SPACE EXPLORATION

When you are finished this unit, you should be able to ...

- relate a number of events to the history of space exploration
- identify and describe space matter outside the solar system
- identify and compare the structures of the solar system
- describe techniques for determining position, distance, and composition of space matter
- identify and describe the technologies used in space study and exploration
- analyze space environments and the challenges related to them
- explain modern technological devices used in collecting data
- describe Canadian contributions to space exploration
- identify issues arising from space exploration

PREREQUISITE SKILLS AND KNOWLEDGE

Prior to beginning this unit, you should be able to ...

- analyze qualitative and quantitative data
- have a general knowledge of space-related terminology
- know how to carry on a debate and carry out a decision
- collect and interpret data
- perform mathematical calculations
- draw to scale and graph data collected
- research information on a given topic
- predict and hypothesize on the basis of observed events

Lesson 1 SPACE TIMELINE

Astronomy: study of objects in space

"Big Bang": a theory of how the universe was formed

Constellation: star pattern

Equinox: time when day and night are of equal length

Solstice: time of the year with either the longest day or longest night

Geocentric model: Earth-centred

Heliocentric model: sun-centred

Ellipse: oval path

Sputnik: first satellite in space

Yuri Gagarin: first cosmonaut (Soviet Union) in space

Neil Armstrong: first astronaut (United States) to step on the moon

Astronomers believe it all started with a "big bang." The universe was created from a giant explosion some 10 to 15 billion years ago. As the flying particles of matter cooled, they formed clouds of molecules. Some clouds became stars, others became planets.

Space has fascinated humans throughout history. The Greeks, Babylonians, Egyptians, and First Nations peoples built up considerable knowledge about the heavenly bodies. They saw patterns of stars and named them **constellations**. Orion, the hunter, and Ursa Major, the Great Bear, were the first patterns to be named. Ancient people watched celestial bodies move and predicted the spring and autumn **equinox**, the summer and winter **solstice**, and the change in seasons.

About 2 000 years ago, Aristotle proposed the **geocentric model** of planetary motion. He said Earth was the centre and all the other planets revolved around it. The invention of viewing and measuring instruments brought a new outlook of space.

In 1530, Copernicus suggested that the sun was the centre of the solar system, and all the planets revolved around it in a circular orbit. Kepler, a few years later, suggested that the path was not circular, but **elliptical**. That is, the planets revolved around the sun in an oval pattern. The sun-centred model, or **heliocentric model,** is still used today for all studies done on the solar system.

The invention of the telescope in the 16^{th} century generated a new interest in space research. It was not until the early 1900s that rockets were built to escape Earth's atmosphere. The space program took off in the late 1950s. Both the Soviet Union and the Unites States spent considerable money on space programs. In 1957, the Soviet Union was the first country to successfully send a satellite, *Sputnik*, into space.

In 1961, the Soviet Union launched their first cosmonaut, Yuri Gagarin, into orbit. This was followed a short time later by the Americans sending a man to the moon. In 1969, Neil Armstrong and Buzz Aldrin were the first humans to set foot on the moon's surface.

In the time period from 1970 to 2000, countless missions were sent into space. They included rockets, satellites, shuttles, and probes. A recent accomplishment was the successful landing of two space probes, Opportunity and Spirit, on the surface of Mars in 2004.

Lesson 2 PLANETARY MOTION

The sun is the centre of the solar system and the nine planets revolve around it. Our solar system is only one of many that make up the Milky Way galaxy. There are countless numbers of galaxies that make up the universe. As you can imagine, space is vast and the number of celestial bodies present in space is extremely large. Earth is only a tiny speck in space.

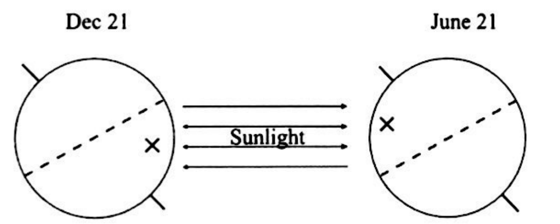
PLANET EARTH

Earth takes 365.25 days to revolve once around the sun. Because Earth is tilted at an angle of 23°, the sun's light does not strike the equator directly all year long. During summer in the Northern Hemisphere, Earth tilts toward the sun; during winter, it tilts away from the sun. During the remaining months of the year, Earth is in transition from one extreme to the next. On June 21, the sun's rays hit directly on 23° N—the Tropic of Cancer. This is the longest day of the year in the Northern Hemisphere and is referred to as the **summer solstice**. On December 21, the sun's rays hit directly on 23° S—the Tropic of Capricorn. This is the shortest day of the year in the Northern Hemisphere and is referred to as the **winter solstice**. On March 21 and September 23, the sun's rays hit the equator directly. This represents the **equinox**, a time when day and night are of an equal length. This is the beginning of the spring and autumn seasons in the Northern Hemisphere. If one were living in the Southern Hemisphere, the seasons would be reversed; summer would start on December 21 and winter on June 21.

Southern hemisphere: that which is south of the equator

Northern hemisphere: that which is north of the equator

Tilt of Earth: 23°



Summer in the Southern Hemisphere — Summer in the Northern Hemisphere

Many cultures have tracked the equinoxes to celebrate special events. Autumn represents harvest and plenty of food. Spring is a time of planting and new growth.

Besides revolving around the sun, Earth **rotates** on its axis. It spins on its axis once every 24 hours. For a portion of the time, one area of Earth is facing the sun. This area is in daylight. When it spins away from the sun, the area is in darkness. The rotation of Earth on its axis is what creates the difference between day and night.

Rotation: the spinning of Earth on its axis

Revolution: orbital movement of an object around another; e.g., Earth revolves around the sun in an elliptical orbit

Interesting Facts:

The length of one rotation of Earth is 24 hours. How do the other planets compare to this?

Mercury – 1 416 hours	Jupiter – 9.9 hours
Venus – 5 832 hours	Neptune – 16.2 hours

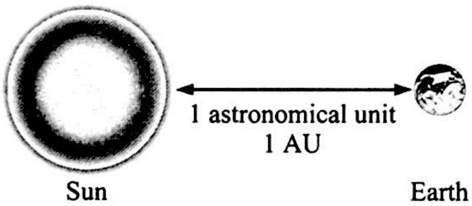
Lesson 3 INSTRUMENTS AND MEASUREMENT

Humans have expressed interested in space since the beginning of time. Sundials, invented about 7 000 years ago, were used to tell time and track the moon and sun through the sky. Other instruments invented were:

- merket—invented by the Egyptians for charting stars
- quadrant—invented by the Egyptians for measuring star heights
- astrolabe—invented by the Arabians to measure angles and determine star position
- cross staff—invented by Gurson to measure the angle between the moon and stars
- telescope—invented by Galileo to view the distant skies

Distance on Earth is expressed in metres and kilometres. Distance in space is expressed in **astronomical units (AU).**

One astronomical unit is the distance from the sun to Earth, approximately 150 000 000 km.



Mercury is 0.39 AU from the sun. Pluto is 39.5 AU from the sun.

The sun is our closest star. The next closest star, Centauri Proxima, is extremely far beyond the sun. Its distance can no longer be measured in AU. It must be measured in **light years.**

Centauri Proxima is 4.3 light years away.

One light year is defined as the distance it takes light to travel in one year. (Note: the speed of light is 300 000 km/second.)

To find this distance: 300 000 km/s × 60 s/min × 60 min/h × 24 h/day × 365 d/y = 9.5×10^{12} km/y

Triangulation:
—method of determining distances in space
—requires 2 angles and a baseline distance

Perpendicular: at a right angle to

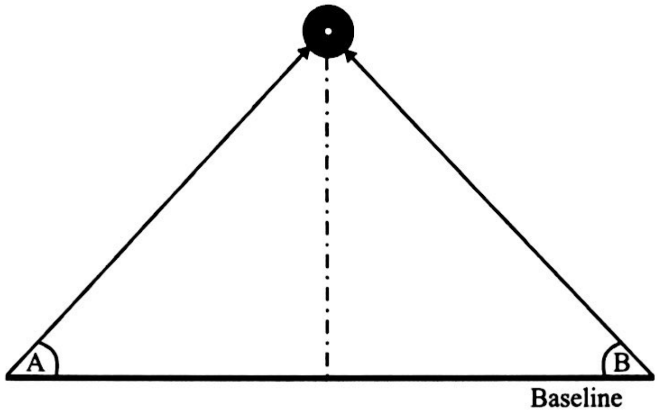
Two methods are used to measure distances in space: **triangulation** and **parallax.**

TRIANGULATION

The method of triangulation uses the **length of a baseline** and measurement of the **angles from the baseline** to determine the distance.

Steps:
1. Determine the length of the baseline.
2. Determine the angle at each end of the baseline.
3. Make a scale diagram on paper.
4. Draw a perpendicular line from the object to the baseline
5. Measure the scale distance.
6. Use a ratio to determine the actual distance.

Parallax: method of using triangulation to determine distance of objects in space



PARALLAX

Parallax is a form of **triangulation**. Parallax refers to the apparent shift in position of an object against a distant background when the object is viewed from two different positions.

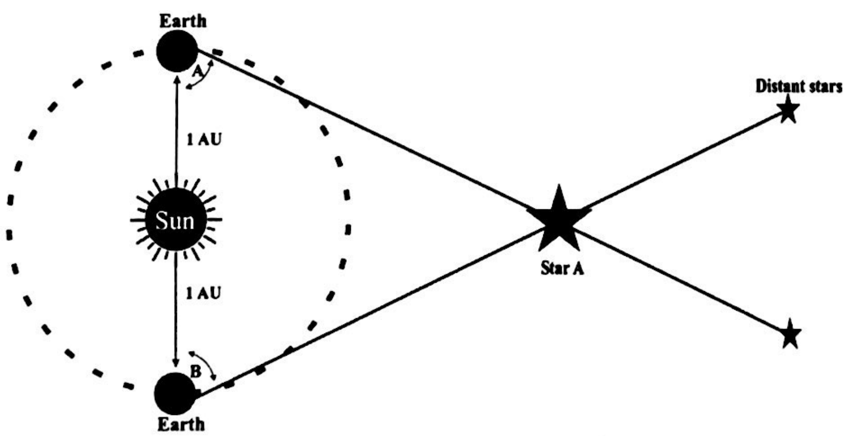
For example,

Star A is lined up with another distant star and viewed from a position on Earth in the spring. The angle is determined. Star A is again lined up with another distant star in the autumn and the angle is determined again.

Because Earth has revolved halfway around the sun in this six month period, it has travelled two astronomical units (2 AU). This distance represents the **baseline**.

Because the baseline and two angles are known, the method of triangulation can be used to calculate the distance of Star A.

Parallax



Lesson 4 POSITION OF SPACE OBJECTS

Star *X* is a newly discovered star. Its distance can be approximated through the method of triangulation. Its position in space can also be determined.

A position in space is determined using two axes: **horizontal** and **vertical.**

Zenith: highest point directly above the observer

Measurement along the horizontal axis is called the azimuth. Measurement along the vertical axis is referred to as the altitude.

Zenith is the highest point above the observer, or the maximum altitude of 90°.

Altitude:

–height of an object

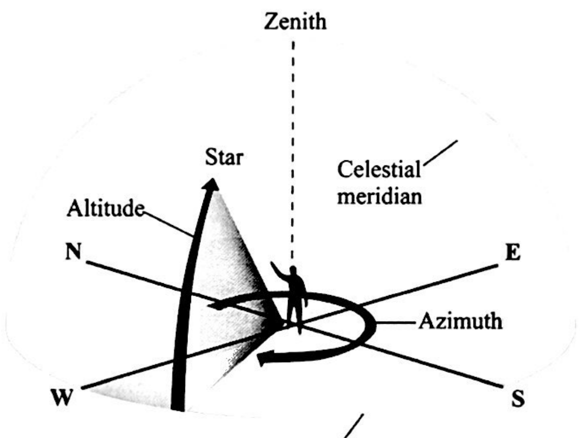
–measure the vertical perspective

Azimuth:

–compass reading of the object relative to the observer

–measures the horizontal perspective

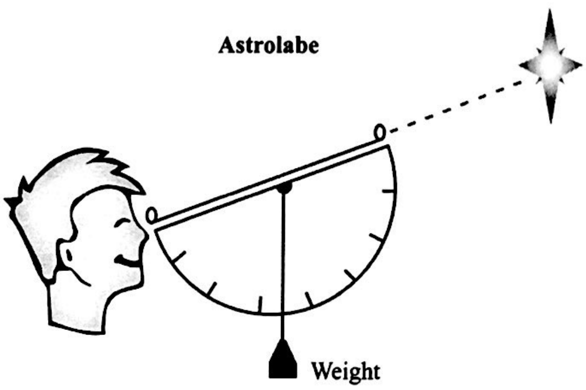
Position in Space



The measurement of the zenith and altitude is made with an **astrolabe**. An astrolabe is simply an upside down protractor with a weighted string hanging from the centre and a sighting tube along its straight edge. It measures, the altitude of celestial bodies. The azimuth is measured with a compass in degrees.

Astrolabe: instrument used to determine the altitude of a celestial body

Astrolabe



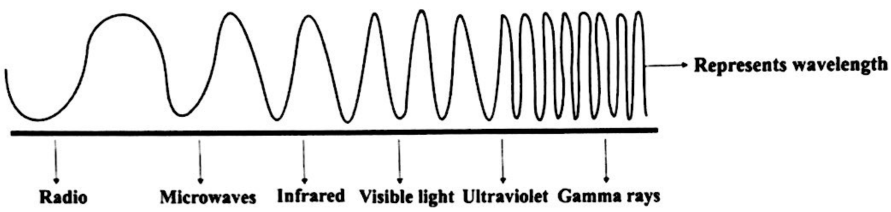
Relative to the observer, Star *X* is located:
Azimuth = 90° Altitude = 45°

Lesson 5 TELESCOPES

The telescope was invented by Galileo in the 1600s. It was a simple device that used light to bring distant objects closer. Today, most telescopes are optical telescopes and use a series of lenses and mirrors to refract or reflect light. Other telescopes use radio waves to produce and read images.

ELECTROMAGNETIC SPECTRUM

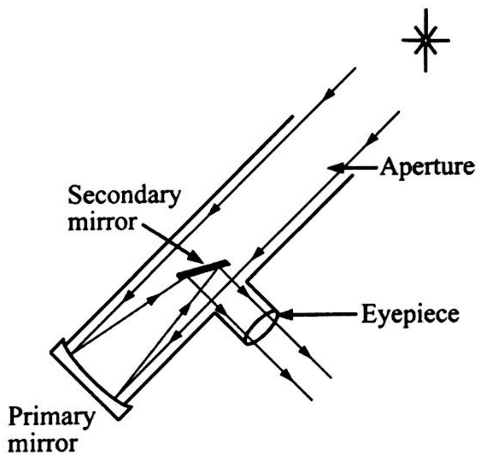
The electromagnetic spectrum below shows types of energy and their wavelengths.



Visible light is one part of the spectrum. Visible light energy has a certain wavelength and frequency. When compared with light energy, radio energy has a much longer wavelength and a lower frequency. Reflecting and refracting telescopes use light energy, while radio telescopes use radio waves.

REFLECTING OPTICAL TELESCOPE

Reflecting telescopes use a series of precision ground mirrors to reflect light from distant objects. For this reason, reflecting telescopes are large in size. Keck I and Keck II telescopes, located on Mount Mauna Kea on the Big Island of Hawaii, have 36 hexagonal mirrors that measure 10 m across.



NOTES

EM: electromagnetic spectrum of energy

Wavelength: distance in angstrom units of one cycle of waves

Angstrom: a unit of length used especially for measuring w avelengths of light

Optical: pertaining to light

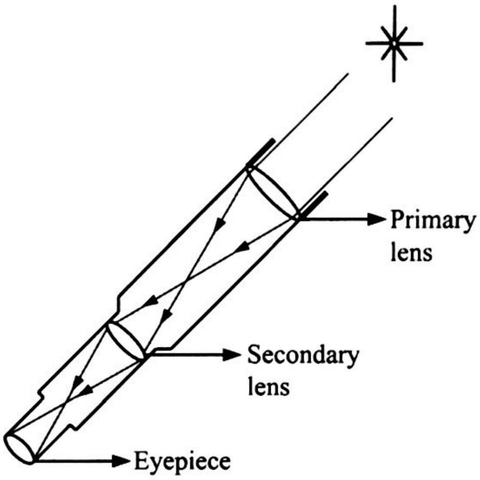
Primary: most important

Aperture: opening that controls the amount of light entering

Eyepiece: what you look through

REFRACTING OPTICAL TELESCOPE

Refracting telescopes use a series of lenses to bend light into a large image. Because lenses are finely ground pieces of glass, refracting telescopes are smaller in size when compare with reflecting telescopes. The largest refracting telescope is located in Wisconsin, USA, and has a lens that is 1 m in diameter.



Optical telescopes are located in an area where there is no city light interference and no atmospheric pollution. Optical telescopes require maximum light.

RADIO TELESCOPE

Radio telescope: uses low-frequency radio waves for imaging

Interstellar: among the stars

Astronomer: scientist who studies space

Dish: concave structure that collects electromagnetic waves

Most of the information that we know about the universe comes from what is visible through optical telescopes using light to gather and focus images. Another type of telescope, the radio telescope, uses low-frequency radio waves to focus images. Radio telescopes are usually in the shape of a large dish made from a metal mesh. The dish acts as an antenna to gather radio waves. It sends the waves to a receiver where they are changed to electrical impulses and read by a computer. A computer-generated image appears. Radio telescopes are used to map the location of neutral hydrogen atoms in interstellar space. This provides astronomers with the location of great clouds of hydrogen in space.

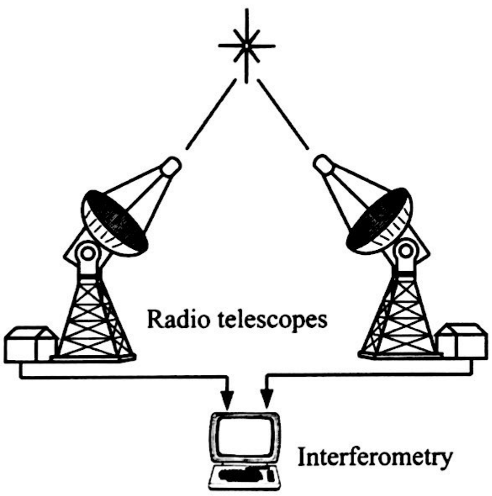
Radio telescopes have several advantages over optical telescopes.

1. Radio telescopes are not affected by weather.
2. Radio telescopes are not distorted by clouds or pollution.
3. Radio telescopes can be used during the day and at night.

INTERFEROMETRY

Resolution refers to clarity of an image. To obtain the best possible clarity, two or more telescopes can be aligned to work together. This technique is called **interferometry** and can be done with optical and radio telescopes. Here are two examples of interferometry.

- The optical reflecting telescopes Keck I and Keck II are placed 85 m apart on Mauna Kea, Hawaii, to work in harmony to detect objects with greater clarity and at greater distances.
- An **array** (group of telescopes) of 27 radio telescopes are positioned in the shape of a "Y" in New Mexico, USA, to produce images with greater resolution.



HUBBLE SPACE TELESCOPE (HST)

The Hubble Space Telescope is a satellite-type telescope that orbits 600 km above Earth's surface. It takes pictures and sends them back to Earth. Since its launch in 1990, HST has sent back thousands of images including pictures of the Black Hole, Shoemaker comet, and Saturn's rings. The reason that the HST takes better pictures than ground-based telescopes is because the image is not distorted by Earth's atmosphere.

NOTES

Resolution: refers to the clarity of an image

Interferometry: alignment of two or more telescopes to produce the best resolution

Array: a grouping of telescopes

HST: Hubble Space Telescope

Lesson 6 MATTER IN SPACE

Technology has brought space closer to us. Today, we have a better understanding of matter that exists beyond Earth's atmosphere.

Gravity: force of attraction between masses

H2: hydrogen gas

He: helium gas

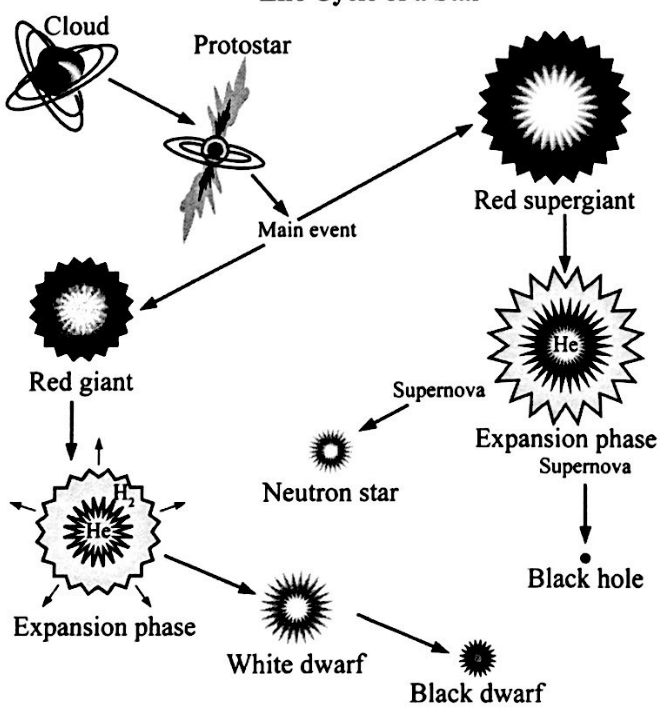
STARS

The thousands of stars seen twinkling in the sky are just a small fraction of the stars scattered throughout the universe. A star is a burning ball of gases, usually hydrogen and helium, that emits light energy. That is why it is visible. Stars go through a cycle; they are born, they live, and they die.

STAGES OF THE STAR'S CYCLE

1. Stars are born when clouds and dust are pulled together by gravity to form a **nebula**.
2. Parts of the nebula collapse which causes the material to clump into a swirling ball called a **protostar**. The interior of the prostar gets hot as hydrogen gas is changed to helium by fusion.
3. When the prostar is converting hydrogen to helium, it is said to be in "main sequence." It is stable in that gravity is being counteracted by the energy of fusion.
4. As the helium core is heated, the layers around it expand to a **red giant** or a **super red giant star**, depending upon the size of the star.
5. When the fuel is used up and fusion stops, gravity causes the star to shrink in size into a **dwarf** star.
6. Further gravity causes the dwarf to explode into a **supernova**.
7. If a core is left after the explosion, it becomes an extremely dense **neutron star**.
8. The neutron star is so dense, that light is unable to penetrate it. This stage is called a **black hole**.

Life Cycle of a Star



Astronomers estimate that the cycle of a star takes about 10 billion years. A star's **distance** is determined using **parallax triangulation**. A star's position is determined using the **altitude** and **azimuth** readings on the astrolabe. A star's composition is determined by using **spectroscopy**.

Light spectrum of colours: ROY G BIV

Red
Orange
Yellow
Green
Blue
Indigo
Violet

SPECTROSCOPY

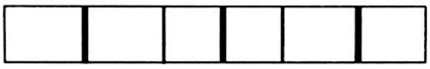
White light (sunlight) is a combination of a rainbow of colours that makes up the visible spectrum. When light is refracted, it is separated into the colours by dark bands that vary in sequence and thickness. This is referred to as a "black line fingerprint." When the spectra fingerprint of a star is compared with that of common elements, the star's composition is determined.

Spectroscopy: technique of refracting light into bands of colour

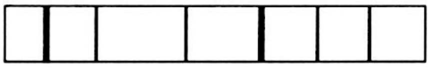
Example

What is the composition of Star *X*?

Spectrum for hydrogen



Spectrum for helium



Spectrum for Star *X*

Solution

The spectrum for Star *X* matches that of hydrogen. Star *X* is composed of hydrogen.

DOPPLER EFFECT

The Doppler Effect is the change in the frequency of light and sound waves as the object and the observer move toward or away from each other.

Example

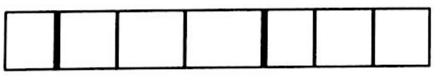
How can the Doppler Effect be used to determine if Star *X* is moving and in what direction it is moving in?

Solution

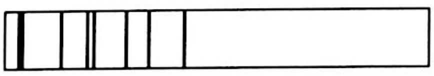
The spectrum bands once again can be used. If the spectrum band of Star *X* is shifting to the blue side of the spectrum (to the left side), Star *X* is moving toward the observer. If the spectrum band of Star *X* is shifting to the red side of the spectrum (right side), Star *X* is moving away from the observer.

Doppler effect: changes in wave frequency as sound or light travels toward or away from an observer;

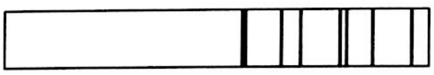
e.g., siren sound of an ambulance coming toward an observer is louder than sound moving away from an observer



Normal spectrum



Moving toward



Moving away

Galaxy: large group of stars

Milky Way: name of the galaxy in which we live

Galaxy types:

–spiral

–elliptical

–irregular

GALAXIES

Millions and millions of stars are grouped and held together by gravity to form galaxies. Galaxies are classified into three types:

- spiral—appears to have one curved arm radiating from a central core nucleus
- elliptical—appears to have the shape of an egg and is made up of mostly old stars
- irregular—appears to have no regular shape and consists of a mix of old and new stars

Spiral Elliptical Irregular

We live in a spiral galaxy called the **Milky Way**. The Milky Way is just one of billions upon billions of galaxies that exist in the universe.

Comet: "dirty snowball" of ice and dust that moves around the sun

Comet structure consists of:

–nucleus

–coma

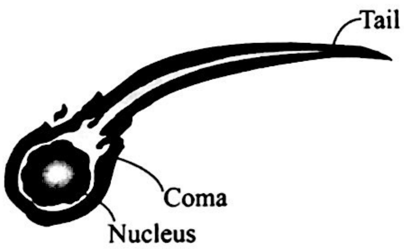
–tail

Halley's Comet: named after the astronomer who observed it. Orbits Earth every 76 years

COMETS

A comet can be described as a "dirty snowball." It consists of a mixture of ice and dust that moves in an elliptical path around the sun. As the comet approaches the sun, the heat vaporizes the gases and forms a trailing tail. Because the tail is blown away by the solar winds, it faces away from the sun.

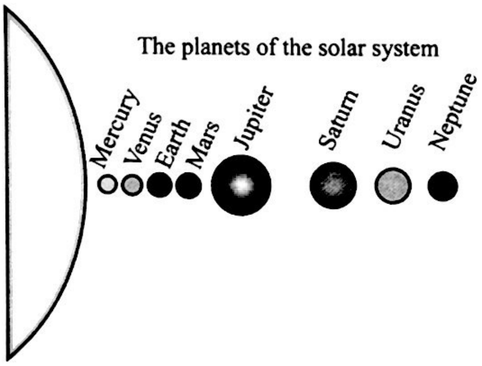
Comet



Halley's Comet orbits the sun in a 76 year cycle. It was visible in 1910, again in 1986, and will appear again in 2062. Hale Bopp, a more recent comet, was best viewed in 1997. Pictures from the Hubble Space Telescope showed Hale Bopp's nucleus to be about 40 km across.

Lesson 7 SOLAR SYSTEM

Galaxies, stars, and comets are matter in space. Much closer to Earth, and more frequently studied, is the solar system. The solar system consists of the **sun, planets, moons, asteroids,** and other smaller rock fragments.

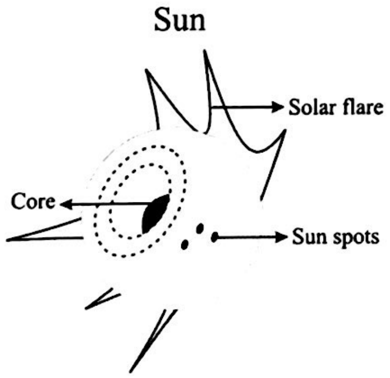


SUN

The sun, our local star, is a burning ball of **hydrogen** and **helium** gases. Tremendous internal pressure turns the sun into a nuclear reactor that fuses hydrogen gas into helium gas. The process releases heat and light energy.

Much of the sun's energy is released from its surface as a fiery tongue called a **solar flare** or **solar prominence**. This radiant energy travels to Earth and affects Earth's magnetic field, to produce the Northern and Southern lights. Charged particles can appear as bands or streams of light in night skies. In the Northern hemisphere these are called aurora borealis; in the Southern hemisphere, aurora australis. Around the middle of the sun are cooler, darker **sunspots**. These are areas of less activity and are frequently linked to stormy weather on Earth.

It is estimated that the internal temperature of the Sun is about 15 000 000°C and its surface temperature is about 6 000°C. It is also estimated that the sun, as a star, has been in existence for 5 billion years. It will continue to burn for another 5 billion years.



Sun: 5 billion year old star; Earth's local star; fuses hydrogen into helium

Fusion: reaction that changes H_2 to He

Northern lights: aurora borealis

Southern lights: aurora australis

Solar flares: burst of energy released on the sun's surface

Terrestrial planets: Mercury, Venus, Earth, and Mars

Jovian planets: Jupiter, Saturn, Uranus, Neptune, and Pluto

How will you remember the order of the planets? Use an acronym:

My Very Educated Mother Just Served Us Nine Pizzas

PLANETS

Earth is one of nine planets that revolve around the sun. The first four planets closest to the sun are called **inner** or **terrestrial planets**. They include Mercury, Venus, Earth, and Mars, and are made of solid rocky material. The remaining four planets, Jupiter, Saturn, Uranus, and Neptune, make up the **outer** or **Jovian planets**. These planets are much larger, have a small rocky core, and are mostly a ball of gas.

With the use of modern technology and space travel, much data have been collected about the planets.

SOME INTERESTING PLANETARY FACTS

- Mercury
  - barren dusty planet
  - closest to the sun
- Venus
  - has an atmosphere of carbon dioxide gas
  - is hotter than Mercury because of the greenhouse effect
  - about the size of Earth
- Earth
  - appears to be the only planet with life
- Mars
  - surface consists of iron oxide dust
  - known as the Red Planet
  - has the largest mountain in the solar system (Olympus Mon)
- Jupiter
  - biggest of all the planets
  - made mostly of hydrogen and helium gas
- Saturn
  - surrounded by a halo of rings
- Uranus
  - rolls around the sun on its side
  - each day and night lasts 42 Earth years
  - composed of hydrogen, helium, and methane gas
- Neptune
  - is bluish in color
  - composed of hydrogen, helium, and methane gases
  - has wind speeds exceeding 2 500 km/hr

Many of the planets have their own orbiting satellites or moons.
Planetary Moons:

- Earth –1
- Mars – 2
- Jupiter – 18
- Saturn – 19
- Uranus – 17
- Neptune – 8

ASTEROIDS

Between Mars and Jupiter lies a belt of dust and rock fragments called the **asteroid belt**. Asteroids vary in size and shape. Four thousand asteroids have been identified to date. It is believed that there are about 22 000 asteroids orbiting in the asteroid belt.

Asteroid Belt: belt of dust and rock fragments between Mars and Jupiter

Smaller rocky material flying in the asteroid belt or elsewhere in space is called a **meteoroid**. If the meteoroid leaves its orbiting path and enters Earth's atmosphere, it becomes a **meteor**. Because of heat created by friction, as a meteor passes through the air it usually burns up and disintegrates. This is referred to as a "shooting star" or a "meteor shower." If the meteor survives and strikes Earth, it becomes known as a **meteorite**. A meteorite is made of an iron material and is magnetic. Several meteorites have been found in Alberta.

Ceres:

–largest asteroid

–about 1 000 km in diametre

–discovered in 1801

Meteoroid → meteor → meterorite

The Planets

	Au	**Radius relative to Erath**	**Mass relative to Earth**	**Density relative to Earth**	**Moons**	**Surface Temp. (°C)**	**Daily Rotation**	**Orbital Revolutions**	**Earth Day Orbitals**
Mercury	.39	.38	.06	1	0	180	59 d	.017	88 d
Venus	.72	.95	.86	1	0	480	243 d	.004	225 d
Earth	1	1	1	1	1	22	23.93 hr	1	365d
Mars	1.52	.53	.11	.71	2	–53	24.6 hr	.98	607d
Jupiter	5.27	11.25	318	.24	18	–108	9.85 hr	2.4	11.9 yr
Saturn	9.54	9.54	95	.13	19	–180	10.38 hr	2.3	29.5 yr
Uranus	19.19	4.10	15	21	17	–214	17.4 hr	2.2	84 yr
Neptune	30.06	3.96	.17	.27	8	–220	16.2 hr	1.6	165 yr

Lesson 8 SPACE TECHNOLOGY

The space age began with the launch of the Sputnik satellite in 1957. Since then, over 4 000 space missions have occurred. Some of missions involved rockets and satellites, others involved shuttles and probes.

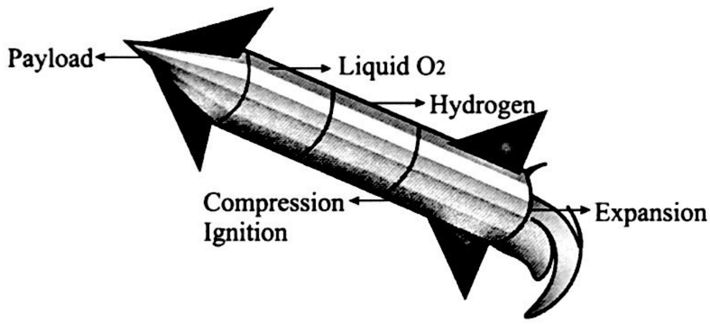
ROCKETS

Newton's Fundamental Law of Physics: for every action there is an equal and opposite reaction

Rockets work on Newton's Fundamental Law of Physics: **for every action, there is an opposite and equal reaction**. Rockets use fuel under pressure to provide the thrust energy required to propel the spaceship in an opposite direction. This is similar to releasing a blown up balloon. Air coming out the back provides the energy to thrust the balloon forward.

There are three basic parts to a rocket:

Parts of a rocket:
- payload
- structure
- fuel



- structural and mechanical component—engine, storage tanks and fins
- fuel—mixture of oxygen, hydrogen, and gasoline
- payload—materials needed for the flight such as food, water, astronauts

Rockets are designed to carry material and equipment into space. Once above Earth's atmosphere and gravitational pull, the rocket requires very little energy to move. Occasionally, booster engines are fired to slightly change the direction of travel.

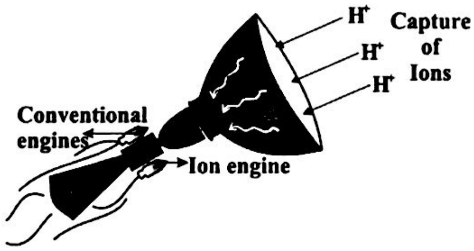
Two other rocket technologies are presently being experimented with: ion drive engines and solar sails.

Propulsion systems in a rocket:
- chemical fuel
- ion drive
- solar sail

An ion drive engine uses electrically charged xenon gas for fuel. Although the ion fuel is less expensive than chemical fuel, the thrust generated by an ion drive engine is about 10 000 times less than that of a chemical engine.

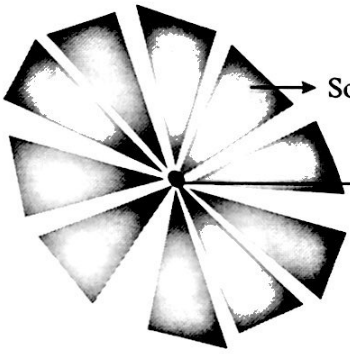
Xenon: gaseous fuel that ionizes

Ion Rocket



Solar sail technology is presently being experimented with as a way of powering spacecraft. Sunlight is changed to energy when it strikes carbon fibres on the sail. The energy is converted to motion.

Solar sail



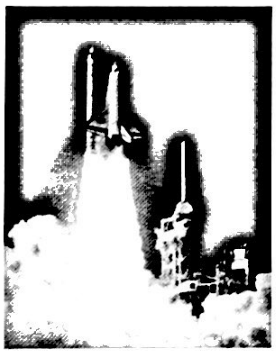
SHUTTLE

The space shuttle is a craft that is launched into space by booster rockets. It completes its mission, re-enters Earth's atmosphere, and lands on an airstrip runway. The space shuttle can be used over and over again for successive missions. Canada's contribution to the shuttle program was the invention of the robotic arm, **Canadarm**.

Canadarm I and II:

–robotic arms attached to the space shuttle

–used for transporting and repairing



SATELLITES

A satellite is a general name for anything that orbits another object. The Earth is a satellite of the sun. The moon is a satellite of Earth. Artificial satellites are technological devices that are launched or transported into space. There, they are released to orbit around Earth. Satellites serve several purposes:

- surveying land,
- telecommunicating,
- tracking weather, and
- tracking objects (GPS).

ISS

–International Space Station

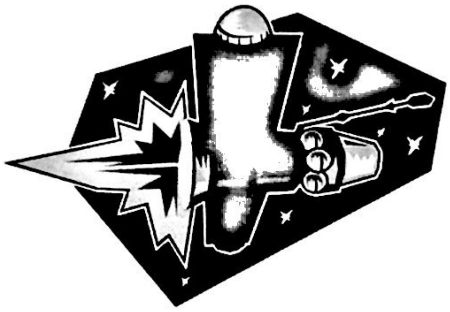
–orbits 350 km above Earth

–Leading countries affiliated with the ISS: USA, Russia, Japan, Canada, Brazil

Opportunity and Spirit: space probes that landed on Mars

SPACE PROBES

Probes are launched into space to collect data and information. The probes "Opportunity" and "Spirit" were launched into space and made a seven–month journey to Mars in 2004. They were successfully parachuted to Mars' surface where they are now collecting valuable information about the planet. The Cassini probe is presently sending back information and images about Saturn and its moon Titan. This allows for exploration without risk to humans and of places that humans cannot travel to.



SPACE STATION

The International Space Station (ISS) is a joint project of 16 nations to set up a viable and workable living space community 350 km above Earth's surface. It is powered by solar energy and is designed to be self-sustaining. When completed, it will have the living and working space of three average-sized Canadian homes and facilities for recycling waste water, producing oxygen, and removing carbon dioxide, dust, and micro-organisms from the air.

Lesson 9 CANADA'S CONTRIBUTION TO THE SPACE PROGRAM

NOTES

Canada has made significant contributions to space exploration.
The following chart represents a small portion of Canada's involvement.

Canadian Contribution to Space Exploration	**Year**
Launch of the first satellite, Alouette, into space	1962
Design of the moon landing gear on the Apollo mission	1969
Launch of the first telecommunications satellite, Anik 1	1972
Design of the robotic Canadarm I for the space shuttle	1981
First Canadian astronaut in space–Marc Garneau	1984
First Canadian female astronaut in space–Roberta Bondar	1992
Launch of the RADARSAT imaging satellite	1995
Design of the landing ramp for the Mars Pathfinder mission	1997
Design and transport of Canadarm 2 to the ISS	2001

The Canadarm

Lesson 10 SPACE TECHNOLOGY TO MEET HUMAN NEEDS

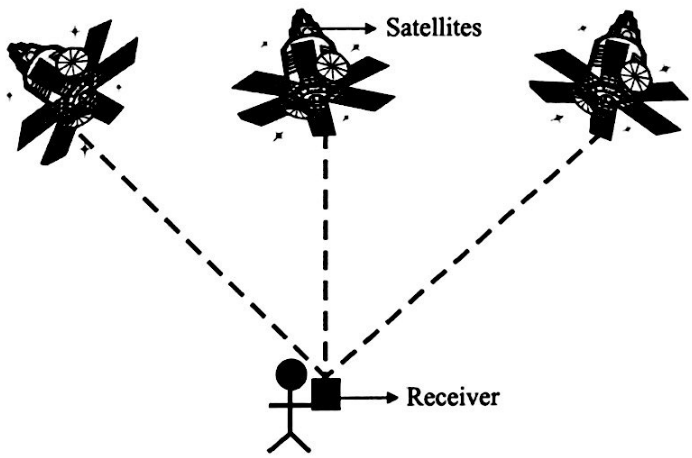
The RADARSAT is only one of hundreds of artificial satellites orbiting above Earth. An artificial satellite is a device launched into space for a specific purpose.

GPS: Global Positioning System
Satellites can have 1 or 2 types of orbit–low–earth or geosynchronous orbit. Geosynchronous satellites take 24 hours to orbit the Earth once. Low-earth satellites orbit the earth every 1 ½ hours

WHAT CAN SATELLITES DO?

1. Certain satellites are designed for wireless telecommunication. Communication satellites have eliminated the need for costly cable laying.
2. Observation satellites take photographs and are used in surveying land.
3. Observation satellites monitor weather patterns and warn of severe weather conditions.
4. Global Positioning System (GPS) satellites are used for personal tracking devices. A vehicle with a GPS device that is involved in an accident can be quickly located. A computer receiving information from a minimum of three satellites calculates the exact position of the vehicle. Assistance can immediately be sent to the location.

HOW DOES GPS WORK?



Lesson 11 THE ISSUES: TRAVEL TO AND SETTLEMENT IN SPACE

There is a fascination about space; however, preparation for and travel into space poses many risks.

PREPARATION

Astronauts must overcame the psychological challenges of living and working in a confined space with the same crew for a long period of time. Astronauts must overcome the biological effects of weightlessness and bodily changes due to a lack of gravity. The heart, muscles, and bones are affected. The heart and muscles become weaker, the bones become less dense, and the backbone stretches.

Astronauts must adapt to the mini-environment of their spacesuit. The spacesuit serves to supply oxygen and water. The spacesuit needs to have toilet, heating, and cooling facilities. It is difficult to move and work with the spacesuit on.

TRAVEL INTO SPACE

Mission control and astronauts are faced with the dangers of space travel. Something can go wrong and often does. In the two shuttle disasters, Challenger in 1986 and Columbia in 2004, all crew-members died.

What are some of the risks and dangers posed by travel into and in space?

1. Malfunctioning equipment—protective heat tiles fall off
2. Space junk and debris—damage caused by a bolt travelling at 17 000 km/hr in space
3. Extreme temperature variations–day and night temperature changes from 180°C to–120°C
4. High levels of radiation–cosmic radiation from space
5. Poor weather conditions–storm during scheduled re-entry

What are other concerns associated with space travel?

1. Cost of space exploration is high–USA is projecting to spend $600 billion in the next 10 years
2. Political, ethical, and environmental issues arise.
   - Who has the right to resources in space?
   - Who owns space?
   - Is it right to spend all that money on space exploration?
   - Who is responsible for cleaning up space junk?

Is it politically and morally justifiable to spend billions of dollars on a space program when there are problems of poverty, hunger, pollution, and disease on Earth? Some critics will argue **No**—let's attempt to solve our local problems first. Other critics will argue **Yes**:

- With a rapidly growing human population, there may be a need to look into space for living accommodations.
- Perhaps there are resources in space that could replace our diminishing non-renewable resources.

Psychological: pertaining to the mind

Biological: pertaining to a "living body"

Microgravity: zero gravity

Mission control: central base where all communication with the space vehicle takes place

Ethical issues: issues as to what is right and what is wrong

REVIEW SUMMARY

- Fascination with space has existed since the beginning of mankind. Historically, the First Nations peoples carefully watched the stars and their constellation formations. Aristotle studied the sun and its planets and proposed the geocentric model of the solar system. He said that Earth was the centre and all the planets revoloved around it. In the 1500s, Copernicus concluded that the sun was the centre of the solar system. His heliocentric model is accepted today. The invention of the telescope in the 1600s made it possible to view objects never seen before.
- The telescope used for space study today includes:
  - optical reflecting—uses mirrors to reflect light
  - optical refracting—uses lenses to bend light
  - radio—uses radio wave frequencies to detect distant objects
- Unlike optical telescopes, the radio telescope is not affected by weather and can be used during day and night.
- Telescopes are often arranged in groups called *arrays* to produce high resolution images. This technique is called *interferometry*.
- The Hubble Space Telescope, launched in 1990 as an orbiting telescope, has sent back thousands of images about comets, Jupiter's moons, Saturn's rings, and other objects in our solar system.
- Scientists use the *astronomical unit* (AU) to measure distances within the solar system. One AU is the distance from Earth to the sun. Greater distances, such as the distance to stars, are measured in *light years*. The nearest star is approximately 4.2 light years away.
- Found within space are stars, asteroids, comets, galaxies, and planets
  - Stars begin as a nebula, then go through stages ranging from red giants, white dwarfs, supernovas and end as black holes or neutron stars.
  - Asteroids are found within a belt that lies between the planets Mars and Jupiter. Occasionally, small fragments leave the belt as meteoroids. Meteoroids enter Earth's atmosphere as meteors or "shooting stars". Meteors that fall on Earth before burning up are called meteorites.
  - Comets are balls of dust and ice that travel in an elliptical pattern around the sun. The heat from the sun causes some of the ice to vaporize producing a huge tail. The most frequently visible comet is Halley's. It appears every 76 years.
  - A galaxy is grouping of billions of stars. We live in the galaxy called the "Milky Way." It is one of millions of galaxies that exist today.
- A planet is defined as a celestial body that revolves around the sun. The eight of our solar system are:
  Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune.

- Mercury, Venus, Earth, and Mars are solid in structure and are referred to as *terrestrial* planets. Because Jupiter, Saturn, Uranus, and Neptune are gaseous in nature, they are called *Jovian* planets. Venus has the highest surface temperature of all planets while Pluto has the lowest. Jupiter has the most satellites or moons of any planet.
- The sun produces heat and light through the process of fission. The fission reaction releases a tremendous quantity of energy when hydrogen is converted into helium. Some of this released energy appears as solar flares.
- Astronomers use different techniques to gather information about objects in space.
- The position of a star can be determined using an astrolabe. The astrolabe provides information on the azimuth (compass direction) and the altitude (height) readings.
- Triangulation and parallax are used to determine the distance of objects in space. Triangulation uses an imaginary triangle between the observer and an object whose distance is being estimated.
- Parallax is an apparent shift in position of an object against a certain background when viewed from two different positions. Parallax is a form of triangulation.
- The technique of spectroscopy uses the light spectrum to determine the composition of space objects and to determine whether they are moving toward or away from Earth. Most stars produce spectra lines similar to those of the elements hydrogen and helium. A shift to the red end of the spectrum indicates the star is moving away from the observer. A shift to the blue end means the star is moving toward the observer.
- Artificial satellites and probes play an important role in space exploration today. Satellites help us communicate, forecast weather, and find locations in space.
- A Global Positioning System (GPS) uses a series of satellites orbiting in a geosynchronous pattern to pinpoint a location. Signals from a minimum of three satellites are picked up and transferred to a computer. A digital display of the exact position is calculated.
- A satellite in a geosynchronous orbit is always above the same position on Earth because it is travelling at the same speed as Earth.
- Probes are remote-controlled devices that carry out remote sensing on objects in space. The "Opportunity" and "Spirit" probes landed on Mars in 2004 and have relayed important information about the Red Planet.
- Rockets are the major transporters of satellites and probes into space. A rocket gets its energy from the chemical fuel it uses. Experimentation today is being done with ionic drive rockets and solar sails as alternative forms of propulsion devises.
- The International Space Station is a joint effort of 16 nations working together to explore the possibilities of living in a specially designed space community.