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**Automobiles have shaped modern society** perhaps more than any other technology. The development of automobiles led to the construction of vast highway systems. Many cities have complex systems of overpasses, underpasses, ramps, and interchanges, such as the one shown here.

## Automobile

**Automobile** is a wheeled machine that serves as the most important form of transportation in the world. People drive about 750 million passenger cars along the world's roads and highways—about 1 car for every 10 people. Trucks transport huge amounts of food, clothing, and other products across vast distances. Since their invention in the late 1800's, automobiles have shaped the way people do business and live their lives. Few technologies have changed the world as much as the automobile has.

A car moves by producing power and channeling it to the wheels, spinning them. Like the human body, a car includes a number of systems that work closely together. Each system is itself a complex machine. Most systems in an automobile have many moving and computerized parts. Some systems work to produce power or transfer it to the wheels. Others work to support the car or provide information to the driver.

All cars use energy to power their motion. Most cars have *internal-combustion engines*. Such engines use energy stored in gasoline or diesel fuel by burning it. Other cars have an *electric motor*. The motor uses energy stored in a rechargeable battery. *Hybrid cars* combine an internal-combustion engine with an electric motor.

Manufacturing a car requires years of planning. Engineers use computer programs to model how the car will look and perform. They build sample cars and test how well the samples work in a variety of conditions. All the parts of the car must be made from scratch or bought. Then, automakers bring the parts together on an *assembly line*. An automobile assembly line is a row of workers. Each worker performs an assigned task, such as inserting a part. The car then passes along to the next worker until it is finished.

Auto manufacturers and related industries employ millions of people throughout the world. This fact causes the health of the auto industry to be closely tied to the health of the world economy. The popularity of automobiles has given rise to vast networks of highways. Gas

stations, motels, and fast-food restaurants owe their existence to the popularity of the automobile.

Automobiles also have their disadvantages. Millions of people have died in car accidents. The construction of car-friendly roads and cities has destroyed or displaced many natural habitats. Cars also cause pollution.

The history of automobiles was shaped by many inventors, engineers, and businesspeople. Cars were once too expensive for most people. But they became cheaper and more plentiful after the introduction of *mass production*. Mass production involves the use of interchangeable parts, machines, and moving assembly lines to produce large quantities of nearly identical goods. By the late 1920's, a few large companies came to dominate the car market.

In the early 2000's, relatively new markets for cars—such as China and India—were growing fast. But the automobile industry, shaken by a global recession, struggled to adapt to demands for greater fuel efficiency and less pollution. Changing consumer preferences, safety concerns, and government regulation reshaped automobile designs and reduced the dominance of the big car companies.

### Automobile systems

When a driver steps on an automobile's gas pedal, the car accelerates. This action and reaction may seem simple. However, a number of complex systems—each consisting of many moving parts—must work together to make it happen. The car's power system, connected to the gas pedal, generates motion within the vehicle. The *power train*—which includes the transmission and the drive system—channels this motion from the car's power system to spin its wheels. Meanwhile, the car's support system holds the car's frame up from the wheels. Steering and brake systems enable the driver to control the moving car. The electrical system connects most of the other systems together.

All of a car's systems use a number of technologies and scientific principles to work. Physical laws govern the spinning, pushing, and pulling motions of a car's engine, axles, wheels, and other internal parts. *Hydraulics*—a branch of physics involving pressure from fluids—plays a major role in steering and brake systems.



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**An electric car**, such as the Tesla Roadster shown here, does not use gasoline, unlike most cars. Instead, a rechargeable battery powers an electric motor that moves the car.

### Outline

- I. Automobile systems**
  - A. Power systems
  - B. From power plant to wheels
  - C. Controlling the car
  - D. Supporting the car
  - E. The passenger compartment
  - F. Providing electric power
- II. Powering an internal-combustion car**
  - A. The engine block
  - B. The engine cycle
  - C. The fuel system
  - D. The exhaust system
  - E. The cooling system
  - F. The lubrication system
- III. Powering electric and hybrid cars**
  - A. Electric motors
  - B. Hybrid power systems
  - C. Batteries and braking
- IV. Driving an automobile**
  - A. Operating a car
  - B. Rules of the road
  - C. Defensive driving
- V. Building an automobile**
  - A. Planning the car
  - B. Engineering the parts
  - C. Testing the car
  - D. Buying materials
  - E. Manufacturing
- VI. The auto industry**
  - A. Where cars are made
  - B. Economic impact
- VII. Automobiles and society**
  - A. Demand for services and facilities
  - B. Demand for petroleum
  - C. Safety problems
- VIII. Automobiles and the environment**
  - A. Damage to natural habitats
  - B. Air pollution
  - C. Global warming
- IX. History**

Most modern cars rely on electronics and advanced computer technology to coordinate their systems.

**Power systems.** A car's power system consists of one or more *power plants*. A power plant is a machine that generates power. Power plants generate electric power for a car's lights and computerized parts. But their main purpose is to generate power for spinning

### Interesting facts about automobiles

**The word *automobile*** was first applied to the horseless carriage in France about 1890. It comes from the Greek word *autos*, meaning *self*, and the French word *mobile*, meaning *moving*.

**A nation on wheels.** The United States has about 15 percent of the world's passenger cars. Americans drive about 3 trillion miles (5 trillion kilometers) a year.

**Car owners.** About 80 percent of all U.S. households own a car, and about 35 percent own two or more.

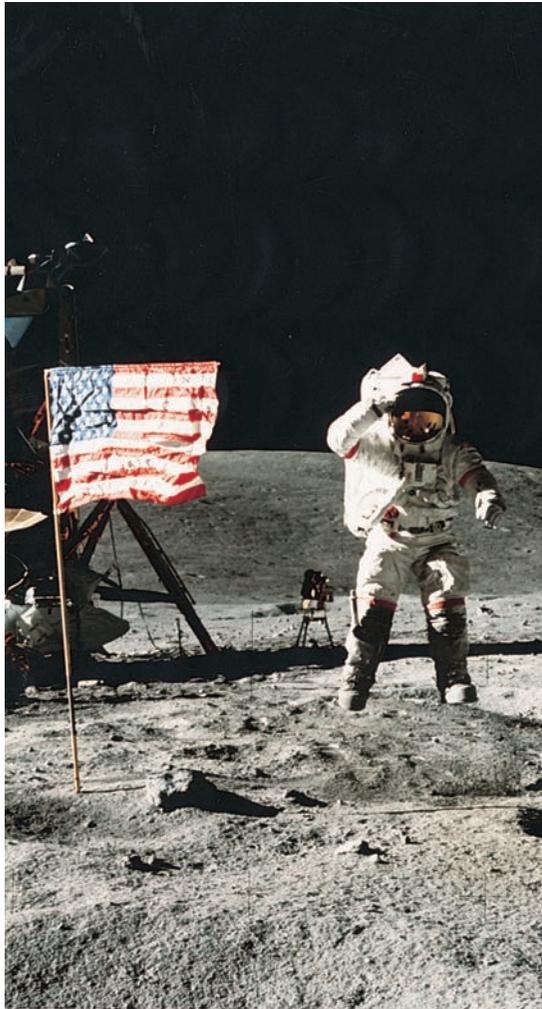
**Vacation travel.** People in the United States use their automobiles for about 80 percent of all vacation trips.

**Fuel consumption** by motor vehicles in the United States totals about 170 billion gallons (645 billion liters) a year—an average of about 670 gallons (2,540 liters) for each motor vehicle.

**Hybrid cars.** The number of hybrid cars sold in the United States annually has increased significantly, from about 2,300 in 2000 to about 380,000 in 2012.

**Insurance premiums** paid on car policies of all types in the United States total about \$190 billion a year.

Sources: U.S. Department of Commerce; U.S. Department of Energy; *Ward's Motor Vehicle Facts & Figures*, Ward's Communications, Inc.



NASA

**United States astronauts landed on the moon** six times between 1969 and 1972. In this photograph, Apollo 16 astronaut John W. Young salutes a U.S. flag on the moon's surface.

## Space exploration

**Space exploration** is our human response to curiosity about Earth, the moon, the planets, the sun and other stars, and the galaxies. Piloted and unpiloted space vehicles venture far beyond the boundaries of Earth to collect valuable information about the universe. Human beings have visited the moon and have lived in space stations for long periods. Space exploration helps us see Earth in its true relation with the rest of the universe. Such exploration could reveal how the sun, the planets, and the stars were formed and whether life exists beyond our own world.

The space age began on Oct. 4, 1957. On that day, the

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U.S. Geological Survey

**Space probes** travel far into space to gather information about moons, planets, comets, and stars. A Voyager probe took this photograph of Io, a moon of Jupiter.

Soviet Union launched Sputnik (later referred to as Sputnik 1), the first artificial satellite to orbit Earth. The first human space flight was made on April 12, 1961, when Yuri A. Gagarin, a Soviet cosmonaut, orbited Earth in the spaceship Vostok (later called Vostok 1).

Remotely controlled vehicles called *space probes* have vastly expanded our knowledge of outer space, the planets, and the stars. In 1959, one Soviet probe passed close to the moon and another hit the moon. A United States probe flew past Venus in 1962. In 1974 and 1976, the United States launched two German probes that passed inside the orbit of Mercury, close to the sun. Two other U.S. probes landed on Mars in 1976. In addition to studying planets and their moons, space probes have investigated comets and asteroids.

The first human voyage to the moon began on Dec. 21, 1968, when the United States launched the Apollo 8 spacecraft. It orbited the moon 10 times and returned safely to Earth. On July 20, 1969, U.S. astronauts Neil



NASA

**Shuttle astronauts** have performed many challenging missions in space. In 1992, three astronauts worked outside the shuttle Endeavour to capture a communications satellite.

A. Armstrong and Buzz Aldrin landed their Apollo 11 lunar module on the moon. Armstrong became the first person to set foot on the moon. United States astronauts made five more landings on the moon before the Apollo lunar program ended in 1972.

During the 1970's, astronauts and cosmonauts developed skills for living in space aboard the Skylab and Salyut space stations. In 1987 and 1988, two Soviet cosmonauts spent 366 consecutive days in orbit.

On April 12, 1981, the U.S. space shuttle Columbia blasted off. It was the first reusable spaceship and the first spacecraft able to land at an ordinary airfield. On Jan. 28, 1986, a tragic accident occurred. The U.S. space shuttle Challenger tore apart in midair, killing all seven astronauts aboard. The shuttle was redesigned, and flights resumed in 1988. Another tragedy struck on Feb. 1, 2003, when the Columbia broke apart as it reentered Earth's atmosphere. All seven crew members died. The United States did not launch a shuttle again until 2005.

In the early years of the space age, the United States and the Soviet Union were engaged in an intense rivalry called the Cold War. As a result, the two nations competed with each other in developing space programs. In

### Important dates in the history of space exploration

- 1926** American scientist Robert H. Goddard launched the world's first liquid-propellant rocket.
- 1957** (Oct. 4) The Soviet Union launched Sputnik (later referred to as Sputnik 1), the first artificial satellite.
- 1958** The National Aeronautics and Space Administration (NASA) was formed.
- 1959** (Sept. 12) The Soviet Union launched Luna 2, the first space probe to hit the moon.
- 1961** (April 12) Soviet cosmonaut Yuri A. Gagarin became the first person to orbit the earth.
- 1961** (May 5) Alan B. Shepard, Jr., became the first U.S. astronaut in space.
- 1962** (Feb. 20) John H. Glenn, Jr., became the first U.S. astronaut to orbit the earth.
- 1963** (June 16) Soviet cosmonaut Valentina Tereshkova became the first woman in space.
- 1964** (Oct. 12) The Soviet Union launched Voskhod (later called Voskhod 1), the first multiperson space capsule.
- 1968** (Dec. 21) The United States launched Apollo 8, the first manned space mission to orbit the moon.
- 1969** (July 20) U.S. astronauts Neil A. Armstrong and Buzz Aldrin made the first manned lunar landing.
- 1970** (Aug. 17) The Soviet Union launched Venera 7, which became the first space probe to transmit data from Venus's surface after it landed on Dec. 15, 1970.
- 1971** (June 7) Soviet cosmonauts boarded Salyut 1, making it the first manned orbiting space station.
- 1975** (June 8) The Soviet Union launched the probe Venera 9, the first spacecraft to photograph the surface of Venus.
- 1975** (July 15) The United States and the Soviet Union launched the first international manned space mission.
- 1975** (Aug. 20) The United States launched the probe Viking 1. This probe, along with a second probe called Viking 2, landed on Mars in 1976 and sent back photos and data.
- 1977** (Aug. 20) The United States launched the probe Voyager 2, which flew past and photographed Jupiter in 1979, Saturn in 1981, Uranus in 1986, and Neptune in 1989.
- 1981** (April 12) The United States launched the space shuttle Columbia, the first reusable manned spacecraft.
- 1985** (July 2) The European Space Agency launched the probe Giotto, which passed Halley's Comet on March 14, 1986, photographed the comet's nucleus, and sent back data.
- 1986** (Jan. 28) The U.S. space shuttle Challenger was destroyed in an accident in midair, killing all seven crew members.
- 1989** (Oct. 18) The United States launched the probe Galileo, which reached Jupiter in 1995. Galileo transmitted information about Jupiter and its satellites.
- 1990** (Aug. 10) The U.S. space probe Magellan began to orbit Venus and return radar images of the planet's surface.
- 1995** (March 22) Cosmonaut Valery Polyakov spent a record 438 days in space on the Russian space station Mir.
- 1996** The United States launched the probe Pathfinder, which landed on Mars on July 4, 1997. The probe and a remote-controlled vehicle sent back photos and data.
- 1996** (Nov. 7) The United States launched the Mars Global Surveyor probe to map the planet. The probe began to orbit Mars in September 1997.
- 1997** (Oct. 15) The United States launched the space probe Cassini, which reached Saturn in 2004.
- 2003** (Feb. 1) The U.S. space shuttle Columbia was destroyed in an accident in midair, killing all seven crew members.
- 2003** (Oct. 15) Yang Liwei became the first person launched into space by China.
- 2004** (June 21) Scaled Composites of Mojave, California, became the first private company to launch a person into space.

the 1960's and 1970's, this "space race" drove both nations to tremendous exploratory efforts.

A major dispute in the development of space programs has been the proper balance of manned and unmanned exploration. Some experts favor unmanned