical conjunction circuit)**) : A circuit that outputs 1 only when all inputs are 1.



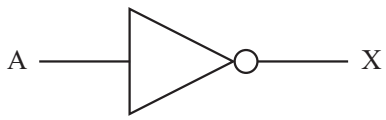
Input		Output
A	B	X
0	0	0
0	1	0
1	0	0
1	1	1

(5) ([5]**OR gate (logical disjunction circuit)**) : A circuit that outputs 1 if at least one of the inputs is 1.



Input		Output
A	B	X
0	0	0
0	1	1
1	0	1
1	1	1

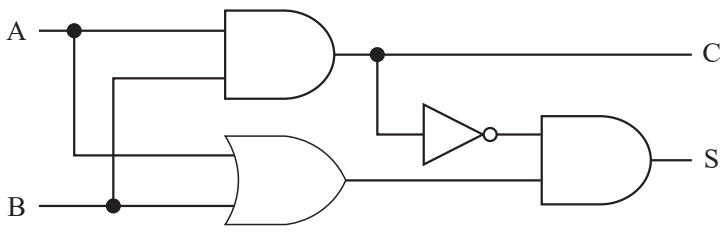
(6) ([6]**NOT circuit (inverter circuit)**) : A circuit that outputs the opposite result of the input.



Input	Output
A	X
0	1
1	0

2 Half Adder Circuit and Full Adder Circuit

(1) ([7]**Half adder circuit**) : A circuit representing the addition of single-digit numbers, composed of AND, OR, and NOT gates.



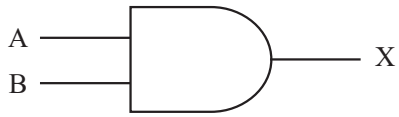
Input		Output	
A	B	C	S
0	0	0	0
0	1	0	1
1	0	0	1
1	1	1	0

(2) ([8]**Full adder circuit**) : A circuit that considers carry from the lower bit and carry to the higher bit.

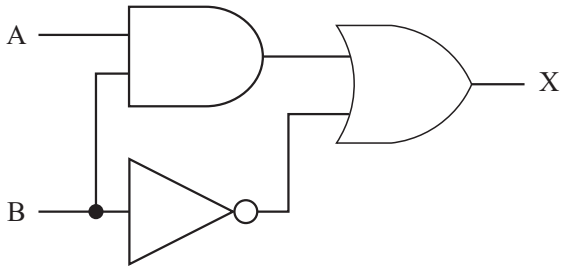
Warm Up

Answer the following questions.

(1) Name the following logic circuit and create a truth table.



(2) A circuit was created by combining logic circuits as shown in the following diagram. In this case, create a truth table for inputs A, B, and output X.



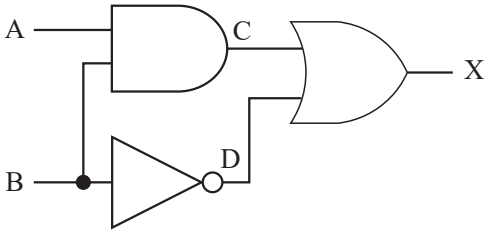
Explanation

(1) AND Circuit (logical conjunction circuit).

An AND circuit is a circuit that outputs 1 only when all inputs are 1. Therefore, the truth table is as follows.

Input		Output
A	B	X
0	0	0
0	1	0
1	0	0
1	1	1

(2) Create and analyze the truth table for each circuit.



A	B	C	D	X
0	0	0	1	1
0	1	0	0	0
1	0	0	1	1
1	1	1	0	1

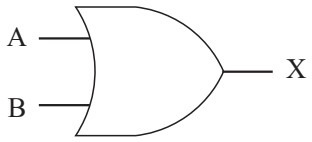
Therefore, the truth table is as follows.

Input		Output
A	B	X
0	0	1
0	1	0
1	0	1
1	1	1

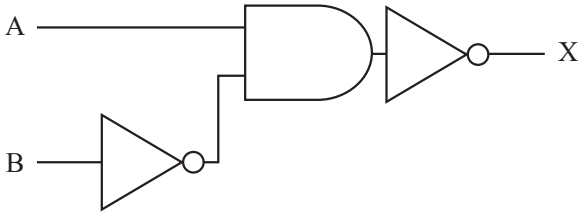
Try

Answer the following questions.

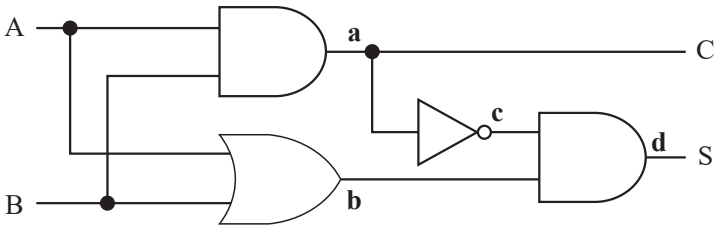
(1) Name the following logic circuit and create a truth table.



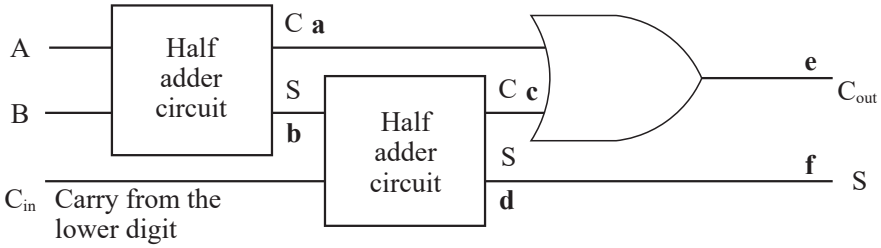
(2) A circuit was created by combining logic circuits as shown in the following diagram. In this case, create a truth table for inputs A, B, and output X.



(3) In the following half adder circuit, determine the values of each output **a** to **d** when input A is 0 and input B is 1.

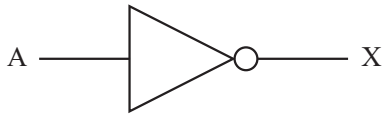


(4) In the following full adder circuit, determine the values of each output **a** to **f** when input A is 1, input B is 1, and input C_{in} is 0.

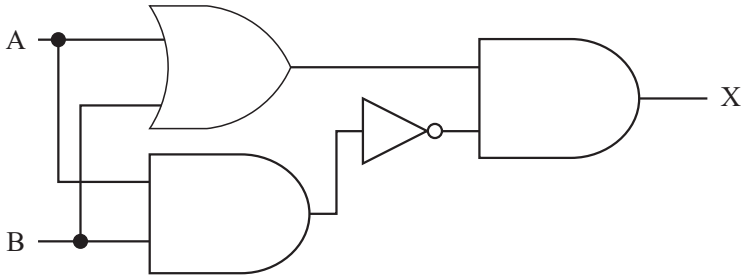


1 Answer the following questions.

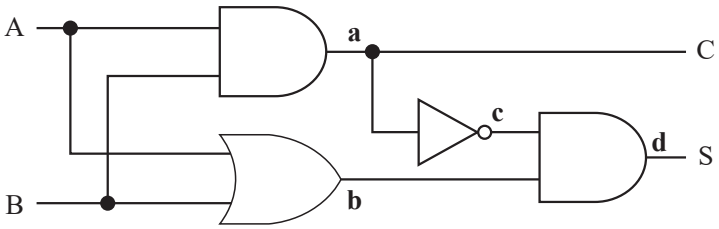
(1) Name the following logic circuit and create a truth table.



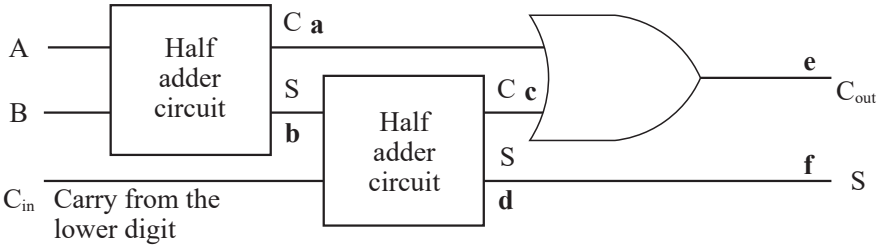
(2) A circuit was created by combining logic circuits as shown in the following diagram. In this case, create a truth table for inputs A, B, and output X.



(3) In the following half adder circuit, determine the values of each output **a** to **d** when input A is 1 and input B is 1.



(4) In the following full adder circuit, determine the values of each output **a** to **f** when input A is 1, input B is 0, and input C_{in} is 1.



8-1 Computer Networks

Point!

1 Information and Communication Networks

(1) ([1]**Information and communication network**) : A network resembling a web that utilizes communication lines to transmit information.

(2) ([2]**Computer network**) : A communication system that connects information communication devices like computers and smartphones, enabling them to exchange data with one another.

(3) Types of Networks

[1] ([3]**LAN**) : A network that connects devices within a limited area, such as within a school or home.

- ([4]**Wired LAN**) : A method of exchanging data by directly connecting to cables.
- ([5]**Wireless LAN**) : A method of exchanging data via wireless radio waves instead of cables.

[2] ([6]**WAN**) : A network that connects a broader area.

(4) ([7]**Internet**) : A network that connects LANs and WANs on a global scale.

(5) Connecting to the Internet

[1] ([8]**ISP (provider)**) : A company that facilitates connection to the internet. It is necessary to sign a contract to connect to the internet.

[2] ([9]**Router**) : A device that relays and forwards data between different networks.

[3] ([10]**Hub**) : A central device that connects multiple cables.

2 Network Usage Patterns

(1) Server and Client

[1] ([11]**Server**) : A computer that provides various services.

- ([12]**File server**) : A server that manages files.
- ([13]**Printer server**) : A server that handles print processing.
- ([14]**Mail server**) : A server that handles the sending and receiving of emails.
- ([15]**Proxy server**) : A server that acts as an intermediary for accessing the internet.

[2] ([16]**Client**) : A computer that requests various services from a server.

(2) Network Usage Patterns

[1] ([17]**Client-server system**) : A method where services are provided and received between a server and a client.

[2] ([18]**Peer-to-peer system**) : A method where computers are in an equal relationship, providing and receiving services to and from each other.

3 Communication Methods

(1) ([19]**Circuit switching method**) : A communication method where a communication path is established between the sender and the recipient before starting the transmission to exchange information.

(2) ([20]**Packet**) : A unit for dividing data into small chunks when transmitting data over a network.

(3) ([21]**Packet switching method**) : A communication method that involves dividing the data being transmitted into packets for exchange.

(4) Advantages and Disadvantages of Communication Methods

	Circuit switching method	Packet switching method
Advantages	Once a communication path is established, stable communication can be achieved.	Even if the network is congested, data can be sent gradually, so the possibility of being completely unable to communicate is low.
Disadvantages	The communication path is occupied by the user, so it is not possible to use the line simultaneously with others.	Packets can sometimes be lost along the way or be affected by network congestion.

Warm Up

Answer the following questions.

(1) Choose one statement that is incorrect regarding network construction devices from the options **A** to **D** below, and answer using the letter.

A Organizations or companies that facilitate connections to the internet are referred to as providers.

B A network limited to areas such as within a school or a home is referred to as a WAN.

C A device that gathers and connects multiple cables is referred to as a hub.

D A device that relays and transfers between different networks is referred to as a router.

(2) Choose the statement that best fits into the blanks [1] to [4] in the following table from the options **A** to **D** below, and answer using the letters.

	Advantages	Disadvantages
Circuit switching method	[1]	[2]
Packet switching method	[3]	[4]

A The line is occupied, which ensures stable communication.

B There may be delays or loss of data during transmission.

C Only the number of lines necessary for communication is required.

D It is possible to handle many communications simultaneously.

Explanation

(1) A network limited to areas such as within a school or a home is referred to as a LAN. Therefore, **B**

(2) [1] **A** [2] **C** [3] **D** [4] **B**

Try

1 Choose the term that best fits into the blanks [1] to [6] in the following sentences from the options **A** to **H** below, and answer using the letters.

> A network within a relatively limited area, such as within a school or home, is referred to as a ([1]), while a network that covers a wider area is referred to as a ([2]). A network that connects ([1]) and ([2]) on a global scale is called the ([3]). In order for regular households to use it, they need to have a contract with a business that facilitates connection to the internet, known as a ([4]).
>
> Additionally, computers within a local range are typically connected via cables through a concentrator device known as a ([5]). When connecting different networks, an intermediary device called a ([6]) is used.

A LAN **B** WAN **C** Wi-Fi **D** Hub
E Server **F** Router **G** Internet **H** ISP (provider)

2 Answer the following questions.

(1) Choose the term that best fits into the blank in the following sentence from the options **A** to **D** below, and answer using the letter.

> A system configuration in which computers connected through a network are structured to allocate roles as service providers and service receivers is referred to as ( ).

A Client-server system **B** Peer-to-peer system
C Local Area Network (LAN) **D** Wide Area Network (WAN)

(2) Fill in the blanks with the appropriate words.

[1] A server that acts as an intermediary for accessing the internet is referred to as a ( ).
[2] A server that manages files is referred to as a ( ).
[3] A computer that requests various services from a server is referred to as a ( ).

3 Answer the following questions.

(1) Complete the following sentences by filling in the blanks [1] and [2] with the appropriate terms.

> There are ([1]) methods and ([2]) methods in communication systems. The ([1]) method is a communication method where a communication path is established between the sender and the recipient before starting communication to exchange information. The ([2]) method is a communication method where the data to be sent is divided into small units called packets for exchange.

(2) Choose all appropriate statements that describe circuit switching method and packet switching method from the options **A** to **D** below, and answer using the letters.

A Circuit switching method allows for high communication speeds because the communication path is shared with other users.
B In circuit switching method, once a connection is established, stable communication is possible because the communication path is occupied.
C Packet switching method involves sharing the communication path, which can result in lower communication speeds.
D Packet switching method has a low likelihood of complete communication failure, even when the network is congested.

Exercise

1 Answer the following questions.

(1) Choose the most appropriate explanation of a WAN from the options **A** to **D** below, and answer using the letter.

A It can only be connected within limited buildings such as schools, companies, and homes.

B It is possible to connect areas that are far apart.

C It is a communication network that connects information and communication devices, such as computers, to exchange information with each other.

D It is possible to interconnect networks around the world.

(2) Choose the term that best fits into the blanks in the following sentences from the options **A** to **D** below, and answer using the letters.

[1] The method of exchanging data by directly connecting cables is referred to as ( ).

[2] The method of exchanging data using wireless radio waves instead of cables is referred to as ( ).

[3] The device that relays and forwards data between different networks is referred to as a ( ).

A Wired LAN **B** Router **C** Hub **D** Wireless LAN

2 Answer the following questions.

(1) Choose one statement that is incorrect regarding the usage patterns of networks from the options **A** to **D** below, and answer using the letter.

A A server that manages data and files on a network is referred to as a file server.

B A computer that requests various services from a server is referred to as an ISP (provider).

C A server that accesses the internet on behalf of a user is referred to as a proxy server.

D A method where computers are in an equal relationship, providing and receiving services to and from each other, is referred to as a peer-to-peer system.

(2) Choose the term that best fits into the blanks [1] to [3] in the following sentences from the options **A** to **D** below, and answer using the letters.

- A server that handles printing processes such as copying and printing is referred to as a ([1]).
- A server that facilitates the sending and receiving of emails between computers is referred to as a ([2]).
- The usage pattern where a server and a client connect over a network and exchange services is referred to as ([3]).

A Client-server system **B** Mail server

C Internet **D** Printer server

(3) If the following statements [1] to [4] pertain to circuit switching method, answer with “A.” If the statements pertain to packet switching method, answer with “B.”

[1] Once a communication path is established, stable communication can be achieved.

[2] Since it can send data in small portions, the possibility of being unable to communicate is low, even if the network gets congested.

[3] Delays, tampering, or loss may occur during data transmission.

[4] Since you cannot use the line simultaneously with others, there is a need for a number of lines dedicated to communication.

8-2 IP Addresses and Domain Names

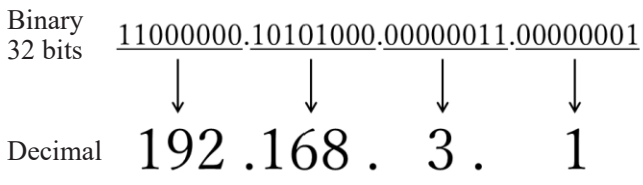
Point!

IP Addresses and Domain Names

(1) ([1]**IP address**) : A unique identification number equivalent to an address assigned to devices on an information and communication network.

<Features of IP Addresses>

- The method of representing an IP address using binary with ([2]**32 bits**) is referred to as ([3]**IPv4**).
- It is represented in four blocks of ([4]**8 bits**) each, separated by a dot (.) and expressed in decimal from 0 to ([5]**255**).



(2) Global IP Address and Private IP Address

[1] ([6]**Global IP address**) : An IP address used on the internet.

[2] ([7]**Private IP address**) : An IP address used within a local network, such as a LAN.

(3) Issue of IP Address Exhaustion

Due to the rapid proliferation of the internet, there are almost no new IPv4 addresses available for allocation. Therefore, we are currently transitioning to ([8]**IPv6**) IP addresses, which have been expanded to ([9]**128 bits**).

(4) ([10]**Domain name**) : A string of characters assigned to make a numerical IP address more understandable for humans.

(5) ([11]**DNS**) : A system that associates domain names with IP addresses and vice versa. The ([12]**DNS server**) is responsible for fulfilling that role.

Warm Up

Choose the appropriate example of an IPv4 IP address for a computer from the options **A** to **D** below, and answer using the letter.

A 192.168.0.1
B kantei.go.jp
C 555-1234-5678
D https://www.example.co.jp/

Explanation

An IPv4 address is divided into four blocks, with each block's value ranging from 0 to 255.
Therefore, **A**

Try

Answer the following questions.

(1) Choose the appropriate example of an IPv4 IP address for a computer from the options **A** to **D** below, and answer using the letter.

A 00.00.11.aa.bb.cc
B 050-1234-5678
C 10.123.45.67
D https://www.example.co.jp/

(2) Fill in the blank in the following sentence with the correct term.

An IP address that is uniquely assigned on the internet with no duplication is referred to as a ( ) IP address.

(3) Choose the correct statement regarding IP addresses from the options **A** to **D**, and answer using the letter.

A The number of IP addresses in a four-byte format like 192.168.1.1 exceeds the population of the Earth, which is approximately 7 billion.
B The issue of IP address exhaustion is resolved by IPv6, which is represented using 128 bits.
C In IPv4, addresses are represented by combining four numbers ranging from 0 to 256.
D A global IP address can be freely used within a local network, such as within the same company.

Exercise

1 Answer the following questions.

(1) Choose the appropriate example of an IPv4 IP address for a computer from the options **A** to **D** below, and answer using the letter.

A saiyo@example.co.jp
B 070-1234-5678
C https://www.example.co.jp/
D 203.216.206.63

(2) Fill in the blank in the following sentence with the correct term.

An IP address that can be freely used within a local network, such as a LAN, is referred to as a ( ) IP address.

(3) Choose the correct explanation regarding DNS from the options **A** to **D** below, and answer using the letter.

A A unique identification number assigned to devices on an information and communication network.
B A string of characters assigned to an IP address to make it easier for humans to understand.
C A system that maps domain names to IP addresses and vice versa.
D An IP address that is uniquely assigned on the internet with no duplication.

8-3 Communication Protocol

Point!

1 Communication Protocol

(1) ([1]**Packet**) : The unit used when data is divided into small chunks to be transmitted over a network. Sent with a ([2]**header**) that includes the destination information.

(2) ([3]**Communication protocol (protocol)**) : A common agreement in information and communication networks.

[1] ([4]**TCP**) : A protocol that divides the data to be sent into packets, arranges the received packets in order, and requests the retransmission of any packets that were lost during communication.

[2] ([5]**UDP**) : A protocol that emphasizes sending data in real time. Used for voice calls and streaming video.

[3] ([6]**IP**) : The protocol that assigns IP addresses to deliver packets to the correct destination.

2 The Mechanism of Communication in TCP/IP

(1) ([7]**TCP/IP**) : A set of protocols used on the internet. The sending and receiving of data is controlled across four layers.

<The 4-Layer Model of TCP/IP>

Layer	Layer names	Main functions	Examples of protocols
Four layers	([8]**Application layer**)	Communication between applications	HTTP, SMTP, etc.
Three layers	([9]**Transport layer**)	Communication control, error detection, and data retransmission	TCP, UDP, etc.
Two layers	([10]**Internet layer**)	IP address allocation and routing decision	IP, etc.
One layer	([11]**Network interface layer**)	Physical connection, interaction between devices	Ethernet, etc.

(2) Mechanism of Data Communication on the internet

1) Divide the data you want to send into ([12]**packets**).

2) Attach the sender or recipient ([13]**IP addresses**) to the header of each packet.

3) Select the optimal communication route for each packet (this is called ([14]**routing**)) and deliver it to the destination.

4) If there any packets are missing upon receipt, a retransmission is requested. The packets are then rearranged in order to complete the data in its entirety.

Warm Up

Answer the following questions.

(1) For the following statements **A** to **D** concerning protocols, mark "○" if the statement is appropriate, and "×" if it is incorrect.

A A communication protocol refers to enhancing security by encrypting data.

B UDP is a protocol that ensures reliable communication by guaranteeing data integrity and order.

C TCP is a protocol that prioritizes data transfer speed, and it ensures the integrity and order of data while minimizing latency.

D IP is a protocol used to assign IP addresses to deliver packets to the correct destination.

(2) Data communication on the internet is transmitted according to TCP/IP. Rearrange the following steps **A** to **D** in the order of communication on the internet.

A Assign IP address of the recipient or the sender.

B Split the data into packets.

C Select the destination and route for the data and deliver it to its destination.

D Reorder the packets in sequence.

Explanation

(1) **A** A communication protocol is a common agreement in information and communication networks. Therefore, ×

B UDP is a protocol that emphasizes sending data in real-time. To prioritize data transfer speed, it does not guarantee the integrity or order of the data. Therefore, ×

C TCP is a protocol that divides the data to be sent into packets and retransmits any packets that are lost during transmission, ensuring reliable communication. Therefore, ×

D ○

(2) **B → A → C → D**

Try

1 Choose the most appropriate explanation of a communication protocol from the options **A** to **D** below, and answer using the letter.

A Cable hub used for connecting devices such as computers and printers to a LAN
B Description of the location of information specified in a web browser and how to retrieve it
C The number used to identify a computer in internet communication
D Protocols for communication over a network

2 Answer the following questions.

(1) Choose the term that best fits into the blanks [1] to [7] in the following sentences from the options **A** to **H** below, and answer using the letters.

> The rules and procedures for communication over an information and communication network are called ([1]). On the internet, ([2]) is primarily used. Among them, ([3]) is responsible for dividing the data to be sent into ([4]), rearranging the received ([4]) in order, and retransmitting any data that may be missing during communication. On the other hand, ([5]) is responsible for attaching the ([6]), which is the destination address, to ([4]) and sending them to the destination. At this time, ([4]) are transmitted via the internet, searching for the most efficient route to the recipient computer. This is referred to as ([7]).

A TCP/IP **B** IP **C** TCP **D** Packets
E IP address **F** MAC address **G** Routing **H** Communication protocol

(2) The layers in TCP/IP for data communication over the internet are summarized in the following table. Choose the term that best fits into the blanks [1] to [4] from the options **A** to **D** below, and answer using the letters.

Layer	Layer names	Main functions
Four layers	([1])	Communication between applications
Three layers	([2])	Communication control, error detection, and data retransmission
Two layers	([3])	IP address allocation, routing decision
One layer	([4])	Physical connection, interaction between devices

A Transport layer **B** Network interface layer
C Internet layer **D** Application layer

(3) Choose the appropriate example for each of the protocols [1] to [4] from the options **A** to **D** below, and answer using the letters.

[1] Transport layer [2] Network interface layer
[3] Internet layer [4] Application layer

A UDP **B** IP **C** SMTP **D** Ethernet

Exercise

1 Choose the term that best fits into the blanks in the following sentences from the options **A** to **D** below, and answer using the letters.

(1) A unique identification number equivalent to an address assigned to devices on an information and communication network is referred to as an ( ).

(2) A common set of rules within an information and communication network is referred to as a ( ).

A IP address **B** TCP/IP **C** Protocol **D** Route

2 Answer the following questions.

(1) Choose the most closely related options for the following sentences from the options **A** to **D** below, and answer using the letters.

[1] A protocol that emphasizes sending data in real time. Used for voice calls and streaming video.
[2] Data that is divided when communicating over a network.
[3] Protocols used on the internet. Divided into four layers.
[4] A protocol that divides the data to be sent into packets and retransmits any packets that are lost during transmission.

A TCP/IP **B** TCP **C** Packet **D** UDP

(2) The layers in TCP/IP for data communication over the internet are summarized in the following table. Choose the function that best fits into the blanks [1] to [4] from the options **A** to **D** below, and answer using the letters.

Layer	Layer names	Main functions	Examples of protocols
Four layers	Application layer	([1])	HTTP, SMTP, etc.
Three layers	Transport layer	([2])	TCP, UDP, etc.
Two layers	Internet layer	([3])	IP, etc.
One layer	Network interface layer	([4])	Ethernet, etc.

A Physical connection, interaction between devices
B Communication between applications
C IP address allocation, routing decision
D Communication control, error detection, and data retransmission

(3) The following statements describe the mechanism of data communication on the internet. Answer the following questions.

1) Divide the data you want to send into (**A**).
2) Assign the (**B**) of the sender or recipient to the header of each packet.
3) Select the optimal communication route for each packet and deliver it to its destination.
4) If there any packets are missing upon receipt, a retransmission is requested. The packets are then rearranged in order to complete the data in its entirety.

[1] Complete the sentences by filling in the blanks **A** and **B** with the appropriate terms.
[2] Answer with the appropriate term for the underlined section.

8-4 Mechanism of Web Pages and Emails

Point!

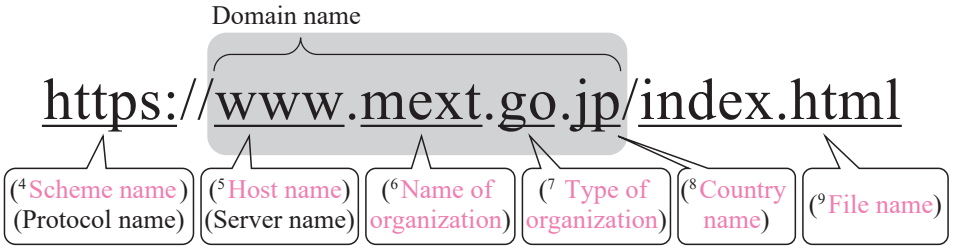
1 Mechanism of the Internet

(1) ([1]**WWW**) : A system that links countless pieces of content on the internet. Users can browse web pages that compile various data. It is commonly referred to as the Web.

(2) ([2]**HTML**) : A language used for creating web pages.

(3) ([3]**URL**) : Represents the location of a web page and the method of communication.

<Structure of a URL>



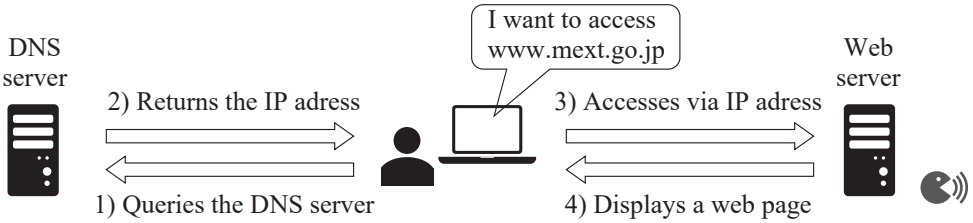
<Examples of Types of Organizations>

Type	Meaning
gov	Government agency
co	Corporation
edu	School (elementary, junior high, and high schools)
ac	University/educational corporation

<Examples of Country Codes>

Code	Country name
eg	Egypt
jp	Japan
hk	Hong Kong
kr	South Korea

(4) Process of Browsing Web Pages



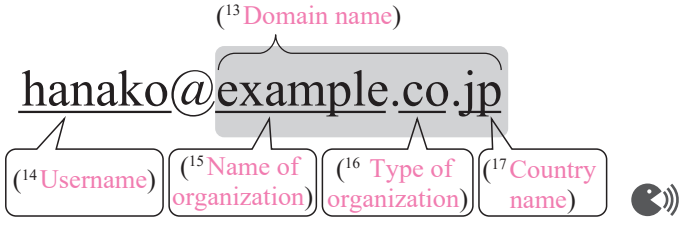
2 Mechanism of Email

(1) Email : A system for exchanging messages and data with specific users via the internet. When sending an email, you use an ([10]**email address**).

(2) Structure of an Email Address

[1] ([11]**Username**) : Identifies the recipient.

[2] ([12]**Domain name**) : Identifies the mail server that the recipient is using.

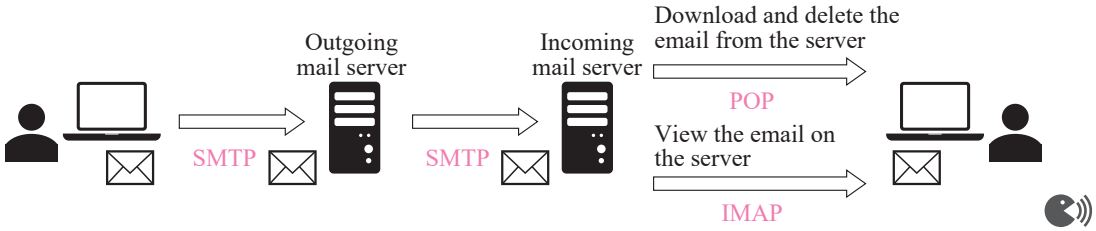


(2) Process of Sending and Receiving Emails

[1] ([18]**SMTP**) : A protocol for sending emails to a mail server.

[2] ([19]**POP**) : A protocol used to download emails from a server and delete them from a server.

[3] ([20]**IMAP**) : A protocol for accessing emails stored on a mail server.



Warm Up

Answer the following questions.

(1) You entered "https://www.example.co.jp" in the web browser and displayed the web page. Rearrange the steps **A** to **D** in the order of processing to display the web page.

A The web server sends the data of the web page.

B Access the IP address returned from the DNS server.

C The DNS server returns the IP address of the web server corresponding to the domain name.

D Query the DNS server for the IP address corresponding to the domain name.

(2) Fill in the blanks [1] to [4] in the following sentence with the appropriate terms.

> An email address is composed of "username@([1])," and the protocol ([2]) is used for sending emails, while ([3]) or ([4]) is utilized for receiving emails.

Explanation

(1) **D → C → B → A**

(2) [1] Domain name [2] SMTP [3] POP [4] IMAP (note: [3] and [4] can be in any order)

Try

1 Answer the following questions.

(1) Choose the term that best fits into the blanks [1] to [4] in the following sentences from the options **A** to **E** below, and answer using the letters.

> Web pages are written in a language called ([1]) and the location and communication protocol of the web page are specified by ([2]). The system for converting domain names and IP addresses within ([2]) is ([3]), and ([4]) fulfills that role.

A URL **B** DNS **C** HTML
D WWW **E** DNS server

(2) What is the name of the service that allows you to view web pages on the internet?

(3) Choose the appropriate names for sections [1] to [6] that compose the following URL from the options **A** to **G** below, and answer using the letters.

https://www.mext.go.jp/index.html
[1] [2] [3] [4] [5] [6]

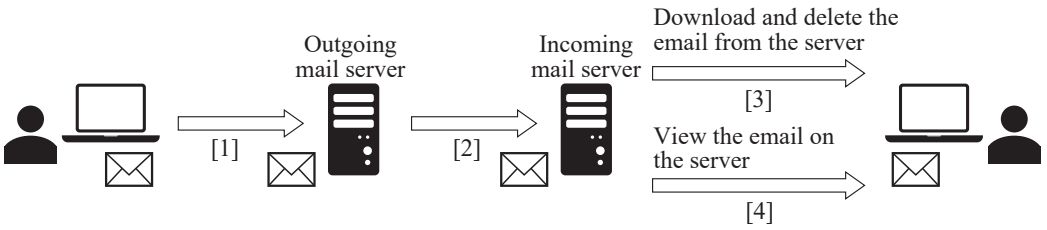
A Scheme name **B** Country name **C** Organization type name **D** Name of organization
E Hostname **F** File name **G** Domain name

2 Answer the following questions.

(1) Name the components labeled [1] and [2] that constitute the following email address.

hanako@example.ed.jp
[1] [2]

(2) The following diagram represents the flow of sending and receiving emails. Choose the appropriate combination of protocols that fit in [1] to [4] in the following diagram from the options **A** to **D** below.



	[1]	[2]	[3]	[4]
A	POP	SMTP	SMTP	IMAP
B	POP	POP	IMAP	SMTP
C	SMTP	SMTP	POP	IMAP
D	SMTP	SMTP	IMAP	POP

Exercise

1 Answer the following questions.

(1) Choose the most appropriate explanation of a DNS from the options **A** to **D** below, and answer using the letter.

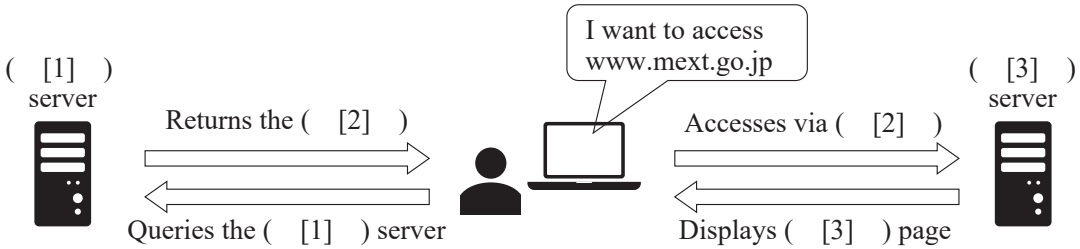
A A system that links countless pieces of content on the internet and is commonly called “the Web.”

B Represents the location of a web page on the internet and the method of communication.

C A language developed for creating web pages.

D A system that maps domain names to IP addresses and vice versa.

(2) The following diagram represents the flow of browsing a web page. Choose the term that best fits into the blanks [1] to [3] in the diagram from the options **A** to **D** below, and answer using the letters.



A Web **B** URL **C** IP address **D** DNS

(3) Choose the appropriate combination of names for the blanks [1] to [6] that compose the following URL from the options **A** to **D** below, and answer using the letter.

https://www.mext.go.jp/index.html
[1] [2] [3] [4] [5] [6]

	[1]	[2]	[3]	[4]	[5]	[6]
A	Scheme name	Hostname	Type of organization	Name of organization	Country name	File name
B	Scheme name	Hostname	Name of organization	Type of organization	Country name	File name
C	Hostname	Scheme name	Type of organization	Name of organization	Country name	File name
D	Hostname	File name	Name of organization	Type of organization	Country name	Scheme name

2 Choose the appropriate options for protocols [1] to [3] from the options **A** to **D** below, and answer using the letters.

(1) Protocol for sending emails to a mail server.

(2) Protocol for accessing emails on a mail server.

(3) A protocol that downloads emails from the mail server and deletes them from the server.

A POP **B** SMTP **C** DNS **D** IMAP

8-5 Network Transfer Speed

Point!

Network Transfer Speed

(1) Transfer speed : The ([1]number of bits) of data that can be transferred per second. The unit is ([2]bps).
1 kbps = ([3]1,000 bps), 1 Mbps = ([4] 1,000 kbps), 1 Gbps = ([5]1,000 Mbps)

(2) The relationship between transfer speed, transfer time, and data volume

[1] Transfer speed [bps] = ([6] $\frac{\text{Data volume [bits]}}{\text{Transmission time [seconds]}}$)

[2] Transfer time [seconds] = ([7] $\frac{\text{Data volume [bits]}}{\text{Data transfer speed [bps]}}$)

[3] Data volume [bits] = ([8]Transfer speed [bps] × Transfer time [seconds])

(3) ([9]Transfer efficiency) : The ratio at which a certain communication speed can be achieved.
Actual transfer speed = ([10]Communication speed [bps] × Transfer efficiency)

Warm Up

Answer the following questions. In these questions, assume that 1 KB = 1,000 B, 1 MB = 1,000 KB, and 1 GB = 1,000 MB.

(1) Calculate the time required to transfer 20 MB of data at a communication speed of 40 Mbps. Assume that the transfer efficiency is 100% and disregard any data other than the data volume.

(2) Calculate the time required to transfer 1 GB of data with a communication speed of 100 Mbps. Assume that the transfer efficiency is 80% and disregard any data other than the data volume.

Explanation

(1) Transfer time [seconds] = $\frac{\text{Data volume [bits]}}{\text{Transfer speed [bps]}}$

1 B = 8 bits, 1 KB = 1,000B, 1 MB = 1,000 KB, therefore,
20 [MB] = 20 × 1,000 × 1,000 × 8 [bits]
Also, 40 [Mbps] = 40 × 1,000 × 1,000 [bps]
Convert units
Therefore, the calculation of transfer time is as follows:

$\frac{20 \times 1{,}000 \times 1{,}000 \times 8 \text{ [bits]}}{40 \times 1{,}000 \times 1{,}000 \text{ [bps]}} = 4 \text{ [seconds]}$ 4 seconds

(2) 1 [GB] = 1 × 1,000 × 1,000 × 1,000 × 8 [bits]
Moreover, since the transfer efficiency is 80%, the actual transfer speed is 100 [Mbps] × 0.8 = 80 [Mbps]
80 [Mbps] = 80 × 1,000 × 1,000 [bps], therefore,
the calculation of transfer time is as follows:

$\frac{1 \times 1{,}000 \times 1{,}000 \times 1{,}000 \times 8 \text{ [bits]}}{80 \times 1{,}000 \times 1{,}000 \text{ [bps]}} = 100 \text{ [seconds]}$ 100 seconds

Try

Answer the following questions. In these questions, assume that 1 KB = 1,000 B, 1 MB = 1,000 KB, and 1 GB = 1,000 MB.

(1) Bps is a unit used to measure data communication speed. Choose the appropriate explanation for 20 Mbps from the options **A** to **D** below, and answer using the letter.
- **A** Capable of transferring data at 20 megabits per minute.
- **B** Capable of transferring data at 20 megabytes per minute.
- **C** Capable of transferring data at 20 megabits per second.
- **D** Capable of transferring data at 20 megabytes per second.

(2) Calculate the maximum data volume, in bytes, that can be transmitted in one minute at a communication speed of 30 bps.

(3) Calculate the maximum data volume, in MB, that can be transmitted in five minutes at a communication speed of 10 Mbps.

(4) Calculate the time required to transfer 20 MB of data at a communication speed of 80 Mbps. Assume that the transfer efficiency is 100% and disregard any data other than the data volume.

(5) Calculate the time required to transfer 1 GB of data at a communication speed of 20 Mbps. Assume that the transfer efficiency is 80% and disregard any data other than the data volume.

Exercise

1 Answer the following questions. In these questions, assume that 1 KB = 1,000 B, 1 MB = 1,000 KB, and 1 GB = 1,000 MB.

(1) Bps is a unit used to measure data communication speed. Choose the appropriate explanation for 40 Mbps from the options **A** to **D** below, and answer using the letter.
- **A** Capable of transferring data at 40 megabits per second.
- **B** Capable of transferring data at 40 megabytes per second.
- **C** Capable of transferring data at 40 megabits per minute.
- **D** Capable of transferring data at 40 megabytes per minute.

(2) Calculate the maximum data volume, in bytes, that can be transmitted in one minute at a communication speed of 120 bps?

(3) Calculate the data volume, in MB, that can be transmitted in three minutes at a communication speed of 20 Mbps.

(4) Calculate the time required to transfer 15 MB of data at a communication speed of 60 Mbps. Assume that the transfer efficiency is 100% and disregard any data other than the data volume.

(5) Calculate the time required to transfer 1 GB of data at a communication speed of 25 Mbps. Assume that the transfer efficiency is 80% and disregard any data other than the data volume.

9-1 Database [1]

Point!

1 Database Management System

(1) ([1]**Database**) : An organized collection of data, organized and stored in a format that makes it easy to access for specific purposes. In addition to collecting data, it also makes it easy to search, process, and share.
<Examples> Smartphone contact lists, company customer information, etc.

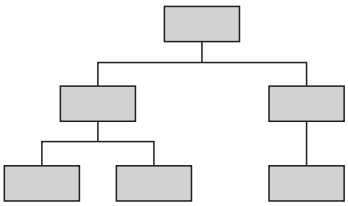
(2) ([2]**Database management system (DBMS)**) : A system that creates, operates, and manages databases.

(3) Database Management System Functions
[1] Data ([3]**consistency**) : Ensuring that concurrent operations for shared data do not cause inconsistencies.
[2] Data ([4]**integrity**) : Preventing duplication, tampering, and unauthorized registration or updating of data.
[3] Data ([5]**independence**) : Managing databases separately from the programs that use them.
[4] Data ([6]**confidentiality**) : Setting access permissions and performing authentication.
[5] Data ([7]**availability**) : Performing backups, restoration, and recovery to prepare for possible failures so that data can be recovered.

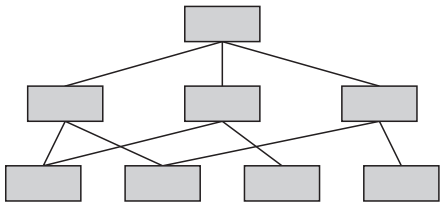
2 Types of Databases

(1) ([8]**Hierarchical database**) : Database where data is represented in a tree-like hierarchical structure.
(2) ([9]**Network database**) : Database where data is represented in a structure similar to a web or mesh.
(3) ([10]**Relational database**) : Database where collected data is organized and managed across multiple tables.

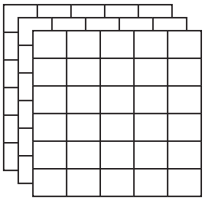
Hierarchical database



Network database



Relational database



(4) ([11]**NoSQL**) : Database management systems other than relational database management systems.

Warm Up

Answer the following questions.

(1) What is the term for information that is organized and stored in a format that makes it easy to access for a specific purpose?

(2) Choose one correct statement regarding data integrity from the options **A** to **D** below, and answer using the letter.

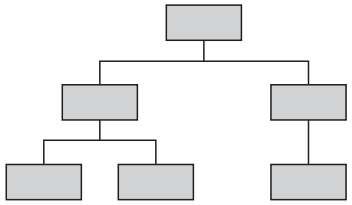
A Function where a database is managed separately from the programs that use it.

B Function that grants access rights to the data being used and limits users.

C Function that prevents duplication, tampering, and unauthorized registration or updating of data.

D Function for backing up and restoring to prepare for data failures.

(3) What is the term for a database with a structure like the one shown on the right?



Explanation

(1) Database

(2) **C**

(3) Data is represented in a tree-like hierarchical structure, therefore hierarchical database

Try

1 Answer the following questions.

(1) Complete the following sentences by filling in the blanks [1] to [4] with the appropriate terms.

> Data that is managed and stored in a certain format to make it easier to use large amounts of data is referred to as a ([1]). A system that creates, operates, and manages a ([1]) is called a ([2]), and it has functions such as data consistency, integrity, independence, ([3]), and ([4]).

(2) Choose the correct explanation for each of the terms [1] to [5] related to database management systems from the options **A** to **E**, and answer using the letters.

[1] Data independence [2] Data integrity [3] Data consistency
[4] Data availability [5] Data confidentiality

A Setting access permissions and performing authentication for data.
B Providing a mechanism to ensure there are no inconsistencies in the relationships between data.
C Method where stored data is managed separately according to its use.
D Backing up and taking other measures so that it is easier to recover data after a failure.
E Providing a mechanism to prevent accidental revisions to or unauthorized tampering of data.

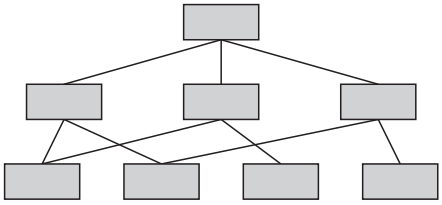
2 Answer the following questions.

(1) Choose the term that best fits into the blanks [1] to [3] in the following sentences from the options **A** to **D** below, and answer using the letters.

> There are several types of databases, including a ([1]) where collected data is organized and managed across multiple tables. Data that is organized in a hierarchical structure resembling a tree is referred to as a ([2]), while data expressed in a network-like structure is referred to as a ([3]).

A Hierarchical database **B** Relational database
C Network database **D** Object-oriented database

(2) What is the term for a database with a structure like the one shown on the right?



(3) What is the term for database management systems other than relational database management systems?

Exercise

1 Answer the following questions.

(1) Complete the following sentences by filling in the blanks [1] and [2] with the appropriate terms.

> A ([1]) refers to data that is organized and stored in a certain format for large-scale use. A ([1]) not only makes data easy to store, but also to search, process, and share. A ([2]) is a system for creating, operating, and managing a ([1]).

(2) Choose one correct statement regarding data availability from the options **A** to **D** below, and answer using the letter.

A Function where a database is managed separately from the programs that use it.
B Function that grants access rights to the data being used and limits users.
C Function that prevents duplication, tampering, and unauthorized registration or updating of data.
D Function for backing up and restoring to prepare for data failures.

(3) For the following statements [1] to [5] regarding the functions of database management systems, mark "○" if the statement is correct, and "×" if it is incorrect.

[1] Data confidentiality involves setting data access rights and implementing authentication.
[2] Data integrity means ensuring that concurrent operations for shared data do not cause inconsistencies.
[3] Data consistency involves not only preventing data duplication but also protecting against data tampering and the registration of fraudulent data.
[4] Data availability involves performing backups, restoration, and recovery to prepare for data failures.
[5] Data independence refers to managing databases separately from the programs that use them.

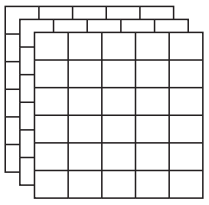
2 Answer the following questions.

(1) Choose the appropriate database for the following items [1] to [3] from the options **A** to **C** below, and answer using the letters.

[1] A database that represents data in a mesh-like structure.
[2] A database where collected data is organized and managed across multiple tables.
[3] A database where data is represented in a tree-like hierarchical structure.

A Hierarchical database **B** Network database
C Relational database

(2) What is the term for a database with a structure like the one shown on the right?



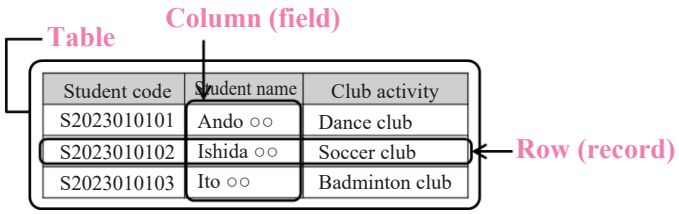
9-2 Database [2]

Point!

Relational Database

(1) ([1]**Relational database** (**RDB**)) : Database where collected data is organized and managed across multiple tables.

- A spreadsheet ([2]**table**) consists of ([3]**rows** (**records**)) and ([4]**columns** (**fields**)).



- Establishing ([5]**relationships**) between multiple tables makes it possible to eliminate duplicate data, which allows data to be handled with integrity.

(2) ([6]**SQL**) : A language used in relational databases to manipulate data.
Performs data registration, insertion, retrieval, and deletion.

(3) Relational Database Operations (Relational Algebra Operations)

[1] ([7]**Selection**) : Only rows that meet given conditions are extracted and displayed.

Student code	Student name	Club code
S2023010101	Ando ○○	C1
S2023010102	Ishida ○○	C2
S2023010103	Ito ○○	C1
S2023010104	Udagawa ○○	C1
S2023010105	Ezawa ○○	C2

Record for club code C2 → **Selection**

Student code	Student name	Club code
S2023010102	Ishida ○○	C2
S2023010105	Ezawa ○○	C2

[2] ([8]**Projection**) : Displaying only certain columns from a table.

Student code	Student name	Club code
S2023010101	Ando ○○	C1
S2023010102	Ishida ○○	C2
S2023010103	Ito ○○	C1
S2023010104	Udagawa ○○	C1
S2023010105	Ezawa ○○	C2

Student name → **Projection**

Student name
Ando ○○
Ishida ○○
Ito ○○
Udagawa ○○
Ezawa ○○

[3] ([9]**Join**) : Linking data from multiple tables according to specific conditions and displaying it as a single table.

Club table

Club code	Club activity
C1	Dance club
C2	Tennis club

Student table

Student code	Student name	Club code
S2023010101	Ando ○○	C1
S2023010102	Ishida ○○	C2
S2023010103	Ito ○○	C1
S2023010104	Udagawa ○○	C1
S2023010105	Ezawa ○○	C2

Join

Student code	Student name	Club code	Club activity
S2023010101	Ando ○○	C1	Dance club
S2023010102	Ishida ○○	C2	Tennis club
S2023010103	Ito ○○	C1	Dance club
S2023010104	Udagawa ○○	C1	Dance club
S2023010105	Ezawa ○○	C2	Tennis club

Warm Up

Answer the following questions.

(1) Complete the following sentences by filling in the blanks [1] to [4] with the appropriate terms.

> Summarizing data into a table often makes it easier to understand. A database where data is managed in a table is referred to as a ([1]). In a ([1]), rows are referred to as ([2]), and columns are referred to as ([3]). Also, establishing ([4]) between multiple tables makes it possible to eliminate duplicate data, which allows data to be handled with integrity.

(2) Consider the operations of relational databases. Table 3 below was created by performing certain operations with Table 1 and Table 2. List all the operations performed among selection, projection, and join.

Table 1

Student code	Student name	Club code
S2023010101	Ando ○○	C1
S2023010102	Ishida ○○	C2
S2023010103	Ito ○○	C1
S2023010104	Udagawa ○○	C1
S2023010105	Ezawa ○○	C2

Table 2

Club code	Club activity
C1	Dance club
C2	Tennis club

Table 3

Student code	Student name	Club activity
S2023010101	Ando ○○	Dance club
S2023010102	Ishida ○○	Tennis club
S2023010103	Ito ○○	Dance club
S2023010104	Udagawa ○○	Dance club
S2023010105	Ezawa ○○	Tennis club

Explanation

(1) [1] Relational database (RDB) [2] Record [3] Field [4] Relationships

(2) Table 3 combines “Student code” and “Student name” from Table 1, and “Club activity” from Table 2, indicating that a join operation has been performed. Also, since the “Club code” in Table 1 is not included in Table 3, it can be concluded that it also involves a projection.
Therefore, join and projection

Try

Answer the following questions.

(1) Choose the appropriate name of the database where data is managed as a table from the options **A** to **C** below, and answer using the letter.

A Hierarchical database **B** Network database

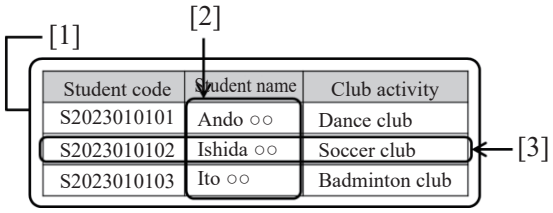
C Relational database

(2) Choose two appropriate names for each of the sections [1] to [3] in the table on the right from the options **A** to **F** below, and answer using the letters.

A Spreadsheet **B** Row

C Column **D** Field

E Table **F** Record



(3) Choose the term that best fits into the blanks [1] to [3] in the following sentences from the options **A** to **D** below, and answer using the letters.

Searches in a relational database are conducted using relational algebra operations.

- The process of extracting multiple columns from a table to create a new table is referred to as ([1]).
- The process of extracting only the rows that meet given conditions to create a new table is referred to as ([2]).
- The process of linking multiple tables based on the relationship between certain items to create a new table is referred to as ([3]).

A Projection **B** Join **C** Selection **D** Normalization

(4) For tables [1] to [3] which were created using the following two tables (Student table and Club table), choose the name of the operation that was performed from the options **A** to **D** below, and answer using the letters.

Student table

Student code	Student name	Club code
S2023010101	Ando ○○	C1
S2023010102	Ishida ○○	C2
S2023010103	Ito ○○	C1
S2023010104	Udagawa ○○	C1
S2023010105	Ezawa ○○	C2

Club table

Club code	Club activity
C1	Dance club
C2	Tennis club

[1]

Student name
Ando ○○
Ishida ○○
Ito ○○
Udagawa ○○
Ezawa ○○

[2]

Student code	Student name	Club code
S2023010102	Ishida ○○	C2
S2023010105	Ezawa ○○	C2

[3]

Student code	Student name	Club code	Club activity
S2023010101	Ando ○○	C1	Dance club
S2023010102	Ishida ○○	C2	Tennis club
S2023010103	Ito ○○	C1	Dance club
S2023010104	Udagawa ○○	C1	Dance club
S2023010105	Ezawa ○○	C2	Tennis club

A Projection **B** Join **C** Selection **D** Normalization

Exercise

1 Answer the following questions.

(1) Choose one correct statement regarding relational databases from the options **A** to **D** below, and answer using the letter.

A The operation of searching for and extracting records that meet specific conditions from a table is called "projection."

B A table consists of records and fields, and allows data to be managed in a table format.

C To maintain data integrity, it is not possible to link data from multiple tables.

D By displaying only specific columns from a table, it is possible to eliminate data redundancy.

(2) Choose one correct statement regarding SQL from the options **A** to **D** below, and answer using the letter.

A Mechanism that ensures the integrity of data stored in a relational database.

B Eliminating duplicate data from a relational database.

C Programming language for manipulating relational databases.

D Operations performed on a relational database such as selection, projection, and join.

(3) Choose one correct statement regarding the "join" operation of a relational database from the options **A** to **D** below, and answer using the letter.

A Creating a new table by linking information from multiple tables based on certain conditions.

B Using a language called SQL to register or delete data in a table.

C Extracting only the records from a table that meet specific conditions.

D Extracting only the fields from information contained in a table that meet specific conditions.

(4) For tables [1] to [3] which were created using the following two tables (Employee table and Branch table), choose the name of the operation that was performed from the options **A** to **D** below, and answer using the letters.

Employee table

Employee number	Name	Department	Branch number
10001	Sato ○○	Sales department	101
10002	Suzuki ○○	General affairs department	101
10003	Sakai ○○	Accounting department	102
10004	Kato ○○	Human resources department	102

Branch table

Branch number	Branch name
101	Tokyo
102	Osaka
103	Kyoto
104	Sapporo

[1]

Employee number	Name	Department	Branch number	Branch name
10001	Sato ○○	Sales department	101	Tokyo
10002	Suzuki ○○	General affairs department	101	Tokyo
10003	Sakai ○○	Accounting department	102	Osaka
10004	Kato ○○	Human resources department	102	Osaka

[2]

Employee number	Name	Department	Branch number
10003	Sakai ○○	Accounting department	102
10004	Kato ○○	Human resources department	102

[3]

Name	Department
Sato ○○	Sales department
Suzuki ○○	General affairs department
Sakai ○○	Accounting department
Kato ○○	Human resources department

A Projection **B** Join **C** Selection **D** Normalization

9-3 Various Information Systems

Point!

1 Information Systems

(1) ([1]**TPS- Transaction Processing System**) : A system that records and processes the company's routine daily transactions

<Example> Point of Sales (POS) System, Airline Reservation System

(2) ([2]**MIS - Management Information System**) : A system that provides periodic reports to manageres to assist them in decision-making.

<Example> Monthly Sales Reports, Inventory Reports.

(3) ([3]**DSS - Decision Support System**): A system that supports manageres in making non-routine decisions through modeling and simulaions.

<Example> "What if" Analysis, Business scenario planning

(4) ([4]**EIS - Executive Information System**): A system that provides summarised information to executive level about the overall performance of the organization.

<Example> Executive Dashboards, KPIs

2 System Integration

(1) ([5]**Vertical Integration**): Linking systems at different levels of the organization (such as TPS with MIS).

(2) ([6]**Horizontal Integration**): Linking the systems at the same level across different departments (such as the sales system with the inventory system).

3 Enterprise Resource Planning (ERP)

(1) ([7]**Enterprise Resource Planning System**) : An integrated system that combines various business functions such as accounting, human resources, supply chain, and customer relationship mnagaement into a single system

Warm Up

Answer the following questions.

(1) Choose the term that best fits into the blanks [1] to [3] in the following sentences from the options **A** to **E** below, and answer using the letters.

> Our daily lives are supported by ([1]) composed of humans, computers, and other information and communication technology equipment. Examples include ([2]) where data is collected and managed at the time a product is sold, and ([3]) where data from satellites is obtained to determine your present location and the operation status of buses and other transportation systems.

A POS system **B** Information systems **C** GPS (Global Positioning System)
D ITS (Intelligent Transport System) **E** SNS (Social Networking Service)

Explanation

(1) [1] **B** [2] **A** [3] **C**

Try

1 Answer the following questions.

(1) Complete the following sentences by filling in the blanks [1] to [4] with the appropriate terms.

> A system that utilizes a network to collect, share, and transmit various data and information is referred to as an (　[1]　). Examples of ([1]) include (　[2]　), which is a system that transmits and receives road information to resolve issues such as traffic accidents and congestion. In addition, a (　[3]　) is a system used in convenience stores and supermarkets to collect and manage data at the point of sales.

(2) What is the term for the satellite positioning system that collects location information for any place on Earth?

Exercise

1 Choose the most appropriate explanation of a POS system from the options **A** to **D** below, and answer using the letter.

A A system that uses artificial satellites to determine current locations.
B A system that operates by utilizing networks to collect, share, and transmit various data and information.
C A system used in convenience stores and other shops to manage product sales information.
D A system for transmitting and receiving road information to resolve issues such as traffic accidents and congestion.

2 Choose the most appropriate explanation for vertical integration from the options **A** to **D** below, and answer using the letter.

A Linking systems at the same level across different departments of the organization..
B Linking systems at different levels of the organization.
C Linking systems at a single level within a specific department.
D Linking systems between two unrelated departments

10-1 Types of Data and Analysis

Point!

1 Types of Data

(1) ([1]**Quantitative data**) : Data that is expressed in numbers and where the size of the numbers has meaning.

[1] ([2]**Interval scale**) : Data where the intervals between numbers have meaning.
<Examples> Time, temperature, calendar year, etc.

[2] ([3]**Ratio scale**) : Data where not only the intervals between numbers but also the ratios of the numbers have meaning.
<Examples> Length, weight, age, etc.

(3) ([4]**Qualitative data**) : Data used to distinguish classifications or types.

[1] ([5]**Nominal scale**) : Data that only holds meaning in distinguishing different categories.
<Examples> Blood type, prefecture, phone number, etc.

[2] ([6]**Ordinal scale**) : Data in which the order is meaningful but the intervals are not meaningful.
<Examples> Grades on report cards, test rankings, grade level, etc.

3 Data Analysis Approachs

(1) ([7]**Discriptive Statistics**) : Summarizing and organizing historical data to get insights about the characteristics of a sample

[1] ([8]**Measures of centeral tendency**) : Mean, Median,and Mode.

[2] ([9]**Measures of Spread**) : Range, Variance,and Standard Deviation

(2) ([10]**Inferential Statistics**) : Used to make inferences, predictions, and generalizations about the entire population from the data of a sample.

[1] ([11]**Hypothesis Testing**)

[2] ([12]**Confidence Intervals**)

Warm Up

Answer the following questions.

(1) For the data shown in [1] to [6] below, answer A for quantitative data and B for qualitative data.

[1] Time [2] Blood type [3] Names of U.S. states
[4] Weight [5] Test ranking [6] Age

(2) Into which scale of measurement can the data in [1] to [6] be classified? Choose one from the options **A** to **D** below, and answer using the letters.

[1] Time [2] Blood type [3] Names of U.S. states
[4] Weight [5] Test ranking [6] Age

A Interval scale **B** Ratio scale **C** Nominal scale **D** Ordinal scale

Explanation

(1) [1] A [2] B [3] B [4] A [5] B [6] A
(2) [1] **A** [2] **C** [3] **C** [4] **B** [5] **D** [6] **B**

Try

1 Answer the following questions.

(1) For the data shown in [1] to [9] below, answer A for quantitative data and B for qualitative data.

[1] Marathon times [2] License plate numbers [3] Number of cars
[4] Sales revenue of a company [5] Impressions of cooking [6] Days of the week
[7] Length of traffic jams [8] Addresses [9] Favorite foods

(2) Choose the description for the characteristics of scales of measurements [1] to [4] from the options **A** to **D** in [Group A]. Then, choose the item that represents the scale from the options a to d in [Group B]. Answer both questions using the letters.

[1] Interval scale [2] Ordinal scale [3] Ratio scale [4] Nominal scale

[Group A]

A A scale with equal intervals but without meaningful ratios
B A scale where the order has meaning, but the intervals do not
C A scale represented by names or characteristics for classification and differentiation
D A scale where the origin is defined and both intervals and ratios have meaning

[Group B]

a Grade b Product prices c Phone numbers d Western calendar years

Exercise

1 Answer the following questions.

(1) Choose the correct explanation for nominal data from the options **A** to **D** below, and answer using the letter.

A Data that is expressed in numbers and where the size of the numbers has meaning.

B Data published on the internet by governments or businesses that is freely accessible and usable by businesses.

C Data to which numbers are assigned that have a meaningful order, but where the intervals have no meaning.

D Data represented by names or characteristics for distinguishing and classifying subjects.

2 Answer the following questions.

(1) Choose one scale of measurement for each of the data types shown in [1] to [6] below from the options **A** to **D** below, and answer using the letters.

[1] Temperature

[2] Occupation

[3] Number of visitors to an amusement park

[4] Uniform numbers of baseball players

[5] Number of cars sold

[6] Marathon ranking

A Interval scale **B** Ratio scale **C** Nominal scale **D** Ordinal scale

10-2 Data Analysis [1]

Point!

Data Organization

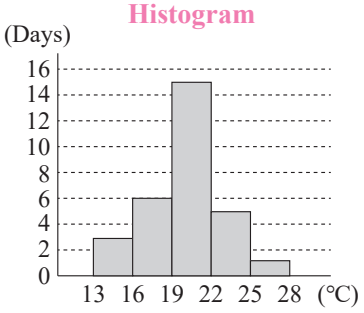
(1) ([1]**Frequency distribution table**) : A table that organizes and summarizes data, as shown on the right.

- The interval of the frequency distribution table is referred to as a ([2]**class**), the width of the interval is called the ([3]**class width**), and the midpoint value of the class is called the ([4]**class mark**).
- The number of data values included in each class is referred to as the ([5]**frequency**).

Frequency distribution table

Class (°C)	Frequency (days)
13 or higher and lower than 16	3
16 to 19	6
19 to 22	15
22 to 25	5
25 to 28	1
Total	30

Histogram



(2) ([6]**Histogram**) : A frequency distribution table presented as a bar graph. (see figure above)

(3) Measure of central tendency

Measure of central tendency : A single numerical value representing the characteristic of a dataset.

[1] ([7]**Mean**) : The value obtained by dividing the sum of the data by the number of data points. In spreadsheet software, it can be determined using the ([8]**AVERAGE**) function.

[Cell I3]=AVERAGE(B3:H3)

	A	B	C	D	E	F	G	H	I
1	Analysis of maximum temperatures in the 4th week of February 2023								
2		19th (Sun.)	20th (Mon.)	21st (Tue.)	22nd (Wed.)	23rd (Thurs.)	24th (Fri.)	25th (Sat.)	Mean
3	Tokyo	18.5	14.7	9.2	10.4	10.4	12.1	12.7	12.57
4	Osaka	14.3	12.7	8.5	10	12.5	8.5	10	10.93

[2] ([9]**Median**) : The value that appears at the center when all the data is arranged in ascending order. If the number of data points is even, the median is the mean of the two central values. In spreadsheet software, it can be determined using the ([10]**MEDIAN**) function.

[Cell I3]=MEDIAN(B3:H3)

	A	B	C	D	E	F	G	H	I
1	Analysis of maximum temperatures in the 4th week of February 2023								
2		19th (Sun.)	20th (Mon.)	21st (Tue.)	22nd (Wed.)	23rd (Thurs.)	24th (Fri.)	25th (Sat.)	Medium
3	Tokyo	18.5	14.7	9.2	10.4	10.4	12.1	12.7	12.10
4	Osaka	14.3	12.7	8.5	10	12.5	8.5	10	10.00

[3] ([11]**Mode**) : The value that appears most frequently. When arranging data in a frequency distribution table, the class mark of the class with the highest frequency is considered the mode. In spreadsheet software, it can be determined using the ([12]**MODE**) function.

[Cell I3]=MODE(B3:H3)

	A	B	C	D	E	F	G	H	I
1	Analysis of maximum temperatures in the 4th week of February 2023								
2		19th (Sun.)	20th (Mon.)	21st (Tue.)	22nd (Wed.)	23rd (Thurs.)	24th (Fri.)	25th (Sat.)	Mode
3	Tokyo	18.5	14.7	9.2	10.4	10.4	12.1	12.7	10.40
4	Osaka	14.3	12.7	8.5	10	12.5	8.5	10	8.50

Warm Up

Answer the following questions.

(1) The data on the right represents the results of a handball throw from a class of 32 students. Answer [1] and [2].

[1] Create a frequency distribution table where the class interval is 12 m to less than 15 m, with each class having a width of 3 m.

[2] Based on the frequency distribution table created in question [1], draw a histogram.

15	20	21	23	30	27	27	16
20	18	22	19	20	21	12	21
24	27	22	26	25	32	24	21
21	23	20	16	23	21	21	24

The unit is m.

(2) The data on the right represents the scores of 12 students who played a game. Determine the mean, median, and mode of the data.

6	9	3	6	10	12
4	3	8	10	7	6

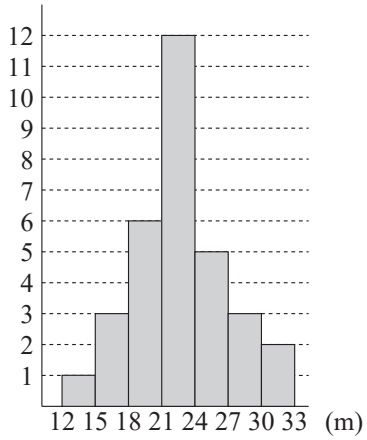
The unit is points.

Explanation

(1) [1]

Class (m)	Frequency (persons)
12 or higher and lower than 15	1
15 to 18	3
18 to 21	6
21 to 24	12
24 to 27	5
27 to 30	3
30 to 33	2
Total	32

[2] (Persons)



(2) Mean: $= \dfrac{6+9+3+6+10+12+4+3+8+10+7+6}{12} = \dfrac{84}{12} = 7$ 7 points

Median: First, arrange all the data in ascending order.

3, 3, 4, 6, 6, 6, 7, 8, 9, 10, 10, 12

Since the number of data points is even, the median is the mean of the two central values, which are 6 and 7.

Therefore, $\dfrac{6+7}{2} = 6.5$ 6.5 points

Mode: The value that occurs most frequently is 6 6 points

Try

1 The following data represents the quiz scores of 20 high school students. Answer the following questions.

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

(1) Determine the mean of the data.
(2) Determine the median of the data.
(3) Determine the mode of the data.

2 The following data shows the recorded daily maximum temperatures in Tokyo for February 2023. Answer the following questions.

13.1	9.2	6.2	11.2	13.6	15.4	11.7	10.6	3.5	12
14.1	16.9	10.3	10.7	7.8	9.6	10.8	15	18.5	14.7
9.2	10.4	14.4	12.1	12.7	10.7	19.4	15	(°C)	

(1) Create a frequency distribution table where the class interval is 14°C to less than 16°C, with each class having a width of 2°C.
(2) Based on the frequency distribution table created in step (1), draw a histogram.

3 The following table summarizes the functions available in spreadsheet software. Choose the term that best fits into the blanks [1] to [3] from the options **A** to **D** below, and answer using the letters.

Function	Explanation
([1])	Determines the mean.
([2])	Determines the median.
([3])	Determines the mode.

A MODE **B** AVERAGE **C** MEDIAN **D** VARP

Exercise

1 Answer the following questions.

(1) The following data records the heights of 30 students in a class. Answer the following questions.

168	151	168	166	183	162	167	176	161	175	
156	165	173	152	165	177	156	171	158	172	
172	148	146	167	173	155	169	180	161	163	(cm)

[1] Create a frequency distribution table where the class interval is 145 cm to less than 150 cm, with each class having a width of 5 cm.

[2] Based on the frequency distribution table created in question [1], draw a histogram.

(2) The following data represents the daily sleep duration of 20 high school students. Answer the following questions.

7	7	5	9	7	6	8	4	8	10	
3	8	6	8	9	5	8	6	8	8	(Time)

[1] Determine the mean of the data.

[2] Determine the median of the data.

[3] Determine the mode of the data.

2 Items **A** to **C** below describe functions available in spreadsheet software. Mark "○" if the statement is appropriate, and "×" if it is inappropriate.

A The mean can be determined using the AVERAGE function in spreadsheet software.

B The median can be determined using the MEDIAN function in spreadsheet software.

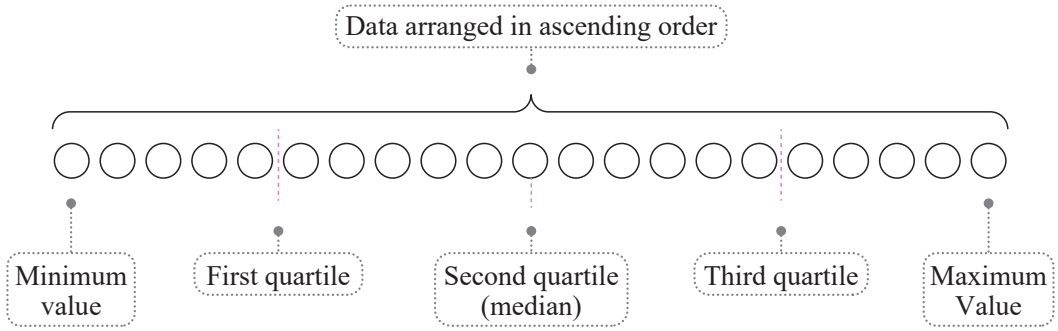
C The mode can be determined using the SUM function in spreadsheet software.

10-3 Data Analysis [2]

Point!

1 Quartiles

(1) ([1]**Quartile**) : The numbers that divide the data into four equal parts when arranged in ascending order. Quartiles are referred to as follows in ascending order: ([2]**first quartile**), ([3]**second quartile**), ([4]**third quartile**). The second quartile is the ([5]**median**).



(2) Steps for determining the quartiles

[1] Arrange the data in ascending order and determine the ([6]**median**).

[2] With the median in [1] as the boundary, divide into two groups: ([7]**less than or equal to the median**) and ([8]**greater than or equal to the median**).

[3] For each group created in [2], determine the ([9]**median**).

2 Box-and-whisker Plots

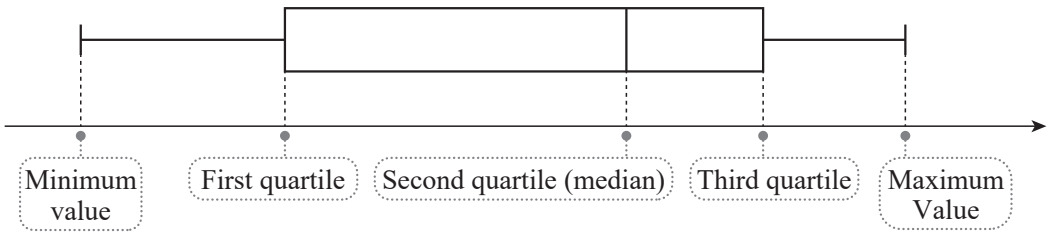
(1) ([10]**Box-and-whisker plot**) : A figure using a box and lines (whiskers) to represent the minimum value, first quartile, second quartile, third quartile, and maximum value in a single figure, as shown below.

(2) Steps to draw a box-and-whisker plot

[1] Determine the ([11]**minimum value**), ([12]**maximum value**), and ([13]**quartiles**), and draw five vertical lines representing the points.

[2] Draw a box with the first quartile as the left edge and the third quartile as the right edge.

[3] Draw a horizontal line from each end of the box to the minimum and maximum values.



*A box-and-whisker plot can also be drawn vertically.

Warm Up

Answer the following questions.

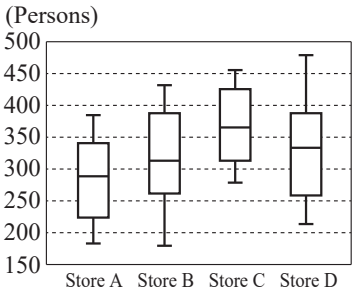
(1) The following data represents the math test scores of ten students.

58 72 52 61 36 43 20 32 38 47 (Points)

[1] Provide the first quartile, second quartile, and third quartile.

[2] Draw a box-and-whisker plot based on this data.

(2) The figure on the right shows data on the number of daily customers at stores A, B, C, and D over a span of 31 days in a box-and-whisker plot.



[1] List all stores with days where the number of customers exceeded 450.

[2] Provide the minimum number of days where the number of customers exceeded 300 at store B.

[3] List all stores that had eight or more days with fewer than 250 customers.

Explanation

(1) [1] When you arrange the data in ascending order,

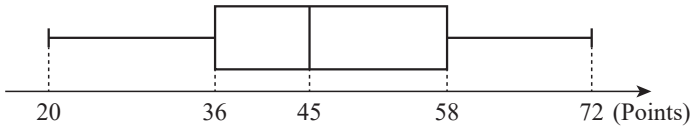
20, 32, 36, 38, 43, 47, 52, 58, 61, 72

The median is (43 + 47) ÷ 2 = 45 (points).

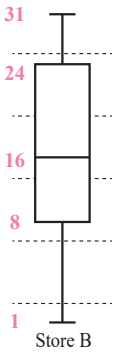
The median of the group less than or equal to the overall median, 20, 32, 36, 38, 43, is 36. The median of the group greater than or equal to the overall median, 47, 52, 58, 61, 72, is 58.

Therefore, the first quartile is 36 points, the second quartile is 45 points, and the third quartile is 58 points.

[2] The minimum value is 20, the maximum value is 72, the first quartile is 36, the second quartile is 45, and the third quartile is 58, so the box-and-whisker plot will look like the figure below.



(2) Since the data was collected over 31 days, the median is the 16th value, the first quartile is the 8th value, and the third quartile is the 24th value. Accordingly, write it into the figure as shown on the right.



[1] Choose the box-and-whisker plots where the maximum exceeds 450, which would be store C and store D.

[2] From the box-and-whisker plot of store B, it can be determined that the median exceeds 300 people. From the figure on the right, the median corresponds to the value of the 16th data point when counted from smallest to largest. Therefore, from the 16th to the 31st data points, the number exceeds 300 people, so it is 16 days.

[3] From the figure on the right, the first quartile is the 8th data point when counted from the smallest. Therefore, we should select the box-and-whisker plot where the first quartile is less than 250 people, so store A.

Try

1 The following data represents the test scores of ten individuals. Answer the following questions.

68 90 75 64 72 32 46 86 59 82 (Points)

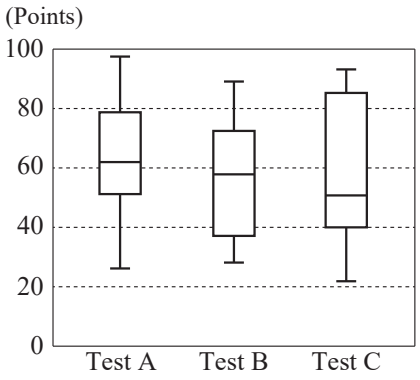
(1) Provide the first quartile, second quartile, and third quartile.

(2) Draw a box-and-whisker plot based on this data.

2 The figure on the right is a box-and-whisker plot representing the scores of tests A, B, and C taken by 50 first-year high school students. Answer the following questions.

(1) Identify all tests where there are 13 or more students scoring 80 or above.

(2) Identify all tests where more than half of the students scored below 60 points.



Exercise

1 The following data represents the Japanese language test scores of 10 individuals. Answer the following questions.

66 77 79 46 30 25 54 95 50 86 (Points)

(1) Provide the first quartile, second quartile, and third quartile.

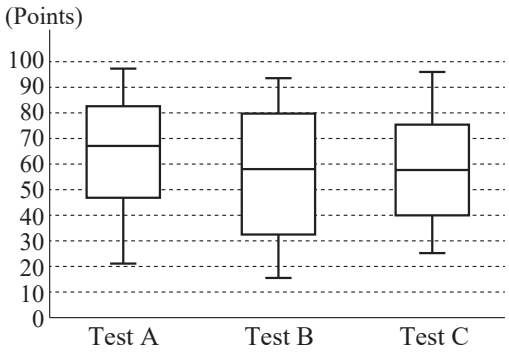
(2) Draw a box-and-whisker plot based on this data.

2 The figure on the right is a box-and-whisker plot representing the scores of tests A, B, and C taken by a class of 30 high school students.

Answer the following questions.

(1) Identify all tests where there are 8 or more students scoring 80 or above.

(2) Identify all tests where more than half of the students scored below 60 points.



10-4 Data Analysis [3]

Point!

Variance and Standard Deviation

• Variance and standard deviation: These represent numerically how much the data is spread out from the mean ([1]**mean**). Let $x_1, x_2, \ldots, x_n$ represent the values of the data. $\bar{x}$ refers to the mean, and n refers to the number of data points.

(1) ([2]**Deviation**) : $x_1 - \bar{x}, x_2 - \bar{x}, \ldots, x_n - \bar{x}$

The deviation is the value obtained by subtracting the mean from a data value.

(2) ([3]**Variance**) : The mean value of $(x - \bar{x})^2$. The ([4]**larger**) the variance, the more dispersed the data is.

In Google Sheets, the VARP function can be used to determine variance, while in Excel, the VAR.P function is used.

(3) ([5]**Standard deviation**) : $s = \sqrt{\text{Variance}}$

The standard deviation is the positive square root of the variance.

In spreadsheet software, the STDEV.P function can be used to determine the variance.

The standard deviation should be expressed in the same unit as the data.

<Steps for Calculating the Standard Deviation>

Summarize data in a table as shown on the right according to the following steps.

[1] Determine the ([6]**mean**) of the data.

[2] Find the ([7]**deviation**) for each individual data point.

[3] ([8]**Square the deviation**) of each individual data point.

[4] Determine the variance, which is the ([9]**mean**) of [3].

	x	$x - \bar{x}$	$(x - \bar{x})^2$
x_1		[2]	[3]
x_2		[2]	[3]
x_3		[2]	[3]
Total			
Mean	[1]		[4]

Variance

Warm Up

The following data represents the results of a handball throw by six individuals.

26, 25, 32, 28, 32, 25 (m)

(1) Determine the mean $\bar{x}$ of the data.

(2) Determine the variance and standard deviation of the data.

Explanation

(1) Summarize the data in a table like the one on the right.
The mean is 28 m.

(2) The variance is 9, and the standard deviation is $\sqrt{9} = 3$ (m).
3 m

	x	$x - \bar{x}$	$(x - \bar{x})^2$
x_1	26	-2	4
x_2	25	-3	9
x_3	32	4	16
x_4	28	0	0
x_5	32	4	16
x_6	25	-3	9
Total	168		54
Mean	28		9

Try

1 The following data represents the English vocabulary test scores of ten students.

9, 3, 4, 10, 10, 5, 7, 9, 10, 3 (points)

(1) Determine the mean of the data.

(2) Determine the variance and standard deviation of the data to two decimal places. However, let $\sqrt{2}$ = 1.414.

2 The following table shows the number of days it took five students to complete two types of assignments, A and B.

A	22	28	25	26	24
B	21	29	27	25	28

(1) Determine the variance for assignment A.

(2) Determine the standard deviation to two decimal places for assignment B. However, let $\sqrt{2}$ = 1.414.

(3) Answer which data set, assignment A or assignment B, has a greater variance.

Exercise

1 The following data represents the weights of eight harvested strawberries.

22, 25, 18, 17, 22, 21, 20, 15 (g)

(1) Determine the mean of the data.

(2) Determine the variance and standard deviation of the data.

2 The following table shows the test scores in math and English for five students.

Math	7	9	6	10	8
English	10	8	6	4	2

(1) Determine the variance of the math scores.

(2) Determine the standard deviation of the English test scores to two decimal places. However, let $\sqrt{2}$ = 1.414.

(3) Answer which data set has a greater variance, math or English.

10-5 Data Analysis [4]

Point!

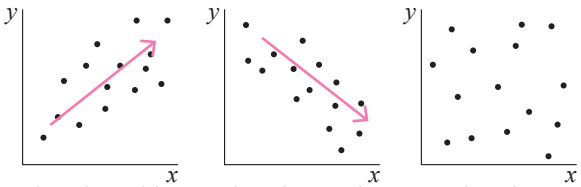
Scatter Plots, Correlations, and Cross Tabulation

(1) ([1]**Scatter plot**) : A graph that represents points on a plane using pairs of variables, x and y, as coordinates.

[1] When there is a tendency for both corresponding x and y to increase with each other, it is referred to as a ([2]**positive correlation**).

[2] When there is a tendency for one of the corresponding x and y to decrease as the other increases, it is referred to as a ([3]**negative correlation**).

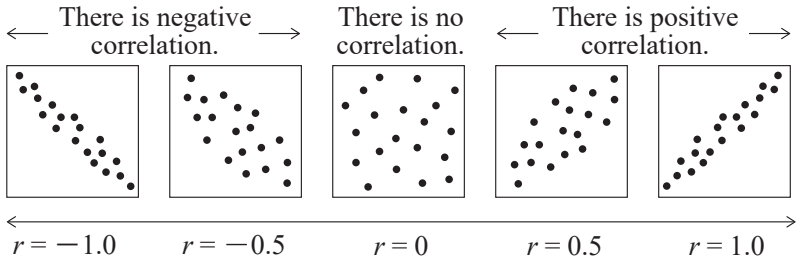
[3] When there is neither a positive nor a negative correlation between the corresponding x and y, it is referred to as ([4]**no correlation**).



There is positive correlation. | There is negative correlation. | There is no correlation.

(2) ([5]**Correlation coefficient**) : An indicator to measure the strength of a correlation.

- The correlation coefficient r is represented by ([6] $-1 \leq r \leq 1$).
- The correlation coefficient r indicates a stronger ([7]**positive correlation**) as it approaches 1, and a stronger ([8]**negative correlation**) as it approaches -1.



- To determine the correlation coefficient using spreadsheet software, you can use the CORREL function.

(3) ([9]**Causal relationship**) : A relationship where one of two things is the cause and the other is the effect.
<Example> When the temperature rises, sales of shaved ice increase.

(4) ([10]**Pseudo-correlation**) : When two things appear to have a causal relationship, even though there is none.
<Example> There is no causal relationship between "As the temperature rises, shaved ice sales increase" and "As the temperature rises, the number of heatstroke cases increases."

(5) ([11]**Cross tabulation**) : An aggregation method for comparing data among two or more categories.

<Example>

	Agree	Oppose	Neither
Male	57	97	46
Female	73	75	52
Total	130	172	98

Warm Up

Answer the following questions.

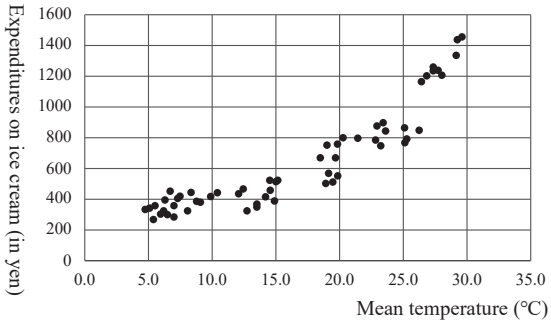
(1) There is data consisting of the following two variables, x and y.

x	7	4	6	2	9	3	8	1	6	3
y	3	6	5	8	3	4	2	9	2	5

[1] Create a scatter plot.

[2] Describe the tendency observed between x and y.

(2) The relationship between mean temperature and ice cream expenditures was investigated and summarized in the scatter plot on the right.



[1] Choose the description representing the tendency of the two from the options **A** to **D** below, and answer using the letter.

A There is a weak negative correlation.

B There is a strong negative correlation.

C There is a weak positive correlation.

D There is a strong positive correlation.

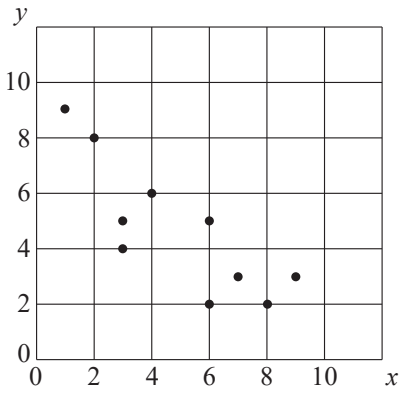
[2] Choose the number that best fits into the blank in the following sentence from the options **A** to **D** below, and answer using the letter.

The correlation coefficient between the mean temperature and ice cream expenditures was ( ).

A -0.9 **B** -0.4 **C** 0.4 **D** 0.9

Explanation

(1) [1] The scatter plot is shown below.



[2] There is a negative correlation according to the scatter plot.

(2) [1] Based on the scatter plot, it can be interpreted as having a “strong positive correlation” because it forms a linear upward graph. Therefore, **D**.

[2] Based on [1], since it is known that there is a strong positive correlation between mean temperature and ice cream expenditure, it can be inferred that the highest value of 0.9 is most appropriate. Therefore, **D**.

Try

1 There is data consisting of the following two variables, x and y.

x	7	4	6	2	8	3	8	1	6	3
y	3	6	5	8	3	4	2	8	2	5

(1) Create a scatter plot.

(2) Describe the tendency observed between x and y.

2 To examine the relationship between study time, commuting time, and test scores, a survey was taken by 40 students in a class regarding their daily study time on weekdays. Below are scatter plots representing the relationship between each student's study time and test scores (Figure 1), and the relationship between commuting time and test scores (Figure 2). Answer the following questions.

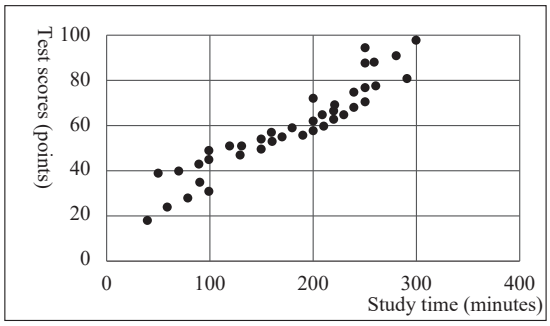


Figure 1: Scatter plot of study time and test scores

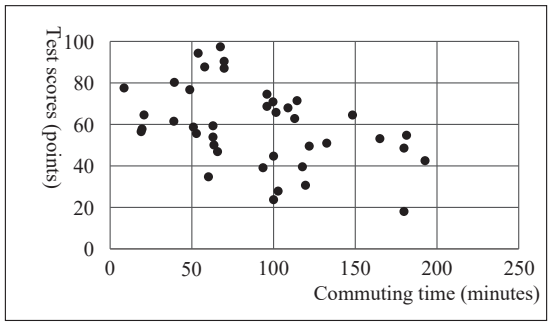


Figure 2: Scatter plot of commuting time and test scores

(1) Compare the two scatter plots, and choose the trend observed in each from the options **A** to **D** below, and answer using the letter.

A Figure 1 shows a strong positive correlation, while Figure 2 shows a strong negative correlation.

B Figure 1 shows a strong positive correlation, while Figure 2 shows a weak negative correlation.

C Figure 1 shows a weak positive correlation, while Figure 2 exhibits a strong negative correlation.

D Figure 1 shows a weak positive correlation, while Figure 2 shows a weak negative correlation.

(2) Choose the number that best fits into the blanks [1] and [2] in the following sentence from the options **A** to **D** below, and answer using the letters.

> When the correlation coefficients for study time, commuting time, and test scores are determined, the correlation coefficient between study time and test scores is ([1]), and the correlation coefficient between commuting time and test scores is ([2]).

A -0.9 **B** -0.4 **C** 0.4 **D** 0.9

3 The table on the right shows the results of a survey taken by 50 students in a class regarding whether they like Japanese, math, and English. Fill in the appropriate values for blanks [1] to [7] in the table.

	Like	Dislike	Neither	Total
Japanese	2	([1])	([2])	([3])
Math	6	([4])	5	13
English	([5])	([6])	1	18
Total	15	21	([7])	50

Exercise

1 There is data consisting of the following two variables, x and y.

x	6	4	7	5	8	6	2	9	8	5
y	7	10	2	4	3	4	4	5	4	7

(1) Create a scatter plot.

(2) Describe the tendency observed between x and y.

2 The rent of rental properties around a station was investigated to examine the relationship with the size of the room and the distance to the nearest station. The following are scatter plots representing the relationship between the size of each room and the rent (Figure 1), and the relationship between the distance to the nearest station from each room and the rent (Figure 2). Answer the following questions.

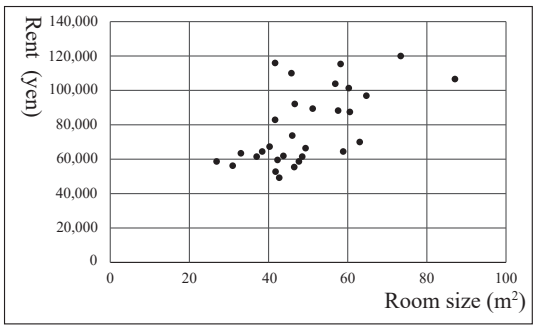


Figure 1: Scatter plot of room size and rent

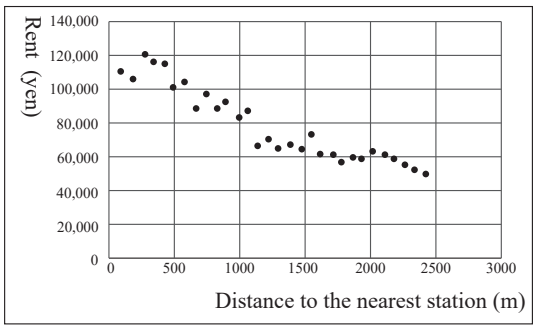


Figure 2: Scatter plot of rent and distance to nearest station

(1) Compare the two scatter plots and provide the tendencies that can be observed in each. Choose one from the options **A** to **D** below, and answer using the letter.

A Figure 1 shows a strong positive correlation, while Figure 2 shows a strong negative correlation.

B Figure 1 shows a weak positive correlation, while Figure 2 exhibits a strong negative correlation.

C Figure 1 shows a strong positive correlation, while Figure 2 shows a weak negative correlation.

D Figure 1 shows a weak positive correlation, while Figure 2 shows a weak negative correlation.

(2) Choose the number that best fits into the blanks [1] and [2] in the following sentence from the options **A** to **D** below, and answer using the letters.

> When the correlation coefficients for room size and rent, and distance to the nearest station and rent are determined, the correlation coefficient between room size and rent is ([1]), and the correlation coefficient between the distance to the nearest station and rent is ([2]).

A -0.9 **B** -0.6 **C** 0.6 **D** 0.9

3 The table on the right shows the results of a survey taken by 200 school students regarding their main means of commuting to and from school, categorized by grade. Fill in the appropriate values for blanks [1] to [7] in the table.

	On foot	Bicycle	Other	Total
Grade 1	29	33	([1])	([2])
Grade 2	([3])	([4])	([5])	67
Grade 3	([6])	32	9	66
Total	([7])	94	24	200

10-6 Data Analysis [5]

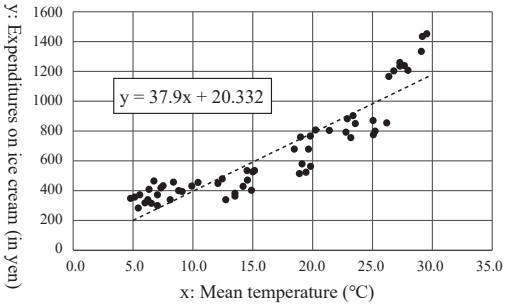
Point!

Regression Analysis

(1) ([1]**Regression analysis**) : A method to investigate and clarify the relationship between a resulting value and a causal value. It is used in predictions and simulations.

(2) ([2]**Simple regression analysis**) : Predicts the outcome variable y using the causal variable x.

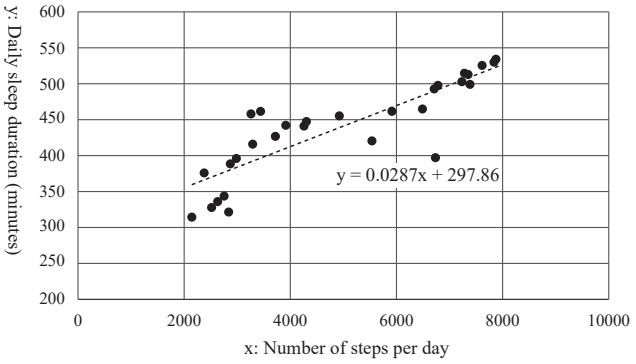
(3) ([3]**Regression line**) : Refers to the line used to determine predicted values in a scatter plot. A regression line can be expressed with the ([4]**regression line equation**) in the form of a first-degree function y = ax + b.



(4) ([5]**Least squares method**) : A method used to ([6]**minimize**) the vertical error, or the ([7]**residual**), between the actual data points and the regression line.

Warm Up

The following scatter plot summarizes the relationship between the number of steps and the sleep duration for a student over the course of one month. Answer the following questions about this graph.



(1) What is the term for describing the process of determining the equation for a straight line in the form y = ax + b representing the relationship between two variables, explanatory variable x and resulting variable y?

(2) Complete the following sentences by filling in the blanks [1] to [3] with the appropriate items.

> When representing the relationship between two variables with a straight line, the ([1]) method is for finding the line that best fits the actual data. In the ([1]) method, a straight line is determined to ([2]) the error, referred to as the ([3]), between each data point and the line.

(3) The straight line in the figure represents the relationship between two variables using a straight line. If the equation of this line is "y = 0.0287x + 297.86," what is the estimated sleep duration in minutes when the number of steps per day is 5,000? Give the answer as an integer (rounded off to the nearest whole number).

Explanation

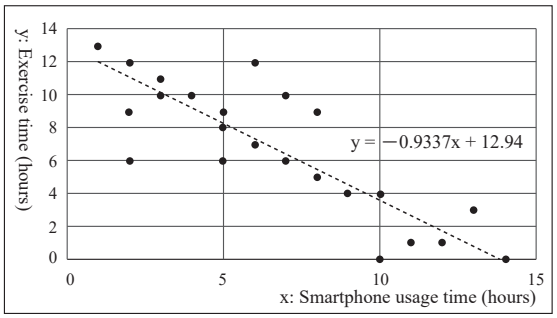
(1) Simple regression analysis

(2) [1] least squares [2] residual [3] minimize

(3) Substituting x = 5,000 into y = 0.0287x + 297.86, we get
y = 0.0287 × 5,000 + 297.86 = 441.36 ≈ 441
Therefore, the sleep duration is estimated at 441 minutes.

Try

The following figure is a scatter plot summarizing the results of a survey taken by 30 students from a class regarding their smartphone usage time and exercise time per day. Refer to this graph and answer the following questions.



(1) What is the term for the equation for a straight line in the form y = ax + b representing the relationship between two variables: causal variable x and resulting variable y?

(2) The straight line in the figure represents the relationship between two variables using a straight line. If the equation for this line is "y = − 0.9337x + 12.94," what is the estimated exercise time when smartphone usage is 10 hours? Give the answer as an integer (rounded off to the nearest whole number).

(3) Choose the term or number that best fits into the blanks [1] and [2] in the following sentences from the options **A** to **D** below.

> The least squares method is used to minimize the error between a straight line representing the relationship between two variables and the actual data. This type of error is referred to as ([1]). If the absolute value of the correlation coefficient is ([2]), the value obtained from the straight line determined by the least squares method is considered an estimate.

A Residual **B** Deviation **C** 1 **D** Other than 1

Exercise

1 The following figure is a scatter plot summarizing the measurement results of the height and weight of 100 adults. Refer to this graph and answer the following questions.

(1) Choose the one that best fits into the blanks [1] and [2] in the following sentences from the options **A** to **D** below.

> Based on the scatter plot, there is a tendency for weight to increase as height increases. Accordingly, when ([1]), it is referred to as a ([2]) between the two variables.

A Positive correlation
B Negative correlation
C One value increases and the other value also increases
D One value increases and the other value decreases

(2) The straight line in the figure represents the relationship between two variables using a straight line. If the equation for the line is "y = 0.5511x − 32.958," what is the approximate weight when the height is 173 cm? Give the answer as an integer (rounded off to the nearest whole number).

11-1 Modeling

Point!

Modeling

(1) ([1]**Model**) : A simplified representation of a target phenomenon.

(2) ([2]**Modeling**) : The process of creating models for events or phenomena.

(3) Classification of Models by Characteristics

[1] ([3]**Static model**) : A model that does not undergo changes over time.
<Examples> Room layout diagrams, the relationship between the radius and volume of a sphere, etc.

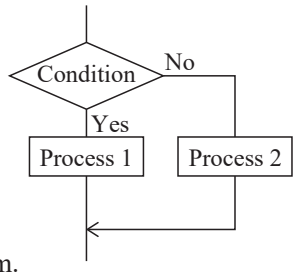
[2] ([4]**Dynamic model**) : A model that is influenced by changes over time.

- ([5]**Deterministic model**) : A model that does not exhibit irregular behavior. There is only one result.
<Examples> Bank account balance, relationship between time and travel distance for a car moving at a constant speed, etc.
- ([6]**Probabilistic model**) : A model that includes irregular behavior. The result is not a single outcome.
<Examples> Outcomes of dice rolls, lottery draws, weather forecasts, etc.

(4) Classification of Models Based on Type of Expression

[1] ([7]**Physical model** (**scale model**)) : A physical representation of an object.

- ([8]**Enlarged model**) : A model that is larger than the actual object.
<Examples> Molecular model, DNA model, etc.
- ([9]**Full-scale model**) : A model that is the same size as the actual object.
<Examples> Model room, life-size dummy, etc.
- ([10]**Reduced model**) : A model smaller than the actual object.
<Examples> Globe, plastic model, etc.



Flowchart

[2] ([11]**Diagrammatic model**) : A representation of something using a diagram.
<Examples> Flowcharts, route maps, etc.

[3] ([12]**Mathematical model**) : A representation of something using mathematical formulas or logical expressions.
<Examples> Speed × Time = Distance,
Current × Resistance = Voltage, etc.

(5) Modeling steps

[1] Clearly define the ([13]**purpose**) of modeling.

[2] Clarify the ([14]**elements that constitute the model**) and their relationships.

[3] Determine the ([15]**representation method**) of the model.

Warm Up

Answer the following questions.

(1) Choose the classification of the models most related to sentences [1] to [4] from the options **A** to **C** below, and answer using the letters.

[1] The relationship between the radius and area of a circle

[2] Outcome of a dice roll

[3] Weather forecast

[4] The relationship between time and distance traveled for a bicycle at a constant speed

A Static model **B** Deterministic model **C** Probabilistic model

(2) Choose the classification of the models most related to sentences [1] to [4] from the options **A** to **C** below, and answer using the letters.

[1] Molecular model [2] Newton's equation of motion

[3] Flowchart of a program [4] Plastic model

A Physical model **B** Diagrammatic model **C** Mathematical model

Explanation

(1) [1] **A** [2] **C** [3] **C** [4] **B**

(2) [1] **A** [2] **C** [3] **B** [4] **A**

Try

Answer the following questions.

(1) Complete the following sentences by filling in the blanks [1] to [5] with the appropriate terms.

> ([1]) are referred to as a simplified representation of a target phenomenon. Types of ([1]) include: a ([2]) model, which is a physical representation of an object; a ([3]) model, which uses mathematical expressions or logical formulas to represent the behavior of phenomena; and a ([4]) model, which uses diagrams to represent phenomena. Examples of ([2]) models include full-scale models, ([5]) models, and scale models.

(2) Choose the classification of the models most related to sentences [1] to [4] from the options **A** to **C** below, and answer using the letters.

[1] A single die was rolled once to calculate the probability of rolling a five.
[2] A layout diagram of a room was created to rearrange its furnishings.
[3] The interest after five years was calculated with an interest rate of 1%.
[4] A prediction of the weather tomorrow.

A Static model **B** Deterministic model **C** Probabilistic model

(3) Choose the models that correspond to [1] to [3] from the options **A** to **F** below, and answer using the letters.

[1] Enlarged model [2] Full-scale model [3] Scale model

A Model room **B** Globe **C** Life-size dummy
D Plastic model **E** DNA model **F** Molecular model

Exercise

1 Answer the following questions.

(1) Choose the term that best fits into the blanks [1] to [3] in the following sentence from the options **A** to **D** below, and answer using the letters.

> The process of creating models of events or phenomena is referred to as ([1]). Additionally, models can be broadly classified based on their characteristics into two categories: ([2]) models that do not undergo changes over time, and ([3]) models that are influenced by changes over time.

A Physical **B** Static **C** Dynamic **D** Modeling

(2) Choose the models that correspond to [1] to [3] from the options **A** to **F** below, and answer using the letters.

[1] Physical model [2] Diagrammatic model [3] Mathematical model

A Plastic model **B** Flowchart **C** Life-size dummy
D Route map **E** DNA model **F** Ohm's law

11-2 Simulations [1]

Point!

1 Methods of Referencing in Spreadsheet Software

(1) ([1]**Relative reference**) : A method of referencing where the position of the referenced cell changes automatically.

(2) ([2]**Absolute reference**) : A method of referencing that keeps the position of the row or column of the referred cell consistently fixed.
By adding "([3]**$**)," it becomes an absolute reference.
<Example> If you copy the formula as "C3," every formula will be able to refer to cell C3.

2 Simulations

(1) ([4]**Simulation**) : Manipulating a model in order to predict phenomena or events. Even when it is difficult to use actual objects, predictions can be made through simulations.

(2) Simulations Using Spreadsheet Software

[1] Water volume simulation

<Example> The relationship between the time water is poured into an empty container and the amount of water accumulated in the container
[Formula] Water volume = ([5]**(Water inflow rate) × (Elapsed time)**)

	A	B	C	D
1	**Simulation of water inflow rate**			
2	**Water inflow rate [L/min]**		**Elapsed time [minutes]**	**Water volume [L]**
3	6		0	0
4			1	6
5			2	12
6			3	18
7			4	24

	A	B	C	D
1	**Simulation of water inflow rate**			
2	**Water inflow rate [L/min]**		**Elapsed time [minutes]**	**Water volume [L]**
3	6		0	= A3*C3
4			1	= A3*C4
5			2	= A3*C5
6			3	= A3*C6
7			4	= A3*C7

[2] Simulation of balance

- ([6]**Compound interest method**) : A method in which the interest generated from the principal (balance) is incorporated into the principal for the next period.

[Formula] Interest = ([7]**(Current balance) × (Interest rate)**)
Next period's balance = ([8]**(Current balance) + (Interest)**)

	A	B	C	D	E	F
1	**Simulation of account balance**					
2	**Principal amount (in yen)**	**Interest rate (%)**		**Number of years**	**Account balance (in yen)**	**Interest (in yen)**
3	1,000,000	3%		0	1,000,000	0
4				1	1,030,000	30,000
5				2	1,060,900	30,900
6				3	1,092,727	31,827

	A	B	C	D	E	F
1	**Simulation of account balance**					
2	**Principal amount (in yen)**	**Interest rate (%)**		**Number of years**	**Account balance (in yen)**	**Interest (in yen)**
3	1,000,000	3%		0	= A3	0
4				1	= E3 + F4	= E3*B3
5				2	= E4 + F5	= E4*B3
6				3	= E5 + F6	= E5*B3
7						

Warm Up

Initially, 1,000 yen was saved. Using spreadsheet software, a table was created like the one below to simulate the relationship between the number of months and the amount saved when saving 500 yen each month. Answer the following questions.

	A	B	C	D	E
1	**Allowance simulation**				
2	**Initial savings amount (in yen)**	**Allowance (yen)**		**Number of months**	**Savings amount**
3	1,000	500		0	1,000
4				1	1,500
5				2	2,000
6				3	2,500

(1) Can this model be represented as a deterministic model or a probabilistic model?

(2) Choose the term that best fits into the blanks [1] to [3] in the following formula from the options **A** to **D** below, and answer using the letters.

Savings amount = [1] + [2] × [3]

A Number of months **B** Allowance

C Initial savings amount **D** Amount saved last month

(3) The formula entered in cell E4 in the diagram is as follows. Note that the formula in cell E4 is copied and used to E6. Complete the following formula by filling in the blanks [1] to [3] with the appropriate answers.

[Cell E4] = [1] + [2] * [3]

Explanation

(1) The number of months and the savings amount change in a regular pattern. Therefore, it is a deterministic model.

(2) Savings in the first month = 1,000 + 500 × 1

Savings in the second month = 1,000 + 500 × 2

⋮

Therefore, [1] **C** [2] **B** [3] **A** (note: [2] and [3] can be in any order)

(3) Based on (2), enter the cell representing the initial savings amount in [1], the allowance in [2], and the number of months in [3]. Since the same cell is always used for [1] and [2], use "$" to make it an absolute reference. Also, for [3], the cell in column E is filled with the value from column D in the same row, so for cell E4, insert the value from D4. Therefore, [1] A3 [2] B3 [3] D4

Try

1 Using spreadsheet software, a table was created like the one below to simulate the relationship between the inflow time and volume of water in a container when water is poured into an empty container. Answer the following questions.

	A	B	C	D
1	**Water volume simulation**			
2	**Water inflow rate [L/min]**		**Elapsed time [minutes]**	**Water volume [L]**
3	5		0	0
4			1	5
5			2	10
6			3	15
7			4	20

(1) Can this model be represented as a deterministic model or a probabilistic model?

(2) The relationship among water volume, inflow rate, and elapsed time is expressed as follows. Complete the following formula by filling in the blanks **A** and **B** with the appropriate terms.

(Water volume) = **A** × **B**

(3) The formula entered in cell D3 in the diagram is as follows. Note that the formula in cell D3 is copied and used to D7. Complete the following formula by filling in the blanks **A** and **B** with the appropriate answers.

[Cell D3] = **A** * **B**

2 Using spreadsheet software, a table was created like the one below to simulate how the remaining balance changes when 1,000,000 yen is deposited with a bank. Answer the following questions. Furthermore, the interest generated from the principal (balance) is incorporated into the principal for the following period.

	A	B	C	D	E	F
1	**Simulation of account balance**					
2	**Principal amount (in yen)**	**Interest rate (%)**		**Number of years**	**Account balance (in yen)**	**Interest (in yen)**
3	1,000,000	4%		0	1,000,000	0
4				1	1,040,000	40,000
5				2	1,081,600	41,600
6				3	1,124,864	43,264
7						

(1) Can this model be represented as a deterministic model or a probabilistic model?

(2) What is the term for the method where interest generated from the principal (balance) is incorporated into the principal for the next period?

(3) Complete the following formulas by filling in the blanks **A** and **B** with the appropriate terms.

Interest = (Current balance) × **A**

Next period's balance = (Current balance) + **B**

(4) The formulas below are entered in cell E4 and cell F4 in the diagram. Complete the following formulas by filling in the blanks **A** to **C** with the appropriate answers. Additionally, the formula in cell E4 is copied and used to E6, and the formula in cell F4 is copied and used to F6.

[Cell E4] = E3 + **A**

[Cell F4] = **B** * **C**

Exercise

1 Answer the following questions.

(1) In spreadsheet software, what are the terms for the following operations?

[1] A method of referencing that keeps the position of the row or column of the referenced cell consistently fixed.

[2] A method of referencing where the position of the referenced cell changes automatically.

(2) In spreadsheet software, what symbol is used to make a formula always refer to the same cell, even when the formula is copied? Answer with the appropriate symbol.

2 Using an appliance with a power consumption of 0.5 kW means that 0.5 kWh of electricity is used each hour. Using spreadsheet software, a table was created like the one below to simulate the relationship between usage time and electricity charges when the electricity cost is 10 yen/kWh. Answer the following questions.

	A	B	C	D	E ▼
1	**Simulation of electricity bills**				
2	**Power consumption (kW)**	**Unit price (yen/kWh)**		**Usage time (h)**	**Electricity rate (in yen)**
3	0.5	10		0	0
4				1	5
5				2	10
6				3	15
7				4	20
8					

(1) Can this model be represented as a deterministic model or a probabilistic model?

(2) The relationship between electricity rate, usage time, unit price, and power consumption can be expressed as follows. Complete the following formula by filling in the blanks **A** to **C** with the appropriate terms.

(Electricity rate) = **A** × **B** × **C**

(3) The formula entered in cell E4 in the diagram is as follows. Note that cell E3 is copied and used to E7. Complete the following formula by filling in the blanks **A** to **C** with the appropriate answers.

[Cell E4] = **A** * **B** * **C**

11-3 Simulations [2]

Point!

1 Using Functions in Spreadsheet Software

(1) ([1]**Random number**) : A number that can appear with equal probability within a certain range.

(2) Functions of Spreadsheet Software

[1] ([2]**SUM (range1:range2)**) : Calculates the sum for cell range1 to range2.

[2] ([3]**IF (logical_expression, value_if_true, value_if_false)**) : When the logical expression is true, the value for "value_if_true" is displayed. When it is not true, the value for "value_if_false" is displayed.

<Example> Display "Pass" if the score is 70 or above, otherwise display "Fail"

Pass/Fail judgment
[Cell B2] =If(A2>=70, "Pass", "Fail")

	A	B
1	**Score**	**Pass/Fail judgement**
2	80	Pass
3		

[3] ([4]**=RAND()**) : Generates a random number between 0 and 1.

2 Simulation of Probabilistic Models

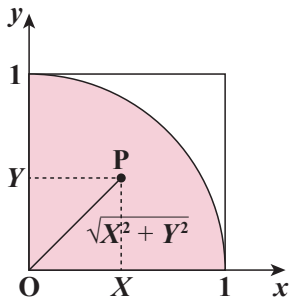
(1) ([5]**Monte Carlo method**) : A method for solving problems by using random numbers in probabilistic models.

(2) Simulation of the Approximate Value of Pi (π)

[1] Use the RAND function to randomly generate 100 points ($= N$) where both the X and Y coordinates are between 0 and 1.

[2] Count the number ($= n$) of ([6]**points that lie within a quadrant**).

[3] N: $n \approx 1$: $\frac{\pi}{4}$ Therefore, $\pi \approx \frac{4n}{N}$.



Points generated randomly using random numbers
[Cell D3] =B3^2+C3^2

Approximate value of pi
[Cell G3] =G3*4

	A	B	C	D	E	F	G	H
1	Simulation of approximate calculation of pi							
2	**Number of times**	**X-coordinate**	**Y-coordinate**	**The value of X^2+Y^2**	**Inside-outside determination**		**Probability of being inside a circle**	**Pi**
3	1	0.9066	0.9304	1.6876	0		0.800	3.200
4	2	0.2029	0.2804	0.3461	1			
5	3	0.2695	0.3481	0.4402	1			
6	4	0.7563	0.9880	1.2443	0			
7	5	0.5256	0.3030	0.6067	1			
8	6	0.1675	0.9127	0.9279	1			
9	7	0.4017	0.9968	1.0758	0			

Probability of a point being inside a circle
[Cell G3] =SUM(E3:E102)/100

Points generated randomly using random numbers
[Cell B3] =RAND()

Determines if a point is inside or outside a circle
[Cell E3] =IF(D3<=1,1,0)

*The accuracy of the approximation of the value of pi ([7]**increases**) as the number of points placed within the square increases.

(3) The Objective of the simulation:

[1] Simulate approximating π using random numbers, without measuring the circle's circumference and diameter.

[2] Draw random points inside a square, calculate the ratio of points inside a quarter circle

Warm Up

Using spreadsheet software, as shown in the diagram below, 100 points were plotted using random numbers between 0 and 1 for the X and Y coordinates. The number of points that fall within the area of a quadrant of a circle with a radius of 1 was examined, and from this, an approximate value of pi was calculated. Answer the following questions.

	A	B	C	D	E	F	G	H
1	**Simulation of approximate calculation of pi**							
2	**Number of times**	**X-coordinate**	**Y-coordinate**	**Distance from the origin**	**Inside-outside determination**		**Probability of being inside a circle**	**Pi**
3	1	0.9090	0.8882	1.6152	0		0.800	3.200
4	2	0.6769	0.1794	0.7003	1			
5	3	0.3127	0.9045	0.9570	1			
6	4	0.4324	0.0900	0.4417	1			
7	5	0.3476	0.8694	0.9363	1			
8	6	0.7042	0.9714	1.1998	0			
9	7	0.1034	0.0875	0.1354	1			

(1) Can this model be represented as a deterministic model or a probabilistic model?

(2) What is the term for the method that solves problems using random numbers in this way?

(3) The following formulas are entered in cells B3, E3, G3, and H3 in the diagram. Complete the following formulas by filling in the blanks **A** to **D** with the appropriate answers.

[Cell B3] = **A** ()

[Cell E3] = **B** (D3<=1, 1, 0)

[Cell G3] = SUM(E3:E102)/ **C**

[Cell H3] = **D** *4

(4) When 1,000 points were randomly plotted within a square, 750 of them fell inside a quadrant. Calculate the approximate value of pi in this situation.

Explanation

(1) Probabilistic model

(2) Monte Carlo method

(3) **A**: RAND **B**: IF **C**: 100 **D**: G3

(4) Since there are 1,000 points in the entire square and 750 of them are inside the quadrant, $\frac{750}{1{,}000} \times 4 = 3$
Therefore, the value of pi is 3

Try

1 A circle with a radius of 1 is drawn within a square with a side length of 2, with the circle centered at the origin. Random points were plotted within this square, and the number of points that fell inside the circle was counted. From this, the value of pi (π) was estimated. Answer the following questions.

(1) What is the term for the method that solves problems using random numbers?

(2) The procedure for calculating pi (π) based on (1) is as follows. Complete the following sentences by filling in the blanks **A** and **B** with the appropriate terms.

> [1] Place points randomly within a square.
> [2] Determine whether those points are (**A**) the circle.
> [3] Determine the (**B**) of the area of the circle to the area of the square using the number of points inside the circle and the total number of points within the square.
> [4] Use this (**B**) to calculate the value of pi (π).

(3) How does the accuracy of the estimated value of pi change as the number of points plotted within the square increases?

(4) When 10,000 points were randomly plotted inside a square, 8,000 of them were found to be inside a quadrant. Calculate the approximate value of pi in this situation.

2 Using spreadsheet software, as shown in the diagram below, 1,000 points were plotted using random numbers between 0 and 1 for the X and Y coordinates. The number of points that fall within the area of a quadrant of a circle with a radius of 1 was examined, and from this, an approximate value of pi was calculated. Answer the following questions.

	A	B	C	D	E	F	G	H
1	**Simulation of approximate calculation of pi**							
2	**Number of times**	**X-coordinate**	**Y-coordinate**	**Distance from the origin**	**Inside-outside determination**		**Probability of being inside a circle**	**Pi**
3	1	0.9090	0.8882	1.6152	0		0.800	3.200
4	2	0.6769	0.1794	0.7003	1			
5	3	0.3127	0.9045	0.9570	1			
6	4	0.4324	0.0900	0.4417	1			
7	5	0.3476	0.8694	0.9363	1			
8	6	0.7042	0.9714	1.1998	0			
9	7	0.1034	0.0875	0.1354	1			

(1) What is the term for the method that solves problems using random numbers in this way?

(2) The following formulas are entered in cells B3, E3, G3, and H3 in the diagram. Choose the formula that best fits into the blanks [1] to [4] from the options **A** to **D** below, and answer using the letters.

[Cell B3] = [1]

[Cell E3] = [2]

[Cell G3] = [3]

[Cell H3] = [4]

A G3*4 **B** IF(D3<=1, 1, 0)

C SUM(E3:E10002)/1000 **D** RAND()

Exercise

1 Answer the following questions.

(1) Regarding the IF function of spreadsheet software, choose the appropriate combination of terms to fill in blanks [1] to [3] from the options **A** to **D** below, and answer using the letter.

IF(([1]), ([2]), ([3]))

A [1] logical_expression [2] value_if_true [3] value_if_false

B [1] logical_expression [2] value_if_false [3] value_if_true

C [1] value_if_true [2] value_if_false [3] logical_expression

D [1] value_if_false [2] value_if_true [3] logical_expression

(2) Using spreadsheet software as shown in the figure on the right, you want to display a 1 in cell B3 if the score in cell A3 is 60 or above, and a 0 if it is not. Choose which function should be entered in cell B3 from the options **A** to **D** below, and answer using the letter.

	A	B
1	**Pass/Fail judgment**	
2	**Score**	**Pass/Fail judgement**
3	80	1

A [Cell B3] =IF(A3<=60, 1, 0)

B [Cell B3] =IF(A3<=60, 0, 1)

C [Cell B3] =IF(A3>=60, 1, 0)

D [Cell B3] =IF(A3>=60, 0, 1)

11-4 Queues

Point!

Queues

([1]**Queue**) : A line formed when customers wait for a service, such as at a supermarket register or an attraction at a theme park.

<Example> Queue at the register of a supermarket

[1] Service start time

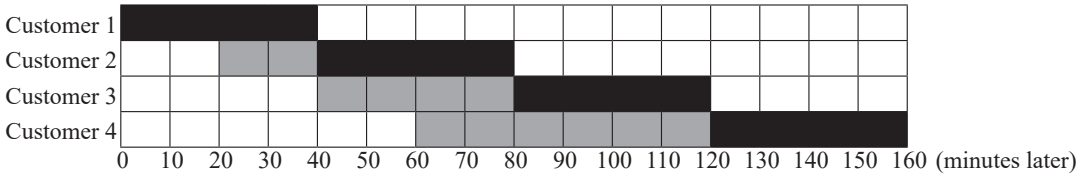
- When there are no customers at the register (no queue)
  Service start time = Time when a customer ([2]**arrives**) at the register
- When there is a previous customer at the register (when there is a queue)
  Service start time = Time when the previous customer ([3]**finished**) getting service

[2] Service end time = Service start time + ([4]**Service duration**)

[3] Waiting time = Service start time - ([5]**Arrival time**)

Warm Up

The following diagram represents changes in the queue at a store, with the vertical axis indicating the number of customers in line and the horizontal axis representing the time in minutes since the arrival of customer 1. The time each customer was receiving service is shaded in black, and the time they were waiting in line is shaded in gray. Answer the following questions.



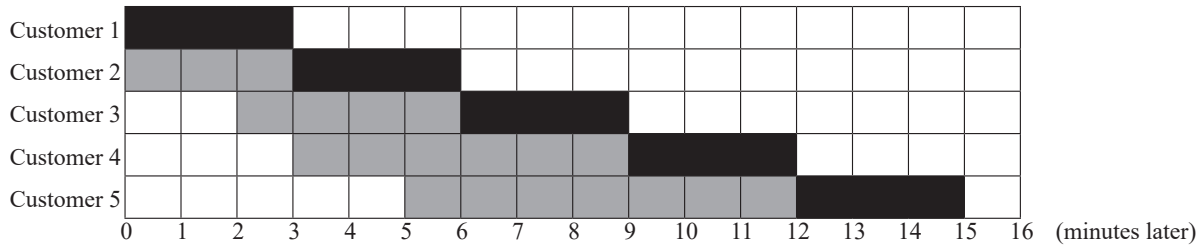
(1) How many minutes did it take to provide service to one customer at this store?
(2) How many minutes after customer 1's arrival was customer 3 able to receive service?
(3) How many minutes did it take from when customer 4 arrived in line until they finished receiving service?
(4) Among customers 1 to 4, who had the longest waiting time?
(5) For how many minutes was the queue the longest?

Explanation

(1) The black cells represent the time when service was being received; therefore, the answer is 40 minutes.
(2) When calculating the time between the arrival of customer 1 and the time customer 3 was able to receive service, 80 minutes have elapsed.
(3) Since customer 4 started waiting in line 60 minutes later and finished receiving service 160 minutes later, the time it took from when customer 4 arrived in line until they finished receiving service is 100 minutes.
(4) From the chart, the waiting times for each customer were as follows: customer 1 was 0 minutes, customer 2 was 20 minutes, customer 3 was 40 minutes, and customer 4 was 60 minutes. Therefore, the customer with the longest waiting time was customer 4.
(5) The queue was longest during the 20-minute period from 60 minutes to 80 minutes, when customers 2, 3, and 4 were waiting in line.

Try

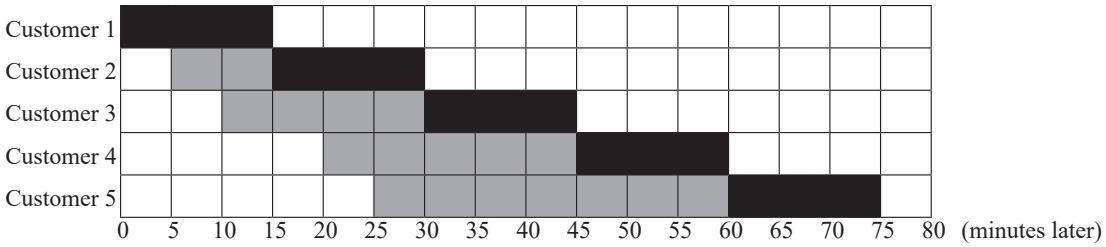
The following diagram represents changes in the line at reception, with the vertical axis indicating the number of customers in line and the horizontal axis representing the time in minutes since the arrival of customer 1. The time each customer was receiving service is shaded in black, and the time they were waiting in line is shaded in gray. Answer the following questions.



(1) What is the term for a line that forms at reception desks, registers, attractions, etc., where customers line up in order to receive services?
(2) How many minutes was the wait time for customer 2?
(3) How many minutes after the arrival of customer 1 did customer 3 arrive in the queue?
(4) How many minutes after the arrival time of customer 1 did customer 4 finish receiving service?
(5) Among customers 1 to 5, who had the longest waiting time?
(6) What was the maximum length of the queue between the arrival of customer 1 and the completion of service for customer 5?

Exercise

1 The following diagram represents changes in the queue at a store, with the vertical axis indicating the number of customers in line and the horizontal axis representing the time in minutes since the arrival of customer 1. The time each customer was receiving service is shaded in black, and the time they were waiting in line is shaded in gray. Answer the following questions.



(1) How many minutes is the service time per customer at this store?
(2) How many minutes after customer 1's arrival was customer 4 able to receive service?
(3) How many minutes did it take from when customer 5 arrived in line until they finished receiving service?
(4) Among customers 1 to 5, who had the longest waiting time?
(5) For how many minutes was the queue the longest?

12-1 Algorithm

Point!

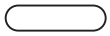
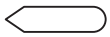
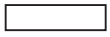
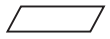
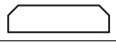
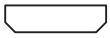
1 Algorithm

(1) ([1]**Algorithm**) : A method or procedure for solving a particular problem.

(2) Flowcharts and activity diagrams : Diagrams that represent algorithms in a visual and comprehensive way.

[1] ([2]**Flowchart**) : Method for illustrating the flow of a single process.

<List of Flowchart Symbols>

Symbol	Name	Meaning
	([3]**Terminal**)	Start/End
	([4]**Display**)	Display on a screen, etc.
	([5]**Data**)	Data input and output
	([6]**Process**)	Operations and other processes
	([7]**Conditional branch**)	Branching according to conditions
	([8]**Repeat**)	Start of a repetition
		End of a repetition
	([9]**Line**)	Flow of data and control

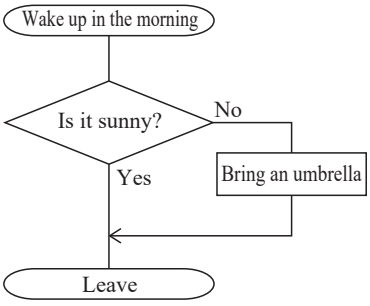
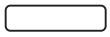
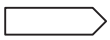


Figure 1: Process flow from waking up to leaving

[2] ([10]**Activity diagram**) : Suitable method for representing parallel process flows.

<List of Symbols in Activity Diagrams>

Symbol	Name
	([11]**Start**)
	([12]**End**)
	([13]**Control**)
	([14]**Transition**)
	([15]**Conditional branch**)
	([16]**Parallel process**)
	([17]**Send**)

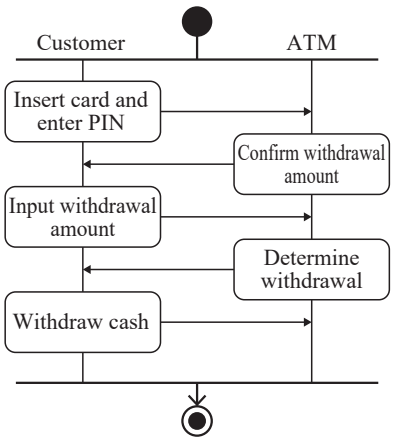
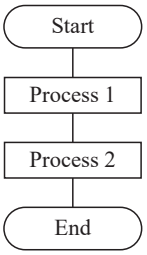
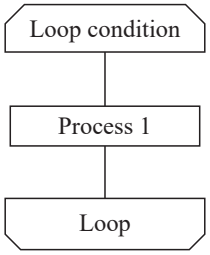
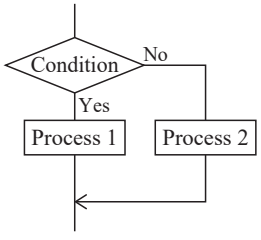


Figure 2: Cash withdrawal process at an ATM

2 Control Structure

Algorithms can essentially be represented using three control structures along with input/output.

([18]**Sequential structure**)	([19]**Repeating structure**)	([20]**Branching structure**)
Executes processes according to the order. 	Repeats the process while the conditions are met. 	Separates processes according to the conditions. 

3 Programming Language

(1) ([21]**Programming language**) : A language used for expressing algorithms in a way that can be understood by a computer.

- Creating a program (source code) using a programming language is referred to as ([22]**programming**).
- Programs are written using programming languages and then translated into a ([23]**machine language**) that can be understood by a computer.

(2) Examples of Programming Languages

[1] ([24]**Python**) : Language used in fields such as artificial intelligence (AI) and statistics, and can be executed with minimal coding.

[2] ([25]**JavaScript**) : Language that can be confirmed only within a web browser, making it optimal for web-related purposes.

[3] ([26]**Scratch**) : A visual programming language developed for educational purposes. Programming is possible using blocks, which is intuitive and easy to understand.

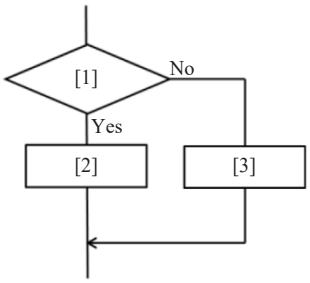
Warm Up

Answer the following questions.

(1) What is the term for describing the order of calculations or the sequence in which things are created?

(2) What is the term for a diagram that visually represents an algorithm and is ideal for showing the flow of parallel processes?

(3) The diagram on the right is a flowchart for pedestrians indicating "Proceed if the signal is green; otherwise, stop." Choose the appropriate option that best fits into the blanks [1] to [3] from the options **A** to **F** below, and answer using the letters.



A The signal is red **B** Signal is yellow
C The signal is not red **D** The signal is not green
E Possible to proceed **F** Stop

(4) What is the term for a control structure like (3)?

(5) What is the programming language that is used in fields like artificial intelligence and statistics, and can be executed with minimal description?

Explanation

(1) Algorithm
(2) Activity diagram
(3) [1] **A** [2] **F** [3] **E**
(4) Branching structure
(5) Python

Try

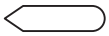
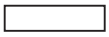
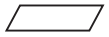
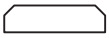
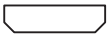
Answer the following questions.

(1) Choose the one that best fits into the blanks [1] to [4] in the following sentences from the options **A** to **F** below, and answer using the letters.

> A method or procedure for solving a particular problem is referred to as an ([1]). A language created to instruct a computer to execute an ([1]) is called ([2]), and creating a program using a ([2]) is called ([3]). In addition, a ([2]) is converted to a ([4]) that can be understood by a computer, and ultimately becomes a set of instructions composed of combinations of 0s and 1s.

A Program **B** Flowchart **C** Algorithm
D Programming **E** Programming language **F** Machine language

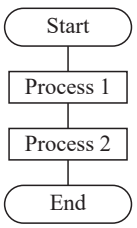
(2) The following table summarizes the symbols used in flowcharts. Choose the option that best fits into the blanks [1] to [8] from the options **A** to **H** below, and answer using the letters.

Symbol	Name	Meaning
	Terminal	([1])
	Display	([2])
	Data	([3])
	Process	([4])
	Conditional branch	([5])
	Repetition	([6])
		([7])
	Line	([8])

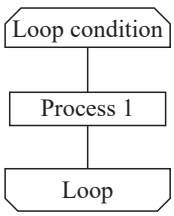
A Start of a repetition
B Start/End
C Flow of data and control
D Branching according to conditions
E End of a repetition
F Display on a screen, etc.
G Data input and output
H Operations and other processes

(3) Choose the one that represents [1] a branching structure and [2] a repeating structure from the following flowcharts **A** to **C**, and answer using the letters.

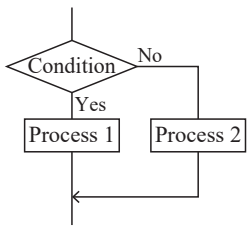
A



B

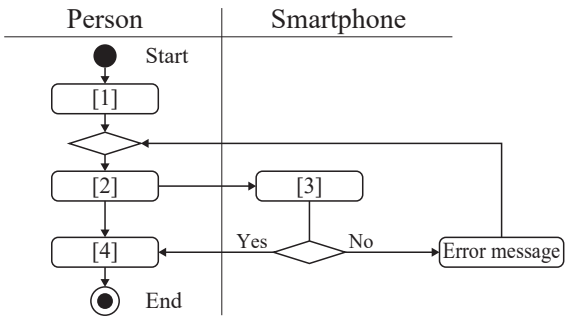


C



(4) The figure on the right is an activity diagram that illustrates the relationship between yourself and a smartphone when unlocking its screen. Choose the option that best fits into the blanks [1] to [4] from the options **A** to **D** below, and answer using the letters.

A Verify password
B Enter password
C Unlock screen
D Screen turns ON



(5) Name the programming language that can be confirmed only within a web browser, making it optimal for web-related purposes.

Exercise

1 Answer the following questions.

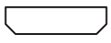
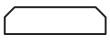
(1) Choose the term that best fits into the blanks [1] to [3] in the following sentences from the options **A** to **F** below, and answer using the letters.

> The order of calculations or the sequence for creating something is referred to as an ([1]). Among the diagrams that visually represent this, the one that is suitable for representing a single process flow is referred to as a ([2]), while the one suitable for representing parallel process flows is referred to as an ([3]).

A Programming **B** Programming language **C** Activity diagram
D Source code **E** Algorithm **F** Flowchart

(2) Choose the symbols used in flowcharts that correspond to the meanings [1] to [4] from the options **A** to **F** below, and answer using the letters.

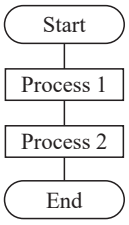
[1] Start/End [2] Branching according to conditions
[3] Start of a repetition [4] Data input and output

A  **B**  **C**  **D** 

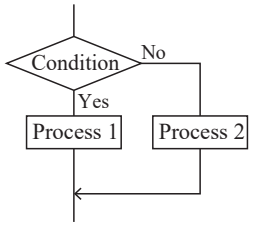
E  **F** 

(3) From the following flowcharts, choose the one from **A** to **C** that best represents a flowchart depicting the case where "If the product is in stock, purchase it; otherwise, stop shopping." Answer with the appropriate letter.

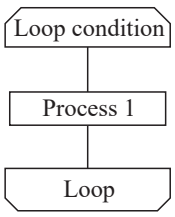
A



B

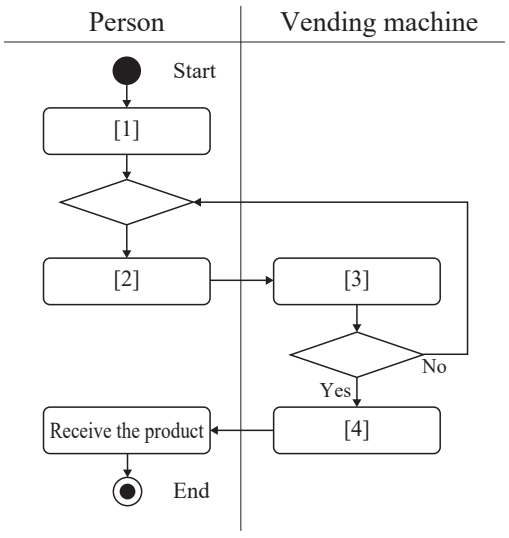


C



(4) The figure on the right is an activity diagram showing the relationship between yourself and a vending machine when purchasing a product. Choose the option that best fits into the blanks [1] to [4] from the options **A** to **D** below, and answer using the letters.

A Insert money
B Money is counted
C Press button to purchase the product
D Product is discharged



(5) Choose the visual programming language developed for beginners and children from the options **A** to **D**, and answer using the letter.

A Python **B** Scratch
C JavaScript **D** BASIC

12-2 Programming Basics [1] (Python)

Point!

Variables and Sequential Structure

(1) ([1]**print**) : Displays the character string or value inside the parentheses ( ).
The character string is enclosed with half-width single quotation marks (') or double quotation marks (").
*Note that numerical values should not be enclosed using half-width quotation marks.

01	`print('Hello Khalid')`	Displays "`Hello Khalid`".
02	`print(2023)`	Displays "`2023`".

Execution result

```
Hello Khalid
2023
```

(2) ([2]**Variable**) : Like a box to store data. Data can be stored in and retrieved from variables.
<Example> A program to display the character string "`Cairo`"

01	`city = 'Cairo'`	Assigns "`Cairo`" to the variable "`city`".
02	`print(city)`	Displays the value for the variable "`city`".

Execution result

```
Cairo
```

* In programming, the "=" symbol does not mean "equal." Rather, it means "([3]**assign the right side to the left side**)."

(3) ([4]**Assignment operator**) : Something such as "=" used to assign a value to a variable.

(4) ([5]**Arithmetic operator**) : A symbol such as "+" and "-" used in calculations.

Arithmetic operator	Meaning
`a + b`	([6]**Addition**)
`a - b`	([7]**Subtraction**)
`a * b`	([8]**Multiplication**)
`a / b`	([9]**Division**)
`a // b`	([10]**Quotient**)
`a % b`	([11]**Remainder when a is divided by b**)
`a ** b`	([12]**a to the power of b**)

<Example> A program that performs four basic arithmetic operations

01	`a = 5`	5 is assigned to variable a.
02	`b = 3`	3 is assigned to variable b.
03	`print(a + b)`	Displays a + b.
04	`print(a - b)`	Displays a - b.
05	`print(a * b)`	Displays a × b.
06	`print(a / b)`	Displays a ÷ b.
07	`print(a // b)`	Displays the quotient when a is divided by b.
08	`print(a % b)`	Displays the remainder when a is divided by b.
09	`print(a ** b)`	Displays a to the power of b.

Execution result

```
8
2
15
1.66666
1
2
125
```

Warm Up

Answer the following questions.

(1) Choose the program that displays "HelloWorld!" from the options **A** to **D** below, and answer using the letter.

A
```
HelloWorld!
```

B
```
'HelloWorld!'
```

C
```
print(HelloWorld!)
```

D
```
print('HelloWorld!')
```

(2) Choose the program that displays "Mr. Suzuki" from the options **A** to **D** below, and answer using the letter.

A
```
print(name)
name = 'Mr. Suzuki'
```

B
```
print(name)
name == 'Mr. Suzuki'
```

C
```
name = 'Mr. Suzuki'
print(name)
```

D
```
name == 'Mr. Suzuki'
print(name)
```

(3) When the following program is executed, give the results for items [1] to [5].

```
a = 6
print(a + 4)     .....[1]
print(a - 1)     .....[2]
print(a * 5)     .....[3]
print(a / 2)     .....[4]
print(a ** 3)    .....[5]
```

Explanation

(1) The `print` function is used to display character strings or values, and the character string "`HelloWorld`"! is enclosed with either ' or ". Therefore, **D**

(2) "`=`" is used to assign a value to a variable. In addition, a variable cannot be used before it is defined. Therefore, **C**

(3) Since the value 6 is assigned to the variable "`a`", [1] is 6 + 4, which equals 10; [2] is 6 - 1, which equals 5; [3] is 6 × 5, which equals 30; [4] is 6 ÷ 2, which equals 3; and [5] is 6 to the power of 3, which equals 216.
Therefore, the answers are [1] `10`, [2] `5`, [3] `30`, [4] `3`, [5] `216`

Try

Answer the following questions.

(1) Choose the program that displays "Hello" from the options **A** to **D** below, and answer using the letter.

A
```
Hello
```

B
```
'Hello'
```

C
```
print(Hello)
```

D
```
print('Hello')
```

(2) Choose the program that displays "Correct" from the options **A** to **D** below, and answer using the letter.

A
```
print(result)
result = 'Correct'
```

B
```
print(result)
result == 'Correct'
```

C
```
result = 'Correct'
print(result)
```

D
```
result == 'Correct'
print(result)
```

(3) Choose the program that displays "2" from the options **A** to **D** below, and answer using the letter.

A
```
a = 20
print(a % 3)
```

B
```
print(a % 3)
a = 20
```

C
```
a = 20
print(a * 3)
```

D
```
print(a * 3)
a = 20
```

(4) Choose the program that displays "81" from the options **A** to **D** below, and answer using the letter.

A
```
b == 9
print(b // 2)
```

B
```
b = 9
print(b // 2)
```

C
```
b == 3
print(b ** 4)
```

D
```
b = 3
print(b ** 4)
```

(5) When the following program is executed, give the results for items [1] to [5].

```
c = 5
print(c + 3)     ……[1]
print(c - 2)     ……[2]
print(c * 4)     ……[3]
print(c / 2)     ……[4]
print(c ** 2)    ……[5]
```

(6) What is the term for a symbol like "=" used to assign a value to a variable? Choose one from the options **A** to **D** below, and answer using the letter.

A Arithmetic operator　　**B** Comparison operator

C Assignment operator　　**D** Logical operator

Exercise

1 Answer the following questions.

(1) Choose the program that displays "`Nice to meet you`" from the options **A** to **D** below, and answer using the letter.

A
```
print('Nice to meet you')
```

B
```
print(Nice to meet you)
```

C
```
'Nice to meet you'
```

D
```
Nice to meet you
```

(2) Choose the program that displays "`17 years old`" from the options **A** to **D** below, and answer using the letter.

A
```
print(age)
age == '17 years old'
```

B
```
print(age)
age = '17 years old'
```

C
```
age == '17 years old'
print(age)
```

D
```
age = '17 years old'
print(age)
```

(3) Choose the program that displays "`15`" from the options **A** to **D** below, and answer using the letter.

A
```
a = 5
print(a % 3)
```

B
```
print(a % 3)
a = 5
```

C
```
a = 5
print(a * 3)
```

D
```
print(a * 3)
a = 5
```

(4) Choose the program that displays "2" from the options **A** to **D** below, and answer using the letter.

A
```
b == 8
print(b // 3)
```

B
```
b = 8
print(b // 3)
```

C
```
b == 8
print(b ** 3)
```

D
```
b = 8
print(b ** 3)
```

(5) When the following program is executed, give the results for items [1] to [5].

```
c = 9
print(c + 2)     ……[1]
print(c - 4)     ……[2]
print(c * 2)     ……[3]
print(c // 2)    ……[4]
print(c % 2)     ……[5]
```

(6) What is the term for symbols such as "+" and "-" that are used in calculations? Choose one from the options **A** to **D** below, and answer using the letter.

A Comparison operator
B Logical operator
C Assignment operator
D Arithmetic operator

12-3 Programming Basics [2] (Python)

Point!

1 Loop Structure

(1) Using a ([1]**for statement**) makes it possible to execute a process repeatedly.
A "for" statement is written as shown below.

```
for␣variable␣in␣range([Variable range]):
␣␣␣␣[Process to repeat]
```

In a "for" statement, the indented block of code is executed repeatedly.

(2) In a "for" statement, the range() instruction can be used to specify a range for a variable.

Writing style	Meaning
range(end value)	The value of the variable increases by 1, starting from ([2]**0**) up to the ([3]**end value - 1**).
range(start value, end value)	The value of the variable increases by 1, starting from the ([4]**start value**) up to the ([5]**end value - 1**).
range(start value, end value, increment)	The value of the variable increases by the specified ([6]**increment**), starting from the ([7]**start value**) up to the ([8]**end value - increment**).

<Example> A program that displays integers from 0 to 3

```
01 for i in range(0, 4):      Repeat variable "i" increasing by 1 from 0 to 3.
02     print(i)               Displays the value of variable "i".
```

Execution result

```
0
1
2
3
```

<Example> A program that displays odd numbers from 1 to 5

```
01 for i in range(1, 7, 2):   Repeat variable "i" increasing by 2 from 1 to 6.
02     print(i)               Displays the value of variable "i".
```

Execution result

```
1
3
5
```

2 Branching Structure

(1) ([9]**Comparison operator**) : Operator used to compare expressions or values.

Comparison operator	Meaning	Example	Meaning of the example
==	([10]**Equal**)	x == 70	x is equal to 70
! =	([11]**Not equal**)	x ! = 70	x is not equal to 70
<	([12]**Less than**)	x < 70	x is less than 70
>	([13]**Greater than**)	x > 70	x is greater than 70
<=	([14]**Less than or equal to**)	x <= 70	x is less than or equal to 70
>=	([15]**Greater than or equal to**)	x >= 70	x is greater than or equal to 70

(2) Using ([16]**if statements**) allows conditions to be branched and processed as conditional expressions.

• ([17]**Conditional expression**) : Expression that determines whether conditions are met and returns "true" if met and "false" if not.

[1] Using ([18]**if ~ else**) makes it possible to describe the process that occurs when a condition is not met.

```
if␣[Conditional expression]:
    [Process when a condition is true]
else:
    [Process when a condition is false]
```

<Example> Program for determining pass or fail

01	`x = 70`	Assign the value `70` to variable `x`.
02	`if␣x >= 60:`	If `x` is `60` or greater,
03	`␣␣␣␣result = 'Pass'`	If true, assign "`Pass`" to the variable `result`.
04	`else:`	If not,
05	`␣␣␣␣result = 'Fail'`	Assign "`Fail`" to the variable `result`.
06	`print(result)`	Displays the value of the variable `result`.

Execution result

```
Pass
```

[2] Using ([19]**if ~ elif ~ else**) makes it possible to determine multiple conditions sequentially.

```
if [Conditional expression 1]:
␣␣␣␣[Process when conditional expression 1 is true]
elif [Conditional expression 2]:
␣␣␣␣[Process when conditional expression 1 is false and conditional expression 2 is true]
else:
␣␣␣␣[Process when both conditional expression 1 and conditional expression 2 are false]
```

<Example> Program for evaluating based on test scores

01	`x = 70`	Assign the value `70` to variable `x`.
02	`if␣x >= 90:`	If `x` is `90` or greater,
03	`␣␣␣␣result = 'Grade is A'`	If true, assign "`Grade is A`" to the variable `result`.
04	`elif␣x >= 50:`	Otherwise, if `x` is `50` or greater,
05	`␣␣␣␣result = 'Grade is B'`	Assign "`Grade is B`" to the variable `result`.
06	`else:`	If none of the conditions are met,
07	`␣␣␣␣result = 'Grade is C'`	Assign "`Grade is C`" to the variable `result`.
08	`print(result)`	Displays the value of the variable `result`.

Execution result `Grade is B`

Warm Up

Answer the following questions.

(1) Choose the program that displays "`Grade is A`" from the options **A** to **D** below, and answer using the letter.

A
```
point = 90
if point >= 85:
    result = 'Grade is A'
else:
    result = 'Grade is B'
```

B
```
point = 90
if point >= 85:
    result = 'Grade is A'
else:
    result = 'Grade is B'
print(result)
```

C
```
point 90
if point >= 85:
    result = 'Grade is A'
else:
    result = 'Grade is B'
print(result)
```

D
```
point 90
if point >= 85:
    result = 'Grade is A'
else:
    result = 'Grade is B'
```

(2) The following program displays the total and the average of all integers from `1` to `10`. Fill in the blanks **A** to **C** with the appropriate characters or numbers to complete the program.

```
total = 0
for i in range(1, [ A ]):
    total = [ B ]
average = [ C ] /10
print(total)
print(average)
```

Explanation

(1) "`=`" is needed to assign a value to the variable "`point`", and the print function is needed to display the value of the variable "`result`". Therefore, **B**

(2) Set the variable "`total`" to an initial value of `0` and then calculate the total by continuously adding integers `1` to `10` as variable "`i`" to the variable "`total`". When counting variables from `1` to `10`, be sure to specify up to the next number, `11`. Therefore, **A**: `11`, **B**: `total+i`, **C**: `total`

Try

Answer the following questions.

(1) Choose the appropriate execution result when the following program is executed from the options **A** to **D** below, and answer using the letter.

```
for i in range(0, 5, 1):
    print(i)
```

A
```
0
1
2
3
4
```

B
```
0
1
2
3
4
5
```

C
```
1
2
3
4
```

D
```
1
2
3
4
5
```

(2) Choose the program that displays "`Pass`" from the options **A** to **D** below, and answer using the letter.

A
```
score 95
if score < 90:
    result = 'Fail'
else:
    result = 'Pass'
print(result)
```

B
```
score 95
if score < 90:
    result = 'Fail'
else:
    result = 'Pass'
```

C
```
score = 95
if score < 90:
    result = 'Fail'
else:
    result = 'Pass'
```

D
```
score = 95
if score < 90:
    result = 'Fail'
else:
    result = 'Pass'
print(result)
```

(3) The following program counts down from 5 to 0, and when it reaches 0, it displays "`Start!`" Fill in the blanks **A** to **C** with the appropriate characters or numbers to complete the program.

```
for i in [ A ]:
    count = [ B ]
    if [ C ]:
        print('Start!')
    else:
        print(count)
```

(4) The following program displays "`It is an even number`" for even numbers from 1 to 100. Fill in the blanks **A** and **B** with the appropriate characters or numbers to complete the program.

```
for i in range(1, [ A ]):
    if [ B ]:
        print('It is an even number')
    else:
        print(i)
```

Exercise

1 Answer the following questions.

(1) Choose the program that would produce the same execution result as the following program from the options **A** to **D** below, and answer using the letter.

```
for i in range(3):
    print(i)
```

A
```
for i in range(0, 3):
    print(3)
```

B
```
for i in range(0, 3, 1):
    print(i)
```

C
```
for i in range(0, 3, 1):
    print(3)
```

D
```
for i in range(0, 3, 2):
    print(i)
```

(2) Choose the appropriate execution result when the following program is executed from the options **A** to **C** below, and answer using the letter.

```
x = 7
if x < 3:
    print('We will seat you at the counter')
elif x <= 10:
    print('We will seat you at a table')
else:
    print('No seats are available')
```

A `We will seat you at the counter`
B `We will seat you at a table`
C `No seats are available`

(3) The following program displays the total for all numbers from 1 to 100. Fill in the blanks **A** and **B** with the appropriate characters or numbers to complete the program.

```
total = 0
for i in range(1, [ A ]):
    total = [ B ]
print(total)
```

(4) The following program displays the number of even numbers between 1 and 10. Fill in the blanks **A** to **C** with the appropriate characters or numbers to complete the program.

```
for i in [ A ]:
    if i % 2 == 0:
        count = count + [ B ]
print( [ C ] )
```

12-4 Application of Programming [1] (Python)

Point!

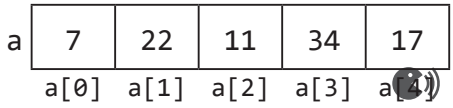
(List)

(1) ([1]List) : A collection of data items arranged in sequence. Data can be managed collectively.

List declaration	List name = [data0, data1, data2, …]
Adding elements to the end of an list	List name.append(data)

<Example> Character string list `week = ['Mon', 'Tue', 'Wed', 'Thu', 'Fri', 'Sat', 'Sun']`
List of numbers `number = [7, 22, 11, 34, 17]`

(2) ([2]Element) : Each value included in an list. Displays the list name and its place number
Using ([3]Index)(element numbers) makes it possible to retrieve elements from a list. Note that Index do not start from 1, but from ([4]0).



(3) List operation : Allows list element to be managed using a single index.
<Example> List declaration and method for accessing elements
Using a variable as a index such as in `a[i]` makes it possible to specify elements with the variable. This is convenient when processing elements one at a time using a "for" statement.

01	`a = [7, 22, 11, 34, 17]`	Declares list "a" and assigns a numerical value to it.
02	`for␣i␣in␣range(0,5,1):`	Repeats while increasing variable `i` from `0` to ([5]4) in increments of `1`.
03	`␣␣␣␣print(a[i])`	Displays elements from list "a" that satisfy the condition ([6]`a[i]`).

Execution result
```
7
22
11
34
17
```

<Example> Adding an element to the end of a one-dimensional list

01	`a = [ ]`	Declares the list "a".
02	`a.append(1)`	Adds ([7]1) to the end of list "a".
03	`a.append(4)`	Adds ([8]4) to the end of list "a".
04	`a.append(9)`	Adds ([9]9) to the end of the list "a".
05	`print(a)`	Displays the values for list "a".

Execution result
```
[1, 4, 9]
```

(4) ([10]Two-dimensional list) : An list that manages data using indexs in both the row and column directions. An element at row "i" and column "j" would be specified using the two indexs as `a[i][j]`.
<Example> Definition of a two-dimensional list and the method for accessing elements

01	`a=[['A', 'B', 'C'], ['D', 'E', 'F'],]`	Declares list "a" and assigns a character string to it.
02	`print(a[0][0])`	Displays the value for ([11]`a[0][0]`).
03	`print(a[1][2])`	Displays the value for ([12]`a[1][2]`).

Execution result
```
A
F
```

Warm Up

Answer the following questions.

(1) For programs **A** and **B** below, give the values displayed when each is executed.

A
```
a = [57, 16, 29, 44]
print(a[2])
```

B
```
a = [[1, 2, 3],
     [4, 5, 6],
     [7, 8, 9]]
print(a[2][1])
```

(2) The following program is designed to find the minimum value among the elements in list "a". Fill in the blanks **A** and **B** with the appropriate characters or numbers to complete the program.

```
a = [34, 52, 11, 40, 17]
min = a[0]
for i in range(1, [ A ], 1):
    if a[i] < min:
        min = [ B ]
print(min)
```

(3) Fill in the blanks **A** to **E** in the following program with the appropriate characters or numbers to complete the program so that it displays the "Execution result" as shown.

```
a = [['A', 'B', 'C', 'D'],
     ['E', 'F', 'G', 'H']]
for i in range([ A ], [ B ], 1):
    for j in range([ C ], [ D ], 1):
        print([ E ])
```

Execution result

```
A
B
C
(Omitted)
H
```

Explanation

(1) Note that list index start at `0`, not `1`. In addition, an element in a two-dimensional list can be represented as `a[i][j]`, where "i" indicates the row and "j" indicates the column. Therefore, **A**: `29`, **B**: `8`

(2) Set "`min`" as the variable that stores the minimum value of the list "`a`" so it is `a[0]`. Next, examine each element of list "`a`" sequentially, and if `a[i]` is smaller than `min`, update `min` to that value.
Therefore, **A**: `5`, **B**: `a[i]`

(3) **A**: `0`, **B**: `2`, **C**: `0`, **D**: `4`, **E**: `a[i][j]`

Try

Answer the following questions.

(1) For programs **A** to **C** below, give the values displayed when each is executed.

A
```
a = [1, 4, 9, 16, 25]
print(a[3])
```

B
```
a = [ ]
a.append(8)
a.append(28)
print(a[1])
```

C
```
a = [['A', 'B', 'C', 'D', 'E'],
     ['F', 'G', 'H', 'I', 'J'],
     ['K', 'L', 'M', 'N', 'O']]
print(a[2][1])
```

(2) The following program finds the total of the elements in list "a". Fill in the blanks **A** to **C** with the appropriate characters or numbers to complete the program.

```
a = [1, 2, 3, 4, 5, 6, 7, 8, 9, 10]
sum = 0
for i in range( A , B , 1):
    sum = sum + C
print(sum)
```

(3) The following program finds the maximum value among the elements in list "a". Fill in the blanks **A** to **C** with the appropriate characters or numbers to complete the program.

```
a = [7, 22, 11, 34, 17]
max = 0
for i in range(0, A , 1):
    if a[i] B max:
        max = C
print(max)
```

(4) Fill in the blanks **A** to **E** in the following program with the appropriate characters or numbers to complete the program so that it displays the "Execution result" as shown.

```
a = [['A', 'B', 'C', 'D', 'E'],
     ['F', 'G', 'H', 'I', 'J']]
for i in range( A , B , 1):
    for j in range( C , D , 1):
        print( E )
```

Execution result

```
A
B
C
(Omitted)
J
```

Exercise

1 Answer the following questions.

(1) For programs **A** to **C** below, give the values displayed when each is executed.

A
```
a = [0, 1, 2, 3]
print(a[1])
```

B
```
a = ['A']
a.append('B')
a.append('C')
print(a[1])
```

C
```
a = [['Japanese', 'Mathematics', 'English'],
     ['Social studies', 'Science', 'Information studies']]
print(a[1][2])
```

(2) The following program is designed to find the minimum value among the elements in list "a". Fill in the blanks **A** to **C** with the appropriate characters or numbers to complete the program.

```
a = [24, 43, 9, 25, 17]
min = [ A ]
for i in range(0, [ B ], 1):
    if a[i] < min:
        min = [ C ]
  print(min)
```

(3) The following program counts the number of elements in list "a" that are greater than 10. Fill in the blanks **A** to **C** with the appropriate characters or numbers to complete the program.

```
a = [12, 8, 9, 13, 11]
count = 0
for i in range([ A ], [ B ], 1):
    if [ C ] > 10:
        count = count + 1
print(count)
```

(4) Fill in the blanks **A** to **E** in the following program with the appropriate characters or numbers to complete the program so that it displays the "Execution result" as shown.

```
a = [['Japanese', 'Mathematics', 'English'],
     ['Social studies', 'Science', 'Information studies']]
for i in range([ A ], [ B ], 1):
    for j in range([ C ], [ D ], 1):
        print([ E ])
```

Execution result

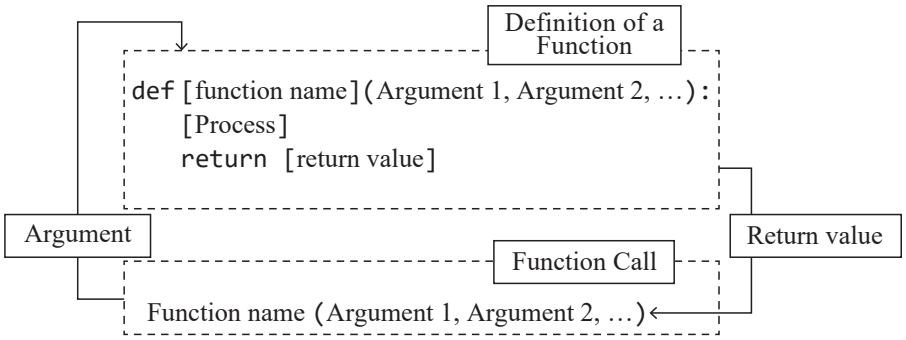
```
Japanese
Mathematics
English
Social studies
Science
Information studies
```

12-5 Application of Programming [2] (Python)

Point!

Functions

(1) ([1]**Function**) : A set of operations performed by a computer described as a cohesive unit. A variable specified to receive a value within a function is referred to as an ([2]**argument**). Using ([3]**return**) makes it possible to pass the value resulting from the process within the function to the caller as a ([4]**return value**). In addition, when a function is used, it is necessary to perform the process of ([5]**calling**) the function.



<Example> Example of a function with one argument: A program to find the function y = 2x

01	`def function(x):`	Defines a `function` called ([6]**function**).
02	`    y = 2 * x`	Assigns the value from `2*x` to variable "`y`".
03	`    return y`	Returns "`y`" as ([7]**return value**).
04	`print(function(5))`	Passes "`x`" as 5 to the `function`.

Execution result

```
10
```

<Example> Example of a function with two arguments: A program to find the area of a triangle

01	`def area(base, height):`	Defines a function called "`area`".
02	`    S= base*height/2`	Assigns the value from "`base*height/2`" to variable "`S`".
03	`    return S`	Returns "`S`" as the return value.
04	`print(area(10, 5))`	Passes "`base`" as ([8]`10`) and "`height`" as ([9]`5`) to the function "`area`".

Execution result

```
25
```

(2) Functions include ([10]**built-in functions**) such as "`print()`" that can be used without definition, and ([11]**user-defined functions**) that you can define.

Warm Up

Answer the following questions.

(1) In the following program, the function "`circle`" is used to calculate the area of a circle. Give the program that fits in blanks **A** and **B**. Also, give the value displayed when row [1] is executed.

```
 A  circle(r):
    S = r * r * 3.14
    B  S
a = circle(5)
print(a)      # [1]
```

(2) In the following program, the function "`judge`" takes the test score as an argument and displays "`Pass`" if the score is 80 or above, and "`Fail`" if it is below 80. Give the program that fits in blanks **A** and **B**.

```
def judge(score):
    if score  A  80:
        print('Pass')
    B :
        print('Fail')
judge(40)
```

Explanation

(1) In programming, the function is defined as shown below.

```
def function name(argument):
    [Process]
    return [return value]
```

Therefore, the programs that fit in blanks **A** and **B** are as follows.

A: `def`, **B**: `return`

In addition, when the function "`circle`" is called in [1], 5 is passed as argument "`r`" in the function "`circle`".

Therefore, when row [1] is executed, it is `5 × 5 × 3.14 = 78.5`, so `78.5` is displayed.

(2) In the programming, a conditional branch was defined as shown below.

```
if conditional expression:
    [Process when a condition is true]
else:
    [Process when a condition is false]
```

Therefore, the programs that fit in blanks **A** and **B** are as follows.

A: `>=`, **B**: `else`

Try

Answer the following questions.

(1) Choose the term that best fits into the blanks [1] and [2] from the options **A** to **D** below, and answer using the letters.

```
def function name ( [1] ):
    [Process]
    return [2]
```

A Argument **B** Return value **C** Complement **D** Random number

(2) In the following program, the function "`area`" is used to calculate the area of a triangle. Give the program that fits in blanks **A** and **B**. Also, give the values displayed when rows [1] and [2] are executed.

```
def area(base, height):
    S = A
    B S
a = area(10, 5)
b = area(6, 7)
print(a)      # [1]
print(b)      # [2]
```

(3) In the following program, the function "`celsius_to_fahrenheit`" converts temperatures from `Celsius` to `Fahrenheit`. Give the program that fits in blanks **A** and **B**.

```
def celsius_to_fahrenheit(celsius):
    fahrenheit = (celsius * 9/5) + 32
    return A
temp_celsius = 25
result = celsius_to_fahrenheit( B )
print(result)
```

(4) In the following program, test scores are given as arguments to the function "`evaluate`". In addition, the relationship between scores and grades is according to the table on the right. Give the program that fits in the blanks **A** to **C**.

Score	Grade
80 or higher	A
50 or higher but less than 80	B
Less than 50	C

```
def evaluate(score):
    if score A 80:
        print('A')
    B score C 50:
        print('B')
    else:
        print('C')
evaluate(40)
```

Exercise

1 Answer the following questions.

(1) In the following program, the function "`add_number`" adds two numbers together. Give the program that fits in blanks **A** and **B**.

```
 A  add_numbers(a, b):
    return  B
result = add_numbers(3, 5)
print(result)
```

(2) In the following program, the function "`area`" is used to calculate the area of a quadrilateral. Give the program that fits in blanks **A** and **B**. Also, give the values displayed when rows [1] and [2] are executed.

```
def area(width, height):
    S =  A
     B  S
a = area(10, 6)
b = area(7, 5)
print(a)      # [1]
print(b)      # [2]
```

(3) In the following program, egg weight is given as an argument to the function "`check_size`". In addition, the relationship between egg weight and size is according to the table on the right. Give the program that fits in blanks **A** and **B**.

Egg weight	Size
Less than 45 g	S
45 g or higher but less than 55 g	M
55 g or higher	L

```
def check_size(weight):
    if weight < 45:
       print('S')
    elif weight  A  55:
       print('M')
     B :
       print('L')
check_size(40)
```

(4) What is the term for a function provided as a standard feature of a programming language such as "`print()`"?