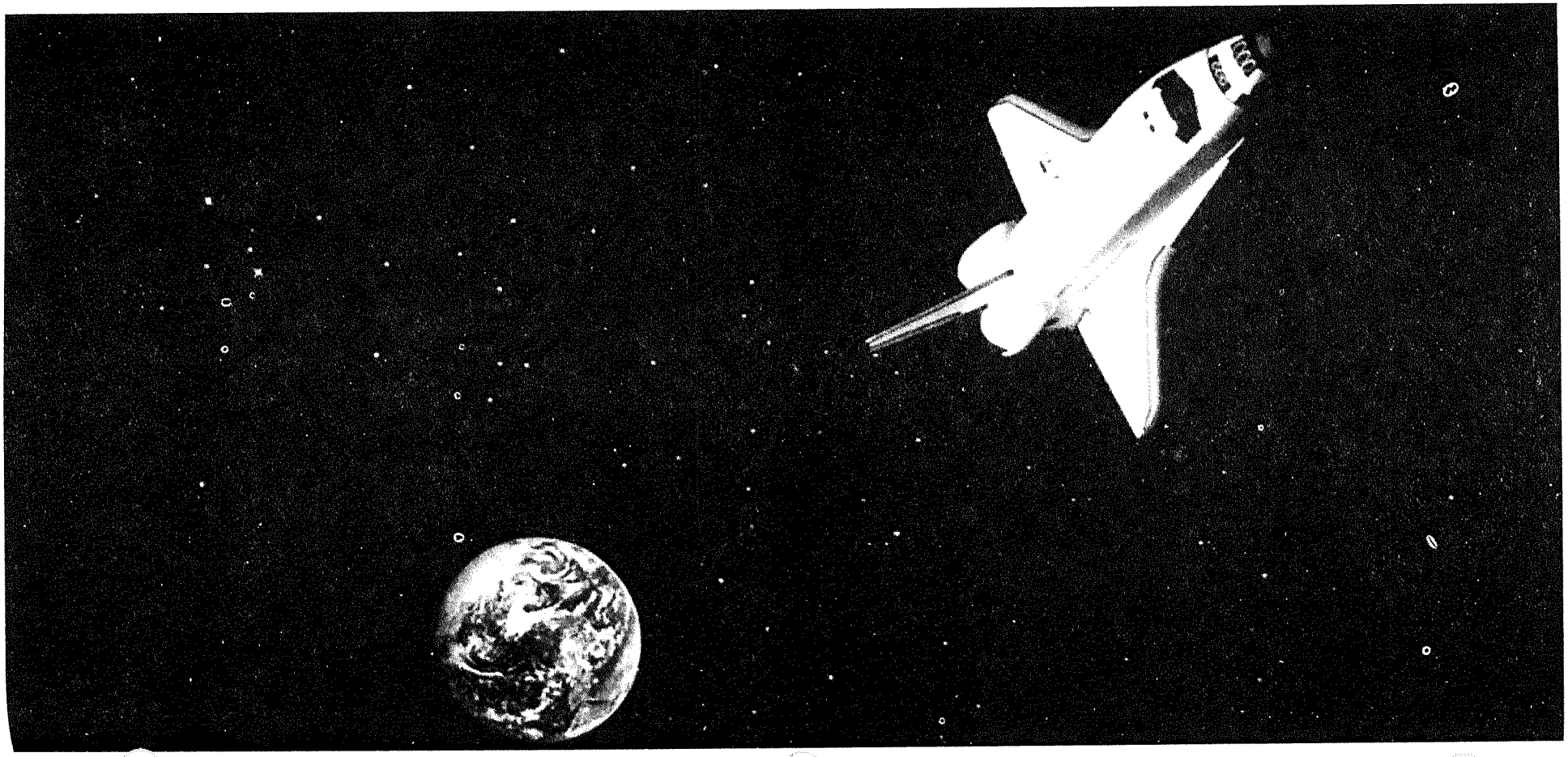
Space Exploration



SPACE EXPLORATION

Table of Correlations			
Specific Expectation	**Practice Questions**	**Unit Test Questions**	**2006 PAT**
Students will:			
E.1. Investigate and describe ways that human understanding of Earth and space has depended on technological development.			
E.1.1 identify different ideas about the nature of Earth and space based on culture and science	1, NR1	1, WR2	41
E.1.2 investigate and illustrate the contributions of technological advances—including optical telescopes, spectral analysis, and space travel—to a scientific understanding of space	2, 3	4, 6	
E.1.3 describe, in general terms, the distribution of matter in star systems, galaxies, nebulae, and the universe as a whole	NR2, NR3	2, 7	NR5
E.1.4 identify evidence for, and describe characteristics of, bodies that make up the solar system, and compare their characteristics with those of Earth	4, 5, 8	3, 5,10	44, 49
E.1.5 describe and apply techniques for determining the position and motion of objects in space including • *constructing and interpreting drawings and physical models that illustrate the motion of objects in space* • *describing in general terms how parallax and the Doppler effect are used to estimate distances of objects in space and to determine their motion* • *describing the position of objects in space using angular coordinates*	NR4, 6	9	42, 43, 45, 47, 50
E.1.6 investigate predictions about the motion, alignment, and collision of bodies in space, and critically examine the evidence on which they are based	7	12	
E.2. Identify problems in developing technologies for space exploration, describe technologies developed for life in space, and explain the scientific principles involved.			
E.2.1 analyze space environments, and identify challenges that must be met in developing life-supporting systems	9	13	
E.2.2 describe technologies for life-support systems, and interpret the scientific principles on which they are based	12	NR 2	

E.2.3 describe technologies for space transport, and interpret the scientific principles involved	13, 14, 15, 16	14, 15, 16	
E.2.4 identify materials and processes developed to meet needs in space, and identify related applications	17		
E.2.5 describe the development of artificial satellites, and explain the major purposes for which they are used	10	18	48
E.3. Describe and interpret the science of optical and radio telescopes, space probes, and remote sensing technologies.			
E.3.1 explain, in general terms, the operation of optical telescopes, including telescopes that are positioned in space environments	19, 20, 21	NR1, 20	
E.3.2 explain the role of radio and optical telescopes in determining characteristics of stars and star systems	22, 23	8	
E.3.3 describe and interpret, in general terms, the technologies used in global positioning systems and remote sensing	18	19, WR3	
E.4. Identify issues and opportunities arising from the application of space technology, identify alternatives involved, and analyze implications.			
E.4.1 recognize risks and dangers associated with space exploration	11	WR1	46
E.4.2 describe Canadian contributions to space research and development and to the astronaut program	24	17	
E.4.3 identify and analyze factors that are important to decisions regarding space exploration and development	25, 26	11	

SPACE EXPLORATION

E.1.1 identify different ideas about the nature of Earth and space based on culture and science

CULTURE AND SCIENCE

Humans have always been fascinated by entities in the sky. Many ancient tribes created stories to explain the presence and movement of objects in space. The people of the First Nations saw a distinct pattern of stars they called the Great Bear. The Egyptians built the pyramids in alignment with the seasonal position of certain stars.

Practice Questions: 1, NR1

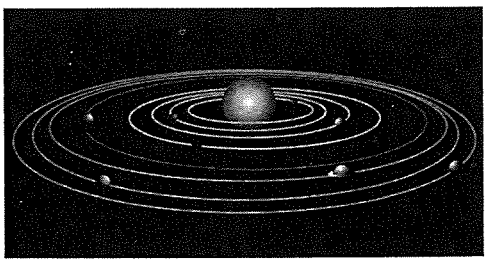
E.1.2 investigate and illustrate the contributions of technological advances—including optical telescopes, spectral analysis, and space travel—to a scientific understanding of space

EARLY THEORIES AND TECHNOLOGICAL ADVANCES

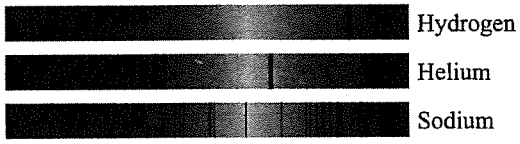
The **geocentric** model of planetary motion was proposed by Aristotle approximately 2 000 years ago. This model has Earth at the centre with the sun, moon, and other planets orbiting it.

In the 1500s, Copernicus proposed the sun-centred, or **heliocentric model**. In this model, all the planets revolve around the sun in a concentric circular pattern.

Later, it was the work of Galileo and Kepler that determined the revolution around the sun to be an elliptical pattern.

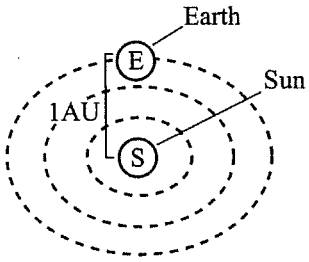


Much of the data collected by early astronomers was gathered using simple instruments such as the quadrant, cross-staff, or astrolabe. It was, however, the invention of the telescope in the early 1600s that provided the necessary tool for studying distant objects. This invention was followed by the discovery of **spectroscopy**, the breakdown of light into its spectrum of colour. The spectrum provided information about the element composition of celestial bodies.



Improved optical and radio telescopes followed, and then came the age of rockets and satellites. Today, advanced computer and space technologies in the form of space stations and rovers are collecting information previously unattainable.

Scientists use the **astronomical unit** (AU) to measure distances within the solar system. The distance from the centre of Earth to the centre of the sun is 1 AU. By comparison, the distance from Mercury to the sun is 0.39 AU and from Pluto to the sun is 39.5 AU.



Distances beyond the solar system are measured in light-years. A **light-year** is the distance light travels in one year. After the sun, the next nearest star to Earth, Proxima Centauri, is 4.2 light-years away. The following calculation expresses the vast distance that Proxima Centauri is from Earth.

$$\begin{aligned} &300\ 000\ \text{km/s} \times 60\ \text{s/min} \\ &\times 60\ \text{min/h} \times 24\ \text{h/day} \\ &\times 365\ \text{days/year} \times 4.2 \\ &= 3.97 \times 10^{13}\ \text{km} \end{aligned}$$

Practice Questions: 2, 3

E.1.3 *describe, in general terms, the distribution of matter in star systems, galaxies, nebulae, and the universe as a whole*

E.1.4 *identify evidence for, and describe characteristics of, bodies that make up the solar system, and compare their characteristics with those of Earth*

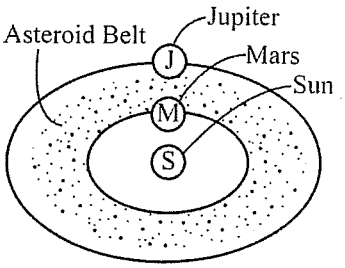
THE SOLAR SYSTEM

It is believed that huge accumulations of dust and gases called **nebulae** are pulled together by gravity to form stars. It appears that stars go through stages of development. They begin as red giants, become white dwarfs, and eventually evolve to supernovas and neutron stars or black holes. Scientific evidence shows they move through this progression.

The sun is the nearest star to Earth. It is the basis of the solar system that includes eight planets and their moons. All the planets revolve around the sun in an elliptical orbit and rotate on their axis to produce day and night.

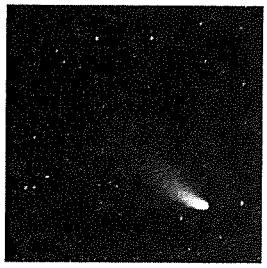
The **terrestrial planets** of Mercury, Venus, Earth, and Mars are closer to the sun and are made of solid material. Jupiter, Saturn, Uranus, and Neptune are much larger but less dense. These planets are made of gases, usually hydrogen and helium and are referred to as **Jovian planets**.

The asteroid belt is found between the orbits of Jupiter and Mars. Asteroids are rocky or metallic and revolve around the sun, as do the other planets.



Fragments of rocks called **meteoroids** are often pulled toward Earth by gravity. As they enter the atmosphere, friction causes the rocks to heat up and shower a streak of light. These shooting stars or **meteors** frequently burn up in the atmosphere. Occasionally, a rock crashes down to Earth's surface as a **meteorite**.

Comets are also found travelling in the solar system. They are made up of dust and ice. The sun's heat causes the ice to vaporize and leave a trail of visible gases. Halley's comet orbits the sun; therefore, it has a predictable schedule and becomes visible every 76 years.



Practice Questions: NR2, NR3, 4, 5, 8

E.1.5 describe and apply techniques for determining the position and motion of objects in space, including

- *constructing and interpreting drawings and physical models that illustrate the motion of objects in space*
- *describing in general terms how parallax and the Doppler effect are used to estimate distances of objects in space and to determine their motion*
- *describing the position of objects in space using angular coordinates*

Measuring Distances in Space

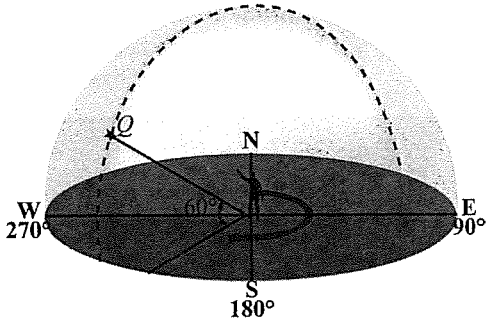
To estimate the distance of an object from Earth, astronomers use the parallax of a star. **Parallax** refers to the apparent shift in position of the star when it is viewed from different places. The speed and direction of motion of an object in space are determined based on the Doppler effect.

The **Doppler effect** is the change in frequency of a wave as it moves toward or away from an observer.

Two important measurements are used to describe the position of objects in space.

1. The **azimuth** is the direction relative to due north (0 degrees).
2. The altitude is the height in the sky of the object measured in degrees from 0 to 90. Zero degrees is at the horizon, while 90 degrees is straight up.

The location of a star is recorded as an azimuth of x degrees and an altitude of y degrees.



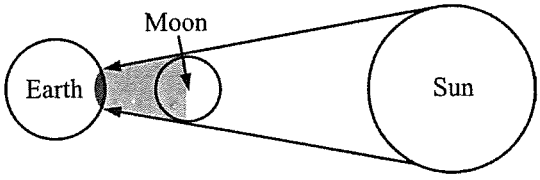
Practice Questions: NR4, 6

E.1.6 investigate predictions about the motion, alignment, and collision of bodies in space, and critically examine the evidence on which they are based

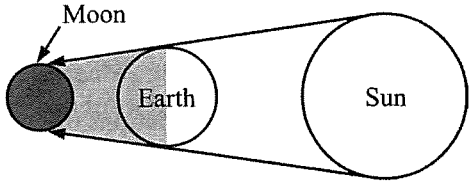
Motion and Eclipses

Because of the predictable pattern of Earth's revolution around the sun and the moon's revolution around Earth, the sun, Earth, and moon can align in a straight line relative to one another. This produces a shadow called an **eclipse**.

A solar eclipse occurs when the moon aligns itself between Earth and the sun.



A lunar eclipse occurs when Earth aligns itself between the sun and the moon.



Planets, comets, asteroids, and meteoroids are in constant motion in space. Occasionally, some space matter leaves its orbit and falls to Earth. It is believed that the Barringer Crater in Arizona was formed by the impact of a meteorite that fell to Earth about 50 000 years ago. More frequent are smaller meteorite collisions with Earth. Thousands of tiny meteorites hit Earth each year.

Practice Question: 7

E.2.1 analyze space environments, and identify challenges that must be met in developing life-supporting systems

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 safely, 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.

The microgravity environment of space is also hard on the bones and muscles of astronauts. Astronauts living in space for extended periods of time must exercise intensely to overcome these effects.

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 time. Currently, astronauts may be on the International Space Station for months at a time. 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.

Practice Question: 9

E.2.2 describe technologies for life-support systems, and interpret the scientific principles on which they are based

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 reaction.

Recycled wastewater is used to produce drinking water. The system for purifying the water on the space station 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 entire 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.

Practice Question: 12

E.2.3 describe technologies for space transport, and interpret the scientific principles involved

SPACE TRANSPORT

The main types of space transport are rockets, space shuttles 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 be travelling at least 28 000 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, which 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, space stations, and space probes.

The **space shuttle** is 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 have 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.

Practice Questions: 13, 14, 15, 16

E.2.4 identify materials and processes developed to meet needs in space, and identify related applications

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 space 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 space is now used in GPS technology on Earth.
- Protective material for space suits is being used for firefighters' suits.

Practice Question: 17

E.2.5 describe the development of artificial satellites, and explain the major purposes for which they are used

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 the 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.

Practice Questions: 10

E.3.1 explain, in general terms, the operation of optical telescopes, including telescopes that are positioned in space environments

Optical Telescopes

A telescope is a device that allows distant objects to be seen as if they are much closer and brighter. Telescopes are used to observe celestial objects.

Most telescopes work by collecting and magnifying the visible light that is given off by stars or reflected from the surface of planets. These telescopes use light and are called **optical telescopes**. There are two main types of optical telescopes: refracting and reflecting telescopes.

Refracting telescopes use convex lenses to collect light from a distant object and focus it so it can be seen clearly. The first telescope ever invented was a refracting telescope.

Reflecting telescopes use curved mirrors to bring reflected light waves to a focal point in order to view distant objects.

Optical interferometry is a technique that uses several telescopes to improve the resolution of images. In this technique, signals from telescopes in separate locations are combined. Optical interferometers are useful for making relatively bright, closely paired objects visible.

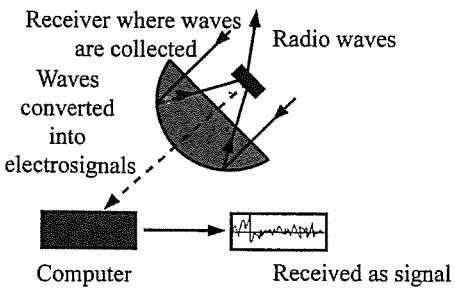
The **Hubble Space Telescope** (HST) is named after American astronomer Edwin P. Hubble. It was launched on April 24, 1990, and orbits about 600 km above Earth. In the Hubble telescope, a series of mirrors are used to focus light from very distant objects. The telescope is 4.3 m in diameter and 13 m in length. In July 1994, HST provided astronomers with the first convincing evidence of the existence of black holes. It also provided amazing images of Jupiter when the comet Shoemaker Levy 9 impacted the planet in July 1994. These images have helped scientists obtain data for spectral analysis of Jupiter's atmosphere.

Practice Questions: 19, 20, 21

E.3.2 explain the role of radio and optical telescopes in determining characteristics of stars and star systems

RADIO TELESCOPES

A **radio telescope** consists of a radio receiver and an antenna system that is used to detect radio frequency radiation. Radio wavelengths are longer than those of visible light, so radio telescopes have to be very large to attain the resolution of optical telescopes.



An advantage of radio telescopes is that they use radio waves and not visible light waves. Radio waves are not as easily distorted as light waves, and they are detectable at any time of day. Radio waves can detect objects that do not emit visible light. These telescopes can also be combined in **radio interferometry** to produce high resolution images. A group of many telescopes is called an **array**.

Optical and radio telescopes provide information about the objects in space.

Practice Questions: 22, 23

E.3.3 describe and interpret, in general terms, the technologies used in global positioning systems and remote sensing

SATELLITE TECHNOLOGIES

The **Global Positioning System** (GPS) is a space-based navigation system. It consists of 24 satellites that are orbiting Earth. At any point in time, three satellites are above a certain area and can relay information about the relative position of a receiver on Earth. Information collected from the three satellites is processed using triangulation.

Remote sensing is another technology involving satellites. Satellites orbiting relatively near Earth use sensors to measure the amount of energy, reflected from Earth's surface. This data provides information about the environment and can show changes that occurred on Earth's surface.

Practice Questions: 18

E.4.1 recognize risks and dangers associated with space exploration

Risks and Dangers Associated with Space Exploration

There are many risks and dangers associated with space exploration. In space, there is no air, no food, and no water. Furthermore, there are deadly hazards such as solar and cosmic radiation, micrometeorites, and extreme temperatures.

Accidents related to space travel result in huge economic loss and often the loss of human life. In February 2003, the space shuttle *Columbia* sustained damage to the heat-resistant tiles on the underside of the craft. When it re-entered Earth's atmosphere, it exploded and burned up over Texas. The entire seven-member crew perished.

Practice Question: 11

E.4.2 describe Canadian contributions to space research and development and to the astronaut program

Canadian Contributions to Space Exploration

Canada's involvement with the space program started in 1962 with the launch of the satellite Alouette 1.

In 1972, Canada launched its first communications satellite Anik. The RADARSAT and Landsat satellites were later launched for the purposes of monitoring environmental changes on Earth's surface. Perhaps Canada's greatest contribution to the program has been the design and construction of the robot arms Canadarm 1 and Canadarm 2. Canadarm 1 was designed for the space shuttle and has been used to repair the Hubble Space Telescope. Canadarm 2 has been used for constructing the International Space Station. Canada was also responsible for making the ramp used during the Mars Pathfinder mission.

Some famous Canadian astronauts include Marc Garneau, who was the first Canadian in space, and more recently, Chris Hadfield, who became the first Canadian to walk in space in 2001.

Practice Question: 24

E.4.3 identify and analyze factors that are important to decisions regarding space exploration and development

Space Exploration Issues and Concerns

Space exploration helps to ensure that humanity can continue to grow and expand even beyond what the natural world here on Earth can provide. At some point in the future, Earth alone may not be able to provide sufficient resources to sustain life. Space contains many mineral resources such as gold, iron, and platinum that could be used. Scientists are also looking for ways of capturing solar energy in space and redirecting it to Earth.

The quest to explore space has led to many great technologies. Medical imaging, bar coding, vision screening, ear thermometers, cordless tools, lithium batteries, and robotic arms are some of the technologies developed from the space program. These technologies are used on Earth for the benefit of humankind. Global positioning systems, remote-sensing, weather forecasting, and satellite communication have opened a great avenue for future development.

Since space contains so many valuable resources, questions arise concerning the ownership of space and what countries these resources belong to. An ethical concern about space exploration is the money spent when worldwide poverty exists.

Environmentalists discuss the topic of protecting space from unnecessary alteration and who will ultimately be responsible for cleaning up space junk and pollution.

Practice Questions: 25, 26

PRACTICE QUESTIONS—SPACE EXPLORATION

1. Throughout time, people have created stories and proposed theories about space. The Aboriginal people are known for their legends that dealt with
   A. predictions of comets
   B. descriptions of planets
   C. explanations of space travel
   D. formations of star constellations

Use the following information to answer the next question.

Four scientists and their contributions to the study of space are listed below.

1. Kepler proposed that the planets revolve around the sun in an elliptical orbit.
2. Aristotle proposed that Earth is in the centre and all the planets revolve around Earth.
3. Galileo used the telescope to confirm the sun-centred model of planetary movement.
4. Copernicus proposed the heliocentric model of planetary motion.

Numerical Response

1. Listed from the earliest contribution to the most recent contribution, the order is ____, ____, ____, and ____. (Record your answer as a **four-digit** number.)

Use the following information to answer the next question.

Proxima Centauri, the star closest to Earth other than the sun, is moving away from Earth.

Astronomers know that Alpha Centauri is moving away from Earth because the wavelength of its light is becoming _*i*_ and the colour band for its light is shifting to the _*ii*_ end of the spectrum.

2. The given statement is completed by the information in row

Row	*i*	*ii*
A.	stretched out	blue
B.	stretched out	red
C.	compressed	blue
D.	compressed	red

3. The Hubble has provided an important contribution to the study of space. It has given information about galaxies, black holes, and supernovas. The Hubble is a
   A. satellite telescope
   B. space shuttle
   C. space probe
   D. rocket

Use the following information to answer the next question.

A star is a burning ball of gases that has different stages in its life cycle. Four of these stages are given below.

1. Neutron star
2. Nebulae
3. Supernova
4. Red giant

Numerical Response

2. Listed in order from the first stage in a star's life cycle to the last stage, the stages are ____, ____, ____, and ____. (Record your answer as a **four-digit** number.)

Use the following information to answer the next question.

I. A formation of stars is called a constellation.

II. Stars start out as an accumulation of dust and gases called a nebula.

III. The Milky Way is another name for an exploding star.

IV. Galaxies can be classified as spiral, elliptical, or irregular.

Numerical Response

3. Place the number 1 in the blank if the corresponding statement is true and the number 2 if it is false.

____ ____ ____ ____

I **II** **III** **IV**

(Record your answer as a **four-digit** number.)

Use the following information to answer the next question.

Students in a Grade 9 science class were asked to imagine that a new planet, *W*, has been discovered and its location has to be determined given certain characteristics.

Planet	Radius (Earth = 1)	Density (Earth = 1)	Surface Material	Atmosphere
Venus	0.95	0.86	Thin rocky crust	Carbon dioxide
Earth	1	1	Rocky mantle/ water	Nitrogen/ oxygen
Jupiter	11.25	0.24	Gaseous	Hydrogen/ helium
Saturn	9.45	0.13	Gaseous	Hydrogen/ helium
Planet *W*	0.89	0.76	Rocky crust	Carbon dioxide

4. Given this information, it can be hypothesized that planet *W* would be located between

A. Venus and Earth

B. Earth and Jupiter

C. Jupiter and Saturn

D. Saturn and Neptune

5. Venus is farther away from the sun than Mercury. However, Venus has a much higher average surface temperature (480°C) compared with that of Mercury (180°C). The reason for this difference is that Venus

A. is a larger planet than Mercury

B. is made up of a red, rocky material

C. has a thick atmosphere of carbon dioxide gas

D. spins more slowly on its axis than Mercury

Use the following information to answer the next question.

Calvin is setting up a model of the solar system. He positions a cardboard sun at one end of a school hallway and Pluto at the other end, 20 m away. Calvin knows that Pluto is 39.5 AU (astronomical units) from the sun and Jupiter is 5.27 AU from the sun.

Numerical Response

4. In order to make his model to scale, how many metres from the cardboard sun should Calvin place Jupiter? _____ m.
(Record your answer to **two** decimal places.)

6. The terms azimuth and altitude are associated with determining the
   - **A.** distance to the stars and planets
   - **B.** location of the stars and planets
   - **C.** brightness of the stars and planets
   - **D.** composition of the stars and planets

7. A total solar eclipse was observed across the Antarctic on November 23, 2003. This meant that the sun, Earth, and moon were in what alignment?
   - **A.** The sun was between Earth and the moon.
   - **B.** The moon was between the sun and Earth.
   - **C.** Earth was between the moon and the sun.
   - **D.** Earth was between the moon and the sun, but the moon was lower and the sun was higher.

8. Small bodies orbiting around a planet are called
   - **A.** asteroids
   - **B.** satellites
   - **C.** galaxies
   - **D.** nebulae

9. Which of the following issues is **not** a challenge in sustaining a safe and healthy environment aboard a spacecraft?
   - **A.** Cosmic radiation
   - **B.** Waste management
   - **C.** Overcoming gravity
   - **D.** Maintaining atmosphere

10. Russia became the first country to launch an artificial satellite in 1957. This satellite was called
    - **A.** Luna
    - **B.** Soyuz
    - **C.** Sputnik
    - **D.** Alouette

Use the following information to answer the next question.

> Russian cosmonaut Valeri Polyakov completed a 438-day tour of duty aboard the Mir Space Station in 1995.

11. Which of the following aspects of living in space would have been the **least** hazardous for him?
    - **A.** Lower food consumption
    - **B.** Environmental dangers
    - **C.** Psychological issues
    - **D.** Microgravity

Use the following information to answer the next question.

> Air, water, and other wastes are recycled aboard the International Space Station (ISS). Oxygen is carried in liquid form.

12. The **main** reason that the ISS has adopted the given strategies is to overcome
    - **A.** the excessive cost of living in space
    - **B.** issues related to onboard experiments
    - **C.** the scarcity of resources on a space station
    - **D.** the lack of storage space aboard a space station

13. A scientific law that explains why rockets are able to lift objects into space was first developed by
    - **A.** Pascal
    - **B.** Kepler
    - **C.** Newton
    - **D.** Rutherford

14. The payload of a spacecraft refers to the

A. materials carried aboard

B. combustion chamber

C. launching pad

D. rocket fuel

15. NASA, the Soviet Space Program, the European Space Agency, and some other participating countries set up a permanent space station called

A. Freedom

B. Skylab

C. Mir

D. ISS

16. Unmanned vehicles launched into space in order to carry out remote sensing and collect data are called

A. space probes

B. space shuttles

C. space stations

D. space laboratories

17. The technology for improving the traction of car tires is adapted from the space technology developed for

A. advanced parachute material

B. structural analysis of spacecraft

C. analysis of rocket engine emissions

D. microcircuitry designs for electronics

Use the following information to answer the next question.

The United States Air Force operates a system called NAVSTAR, which is a global positioning system (GPS) that consists of 24 satellites.

18. To find the position of any object on Earth, the GPS uses signals from

A. six out of 24 satellites

B. two out of 24 satellites

C. five out of 24 satellites

D. three out of 24 satellites

19. Telescopes in which lenses are used to bend light and bring it images into focus are called

A. refracting telescopes

B. reflecting telescopes

C. radiation telescopes

D. glass telescopes

20. Reflecting telescopes collect light by using a combination of

A. convex lenses

B. concave lenses

C. convex mirrors

D. concave mirrors

21. Astronomers use computers to correct the image distortion caused by Earth's atmosphere on the quality of images gathered by telescopes. This technique is known as

A. refractive optics

B. reflective optics

C. adaptive optics

D. binary optics

22. Radio telescopes have a larger dish than optical telescopes because radio waves

A. travel at a higher speed

B. travel a greater distance

C. are easily distorted by atmosphere.

D. have a longer wavelength than that of visible light

23. Which of the following statements about radio waves is **false**?

A. Radio waves are unaffected by clouds, pollution, and atmospheric disturbances.

B. Radio telescopes are used to study objects in space.

C. Radio waves cannot be detected during the day.

D. Radio waves can be detected at night.

Use the following information to answer the next question.

Since its maiden voyage aboard the space shuttle Columbia in 1981, the Canadarm I has demonstrated its reliability. It is one of Canada's major contributions to the field of space exploration.

24. The Canadarm I has been used on the Hubble Space Telescope as a

A. landing pad

B. repairing tool

C. stabilizer

D. launcher

Use the following information to answer the next question.

Marla writes these statements about the International Space Station (ISS).

1. The ISS is solely an American project.
2. The ISS is powered by the sun's energy.
3. The ISS is a research facility.
4. The ISS orbits around Earth.

25. Which of the given statements describing the ISS is incorrect?

A. Statement 1

B. Statement 2

C. Statement 3

D. Statement 4

Use the following information to answer the next question.

Shelley was given a list of facts related to space exploration and was assigned the task of grouping them into the positive and negative aspects of space research.

1. Space exploration is dangerous and poses a risk to human life.
2. Space exploration has resulted in a more efficient method of communication.
3. Space exploration is a possible source of future resources.
4. Space exploration could provide a place to live.
5. Space exploration is a very costly venture.

26. The facts that Shelley would **most likely** classify as positive aspects for space exploration are facts

A. 1, 2, and 3

B. 2, 4, and 5

C. 1, 2, and 5

D. 2, 3, and 4

ANSWERS AND SOLUTIONS—PRACTICE QUESTIONS

1. D	4. A	9. C	15. D	21. C
NR1. 2413	5. C	10. C	16. A	22. D
2. B	NR4. 2.67	11. A	17. A	23. C
3. A	6. B	12. D	18. D	24. B
NR2. 2431	7. B	13. C	19. A	25. A
NR3. 1121	8. B	14. A	20. D	26. D

1. D

The aboriginal people looked into the skies and saw star formations. For example, they saw the constellation Ursa Major as a bear running away from hunters.

NR 1 2413

Aristotle (320 BC) proposed that Earth was the centre of all activity. According to him, the sun, moon, and all visible planets revolved around Earth. Copernicus (1543) proposed that the sun was the centre of all planetary movement and all planets revolved in concentric circles.
Kepler (1609) said that the movement of the planets was in an elliptical pattern rather than in concentric circles. With the aid of the telescope, Galileo (1615) confirmed planetary motion around the sun.

2. B

Scientists can tell that Alpha Centauri is moving away from Earth because the wavelength of its light is becoming stretched out and the colour band for its light is shifting to the red end of the spectrum. This redshift of the colour band occurs when a light source moves away from an observer.

3. A

The Hubble, sometimes called HST (Hubble Space Telescope), was first launched in 1990. HST has sent to Earth well over 100 000 pictures of nebulae, galaxies, planets, black holes, and fragments of the comet Shoemaker colliding with Jupiter.

NR 2 2431

A star is an accumulation of dust and gases that starts out as a nebula. As more material is drawn into the spinning nebula, temperatures reach nearly 10 000 000° C, changing hydrogen gas to helium gas. Eventually, the hydrogen gets used up and further nuclear reactions cause the expansion of the outer layers. The star becomes a red giant.
Eventually, the nuclear reaction stops. This causes the star to shrink into a dwarf. When the star runs out of fuel, gravity causes the star to collapse.
An explosion occurs and a supernova is born.
If a core still remains, the intense gravity causes a neutron star or black hole to form.

NR 3 1121

Some 88 different groupings of stars or constellations have been identified. Orion, the Hunter, is one of them. Stars start out as an accumulation of gases and dust drawn together by gravity to form nebulae. Groupings of billions of stars held together by gravity are often called galaxies. Galaxies can appear spiral, elliptical, or irregular. The spiral galaxy that Earth is located in is the Milky Way.

4. A

The so-called terrestrial planets near the sun are composed of a more dense solid material.
The larger Jovian planets are composed of a less dense gaseous material and are distant from the sun. Because Planet *W* is small (radius 0.95) and relatively dense (0.76) one can assume that it would belong to the inner terrestrial planets. Therefore, Planet *W* would orbit between Venus and Earth.

5. C

Venus has an atmosphere of carbon dioxide gas. Carbon dioxide has the ability to trap the sun's heat. This is known as the greenhouse effect.

NR 4 2.67

Pluto: 39.5 AU $\rightarrow$ 20 m
Jupiter: 5.27 AU $\rightarrow d$

Set up a ratio and cross-multiply.

$$39.5d = 5.27 \times 20$$
$$d = \frac{5.27 \times 20}{39.5}$$
$$= 2.668 \text{ or } 2.67 \text{ (two decimal places)}$$

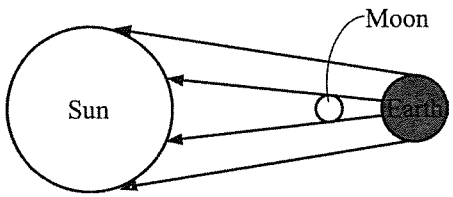
Jupiter should be placed 2.67 m from the sun.

6. B

Azimuth is a compass reading relative to north. It can be a reading up to 360° horizontally. Altitude is the measure of a celestial body above the horizon. Its reading can be an angle up to 90°. Together, the azimuth and the altitude determine the location of distant objects such as stars.

7. B

A total eclipse occurs when the moon is in direct alignment between the sun and Earth. The result is a total blockage of the sun with the exception of the outer fringe.



8. B

Small bodies orbiting around large bodies in space are called satellites. The moon revolves around Earth; hence, the moon is called a satellite of Earth. The moon is a natural satellite. Artificial satellites have been launched into space for various purposes and revolve around Earth. Asteroids are space rocks. Nebulae are the birthplace of stars. The sun, moon, and the eight planets of the solar system belong to a galaxy called the Milky Way.

9. C

Overcoming gravity is a challenge to get into space. But once there, waste management, maintaining atmosphere, and cosmic radiation are challenges to the environment of the spacecraft.

10. C

Russia became the first country to launch an artificial satellite in 1957. It was called Sputnik, which is the Russian word for satellite. It was only about as large as a basketball.

11. A

Lower food consumption is not a major concern while living in space. Some major concerns are the fact that space has no atmosphere, no air to breathe, no water to drink, and zero gravity. There are also many small celestial bodies such as meteorites that may hit the spacecraft. The crew members have to spend every minute of every day in a small chamber with the same people for long periods. This may lead to psychological problems. Exposure to microgravity has physical effects on the human body.

12. D

The main reason for adopting these strategies is the lack of storage space aboard the space station. An average human needs approximately 3.5 kg of oxygen, food, and water per day. If these items were carried to space in their original form, they would occupy too much space and weigh too much.

13. C

Sir Isaac Newton stated three laws of motion. Rocket liftoff is based on the third law of motion, which states that every action has an equal and opposite reaction.

14. A

Payload refers to the materials carried during a flight including crew, food, water, and air.

15. D

The International Space Station (ISS) is a joint venture of NASA, the Soviet Space Program, the European Space Agency, and other countries.

Skylab was a space station launched in 1973, and Freedom was a space station launched in 1984. These two space stations were the achievements of NASA. Russia launched Mir space station in 1994. The projects of the Freedom and Mir space stations were combined to set up ISS permanently in space. Canada provided a robotic arm and a service centre. The work started in 1998. The first crew consisting of an American and two Russians arrived there in November 2000.

16. A

Space probes such as Ranger, Mariner, Global Explorer (2000), and Mars Pathfinder (2004) were unmanned vehicle launched into space to carry out remote sensing and collect data. These probes were able to carry equipment to planets where humans cannot yet reach.

17. A

The technology for improving the traction of car tires is adapted from the space technology that arose from the development of parachute material for the Viking space mission.

18. D

There are 24 GPS satellites orbiting Earth at all times. The GPS system uses signals from three out of 24 satellites at any one time. The global positioning system is a space-based navigation system. Receivers pick up the GPS satellite signals, which are translated into a message by a computer in the receiver.

19. A

In refracting telescopes, the lenses are used to bend (refract) light and bring it into focus. Reflecting telescopes use a mirror and a lens to collect and focus light. Radiation telescopes capture images outside of the visible spectrum, and in glass telescopes, light passes directly through the glass without being altered.

20. D

Reflecting telescopes use a combination of concave mirrors to collect light. The light is then focused into an eyepiece using a concave lens.

21. C

Astronomers have used computers to develop a technique known as adaptive optics to improve the quality of images gathered by telescopes. The adaptive optic technology analyzes the blurring created by the atmosphere and compensates for the distortion, creating sharper images.

22. D

Radio telescopes must be larger than optical telescopes because radio waves have a longer wavelength compared to that of visible light. Electromagnetic waves of light have a wavelength of about 1 micrometre (0.001), but radio waves are between 1 m to 1 km in length. It requires a larger dish to collect the longer waves.

23. C

Radio waves can be detected during the day as well as at night. Even faint radio signals can be detected around the clock. Radio telescopes have advantages over optical telescopes because radio waves have a long wavelength and are unaffected by clouds and pollution.

24. B

The Canadarm I space shutter was used to make repairs on the Hubble Space Telescope.

25. A

The ISS is a joint venture of 16 countries.
It is a research facility that orbits Earth.
The ISS is powered by photovoltaic cells that use the sun's energy.

26. D

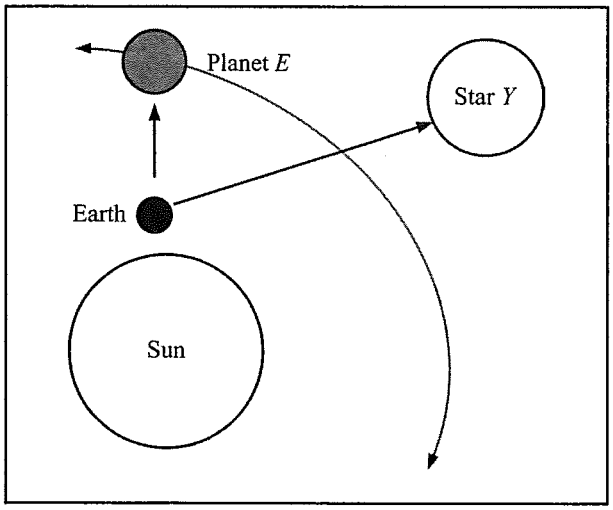
These are some positive aspects of space exploration:

1. Development of the satellite system used for communication.
2. Iron in asteroids and meteors that could possibly be tapped into when supplies on Earth are depleted.
3. Space stations that could serve as human habitats when extreme overcrowding takes place on Earth.

UNIT TEST—SPACE EXPLORATION

1. Ursa Major (Great Bear) is the name that was given to a
   - **A.** comet
   - **B.** planet
   - **C.** satellite
   - **D.** constellation

Use the following information to answer the next question.



2. The distances between Planet *E* and Earth and Star *Y* and Earth can **best** be measured in
   - **A.** light-years for both distances
   - **B.** astronomical units for both distances
   - **C.** astronomical units for planet *E* and light-years for star *Y*
   - **D.** light-years for planet *E* and astronomical units for star *Y*

3. Which of the following statements about the solar system is **true**?
   - **A.** Jupiter is larger and closer to the sun than Earth.
   - **B.** Venus is larger and closer to the sun than Earth.
   - **C.** Saturn is smaller and farther from the sun than Earth.
   - **D.** Mars is smaller and farther from the sun than Earth.

Use the following information to answer the next question.

Amy was given this list of notes on early theories of celestial bodies (sun, moon, and planets).

- **A.** Earth centred
- **B.** Sun centred
- **C.** Proposed in the 1500s
- **D.** Proposed 2 000 years ago
- **E.** Proposed by Aristotle
- **F.** Proposed by Copernicus

4. The notes that are related to the heliocentric model of planetary motion are labelled
   - **A.** A, C, and F
   - **B.** B, C, and F
   - **C.** A, D, and E
   - **D.** B, C, and E

Use the following information to answer the next question.

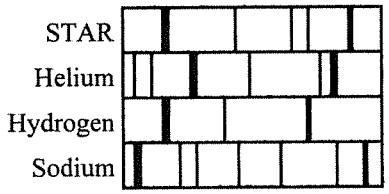
To their surprise, a New Zealand family found that some space rock had fallen through the roof of their house and landed in the living room. The rock started out in space as a ___i___ and ended up on Earth as a ___ii___.

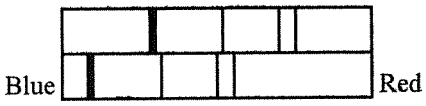
5. This statement is completed by the information in row

Row	*i*	*ii*
A.	meteor	meteorite
B.	meteoroid	meteor
C.	meteoroid	meteorite
D.	meteorite	meteor

Use the following information to answer the next question.

Using the results of spectroscopy, an astronomer is able to determine a star's composition and its direction of movement.





6. The star corresponding to this spectrogram appears to be moving ___i___ Earth. This shift is called the ___ii___ effect.

The given statement is completed by the information in row

Row	*i*	*ii*
A.	toward	Kepler
B.	toward	Doppler
C.	away from	Kepler
D.	away from	Doppler

Use the following information to answer the next question.

Four characteristics of a certain type of star follow:

- Contains extremely high-density material
- Has a strong gravitational pull
- Light cannot escape from its pull of gravity
- Is difficult to detect

7. The type of star that these characteristics describe is a

A. nebula

B. black hole

C. supernova

D. white dwarf

8. By combining the information from two telescopes 100 m apart, astronomers can improve the accuracy of the images. This technique is called

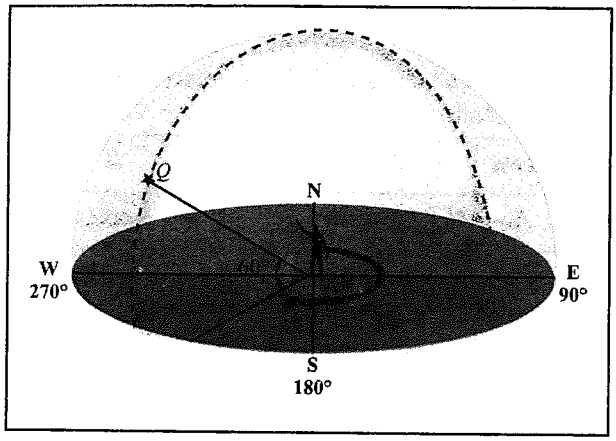
A. triangulation

B. spectroscopy

C. interferometry

D. electromagnetic induction

Use the following diagram to answer the next question.



9. Which of the following rows identifies the altitude and azimuth of star *Q* relative to the position of the observer?

Row	Altitude (degrees)	Azimuth (degrees)
A.	30	80
B.	60	210
C.	80	30
D.	80	60

10. The second largest planet with rings in the solar system is

A. Neptune

B. Uranus

C. Jupiter

D. Saturn

11. Valuable natural resources such as gold and iron are known to exist in space. They are **most likely** to be found

A. in the asteroid belt

B. on the moon

C. on Jupiter

D. on Mars

12. Jen read in an astronomy book that Earth passes through the Leonid stream every 33 years, resulting in a shower of shooting stars visible on Earth. This shower is actually

A. the tail end of a comet

B. a cluster of brightly lit stars

C. an explosion of a supernova

D. many meteors entering the atmosphere

Use the following information to answer the next question.

As a result of zero gravity, crewmembers aboard spacecraft experience weightlessness.

13. Weightlessness causes physical complications that may include all of the following conditions **except**

A. anemia

B. blocked sinuses

C. extra weight gain

D. loss of bone tissue

Use the following information to answer the next question.

The most powerful rocket is the Energia multistage rocket, which was used by the Soviet Space Shuttle. In multistage rockets, each stage is separated and discarded once its fuel has been consumed.

14. This successive discarding of stages is done in order to

A. reduce the weight of the fuselage

B. minimize the risk of malfunctions

C. decrease the speed of the rocket

D. reduce the cost of launching

15. While ion drives are engines that use xenon gas instead of chemical fuels, solar sails use

A. energy of the wind

B. heat energy of the sun

C. electromagnetic energy of the sun

D. recycled energy of conventional hydrocarbon fuels

16. Space shuttles are used for deploying satellites into orbit, carrying out scientific experiments, and repairing orbiting satellites. Which of the following functions is also a function of a space shuttle?

A. Returning previously deployed satellites to Earth

B. Forecasting weather conditions

C. Taking photographs in space

D. Observing celestial bodies

17. Satellites are used to follow ships at sea, monitor soil quality, track forest fires, and search for natural resources. The name of one of these Canadian satellites is

A. Telestar **B.** Landsat

C. TIROS **D.** GOES

Use the following information to answer the next question.

NASA launched the first telephone and television satellite in 1962. The United States Department of Defence launched Syncom 3 in 1964.

18. In order to receive continuous signals for television communication and direct broadcast, a satellite is placed in a

A. high orbit around Earth

B. low orbit around Earth

C. geostationary orbit

D. synchronous orbit

19. The Hubble Space Telescope has provided the best available information about

A. life on the moon

B. the rings around Saturn

C. the presence of useful natural resources on the moon

D. the collision of Jupiter and the comet Shoemaker Levy 9

Use the following information to answer the next two questions.

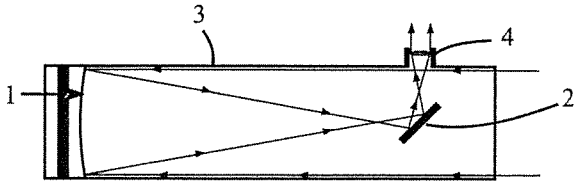


Diagram of a reflecting telescope

20. A technique that uses several telescopes linked together to produce an image with a sharper resolution is called

A. an array

B. magnification

C. interferometry

D. remote sensing

Numerical Response

1. Match each numbered structure on the diagram of the reflecting telescope with its corresponding name.

____	____	____	____
Eyepiece	Secondary mirror	Primary mirror	Body tube

(Record your answer as a **four-digit** number.)

Use the following information to answer the next question.

Space exploration is making use of new technologies. Here are four statements about recent technological advancements:

1. Cost-effective xenon gas is used as rocket fuel.
2. Sunlight is harnessed to propel space vehicles.
3. Spacecraft can carry out robotic exploration.
4. Orbiting space communities now exist.

Numerical Response

2. Match each statement above with the technology that relates to it, as given below.

____	____	____	____
Solar sail	Ion drive	Space probe	Space station

(Record your answer as a **four-digit** number.)

Written Response

1. List four hazards associated with survival in space.

(2 marks)

2. Compare the heliocentric and geocentric models of the solar system.

	Heliocentric Model	**Geocentric Model**
Who proposed the model?		
What was proposed?		

(2 marks)

3. A car is stuck in a remote rural area, but luckily it has a GPS system. Explain what GPS is and how it works to locate the stranded vehicle.

(2 marks)

ANSWERS AND SOLUTIONS—UNIT TEST

1. D	6. D	11. A	16. A	NR1. 4213
2. C	7. B	12. D	17. B	NR2. 2134
3. D	8. C	13. C	18. C	WR1. See Solution
4. B	9. B	14. A	19. D	WR2. See Solution
5. C	10. D	15. C	20. C	WR3. See Solution

1. D

Ancient people created stories to explain star formations. The Aboriginal people pictured the constellation Ursa Major as a bear running away from hunters.

2. C

Astronomical units are used to measure local distances such as those within the solar system. Light-years are used to measure distances beyond the solar system. Therefore, astronomical units are used for Planet *E*, and light-year units for Star *Y*.

3. D

The order of the planets from the sun is Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune.

The size of planets in order from smallest to largest is Mercury, Mars, Venus, Earth, Neptune, Uranus, Saturn, and Jupiter.

Therefore, Mars is smaller and farther from the sun than Earth.

4. B

In the mid-1500s, Copernicus proposed that the sun was the centre of all activity and that all planets revolved around the sun. These notes relate to the sun-centred model that is called the heliocentric model of planetary motion.

5. C

Space debris called meteoroids become meteors as they enter Earth's atmosphere. Friction upon entry causes the meteor to burn up and shower sparks as a shooting star. If pieces land on Earth, they are called meteorites.

6. D

A star's spectrum indicates which elements are present in that star. If the star is moving away from the sun the light waves seem stretched and the spectrum has a red-shift. If the star is moving toward the sun the light waves seems squished and the spectrum has a blue-shift. This phenomenon is called the Doppler effect.

7. B

A black hole is an extremely dense remnant of a dying star. It is held together by a powerful gravitation force that does not allow light to escape. Black holes are invisible to telescopes. Astronomers know of black holes indirectly because the material near a black hole is hot and bright.

8. C

This technique is called optical interferometry. By using the Keck I and Keck II reflecting telescopes together on Mauna Kea in Hawaii, scientists are able to span greater distances and come up with clearer images of celestial bodies.

9. B

Altitude represents the height above the observer, which in this case is 60°. The azimuth is the horizontal reading starting from north and rotating 360°. In this case, the angle is 30° past south or 180° + 30° = 210°.

10. D

Jupiter is the largest planet with three thin rings. Saturn is the second largest planet with over a thousand distinctive rings.

11. A

Outer space can be a potential source for natural resources. An asteroid belt lies between Mars and Jupiter and contains rocky chunks floating in space. These rocks contain iron, gold, and platinum. Mars and Jupiter are still relatively unexplored and cannot be listed as sources for natural resources. Recent analysis has shown that a large portion of the moon's surface is covered by silicon, aluminum, and magnesium, which are less valuable natural resources than gold and iron.

12. D

The Leonid stream is a stream of meteoroids left behind by the dust trail of the temple-tuttle comet. Earth passes through this stream every fall. Due to friction with the atmosphere, they become visible and the effect is known as a meteor shower.

13. C

Weightlessness due to the effect of microgravity causes many complications but not extra weight gain. Bones and muscles have less pressure so they expand. Astronauts experience a loss of bone tissue, which leads to backaches. Body fluid migration from the heart toward the brain leads to blocked sinuses. Red blood cell count falls, which leads to anemia. All these conditions are due to microgravity.

14. A

In multistage rockets, the successive discarding of the stages is done in order to reduce the weight of the fuselage and increase the mass to ratio of the rocket. It is an efficient method of increasing the speed of the rocket.

15. C

Ion drives use xenon gas instead of chemical fuels, but solar sails use the electromagnetic energy of the sun in the form of photons. Solar energy is transmitted into motion.

16. A

Space shuttles are also used in returning previously deployed satellites to Earth. Telescopes are used to observe celestial bodies, cameras are used to take photographs, and weather forecasting is done by Earth-orbiting satellites.

17. B

Landsat and RADARSAT are two Canadian satellites that are used to follow ships, monitor soil quality, track forest fires, and search for natural resources. They are not in geosynchronous orbit.

18. C

To receive the continuous signals for television communication and direct broadcast, a satellite is placed in a geostationary orbit. In this type of orbit, the satellite remains over the same spot on Earth's equator. Satellites in geostationary orbit enable long-distance voice, data, and television communication, to occur.

19. D

The Hubble Space Telescope has provided the best available view of a collision of Jupiter and Shoemaker Levy 9 in 1994. It has also provided evidence of the existence of black holes.

20. C

Optical interferometry is used to improve the resdution of images. To achieve this, signals from several telescopes in different locations are combined into one image.

NR 1 4213

A reflecting telescope uses a large primary mirror and a smaller secondary mirror to enlarge the image.

NR 2 2134

The solar sail allows space vehicles to use sunlight to propel themselves. The ion drive is a type of engine that uses cost-effective xenon gas as fuel. A space probe is a spacecraft that can carry out robotic exploration. A space station is considered to be an orbiting space community.

1. *List four hazards associated with survival in space.*

These are some of the possible hazards associated with survival in space:

1. Psychological problems associated with being confined in a small space
2. Exposure to high levels of radiation
3. Dangers associated with floating space junk
4. Physical strain on the body
5. Problems associated with weightlessness

2. *Compare the heliocentric and geocentric models of the solar system.*

The geocentric model was proposed by Aristotle about 2 000 years ago. It stated that Earth was the centre of the solar system and all planets revolved around Earth.

Copernicus proposed the heliocentric model in the 1500s. He stated that the sun was the centre of the solar system and all planets revolved around the sun.

3. *A car is stuck in a remote rural area, but luckily it has a GPS system. Explain what GPS is and how it works to locate the stranded vehicle.*

GPS or global positioning system works by sending signals to satellites.

A built-in receiver sends signals to a minimum of three orbiting satellites. From the satellite signals, a computer calculation can pinpoint the exact location of the stranded vehicle in relation to the location of the satellites.