香港科學館
Hong Kong Science Museum

Teachers' Guide

—盛世啟航—

新中國成立75周年成就

Glorious Voyage

Splendid Achievements of the People's Republic of China in Its 75 Years

展覽系列：科技創新
Exhibition Series : Scientific Breakthroughs

展覽系列：智慧時代
Exhibition Series : Era of Intelligence

75 1949-2024
中華人民共和國成立七十五周年
75th Anniversary of the Founding of the People's Republic of China

主辦 Presented by
康樂及文化事務署 Leisure and Cultural Services Department

聯合策劃 Jointly organised by
弘揚中華文化辦公室 CHINESE CULTURE PROMOTION OFFICE
香港科學館 HONG KONG SCIENCE MUSEUM
大館文匯 HKTKWW
中國科學技術館 CHINA SCIENCE AND TECHNOLOGY MUSEUM

協辦 In collaboration with
香港歷史博物館 HONG KONG MUSEUM OF HISTORY
中国科协港澳台办公室 The Office of Hong Kong, Macao and Taiwan Affairs of the China Association for Science and Technology
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香港科學館
Hong Kong Science Museum

Lesson Plan

Aims

- ✓ To explain the scientific achievements and related concepts
- ✓ To stimulate students' thinking, creativity and imagination through experiencing exhibits that incorporate artificial intelligence

Expected Outcome

- 👍 To understand the basic knowledge of petroleum, nuclear technology, aerospace technology, chips, and artificial intelligence
- 👍 To arouse students' interest in science and technology through experience and imagination
- 👍 To contemplate the impact of technology on human life

Relevant Curriculum

- ✎ General Studies: Science and Technology in Everyday Life
- ✎ Science (S1-S3): The Materials World
- ✎ Chemistry and Physics (S4-S6)

Before the Visit

- Discuss with students the various needs of daily life, including clothing, food, housing and transportation.
- Guide students to list common technological products, and explain how these products solve their daily needs.
- Invite students to draw inspiration from the exhibits to create a technological product that solves daily needs.

At the Museum

- Encourage students to pay attention to the scientific achievements and the underlying principles and technologies in the exhibition, as well as to understand the trends and advancement in technology.
- Encourage students to experience various interactive exhibits and think about how these exhibits can be applied in daily life, or reflect on how to optimise current technology.

After the Visit

- Guide students to design an innovative technological product based on the instructions provided in the activity sheet.
- You are welcome to share the work of your class with the Museum!

Teaching Notes

Introduction of the Exhibition

"Glorious Voyage: Splendid Achievements of the People's Republic of China in Its 75 Years" Exhibition Series include exhibitions held at the Hong Kong Science Museum, which takes technological innovation as its main theme. The exhibition introduces scientific and research achievements that have had a profound impact on our lives. It covers four areas including Petroleum, the "Two Bombs, One Satellite" (nuclear bombs, missiles and satellites), Chips and Artificial Intelligence (AI).

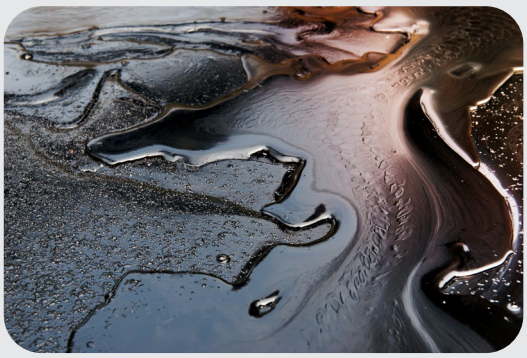
Class inspiration

Are there any renewable energy alternatives?

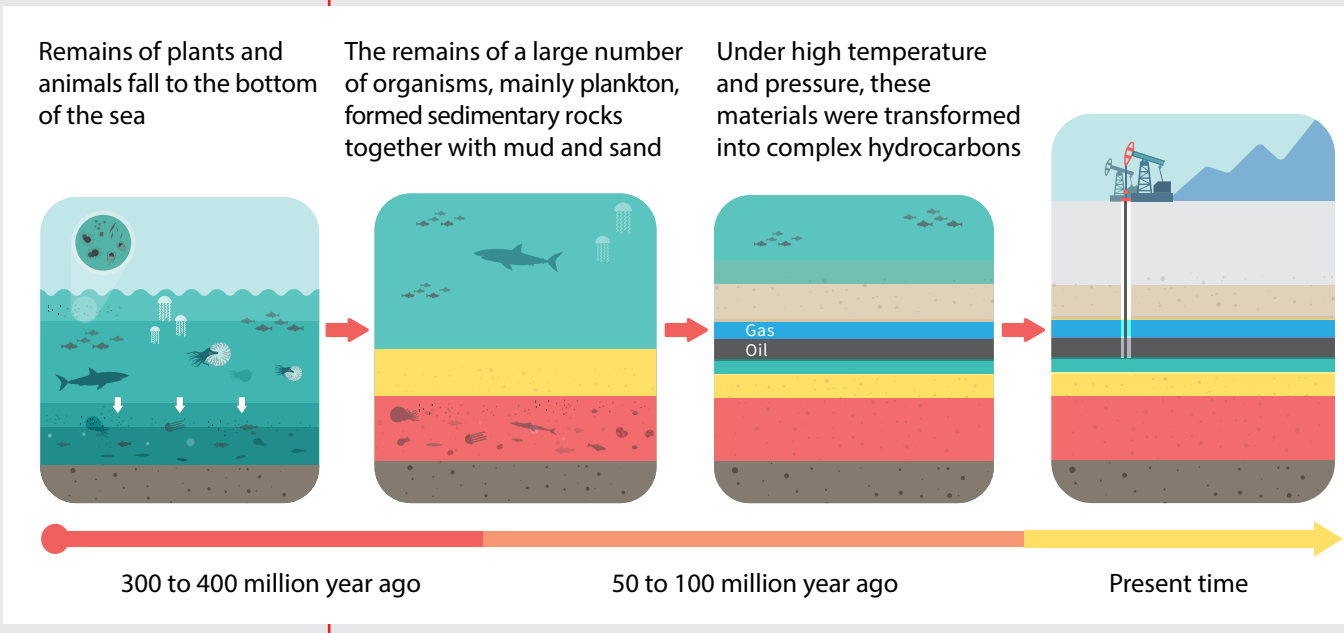
Students are encouraged to reflect on the alternative fuels that have been developed to replace petroleum. Examples include Biodiesel, Hydrogen fuel, etc.

A. Petroleum

Formation of Petroleum



Petroleum originates from geological strata that were once oceans or lakes. The remains of a large number of organisms, mainly plankton, gradually accumulated over time and formed **sedimentary rocks** together with mud and sand. Under high temperature and pressure, these materials were transformed into complex **hydrocarbons**. Among these hydrocarbons, those with a **higher density** form the viscous substance known as **petroleum**; whereas those with a **lower density** are classified as the easily vapourised **natural gas**.

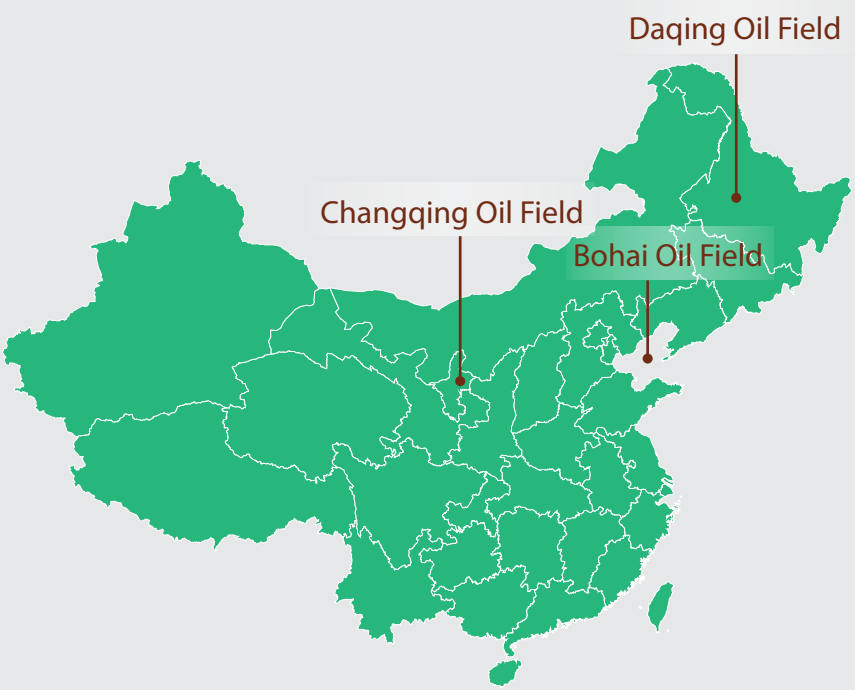


▲ The formation of petroleum and natural gas

Class inspiration

The exhibition introduces different experts, including geologists, engineers, environmental scientists, etc. They have been working tirelessly in the petroleum exploration and extraction. Discover from the exhibits how exploration and extraction are conducted. Discuss with students what the most difficult step is and how the experts solved challenges and succeeded in this adventure.

Prominent Oil Fields of China

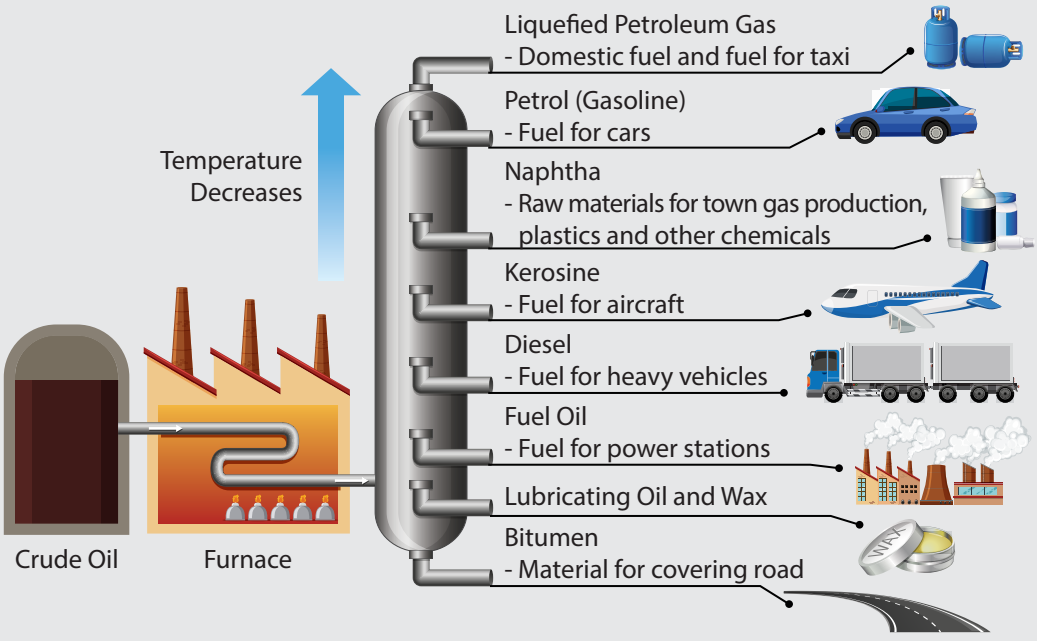


Class inspiration

Encourage students to discover everyday petroleum products. Examples include cosmetics, Vaseline, soap, chewing gum, plastic toys, etc.

Fractional Distillation of Crude Oil

Petroleum is made up of different hydrocarbons and a small amount of sulfur compounds, such as alkanes, alkenes, cyclic compounds, thiols, etc. Through **fractional distillation**, by using the principle that molecules with different sizes have different boiling points, molecules of the extracted crude oil, the liquid petroleum, are separated and further processed and refined into products of different usages.



▲ Oil refinement under combustion results in different products

B. "Two Bombs, One Satellite"

The term refers to **nuclear bombs**, **missiles**, and **satellites**, where nuclear bombs include **atomic bombs** and **hydrogen bombs**.

Atomic Bombs and Hydrogen Bombs

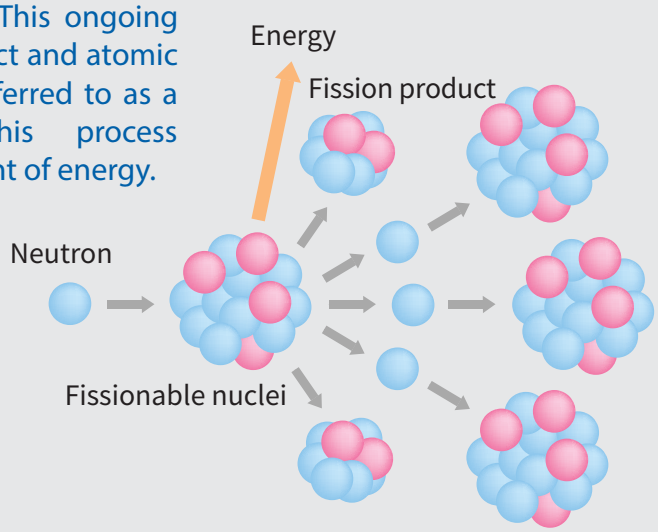
Atomic bombs and hydrogen bombs are both nuclear weapons with tremendous destructive power, but they are under completely different principles. **Atomic bombs** generate energy through the process of **nuclear fission**; while **hydrogen bombs** generate energy through the process of **nuclear fusion**.

Class inspiration

In addition to weapon manufacturing, what applications do nuclear fission and nuclear fusion have in daily life? Examples include power generation, healthcare sector, scientific research, etc.

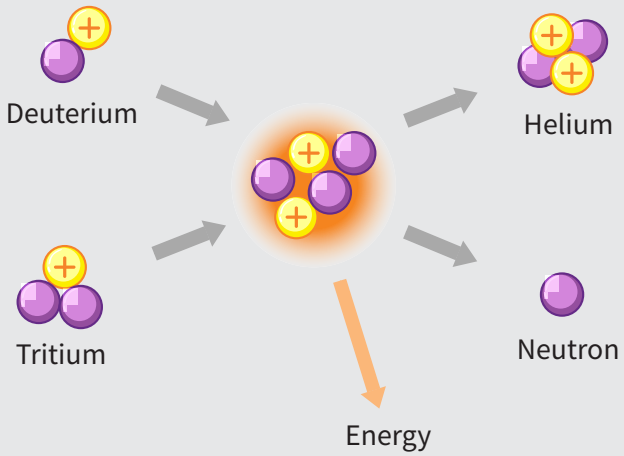
Nuclear Fission

Nuclear fission is a process in which a larger atomic nucleus, for examples, **Uranium and Plutonium**, splits into two smaller atomic nuclei along with several neutrons. Under certain conditions, the released neutrons can collide with other atomic nuclei, causing them to split into more atomic nuclei and neutrons. This ongoing cycle of neutron impact and atomic nucleus splitting is referred to as a "chain reaction". This process releases a huge amount of energy.



Nuclear Fusion

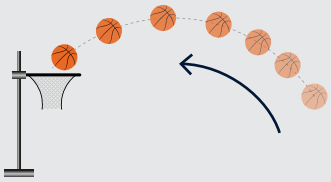
Nuclear fusion occurs where two light atomic nuclei, such as the **Hydrogen isotopes Deuterium and Tritium**, combine to form a heavier atomic nucleus. This process also releases a significant amount of energy. Since atomic nuclei carry a positive charge, they naturally repel other atomic nuclei. Only at extremely high temperatures, these positively charged atomic nuclei can gain sufficient kinetic energy to overcome the electric repulsion between them and merge into a more massive atomic nucleus.



Class inspiration

What is projectile motion?

Projectile motion describes the phenomenon of an object moving along a parabolic trajectory, after being launched with a specific initial velocity and angle under the influence of gravity. Basketball shooting is a typical example of projectile motion.



Missiles

Missiles are weapons propelled by engines and equipped with control systems to guide them swiftly and accurately to their targets. Their "warheads" can carry explosives, nuclear weapons, or biochemical weapons.

The main difference between **cruise missiles** and **ballistic missiles** is that cruise missiles utilise jet engine propulsion and aerodynamic lift from their wings to fly within the atmosphere, whereas ballistic missiles, utilising the principles of **projectile motion**, are propelled by rocket engines during the initial stage of flight. After reaching a certain height, they rely on the Earth's gravity and follow the trajectory of a free-falling object to reach their target.

	Cruise Missile	Ballistic Missile
Propulsion	Jet engine	Rocket engine
Speed	Subsonic / Supersonic	Supersonic / Hypersonic
Flight Altitude	Within the Atmosphere	Outside the Atmosphere

▲ Comparison of cruise and ballistic missiles

Rocket engines that propel ballistic missiles are widely used in aerospace technology to carry satellites, manned spacecraft and space probes, enabling them to accurately enter the orbit.

Satellites

Satellites are small celestial bodies that orbit around larger celestial bodies. They can be divided into **natural** and **artificial satellites**. In the solar system, except for Mercury and Venus, all other planets have natural satellites. The Moon is the natural satellite of Earth.

Most artificial satellites are launched into space by rockets, orbiting the Earth in predetermined orbits. For example, some communication satellites operate in geostationary orbit. These satellites move at the same speed as the Earth's rotation. Thus, the receiving and transmitting antennas can be kept in a fixed position to transmit data.

Class inspiration

Computer operations are based on the switching characteristics of transistors in the chips. These switching characteristics represent two states, 0 and 1, which are used in the binary system for encoding and computation in computer systems. The more transistors there are inside a chip, the more data the computer can process simultaneously, and the faster the computation speed.

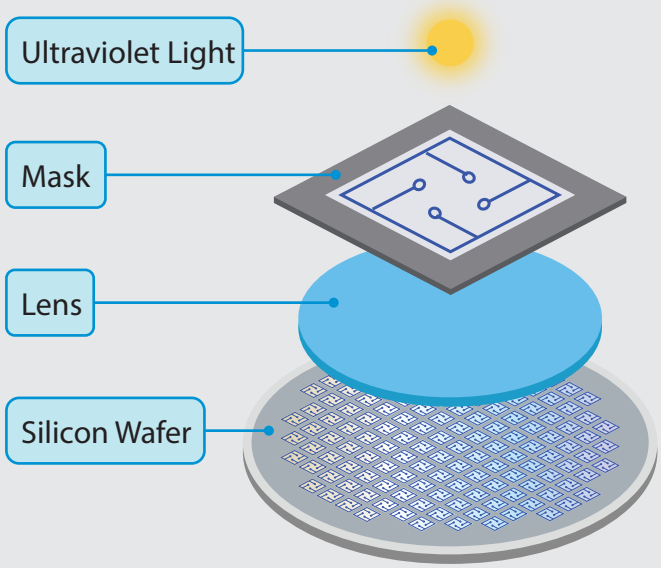
C. Integrated Circuit

Integrated Circuits (ICs), commonly referred to as "Chips", are fundamental components of electronic devices. They consist of numerous tiny transistors that can control the flow of electricity, enabling the chip to perform various functions such as **calculations** and **logical operations**.

▲ Mobile phones contain chips with various functions, such as central processing units (CPUs), camera power ICs, and Bluetooth chips. The CPU alone is composed of tens to hundreds of billions of transistors.

How are Chips Manufactured?

To manufacture chips, the process begins with designing circuits that meet specific functional requirements. Through **photolithography**, the circuits are constructed on wafers (substrate carrier for circuits), and then cut into individual chips. Photolithography involves coating the surface of semiconductor wafers with a layer of photoresist material, followed by exposure to ultraviolet light. The areas exposed to the light undergo a chemical reaction, and the unwanted parts are then removed through dissolution and etching. This process is repeated multiple times to transfer complex circuit patterns onto the chips.



Class Inspiration

Semiconductors play an indispensable role in our daily lives. Traces of semiconductor components can be found in items from simple household appliances to complex intelligent systems.

Key Materials of Chips – Semiconductor

Semiconductor materials are key to chip manufacturing, with **their conductivity falling between that of conductors and insulators**. Their conductivity is usually affected by temperature, light exposure, and magnetic fields. We can also alter their conductivity by doping the pure semiconductor material with trace amounts of other elements.

	Elemental Semiconductor	*Compound Semiconductor*
Definition	Composed of a single element	Consists of chemical elements from two or more different groups
Material/ Combination	Silicon (Si), Germanium (Ge)	Group III-V: Gallium Arsenide (GaAs), Gallium Nitride (GaN), Indium Phosphide (InP), Group IV-IV: Silicon Carbide (SiC)
Applications	ICs in mobile phones and computers	Green energy generation equipment, lighting equipment, and optical fiber communications

▲ Introduction to semiconductor types

One of the exhibits at the Hong Kong Science Museum showcases the unprocessed form of the semiconductors. Can you find this exhibit? (Name of the exhibit: Periodic Table)

▲ Silicon (Si)

▲ Germanium (Ge)

▲ Gallium (Ga)

Class inspiration

Artificial intelligence involves various underlying technologies. Let's get to know some relevant terminology!

➔ **Machine Learning**: Artificial intelligence learns from data and algorithms

➔ **Deep Learning**: A branch of machine learning that mimics the way the human brain's neural connections work

➔ **Big Data**: The amount of data is constantly increasing, becoming more diverse and being generated at an ever-faster rate.

➔ **Cloud Computing**: Access to computing resources over the network, including application development tools, servers, data storage, etc.

➔ **Natural Language Processing**: Technologies that can input, understand, interpret and process human language.

D. Artificial Intelligence

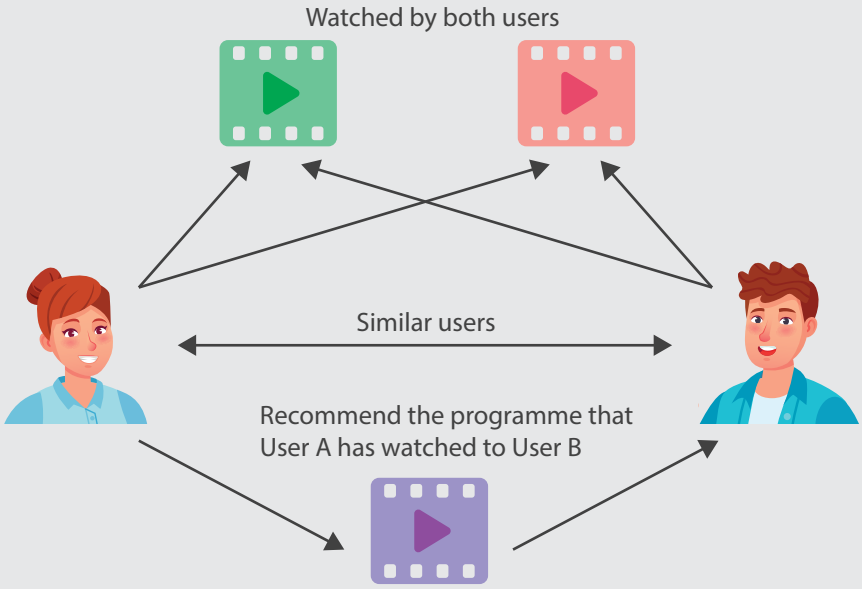
Artificial intelligence (AI) refers to the development of computer systems that simulate human intelligence patterns. Supported by **big data** and **cloud computing**, AI can continuously self-learn and expand its knowledge through **machine learning**.

Artificial Intelligence in Everyday Life

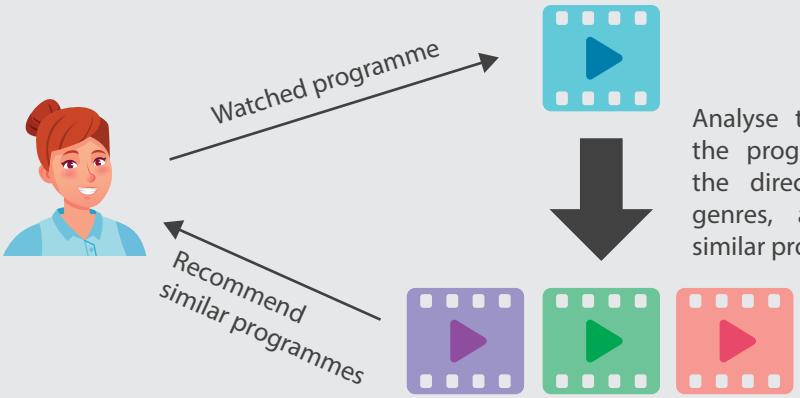
Recommendation on Streaming Platforms

Machine learning can analyse large amounts of user behaviour data, such as viewing history, search records, and viewing time, to understand targets' interests and preferences. Natural language processing technology can also extract the content of audience comments and incorporate it as part of the data used in the recommendation process. The recommendation systems use a variety of algorithms and techniques, including two common methods:

► **Collaborative Filtering:** Identify users with similar preferences and recommend programmes they may be interested in.



► **Content-Based Filtering:** Analyse the metadata of the videos or music users have watched or listened to in the past, such as the actors, singers, genres, styles, and keywords, so as to recommend content with similar features, providing a personalised user experience.



Class inspiration

With further breakthroughs in AI technology, future AI will be able to participate in a wider range of tasks. Students can share what they hope AI will be able to do 50 years from now.

Generative Artificial Intelligence

Generative AI utilises deep learning models to analyse and train on large datasets, then create new content, such as text, images, artworks, music and videos. Generative AI has become increasingly prevalent in recent years. This exhibition showcases creative applications of the technology.

Robotics and Artificial Intelligence

In recent years, robots have been widely applied in our daily lives. Products supported by AI technology can accurately perceive and analyse visual information through the use of various sensors and machine learning. They can also learn from the surrounding environment to make inferences and judgements. With the advancement of natural language processing technology, robots and robotic arms can also interact with humans through speech and text, understanding complex commands and answering questions, thus significantly enhancing the user experience.

▲ Monitor crops, automate harvesting, and detect pests

▲ Identify and analyse the surrounding, to avoid obstacles

▲ Analyse patients' conditions more accurately and monitor the surgical safety