E2 Identify problems in developing technologies for space exploration, describe technologies developed for life in space, and explain the scientific principles involved

E2.1 analyze space environments, and identify challenges that must be met in developing life-supporting systems (e.g., analyze implications of variations in gravity, temperature, availability of water, atmospheric pressure and atmospheric composition)

Space Environment

Space is a harsh and dangerous environment. There are many challenges that must be met in order for people to safely work and live.

There is no air or atmospheric pressure in space. There is no food or water. Everything people need to survive must be taken with them. Spacecraft must also have systems to dispose of and recycle waste safety, including human waste.

Earth's atmosphere keeps it warm and protects living things from most cosmic radiation. In space, there is no protection. It is extremely cold and has dangerous cosmic radiation and micrometeorites. The walls of a spacecraft and space suits used for space walks must be constructed of materials that can withstand these hazards.

Objects in space are very far apart. This means that astronauts may be in space for extended periods of time as they travel from one place to another. In the days of the Apollo missions to the moon, astronauts were in space between 8 and 12 days at a times. Currently, astronauts may be on the International Space Station for months at a time. The NASA One-Year Mission with Mikhail Kornienko and Scott Kelly finished March 2016. The two astronauts spent 340 days on the ISS.

In the future, missions to Mars will be up to two years long. This extended time means that they are exposed to the dangers of space for longer and longer durations.

E2.2 describe technologies for life-support systems, and interpret the scientific principles on which they are based (e.g., investigate systems that involve the recycling of water and air)

Life-Support Systems in Space

The International Space Station (ISS) has a number of different life-support systems. These systems are designed to meet the challenges of living and working in space.

Oxygen is both shipped to the ISS in pressurized tanks and created onboard using recycled water. The oxygen and hydrogen are separated using a process called electrolysis. As a backup, there is a system called a perchlorate candle that produces oxygen through a chemical process.

Recycled wastewater is used to produce drinking water. The system for purifying the water on the ISS mimics the natural water cycle on Earth.

Scientists are also experimenting with growing food in space. This will be necessary for long manned flights such as missions to Mars where it will be impossible to take all the food they would need for the journey. They are experimenting with hydroponic systems where plants grow in a liquid environment. These plants may also one day provide not only food, but a system to produce oxygen and remove carbon dioxide from the air, just as they do on Earth.

E2.3 describe technologies for space transport, and interpret the scientific principles involved(e.g., describe the development of multistage rockets, shuttles and space stations; build a model vehicle to explore a planet or moon)

Space Transport

The main types of space transport are rockets, space shuttles (retired), space stations, and space probes.

Rockets

A rocket is a transport vehicle that carries astronauts and satellites into space. To overcome the force of gravity, an object needs to to travelling at least 28000 km/h. Burning solid fuels such as oxygen and nitrogen creates the propulsion required. The gas is compressed and pushed out through the boosters. This causes a reaction that moves the rocket forward.

The power of rockets to lift objects into space is described by **Newton's third law of motion**, which states that every action causes an equal and opposite reaction.

The motion of satellites and interplanetary spacecraft in space is described by the laws of motion formulated by Kepler, with state that the closer a satellite is to Earth, the faster it orbits.

Multistage rockets consist of two or more sections called **stages**. In multistage rockets, each stage is separated and discarded once its fuel has been consumed. Successively discarding the stages reduces the weight of the fuselage and increases the mass ratio of the rocket. This is an efficient method of increasing the speed of the rocket.

A rocket consists of three main parts:

- Payload - crew and cargo
- Fuel - combination of gases
- Mechanical structure - combustion chamber and tanks

Space Shuttles, Space Stations, and Space Probes

There are three main types of spacecraft in use: space shuttles (retired), space stations, and space probes.

The **space shuttle** was a reusable rocket-launched vehicle designed to go into Earth's orbit, transport people and cargo between Earth and orbiting spacecrafts, and glide to a landing back on Earth. Space shuttles had been used to service and repair orbiting satellites, to return previously deployed spacecrafts, and to conduct scientific experiments in space.

Space stations are facilities that enable humans to live in space for long periods of time.

Space stations are used as laboratories where scientific and engineering experiments can be conducted. One day, they will be used as servicing centres where spacecrafts can be repaired, upgraded, or even constructed, and as spaceports where spacecrafts can pick up and deliver people, cargo, and fuel on the way to or returning from distant destinations.

Space probes are unmanned satellites or remote-controlled landing devices that explore objects and areas in space. Space probes have been used to carry out remote sensing on Mercury and Jupiter. They have been used to collect samples of soil on Mars, to collect data on Venus. And study the nature of Saturn's rings.

Some Examples of Probes:

- Voyager - The interstellar mission in 1977
- Curiosity - Rover on Mars
- New Horizons - First high-resolution pictures of Pluto 2015

E2.4 identify materials and processes developed to meet needs in space, and identify related applications (e.g., medicines, remote sensing, microelectronics, polymers, medical imaging, wireless communication technologies, synthesis of fuels)

Technology Needs in Space and Their Spinoffs

Space exploration requires specialized mechanical, computer, communications, and medical technology. There are many technologies that people use in their day-to-day activities that are spinoffs from the technologies used in space exploration.

- Specialized computer chips used for images in the Hubble Space Telescope are used for digital imaging in diagnosing medical conditions, such as some types of cancer.
- Air Monitoring equipment for apce is used to check for industrial pollution emissions.
- Water purification systems used for recovering and purifying water in space are used as commercial and residential purifiers.
- Food preservation and packing techniques for meeting needs in space are used for emergency reserves on Earth.
- Structural analysis equipment used to detect structural defects in spacecraft is now used in the automobile industry for checking welding joints.
- Robots for repair and assembly in space are used in the automobile industry for the assembly of parts.
- Wireless communication technology developed for apce is now used in GPS technology on Earth.
- Protective material for space suits is being used for firefighters' suits.

E2.5 describe the development of artificial satellites, and explain the major purposes for which they are used (e.g., communication, GPS - global positioning system, weather observation)

Artificial Satellites

Any object purposely placed in Earth's orbit or in orbit around other planets is called an **artificial satellite**. The first artificial satellite was launched in 1957. Since then, thousands of satellites have been rocketed into Earth's orbit. Artificial satellites play an important role in communication, military intelligence, and scientific studies.

The telecommunication industry uses communications satellites to carry radio, television, and telephone signals. Navigational satellites point out locations of objects on Earth, while weather satellites help meteorological departments forecast weather. Satellites can also be used for research purposes. Landsat and RADARSAT, two Canadian satellites, have been used for activities such as monitoring environmental changes, tracking forest fires, and even monitoring soil quality.