Mr. Brown's Science Labs

Earth & Space Sciences

Astronomy & Space Exploration
20 Cluster Questions

NYS Regents-Style Practice — modeled on the
January 2026 *and* ***August 2025*** *Earth and Space Sciences Regents Examinations*

Cluster	Topic	Question Types
1	The Moon and Eccentricity	Jan 26: Type 1 · Type 2
2	The Big Bang and Energy	Jan 26: Type 6 · Type 22
3	The Sun and Sunspots	Jan 26: Type 14 · Type 16 · Type 9
4	Telescopes and Space Exploration	Jan 26: Type 2 · Type 9 · Type 19
5	Galaxies and the Expanding Universe	Aug 25: Types 1, 2, 3, 4, 5
6	Exoplanets and Habitable Zones	Aug 25: Types 11, 12, 13, 14, 15

Name: _____

Period: _____ Date: _____

Teacher: _____

Directions: Answer all questions. Each question is worth 1 point. Write your answers neatly in the space provided. Use the 2024 Edition Reference Tables for Earth and Space Sciences (ESRT) when needed. Show all work.

Final grade will be calculated at the end of the packet, based on a total of 20 points (1 point per question).

Cluster 1 — The Moon and Eccentricity

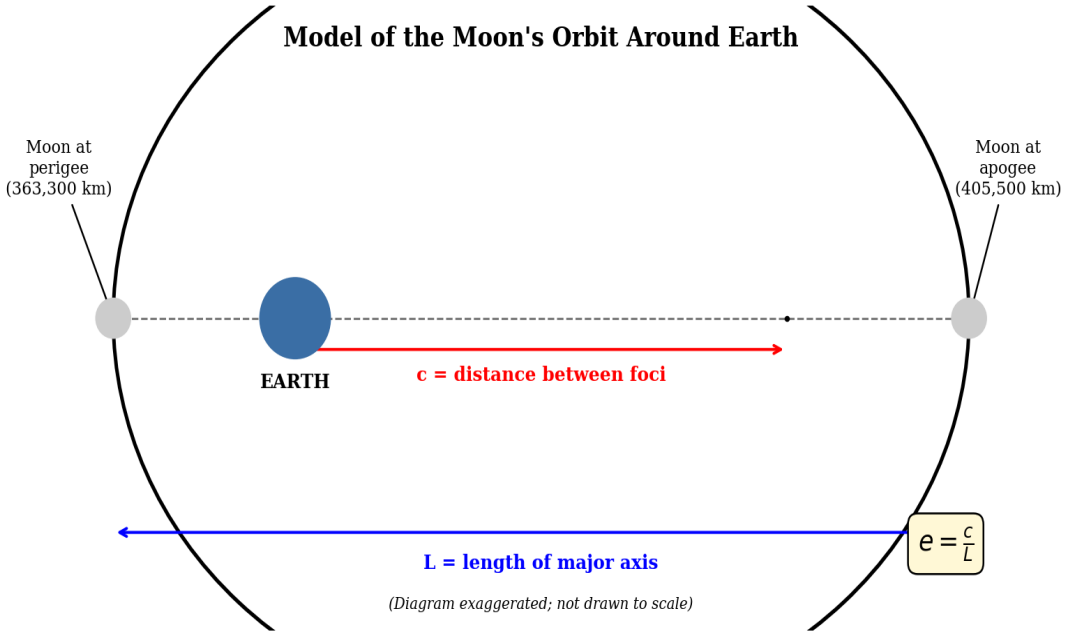
Base your answers to questions 1 and 2 on the information below and on your knowledge of Earth and Space Sciences. Some questions may require the use of the 2024 Edition Reference Tables for Earth and Space Sciences. Be sure to record your answers in the space provided.

The Moon's Elliptical Orbit

Earth's Moon orbits Earth in an elliptical path, not a perfect circle. The shape of every ellipse is described by its eccentricity (e), calculated using the formula **e = c / L**, where **c** is the distance between the two foci of the ellipse and **L** is the length of the major axis. An eccentricity of 0 represents a perfect circle, while values approaching 1 represent very elongated ellipses. Earth's Moon has an eccentricity of approximately 0.0549.

Because of this elliptical shape, the Moon's distance from Earth changes throughout its orbit. The closest point is called **perigee**, where the Moon is about 363,300 km from Earth. The farthest point is called **apogee**, where the Moon is about 405,500 km from Earth. According to Kepler's Second Law, the Moon sweeps out equal areas in equal time intervals, which means the Moon must travel faster at perigee and slower at apogee.

When a full moon occurs near perigee, the event is commonly called a **supermoon**. During a supermoon, the Moon appears approximately 14% larger and 30% brighter than during a full moon that occurs at apogee.



1 Complete each of the three statements below to correctly describe the Moon's orbital characteristics by placing an X in the box to indicate which phrase correctly completes each statement. ***[1]***

Statement 1: Earth's Moon has an eccentricity of 0.0549, which means its orbit is

☐	nearly circular because the value is close to 0
☐	highly elongated because the value is close to 1

Statement 2: As the Moon moves from apogee toward perigee, its orbital speed

☐	increases because the gravitational pull of Earth becomes greater
☐	decreases because the gravitational pull of Earth becomes weaker

Statement 3: A supermoon appears 14% larger than a normal full moon because

☐	the Moon is near perigee, the closest point in its elliptical orbit
☐	the Moon is near apogee, the farthest point in its elliptical orbit

Six statements about the Moon's elliptical orbit are listed below.

Statement 1: An eccentricity value of 0 represents a perfectly circular orbit.

Statement 2: The Moon's orbital speed remains constant throughout its orbit around Earth.

Statement 3: According to Kepler's Second Law, the Moon moves fastest at perigee.

Statement 4: The Moon's eccentricity value of 0.0549 is closer to 1 than to 0.

Statement 5: At apogee, the Moon moves at its slowest orbital speed.

Statement 6: Earth is located at the exact geometric center of the Moon's elliptical orbit.

2 Which statements correctly describe the Moon's orbital motion? ***[1]***

(1) Statements 1, 3, 5

(2) Statements 2, 4, 6

(3) Statements 1, 2, 4

(4) Statements 3, 5, 6

Answer: _____

Cluster 2 — The Big Bang and Energy

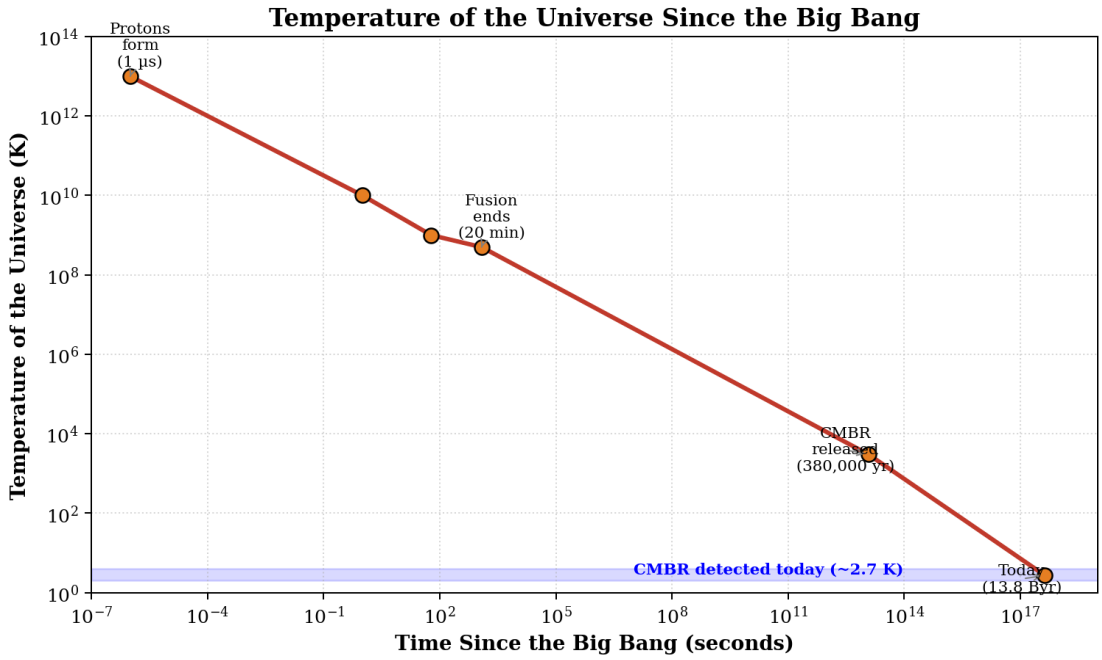
Base your answers to questions 3 and 4 on the information below and on your knowledge of Earth and Space Sciences. Some questions may require the use of the 2024 Edition Reference Tables for Earth and Space Sciences.

Energy in the Early Universe

The Big Bang theory describes how the universe expanded from an extremely hot, dense state approximately 13.8 billion years ago. As the universe expanded, it cooled, allowing matter and energy to take on different forms. In the first fraction of a second, the universe underwent a period of rapid **inflation**, during which space itself stretched outward.

Three pieces of evidence support the Big Bang theory: (1) the observed **redshift** of distant galaxies, indicating an expanding universe; (2) the **cosmic microwave background radiation (CMBR)**, the leftover thermal energy from the early universe; and (3) the relative abundance of light elements such as hydrogen and helium, which matches predictions of nuclear fusion (nucleosynthesis) during the first 20 minutes after the Big Bang.

Energy in the early universe existed primarily as photons (particles of light). As the universe expanded and cooled, energy converted into matter. Today, the CMBR has cooled to approximately 2.7 Kelvin (K) and is detected as faint microwave radiation reaching Earth from all directions in space.



3 Complete each of the three statements below by placing an X to correctly describe how energy and matter behaved during the early universe. ***[1]***

Statement 1: The cosmic microwave background radiation provides evidence of the Big Bang because it represents

☐	energy released when the universe became transparent and electrons combined with nuclei
☐	matter that has fused together to form the heaviest elements in the universe

Statement 2: As the universe expanded after the Big Bang, the temperature of the universe

☐	increased because matter became more concentrated
☐	decreased because energy spread out over a larger volume

Statement 3: The relative abundance of hydrogen and helium in the modern universe is best explained by

☐	nuclear fusion reactions that occurred within the first 20 minutes after the Big Bang
☐	chemical reactions that occurred in the cores of stars billions of years later

Cluster 2 — continued

A student studied the graph and reading and made the following claim:

> *The CMBR temperature of 2.7 K and the observed redshift of distant galaxies provide two independent pieces of evidence that support the Big Bang theory.*

4 Place a check mark (✓) in either the Support or Refute box below to indicate if the given information supports or refutes the student's claim. Justify your response using evidence from the passage and graph. ***[1]***

☐	**Support**
☐	**Refute**

Justification:

_____

_____

_____

Cluster 3 — The Sun and Sunspots

Base your answers to questions 5 through 7 on the information below and on your knowledge of Earth and Space Sciences. Some questions may require the use of the 2024 Edition Reference Tables for Earth and Space Sciences.

Solar Cycle 25 and Sunspot Activity

The Sun's surface activity is not constant. It follows an approximately 11-year cycle of high and low activity. During **solar maximum**, the surface displays many **sunspots** — cooler, darker regions caused by intense magnetic activity. During solar minimum, sunspots are rare or absent. Sunspots typically appear in pairs of opposite magnetic polarity and last from a few days to several months.

Astronomers have been counting sunspots and tracking the solar cycle since the early 1700s. The current cycle, **Solar Cycle 25**, began in December 2019 and reached its peak in 2024–2025. During solar maximum, the Sun also releases more solar flares and coronal mass ejections (CMEs). These can disrupt Earth's magnetic field, satellites, and power grids, and produce more frequent auroras at high latitudes.

A class of students studying images of the Sun from Solar Cycle 25 recorded the following observations of a sunspot group on the Sun's photosphere:

A. The sunspot group appeared darker than the surrounding photosphere.

B. The sunspots were located in the northern hemisphere of the Sun, about 30° north of the Sun's equator.

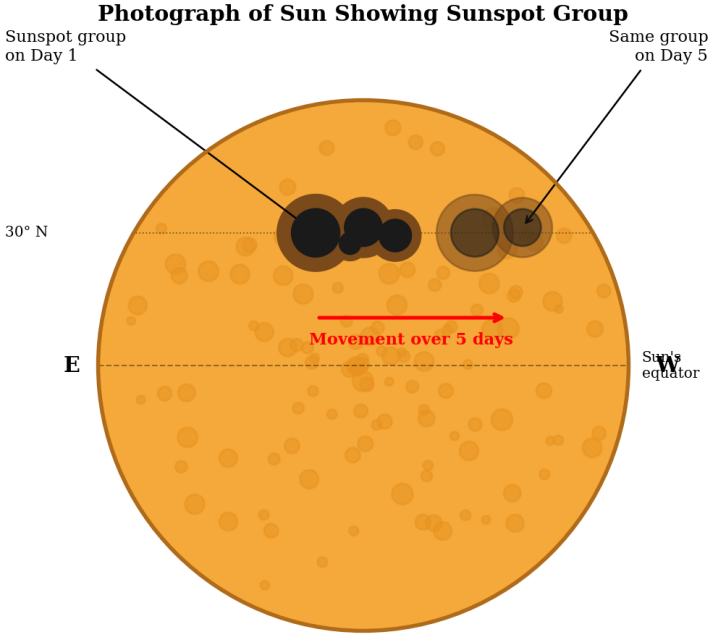
C. The sunspot group had a temperature of approximately 4,000 K.

D. The surrounding photosphere had a temperature of approximately 5,800 K.

E. The sunspots changed position over five days, moving from east to west across the Sun's face.

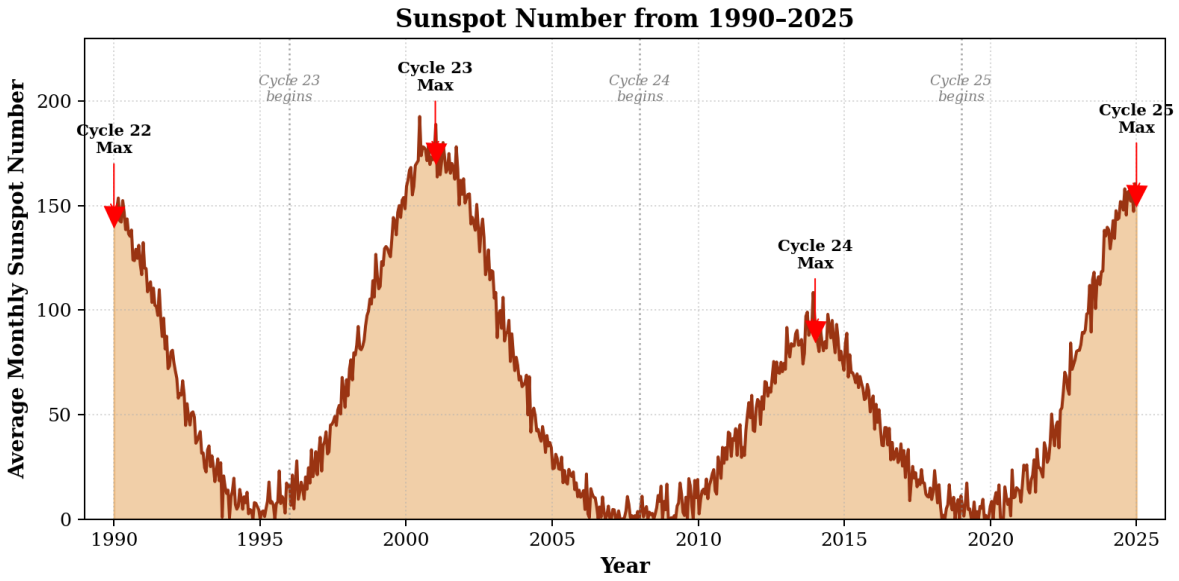
F. Light from the sunspot region showed a Zeeman splitting pattern in its spectrum, indicating a strong magnetic field.

Photograph of Sun Showing Sunspot Group



(Composite image of a sunspot group during Solar Cycle 25)

Cluster 3 — continued



5 Based on the student's observations, which set of observations correctly identifies evidence that the Sun rotates on its axis and that sunspots are caused by magnetic activity? ***[1]***

(1) Observations A, B, and C identify rotation and magnetic activity.

(2) Observations B, D, and F identify rotation and magnetic activity.

(3) Observations A, C, and D identify rotation and magnetic activity.

(4) Observations E, B, and F identify rotation and magnetic activity.

Answer: _____

6 Write the correct letter from the choices below on the line at the end of each sentence to complete each statement about Solar Cycle 25 and its impact on Earth. ***[1]***

Choices for Statement 1:

A — increase the risk of geomagnetic storms that can disrupt satellite communications and power grids

B — increase the amount of visible light reaching Earth's surface, raising global average temperatures by 5 °C

Choices for Statement 2:

C — decrease the number of solar flares and coronal mass ejections, providing safer conditions for astronauts in low Earth orbit

D — increase the number of solar flares and coronal mass ejections, producing more frequent auroras at high latitudes

Choices for Statement 3:

E — provide evidence that the Sun's magnetic activity is stable and unchanging across decades

F — provide evidence that the Sun's magnetic activity follows a predictable cyclical pattern of about 11 years

Statement 1: During solar maximum, increased sunspot activity will _____.

Statement 2: As Solar Cycle 25 reaches its peak, scientists expect it to _____.

Statement 3: Tracking sunspot numbers from 1990 to 2025 will _____.

Cluster 3 — continued

7 A student makes a claim that solar activity follows a predictable cycle and impacts technology on Earth. Using all the information provided in the reading and graph, which statement provides the most correct evidence to support this claim? ***[1]***

(1) Sunspot numbers have remained constant from 1990 to 2025, providing reliable conditions for satellites in orbit around Earth.

(2) Sunspot numbers peaked approximately every 11 years between 1990 and 2025, and during solar maximum the Sun releases more flares and CMEs that can disrupt power grids and satellites.

(3) Solar Cycle 25 began in 2019 and is the strongest cycle ever recorded, providing evidence that solar activity steadily increases across all future cycles.

(4) The graph shows that sunspot numbers decrease during solar maximum, which is when the Sun releases the fewest solar flares.

Answer: _____

Cluster 4 — Telescopes and Space Exploration

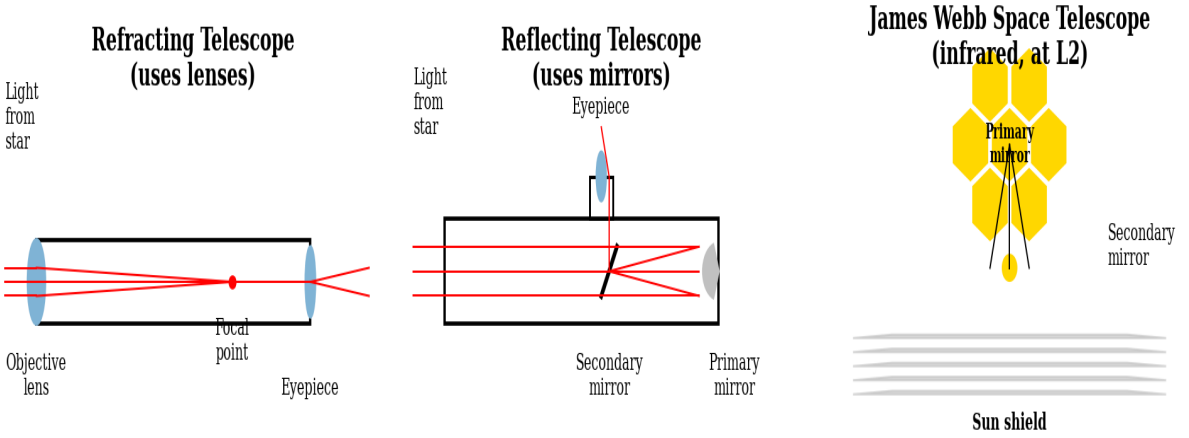
Base your answers to questions 8 through 10 on the information below and on your knowledge of Earth and Space Sciences. Some questions may require the use of the 2024 Edition Reference Tables for Earth and Space Sciences.

From Galileo to JWST: A History of Telescopes

Telescopes have transformed humanity's understanding of the universe. The first **refracting telescope**, used by Galileo in 1609, used glass lenses to bend (refract) light. Larger lens telescopes have a limit because heavy glass lenses sag under their own weight. To overcome this limit, Isaac Newton invented the **reflecting telescope** in 1668, which uses curved mirrors instead of lenses. Most large modern telescopes are reflecting telescopes.

Earth's atmosphere distorts incoming light and absorbs many wavelengths, which is why important telescopes are placed in space. The **Hubble Space Telescope** (launched 1990) operates in low Earth orbit at an altitude of about 540 km and detects visible, ultraviolet, and near-infrared light. The **James Webb Space Telescope (JWST)**, launched in 2021, orbits the Sun at the L2 Lagrange point about 1,500,000 km from Earth, and is optimized for infrared observations. JWST can detect the faint heat signatures of the earliest galaxies that formed after the Big Bang.

Radio telescopes, such as the FAST telescope in China and the former Arecibo telescope, detect radio waves from distant galaxies, pulsars, and quasars. Radio waves pass easily through Earth's atmosphere, so radio telescopes can be ground-based.



Cluster 4 — continued

Six statements about telescopes and space exploration are listed below.

Statement 1: Refracting telescopes use lenses to bend light, while reflecting telescopes use mirrors to focus light.

Statement 2: All telescopes must be placed in space to avoid distortion by Earth's atmosphere.

Statement 3: The James Webb Space Telescope is optimized for infrared observations and orbits the Sun, not Earth.

Statement 4: Radio telescopes cannot detect signals from Earth's surface because radio waves are absorbed by the atmosphere.

Statement 5: The Hubble Space Telescope detects visible, ultraviolet, and near-infrared light.

Statement 6: Galileo invented the first reflecting telescope in 1609.

8 Which statements correctly describe telescopes and space exploration? ***[1]***

(1) Statements 1, 3, 5

(2) Statements 2, 4, 6

(3) Statements 1, 4, 6

(4) Statements 3, 5, 6

Answer: _____

Cluster 4 — continued

9 A student claims that placing telescopes in space provides better observations of distant galaxies than ground-based telescopes do. Using the information from the reading, which statement provides the most correct evidence to support this claim? ***[1]***

(1) Space telescopes such as Hubble and JWST avoid atmospheric distortion and can detect wavelengths of light that are absorbed before reaching Earth's surface.

(2) Space telescopes are larger than ground-based telescopes and use bigger lenses to gather more light.

(3) Space telescopes are placed in low Earth orbit at all times to provide a stable view of the entire night sky.

(4) Space telescopes detect only visible light, which gives them an advantage over ground-based telescopes that detect radio waves.

Answer: _____

The data table below shows information about four objects that orbit Earth.

Object	Average Distance from Earth's Center (km)
International Space Station (ISS)	6,778
Hubble Space Telescope	6,920
Geostationary weather satellite	42,164
Earth's Moon	384,400

10 Using the data table, list the four objects in order from shortest orbital period around Earth to longest orbital period around Earth. Justify your response using one of Kepler's laws. ***[1]***

Shortest orbital period → _____

_____

_____

Longest orbital period → _____

Justification:

_____

_____

_____

Cluster 5 — Galaxies and the Expanding Universe

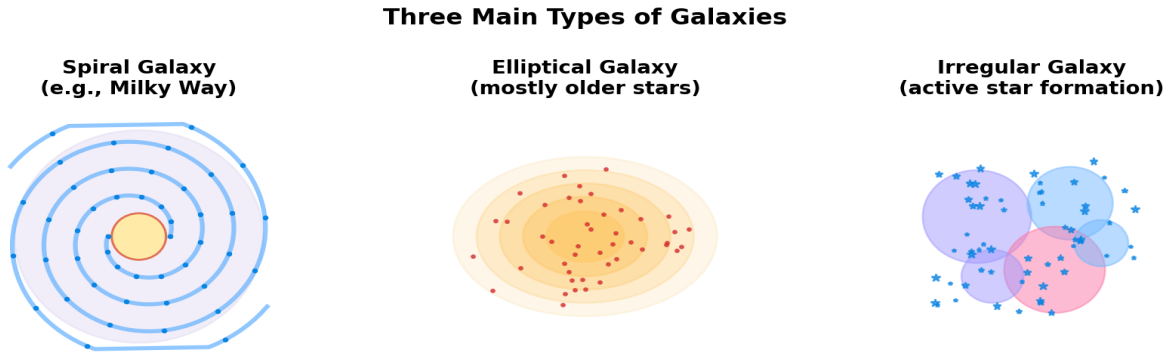
Base your answers to questions 11 through 15 on the information below and on your knowledge of Earth and Space Sciences. Some questions may require the use of the 2024 Edition Reference Tables for Earth and Space Sciences.

Hubble's Discovery and the Expanding Universe

In the 1920s, astronomer Edwin Hubble used the 100-inch telescope at the Mount Wilson Observatory to make a discovery that changed our understanding of the universe. By measuring the spectra of distant **galaxies** — large systems of stars, gas, and dust held together by gravity — Hubble found that nearly every galaxy outside our own Milky Way is moving away from us. Even more remarkably, he discovered that the farther away a galaxy is, the faster it is receding.

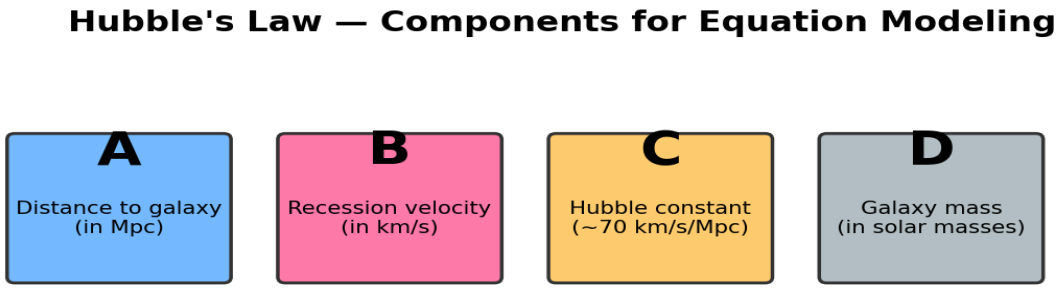
This relationship is now known as **Hubble's Law**: $v = H_0 \times d$, where v is the recession velocity of a galaxy (in km/s), d is the distance to the galaxy (in megaparsecs, Mpc), and H_0 is the Hubble constant (approximately 70 km/s/Mpc). Hubble's Law provides direct evidence that the universe is expanding. As space itself stretches, the wavelengths of light traveling through space are stretched too — a phenomenon called **redshift**. The greater a galaxy's distance, the more its light is shifted toward longer (redder) wavelengths.

Galaxies come in three main types. **Spiral galaxies**, like our own Milky Way, have rotating disks of stars with curved arms and contain both old and newly forming stars. **Elliptical galaxies** are smooth, rounded systems containing mostly older stars and very little gas or dust, so very few new stars are forming in them. **Irregular galaxies** have no defined shape and often contain large regions of active star formation.



Cluster 5 — continued

Four components of Hubble's Law, labeled A, B, C, and D, are shown below.



(One component above is not used in the equation.)

11 Complete the model of Hubble's Law by placing the letter of the correct component into each blank position in the equation. ***[1]***

$$\_\_\_\_\_ = \_\_\_\_\_ \times \_\_\_\_\_$$

(recession velocity) = (Hubble constant) × (distance to galaxy)

12 Which claim best describes how astronomers detect that distant galaxies are moving away from Earth? ***[1]***

(1) Light from galaxies appears blueshifted to shorter wavelengths, indicating that galaxies are moving away from Earth.

(2) Light from galaxies appears redshifted to longer wavelengths, indicating that galaxies are moving away from Earth.

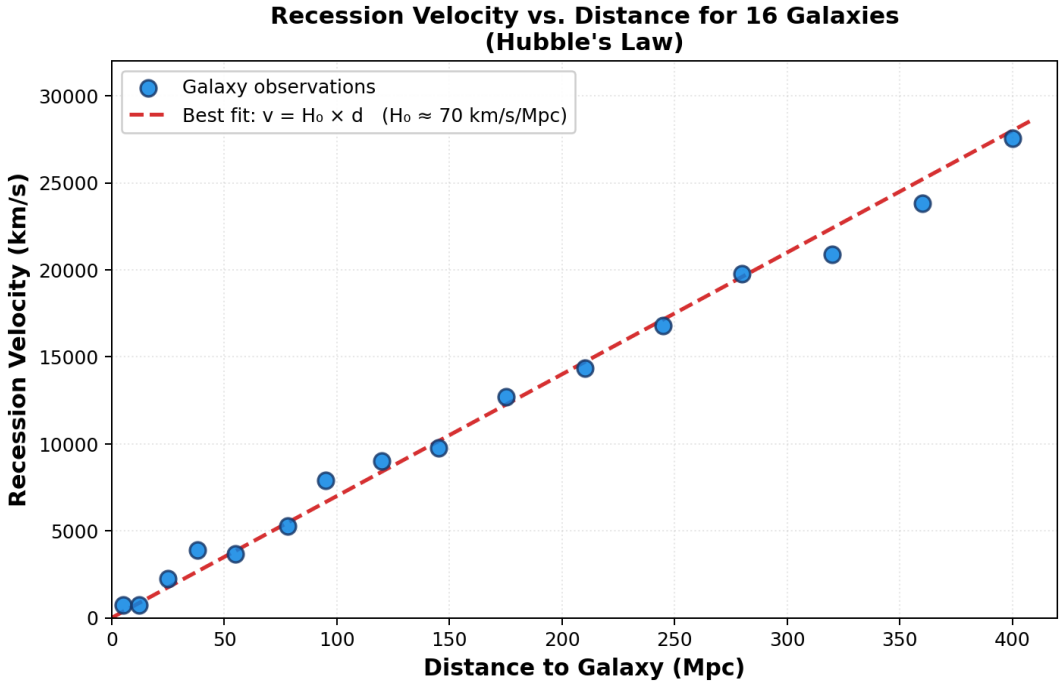
(3) Galaxies emit no light of their own, so astronomers detect their motion using only the gravitational pull on nearby stars.

(4) The brightness of every galaxy is increasing over time, which indicates that galaxies are moving toward Earth.

Answer: _____

Cluster 5 — continued

The graph below shows recession velocity versus distance for sixteen galaxies. The dashed line represents the best-fit relationship, also known as Hubble's Law.

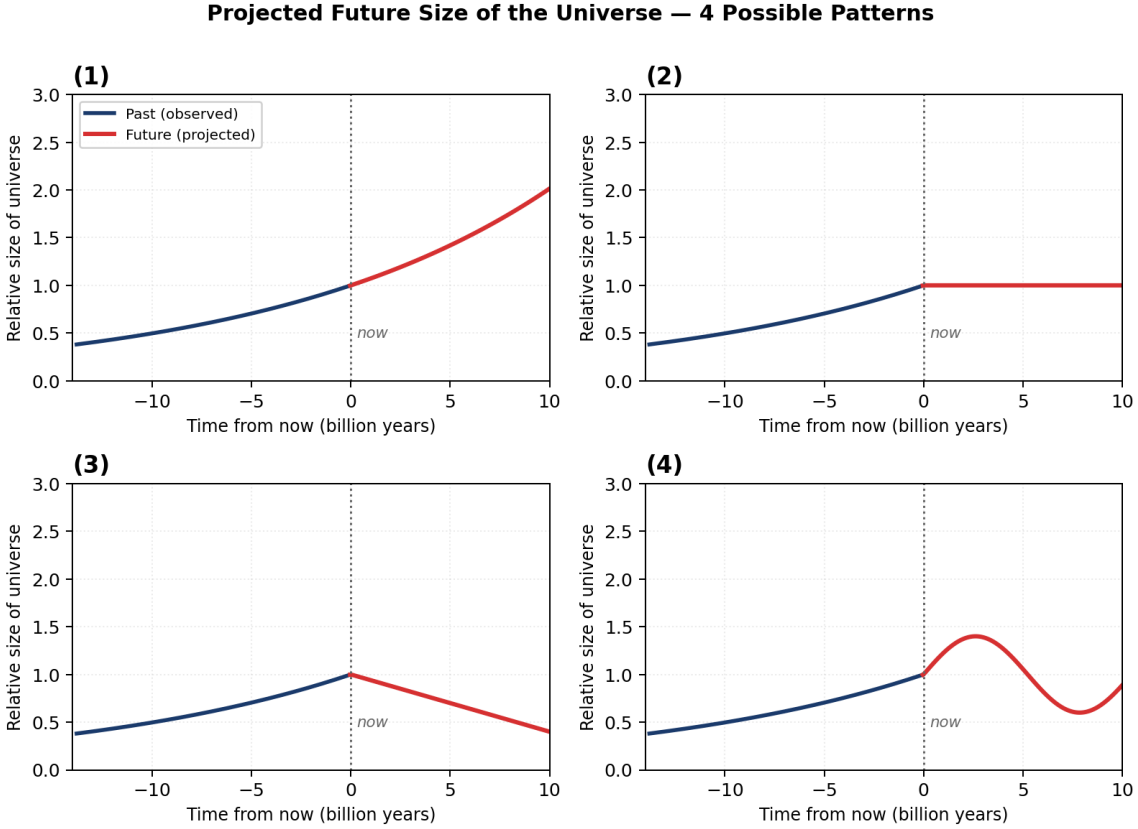


13 Use evidence from the graph to describe the relationship between the distance to a galaxy and its recession velocity. Then explain how this relationship provides evidence that the universe is expanding. ***[1]***

Cluster 5 — continued

Recent observations of distant supernovas have shown that the expansion of the universe is currently accelerating — that is, the rate of expansion is speeding up over time. Astronomers use this evidence, along with Hubble's Law, to predict the future size of the universe.

14 Which graph below best illustrates the projected size of the universe over the next 10 billion years, based on evidence from the data and the model? ***[1]***



Answer: _____

Cluster 5 — continued

The chart below summarizes some properties of the three main galaxy types.

Galaxy Type	Shape	Star Population	Gas & Dust	Star Formation
Spiral	Flat disk with curved arms	Mix of old and young stars	Abundant	Active
Elliptical	Smooth, rounded ellipse	Mostly older stars	Very little	Very limited
Irregular	No defined shape	Many young stars	Abundant	Very active

15 Which claim best describes how the type of a galaxy is related to its current rate of star formation? ***[1]***

(1) Elliptical galaxies form the most new stars because they contain mostly older stars.

(2) Spiral and irregular galaxies form new stars more actively than elliptical galaxies because they have abundant gas and dust available.

(3) All three galaxy types form new stars at the same rate because all galaxies contain the same amount of gas and dust.

(4) Irregular galaxies form the fewest new stars because they have no defined shape.

Answer: _____

Cluster 6 — Exoplanets and Habitable Zones

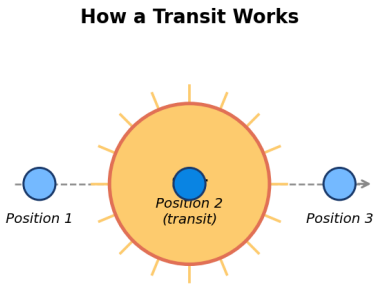
Base your answers to questions 16 through 20 on the information below and on your knowledge of Earth and Space Sciences. Some questions may require the use of the 2024 Edition Reference Tables for Earth and Space Sciences.

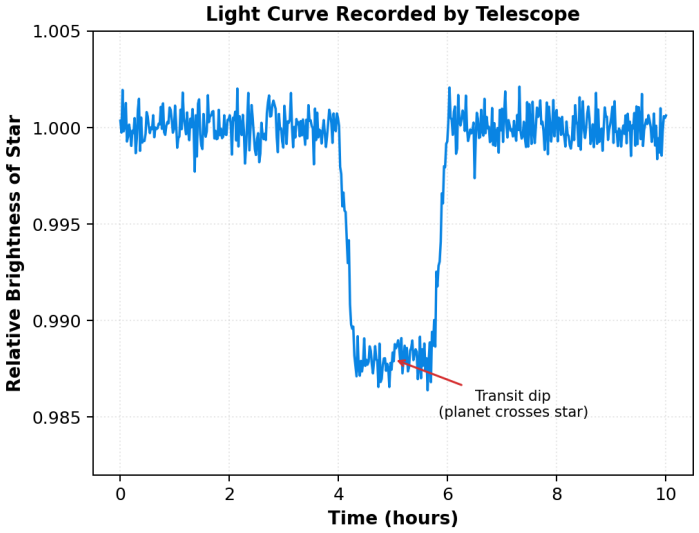
The Search for Worlds Beyond the Solar System

An **exoplanet** is a planet that orbits a star other than our Sun. Since the launch of NASA's **Kepler Space Telescope** in 2009, and more recently the Transiting Exoplanet Survey Satellite (**TESS**) in 2018, astronomers have confirmed the existence of more than 5,500 exoplanets. Most of these were detected using the **transit method**: when a planet passes in front of its host star, the star's brightness dips slightly. By measuring how much and how often a star's brightness dips, astronomers can calculate the size of the planet and its orbital period.

Of particular interest are planets that orbit within their star's **habitable zone** — the range of distances from a star where a planet's surface temperature could allow liquid water to exist. The location of the habitable zone depends on the star's temperature: hot stars have habitable zones far from the star, while cool stars have habitable zones close to the star. The **TRAPPIST-1 system**, discovered in 2017, contains seven Earth-sized rocky planets orbiting a small, cool red dwarf star located about 40 light-years from Earth. Three of these planets — TRAPPIST-1e, f, and g — orbit within the star's habitable zone.

The composition and density of an exoplanet provide important evidence about whether it is a small **terrestrial** (rocky) planet like Earth or a large **gas giant** like Jupiter. Terrestrial planets have higher densities (typically 3 to 6 g/cm^3) because they are composed mostly of silicate rock and metals. Gas giants have much lower densities (typically less than 2 g/cm^3) because they are composed mostly of hydrogen and helium.





Cluster 6 — continued

16 Which explanation about the transit method provides the best evidence for the existence of an exoplanet around a distant star? ***[1]***

(1) When a planet passes behind its star, the star's brightness increases, which allows astronomers to detect the planet directly through its own light.

(2) When a planet passes in front of its star, the star's brightness dips by a small, predictable amount; repeated dips of equal size and equal timing confirm the planet's existence and its orbital period.

(3) Exoplanets emit their own visible light, which can be detected as bright spots near their host star using ground-based telescopes.

(4) Exoplanets emit radio waves that interfere with starlight, causing the host star's brightness to fluctuate randomly over time.

Answer: _____

17 Describe how the brightness of a star changes during a planetary transit, and explain how the size of this brightness change provides evidence about the size of the exoplanet. Use evidence from the light-curve graph in your answer. ***[1]***

_____

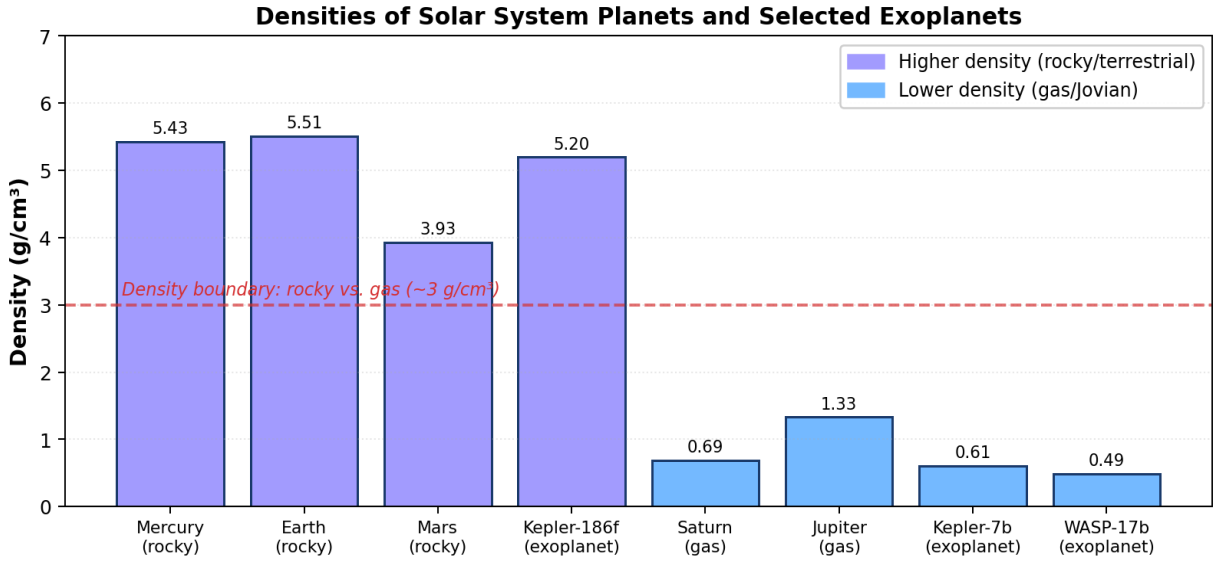
_____

_____

_____

Cluster 6 — continued

The bar graph below shows the densities of the three rocky planets nearest the Sun, two gas giants from our solar system, and three confirmed exoplanets.



18 Which statement correctly explains why the density of Kepler-186f provides evidence that it is a terrestrial (rocky) exoplanet rather than a gas giant? ***[1]***

(1) Kepler-186f has a density of about 0.61 g/cm^3, similar to Saturn, which is consistent with a planet made mostly of hydrogen and helium.

(2) Kepler-186f has a density of about 5.20 g/cm^3, similar to Earth and Mercury, which is consistent with a planet made mostly of rock and metal.

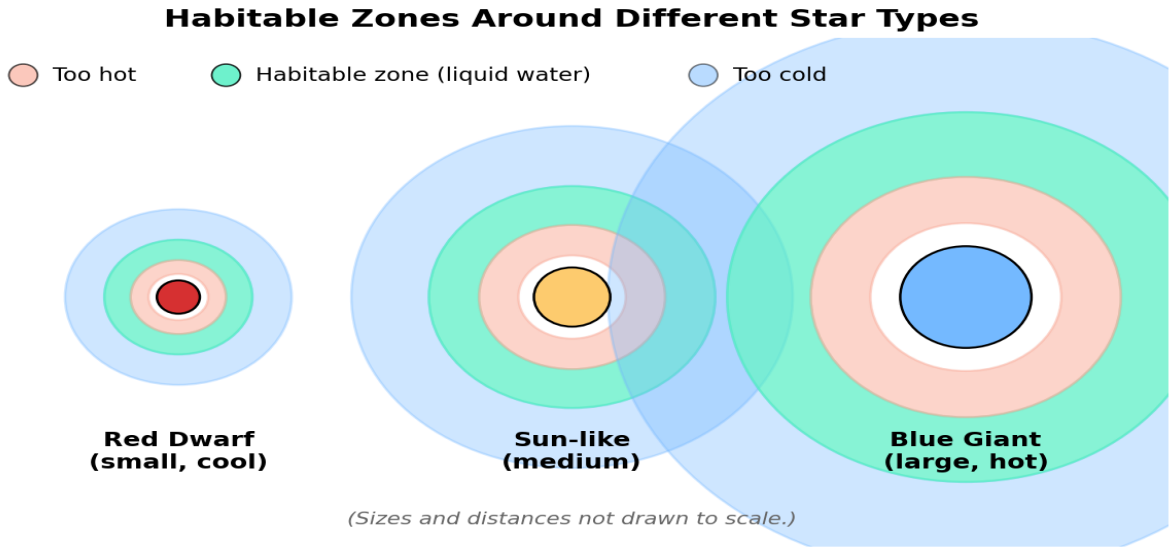
(3) Kepler-186f has a density of about 1.33 g/cm^3, similar to Jupiter, which is consistent with a planet made mostly of liquid water.

(4) Kepler-186f has a density of about 0.49 g/cm^3, similar to WASP-17b, which is consistent with a planet made entirely of solid iron.

Answer: _____

Cluster 6 — continued

The model below shows the habitable zones around three different star types. Notice that the habitable zone of a small, cool red dwarf is much closer to the star than the habitable zone of a Sun-like star.



The orbital motion of a planet around its host star is determined by the strength of the star's gravitational field at the planet's location. The same gravitational-field model used for satellites orbiting Earth applies: the gravitational field strength is *greater* when the orbiting body is *closer* to the central object, and the orbital period is *shorter* when the gravitational field strength is greater.

19 Use the word list to complete the passage by placing the correct terms on the lines below to describe how the orbital motion of a habitable-zone planet around a red dwarf star compares to Earth's orbital motion around the Sun. ***[1]***

Word List

A	B	C
closer	less	shorter
farther	greater	longer

Compared to the average distance from the Sun to Earth, the average distance from a red dwarf star to a planet in its habitable zone is **__A__**. As a result, the gravitational field strength of the red dwarf at the location of the planet is **__B__** than the Sun's gravitational field strength at Earth's location. Therefore, in order to remain in a stable orbit, the orbital period of the planet must be **__C__** than Earth's orbital period.

A: _____

B: _____

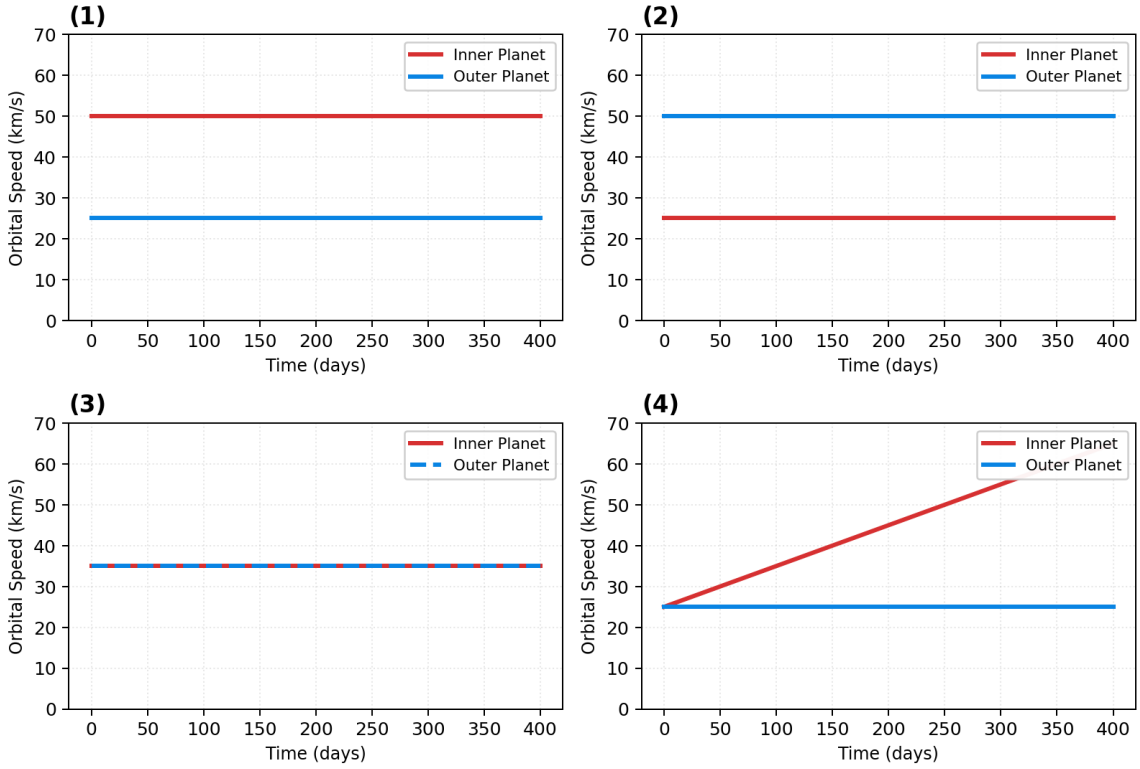
C: _____

Cluster 6 — continued

Suppose a star similar to our Sun has two confirmed exoplanets: an inner planet that orbits within the star's habitable zone, and an outer planet that orbits much farther away (like a gas giant). The inner planet completes one orbit every 50 days, while the outer planet completes one orbit every 200 days.

20 Based on Kepler's Laws, which graph below correctly represents the relative orbital speeds of the inner planet and the outer planet during the same time period? ***[1]***

Relative Orbital Speeds of Inner and Outer Planets — 4 Possible Graphs



Answer: _____

Final Grade

Each question in this cluster packet is worth **1 point** for a total of **20 points**. Calculate your final grade below.

Question	Type	Topic	Points Earned	Points Possible
1	X-box (3 statements)	Moon eccentricity	____	1
2	Statement combination	Moon orbital motion	____	1
3	X-box (3 statements)	Big Bang energy	____	1
4	Support / Refute	CMBR & redshift evidence	____	1
5	Observations identification	Sun rotation & magnetism	____	1
6	Letter completion	Solar Cycle 25 impacts	____	1
7	Evidence-based claim (MC)	Solar cycle predictability	____	1
8	Statement combination	Telescope basics	____	1
9	Evidence-based claim (MC)	Space-based observation	____	1
10	Ranking + justification	Kepler's Third Law	____	1
11	Letter labeling (model)	Hubble's Law equation	____	1
12	Evidence-based claim (MC)	Galaxy redshift	____	1
13	Constructed response	Hubble's Law graph	____	1
14	Pattern projection (MC)	Universe expansion	____	1
15	Evidence-based claim (MC)	Galaxy classification	____	1
16	Evidence-based claim (MC)	Transit method	____	1
17	Constructed response	Light curve & planet size	____	1
18	Evidence-based claim (MC)	Exoplanet density	____	1
19	Word list completion	Habitable zones & gravity	____	1
20	Graph identification (MC)	Kepler's Laws & orbits	____	1
		TOTAL	**____**	**20**

Grade Conversion Scale

Score	Percentage	Letter Grade
20 / 20	100%	A+
18 / 20	90%	A
16 / 20	80%	B
14 / 20	70%	C
12 / 20	60%	D (mastery floor)
≤ 10 / 20	≤ 50%	Re-do recommended

My Final Grade:

Score: _____ / 20 Percentage: _____ % Letter Grade: _____

Answer Key — Teacher Use Only

Detach this page or fold it under before distributing to students.

1. Statement 1: nearly circular because the value is close to 0. **Statement 2:** increases because the gravitational pull of Earth becomes greater. **Statement 3:** the Moon is near perigee, the closest point in its elliptical orbit. *(All three correct = 1 point.)*

2. (1) Statements 1, 3, 5. — A perfect circle has e = 0; Kepler's 2nd Law makes the Moon fastest at perigee and slowest at apogee.

3. Statement 1: energy released when the universe became transparent and electrons combined with nuclei. **Statement 2:** decreased because energy spread out over a larger volume. **Statement 3:** nuclear fusion reactions that occurred within the first 20 minutes after the Big Bang. *(All three correct = 1 point.)*

4. SUPPORT. CMBR and redshift are independent observations: CMBR is leftover thermal energy from the hot, dense early universe (consistent with the graph showing the universe cooling from ~10^{13} K to 2.7 K), while redshift of distant galaxies shows that space itself is expanding. Both observations are predicted by the Big Bang model.

5. (4) Observations E, B, and F. — E shows rotation (sunspots tracked east → west across 5 days); B confirms the latitude pattern of sunspots maintained as the Sun rotates; F (Zeeman splitting) is direct evidence of strong magnetic activity.

6. Statement 1: A. **Statement 2:** D. **Statement 3:** F. *(All three correct = 1 point.)*

7. (2) — The graph shows ~11-year peaks (Cycles 22, 23, 24, 25), and the reading ties solar maximum to flares/CMEs that disrupt power grids and satellites.

8. (1) Statements 1, 3, 5. — Statement 2 is false (radio telescopes work from the ground); Statement 4 is false (radio waves pass through the atmosphere); Statement 6 is false (Galileo built a refractor; Newton invented the reflector).

9. (1) — Space telescopes avoid atmospheric distortion and can detect wavelengths (such as UV and most IR) that are absorbed by Earth's atmosphere.

10. Order (shortest → longest period): ISS → Hubble → Geostationary satellite → Moon. **Justification:** Kepler's Third Law states that the square of the orbital period is proportional to the cube of the mean orbital distance ($T^2 \propto r^3$). Therefore, the object with the smallest distance from Earth's center (ISS, 6,778 km) has the shortest period and the object with the greatest distance (Moon, 384,400 km) has the longest period.

11. B = C × A. Recession velocity (B) equals the Hubble constant (C) multiplied by the distance to the galaxy (A). Component D (galaxy mass) is the distractor and is not used in Hubble's Law.

12. (2) — Light from receding galaxies is stretched to longer (redder) wavelengths. This redshift is direct evidence that distant galaxies are moving away from Earth as space itself expands.

13. Relationship: As the distance to a galaxy increases, the recession velocity also increases — a direct, linear relationship through the origin. **Evidence for expansion:** Because every galaxy is moving away from us, and more distant galaxies recede faster, space itself must be stretching uniformly in all directions, which is exactly what an expanding universe predicts.

14. (1) — Continuing accelerated expansion. Recent supernova observations show that the universe's expansion is speeding up, so the relative size of the universe should continue to increase at an increasing rate. Graphs (2) leveling, (3) contraction, and (4) oscillation contradict the data.

15. (2) — Spiral and irregular galaxies have abundant gas and dust (the raw material for new stars), so they have active or very active star formation. Elliptical galaxies have very little gas and dust, so very few new stars form.

16. (2) — A repeated, predictable dip of the same size and timing is the signature evidence that a planet is orbiting the star and crossing in front of it on each orbit. Choices (1), (3), and (4) describe processes that do not actually occur.

17. Brightness change: The star's brightness decreases (drops by a small amount, roughly 1.2% in the graph shown) for several hours while the planet is in front of the star, then returns to its original level after the planet has passed. **Evidence for size:** The deeper the dip, the more light the planet blocks, so the larger the planet must be relative to its star. A small dip indicates a small planet; a large dip indicates a large planet.

18. (2) — Kepler-186f's density of 5.20 g/cm^3 falls in the same range as Earth (5.51), Mercury (5.43), and Mars (3.93), all of which are above the ~3 g/cm^3 rocky/gas boundary. This high density is consistent with a planet made of rock and metal — a terrestrial planet.

19. A: closer. **B:** greater. **C:** shorter. *(All three correct = 1 point.)* Because the red dwarf is cooler, its habitable zone is closer to the star than Earth is to the Sun. A closer planet experiences a stronger gravitational field and therefore must orbit faster (in a shorter period) to remain in a stable orbit, consistent with Kepler's Third Law.

20. (1) — Per Kepler's Third Law, the inner planet (with the shorter period of 50 days) orbits at a higher constant speed than the outer planet (200-day period). Graph (1) shows the inner planet at a higher constant speed than the outer planet, which is correct.

Tags: *Mr. Brown's Science Labs · Earth and Space Sciences Regents · January 2026 Regents practice · August 2025 Regents practice · Big Bang theory · cosmic microwave background radiation (CMBR) · redshift · Hubble's Law · Hubble constant · expanding universe · spiral galaxy · elliptical galaxy · irregular galaxy · galaxy classification · accelerating expansion · supernovas · Moon orbit eccentricity · perigee · apogee · supermoon · Kepler's First Law · Kepler's Second Law · Kepler's Third Law · Sun · sunspots · Solar Cycle 25 · solar maximum · solar flares · coronal mass ejections (CMEs) · Zeeman splitting · refracting telescope · reflecting telescope · radio telescope · Hubble Space Telescope (HST) · James Webb Space Telescope (JWST) · L2 Lagrange point · electromagnetic spectrum · exoplanets · transit method · light curve · habitable zone · Kepler Space Telescope · TESS · TRAPPIST-1 · terrestrial planets · gas giants · planetary density · gravitational field · NYS Earth and Space Sciences Reference Tables (ESRT) 2024 Edition · NGSS HS-ESS1-1 · HS-ESS1-2 · HS-ESS1-3 · HS-ESS1-4 · cluster questions · constructed response.*