

Programming and Artificial Intelligence

An Introduction to
Information and Communication Technology

Egyptian Baccalaureate

2nd Year

Part One

11

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Programming and Artificial Intelligence

Egyptian Baccalaureate

2nd Year



The International Baccalaureate™

has reviewed the pedagogical and assessment approaches underpinning this textbook.

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Ministry of Education and Technical Education

New Administrative Capital

Cairo, Egypt

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Introduction

In light of Egypt's Vision 2030 and the state's ongoing efforts to develop education, the Ministry of Education and Technical Education places great emphasis on updating school curriculums — particularly in information and communication technology — due to its vital role in fostering critical thinking skills, problem-solving abilities, and a focus on building a deep understanding of fundamental concepts, moving away from rote memorization, especially in the early stages. The content is organized in a gradual and systematic manner that enables students to progress smoothly from simple to complex concepts, linking technical concepts to real-life situations, and relying on interactive methods that include teamwork and discussion, making learning more enjoyable.

In this context, the Ministry has been keen to benefit from successful international experiences. This has led to collaboration between the Egyptian and Japanese sides in developing information and communication technology curriculums, given Japan's global excellence in this field, as evidenced by its notable achievements in international competitions, which reflect the strength of its curriculums and teaching methods.

From this concern, this book is the result of the contribution between the Ministry of Education and Technical Education and the Japanese side.

This book represents a first step within a comprehensive plan to develop information and communication technology curriculums across all grade levels, with the aim of building an integrated educational system that combines the best international practices with Egypt's authentic identity.

The Ministry of Education and Technical Education firmly believes that developing education is a true investment in the nation's future, and that updating curriculums is not an end in itself, but rather a means to build an aware, creative generation, capable of keeping pace with scientific and technological changes in today's world.

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Lesson 1-1

Development of Information Technology and Social Transformation

Learning Objectives

- Explain the major stages in the development of information technology and their impact on society.
- Give examples of social changes and emerging technologies brought about by information technology, and explain their characteristics.

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On an ordinary day, a student in Egypt checks messages on an SNS app, pays for breakfast with a cashless app, joins a lesson through online learning, and orders a book from an e-commerce (EC) shop. Twenty years ago, most of this was not possible. Information technology has developed through a series of stages — from the first computers to cloud computing — and at each stage it has changed the way people communicate, work, learn, and pay.

? Guiding question: How has information technology developed through its major stages, and how has each stage changed society?

✎ Explore (in pairs)

With a partner, look at the five time periods in the table below before you read on. For each period, name one device or service from that era that you still use or hear about today. Then predict which stage changed daily life the most, and give one reason.

Key Fact:
At each stage, information technology introduced a new technology or service and also changed how society communicates, works, and does business.

Key Concepts:

- Moore's Law
- SNS
- e-commerce
- remote work
- online learning
- cashless payment
- edge computing
- autonomous driving
- AR / VR
- quantum computing

📌 Point!

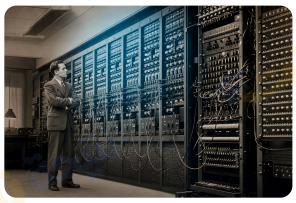
1. The History of Information Technology (IT)

(1) The major stages in the development of information technology are summarized in the table below.

Time period	Major technologies and events	Impact on society
1940s-60s	Birth of the computer (ENIAC, vacuum tubes)	Mainly used for military and scientific computation
1970s-80s	Spread of personal computers (PCs)	Beginning of personal computer use
1990s	Commercialization of the Internet; the Web	Globalization of information; spread of email
2000s	Rise of smartphones (iPhone, etc.)	Explosive spread of mobile Internet
2010s onward	Spread of cloud computing	Large-scale data analysis and AI; "IT as a service" becomes widespread



IT advanced in stages, each smaller and more connected.



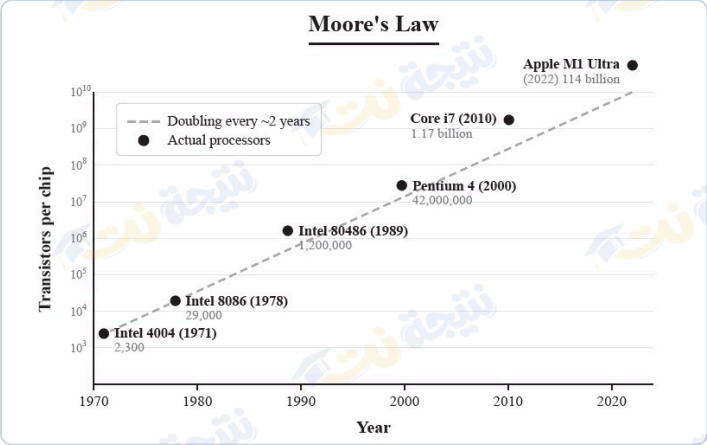
The first computers filled a whole room.

(2) **(Moore's Law)**...the empirical observation that "the number of transistors on an integrated circuit doubles approximately every two years."

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This remained largely accurate for many years, and computing power increased dramatically.

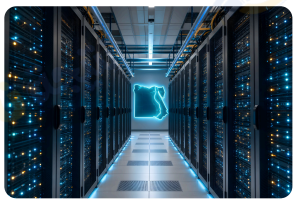
However, in recent years, miniaturization of transistors has been approaching a physical limit. If circuits are made any smaller, problems arise such as the quantum tunneling effect, in which electrons slip through barriers, and leakage current, in which current escapes unintentionally, making it difficult to achieve both higher performance and lower power consumption at the same time. In response, new directions for performance improvement are being pursued, such as parallel processing using multiple processor cores, and quantum computers based on the principles of quantum mechanics.



Moore's Law: transistor count over time

KEY TERMS

Moore's Law — the observation that the number of transistors on a chip roughly doubles about every two years.



This is "the cloud" — real machines in a real place.

2. Social Changes Resulting from Information Technology

(1) **(SNS (Social Networking Service))**...services that allow users to connect with each other and post and share information. They are highly effective at spreading information rapidly.

(2) **(E-commerce (EC))**...buying and selling goods and services through the Internet.

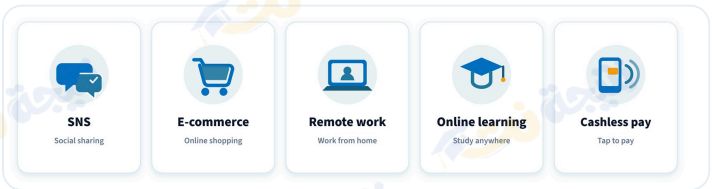
e.g., online shops such as Amazon and eBay

(3) **(Remote work)**...a working style in which work is performed from home or other remote locations using the Internet.

(4) **(Online learning)**...a learning style in which classes and study materials are delivered using the Internet.

(5) **(Cashless payment)**...a system for making payments using electronic money, QR codes, etc., without using cash.

e.g., credit cards, debit cards, mobile payment apps



Five social changes driven by information technology.

PAUSE & THINK

Of these five changes, which would be hardest to give up — and why?

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3. Notable Emerging Technologies

(1) **(Autonomous driving)**...a technology that uses AI to drive a vehicle without human operation. It uses cameras and sensors to recognize the surroundings, makes driving decisions, and controls a vehicle. Because a delay of even 0.1 seconds can lead to an accident, edge computing, in which processing is performed instantly on the vehicle itself rather than sending data to the cloud for judgment, is used.

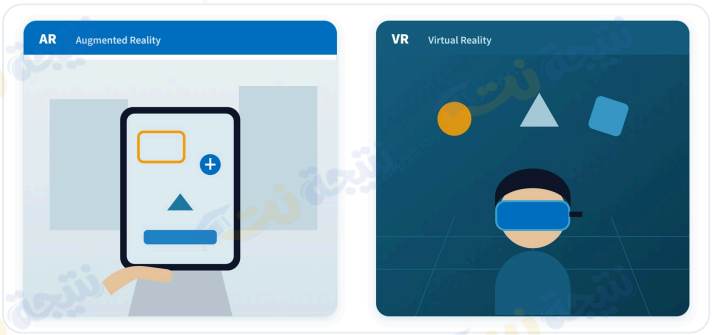


A self-driving car decides on board (edge computing), without waiting for the cloud.

(2) AR / VR

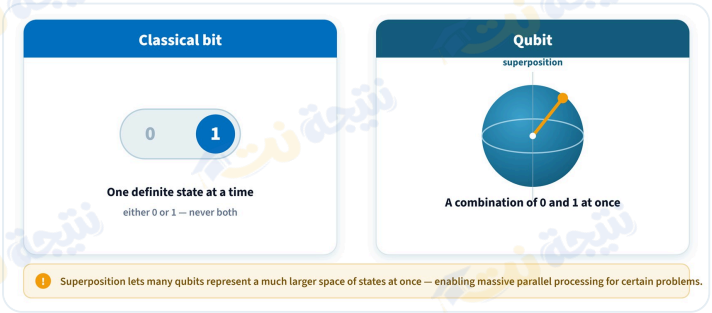
① **(AR (Augmented Reality))**...a technology that overlays digital information on real-world images.

② **(VR (Virtual Reality))**...a technology that allows users to immerse themselves in a virtual space generated by a computer.



AR adds digital layers to the real world; VR replaces it with a virtual one.

(3) **(Quantum computing)**...a technology expected to dramatically speed up computations that are difficult or impossible for traditional computers, by using the principles of quantum mechanics.



A classical bit holds one state; a qubit uses superposition.

KEY TERMS

edge computing — processing data on the device itself, instantly, instead of sending it to the cloud.

PAUSE & THINK

In autonomous driving, why is it necessary to process data instantly on the vehicle side using edge computing, rather than sending the data to the cloud for judgment? Explain your answer.

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✎ Worked Example

(1) From the following options (A–D), choose the one that lists the stages of information technology (IT) development in the correct chronological order.

A Birth of the computer → Rise of smartphones → Commercialization of the Internet → Spread of cloud computing

B Birth of the computer → Commercialization of the Internet → Rise of smartphones → Spread of cloud computing

C Commercialization of the Internet → Birth of the computer → Spread of cloud computing → Rise of smartphones

D Rise of smartphones → Commercialization of the Internet → Birth of the computer → Spread of cloud computing

(2) Mark each statement (A–D) with ○ if true or × if false.

A Moore's Law is the empirical observation that "the number of transistors on an integrated circuit doubles approximately every two years."

B Moore's Law has been said to be approaching a physical limit in recent years.

C SNS is highly effective at spreading information rapidly.

D E-commerce (EC) refers to purchasing goods at physical stores using cash.

(3) Match each description (a–c) with the most appropriate technology from the choices below (A–C).

a A technology that overlays digital information on real-world images

b A technology that uses AI to drive a vehicle without human operation

c A technology that allows users to immerse themselves in a virtual space generated by a computer

[Choices] **A** Autonomous driving **B** AR **C** VR

✓ Solution

(1) The correct order is "Birth of the computer (1940s-60s) → Commercialization of the Internet (1990s) → Rise of smartphones (2000s) → Spread of cloud computing (2010s onward)." Therefore, **B**.

(2)

A Correct definition of Moore's Law. Therefore, ○.

B It has been said to be approaching a physical limit in recent years. Therefore, ○.

C SNS is a service highly effective at spreading information rapidly. Therefore, ○.

D E-commerce refers to buying and selling through the Internet, not purchases at physical stores using cash. Therefore, ×.

KEY TERMS

Moore's Law — transistors per chip roughly double every two years.

edge computing — data processed on the device itself, instantly.

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(3)

a: Overlaying digital information on real-world images is AR (Augmented Reality). **B**

b: Driving a vehicle without human operation is autonomous driving. **A**

c: Immersing oneself in a virtual space is VR (Virtual Reality). **C**

Try

1 Answer the following questions.

1. What is the name of the empirical observation that "the number of transistors on an integrated circuit doubles approximately every two years"?
2. What is the term for the buying and selling of goods and services using the Internet?
3. What is the term for the working style in which one works from home or other remote locations using the Internet?
4. What is the term for the system for making payments using electronic money, QR codes, etc., without using cash?
5. What is the term for the technology that uses AI to drive a vehicle without human operation?

2 Answer the following questions.

(1) For each of a–d, indicate which of the following is most closely related: **A** Changes in daily life, **B** Changes in industry and the economy, **C** Changes in healthcare and education.

a Taking classes through online learning.

b Paying for purchases using a mobile payment app on a smartphone.

c Sharing photos with friends on SNS.

d A company introducing a work-from-home system.

(2) From the following options (A–D), choose the one that is NOT an appropriate description of an emerging technology.

A Autonomous driving uses AI to drive a vehicle without human operation.

B AR is a technology that overlays digital information on real-world images.

C VR is a technology that dramatically improves the processing speed of a computer.

D Quantum computing is expected to speed up computations that are difficult for traditional computers.

EXAM-STYLE QUESTION

Analyze how the spread of cloud computing (from the 2010s onward) has changed the way information technology is used. **[6] In your answer, refer to:** large-scale data analysis, AI, and "IT as a service".

KEY TERMS

remote work — working from home or another remote location using the Internet.

online learning — classes and materials delivered over the Internet.

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⚙ Think as an Engineer — Investigate & Decide

Start from the advantage and concern you named in the Pause & Think note, then investigate further and decide.

1 · Collect data. Survey ten classmates: do they usually pay with cash or with a cashless method (card, mobile app, or QR code)? Record the results in a table and identify the most common response.

2 · Analyze the stakeholders. Using your survey and your own reasoning, note one benefit and one drawback of a fully cashless society for each group below.

Group	Benefit	Drawback
A customer paying		
A small shop owner		
A person with no bank card or smartphone		

3 · Decide. Using your survey and your table, decide: should your community move toward cashless payment? Recommend one step and give two reasons.

Stuck? Start with the customer — one benefit is speed of payment; one drawback is needing a card or a phone.

💡 PAUSE & THINK

Cashless payment is spreading in many countries. If a fully cashless society were realized, choose one advantage and one possible concern, and briefly explain the reason for each.

🌍 In a New Context

A village that has never had Internet access is connected to high-speed Internet and cashless payment for the first time. Using the stages and social changes you studied, predict two ways daily life in the village will change, and identify one new problem the village may face.

KEY TERMS

cloud computing — IT delivered as a service over the Internet.

e-commerce — buying and selling through the Internet.

❓ Lesson Question — Answered

The lesson question asked how information technology developed and how each stage changed society. Information technology advanced through a series of stages rather than in a single step, and each stage changed much more than the technology itself. As computing spread, information became global and then mobile, many everyday activities moved online, and information technology grew into a service that supports large-scale data analysis and AI. Each stage also brought social changes in how people communicate, work, learn, and make payments. Overall, the development of information technology is not only about faster machines; at every stage it has reshaped daily life, industry, and the way society handles information.

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Exercise

1 Cover the Point! section with a red plastic sheet and quiz yourself in your notebook in numerical order.

2 Read the following passage and answer each question.

Computers were invented in the 1940s and were initially used mainly for military and scientific computation. Later, in the 1970s and 1980s, (a) became widespread, allowing individuals to use computers. In the 1990s, (b) was commercialized, advancing the globalization of information. In the 2000s, (c) emerged, leading to the explosive spread of mobile Internet.

1. Fill in the blanks (a)–(c).
2. What technology, which spread from the 2010s onward, supports large-scale data analysis and the use of AI?
3. According to Moore's Law, about how often does the number of transistors on an integrated circuit double?

3 Answer the following questions.

(1) From the following options (A–F), choose all that are emerging technologies.

A Email **B** Autonomous driving **C** Personal computers **D** AR **E** VR **F** Quantum computing

(2) From the following options (A–D), choose the one that most appropriately describes the characteristics of SNS.

A A service that allows users to connect with each other and post and share information, and is highly effective at spreading information rapidly.

B A service for buying and selling goods and services through the Internet.

C A working style in which one works from home or other remote locations.

D A system for making payments using electronic money or QR codes without using cash.

REFLECT & CHALLENGE

Reflect: Which stage of information technology do you think will matter most in the next ten years? Give one reason. Was your prediction at the start of the lesson correct? What changed your mind? **Challenge:** Choose one emerging technology from this lesson (autonomous driving, AR, VR, or quantum computing). Suggest one way it could help solve a real problem, and state one risk.

KEY TERMS

SNS — connects users to post and share information.
cashless payment — payment without cash (e-money, QR).

Key takeaway

Remember:
Information technology developed in stages — computers, the Internet, smartphones, and cloud computing. At each stage it introduced a new technology or service and also changed how society communicates, works, learns, and pays.

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Learning Objectives

- Explain what AI is.
- Explain how generative AI is positioned within AI technologies.

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When you use a phone, AI is often at work. A spam filter sorts your email, a store recommends products you might buy, a translation app changes one language into another, and ChatGPT generates text from a prompt. These are all examples of AI, but they are not all the same kind. AI includes machine learning, within machine learning is deep learning, and today's generative AI systems are built on deep learning — a series of nested technologies, each more specialized than the last.

? Guiding question: What is AI, and how are machine learning, deep learning, and generative AI related?

✎ Explore · In Pairs

With a partner, list three tasks a phone or computer does for you that seem to need "intelligence" (for example, sorting spam, recommending a video, or translating text). Then predict: does the computer follow fixed rules, or does it learn from examples? Give one reason.

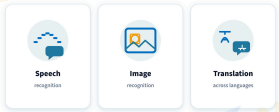
📌 Point!

1. What is Artificial Intelligence (AI)?

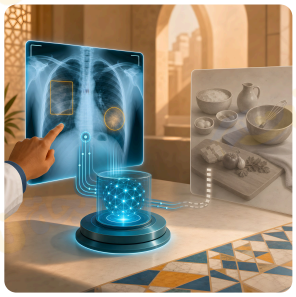
(1) **(AI (Artificial Intelligence))**…a general term for technologies that reproduce or perform intelligent human behavior (learning, reasoning, judgment, etc.) on a computer.
e.g., speech recognition, image recognition, translation

2. The Relationship between AI and Machine Learning

(1) Within AI technologies, there is machine learning; within machine learning, there is deep learning; and within deep learning, there is generative AI. The broad field of AI includes increasingly specialized technologies as a series of nested categories.



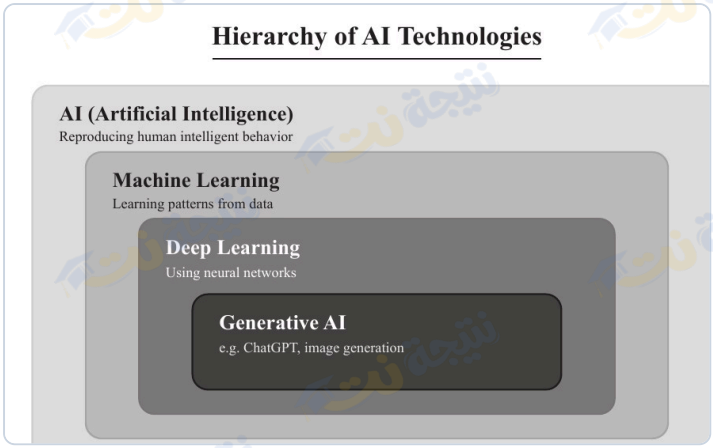
Three everyday AI examples: speech, image, translation.


Today's AI is narrow — expert at one task only.

💡 THINK IT THROUGH

Spam filters and product recommendations are both examples of machine learning, but the tasks they perform are completely different. From the perspective of how AI works, explain what these two applications have in common.

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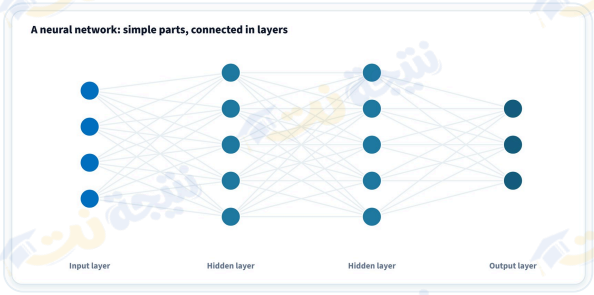


Hierarchy of AI Technologies

(2) **(Machine Learning)**…one of the learning technologies that makes AI work. It learns patterns from data to make predictions and judgments.
e.g., spam filters, product recommendations

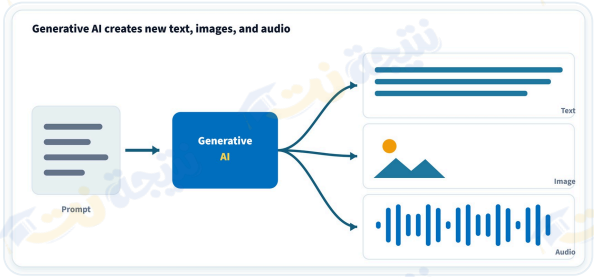
(3) **(Deep Learning)**…an advanced technology within machine learning that uses neural networks. It learns complex patterns using large-scale data.
e.g., image analysis for autonomous driving, speech synthesis

(4) **(Neural network)**…a system modeled after the workings of the nerve cells (neurons) of the human brain. By connecting many components, it learns from data and becomes capable of making complex judgments. It is the core technology supporting recent advances in AI.

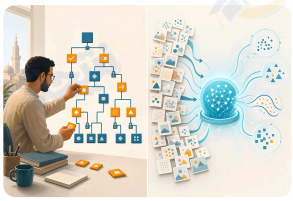


A neural network connects many simple components.

(5) **(Generative AI)**…AI technology that uses deep learning to generate new data (text, images, audio, programs, etc.).
e.g., ChatGPT, image generation AIs



Generative AI creates new text, images, and audio.



Fixed hand-written rules versus rules learned from data.

PAUSE & THINK

Deep learning needs large-scale data to learn. Why might an AI struggle with something it has rarely seen in its data?

KEY TERMS

neural network — a system modeled after the nerve cells (neurons) of the human brain, used to learn from data and make complex judgments.

KEY TERMS

generative AI — AI that uses deep learning to generate new data such as text, images, and audio.

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✎ Worked Example

(1) Mark each statement (A–D) with ○ if true or × if false.

A Machine learning is one of the technologies that makes AI work.

B Deep learning is a completely different technology from machine learning.

C Generative AI is a technology that uses deep learning to generate new data.

D AI and machine learning have the same meaning.

(2) Match each description (a–c) with the most appropriate term from the choices below (A–C).

a A technology that learns patterns from data to make predictions and judgments

b A technology that uses neural networks to learn complex patterns

c AI technology that generates new data such as text and images

[Choices] **A** Machine learning **B** Deep learning **C** Generative AI

✓ Solution

(1)

A Machine learning is one of the learning technologies that makes AI work. Therefore, ○.

B Deep learning is a type of machine learning (an advanced technology within machine learning). Therefore, ×.

C Correct description of generative AI. Therefore, ○.

D AI is a broad concept, and machine learning is one of the technologies within it. They do not have the same meaning. Therefore, ×.

(2)

a: Learning patterns from data is machine learning. **A**

b: Using neural networks is deep learning. **B**

c: Generating new data is generative AI. **C**

KEY TERMS

machine learning — learns patterns from data.

deep learning — uses neural networks on large-scale data.

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Try

1 Answer the following questions.

1. What is the general term, expressed by a two-letter abbreviation, for technologies that reproduce or perform intelligent human behavior on a computer?
2. What is the term for the learning technology that makes AI work by learning patterns from data to make predictions and judgments?
3. What is the term for the advanced technology within machine learning that uses neural networks?
4. What is the term for the AI technology that uses deep learning to generate new data?

2 Answer the following questions.

(1) From the following options (A–D), choose the one that correctly describes the relationship between AI, machine learning, deep learning, and generative AI.

A AI > Deep Learning > Machine Learning > Generative AI

B Machine Learning > AI > Generative AI > Deep Learning

C AI > Machine Learning > Deep Learning > Generative AI

D Generative AI > Deep Learning > Machine Learning > AI

(2) From the following options (A–D), choose the one that is NOT an appropriate example of generative AI.

A ChatGPT

B Image generation AI

C Spam filter

D Audio generation AI

Think as an Engineer — Investigate & Decide

Starting from the Think It Through note about hallucination, investigate further and decide.

1 · Investigate. Find one documented example where a generative AI gave an answer that sounded correct but was actually wrong (a "hallucination"). Record its source — a news article, an official report, or a prompt you tested yourself with a screenshot — and note where you found it. Do not rely on an example recalled from memory without a source.

2 · Weigh it up. Note one benefit and one risk of using generative AI to write a school report — for the student, and for the teacher.

3 · Decide. Should generative AI be allowed for homework in your school? Recommend one rule and give two reasons.

EXAM-STYLE QUESTION

Analyze the relationship between AI, machine learning, deep learning, and generative AI. **[6] In your answer:** use the idea of nested categories, and give one example of each.

THINK IT THROUGH

Generative AI can produce text that sounds plausible but is factually incorrect (a "hallucination"). Explain why it is dangerous to use such output as the answer to a school report as-is, and state what learners should do instead.

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Stuck? One benefit is speed; one risk is that the answer may be factually incorrect, so it must be checked.

🌍 In a New Context

A farmer wants to use AI to distinguish healthy crops from diseased ones in photographs. Using what you learned about deep learning and image analysis, explain what the AI would need to learn from, and identify one reason its judgment might be wrong.

❓ Lesson Question — Answered

The lesson question asked what AI is and how machine learning, deep learning, and generative AI are related. AI is a general term for technologies that reproduce or perform intelligent human behavior on a computer, and machine learning, deep learning, and generative AI are increasingly specialized fields nested within it rather than parallel to it. The key idea from this lesson is that these are not four separate technologies to learn in isolation, but one broad field understood at different levels of specialization.

KEY TERMS

deep learning — uses neural networks to learn complex patterns.

generative AI — uses deep learning to generate new data.

Exercise

1 Cover the Point! section with a red plastic sheet and quiz yourself in your notebook in numerical order.

2 Read the following passage and answer each question.

The general term for technologies that reproduce or perform intelligent human behavior on a computer is (a). One of the learning technologies that makes (a) work by learning patterns from data is (b). Within (b), an advanced technology that uses neural networks is (c). Furthermore, the technology that uses (c) to generate new data is (d).

1. Fill in the blanks (a)–(d).

⭐ REFLECT & CHALLENGE

Reflect: Before this lesson, did you think AI was one single technology? How has your idea changed? Which of the four — AI, machine learning, deep learning, generative AI — was hardest to tell apart, and why?

Challenge: Generative AI can create text, images, and audio. Suggest one helpful use and one possible misuse, and say how the misuse could be reduced.

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3 Answer the following questions.

(1) For each example (a–d), indicate which of the following is most closely related: **A** Machine learning, **B** Deep learning, **C** Generative AI.

a Automatically sorting spam emails

b Recognizing pedestrians on the road in autonomous driving

c Automatically generating new images from text

d Recommending products based on a user's purchase history

(2) From the following options (A–D), choose the one that most appropriately describes the relationship between AI, machine learning, deep learning, and generative AI.

A Machine learning is a type of AI, and deep learning is a type of machine learning.

B AI is a type of machine learning, and generative AI is a type of AI.

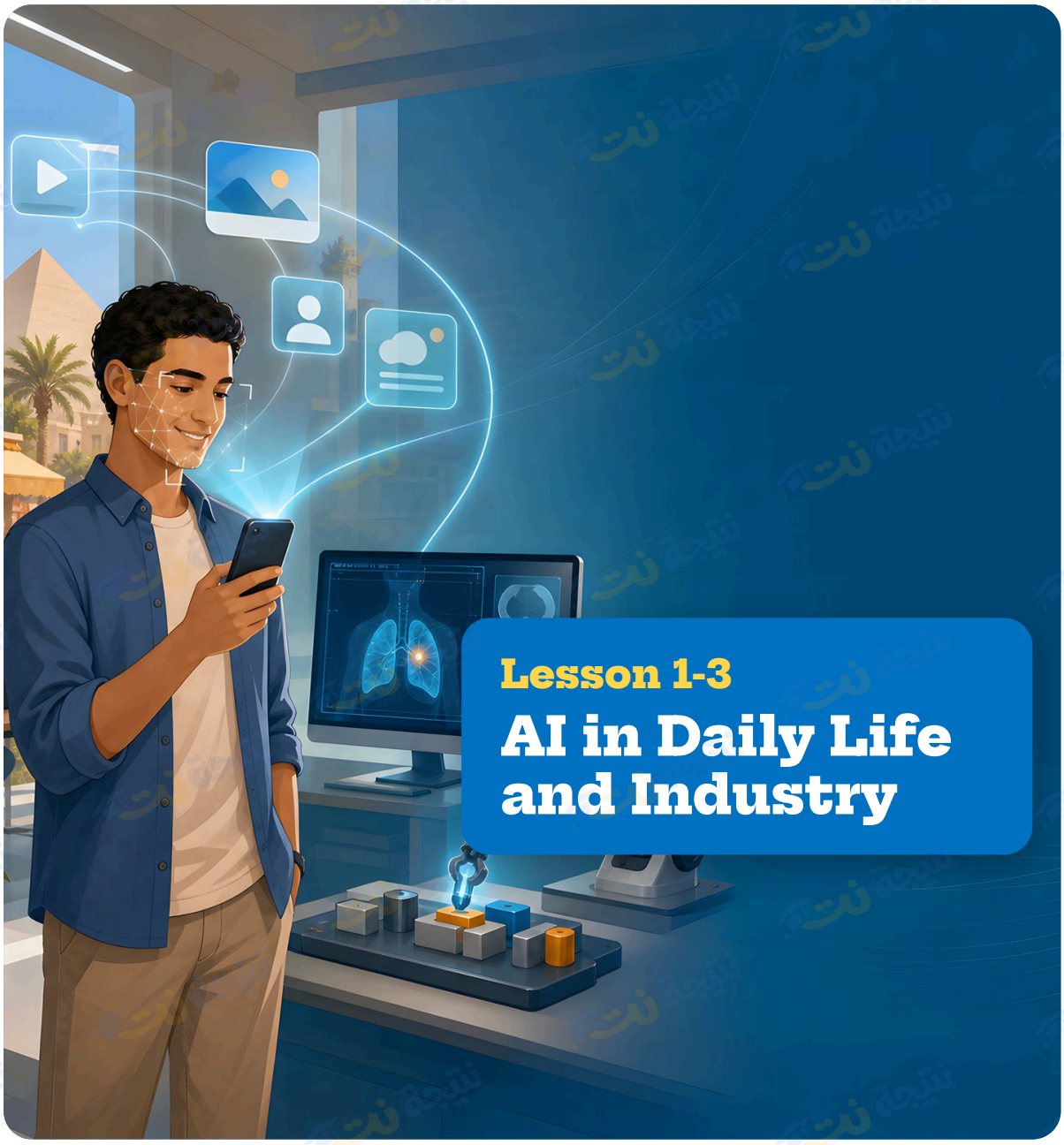
C Deep learning and machine learning are completely different technologies.

D Generative AI is a technology that generates data without using machine learning.

⭐ Key takeaway

Remember:
AI is the broad field; machine learning sits inside it, deep learning inside machine learning, and today's generative AI is built on deep learning — from the broadest idea to the most specialized.

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Lesson 1-3

AI in Daily Life and Industry

Learning Objectives

- Give examples of how AI is used in daily life and various industries.
- Explain what AI is good at and what requires caution when using AI.

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AI is already part of many everyday services. A video site recommends the next clip, a voice assistant answers a spoken question, a translation tool converts text on a foreign menu, and a phone unlocks by recognizing your face. In industry, AI analyzes medical images, predicts when a machine will fail, and plans delivery routes. AI is effective at identifying patterns in data, but it is not suited to every task, and some uses require caution.

? Guiding question: Where is AI used in daily life and industry, what is AI good at, and what needs caution?

✎ Explore · In Pairs

With a partner, list three services you used this week that you think used AI (for example, a video recommendation, a voice assistant, or a translation). For each, predict what data the AI needed to do its job. Then decide together: which one would matter most if it made a mistake?

Key Fact:
AI is good at finding patterns in data, but human judgment is still needed where ethics, privacy, and responsibility are involved.

Key Concepts:

- recommendation system
- voice assistant
- machine translation
- face recognition
- image-diagnosis AI
- predictive maintenance
- black-box problem
- hallucination

Point!

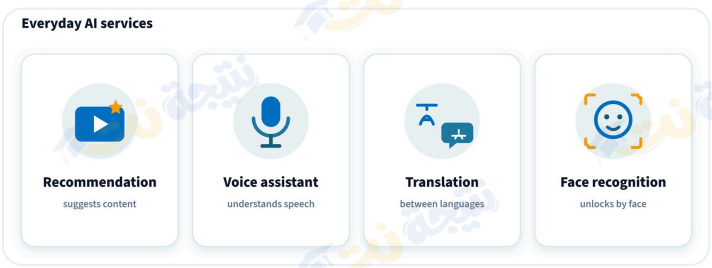
1. Use of AI in Daily Life

(1) Various AI technologies are already in use around us.

Service	Role of AI	Examples
Recommendation systems	Predict preferences from past behavior data and display recommendations.	YouTube, Amazon, Spotify, etc.
Voice assistants	Recognize a voice, understand commands, and execute them.	Siri, Google Assistant, etc.
Machine translation	Automatically translate text into different languages.	Google Translate, DeepL, etc.
Face recognition	Automatically detect and identify human faces in photographs.	Smartphone unlocking, etc.



Recommenders match new items to your past choices.



Four everyday-life AI services

KEY TERMS
recommendation system — a system that predicts preferences from past behavior data and displays recommendations.

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2. Use of AI in Industry

(1) AI technologies are also being introduced in various industries.

Industry	Examples of AI use
Healthcare	Image-diagnosis AI (detecting diseases from X-ray and CT images), drug-discovery support
Agriculture	Predicting harvest timing, detecting pests and diseases
Manufacturing	Automation of product quality inspection, predictive maintenance
Logistics	Optimization of delivery routes



Four industries where AI is used

3. Characteristics of AI and Cautions for Use

(1) What AI is good at

- Finding and classifying patterns in complex data such as images and text
- Recognition and generation of images, audio, and text
- Probabilistic reasoning and prediction based on data

(2) What requires caution when using AI

- Ethical judgments (may lead to discrimination or prejudice)
- Judgments involving personal information or privacy
- Final decision-making (who is responsible for the result)
- Accuracy of judgments when training data is biased
- Generating content that differs from the facts (hallucination)
- Issues of rights when using copyrighted works as training data
- Loss of clarity about how a judgment was made (the black-box problem)

✎ Worked Example

(1) For each of a-d, match the AI technology used in the service with the most appropriate term from the choices below (A–D).

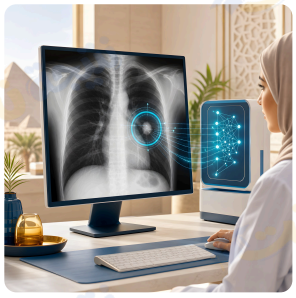
a YouTube recommends videos that match the user's preferences

b Speaking to a smartphone to check the weather

c Translating a foreign-language website into one's native language

d A smartphone camera automatically detects a person's face

[Choices] **A** Recommendation system **B** Voice assistant **C** Machine translation **D** Face recognition



In industry, AI flags what humans might miss.

💡 THINK IT THROUGH

A hospital is considering using image-diagnosis AI to detect diseases from X-ray images. Explain why the final diagnosis should be confirmed by a human doctor rather than left to AI alone.

💡 PAUSE & THINK

AI services often use your personal data — what you watch, buy, or say. Why does this raise privacy concerns, and who should decide how your data is used?

KEY TERMS

black-box problem — when it is unclear how an AI reached its judgment.

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(2) Mark each statement (A–D) with ○ if true or × if false.

A AI is good at probabilistic reasoning and prediction based on data.

B AI is good at recognizing images and audio.

C It is fine to leave ethical judgments entirely to AI.

D AI judgments can become inaccurate when training data is biased.

✓ Solution

(1)

a: Recommendations matched to preferences come from a recommendation system. **A**

b: Operating by speaking is a voice assistant. **B**

c: Translating a foreign language into one's native language is machine translation. **C**

d: Detecting a person's face is face recognition. **D**

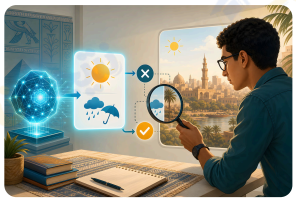
(2)

A AI is good at probabilistic reasoning and prediction based on data. Therefore, ○.

B AI is good at recognizing images, audio, and text. Therefore, ○.

C AI judgments can lead to discrimination or prejudice, so ethical judgments should not be left entirely to AI. Therefore, ×.

D Bias in training data affects the accuracy of AI judgments. Therefore, ○.



AI can be confidently wrong — verify its output.

Try

1 Answer the following questions.

1. What is the term for the system that predicts preferences from past behavior data and displays recommendations?
2. What is the term for the AI technology that recognizes a voice, understands commands, and executes them?
3. In which industry are image-diagnosis AIs used?
4. In manufacturing, what is the term for the system that predicts product failures in advance?

EXAM-STYLE QUESTION

Analyze why AI is well suited to some tasks but requires caution in others. **[6] In your answer:** refer to what AI is good at (finding patterns, recognition, prediction) and to what needs caution (ethical judgments, privacy, final decision-making).

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2 Answer the following questions.

(1) From the following options (A–D), choose the one that does NOT belong to "what requires caution when using AI."

A Ethical judgments

B Finding and classifying patterns

C Judgments involving personal information or privacy

D Final decision-making

(2) For each AI usage example (a–d), indicate which industry is most closely related: **A** Healthcare, **B** Agriculture, **C** Manufacturing, **D** Logistics.

a Optimizing delivery routes

b Detecting diseases from X-ray images

c Detecting pests and diseases

d Automating product quality inspection

⚙ Think as an Engineer — Investigate & Decide

You have just discussed agriculture in the Think It Through note. Now investigate a different industry and decide.

1 · Investigate. Choose one industry from the lesson other than agriculture — healthcare, manufacturing, or logistics. Find one real, documented example of AI being used in it, and record the source you used.

2 · Weigh it up. Note one benefit and one caution of using AI in that industry, using the ideas of what AI is good at and what needs caution.

3 · Decide. Should this industry use AI for this task on its own, or with a human checking the result? Recommend one approach and give two reasons.

Stuck? AI is good at finding patterns quickly; but a human is needed where a wrong result could harm someone or involve responsibility.

🌍 In a New Context

A school library wants to use AI to recommend books to students based on what they have borrowed before. Using what you learned about recommendation systems and what AI is good at, explain how the AI would work, and identify one caution the school should consider.

💡 THINK IT THROUGH

In agriculture, give one realistic advantage of introducing AI and one concern that should be considered before introduction, and briefly explain the reason for each.

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❓ Lesson Question — Answered

AI is used widely in daily life — in recommendation systems, voice assistants, machine translation, and face recognition — and in industry, across fields such as healthcare, agriculture, manufacturing, and logistics. AI is good at finding and classifying patterns in data, recognizing and generating images, audio, and text, and making probabilistic predictions from data. However, it needs caution where ethical judgments, personal information and privacy, and final decision-making are involved, and where training data is biased. So AI is a powerful tool for pattern-based tasks, but human judgment is still needed for responsibility, ethics, and fairness.

Exercise

1 Cover the Point! section with a red plastic sheet and quiz yourself in your notebook in numerical order.

2 Answer the following questions.

(1) Select all options that AI excels at.

A Ethical judgments

B Finding features in images and text and classifying them

C Judgments involving personal information

D Probabilistic reasoning and prediction based on data

E Decision-making that bears responsibility for results

F Recognition and generation of images, audio, and text

(2) From the following options (A–D), choose the one that is NOT an appropriate description of services that use AI.

A A recommendation system predicts preferences from past behavior data and displays recommendations.

B A voice assistant recognizes a voice, understands commands, and executes them.

C Machine translation is a system in which humans manually translate foreign languages.

D Face recognition automatically detects and identifies human faces in photographs.

3 Read the following passage and answer each question.

AI is widely used in our daily lives. For example, recommendations of videos that match one's preferences on a video site come from a (a) system. Also, AI

⭐ REFLECT & CHALLENGE

Reflect: Which use of AI in this lesson surprised you most? Where in your own life do you think AI is making decisions about you? **Challenge:** Choose one task where AI needs caution (ethics, privacy, or final decisions). Suggest one rule that would make using AI for that task safer.

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technology is used in (b), with which one can speak to a smartphone to operate it, and in (c), which converts foreign-language text into one's native language.

1. Fill in the blanks (a)–(c).

(2) From the following (a–d), choose all that require caution when using AI.

a High-speed processing of large amounts of data

b Ethical judgments

c Judgments involving personal information or privacy

d Recognition of images and audio

Key takeaway

Remember:
AI is good at finding and classifying patterns in data — recommendations, voice, translation, face recognition, and many industry tasks — but human judgment is still needed where ethics, privacy, and responsibility are involved.

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Lesson 1-4

Ethical Issues with AI

Learning Objectives

- Explain what algorithmic bias is and describe its main causes.
- Connect the basic principles of AI ethics (fairness, transparency, privacy protection, and accountability) to specific situations.

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AI now helps make real decisions about people: selecting candidates for job interviews, identifying individuals through face recognition, and determining how personal data is used. But an AI can be unfair if the data it learned from was biased, and it can be hard to know why it made a decision at all. As AI spreads, questions arise about how to keep it fair, transparent, and accountable, and about who is responsible when it produces an incorrect or unfair result.

? Guiding question: What ethical issues arise as AI spreads, and what principles should guide how we use it?

✎ Explore · In Pairs

With a partner, look at this situation: a face-recognition AI is more likely to misidentify people from some ethnic groups than others. Before you read on, predict who could be harmed by this, and how. Give a reason.

Point!

1. Algorithmic Bias

(1) **(Algorithmic bias)**…bias in AI judgments caused by bias in the training data. *e.g., a hiring AI unfairly evaluating a particular gender; a face-recognition AI being more likely to misidentify particular ethnic groups*

(2) Main causes of bias

- Training data is biased (e.g., insufficient data on certain attributes; past discriminatory tendencies are reflected in the data). Bias can also enter through the way the system is built — for example, an inappropriate choice of variables, a proxy variable that indirectly stands in for a protected attribute, or the design of the model itself.

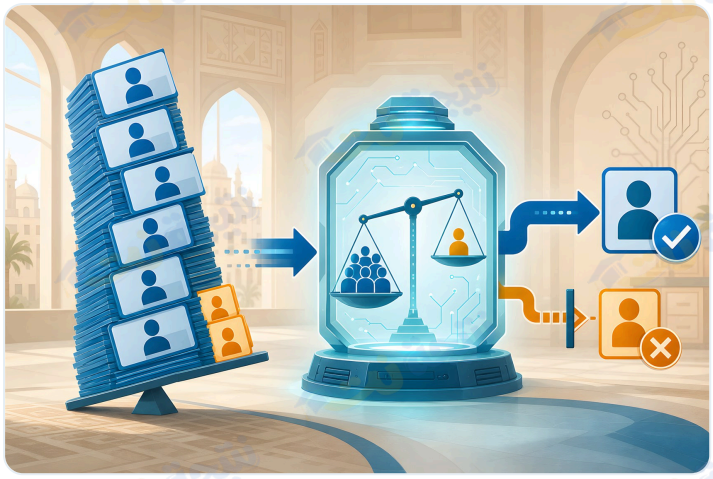
Key Fact:
If the training data is biased, an AI can reproduce that bias in its judgments; using AI responsibly means checking for bias, being able to explain decisions, and knowing who is accountable.

Key Concepts:

- algorithmic bias
- training data
- face recognition
- privacy
- explainable AI (XAI)
- black-box problem
- responsibility
- fairness
- transparency
- privacy protection
- accountability

KEY TERMS
algorithmic bias — bias in AI judgments caused by bias in the training data.

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Biased training data leads to biased AI judgments

2. Privacy Issues

(1) The development of AI technology has given rise to new issues concerning **(privacy)**.

① Surveillance through face-recognition technology…cameras in public spaces can identify and track individuals.

② Mass collection of personal data…large amounts of online behavior data are collected and analyzed.

3. Explainable AI (XAI) and Responsibility

(1) **(Explainable AI (XAI))**…technology that makes it possible for humans to understand why an AI made a particular judgment.
When an AI's decision-making process is opaque (a black box), it is difficult to verify whether the result is correct.

(2) **(Responsibility)**…the question of who is responsible when an AI makes an incorrect judgment.
Views on responsibility differ depending on whether one is the developer, the user, the operator, etc.

4. Basic Principles of AI Ethics

(1) The following basic principles are considered important for using AI appropriately.

Principle	Description
Fairness	Not unjustly discriminating against any particular person or group
Transparency	Showing the AI's decision-making process and inner workings clearly
Privacy protection	Handling personal information appropriately and protecting privacy
Accountability	Being answerable for the AI's decisions

THINK IT THROUGH

When face-recognition technology is used in public spaces, safety and convenience may improve, but privacy concerns also arise. Explain how convenience, safety, and privacy protection should be balanced, and state which basic principle of AI ethics is most closely related to your view.



Privacy: control which personal data is shared.

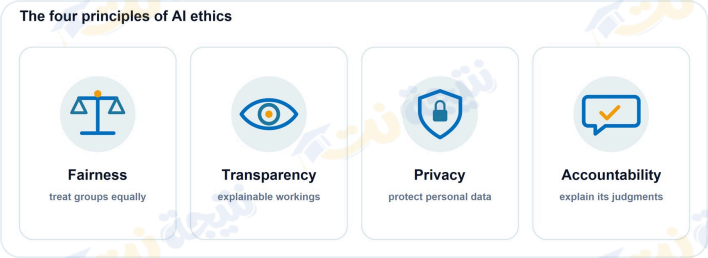
KEY TERMS

explainable AI (XAI) — technology that makes it possible for humans to understand why an AI made a particular judgment.



Explainable AI reveals the reasons behind a decision.

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The four principles of AI ethics

PAUSE & THINK

If no one can explain why an AI rejected someone's job application, is that fair? Which principle of AI ethics is missing?

KEY TERMS

fairness — no unjust discrimination against a person or group.
accountability — being answerable for the AI's decisions.

✎ Worked Example

(1) Mark each statement (A–D) with ○ if true or × if false.

A Algorithmic bias is bias in AI judgments caused by bias in the training data.

B Even if an AI's decision-making process is opaque, there is no problem as long as the result is correct.

C Explainable AI (XAI) is a technology that makes it possible for humans to understand the AI's reasoning.

D When an AI makes an incorrect judgment, who is responsible has already been clearly determined.

(2) Match each description (a–d) with the most appropriate AI ethics basic principle from the choices below (A–D).

a Not unjustly discriminating against any particular person or group

b Showing the AI's decision-making process and inner workings clearly

c Handling personal information appropriately and protecting privacy

d Being answerable for the AI's decisions

[Choices] **A** Fairness **B** Transparency **C** Privacy protection **D** Accountability

✓ Solution

(1)

A Correct definition of algorithmic bias. Therefore, ○.

B When an AI's decision-making process is opaque, it is difficult to verify whether the result is correct. Therefore, ×.

C Correct description of Explainable AI (XAI). Therefore, ○.

D Views on responsibility when an AI makes an incorrect judgment differ depending on whether one is the developer, the user, the operator, etc., and have not yet been clearly determined. Therefore, ×.

(2)

a: Not discriminating is fairness. **A**

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b: Showing the decision-making process is transparency. **B**

c: Protecting privacy is privacy protection. **C**

d: Being answerable for decisions is accountability. **D**

Try

1 Answer the following questions.

1. What is the term for the phenomenon in which bias arises in AI judgments due to bias in the training data?
2. What is the term for the technology that makes it possible for humans to understand why an AI made a particular judgment? Also, give its three-letter abbreviation.
3. Among the basic principles of AI ethics, what is the term for the principle that requires not unjustly discriminating against any particular person or group?
4. Among the basic principles of AI ethics, what is the term for the principle that requires handling personal information appropriately?

2 Answer the following questions.

(1) From the following options (A–D), choose the one that is NOT an appropriate cause of algorithmic bias.

A Training data is biased.

B Past discriminatory tendencies are reflected in the data.

C The processing speed of the computer is slow.

D There is insufficient data on certain attributes.

(2) From the following options (A–D), choose all that are privacy issues associated with AI.

A Individuals are identified and tracked through face-recognition technology.

B Online behavior data is collected and analyzed in large quantities.

C AI creates creative works.

D AI computation speed improves.

Think as an Engineer — Investigate & Decide

Building on the hiring-AI case in the Think It Through note, investigate a real example and decide on a rule.

1 · Investigate. Find one documented case where an AI system was accused of being unfair or biased, and record the source you used (a news report, study, or official statement). What group did it affect, and what data might have caused it?

KEY TERMS

privacy — appropriate handling and protection of personal data.

responsibility — who answers when an AI judgment is wrong.

EXAM-STYLE QUESTION

Analyze how algorithmic bias can arise in an AI system, and how it can be reduced. **[6] In your answer:** refer to the cause of bias (biased or insufficient training data) and to how the principles of fairness and transparency help address it.

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2 · Consider responsibility. When an AI makes an unfair decision, who is responsible — the developer, the company using it, or the operator? Note the responsibility each one holds.

3 · Decide. Before a company uses a hiring AI, what one rule should it follow to make the system fairer? Justify your rule using the principles of AI ethics.

Stuck? If the training data reflects past bias, the AI can repeat it — one fix is to check the data and test the AI's results across different groups.

THINK IT THROUGH

A hiring AI was found to rate applicants of a particular gender lower. Using the ideas of algorithmic bias and the basic principles of AI ethics, explain the most likely cause and one possible measure to address it. There can be more than one reasonable view. Give the basis for your answer.

KEY TERMS

transparency — showing the AI's decision-making process clearly.

privacy protection — handling personal information appropriately.

In a New Context

A school wants to use face-recognition cameras at its gate to record attendance automatically. Identify one practical benefit for the school and one privacy concern. Then, if the camera misidentifies a student, who should be responsible — the school, or the company that made the AI? Give a reason.

Lesson Question — Answered

The lesson question asked what ethical issues arise as AI spreads and what principles should guide how we use it. Because AI now makes decisions that affect people, three concerns stand out: an AI can be unfair when it learns from biased data; it can put people's privacy at risk; and it can be difficult to understand, or to hold anyone answerable for, its decisions. Handling these well takes more than accuracy. The lesson sets out four principles to aim for — fairness, transparency, privacy protection, and accountability — and keeping AI fair, transparent, privacy-respecting, and accountable is what makes its use responsible.

Exercise

1 Cover the Point! section with a red plastic sheet and quiz yourself in your notebook in numerical order.

2 Read the following passage and answer each question.

As AI technology spreads widely in society, attention has been drawn to various ethical issues. For example, there is the issue of (a), in which bias arises in AI judgments due to bias in the training data. Also, for the "black-box" problem—where it is unclear why an AI made a particular judgment—a technology called (

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b) is being researched. Furthermore, when an AI makes an incorrect judgment, (c) is questioned, but no clear standard has yet been established among developers, users, and operators.

1. Fill in the blanks (a)–(c).

3 Answer the following questions.

(1) For each of a-d, indicate which AI ethics basic principle is most closely related: **A** Fairness, **B** Transparency, **C** Privacy protection, **D** Accountability.

a Ensuring that a hiring AI evaluates fairly regardless of gender.

b Disclosing the AI's decision-making process to users in an easy-to-understand way.

c Not using collected personal data for purposes other than as originally intended.

d Being answerable when an AI's diagnostic result turns out to be wrong.

(2) From the following options (A–D), choose the one that most appropriately describes ethical issues with AI.

A There are no ethical issues with AI.

B Algorithmic bias is caused by the AI's processing speed.

C Bias in training data can cause discriminatory bias in AI judgments.

D Even if an AI's decision-making process is opaque, there is no problem for users.

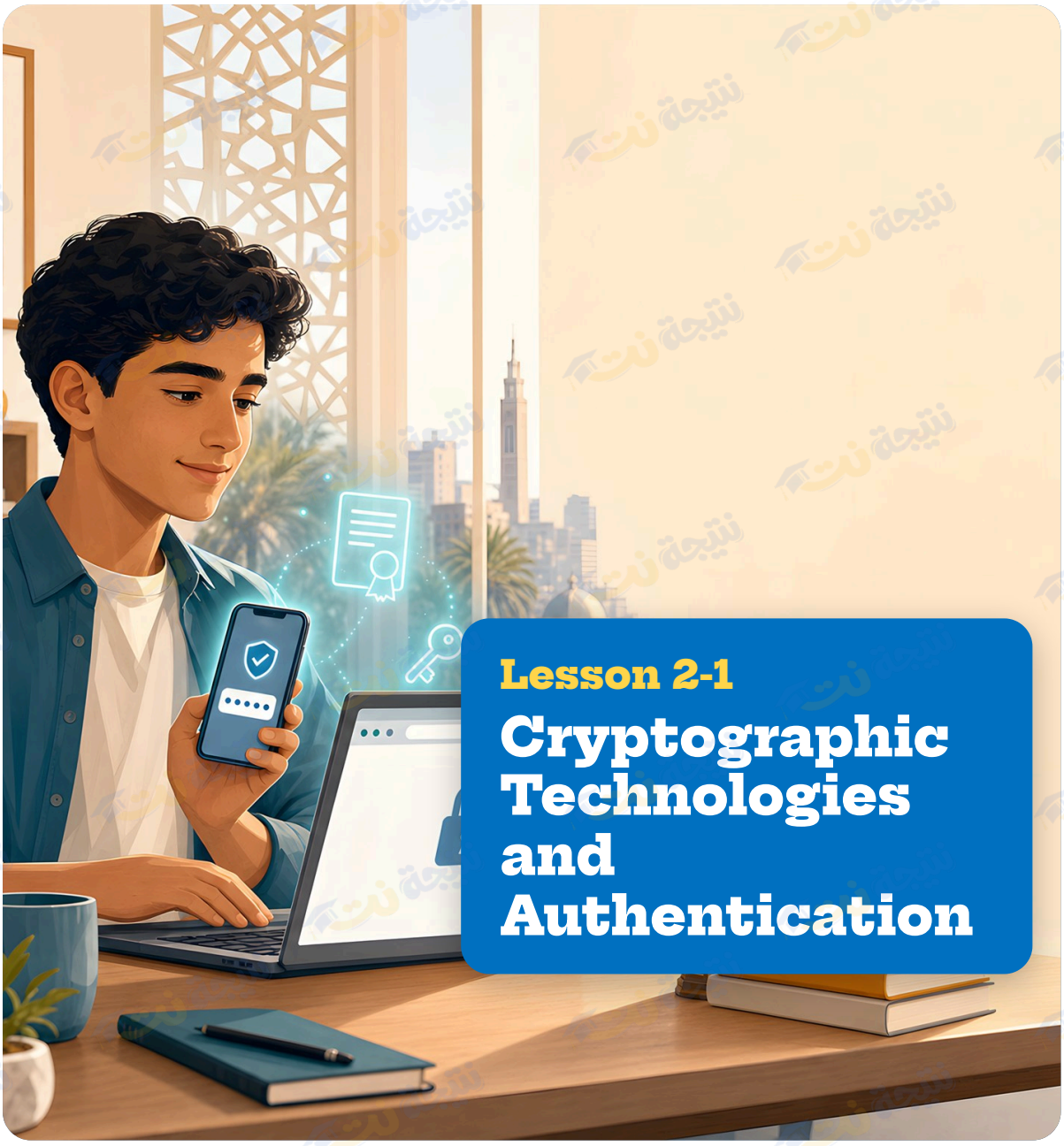
⭐ REFLECT & CHALLENGE

Reflect: Has this lesson changed how much you would trust an AI decision about you? Which of the four principles do you think is hardest to guarantee, and why?
Challenge: Choose one place AI is used (hiring, face recognition, or recommendations). Suggest one rule based on the AI ethics principles that would make it more trustworthy.

⭐ Key takeaway

Remember:
If training data is biased, an AI can reproduce that bias; using AI responsibly means checking for bias, being able to explain decisions, and knowing who is accountable — guided by fairness, transparency, privacy protection, and accountability.

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Lesson 2-1

Cryptographic Technologies and Authentication

Learning Objectives

- Explain how HTTPS secures communication: how the TLS handshake uses public-key cryptography to share a key safely, and how common-key cryptography then protects the data that follows.
- Describe how authentication, including multi-factor authentication, is used in real services, and explain why security technologies are combined.

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Every time you log in to a bank app, buy something online, or open a website with a small padlock in the address bar, hidden technologies are working to keep your information safe. Messages are scrambled so no one else can read them, the website proves that it is genuine, and your identity is checked before you are granted access. Without these protections, passwords could be stolen and private data could be read by unauthorized people.

? Guiding question: How do cryptographic technologies and authentication work together to keep online communication and services secure?

Point!

1. How HTTPS Communication Works

(1) **(HTTPS (HTTP Secure))**…a communication protocol that adds TLS encryption to HTTP. By providing encryption, detection of tampering, and verification of the communication partner, it protects users from threats such as eavesdropping, tampering, and impersonation. The procedure for establishing a secure communication is called the TLS handshake.

(2) HTTPS combines common-key (symmetric-key) cryptography and public-key cryptography as follows, taking advantage of the strengths of both methods.

Stage	What happens	Cryptographic method used
① **Connection**	The web server sends a digital certificate and a public key to the browser. The browser verifies the server's authenticity through a certificate authority (CA).	Public-key cryptography
② **Key exchange**	The browser creates a common key for communication, encrypts it with the server's public key, and sends it. The server decrypts it with its private key to obtain the common key.	Public-key cryptography
③ **Data communication**	Data is encrypted and exchanged using the shared common key.	Common-key cryptography

Note: the exchange above shows one way a common key can be shared. Current versions of TLS use Diffie-Hellman key agreement instead.

Key Fact:
Secure online communication and services depend on combining cryptography and authentication — not on any single technology.

Key Concepts:

- HTTPS
- common-key cryptography
- public-key cryptography
- TLS handshake
- multi-factor authentication
- digital signature
- digital certificate
- non-repudiation

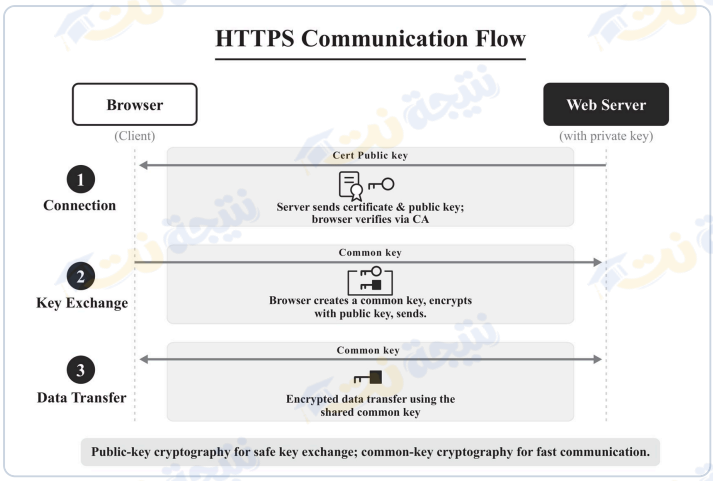
KEY TERMS

HTTPS — HTTP with TLS encryption added (encryption, tamper detection, and partner verification).



A public key locks; a different private key unlocks. In a digital signature the direction reverses: the private key signs and the public key verifies.

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HTTPS Communication Flow

(3) Public-key cryptography is used to "share keys safely," and common-key cryptography is used to "exchange large amounts of data quickly." This division of roles makes it possible to achieve both security and communication speed.

2. Use of Authentication in Real Services

(1) Many services adopt **(multi-factor authentication)**, in which two or more of the three factors of authentication (knowledge, possession, biometric) are combined.

(2) When only one factor is used, an unauthorized party can gain access if that factor is broken. By combining multiple factors, even if one is broken, another can still prevent access.
e.g., If only a password (knowledge) is used, an unauthorized login is possible once the password is leaked. However, if a notification to a smartphone (possession) is also required, an attacker cannot log in without the device, even if the password is leaked.

(3) The following examples of multi-factor authentication are used in various services.

Service	Examples of authentication used
Online banking	Password (knowledge) + one-time password (possession)
SNS login	Password (knowledge) + SMS authentication (possession)
Company laptop login	Smart card (possession) + fingerprint authentication (biometric)
Online shopping	Password (knowledge) + one-time code from 3-D Secure (possession)

3. Combinations of Security Technologies

(1) Safe communication and services are achieved not by a single technology, but by combining multiple security technologies.



Strong login combines two or more different factors.

KEY TERMS
multi-factor authentication — combining two or more of the three factors: knowledge, possession, biometric.

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Technology	Effect
Encryption (common-key, public-key)	Prevents communication content from being read by third parties
Digital signature	Detects data tampering or impersonation of the sender, and makes it impossible for the sender to deny having sent the data afterward (non-repudiation)
Digital certificate	Verifies that the communication partner is authentic
Multi-factor authentication	Prevents unauthorized logins

(2) For example, when purchasing a product through online shopping, these technologies are combined and used as follows.

① When you access the site, HTTPS communication begins, and **(encryption)** prevents communication content from being read by third parties.

② The browser checks the **(digital certificate)** to confirm that the destination is the genuine shopping site.

③ For account login, **(multi-factor authentication)** combining a password and SMS authentication, etc., prevents unauthorized logins.

④ When sending order details, a **(digital signature)** can also be used so that tampering during communication can be detected.

(3) By combining multiple technologies in this way, various threats such as "eavesdropping," "tampering," "impersonation," and "unauthorized login" can be addressed simultaneously.

✎ Worked Example

(1) Mark each statement (A–D) with ○ if true or × if false.

A HTTPS communication uses both public-key cryptography and common-key cryptography.

B HTTPS communication exchanges all data using public-key cryptography.

C Multi-factor authentication is a method that combines two or more of the three factors of authentication.

D An example of multi-factor authentication is setting two passwords.

(2) Match each threat (a–c) with the most appropriate security technology from the choices below (A–C).

a I want to prevent communication content from being read by third parties.

b I want to verify that data has not been altered during communication.

KEY TERMS

digital signature — detects tampering and impersonation, and provides non-repudiation.



A certificate authority vouches that a site is genuine.

PAUSE & THINK

If a password is leaked, why can a second factor sent to a phone still keep the account safe?

KEY TERMS

public-key cryptography — shares a key safely.
common-key cryptography — exchanges data quickly.

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c I want to verify that the communication partner is authentic.

[Choices] **A** Encryption **B** Digital signature **C** Digital certificate

✓ Solution

(1)

A HTTPS communication uses public-key cryptography for key exchange and common-key cryptography for data communication. Therefore, ○.

B Exchanging all data using public-key cryptography would be slow, so common-key cryptography is used for data communication. Therefore, ×.

C Correct definition of multi-factor authentication. Therefore, ○.

D Even if two passwords are set, both are "knowledge" factors, so this does not constitute multi-factor authentication (it is two-step authentication using the same factor). Therefore, ×.

(2)

a: Preventing reading of communication content is encryption. **A**

b: Detecting data tampering is a digital signature. **B**

c: Verifying the authenticity of the communication partner is a digital certificate. **C**

EXAM-STYLE QUESTION

Explain why HTTPS uses public-key cryptography to share the key but common-key cryptography to exchange the data. **[6] Refer to:** security and speed.

Try

1 Answer the following questions.

1. In HTTPS communication, what cryptographic method is used so that the browser and server can safely share a common key?
2. In HTTPS communication, what cryptographic method is used for data communication after the common key has been shared?
3. Briefly explain the reason for combining the cryptographic methods in (1) and (2), based on the characteristics of each method.

2 Answer the following questions.

(1) For each service (a–d), indicate which combination of authentication factors is used: **A** Knowledge + possession, **B** Knowledge + biometric, **C** Biometric + possession.

a Password + one-time password

b Password + fingerprint authentication

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c Password + SMS authentication

d Face recognition + smart card

(2) From the following options (A–D), choose the one that is NOT an appropriate description of combinations of security technologies.

A Encryption is a technology that prevents communication content from being read by third parties.

B Digital signatures are a technology that improves communication speed.

C Digital certificates are a system for verifying that the communication partner is authentic.

D By combining multiple security technologies, various threats can be addressed.

Think as an Engineer — Investigate & Decide

A school in your city is building an online portal where students check their grades and pay fees. You must choose how students log in. Which is the better choice for this service?

☐ **A password only** ☐ **A password plus a one-time password sent to the phone**

1 · Collect data. Ask ten classmates which login methods they use and trust (password, one-time password, SMS, fingerprint or face). Record the results in a table and find the most common answer.

2 · Analyze the stakeholders. For each group — a student, the school, and a student with no smartphone — note one benefit and one drawback of requiring a second factor.

3 · Decide. Recommend one login method for the portal and give two reasons based on your survey and your table. **In pairs,** compare your recommendations and agree together on the single strongest reason before you write it down.

Give evidence for your answer.

Stuck? Start with the user: a password alone fails once it leaks; adding a possession factor (a one-time password) still blocks the login.

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🌍 In a New Context

A small online shop wants to secure both customer login and payment. Using what you learned, name two security technologies it should use and say where each one helps, then identify one threat that could still remain.

❓ Lesson Question — Answered

The lesson asked how cryptographic technologies and authentication keep communication and services secure. HTTPS combines public-key cryptography — used to share a key safely — with common-key cryptography — used to exchange data quickly — so communication is both secure and fast. Beyond communication, services stay safe by combining several technologies: encryption hides content, digital certificates prove a site is genuine, digital signatures detect tampering, and multi-factor authentication blocks unauthorized logins. Security online therefore comes from layering these technologies so that many threats are addressed at the same time.

KEY TERMS

digital certificate — proves a site is genuine.
multi-factor authentication — blocks unauthorized logins.

Exercise

1 Cover the Point! section with a red plastic sheet and quiz yourself in your notebook in numerical order.

2 Read the following passage and answer each question.

HTTPS communication, used to access websites safely, combines multiple cryptographic technologies. First, the web server sends a (a) and a public key to the browser. The browser verifies whether the server is authentic through (b). Next, the browser creates a (c) for communication and encrypts it with the server's public key before sending. After this, all data communication is encrypted using this (c).

1. Fill in the blanks (a)–(c).
2. Briefly explain the reason for using common-key cryptography rather than public-key cryptography for data communication.

⭐ REFLECT & CHALLENGE

Reflect: Which of these protections do you rely on most when you go online?
Challenge: Suggest one extra security measure an online shop could add, and one threat it would still not remove.

KEY TERMS

encryption — keeps content private.
digital signature — detects tampering; gives non-repudiation.

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3 Answer the following questions.

(1) For each threat (a–d), indicate which technology is primarily used to address it: **A** Encryption, **B** Digital signature, **C** Digital certificate, **D** Multi-factor authentication.

a A password is leaked and unauthorized login occurs.

b Data is altered during communication.

c A user is led to a fake website.

d Communication content is intercepted by a third party.

(2) From the following options (A–D), choose the one that is NOT an appropriate example of multi-factor authentication.

A Password + smartphone notification

B Password + secret question

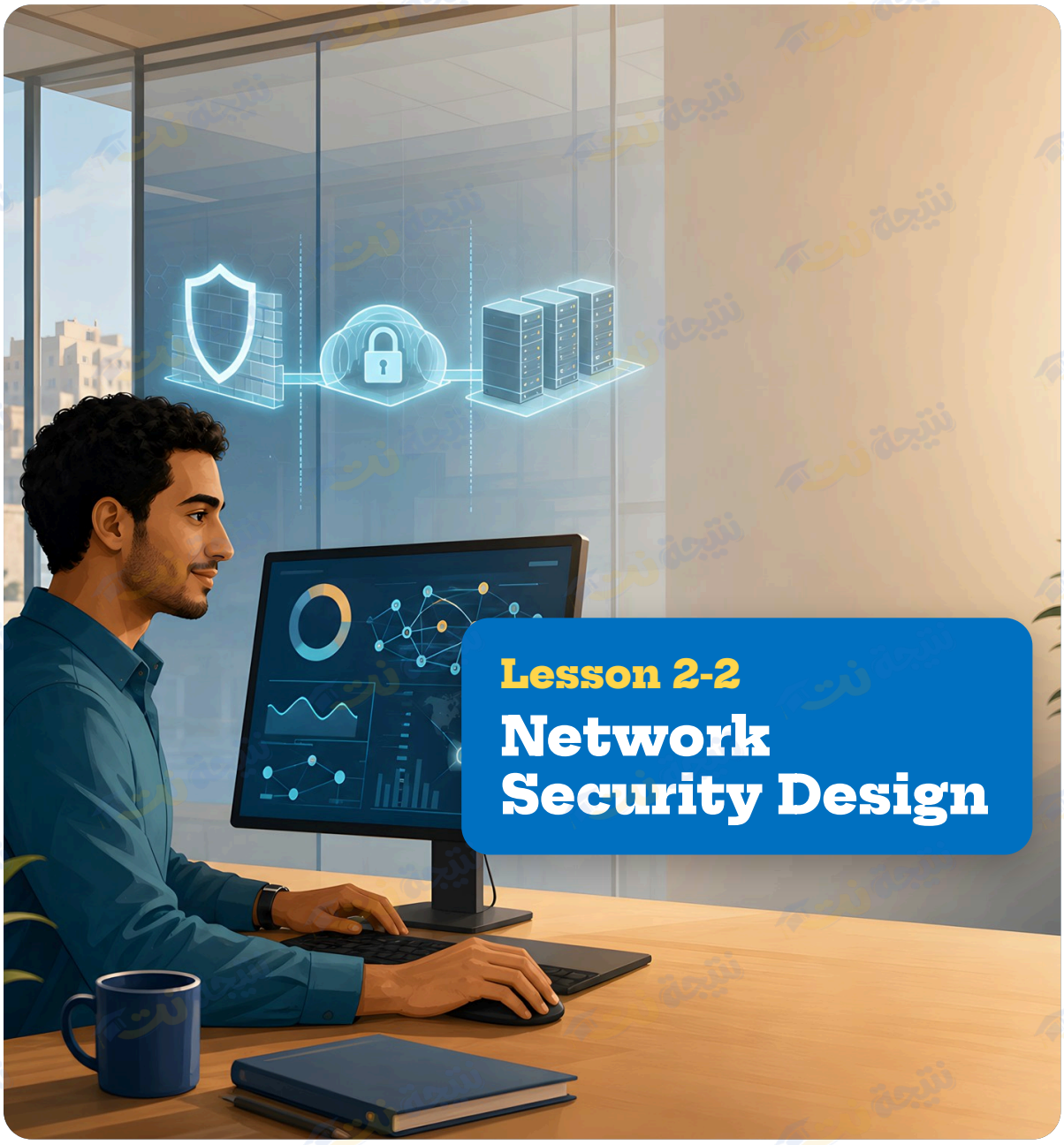
C Fingerprint authentication + smart card

D Password + SMS authentication

⭐ Key takeaway

Remember:
HTTPS uses public-key cryptography to share a key safely and common-key cryptography to move data quickly. Services stay safe by layering encryption, certificates, signatures, and multi-factor authentication.

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Learning Objectives

- Explain the roles of firewalls, VPNs, and DMZs in protecting a network.
- Describe defense in depth and zero trust, and explain why layered, verified access is stronger than a single barrier.

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An organization's network holds confidential data — customer records, financial files, and private messages. Attackers constantly look for a way in. A single lock on the front door is not enough: if it is picked, everything inside is exposed. For this reason, modern network security uses several layers, so that even when one defense is breached, the next one still protects the system.

? Guiding question: How can an organization design its network so that, even if one defense is breached, the system stays protected?

📌 Point!

1. The Role of Firewalls

(1) **(Firewall)**…a system installed at the entry/exit point of a network that allows or denies communication based on rules set in advance.
e.g., Allow access to the web server, but deny direct external access to the database server.

2. VPN (Virtual Private Network)

(1) **(VPN)**…a technology that creates an encrypted virtual private line (tunnel) over the Internet, allowing safe connection to a network from a remote location.

(2) Main uses of VPN

① Remote work…connecting safely to an organization's network from home or while away.

② Connecting branches…connecting offices in different locations safely.

(3) Because communication content is encrypted when using a VPN, the risk of eavesdropping is reduced even when using public Wi-Fi.

3. DMZ (Demilitarized Zone)

(1) **(DMZ)**…an area where servers exposed to the external network (web servers, mail servers, etc.) are placed separately from the internal network.

(2) By providing a DMZ, even if a public-facing server is attacked, damage to the internal network can be prevented.

Key Fact:
Strong network security comes from layering measures — firewall, VPN, DMZ, endpoint protection — and from verifying every access (zero trust), not from a single barrier.

Key Concepts:

- firewall
- VPN
- DMZ
- defense in depth
- zero trust
- perimeter

KEY TERMS
firewall — allows or denies communication at a network's entry/exit point based on preset rules.



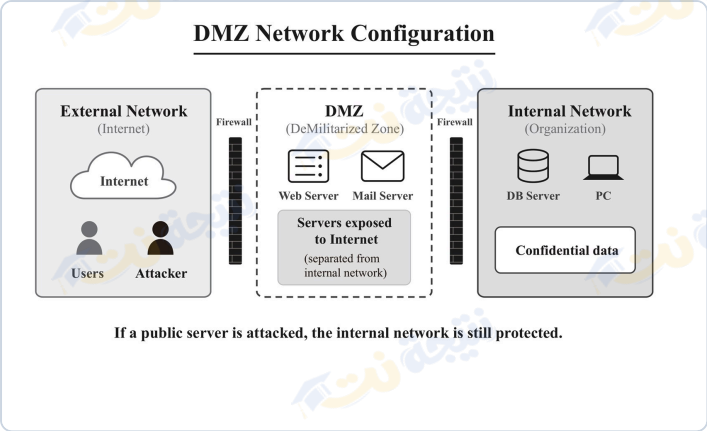
A firewall allows or blocks traffic by rules.



A VPN tunnels data safely through a hostile network.

KEY TERMS
DMZ — a zone for public-facing servers, separated from the internal network.

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DMZ Network Configuration

4. Defense in Depth

(1) **(Defense in depth)**…the concept of layering multiple security measures so that, even if one measure is breached, the next can still protect the system.

(2) In network security, multiple measures are combined as follows.

Layer	Examples of measures
Layer 1: Network entry	Block unauthorized communication using a firewall
Layer 2: Communication path	Encrypt communication using a VPN
Layer 3: Server placement	Separate public-facing servers from the internal network using a DMZ
Layer 4: Endpoints	Install antivirus software and keep the OS updated

5. The Concept of Zero Trust

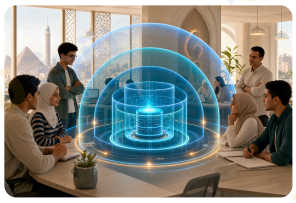
(1) **(Zero trust)**…a security concept that means the system does not trust any communication, including from within the organization's network, and always verifies it.

e.g., Even for access from inside the organization, identity verification and access permission checks are performed every time.

(2) Conventional network security was designed mainly around protecting a perimeter, based on the premise that "inside the organization's network is safe, and outside is dangerous." However, with the spread of cloud services and remote work, the boundary between "inside" and "outside" has become blurred, and designs that protect only the perimeter have become insufficient.

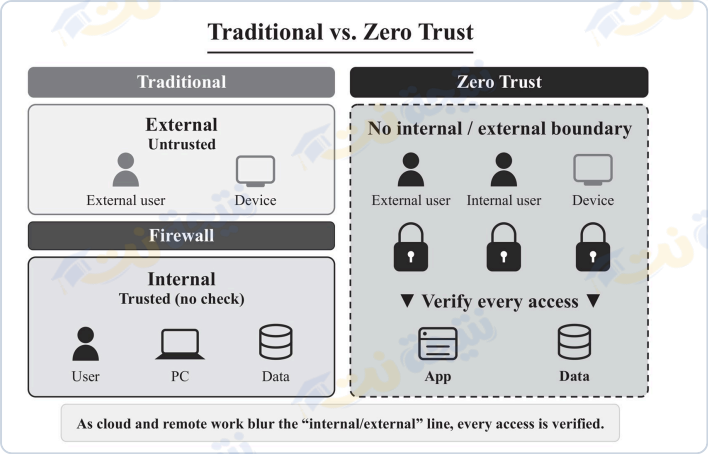
PAUSE & THINK

Why is it safer to place a public web server in a DMZ rather than inside the internal network?



Defense in depth: if one layer falls, the next holds.

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Traditional vs. Zero Trust

✎ Worked Example

(1) Mark each statement (A–D) with ○ if true or × if false.

A A firewall allows or denies communication based on rules set in advance.

B Using a VPN can reduce the risk of eavesdropping even on public Wi-Fi.

C A DMZ is a system that exposes all servers to the outside.

D Defense in depth is the concept of layering multiple security measures.

(2) Match each description (a–c) with the most appropriate term from the choices below (A–C).

a A technology that creates an encrypted virtual private line over the Internet for safe connection from a remote location

b An area where servers exposed to the outside are placed separately from the internal network

c A system that allows or denies communication based on rules set in advance

[Choices] **A** Firewall **B** VPN **C** DMZ

✓ Solution

(1)

A A firewall controls communication based on rules. Therefore, ○.

B A VPN encrypts communication, reducing the risk of eavesdropping on public Wi-Fi. Therefore, ○.

C A DMZ is an area where public-facing servers are placed separately from the internal network, not a system that exposes all servers. Therefore, ×.

KEY TERMS

defense in depth — layering measures.

zero trust — verify every access.

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D Correct definition of defense in depth. Therefore, ○.

(2)

a: An encrypted virtual private line is a VPN. **B**

b: An area where public-facing servers are isolated is a DMZ. **C**

c: A system that allows or denies communication is a firewall. **A**

Try

1 Answer the following questions.

1. What is the term for the system installed at the entry/exit point of a network that allows or denies communication based on rules?
2. What is the three-letter abbreviation for the technology that creates an encrypted virtual private line over the Internet for safe communication?
3. What is the three-letter abbreviation for the area where servers exposed to the outside are placed separately from the internal network?
4. What is the term for the concept of layering multiple security measures?

2 Answer the following questions.

(1) From the following options (A–D), choose the one that is NOT an appropriate use of a VPN.

A Connecting safely from home to an organization's network

B Connecting offices in different locations safely

C Automatically deleting files infected with viruses

D Encrypting communication content on public Wi-Fi

(2) For each of the security measures (a–d), indicate which layer of defense in depth (A–D) it belongs to.

a Blocking unauthorized communication with a firewall

b Encrypting communication with a VPN

c Installing antivirus software

d Separating public-facing servers from the internal network using a DMZ

[Layers] **A** Network entry **B** Communication path **C** Server placement **D** Endpoints

Think as an Engineer — Investigate & Decide

A company in your city is setting up its office network. It has a public website, staff who work from home, and confidential customer data. You advise on the security design.

EXAM-STYLE QUESTION

Explain why layering several security measures (defense in depth) protects an organization better than relying on a firewall alone. **[6] Refer to:** what happens if one measure is breached.

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☐ A firewall only

☐ A layered design (firewall + VPN + DMZ + endpoints) that also verifies every access (zero trust)

1 · Collect data. List the company's three assets (public website, remote staff, customer database) and the main threat to each.

2 · Rank the layers. For this company, rank the four defense-in-depth layers (network entry, communication path, server placement, endpoints) from most to least critical, and justify your top choice.

3 · Decide. Recommend a design and give two reasons why layering is safer than a single firewall. **In pairs,** compare your designs and agree together on the strongest reason before you write it down.

Give evidence for your answer.

Stuck? Start with the most exposed asset — the public website — and place it in a DMZ so that an attack there cannot reach the internal database.

🌍 In a New Context

A hospital moves its patient records to a cloud service and lets doctors access them from home. Using zero trust and defense in depth, suggest two measures it should apply and say where each one helps, then identify one risk that could still remain.

❓ Lesson Question — Answered

The lesson asked how to design a network so that one breach does not expose everything. The answer is layering. A firewall controls what enters and leaves the network; a VPN encrypts communication from remote locations; a DMZ separates public-facing servers so that an attack on them cannot reach internal data; and endpoint measures protect each device. Because cloud services and remote work have blurred the line between "inside" and "outside," zero trust adds a further principle: no access is trusted automatically, and every request is verified. Together, defense in depth and zero trust keep the network protected even when a single measure fails.

KEY TERMS

perimeter — the old "inside is safe" boundary that cloud and remote work have blurred.

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Exercise

1 Cover the Point! section with a red plastic sheet and quiz yourself in your notebook in numerical order.

2 Read the following passage and answer each question.

To protect an organization's network, it is important to combine multiple security measures. First, a (a) is installed at the entry/exit point of the network to block unauthorized communication based on rules. Web servers and other servers exposed to the outside are placed in a (b), separated from the internal network. To connect safely from outside, such as with remote work, communication is encrypted using a (c). The concept of layering multiple measures in this way is called (d).

1. Fill in the blanks (a)–(d).

3 Answer the following questions.

(1) From the following options (A–D), choose the most appropriate reason for providing a DMZ.

A To improve communication speed.

B To expose all servers to the outside.

C To prevent damage to the internal network even if a public-facing server is attacked.

D To automatically detect and remove viruses.

(2) From the following options (A–D), choose the one that most appropriately describes the concept of zero trust.

A Access from within the organization's network is safe, so verification is unnecessary.

B A firewall alone is sufficient to protect the network.

C No communication is trusted and is always verified.

D Only access from outside needs to be monitored.

⭐ REFLECT & CHALLENGE

Reflect: Which layer of defense do you think is easiest for an attacker to get past, and why?
Challenge: Suggest one measure a small company could add beyond a firewall, and one threat it would still not remove.

⭐ Key takeaway

Remember:
Layer your defenses — firewall, VPN, DMZ, endpoints — and verify every access (zero trust). One breach is then far less likely to expose the whole network.

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Lesson 2-3

Incident Response and Risk Management

Learning Objectives

- Explain what a security incident is and describe the stages of incident response in the correct order.
- Apply the idea of risk assessment by prioritizing risks according to their impact and likelihood.

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Even a well-protected system can be attacked. When a security incident happens — data leaked, files tampered with, or a service knocked offline — a rushed and unplanned reaction only makes the damage worse. Organizations follow a clear, ordered response so that damage is contained, the cause is removed, and the same problem does not return. They also decide in advance which risks to guard against first, because no team can fix everything at once.

? Guiding question: When a security incident happens, how should an organization respond in order — and how does it decide which risks to address first?

Key Fact:
Incident response follows six ordered stages, and risk assessment prioritizes risks by impact × likelihood — so an organization acts in the right order and on the right risks first.

Key Concepts:

- security incident
- the six stages
- containment / eradication
- risk = impact × likelihood

Point!

1. What is a Security Incident

(1) **(Security incident)**…a situation in which actual damage occurs due to an information security problem.

(2) Typical examples of security incidents

Type	Description
Information leak	Personal information or confidential information is leaked to the outside
Data tampering	Data within a system is altered without authorization
Service outage	A service becomes unavailable due to attacks on the server, etc.

KEY TERMS
security incident — a situation in which actual damage occurs due to an information security problem.

2. The Flow of Incident Response

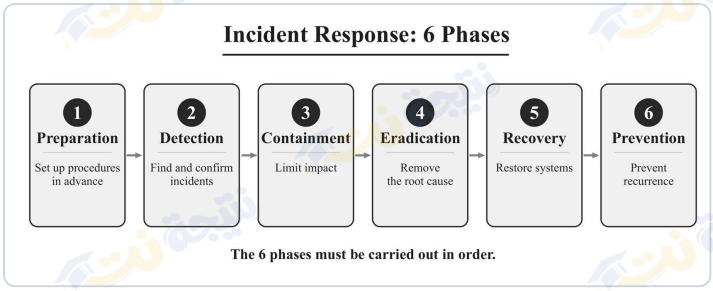
(1) When a security incident occurs, response proceeds through the following six stages.

Stage	Description
① **Preparation**	Establish response procedures and structures in advance, in preparation for incidents
② **Detection**	Discover and confirm that an incident has occurred
③ **Containment**	Limit the scope of impact so that damage does not spread further
④ **Eradication**	Remove the cause of the incident (e.g., remove malware)
⑤ **Recovery**	Return systems and services to their normal state
⑥ **Prevention of recurrence**	Analyze the cause and take measures so that the same incident does not occur again



Contain first: isolate the infected machine.

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Incident Response: 6 Phases

(2) It is important to proceed through the six stages of incident response in order. For example, if recovery is performed without identifying the cause, the same incident may occur again.

3. The Concept of Risk Assessment

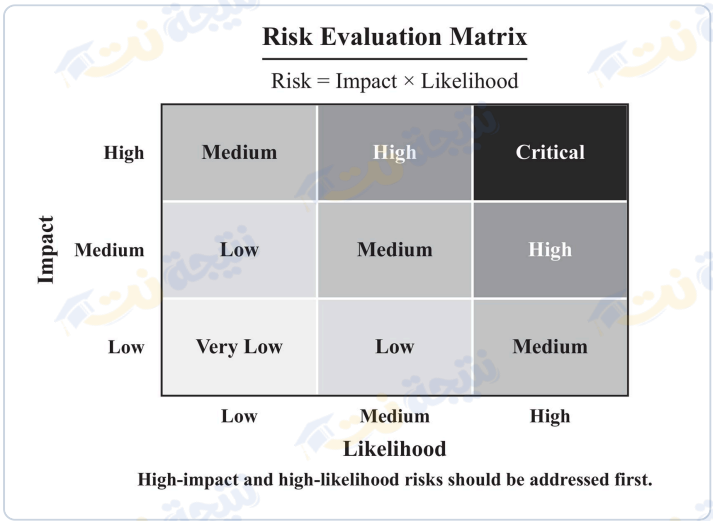
(1) **(Risk)**…the possibility of an information security problem occurring in the future, and its impact.

(2) The size of a risk is determined by the following two factors.

$$\text{Risk size} = \text{Impact} \times \text{Likelihood}$$

① **(Impact)**…how much damage occurs if the risk actually materializes.

② **(Likelihood)**…how high the probability is that the risk will actually materialize.



Risk Evaluation Matrix

(3) Risks with both high impact and high likelihood should be addressed first. Since it is difficult to address all risks at the same time, it is important to set priorities and take measures systematically.

✎ Worked Example

(1) Mark each statement (A–D) with ○ if true or × if false.

A A security incident is a situation in which actual damage occurs due to an information security problem.



Recover: restore a clean system from backup.

PAUSE & THINK

Why must containment come before eradication in the six-stage response?



Rank risks by impact and likelihood; fix the worst first.

KEY TERMS

impact — how much damage if a risk occurs.

likelihood — how probable the risk is.

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B In incident response, it is important to first prevent the spread of damage before removing the cause.

C The size of a risk can be determined by impact alone.

D The final stage of incident response is prevention of recurrence.

(2) For each of a–d, indicate which stage of the six stages of incident response (A–D) it belongs to.

a Establishing response procedures in advance, in preparation for incidents

b Disconnecting a malware-infected computer from the network

c Removing the malware infection

d Analyzing the cause and taking measures so that the same incident does not occur again

[Choices] **A** Preparation **B** Containment **C** Eradication **D** Prevention of recurrence

✓ Solution

(1)

A Correct definition of a security incident. Therefore, ○.

B Containment (preventing the spread of damage) is performed before eradication (removing the cause). Therefore, ○.

C The size of a risk is determined by both impact and likelihood. Therefore, ×.

D The final stage of the six stages is prevention of recurrence. Therefore, ○.

(2)

a: Preparing in advance is preparation. **A**

b: Disconnecting from the network to prevent the spread of damage is containment. **B**

c: Removing malware is eradication. **C**

d: Cause analysis and countermeasures are prevention of recurrence. **D**

EXAM-STYLE QUESTION

Explain why the six stages of incident response must be carried out in order, using recovery and eradication as an example. **[6] Refer to:** what happens if the cause is not removed.

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Try

1 Answer the following questions.

1. What is the term for a situation in which actual damage occurs due to an information security problem?
2. Name the six stages of incident response in order.
3. What are the two factors used to determine the size of a risk?

2 Answer the following questions.

(1) From the following options (A–D), choose the one that is NOT an appropriate example of a security incident.

A Data was encrypted by a ransomware infection.

B Customer information was leaked to the outside through unauthorized access.

C A software update was performed to add new features.

D A web service became unavailable due to an attack on the server.

(2) From the following options (A–D), choose the one that most appropriately describes the concept of risk assessment.

A It is enough to address only risks with large impact.

B It is enough to address only risks with high likelihood.

C Risks with both high impact and high likelihood should be addressed first.

D All risks must be addressed simultaneously.

Think as an Engineer — Investigate & Decide

A school's student-records system is hit by ransomware: files are encrypted and staff cannot log in. You lead the response.

☐ **Restore from backup immediately** ☐ **Follow the six-stage response in order**

1 · Respond from here. This incident has just been **detected** — files are encrypted and staff are locked out. Starting from where the school is **now**, list the stages still to carry out, and say what each one means for this specific incident.

2 · Assess the risks. For two risks the school faces — (i) another ransomware attack, (ii) a brief power cut — estimate impact and likelihood, and say which to address first.

3 · Decide. Recommend the first three actions the school should take, and give one reason why order matters. **In pairs,** compare your orders and agree together on the single most important first step.

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Give evidence for your answer.

Stuck? If you recover before you eradicate the cause, the malware is still there — and the same incident can happen again.

🌍 In a New Context

An online shop has just **detected** that customer data has been leaked. Using the six-stage response and risk assessment, name the next two stages it should carry out and why, and identify one risk it should prioritize afterward.

❓ Lesson Question — Answered

The lesson asked how to respond to an incident in order, and how to prioritize risks. A security incident is any situation where real damage occurs. The response follows six stages in a fixed order — preparation, detection, containment, eradication, recovery, and prevention of recurrence — because acting out of order (for example, recovering before removing the cause) lets the same incident return. To decide what to guard against first, an organization assesses each risk by its size = impact × likelihood, and addresses high-impact, high-likelihood risks first, since no team can fix everything at once. Responding in order and prioritizing by risk together keep damage small and prevent repeats.

KEY TERMS

containment — limit the spread of damage.

eradication — remove the cause.

⭐ REFLECT & CHALLENGE

Reflect: Which stage of incident response do you think is hardest to do well under pressure, and why? **Challenge:** Suggest one thing an organization could prepare in advance (stage 1) that would make the other phases faster.

Exercise

1 Cover the Point! section with a red plastic sheet and quiz yourself in your notebook in numerical order.

2 Read the following passage and answer each question.

A situation in which actual damage occurs due to an information security problem is called (a). When (a) occurs, (b), which prevents the spread of damage, is performed first, followed by (c), which removes the cause of the incident. After that, (d), which returns the system to its normal state, is performed, and finally (e), in which the cause is analyzed to prevent recurrence, is performed.

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1. Fill in the blanks (a)–(e).

3 Answer the following questions.

(1) Reorder the risks (a–d) from highest priority to lowest priority based on the concept of risk assessment (impact × likelihood).

a Impact: large (3), Likelihood: high (3)

b Impact: small (1), Likelihood: high (3)

c Impact: large (3), Likelihood: medium (2)

d Impact: small (1), Likelihood: low (1)

(2) From the following options (A–D), choose the one that most appropriately describes the order of incident response.

A Detection → Eradication → Containment → Recovery

B Preparation → Detection → Containment → Eradication → Recovery → Prevention of recurrence

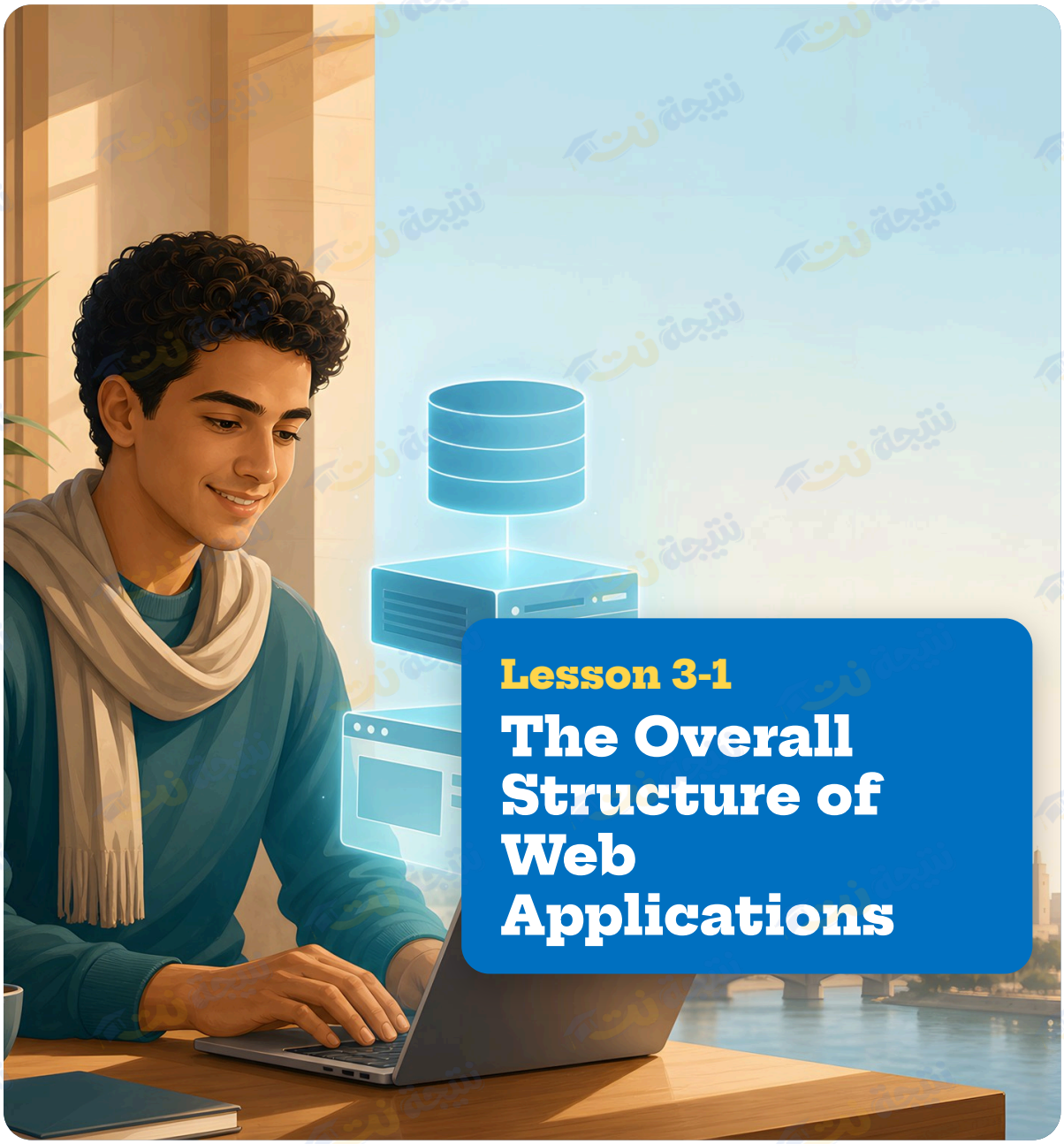
C Detection → Recovery → Containment → Prevention of recurrence

D Containment → Detection → Eradication → Preparation

⭐ Key takeaway

Remember:
Follow the six stages in order (prepare → detect → contain → eradicate → recover → prevent), and prioritize risks by impact × likelihood.

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Lesson 3-1

The Overall Structure of Web Applications

Learning Objectives

- Explain what a web application is and describe the roles of its three tiers: frontend, backend, and database.
- Trace how the three tiers cooperate to turn a user's action into a result, using familiar services as examples.

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Every time you search on YouTube, buy on Amazon, or open Gmail, you are using a web application — a program you use through your browser, with nothing to install. Behind the simple screen, three tiers work together: the page you interact with, the hidden server that processes the request, and the database that holds all the data. Understanding these three tiers explains how almost every online service is built.

? Guiding question: How is a web application structured, and how do its three tiers work together to respond to what a user does?

Key Fact:
A web application is built from three tiers — frontend, backend, and database — that cooperate to turn a user's action into a result.

Key Concepts:
- web application
- frontend
- backend
- database
- three-tier architecture

KEY TERMS
web application — an application used through a web browser, with no dedicated software to install.

Point!

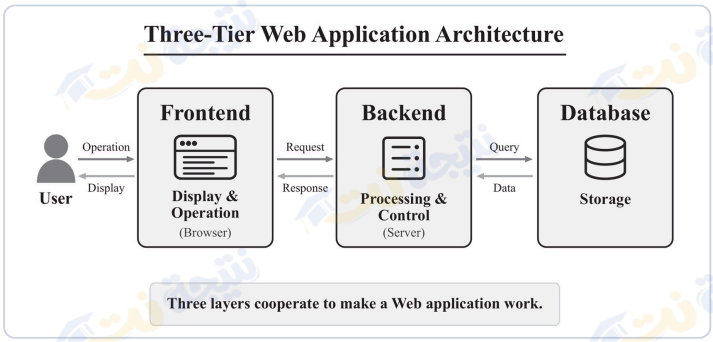
1. What is a Web Application?

(1) **(Web application)**…an application used through a web browser. It can be used as long as you have a browser, without needing to install dedicated software.
e.g., YouTube, Amazon, Gmail, Google Maps

2. The Three Tiers of a Web Application

(1) A web application is broadly composed of the following three tiers.

Tier	Role	Examples
Frontend	The screen component that users see directly. It runs on the browser and accepts user input.	Search screen, product listing pages, input forms, etc.
Backend	The server-side processing that users do not see. It processes data and makes decisions.	Searching for products that match search criteria, login authentication, etc.
Database	A system that organizes, stores, and manages data. It retrieves data when needed and records new data.	Product information, user information, order history, etc.



Three-Tier Web Application Architecture



The data tier stores and serves the records.



Three tiers: presentation, logic, and data.

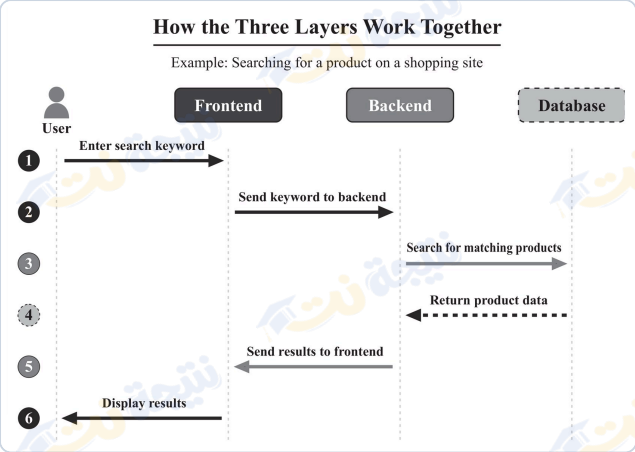
3. The Flow of How the Three Tiers Cooperate

(1) When a user operates a web application, the three tiers cooperate to perform the processing to make it work.

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e.g., Searching for a product on an online shopping site

① The frontend receives the search keywords entered by the user.
② The frontend sends the search keywords to the backend.
③ The backend searches the database for products that match the criteria.
④ The database returns the data of matching products to the backend.
⑤ The backend organizes the search results and returns them to the frontend.
⑥ The frontend displays the search results on the user's screen.



How the Three Layers Work Together

4. Familiar Web Application Configurations

(1) All familiar web applications also operate on this three-tier architecture.

Service	Frontend (display and interaction)	Backend (processing and control)	Database (storage and management)
Video sharing site	Display of video playback and search screens; reception of user operations	Selection of recommended videos; aggregation of view counts	Storage of video data, user information, and viewing history
SNS	Display of timelines and post screens; sending of input content	Determining the audience for posts; control of push notifications	Storage of post data, follow relationships, and messages
E-commerce site	Display of product listings and cart screens; reception of order operations	Stock checking; execution of payment systems	Storage of product information, order history, and customer information

✎ Worked Example

(1) Mark each statement (A–D) with ○ if true or × if false.

A The frontend is the screen component that users see directly.
B The backend is the part that runs on the browser.
C A database is a system that organizes, stores, and manages data.
D A web application operates with the frontend alone.

PAUSE & THINK

When you type in a search box and see results, which tier collected your input, and which tier found the answer?



A request flows down the tiers and a reply returns.

KEY TERMS

frontend — the screen users see and interact with.
backend — the hidden server-side processing.
database — where data is stored and managed.

PAUSE & THINK

In the table, every service uses the same three tiers — what changes from one service to the next?

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(2) Match each description (a–c) with the most appropriate term from the choices below (A–C).

a The part responsible for server-side processing that users do not see

b The screen component that users interact with directly

c A system that organizes, stores, and manages data

[Choices] **A** Frontend **B** Backend **C** Database

✓ Solution

(1)

A The frontend is the screen component that users see directly. Therefore, ○.

B The backend is the part that runs on the server, not on the browser. Therefore, ×.

C Correct definition of a database. Therefore, ○.

D A web application operates with three tiers: frontend, backend, and database. Therefore, ×.

(2)

a: Server-side processing is the backend. **B**

b: The screen that users interact with is the frontend. **A**

c: Storing and managing data is the database. **C**

EXAM-STYLE QUESTION

Explain how the three tiers of a web application cooperate when a user posts a photo on a social media app. **[6] Refer to:** the role of the frontend, backend, and database.

Try

1 Answer the following questions.

1. What is the term for an application used through a web browser?
2. What is the term for the screen component that users see directly?
3. What is the term for the part responsible for server-side processing that users do not see?
4. What is the term for a system that organizes, stores, and manages data?

2 Answer the following questions.

(1) When searching for a product on an online shopping site, which of the following is responsible for searching through data for products that match the search keywords: **A** Frontend, **B** Backend, **C** Database?

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(2) For each of a–f, indicate which tier of an e-commerce site it belongs to: **A** Frontend, **B** Backend, **C** Database.

a Product listing page

b Stock checking processing

c Storage of customer information

d Cart screen

e Payment processing

f Storage of order history

⚙ Think as an Engineer — Investigate & Decide

A clinic wants a web app where patients book appointments, check which time slots are free, and see their past visits. You plan its three tiers.

☐ **Put everything in one program** ☐ **Separate the frontend, backend, and database**

1 · Assign the work. For three features — the booking form, checking which time slots are free, and storing past visits — say which tier (frontend, backend, or database) should handle each, and why.

2 · Diagnose a fault. The booking page opens normally, but no free slots appear on screen. Which tier is clearly working, and which one has probably failed? Explain your reasoning.

3 · Decide. Recommend whether the clinic should separate its app into three tiers, and give two reasons. **In pairs,** compare your assignments and agree together on where checking free time slots belongs.

Give evidence for your answer.

Stuck? The frontend shows and collects; the backend decides and processes; the database stores and retrieves.

🌍 In a New Context

A weather app lets users type a city and see the forecast. Using the three-tier model, name which tier does each job — taking the city name, looking up the forecast data, and storing past forecasts — and identify one job the frontend cannot do on its own.

KEY TERMS

three-tier architecture — frontend + backend + database cooperating.

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❓ Lesson Question — Answered

The lesson asked how a web application is structured and how its tiers cooperate. A web application runs in a browser and is built from three tiers. The frontend is the screen the user sees and interacts with; the backend is the hidden server-side processing that makes decisions; and the database organizes, stores, and manages the data. When a user acts — for example, searching for a product — the frontend collects the input and passes it to the backend, the backend queries the database, the database returns the data, and the backend sends the organized result back to the frontend to display. Overall, a web application works not through one part but through three tiers cooperating, each with a clear role.

Exercise

1 Cover the Point! section with a red plastic sheet and quiz yourself in your notebook in numerical order.

2 Read the following passage and answer each question.

A web application is broadly composed of three tiers. The screen component that users see directly is called the (a). The part responsible for server-side processing that users do not see is called the (b). A system that organizes, stores, and manages data is called the (c). In response to user actions, these three tiers cooperate to perform processing.

1. Fill in the blanks (a)–(c).

3 Answer the following questions.

(1) For each of a–f, indicate which tier of an SNS it belongs to: **A** Frontend, **B** Backend, **C** Database.

a Timeline screen
b Processing that determines the audience for a post
c Storage of post data
d Post screen
e Notification processing
f Storage of follow relationships

⭐ REFLECT & CHALLENGE

Reflect: Which tier do you think fails most noticeably to a user when something goes wrong, and why? **Challenge:** Name one online service you use and describe what its frontend, backend, and database each do.

⭐ Key takeaway

Remember:
Frontend shows and collects, backend decides and processes, database stores and retrieves — three tiers cooperating make a web application work.

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(2) From the following options (A–D), choose the one that most appropriately describes the three-tier architecture of a web application.

A The frontend has the role of storing and managing data.

B The backend is the part that users interact with directly on the browser.

C In response to user actions, the frontend, backend, and database cooperate to perform processing.

D The database has the role of displaying screens to users.

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Lesson 3-2

Web Application Communication Methods

Learning Objectives

- Explain the client and server model and the difference between HTTP and HTTPS.
- Describe how HTTP requests and responses work, and explain the role of an API in exchanging data.

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When you click a link or press “search,” your device does not hold the whole website — it asks a distant computer for it. Your browser is the client that makes the request; a server somewhere answers with a response. This exchange, governed by shared rules called protocols, is how every web application communicates. Knowing how requests, responses, and APIs work explains what happens between your click and the page you see.

? Guiding question: How do the client and server communicate to make a web application work, and what rules and messages do they use?

Key Fact:
Web applications work by a client sending requests and a server returning responses, using protocols (HTTP/HTTPS) and often APIs that exchange data in formats like JSON.

Key Concepts:

- client / server
- HTTP / HTTPS
- HTTP method
- status code
- API / JSON

KEY TERMS
client — the side that requests data or processing.
server — the side that processes requests and returns responses.



Many clients request; one server responds.

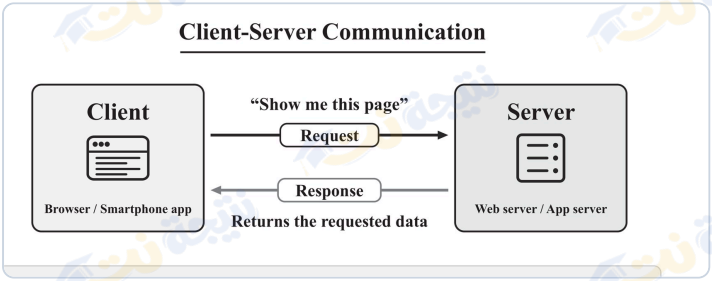
Point!

1. Client and Server

(1) **(Client)**…the side that requests data or processing from the server. Web browsers and smartphone apps fall into this category.

(2) **(Server)**…the side that receives requests from clients, processes them, and returns responses.

(3) A web application operates by the client sending a request and the server returning a response.



Client-Server Communication

2. HTTP and HTTPS

(1) **(HTTP (HyperText Transfer Protocol))**…a communication protocol for exchanging data between clients (browsers and apps) and servers.

(2) **(HTTPS (HTTP Secure))**…a communication protocol that adds TLS encryption to HTTP. Because communication content is encrypted, the risk of its being read by third parties is reduced.

(3) Websites whose URLs begin with “https://” use HTTPS communication.

3. HTTP Requests and Responses

(1) Requests sent from the client to the server include information called an HTTP method that indicates “what kind of operation is desired.”

PAUSE & THINK

Why should a login page use HTTPS rather than plain HTTP?

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Method	Role	Examples
GET	Retrieve data from the server	Displaying a web page, retrieving search results
POST	Send data to the server	Sending login information, submitting form contents

(2) Responses returned from the server to the client include a number indicating the result of processing, called a status code. Some typical examples are as follows.

Status code	Meaning
200	Success (the request was processed successfully)
404	Page not found (the specified URL does not exist)
500	Server error (a problem occurred on the server side)

4. API (Application Programming Interface)

(1) **(API)**…a system for exchanging data between different pieces of software.

(2) In web applications, the frontend often sends requests to the backend through an API and receives data.

(3) Data exchanged through an API is often described in a format called **(JSON (JavaScript Object Notation))**. JSON is a data format that is both easy for humans to read and for computers to process.

✎ Worked Example

(1) Mark each statement (A–D) with ○ if true or × if false.

A The client is the side that requests data or processing from the server, and the server is the side that returns the response.

B HTTPS is a communication protocol that adds encryption to HTTP.

C The GET method is for sending data to the server.

D Status code 404 indicates that the page is not found.

(2) Match each description (a–c) with the most appropriate term from the choices below (A–C).

a A communication protocol for exchanging data between web browsers and servers

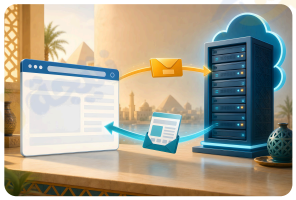
b A system for exchanging data between different pieces of software

c A communication protocol that adds encryption to HTTP

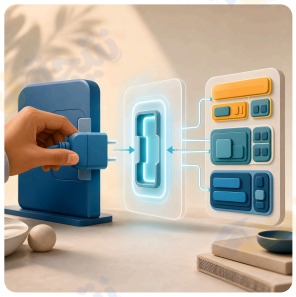
[Choices] **A** HTTP **B** API **C** HTTPS

KEY TERMS

HTTP method — says what is wanted (GET, POST).
status code — reports the result (200, 404, 500).



One HTTP request, one matching response.



An API is a fixed contract for exchanging data.

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✓ Solution

(1)

A Correct description of the roles of client and server. Therefore, ○.

B HTTPS adds SSL/TLS encryption to HTTP. Therefore, ○.

C The GET method is for retrieving data from the server and the POST method is for sending data. Therefore, ×.

D 404 is a status code indicating that the page is not found. Therefore, ○.

(2)

a: The web communication protocol is HTTP. **A**

b: Data exchange between pieces of software is API. **B**

c: HTTP with added encryption is HTTPS. **C**

Try

1 Answer the following questions.

1. What is the term for the side that requests data or processing from the server (e.g., a web browser)?
2. What is the term for the side that receives requests from clients, processes them, and returns responses?
3. What is the term for the communication protocol that adds encryption to HTTP?
4. What is the term for the HTTP method for retrieving data from the server?
5. What is the term for the system for exchanging data between different pieces of software?

2 Answer the following questions.

(1) From the following options (A–D), choose the combination of status code and meaning that is NOT appropriate.

A 200 — The request was processed successfully

B 404 — Page not found

C 500 — The request was processed successfully

D 500 — A problem occurred on the server side

EXAM-STYLE QUESTION

Explain what happens, step by step, when a browser requests a web page and the server responds. **[6] Refer to:** client, request, HTTP method, response, status code.

PAUSE & THINK

If a browser receives status code 404, what should it tell the user — and whose side had the problem?

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(2) From the following options (A–D), choose the one that most appropriately describes an API.

A A technology for adjusting the appearance of web pages

B A system for exchanging data between different pieces of software

C A technology for encrypting data and sending it safely

D An HTTP method for retrieving data from the server

Think as an Engineer — Investigate & Decide

A school in your city wants a web app where students log in, view their timetable, and download a PDF. You plan how the client and server communicate.

☐ **Send everything over plain HTTP**

☐ **Use HTTPS and the right method for each action**

1 · Choose the method. For three actions — loading a student's grade history, submitting the login form, and requesting today's schedule from another school system — say whether GET or POST fits, and for the last say whether an API is involved.

2 · Choose the protocol. Decide whether the login should use HTTP or HTTPS, and give the reason.

3 · Decide. Recommend the communication design and give two reasons. **In pairs,** compare your method choices and agree together on which action must use POST.

Give evidence for your answer.

Stuck? GET retrieves and shows; POST sends data such as a login; HTTPS encrypts so passwords are not intercepted.

In a New Context

A weather service offers an API that returns today's forecast when a client sends a request. Using what you learned, name which HTTP method the client would use to retrieve the forecast, why the service should use HTTPS, and one advantage of receiving the data as JSON.

KEY TERMS

API — lets different software exchange data.

JSON — a readable data format.

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❓ Lesson Question — Answered

The lesson asked how the client and server communicate and what rules and messages they use. A web application works when a client — a browser or app — sends a request and a server processes it and returns a response. They communicate through a protocol: HTTP carries the messages, and HTTPS adds SSL/TLS encryption so the content is not easily intercepted. Each request carries an HTTP method that says what is wanted — GET to retrieve, POST to send — and each response carries a status code that reports the result, such as 200 for success or 404 for not found. Often the frontend and backend exchange data through an API, frequently in the JSON format, which is easy for both people and computers to read. Overall, communication in a web application is an organized exchange of requests and responses, shaped by protocols, methods, status codes, and APIs.

Exercise

1 Cover the Point! section with a red plastic sheet and quiz yourself in your notebook in numerical order.

2 Read the following passage and answer each question.

A web application operates by communication between a (a), which requests data or processing from the server, and a (b), which receives the request, processes it, and returns a response. This communication uses a protocol called (c). The protocol that adds SSL/TLS encryption to (c) is called (d).

1. Fill in the blanks (a)–(d).

3 Answer the following questions.

(1) For each of operations (a–d), indicate which HTTP method is used: **A** GET, **B** POST.

a Displaying a web page
b Entering an ID and password into a login form and submitting them
c Displaying search results
d Submitting the contents of a contact form

(2) From the following options (A–D), choose the one that most appropriately describes HTTPS.

A A method for retrieving data from the server
B A system for exchanging data between different pieces of software
C A communication protocol that adds SSL/TLS encryption to HTTP
D A status code indicating that a problem has occurred on the server side

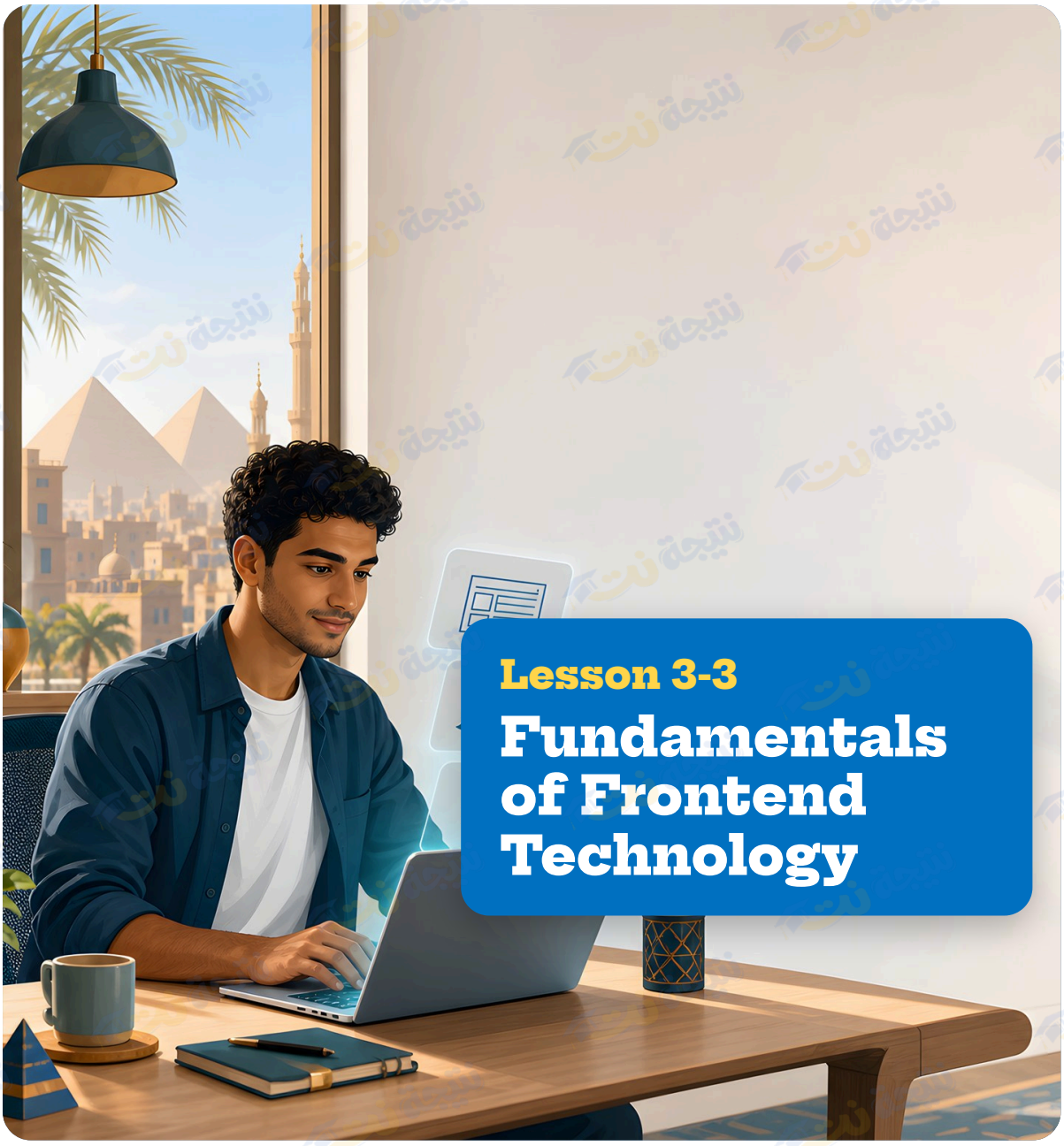
⭐ REFLECT & CHALLENGE

Reflect: When a page fails to load, which status code would help you most to understand why, and what would it tell you?
Challenge: Name one app you use and describe one request it sends and the response it expects.

⭐ Key takeaway

Remember:
Client requests, server responds — over HTTP/HTTPS, with a method (GET/POST), a status code, and often an API returning JSON.

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Learning Objectives

- Explain the distinct roles of HTML, CSS, and JavaScript in building a web page.
- Describe how semantic HTML, responsive design, and frameworks improve a modern frontend.

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Open any web page and you are seeing three technologies at work together. HTML builds the structure — the headings, paragraphs, and links, like the frame of a building. CSS adds the appearance — colors, layout, and fonts, like a building's interior. JavaScript adds behavior — search boxes that respond, buttons that count, screens that update. A modern frontend goes further: it makes pages meaningful, adaptable to every screen, and faster to build.

? Guiding question: How do HTML, CSS, and JavaScript work together to build a web page, and what makes a modern frontend meaningful, adaptable, and efficient to build?

Key Fact:
A web page is built from HTML (structure), CSS (appearance), and JavaScript (behavior); a modern frontend adds semantic HTML, responsive design, and frameworks.

Key Concepts:

- HTML / CSS / JavaScript
- semantic HTML
- accessibility / SEO
- responsive design
- framework

KEY TERMS
HTML — structure.
CSS — appearance.
JavaScript — behavior.



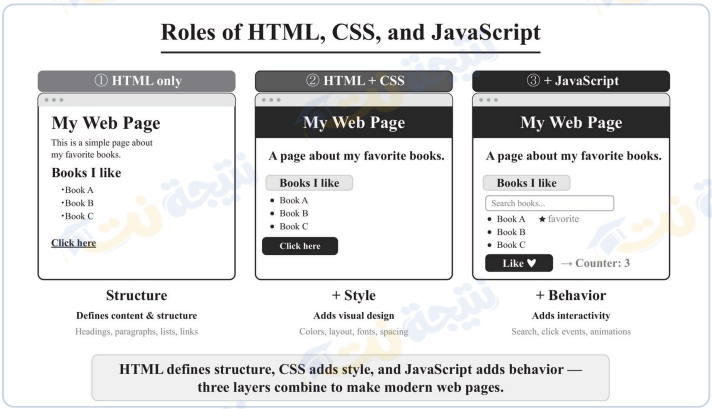
HTML structures, CSS styles, JS adds behavior.

Point!

1. The Roles of HTML, CSS, and JavaScript

(1) Web pages are mainly based on the following three technologies.

Technology	Role	Analogy
HTML	Defines the structure (skeleton) of a web page. Describes elements such as headings, paragraphs, images, and links.	The frame of a building
CSS	Specifies the appearance of a web page (colors, layout, size, fonts, etc.).	The interior and exterior of a building
JavaScript	Adds behavior and interactivity to a web page. Activates responses when buttons are pressed and updates only part of the screen.	The electrical and plumbing systems of a building



Roles of HTML, CSS, and JavaScript

(2) These three technologies each have independent roles, and a web page is created using all of them in combination.

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2. Semantic HTML

(1) **(Semantic HTML)**…the concept of describing each part of a web page using element names (tags) that indicate their meaning.
e.g., Use <header> at the top of the page, <nav> for navigation, <main> for the body, and <footer> at the bottom of the page.

(2) Benefits of using semantic HTML

① Improved **(accessibility)**…screen reader software can correctly understand the structure of the page. Information becomes easier to convey to users with visual impairments.

② Improved **(SEO (Search Engine Optimization))**…search engines can more easily understand the content of a web page correctly, making it more likely to be displayed appropriately in search results.

3. Responsive Design

(1) **(Responsive design)**…a design concept in which the layout is automatically adjusted according to different screen sizes such as PCs, smartphones, and tablets.

(2) With a single web page, a display that is easy to view from any device can be achieved.

(3) As of 2026, websites are frequently accessed from smartphones, and support for responsive design is widely required. Against this backdrop, the **(mobile-first)** concept—prioritizing small screens such as smartphones from the design stage—has also become widespread.

4. Frameworks

(1) **(Framework)**…a structure that provides commonly used functions and components in advance, in order to make web application development more efficient.

(2) By using a framework, developers do not need to write all code from scratch and can develop more efficiently.

(3) Major frontend frameworks

Framework name	Characteristics
React	Developed by Meta (formerly Facebook). It can efficiently update only part of the screen and is suited to large-scale web applications.
Vue	Has a simple structure and allows web applications to be built incrementally from small features.
Next.js	In addition to React's features, includes mechanisms to speed up page display.

PAUSE & THINK

On a page you use often, which parts are structure (HTML), which are style (CSS), and which react to you (JavaScript)?



Responsive design re-flows to each screen size.

KEY TERMS

responsive design — layout adapts to screen size.
framework — ready-made functions for efficient development.



Frameworks assemble pages from ready-made parts.

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✎ Worked Example

(1) Mark each statement (A–D) with ○ if true or × if false.

A HTML is a technology that defines the structure (skeleton) of a web page.

B CSS is a technology that adds behavior to a web page.

C Responsive design is a concept in which the layout is automatically adjusted according to different screen sizes.

D Using a framework eliminates the need to write all code from scratch and allows efficient development.

(2) Match each role (a–c) with the most appropriate technology from the choices below (A–C).

a Defines the structure of a web page

b Specifies the appearance of a web page

c Adds behavior and interactivity to a web page

[Choices] **A** HTML **B** CSS **C** JavaScript

✓ Solution

(1)

A HTML defines the structure of a web page. Therefore, ○.

B CSS is a technology that specifies the appearance of a web page. Adding behavior is JavaScript. Therefore, ×.

C Correct definition of responsive design. Therefore, ○.

D Correct description of the benefit of frameworks. Therefore, ○.

(2)

a: Defining structure is HTML. **A**

b: Specifying appearance is CSS. **B**

c: Adding behavior is JavaScript. **C**

PAUSE & THINK

Why does a screen reader understand a page better when it uses <header>, <nav>, and <main> instead of plain boxes?

EXAM-STYLE QUESTION

Explain how HTML, CSS, and JavaScript each contribute to a library page that lists books, is styled, and filters the results as the user types. **[6] Refer to:** structure, appearance, behavior.

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Try

1 Answer the following questions.

1. What is the four-letter abbreviation for the technology that defines the structure (skeleton) of a web page?
2. What is the three-letter abbreviation for the technology that specifies the appearance of a web page (colors, layout, size, etc.)?
3. What is the term for the technology that adds behavior and interactivity to a web page?
4. What is the term for the design concept in which the layout is automatically adjusted according to different screen sizes?

2 Answer the following questions.

(1) From the following options (A–D), choose the one that is NOT an appropriate benefit of using semantic HTML.

A Screen reader software can correctly understand the structure of the page.
B Search engines can more easily understand the content of a web page.
C The display speed of a web page necessarily becomes faster.
D Information becomes easier to convey to users with visual impairments.

(2) From the following options (A–D), choose the one that most appropriately describes a framework.

A A language for defining the structure of a web page
B A structure for making web application development more efficient
C A technology for encrypting data and sending it safely
D A design concept for supporting different screen sizes

PAUSE & THINK

Which of the benefits below is about how the page looks, and which is about how well others can find and read it?

Think as an Engineer — Investigate & Decide

A student club wants a simple web page that lists its events, is styled in the club's colors, and has a button showing how many people have signed up.

☐ **Write everything in one file**

☐ **Use HTML, CSS, and JavaScript for their proper roles**

1 · Observe first. Open one web page you use often and note two things on it that change when you click or type. Then, for three features of the club page — the list of events, the club's colors and layout, and the live sign-up counter — say which technology (HTML, CSS, or JavaScript) does each, and why.

2 · Make it reach everyone. Name one change that would make the page easier to read on a phone (responsive design), and one semantic-HTML choice that would help a screen reader.

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3 · Decide. Recommend whether the club should separate HTML, CSS, and JavaScript, and give two reasons. **In pairs,** compare your role assignments and agree together on what the sign-up counter needs.

Give evidence for your answer.

Stuck? HTML holds the content; CSS styles it; JavaScript makes it react and update.

🌍 In a New Context

A news site must look good on phones and be found easily by search engines. Using what you learned, name one responsive-design choice and one semantic-HTML choice it should make, and say what each one improves.

❓ Lesson Question — Answered

The lesson asked how HTML, CSS, and JavaScript work together and what makes a modern frontend strong. A web page is built from three technologies with independent roles: HTML defines the structure, CSS specifies the appearance, and JavaScript adds behavior and interactivity — combined, they create the page. A modern frontend goes further: semantic HTML uses meaningful tags so screen readers and search engines understand the page (improving accessibility and SEO); responsive design adjusts the layout to any screen size, with a mobile-first approach; and frameworks such as React, Vue, and Next.js provide ready-made functions so developers build efficiently without writing everything from scratch. A modern web page is therefore not one technology but a combination — structured, styled, interactive, meaningful, adaptable, and efficient to build.

Exercise

KEY TERMS

accessibility — usable by people with impairments.
SEO — being found by search engines.

⭐ REFLECT & CHALLENGE

Reflect: Of structure, style, and behavior, which do you notice most when a web page is badly made, and why? **Challenge:** Name one website you use and describe one thing HTML, CSS, and JavaScript each do on it.

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1 Cover the Point! section with a red plastic sheet and quiz yourself in your notebook in numerical order.

2 Read the following passage and answer each question.

Web pages are mainly composed of three technologies: (a), which defines the structure of the page; (b), which specifies the appearance; and (c), which adds behavior and interactivity. The concept of adjusting the layout according to different screen sizes such as PCs, smartphones, and tablets is called (d).

1. Fill in the blanks (a)–(d).

3 Answer the following questions.

(1) For each of tasks (a–f), indicate which technology is used to achieve it: **A** HTML, **B** CSS, **C** JavaScript.

a Describing the structure of headings and paragraphs

b Changing the color and size of text

c Updating part of the screen when a button is pressed

d Placing images and links

e Setting the background color of the entire page

f Validating the contents entered into a form

(2) From the following options (A–D), choose the one that most appropriately describes the reason responsive design is needed.

A To improve the display speed of websites

B Because websites are accessed from various devices such as PCs, smartphones, and tablets

C To raise rankings in search engines

D To add behavior to web pages

Key takeaway

Remember:
HTML structures, CSS styles, JavaScript behaves — and semantic HTML, responsive design, and frameworks make a modern frontend meaningful, adaptable, and efficient.

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Lesson 4-1

Types and Characteristics of Media

Learning Objectives

- Compare the characteristics of different media, and explain the strengths and constraints of websites.
- Choose suitable media for a given purpose and audience, and justify the choice.

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Before building a website, it helps to ask: why a website at all? TV reaches millions at once but only one way. Radio can be received almost anywhere but conveys sound only. A newspaper lasts on paper without the Internet. A website combines text, images, and video, updates at any time, and can even respond through forms — while SNS (social networking services) spreads news the fastest of all. Each medium has its own strengths and constraints, so the smart choice depends on the message and the audience.

? Guiding question: What are the strengths and constraints of different media, and how do you choose the right one for a purpose and audience?

Key Fact:
Each medium has different strengths and constraints; choosing the right medium — often several combined — depends on the purpose and the target audience.

Key Concepts:

- TV / radio / newspaper
- website / SNS
- one-way / two-way
- strengths / constraints
- combining media

KEY TERMS

one-way — from sender to receiver only.

two-way — users can respond and share.

Point!

1. Comparison of the Characteristics of Different Media

(1) Each medium for conveying information has different characteristics. When planning a website, it is important to understand the differences from other media.

Medium	Information conveyed	Characteristics
TV	Video + audio	Reaches many people simultaneously. Appeals to sight and hearing. One-way, from sender to receiver.
Radio	Audio	Appeals only to hearing. Can be received almost anywhere and alongside other tasks. One-way.
Newspaper	Text + images	Remains physically as a printed medium. Can be read without an Internet connection. One-way.
Website	Text + images + video + audio	Diverse information can be combined. Can be updated at any time. Basically one-way, but two-way interaction is also possible through forms, comments, etc.
SNS	Text + images + video + audio	Highly effective at spreading information rapidly. Users can post and share information. Two-way.

2. Strengths and Constraints of Websites

(1) Strengths of websites

① Diverse information such as text, images, and video can be combined and presented.

② Information can be updated at any time.

③ Can be accessed from almost anywhere in the world.

④ Two-way interaction with users is possible through forms, comments, etc.

⑤ Can be used with just a browser; no dedicated app installation is required.



Traditional and digital media, side by side.

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(2) Constraints of websites

① Normally requires an Internet connection (unless the page is cached).

② Information does not reach users unless they actively access it.

③ Display and loading speed may differ depending on the user's device and network environment.



A website combines strengths one-way media lack.

PAUSE & THINK

Which medium would you choose to reach the most people at once — and which to let them respond to you?

3. Choosing Media According to Purpose

(1) When conveying information, it is important to choose the most suitable medium according to the purpose and target audience.

Purpose	Examples of suitable media	Reason
Inform many people at once	TV, SNS ads	Wide reach
Provide detailed information	Website	No limit on information volume; can be viewed at any time
Deliver information directly to specific people	Email, direct messages	Can be delivered individually
Spread by word of mouth	SNS	Users can voluntarily share and spread information



Match the medium to the purpose and audience.

(2) In practice, multiple media are often used in combination.

e.g., A TV commercial directs viewers to a website, and the website encourages spreading information through SNS.

✎ Worked Example

(1) Mark each statement (A–D) with ○ if true or × if false.

A A website can present diverse information such as text, images, and video in combination.

B TV is a medium that allows two-way interaction with users.

C SNS is a medium highly effective at spreading information rapidly.

D A website normally can be viewed even without an Internet connection.

(2) Match each purpose (a–c) with the most suitable medium from the choices below (A–C).

a Make detailed information viewable at any time

b Have users spread information by word of mouth

c Inform many people at once with video

[Choices] **A** TV **B** Website **C** SNS

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✓ Solution

(1)

A Correct as a strength of websites. Therefore, ○.

B TV is a one-way medium from sender to receiver. Therefore, ×.

C Correct description of the characteristics of SNS. Therefore, ○.

D A website normally requires an Internet connection. Therefore, ×.

(2)

a: A website allows detailed information to be viewed at any time. **B**

b: SNS spreads easily by word of mouth. **C**

c: TV reaches many people with video. **A**

Try

1 Answer the following questions.

1. Name two strengths of websites.
2. Name two constraints of websites.

2 Answer the following questions.

(1) From the following options (A–D), choose the one that is NOT an appropriate characteristic of websites.

A Information can be updated at any time.

B Information automatically reaches users without them actively accessing it.

C Text, images, and video can be combined and presented.

D Two-way interaction is possible through forms and comments.

(2) For each situation (a–d), indicate which medium is most suitable: **A** TV, **B** Website, **C** SNS, **D** Email.

a Make the detailed specifications and usage of a new product available at any time.

b Have users spread information about a new product by word of mouth.

c Deliver video of a new product to many people at once.

d Send campaign information directly to existing customers.

Think as an Engineer — Investigate & Decide

A public library in your city wants to tell people about a new free reading program. You advise on which media to use.

☐ **Use one medium only** ☐ **Combine media by purpose**

1 · Collect data. Survey ten classmates or family members: where do they actually notice local announcements — a printed poster, Facebook,

EXAM-STYLE QUESTION

Explain why an organization might use a website, TV, and SNS together rather than only one, to promote a new service. **[6] Refer to:** reach, depth, and spreading by word of mouth.

PAUSE & THINK

For each situation below, ask first: is the goal wide reach, full detail, spreading, or a direct message?

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WhatsApp, or local radio? Record the results in a table and find the most common channel.

2 · Analyze the audience. For each group — a family with no home Internet, a student, and the librarian — note one benefit and one drawback of using a website as the library's main channel.

3 · Decide. Using your survey and your table, recommend a media plan (which media, in what roles) and give two reasons. **In pairs,** compare your plans and agree together on the single best medium for reaching families who may not be online.

Give evidence for your answer.

Stuck? Start from the audience your survey shows is hardest to reach — which medium already reaches them where they are?

🌍 In a New Context

A hospital wants to inform patients about new opening hours and let them ask questions. Name one medium for reaching many people quickly and one that allows two-way interaction, and say why each one fits.

❓ Lesson Question — Answered

The lesson asked about the strengths and constraints of different media and how to choose. Each medium has its own character: TV reaches many at once but one-way; radio is sound only but reaches anywhere; a newspaper lasts on paper without the Internet; a website combines text, images, and video, updates any time, and allows two-way interaction, though it needs an Internet connection and only reaches those who seek it; and SNS spreads information fastest and is two-way. Because no single medium is best for everything, the right choice depends on the purpose and the target audience — wide reach, full detail, direct delivery, or word-of-mouth — and in practice several media are combined so each does what it does best.

KEY TERMS

website strengths — diverse, updatable, global, two-way.

website constraints — needs Internet; users must seek it.

Exercise

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1 Cover the Point! section with a red plastic sheet and quiz yourself in your notebook in numerical order.

2 Read the following passage and answer each question.

Each medium for conveying information has different characteristics. A website has the strengths of being able to present diverse information such as text, images, and video, and being updatable at any time. On the other hand, it has the constraints that it cannot be viewed without an (a) connection, and that information does not reach users unless they actively (b) it. In actual information dissemination, (c) media are often combined, such as directing viewers from a TV commercial to a website.

1. Fill in the blanks (a)–(c).

3 Answer the following questions.

(1) From the following options (A–D), choose the one that most appropriately describes the characteristics of media.

A Radio is a medium that conveys information through video and audio.

B Newspapers are media highly effective at spreading information rapidly.

C SNS is a medium that allows users to post and share information.

D TV is a medium that allows two-way interaction with users.

(2) From the following options (A–D), choose the one that most appropriately describes the choice of media.

A Information dissemination should always use only one medium.

B Regardless of purpose or target audience, a website is sufficient.

C It is important to choose the most suitable medium according to the purpose and target audience.

D With SNS, TV and websites are not needed.

REFLECT & CHALLENGE

Reflect: Which medium do you personally trust most for important news, and why?
Challenge: Plan the media mix for announcing a school event on a budget that rules out TV — then name one audience your mix might still miss, and why.

Key takeaway

Remember:
No medium is best for everything — match the medium to the purpose and audience, and combine media so each does what it does best.

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Lesson 4-2

Information Design and User Experience for Websites

Learning Objectives

- Explain how personas and wireframes are used to plan a website before designing its appearance.
- Apply the four principles of design (contrast, repetition, alignment, proximity) and explain the idea of user-centered design.

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A website that makes sense to its designer can still confuse its visitors. Good design therefore begins with the user, not the creator. Designers first picture a real user (a persona), sketch where information will go before choosing any colors (a wireframe), and follow four simple principles — contrast, repetition, alignment, and proximity — so the page is clear at a glance. This user-first mindset is called user-centered design.

? Guiding question: How do designers plan a website around its users, and what principles make a page clear and easy to use?

Key Fact:
Good web design starts from the user: a persona clarifies who they are, a wireframe fixes what goes where, the CRAP principles make it clear, and user-centered design keeps every choice on the user's side.

Key Concepts:

- persona
- wireframe
- contrast / repetition
- alignment / proximity
- user-centered design

KEY TERMS
persona — a typical user pictured as a concrete person.
wireframe — a layout blueprint before any color or decoration.

Point!

1. Persona

(1) **(Persona)**…a typical user image of those who will use the website, set up as a concrete person. Details such as age, occupation, purpose, and challenges are selected.

(2) By setting up a persona, designers can think specifically about "what this user needs," and the direction of the design becomes less likely to drift.
e.g., Person in their 30s, an office worker, wants to compare products on a smartphone during commute, wants to obtain information in a short time.

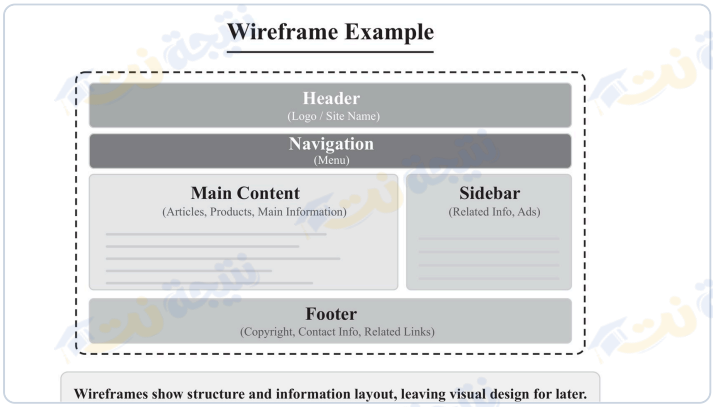


A persona captures one target user's goals.

2. Wireframe

(1) **(Wireframe)**…a rough blueprint of the layout of a web page. It does not include color or design decoration; it is created to determine the placement and priority of information.

(2) By using a wireframe, "what information to place where" can be considered separately from visual design. If decorations such as colors and fonts are decided first, discussions tend to drift toward personal preferences in appearance, so finalizing the placement and priority of information first makes it easier for stakeholders to reach agreement.



Wireframe Example



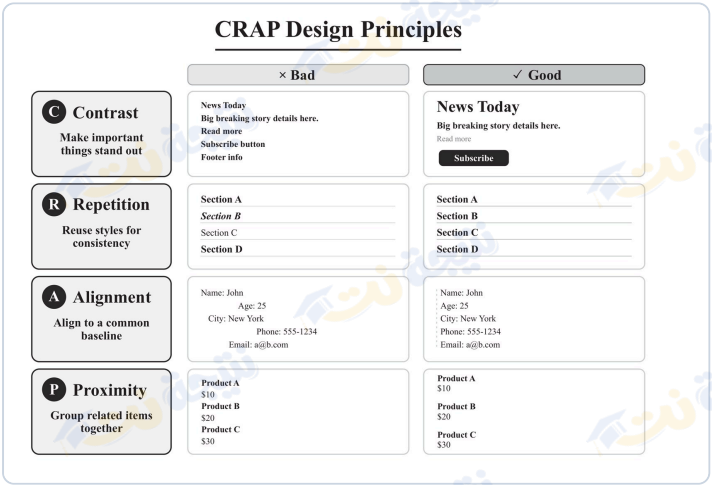
A wireframe grows into a finished design.

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3. The Four Principles of Design (CRAP Principles)

(1) Designs that are easy to view and understand follow these four principles.

Principle	Description (purpose)	Specific techniques and examples
(Contrast)	Make the priority of information clear and immediately highlight the most important elements	• Make headings large and bold to differentiate them from body text • Use accent colors for important buttons (e.g., purchase)
(Repetition)	Repeat specific characteristics so that the whole design has consistency, allowing users to navigate without getting lost	• Standardize the color, size, and font of headings on each page • Match the design of bullet point icons
(Alignment)	Align the position of each element to a common baseline, giving order to the entire screen	• Align the left edges of text and images precisely • Make a consistent rule for whether to use center or left alignment
(Proximity)	Place related information close together so that it can be perceived as a single group at a glance	• Group product images, names, and prices together • Leave appropriate spacing (margins) between items



CRAP Design Principles

4. User-Centered Design (UCD)

(1) **(User-Centered Design (UCD))**…a design approach that designs websites and services from the perspective of the user, rather than the convenience of the creator.

(2) In UCD, design begins from “what the user needs” and “in what situation it will be used.” Setting up a persona is one specific way of practicing UCD; by

PAUSE & THINK

Why decide where information goes (wireframe) before choosing colors and fonts?

KEY TERMS

CRAP — contrast, repetition, alignment, proximity.
user-centered design — designing from the user's perspective.

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clarifying the user image, design decisions can be kept consistently aligned with the user's perspective.

(3) Improving usability for users and accessibility for a wide range of people are important goals of UCD.



User-centered design loops around the real user.

PAUSE & THINK

Which principle groups related items together, and which makes the most important item stand out?

✎ Worked Example

(1) Mark each statement (A–D) with ○ if true or × if false.

A A persona is a typical user image of those who will use the website, set up as a concrete person.

B A wireframe is a final-version design that includes color and design decoration.

C "Proximity" in the four principles of design means grouping related information close together.

D User-centered design is a design approach that prioritizes the convenience of the creator.

(2) Match each description (a–d) with the most appropriate principle of design from the choices below (A–D).

a Highlight important information and visually indicate priority

b Repeat the same style to give a unified appearance

c Align the positions of elements to give an organized look

d Group related information close together

[Choices] **A** Contrast **B** Repetition **C** Alignment **D** Proximity

✓ Solution

(1)

A Correct definition of a persona. Therefore, ○.

B A wireframe is a blueprint for determining the placement and priority of information, without including color or design decoration. Therefore, ×.

C Correct definition of proximity. Therefore, ○.

D User-centered design is a design approach from the perspective of the user. Therefore, ×.

(2)

a: Highlighting information is contrast. **A**

b: Creating a unified appearance is repetition. **B**

c: Aligning positions is alignment. **C**

d: Grouping related information is proximity. **D**

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Try

1 Answer the following questions.

1. What is the term for a typical user image of those who will use the website, set up as a concrete person?
2. What is the term for a blueprint that shows the placement and priority of information on a web page?
3. What are the four principles of design called when expressed by their English initials?
4. What is the term for the design approach that designs websites and services from the perspective of the user? Also give its three-letter abbreviation.

2 Answer the following questions.

(1) From the following options (A–D), choose the one that is NOT an appropriate piece of information to include in setting up a persona.

A The user's age and occupation
B The user's purpose for using the website
C The performance of the website's server
D The challenges the user faces

(2) For each of design improvements (a–d), indicate which of the four principles of design (A–D) it corresponds to.

a Making headings large and bold to distinguish them from body text
b Grouping product names, prices, and photos close together
c Aligning the left edges of text and images
d Standardizing the font and color of headings across all pages

A Contrast **B** Repetition **C** Alignment **D** Proximity

Think as an Engineer — Investigate & Decide

A community clinic in your city wants a simple website so patients can find opening hours, services, and directions. You lead the design.

☐ **Start by choosing colors and fonts** ☐ **Start from the user, then design**

1 · Collect data. Ask about eight to ten classmates: "If you opened a community clinic's website, what is the one thing you would look for first?" Record the answers in a tally table.

2 · Analyze your users. Group the answers into user types. Include at least one user who is not a typical smartphone visitor — for example an elderly

EXAM-STYLE QUESTION

Explain why a designer creates a persona and a wireframe before choosing colors and fonts. **[6] Refer to:** the user's needs and reaching agreement with stakeholders.

PAUSE & THINK

For each improvement below, ask: does it highlight, unify, order, or group?

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patient with low vision, or someone with no home Internet using a library computer. Write what each type needs most.

3 · Decide from your data. Using your tally, decide the priority order of the four home-page blocks and justify each position from your data, not your taste. Then choose one CRAP principle and say exactly how you would apply it for the user type you added. **In pairs,** compare tables and agree on the top block.

Give evidence for your answer.

Stuck? Start with your tally: which need appeared most? Put that block at the top. Then ask of each block — highlight, unify, order, or group? Pick the CRAP principle that fixes the weakest spot for the user you added.

🌍 In a New Context

A school wants to redesign its cluttered results page so parents can find their child's grades quickly. Name the persona you would define, one wireframe decision, and one CRAP principle you would apply, and say what each one improves.

❓ Lesson Question — Answered

The lesson asked how designers plan a website around its users and what makes a page clear. Design begins from the user, not the creator. A persona pictures a typical user as a concrete person — age, occupation, purpose, and challenges — so the team can focus on what that user needs. A wireframe then fixes the placement and priority of information before any color or decoration, which keeps discussion on structure and helps stakeholders agree. To make the page clear, four principles are applied: contrast to highlight priority, repetition for consistency, alignment for order, and proximity to group related items. All of this is guided by user-centered design (UCD), which starts from what the user needs and aims to improve usability and accessibility. Good design, therefore, is planned from the user inward — who they are, what goes where, and how to make it clear.

KEY TERMS

usability — how easily users can use the site.

accessibility — usable by a wide range of people.

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Exercise

1 Cover the Point! section with a red plastic sheet and quiz yourself in your notebook in numerical order.

2 Read the following passage and answer each question.

When designing a website, it is important to view it from the user's perspective. First, create a (a), in which a typical user image is set up as a concrete person, and clarify "what this user needs." Next, create a (b), a blueprint for determining the placement and priority of information. In design, to improve viewability and clarity, the (c)—contrast, repetition, alignment, and proximity—should be kept in mind.

1. Fill in the blanks (a)–(c).

3 Answer the following questions.

(1) From the following options (A–D), choose the one that is NOT included in the four principles of design (CRAP principles).

A Contrast
B Encryption
C Alignment
D Proximity

(2) From the following options (A–D), choose the one that most appropriately describes the concept of user-centered design.

A Prioritize the design that the developer finds easy to use.
B Place the highest importance on visual design.
C Begin the design from what the user needs.
D Use as many of the latest technologies as possible.

⭐ REFLECT & CHALLENGE

Reflect: On a website you find confusing, which CRAP principle seems most broken, and why? **Challenge:** Your clinic can fund only one accessibility improvement this year. For the low-vision or no-Internet user you identified, choose one CRAP principle to apply — and say what you would give up (a decoration or feature) to make room for it, and why that trade-off serves the user better.

⭐ Key takeaway

Remember:
Persona (who) → wireframe (where) → CRAP (make it clear) → UCD (decide for the user). Design from the user inward.

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Lesson 4-3

Methods for Evaluating Websites

Learning Objectives

- Distinguish qualitative from quantitative evaluation, and explain the major indicators used in web analytics.
- Explain how heuristic evaluation works, and why combining both approaches gives a clearer picture of a website.

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How do you know whether a website works well for its users? You can watch real users try it and ask what confuses them — that is qualitative evaluation. Or you can count how many people visit, how long they stay, and how many buy — that is quantitative evaluation. Numbers tell you how much is happening; users' voices tell you why. The best teams use both, together with expert checks, to see a site clearly and improve it.

? Guiding question: How can a website be evaluated, and why is it useful to combine numbers with users' voices?

Key Fact:
Websites are evaluated qualitatively (why — usability tests, interviews, heuristic checks) and quantitatively (how much — web analytics: PV, bounce rate, CVR); combining both gives the clearest picture.

Key Concepts:

- qualitative evaluation
- quantitative evaluation
- web analytics
- PV / bounce rate / CVR
- heuristic evaluation

KEY TERMS
qualitative evaluation — the "why" from users' voices and behavior.
quantitative evaluation — the "how much" from numerical data.

Point!

1. Qualitative and Quantitative Evaluation

(1) Methods for evaluation generally fall into two main categories: **(qualitative evaluation)** and **(quantitative evaluation)**. These evaluation methods are used in a wide range of applications, and the same concepts apply to website evaluation.

Evaluation method	Description (purpose)	Specific techniques
Qualitative evaluation	Explore in depth the "reasons" behind users' psychology and behavior, and evaluate qualitative aspects that cannot be expressed in numbers.	• Usability testing: observe actual operations to identify points that are hard to use. • Interviews: hear users' direct voices to understand their needs and dissatisfactions.
Quantitative evaluation	Use numerical data such as access counts and time, and evaluate the current state objectively and statistically.	• Web analytics: analyze metrics such as PV count and time spent. • A/B testing: compare two options to verify which leads to better results.



Qualitative watches users; quantitative reads numbers.

(2) Qualitative evaluation is suited to exploring the cause of "why is it hard to use," while quantitative evaluation is suited to grasping the overall trend of "how much is it being used." By combining both, more accurate evaluation is possible.

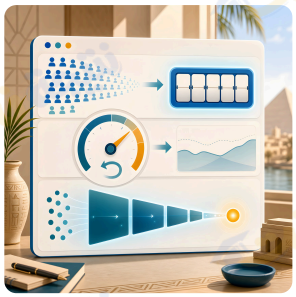
2. Major Indicators in Web Analytics

(1) **(Web analytics)**…a technique for analyzing how a website is accessed using numerical values; it is the central method of quantitative evaluation for websites. The following indicators are commonly used.

PAUSE & THINK
Would counting visits tell you *why* people leave a page? Which method would?

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Indicator	Meaning	Description
(PV (Page View))	The total number of times a page has been viewed.	A basic indicator that measures how widely the site is seen and how much exposure it gets.
(Bounce rate)	The proportion of visits that ended after viewing only the first page.	An indicator of whether the page content matched the user's expectations and whether further actions were prompted.
(Conversion rate (CVR))	The proportion of visits that achieved a target action (purchase, registration, etc.).	A very important indicator that measures how much the site contributes to business results (profits).



Analytics tracks visits, bounce, and conversions.

3. Heuristic Evaluation

(1) **(Heuristic evaluation)**…a method in which experts identify problems in a website's UI (user interface) based on rules of thumb (heuristics). It is a form of qualitative evaluation, used along with usability testing and other methods to investigate the causes of usability problems.

(2) Major evaluation perspectives

① Consistency…whether the design and operations are unified across the site.

② Error prevention…whether the design makes it hard for users to make mistakes.

③ Visibility of system status…whether system status is clearly indicated to users (e.g., processing indicators, input error messages).

KEY TERMS

PV — total page views.
bounce rate — the share of visits that end after only one page.
CVR — the share of visits that reach the target action.



Heuristic review checks a site against usability rules.

PAUSE & THINK

Match the question to the method: “how many?” vs “why?”

✎ Worked Example

(1) Mark each statement (A–D) with ○ if true or × if false.

A Qualitative evaluation is a method that uses numerical data to evaluate quantitatively.

B PV (Page View) is an indicator showing the number of times a page has been viewed.

C The bounce rate is an indicator showing the proportion of visits that achieved a target action.

D Heuristic evaluation is a method in which experts identify UI problems based on rules of thumb.

(2) Match each description (a–c) with the most appropriate indicator from the choices below (A–C).

a The number of times a page has been viewed

b The proportion of visits that ended after viewing only the first page

c The proportion of visits that achieved a target action

[Choices] **A** PV (Page View) **B** Bounce rate **C** Conversion rate

✓ Solution

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(1)

A Qualitative evaluation observes user voices and behavior to evaluate qualitatively. Using numerical data is quantitative evaluation. Therefore, ×.

B Correct definition of PV. Therefore, ○.

C The bounce rate is the proportion of visits that ended after viewing only the first page. The proportion of target action achievement is the conversion rate. Therefore, ×.

D Correct definition of heuristic evaluation. Therefore, ○.

(2)

a: The number of page views is PV. **A**

b: The proportion who left after only the first page is the bounce rate. **B**

c: The proportion who achieved a target is the conversion rate. **C**

Try

1 Answer the following questions.

1. What is the term for the method that evaluates qualitatively by observing user voices and behavior?
2. What is the term for the method that evaluates quantitatively using numerical data?
3. What is the two-letter abbreviation for the indicator showing the number of times a page has been viewed?
4. What is the term for the method in which experts identify UI problems based on rules of thumb?

2 Answer the following questions.

(1) From the following options (A–D), choose all terms that are part of quantitative evaluation methods.

A Usability testing

B Web analytics

C Interviews

D A/B testing

EXAM-STYLE QUESTION

Explain why a website team should use both qualitative and quantitative evaluation rather than only one. **[6] Refer to:** what numbers show and what users' voices show.

PAUSE & THINK

Which of the four above rely on numbers, and which on people's words?

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(2) From the following options (A–D), choose the one that most appropriately describes the conversion rate.

A The proportion of times a page has been viewed

B The proportion of visits that ended after viewing only the first page

C The proportion of visits that achieved a target action (product purchase, member registration, etc.)

D The proportion of viewed pages relative to the total number of pages on the site

Think as an Engineer — Investigate & Decide

A small online bookstore in your city wants to know whether its website really works for customers. You plan how to evaluate it.

☐ **Rely on the owner's opinion** ☐ **Use both quantitative and qualitative methods**

1 · Collect data. Ask five classmates who have used an online bookstore to visit any online shop and, for each, record one number you could measure (e.g., how many pages they viewed) and one thing they said was confusing. Put the results in a small table.

2 · Analyze the signals. Suppose the bookstore's PV is high but its conversion rate is very low. What might that mean — and which method (quantitative or qualitative) would tell you *why*? Then consider one customer the data may hide — for example, someone shopping only on a small phone screen, or a first-time visitor — and note one difficulty they might face that a raw PV count would never show.

3 · Decide. Recommend which two evaluation methods the bookstore should use first and give two reasons drawn from the table you built in step 1. **In pairs,** compare your choices and agree together on the single most useful indicator to track.

Give evidence for your answer.

Stuck? Start from the gap in the data: a high PV with a low CVR means people arrive but don't act — so the numbers only point to *where* to look. Pick the qualitative method (a short usability test or an interview) that answers the exact question your numbers raised.

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🌍 In a New Context

A school's new website gets many visits, but most people leave after the first page. Name one quantitative indicator that reveals this problem, one qualitative method to find its cause, and one likely fix.

❓ Lesson Question — Answered

The lesson asked how a website can be evaluated and why numbers and users' voices are combined. Evaluation falls into two kinds. Quantitative evaluation uses numerical data — through web analytics indicators such as PV (how many views), bounce rate (how many leave after the first page), and CVR (how many reach a target action) — to show how much a site is used. Qualitative evaluation explores the reasons behind users' behavior through usability testing, interviews, and heuristic evaluation, in which experts check the UI against rules of thumb. Numbers reveal what is happening but not why; users' voices and expert checks reveal the causes. Combining both — the "how much" and the "why" — gives the most accurate evaluation and the clearest path to improvement.

KEY TERMS

web analytics — numbers on how a site is accessed.
heuristic evaluation — experts check the UI by rules of thumb.

Exercise

1 Cover the Point! section with a red plastic sheet and quiz yourself in your notebook in numerical order.

2 Read the following passage and answer each question.

Methods for evaluating a website include (a) evaluation, which observes user voices and behavior, and (b) evaluation, which analyzes using numerical data. Typical indicators used in (b) evaluation are (c), which shows the number of times a page has been viewed; (d), which shows the proportion of visits that ended after viewing only the first page; and (e), which shows the proportion of visits that achieved a target action.

1. Fill in the blanks (a)–(e).

3 Answer the following questions.

(1) For each of evaluation methods (a–c), indicate which it falls under: **A** Qualitative evaluation, **B** Quantitative evaluation.

a Have users actually explore the website and observe its usability
b Tally the access counts and page views of the website
c Interview users to hear their impressions and improvement requests

⭐ REFLECT & CHALLENGE

Reflect: If you could see only one metric for a site you use, would you choose PV, bounce rate, or CVR — and why?
Challenge: A page has a high bounce rate. Design a short qualitative test that would reveal the cause, and say what you would change first.

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(2) From the following options (A–D), choose the one that most appropriately describes heuristic evaluation.

A A method in which users explore the site and usability is observed

B A method in which numerical data is tallied and site usage is analyzed

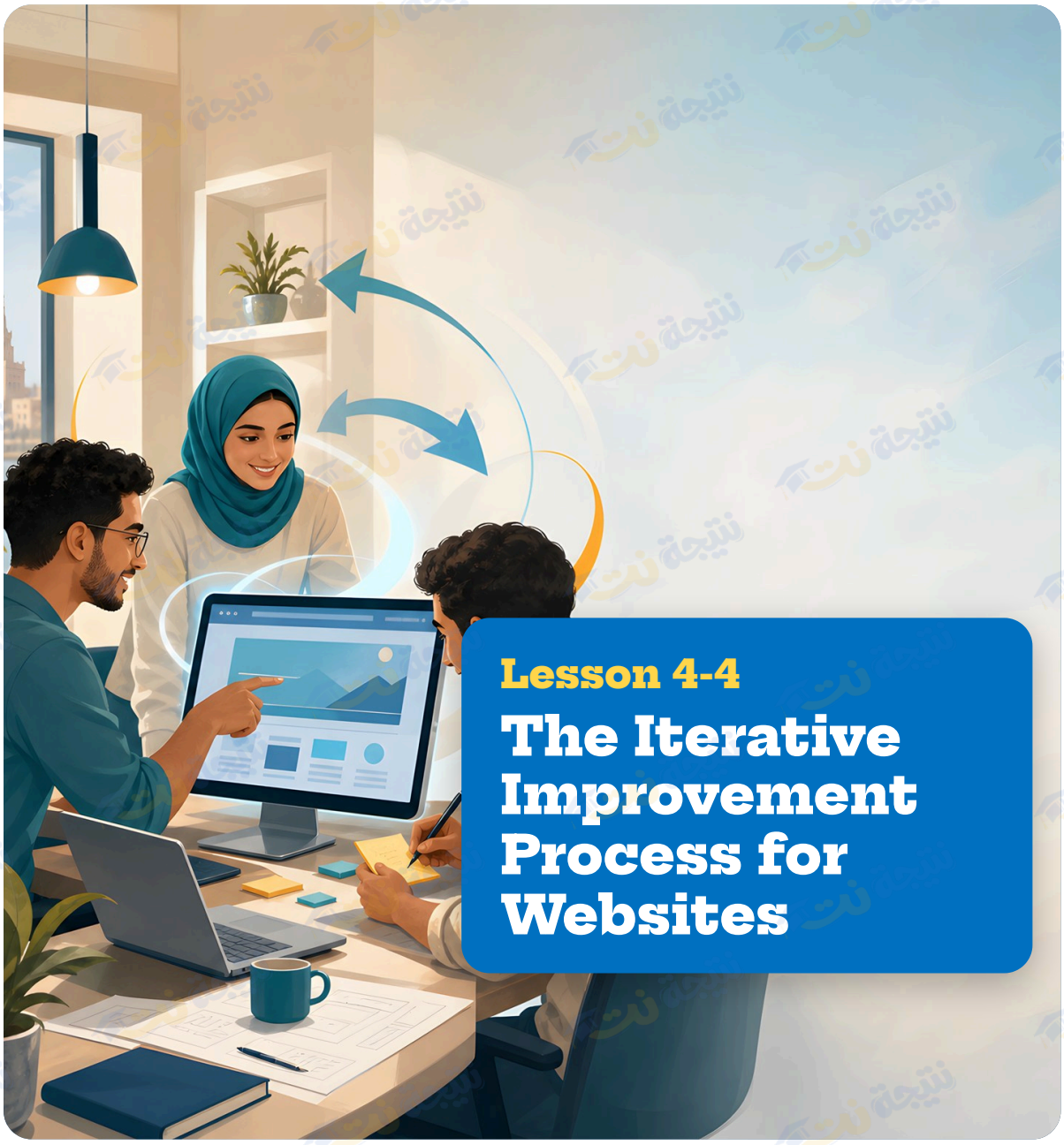
C A method in which experts identify UI problems based on rules of thumb

D A method in which two patterns are prepared and compared with data to see which is more effective

Key takeaway

Remember:
Quantitative (PV, bounce rate, CVR) shows how much; qualitative (usability tests, interviews, heuristic checks) shows why. Combine both to evaluate a site clearly.

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Lesson 4-4

The Iterative Improvement Process for Websites

Learning Objectives

- Explain the PDCA cycle and the steps of design thinking as ways of improving a website.
- Describe how A/B testing compares two options using real data, and explain why improvement is repeated in cycles.

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A website is never truly finished. The first version is only a best guess, and a team learns what truly works only after real people use it. That is why good teams improve in loops: they plan a change, make it, measure the result, and act on what they learn — the PDCA cycle. They also design from the user's side (design thinking) and test real choices with data (A/B testing). Small, repeated improvements are better than waiting for one perfect launch.

? Guiding question: Why is improving a website a repeated loop rather than a one-time job, and how do teams decide what to change?

Key Fact:
Websites improve through repeated cycles: PDCA (Plan, Do, Check, Act) drives continuous improvement; design thinking finds problems from the user's side; A/B testing compares two options with real data.

Key Concepts:

- PDCA cycle
- Plan / Do / Check / Act
- design thinking
- A/B testing

KEY TERMS
PDCA cycle — Plan→Do→Check→Act, repeated.
continuous improvement — getting better a little at a time.

Point!

1. The PDCA Cycle

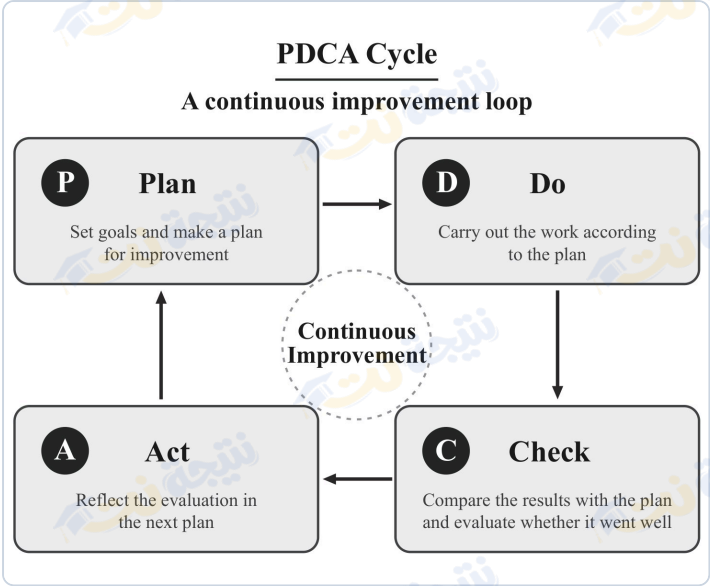
(1) **(PDCA cycle)**…a method that continuously advances improvement by repeating the following four steps. It is used widely in fields such as business improvement and quality management, not just websites.

Step	Description	Example in website improvement
Plan	Set goals and create a plan for improvement	Set the goal “reduce bounce rate by 10%” and plan a redesign of the homepage
Do	Execute according to the plan	Change the design of the homepage
Check	Measure results and evaluate the level of goal achievement	Measure the bounce rate after the change and evaluate whether the goal (10% reduction) was achieved
Act	Based on the evaluation, consider the next improvement measures	If the effect is sufficient, continue; if not, consider next steps such as revising headings or image placement



Each Plan-Do-Check-Act cycle improves the site.

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The PDCA cycle as a continuous improvement loop

(2) The important point of the PDCA cycle is not to aim for completion in one round, but to gradually improve through repetition.

2. Design Thinking

(1) **(Design thinking)**…a way of thinking that leads to discovering problems and generating solutions from the perspective of the user. It proceeds through the following five steps.

Step	Description
① **Empathize**	Put yourself in the user's position and understand their challenges and needs
② **Define**	Based on the information gleaned from empathy, clarify the problem to be solved
③ **Ideate**	Generate many ideas to solve the problem
④ **Prototype**	Quickly create a prototype based on the ideas
⑤ **Test**	Have users try the prototype and obtain feedback from them

(2) Based on test results, one may go back to the empathize or define stage. Improvement proceeds back and forth, not one-way.

PAUSE & THINK

Which PDCA step tells you whether your change actually worked?



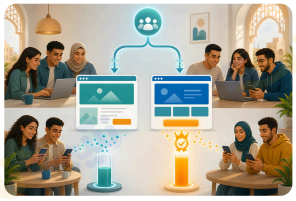
Design thinking: ideate, prototype, test, repeat.

3. A/B Testing

(1) **(A/B testing)**…a method in which two patterns (option A and option B) are prepared, each is shown to actual users, and data is examined to determine which is more effective.

e.g., Compare option A with a red purchase button and option B with a blue purchase button to see which gets clicked more.

(2) Key points of A/B testing



A/B testing compares two versions with real users.

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① Change only one element at a time (if multiple elements are changed, it is unclear which change produced the effect).

② Make decisions only after collecting a sufficient amount of data.

✎ Worked Example

(1) Mark each statement (A–D) with ○ if true or × if false.

A The PDCA cycle is a method that repeats the four steps Plan→Do→Check→Act.

B Design thinking is a way of thinking that solves problems from the developer's perspective.

C In A/B testing, it is important to change only one element at a time.

D The PDCA cycle is a method that is complete after one execution.

(2) For each of a–e, indicate which of the five steps of design thinking (A–E) it corresponds to.

a Understand the user's challenges and needs.

b Clarify the problem to be solved.

c Generate many ideas.

d Quickly create a prototype.

e Have users try the prototype.

A Empathize **B Define** **C Ideate** **D Prototype** **E Test**

✓ Solution

(1)

A Correct definition of the PDCA cycle. Therefore, ○.

B Design thinking is a way of thinking from the user's perspective. Therefore, ×.

C It is important to limit the changed element to one in A/B testing. Therefore, ○.

D The PDCA cycle is meaningful when repeated. Therefore, ×.

(2)

a: Understanding the user is empathize. **A**

b: Clarifying the problem is define. **B**

c: Generating ideas is ideate. **C**

d: Creating a prototype is prototype. **D**

e: Having users try is test. **E**

KEY TERMS

design thinking — solve from the user's view in five steps.

A/B testing — compare two options with real data.

PAUSE & THINK

In A/B testing, why change only one element at a time?

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Try

1 Answer the following questions.

1. What is the term for the improvement method that repeats the four steps Plan→Do→Check→Act?
2. What is the term for the way of thinking for discovering problems and generating solutions from the perspective of the user?
3. What is the term for the method in which two patterns are prepared and compared with data to see which is more effective?
4. Name the five steps of design thinking in order.

2 Answer the following questions.

(1) From the following options (A–D), choose the one that corresponds to "Check" in the PDCA cycle.

A Set the goal of reducing the bounce rate by 10%.
B Change the design of the homepage.
C Measure the bounce rate after the change.
D Consider another improvement measure.

(2) From the following options (A–D), choose the one that is NOT an appropriate way of conducting A/B testing.

A Prepare two patterns and compare them.
B Change multiple elements at the same time.
C Make decisions only after collecting a sufficient amount of data.
D Show each pattern to actual users.

Think as an Engineer — Investigate & Decide

Your school club runs a web page for its yearly event, but few students sign up through it. You lead one round of improvement using the PDCA cycle.

☐ **Redesign everything at once** ☐ **Improve in one measured PDCA loop**

1 · Collect data (Check first). Decide one number you could measure now — for example, how many of ten classmates find the "sign up" link within five seconds. Record the result as your starting point.

2 · Plan one change. From the users you watched, name the single biggest obstacle (for a specific group, such as a student opening the page on a small phone screen) and plan one change to fix it. State the goal as a number (e.g., "8 of 10 find it in five seconds").

EXAM-STYLE QUESTION

Explain why a website team improves in repeated PDCA cycles instead of trying to build a perfect site in one go. **[6]**
Refer to: measuring results and acting on them.

PAUSE & THINK

Match each option above to a PDCA step: which is Plan, Do, Check, Act?

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3 · Do, Check, Act — and decide. Describe how you would make the change, measure again, and decide the next step. Choose one element to settle with an A/B test, and say why you change only that one element. **In pairs,** compare plans and agree on the single change to try first.

Give evidence for your answer.

Stuck? Start from your measured number (Check), pick the one obstacle it exposes, plan a single fix (Plan), then loop — do not change everything at once.

🌍 In a New Context

An online shop finds that its “buy” button is rarely clicked. Describe how you would use one A/B test (changing only one element) and one PDCA loop to improve it, and say which number would tell you it worked.

❓ Lesson Question — Answered

The lesson asked why improving a website is a repeated loop and how teams decide what to change. A first version is only a guess, so teams improve continuously rather than once. The PDCA cycle repeats four steps — Plan (set a goal and plan a change), Do (make it), Check (measure the result), and Act (decide the next step) — and its point is not completion in one round but gradual improvement through repetition. To decide what to change, design thinking works from the user's side through five steps (Empathize, Define, Ideate, Prototype, Test), moving back and forth rather than one-way, while A/B testing compares two options with real data, changing only one element at a time and deciding only after enough data. Together they make improvement small, measured, and repeatable.

KEY TERMS

prototype — a quick, testable draft.

iterate — repeat the loop to improve.

Exercise

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1 Cover the Point! section with a red plastic sheet and quiz yourself in your notebook in numerical order.

2 Read the following passage and answer each question.

As a method for improving websites, there is the (a) cycle. It repeats four steps: (b), in which goals are set; (c), in which the plan is executed; (d), in which results are measured; and (e), in which improvement measures are considered. Also, (f), in which two patterns are prepared and compared with data to see which is more effective, is a useful method.

1. Fill in the blanks (a)–(f).

3 Answer the following questions.

(1) From the following options (A–D), choose the one that most appropriately describes design thinking.

A A method that uses numerical data to analyze website usage.

B A way of thinking that leads to discovering problems and generating solutions from the perspective of the user.

C A method in which experts identify UI problems based on rules of thumb.

D A method of creating a blueprint that roughly shows the layout of a web page.

(2) From the following options (A–D), choose the one that most appropriately describes the concept of the website improvement process.

A If a perfect website is built initially, no improvement is needed.

B It is enough to improve only the visual design.

C It is important to gradually improve by repeating evaluation and improvement.

D All improvements should be done with A/B testing alone.

REFLECT & CHALLENGE

Reflect: Think of a website you use often. Which one small change do you think would help most, and how would you measure whether it worked?
Challenge: You may run only one A/B test this month on the event page. Choose the single element to test, predict which option will win and why, and say what number would prove you right or wrong.

Key takeaway

Remember:
Improve in loops: PDCA (Plan, Do, Check, Act) for continuous improvement, design thinking (Empathize, Define, Ideate, Prototype, Test) from the user's side, and A/B testing to settle one change with data.

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