Unit E: Space Exploration

Focusing Questions:

1. How have humans attained a presence in space?
2. What technologies have been developed and on what scientific ideas are they based?
3. How has the development of these technologies contributed to the exploration, use and understanding of space and to benefits on Earth?

Key concepts:

- technologies for space exploration and observation
- reference frames for describing position and motion in space
- satellites and orbits
- distribution of matter through space
- composition and characteristics of bodies in space
- life-support technologies
- communication technologies

Learning outcomes:

1. Identify different perspectives on the nature of Earth and space.
2. Investigate and illustrate the contributions of technological advances to a scientific understanding of space.
3. Describe the distribution of matter in space.
4. Describe and apply techniques for determining the position and motion of objects in space.
5. Analyze space environments, and identify challenges that must be met in developing life-supporting systems.
6. Describe technologies for space transport, and interpret the scientific principles involved.
7. Describe the development of artificial satellites, and explain the major purposes for which they are used.
8. Explain, in general terms, the operation of optical telescopes, including telescopes that are placed in space environments.
9. Explain the role of radio and optical telescopes in determining the characteristics of stars and star systems.
10. Describe and interpret, in general terms, the technologies used in global positioning systems and in remote sensing.

11. Recognize the ricks and dangers associated with space exploration.

12. Describe Canadian contributions to space research and development and to the astronaut program.

13. Identify and analyze factors that are important to decisions regarding space exploration and development.

observing with eyes (pre-history–1600s)	• The stars, Moon, Sun, and planets appear to circle Earth. • Is the universe Earth-centred or Sun-centred?
observing with simple telescopes (1600s–1700s)	• Galileo's telescopic observations help secure the Sun-centered model of the universe (solar system).
observing with spectroscopes (1800s–present)	• The spectroscope helps determine the composition and motion of stars.
telescopes become bigger and "smarter" (1700s–present)	• With finer measurements, one can determine distances to the stars. • Our understanding of the size of the universe increases.
observing with radio telescopes (1930s–present)	• Opens the door to observing radio emissions in the universe.
using rockets and computers (1940s–present)	• Rockets provide access to space, enabling observations of the universe without the blanketing effects of Earth's atmosphere. • Computers play a crucial role in space exploration: imaging, remote sensing, space probe manoeuvring.
observing with unmanned space probes (1970s–present)	• Observing the planets, Sun, and Moon up close shows us that each is unique.
manned space exploration (1950s–present)	• From suborbital flights, to the *International Space Station*, people learn to work in space. • Microgravity research benefits people on Earth.

Topic 1 – For Our Eyes Only

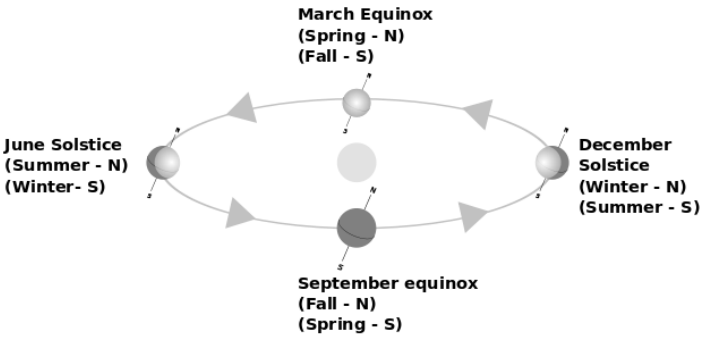
1. Latitude, longitude and altitude are all examples of **frames of reference**. Explain this phrase.

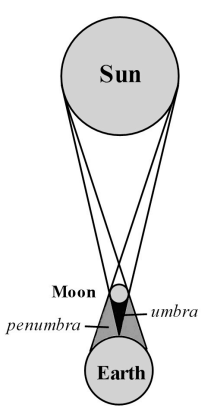
2. Celestial bodies:

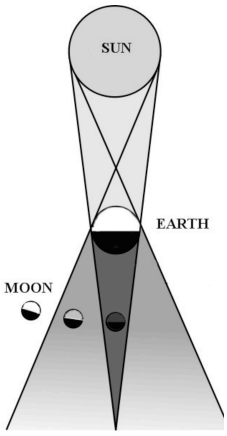
   We can see stars and planets because stars _____ light and planets _____ light.

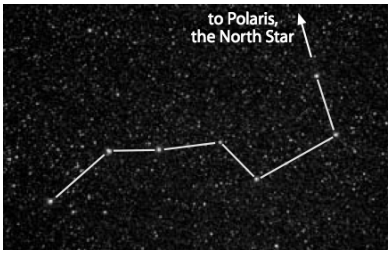
3. Grouping of stars that form patterns such as Orion, the hunter are called _____.
   Why did ancient people think that the Earth was the centre of the universe?

4. By watching celestial bodies move, ancient people could predict the spring and summer equinox, the summer and winter solstice, and solar and lunar eclipses.



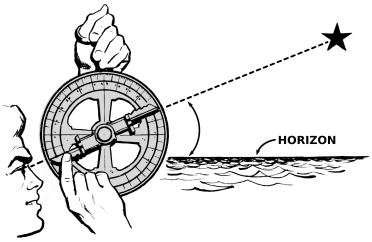






5. The _____ _____ (_____) can be used to find directions at night because it is a fixed point almost directly above the Earth's North Pole. The big Dipper appears to move counter-clockwise around it.

6. Angles used to specify the coordinates of a celestial body relative to a fixed Earth are called _____ - _____ _____:

Angle name:	**Altitude**	**Azimuth**
Explain what it is and how to calculate:		
Device used to measure:		

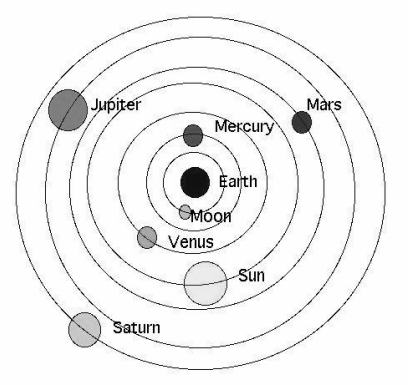
Note: Zenith is the highest point above the observer, or the maximum altitude of 90°.

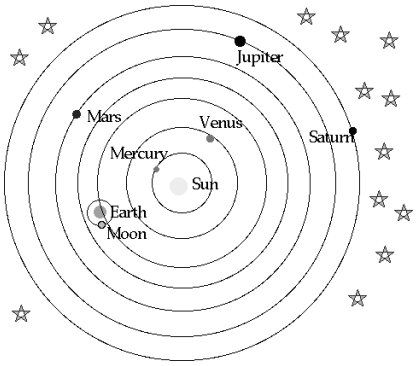
7. Complete Practice Problems #1 – 3on page 359.

   #1 = star ____ #2 = star ____ #3 = star ____

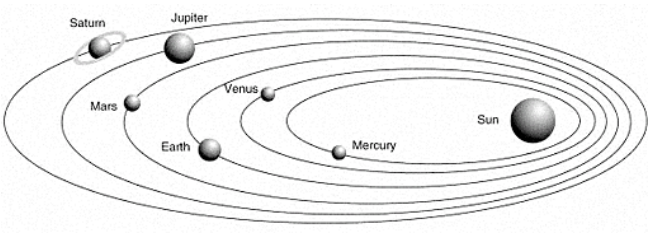
8. Because of the Earth's _____, the stars and planets appear to circle above the Earth. Therefore, the Earth should not be used as a frame of reference when tracking the actual motion of celestial bodies. Instead, you should use _____ as the frame of reference.

9. How does the Copernicus' **heliocentric model** of the universe differ from the Aristotle's **geocentric model**?





10. How does the current heliocentric model (Kepler p. 371) differ from Copernicus' older version?



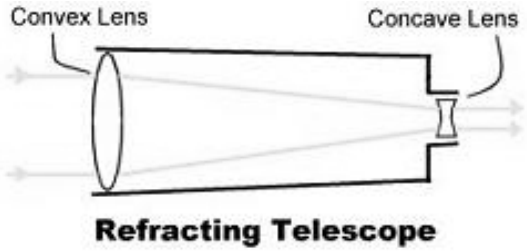
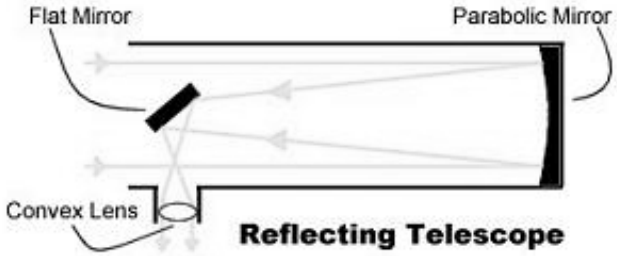
Topic 2 – Stronger Eyes and Better Numbers

1. A _____ is used to magnify objects at great distances. Differentiate between **objective** and **ocular lenses**.

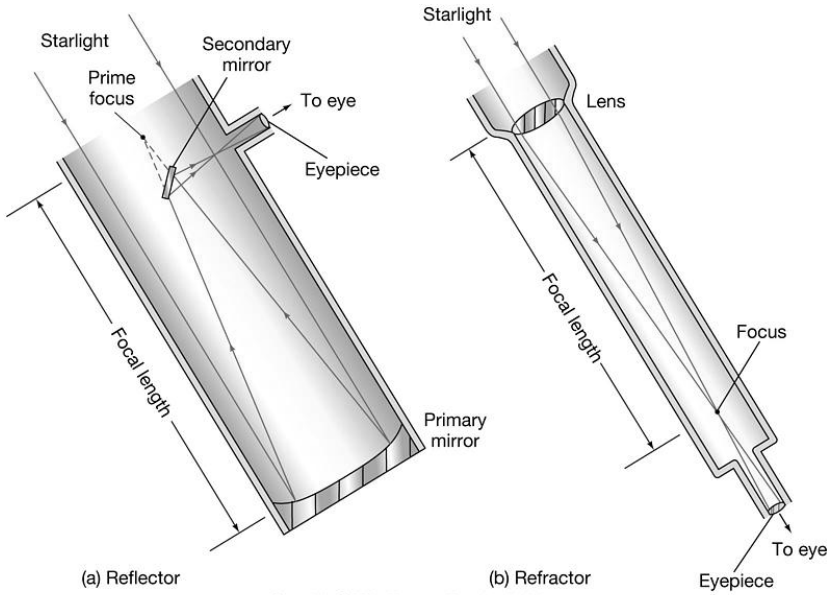
2. _____ telescopic study of Jupiter and its four orbiting moons supported the ____-centric model of the universe.

3. The ability to distinguish fine detail is referred to as _____ _____ (**resolution**) and can be increased by using _____ diameter objective lenses or by using multiple telescopes (**optical interferometry**).

4.

Optical Telescopes	
Refracting Telescopes	**Reflecting Telescopes**
Refracting telescopes use _____ that _____ light.	Reflecting telescopes use _____ that _____ light.
	
Advantage:	Advantage:
First telescope used.	Example: Hubble telescope

You must be able to label each of the following telescopes:



Movie - Understanding the Universe

1. Which planet is closest to the sun and which planet is furthest from the sun?
2. How many light-years away is the nearest star after our sun?
3. Who invented the first telescope?
4. When an object is moving away, its spectrum becomes _____ shifted?
5. Explain the big bang theory.
6. How old is the universe according to this theory?
7. Why do astronomers move to remote areas for observations?
8. What are supernovas?
9. What causes the twinkling (twisting and shimmering) of stars?
10. What was the name of the first telescope place above the Earth's orbit?
11. The brightest stars in a cluster burn what gas?
12. Scientists owe most of what they know about the universe to a low pitch "hiss" called _____ waves.
13. Is the universe expanding uniformly or not?
14. What is the 90% of the universe that is not visible is called?
15. Theoretically, gravity will cause the end of the universe in an event called the Big _____.
16. The fusion of hydrogen atoms results in _____ atoms.
17. What is a gravitational field so intense that even light cannot escape is called?
18. What are wormholes?
19. According to modern physics, what is the fasted speed attainable?
20. Where do the atoms in your body come from?

Unit E – Topics 1-2 Review

Definitions:

1. altitude

2. frame of reference

3. eyepiece

4. resolving power

5. geocentric

Matching

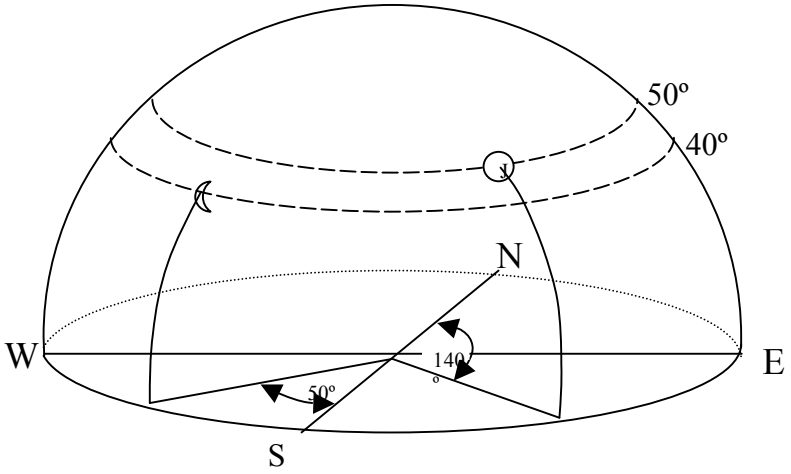
A	B
6. Kepler's discovery — the shape of planetary orbits	rotation
7. instrument used to measure azimuth	celestial body
8. telescope with a mirror for an objective	reflecting
9. an object seen in the sky beyond Earth	elliptical
10. a planet turns on its axis	compass

11. While Jack runs past Sally at 15 km/h toward the east, Sam passes Jack at a speed 5 km/h faster than Jack's speed.
    (a) What is Sam's speed, including direction, relative to Sally?

    (b) What is Jack's speed, including direction, relative to Sam?

12. How did the ancient astronomers know that the planets were different from the stars (hint: what do star do that planets can't)?

Use this diagram to answer the next question.



13. Write the altitude-azimuth co-ordinates for the Moon and Jupiter in the diagram.

14. How was the model of the universe that Copernicus presented similar to and different from the model used by Ptolemy?

15. When people buy astronomical telescopes, they have an option to buy a set of eyepieces to go with the telescope. If Fred bought a telescope with an objective with a focal length of 2000 mm, and eyepieces with focal lengths of 40 mm, 16 mm, and 8 mm, then what magnifications will Fred expect from his telescope?

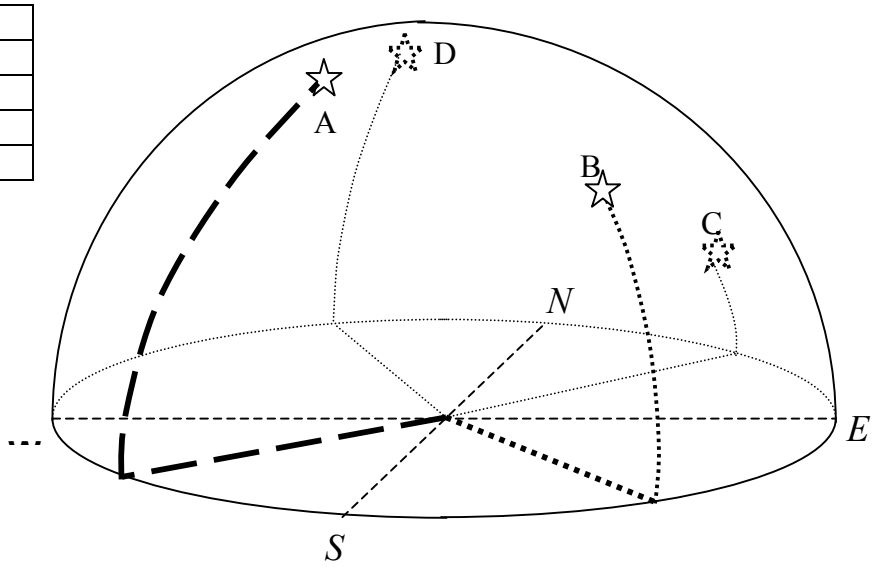
16. How did Galileo come to the conclusion that the moon has mountains on its surface?

17. Match the astronomer or scientist in Column A to their theory or invention in Column B. There may be more than item in Column B that matches the scientists listed.

A	B
1. Galileo Galilei	law of universal gravitation
2. Hans Lippershey	sun-centred model of the universe
3. Johannes Kepler	invented the reflecting telescope
4. Ptolemy	Earth-centred model of the universe
5. Copernicus	disproved the Earth-centred model of the universe
6. Issac Newton	invented the telescope in 1608
	theorized that planetary orbits were elliptical
	discovered the shape and scale of the entire known solar system.

18. Use the following diagram to identify the star with each of these coordinates:

Star	Altitude	Azimuth
	80º	330º
	45º	135º
	70º	245º
	25º	50º



Topic 3 – Spectroscopy

Visible light is often referred to as _____ _____. By passing a beam of light through a _____, Newton discovered that white light is actually a mixture of all the different colours of a rainbow or _____ **(ROY G. BIV)**. (demo)

A _____ can be used to produce a "focused" spectrum or spectra. An expensive spectroscope consists of a prism and several lenses, but an inexpensive spectroscope (the one you'll use) consists of **diffraction gratings** (flat piece of glass/plastic etched with thousands of slits). Studying spectra is a science known as _____.

Three Types of Spectra:

When an object/element is heated sufficiently it starts to glow and gives off a _____ _____, a complete rainbow of colours without any _____ **lines** (fine dark lines on a spectrum). (demo)

If there is an unexcited/cool gas between the hot, glowing substance and the spectroscope, the spectrum will have dark spectral lines because the gas absorbs the energy of some of the wavelengths of the light. _____ _____ _____ are known as _____ **spectra.**

If the dark line spectrum is viewed at an angle away from the light source, a pattern of bright spectral lines appear. _____ _____ _____ are known as _____ **spectra.** (demos)

Note: the bright lines in an emission spectrum occur at exactly the same positions as the dark lines in the absorption spectrum of the same _____.

Every element produces its own unique pattern of absorption or emission spectra. Therefore, we can identify <u>some</u> of the elements present in stars by examining the spectra they produce. This process is referred to as _____ _____.

Complete Investigation 5-E in the space below:

1.

2.

3.

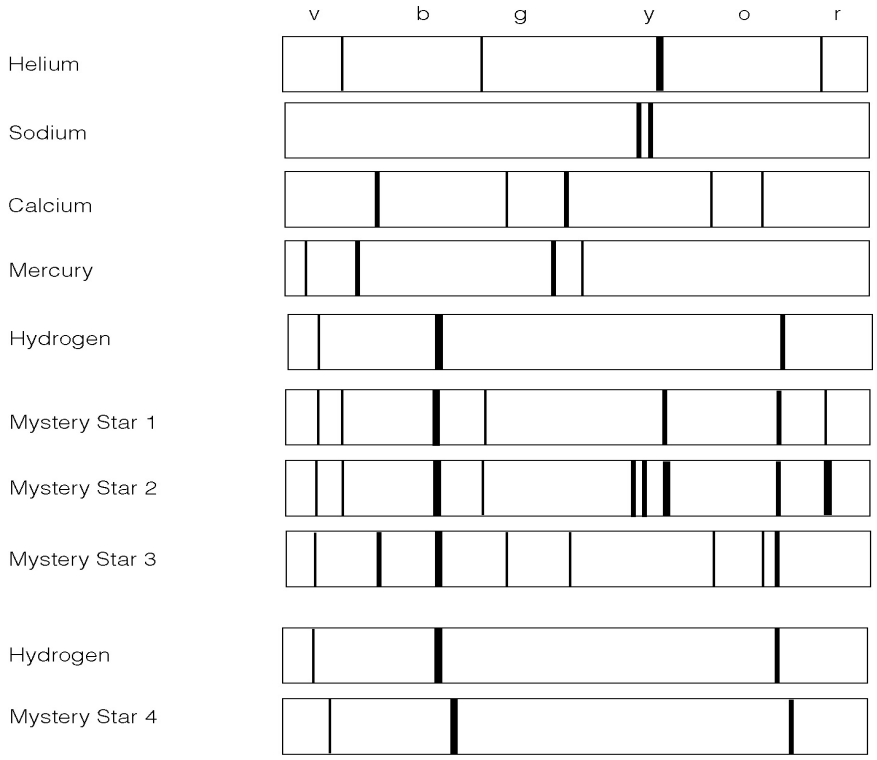
4.

5.

6.

More Spectral Analysis

Analyze the spectra below in order to answer the following questions.



Questions

1. List the chemical elements in:
   (a) Mystery Star 1

   (b) Mystery Star 2

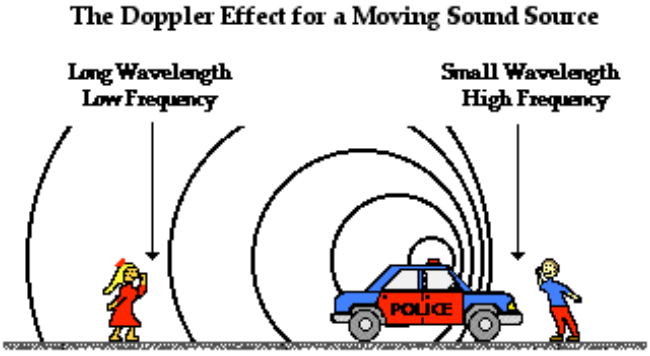
   (c) Mystery Star 3

2. (a) There is something strange about Mystery Star 4's spectrum. What chemical is in Mystery Star 4?

   (b) What is odd about the spectrum?

What does spectroscopy tell us about the movement of stars?

Think about the sound of an ambulance or police siren as it approaches your car and then passes it. When a sound source is moving towards you, the frequency (pitch)_____. Once a sound source passes by, the pitch _____. This effect is called the _____ _____.



Motion has the same effect on light waves. If a star is moving _____ from an observer, the spectral lines are shifted towards the red end of the spectrum. This is called _____ _____.

If a star is moving towards an observer, the spectral lines shift towards the _____ end of the spectrum. This is called _____ _____.

Note: The greater the shift, the faster it is moving.

What three factors can we determine from the spectral analysis of a star?

-
-
-

Complete #2– 4 p. 384

2.

3.

4.

Topic 4 – Bigger and Smaller Telescopes

1. Mr. Ferrige desperately wants to explain why the Hubble telescope which is 600 km above the Earth's surface and other telescopes placed above the atmosphere are better than land-based telescopes so please ask him.

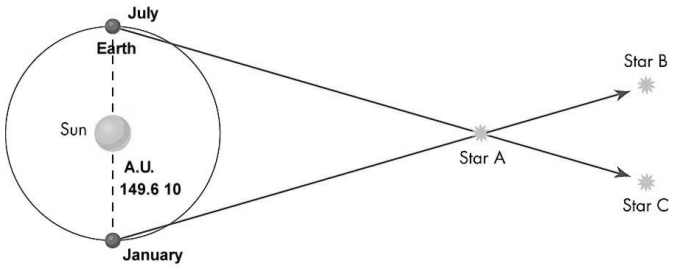
2. Why do astronomers continue to build even larger telescopes?

3. What is **adaptive optics**? How does this technique work?

4. Two methods can be used to measure distance in space: triangulation and parallax

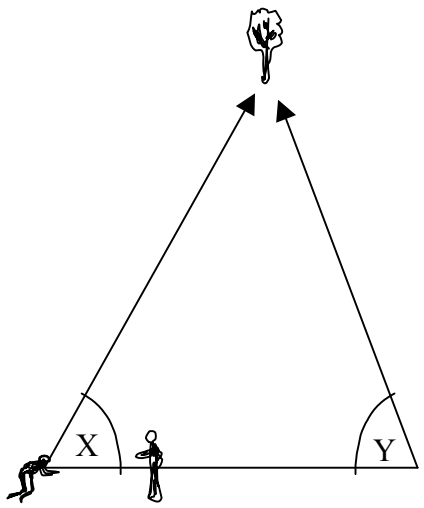
    a. Define **triangulation** and explain how it works.

    b. Define **parallax (technique)** and explain how it works.



5. A group of students went to a park to practice their triangulation skills. They picked an object far away, set up a baseline, and measured the angle to their object at each end of the baseline, (see diagram). Their results are shown here. For each group below, use triangulation to find the distance to the far object.

Group	Baseline length (m)	angle X	angle Y
A	46	75º	78º
B	20	81º	77º
C	89	55º	71º



6. The _____ the baselines, the more accurate the triangulation will be. What do astronomers use as the baseline for triangulating distant stars?

7. Because it takes ____ months to generate this baseline, astronomers use _____ _____ as reference points.

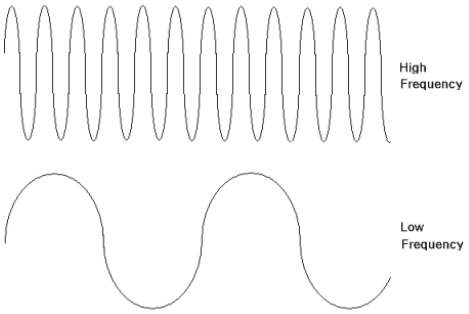
8. Because universal distances are so great, there is a need for different measuring techniques and units. Differentiate between an **astronomical unit (AU)** and a **light year**.

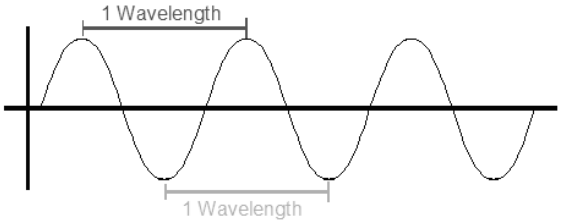
Note: a parsec is a basic unit of length (3.26 light years) for measuring distances to stars and galaxies

Topics 5 - What Channel Is That?

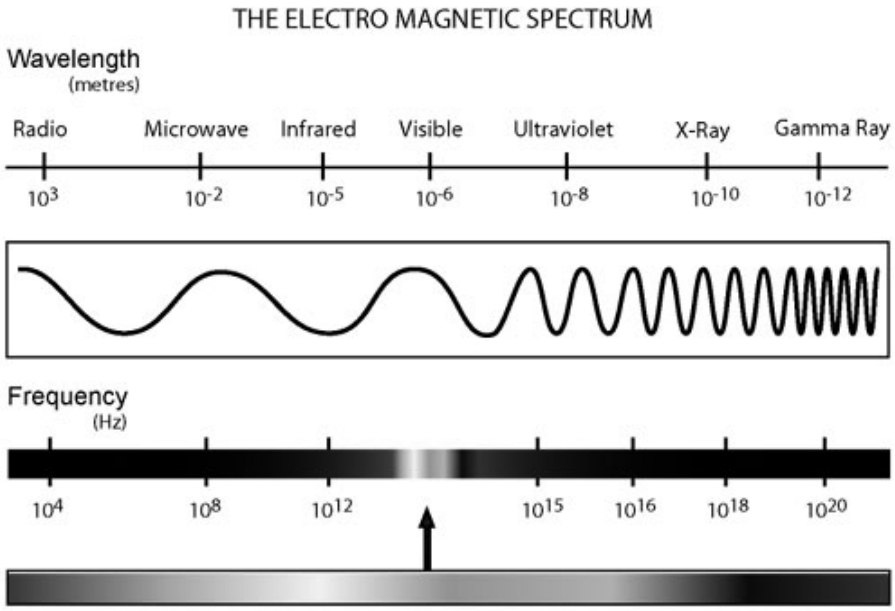
Note: your textbook uses the terms frequency and wavelength when discussing waves but never explains what they are. Therefore:

Frequency: how many times per second a signal is sent. A frequency of 100 Hz means 100 signals per second.





Wavelength: the distance between two waves (signals).



As the frequency increases, the wavelength _____.

1. **Electromagnetic radiation (EMR)** is waves composed of electric and magnetic fields that travel at the speed of light (3×10^8 m/s). List the different forms of EMR in order of increasing frequency (decreasing wavelength).

2. **Radio telescopes** (**radio astronomy)**:

3. Celestial objects or certain areas in space that produce large amounts of radio waves (loud static) are called _____ _____. Telescopes that detect these waves are called _____ _____. These telescopes have a greater range than optical and can penetrate _____ _____. These telescopes produce images with less resolution that optical telescopes, however, the resolution can be increased if focusing on waves with _____ wavelengths or using interferometry.

4. What are VLAs? Explain the technique of radio **interferometry**.

5. Describe how **very long base line (VLBI) interferometry** works.

Topics 3–5 Review

1. Define each term:
   (a) spectrum:_____
   _____

   (b) light-year: _____
   _____

   (c) triangulation:_____
   _____

   (d) radio waves: _____
   _____

   (e) adaptive optics:_____
   _____

Match each definition in column A with the correct term in column B. Draw a line from each definition to the corresponding term.

A	B
2. energy waves which include visible light	diffraction grating
3. apparent change of wave frequency caused by motion	interferometry
4. a device used to produce a spectrum	electromagnetic radiation
5. spectrum of a hot solid	continuous
6. technique that combines images from two telescopes	Doppler effect

Short Answers

7. How is an element identified in the Sun's spectrum?

   _____
   _____
   _____

8. How do astronomers analyze starlight to decide if a star is moving toward or away from us?

   _____
   _____

9. The star Vega is 25 light-years away from us. If we sent a radio message to Vega, and another civilization on a planet circling that star answered us, in what year could we expect to here a reply?

   _____
   _____
   _____

10. Why was it necessary to make radio telescopes so much bigger than optical telescopes?

    _____
    _____

11. Define each of the following terms in the space provided, and use the word in a complete sentence.

(a) electromagnetic radiation

(b) radio astronomy

(c) radio objects

(d) interferometry

(e) very long base line interferometry (VLBI)

12. How do astronomers use radio waves to learn about the composition of stars?

Topic 6 - Above the Atmosphere and Under Control

1. Differentiate between a **rocket** and a **payload**.

2. What is **exhaust velocity** and what does it determine?

3. Why do modern rockets like those used by the Space Shuttle use liquid fuel instead of solid fuel as a source of _____ energy?

   Two other rocket technologies are presently being experimented with: **ion drive engines** that use electrically charged xenon gas for fuel and **solar sails** that harvest solar energy.

4. What are **multistage rockets**? What's the advantage?

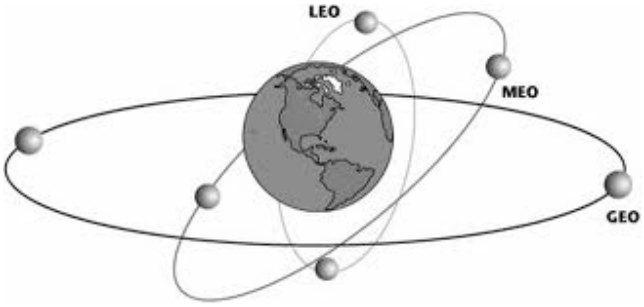
5. _____ have allowed the orbits of rockets to be calculated and controlled.

6. Explain the technique of **gravitational assist**.

7. Differentiate between **natural** and **artificial satellites**?

8. Identify and describe the two types of artificial satellites identified in your textbook on page 404. What are these satellites used for?

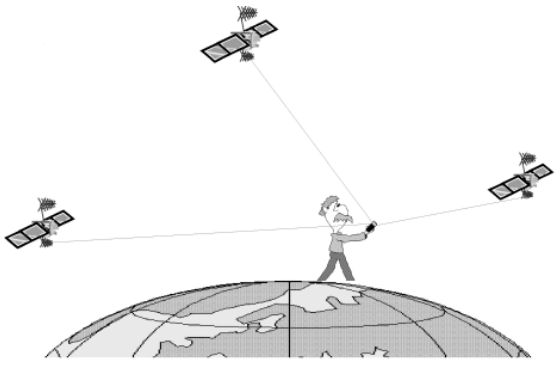
9. A satellite could transmit signals over a greater area of the Earth's surface if you _____ the radius of orbit.



10. Old satellites become **space junk**, which is dangerous, so how do we get rid of them?

11. What is **remote sensing**? Provide several applications of this technology.

12. What does **GPS** stand for and what is it used for?



Topic 7 - The Solar System

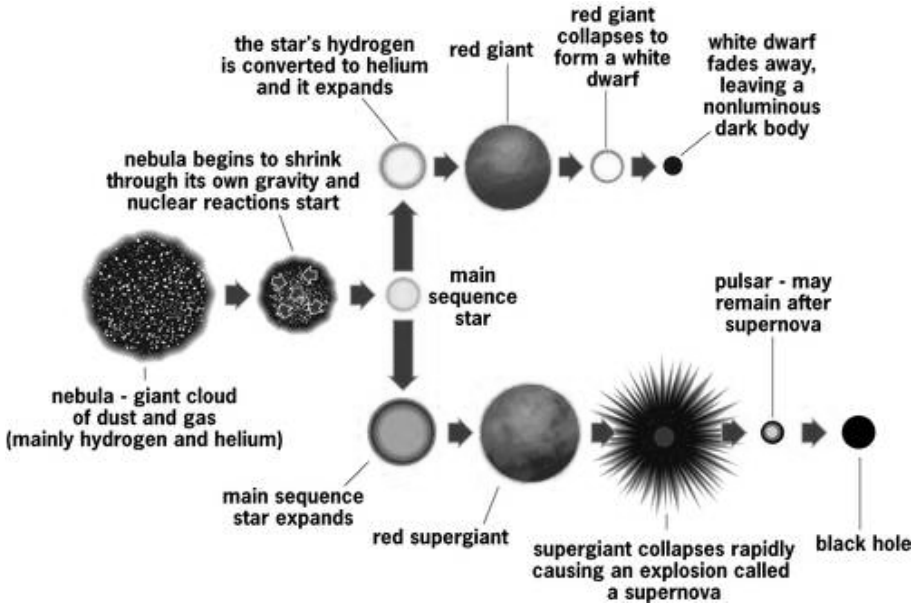
1. What is *your* understanding of the Big Bang Theory?

2. What is a galaxy? What is the name of the spiral galaxy that our solar system belongs to?

3. Milky way > solar system > sun > earth (size and mass)

4. The solar system consists of the sun, planets, moons, asteroids, and other smaller rock fragments.

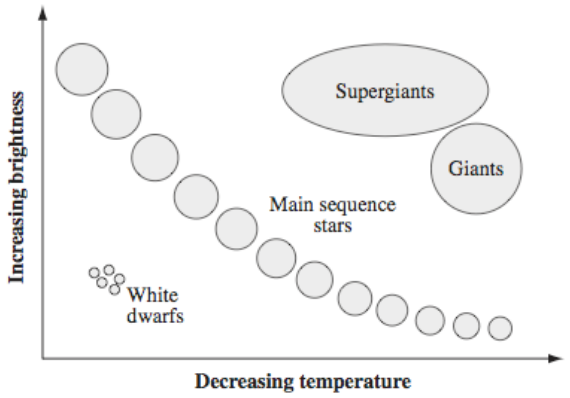
5. Life-cycle of a star: It is believed that huge accumulations of dust and gases called **nebulae** are pulled together by gravity to form stars that go through stages of development.



They begin as red giants, become white dwarfs, and eventually evolve to supernova and neutron stars or black holes.

6. Composed mostly of the gas _____, the _____ is our closest *star* and the center of our _____ system. With a diameter 110 times that of Earth, its gravitational field is so intense that **nuclear fusion** takes place. What is nuclear fusion?

7. In the 1920s, E. Hertzsprung and H. Russell compared the surface temperature of stars with its brightness (luminosity). Stars fall into distinct groups:



8. **Solar flares** are bursts of energy released from the sun's surface. These are associated with the Northern and Southern lights. 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. What is **solar wind**?

9. Planets:

a. Make a phrase that will enable you to recite the planets in our solar system starting with the planet closest to the sun.

b. The **inner planets** are also referred to as the _____ planets because they have a _____ composition. Name the inner planets:

c. The **outer planets** are also referred to as the Jovian planets because they have a _____ composition. Name the outer planets:

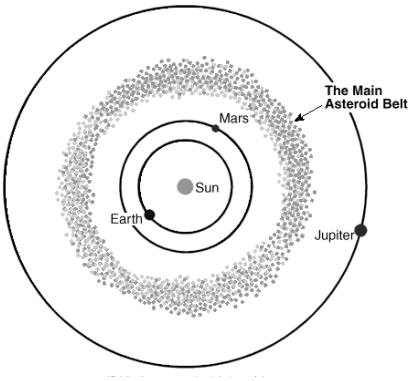
d. What is the relationship between average temperature of a planet and its distance from the sun? Draw a graph to show this relationship. Which planet seems to be an exception? Why?

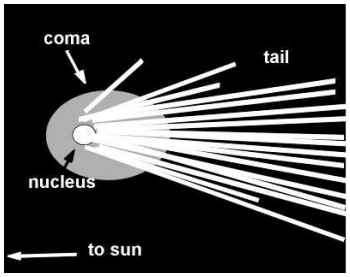
e. It takes the Earth one year (12 Earth months) to orbit the sun. What is the relationship between the orbital period (the time it takes to orbit the sun) and the distance of the planet from the sun? Draw a graph to show this relationship.

f. It takes the Earth one day (24 Earth hours) to rotate on its axis. What is the relationship between the rotational period (the time it takes to rotate on its axis) and the length of day? Draw a graph to show this relationship.

10. What are moons?

11. There is an asteroid belt between the orbits of Jupiter and Mars. What are asteroids?





12. What are comets? Why do we see some comets more often than others?

13. Differentiate between a meteoroid, a meteor and a meteorite.

14. What is the purpose of **space probes** like the Voyager 1 and 2 spacecrafts?

Topic 8 - People in Space

In space there are many risks and dangers like solar and cosmic radiation, micrometeorites, and extreme temperatures. Plus there's no food, air, or water. That is why the first flights into space were unmanned.

1. In 1957, the Russian Sputnik became big news. Why?

2. What is the name of the first spacecraft to *orbit* the Earth with a human payload (1961)?

3. What was the goal of the American Project Mercury?

4. What was the goal of the American Apollo Program? Identify when and who accomplished this goal?

5. What is the purpose of the **Space Shuttle** program? What is Canada's major contribution the space shuttle program?

6. Explain the term **microgravity**.

7. Who was the first Canadian in space (1984)?

8. What is the purpose of the **International Space Station (ISS)**?

To be self-sufficient, inhabitants of the ISS must purify dirty water for drinking, recover moisture from inside the station and use solar panels for electricity.

Topics 6–8 Review

Definitions:

1. staged rocket

2. remote sensing

3. solar wind

4. microgravity

5. comets

Matching

6. device that records images from newer telescopes	GPS
7. orbit that makes a satellite stay over one location on Earth	Pluto
8. using a planet to change the orbit of a spacecraft	CCD
9. satellite system used to locate things on Earth	gravitational assist
10. the only planet not visited by a spacecraft from Earth	geosynchronous

Short Answers

11. Suppose that a spacecraft were to be sent to Venus and another to Mars. Which spacecraft would need more shielding from the solar wind? Why?

12. The space shuttle is powered by a staged rocket system. Why?

Unit E Review

Definitions

1. heliocentric

2. spectroscope

3. red shift

4. payload

5. cosmonaut

True or False

_____ 6. Planets follow circular orbits around the Sun.
_____ 7. The angle above the horizon of a star is its altitude.
_____ 8. The Sun's light exhibits an emission spectrum.
_____ 9. An astronomical unit (AU) is the distance light travels in one year.
_____ 10. A satellite that orbits Earth in about 1.5 h is in a low Earth orbit.

Multiple Choice

11. An astronaut is tethered to the *International Space Station*, keeping a constant distance from the station.
    The false statement here is
    (a) The station's velocity relative to the astronaut is zero.
    (b) The astronaut's velocity relative to the station is zero.
    (c) The velocities of the station and the astronaut relative to Earth are different.
    (d) The velocities of the station and the astronaut relative to Earth are the same.

12. The correct statement about a scientist and what he discovered is:
    (a) Galileo, spectroscope
    (b) Kepler, radio telescope
    (c) Newton, law of gravity
    (d) Ptolemy, elliptical orbits

13. Satellite dishes are becoming more popular with people interested in watching many TV channels. The satellites that these dishes are aimed at are in:
    (a) geosynchronous orbits so that the satellite dish need not be moved
    (b) low Earth orbits so the signals reach the customers in a fraction of a second
    (c) low Earth orbits so the signals don't have to be very powerful, thus saving money
    (d) geosynchronous orbits so that the satellites can't be harmed from Earth

Fill in the Blanks

14. When measuring the position of the Moon in the sky we can use _____ -_____ coordinates. The angle clockwise from north is the _____ and the _____ is the angle above the horizon.

15. Reflecting telescopes have _____ for objectives. The magnification of a telescope is found by _____ the objective's focal length by the eyepiece's focal length.

16. If a star is approaching us, its light will be _____ _____. This is due to the _____ _____.

17. When triangulating to find the distance of an object that is far away, a _____ baseline is preferred in order to increase the _____ of the measurement.

18. Radio waves have an advantage over visible light for astronomy in that they can penetrate _____ and _____.

19. A rocket consists of a _____, _____, and a _____.

20. The weightless conditions that astronauts feel when in orbit is called _____. It is caused by _____.

21. Earth's natural satellite is _____. The planet with the hottest surface temperature is _____. _____ is the biggest planet, and the farthest planet yet reached by a spacecraft from Earth is _____.

Short Answers

22. Explain how the rising and setting of the Sun and Moon are explained in a geocentric and heliocentric model of the universe.
    (a) geocentric _____

    _____

    (b) heliocentric _____

    _____

23. What did astronomers conclude from the observation that the light from almost all the galaxies is red shifted?

    _____

    _____

    _____

24. Why do astronomers want to make bigger and bigger telescopes? Give two reasons.

    _____

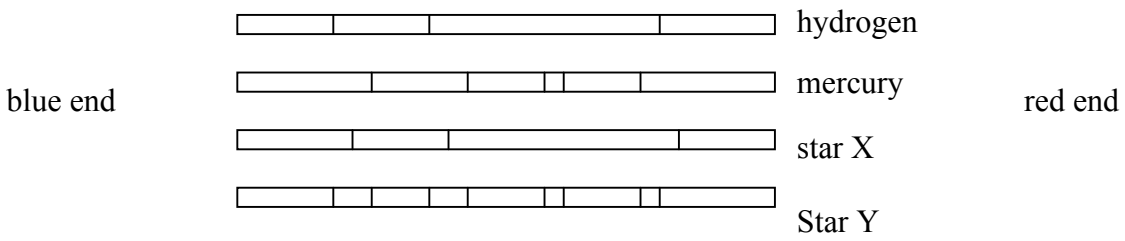
    _____

    _____

25. Give three ways that people are using the Global Positioning System.

26. Why did astronomers want a telescope in space when they can build bigger ones on Earth?

Use the spectra here to answer the next question.



27. Explain what the spectra of stars X and Y tell us about these stars.

Unit E Review – "I Can" Statements

I can: (Topic 1)
- Provide examples of celestial bodies and events
- Differentiate between altitude and azimuth
- Explain how the original geocentric model of the universe has evolved into the modern heliocentric model

I can: (Topic 2)
- Differentiate between reflecting and refracting telescopes

I can: (Topic 3)
- Describe how a spectroscope works
- Explain the Doppler effect
- Explain what can be determined from the spectral analysis of a star

I can: (Topic 4)
- Describe the advantage of building larger telescopes and of putting telescopes above the Earth's atmosphere
- Describe how parallax and triangulation can be used to determine distances in space
- Differentiate between a light year and an astronomical unit

I can: (Topic 5)
- Describe different form of EMR in terms of frequency and wavelength
- Describe the advantages of radio telescopes and interferometry

I can: (Topic 6)
- Describe the parts of a rocket and the advantage of staged rockets
- Identify and describe different types of satellites and their uses

I can: (Topic 7)
- Define galaxy and explain the life cycle of a star
- Differentiate between the inner and outer planets
- Differentiate between a planets period of orbit versus its period of rotation
- Describe how space probes have increased our knowledge of space

I can: (Topic 8)
- Identify Canada's contribution to the space exploration
- Describe how the Space Shuttle and the International Space Station have increased our knowledge of space
- Describe how the absence of gravity affects astronauts and space exploration