



National Evaluation Series™

NES

PROFILE

Earth and Space Science (307)

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NES Profile: Earth and Space Science (307)

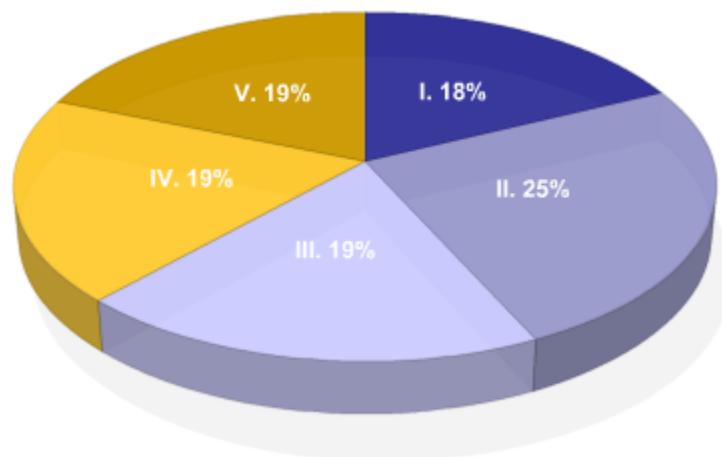
Overview

This *NES Profile* provides information about the test, including the approximate percentage of the total test score derived from each content domain. The complete set of the content domains, the test framework, is provided here and contains all of the competencies and descriptive statements that define the content of the test.

This *NES Profile* includes the following materials:

- » the test competencies associated with each content domain
- » a set of descriptive statements that further explain each competency
- » sample test questions aligned to the competencies
- » any applicable reference materials, as noted below

Test Field	Earth and Space Science (307)
Test Format	Multiple-choice questions
Number of Questions	Approximately 150
Test Duration	Up to 3 hours
Reference Materials	None required



Key	Approximate Percentage of Test	Content Domain	Range of Competencies
I	18%	I. Nature of Science	0001–0003
II	25%	II. Geology	0004–0007
III	19%	III. Oceanography and Freshwater Systems	0008–0010
IV	19%	IV. The Atmosphere, Weather, and Climate	0011–0013
V	19%	V. Astronomy	0014–0016

Content Domain I: Nature of Science

Competencies:

0001 Understand principles and processes of scientific inquiry.

Descriptive Statements:

- » Demonstrate knowledge of the principles and processes for designing and carrying out scientific investigations.
- » Apply methods and criteria for collecting, organizing, interpreting, analyzing, synthesizing, and presenting scientific data.
- » Recognize the evidential basis of scientific claims.
- » Demonstrate knowledge of safety procedures and hazards associated with Earth and space science investigations and the materials, equipment, and technology used in Earth and space science.
- » Apply appropriate mathematical procedures, units, and scientific notation in reporting data and solving problems in Earth and space science.

Sample Item:

A researcher collects water samples from a pond. The dissolved oxygen content of the samples will be measured later in a laboratory to determine the dissolved oxygen content of the pond's water. Which of the following procedural steps taken by the researcher will help ensure that the samples accurately reflect the dissolved oxygen content of the pond water?

- A. collecting samples from the surface in the same near-shore location and keeping the sample jars cool until testing is done
- B. filling sample jars to the top with water collected from several recorded depths and locations and then rapidly sealing them for storage
- C. allowing the samples to sit open for a period of time to equilibrate with atmospheric conditions and then sealing them until they are tested
- D. mixing the samples together to minimize differences that may result from human error and from the variability of the samples

Correct Response and Explanation

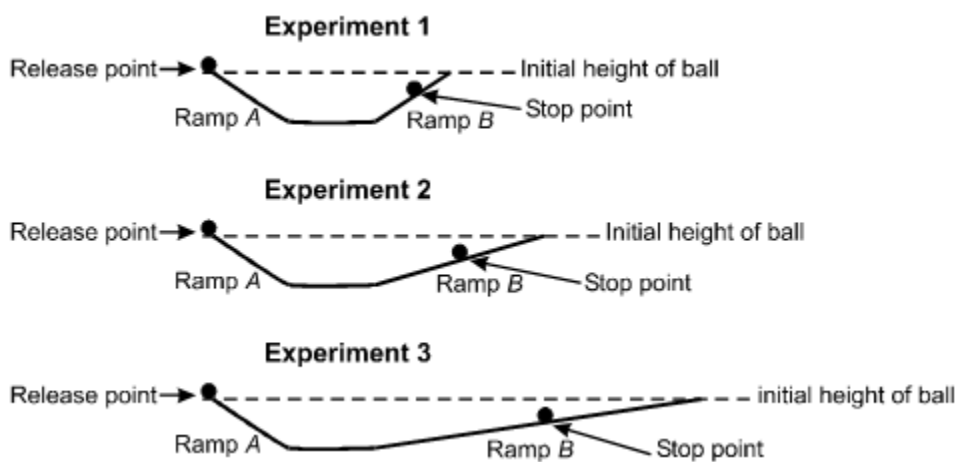
B. This question requires the examinee to apply methods and criteria for collecting scientific data. In this case, the examinee is required to evaluate proper collection procedures for water samples that will be collected from a pond. The water samples are to be analyzed later in a laboratory for dissolved oxygen content. The dissolved oxygen content of samples can change when the water is exposed to the atmosphere, so the sample containers should be filled to the top and rapidly sealed. Since the dissolved oxygen content of pond water can vary at different locations and depths, it is important that the sampling include several locations and that these details be recorded on the containers.

0002 Understand the history and nature of science.

Descriptive Statements:

- » Demonstrate knowledge of the historical development of major scientific ideas.
- » Demonstrate knowledge of major contemporary theories, models, and concepts in the other sciences, including physics, chemistry, and biology.
- » Demonstrate knowledge of unifying themes, principles, and relationships that connect the different branches of the sciences and the uses and limitations of models.
- » Demonstrate knowledge of the major principles of the nature of science and its characteristics as a system of inquiry.

Sample Item:



A researcher conducts three experiments as shown in the diagram above. In each experiment, a ball is released at the top of Ramp A. The researcher observes the ball as it rolls down Ramp A, across a flat surface, and up Ramp B, where it eventually stops and then rolls back toward Ramp A. The researcher predicts that if Ramp B was actually flat and friction did not slow the ball, the ball would roll forever. This series of experiments most closely resembles experiments conducted by:

- A. Archimedes as he developed his law of buoyant force.
- B. Kepler to explain the character of planetary motions.
- C. Galileo as he developed the concept of inertia.
- D. Newton as he developed his third law explaining action-reaction pairs.

Correct Response and Explanation

C. This question requires the examinee to demonstrate knowledge of the principle of inertia developed by Galileo and the inclined plane experiments associated with that work. In his writings, Galileo noted that a ball rolling down an inclined plane and then up a second inclined plane seeks to retain its original height, regardless of the angle of the second incline. From this observation, Galileo speculated that if the second inclined plane were instead a flat, frictionless plane, the ball would continue rolling at the velocity it had attained during its descent. Galileo's idea that an object resists change to its state of motion unless acted on by a force provided the basis for Isaac Newton's law of inertia.

0003 Understand the relationships between science, technology, engineering, and mathematics.

Descriptive Statements:

- » Analyze the interrelationships of science, technology, engineering, and mathematics in the Earth and space sciences.
- » Evaluate scientific research and the validity of coverage of science in the media.
- » Analyze social, economic, and ethical issues associated with technological and scientific developments.
- » Demonstrate knowledge of maps, models, and other geospatial technologies used to present scientific information.

Sample Item:

Which of the following technologies has been most widely used to locate offshore petroleum resources?

- A. sonar
- B. seismic wave reflection
- C. magnetometry
- D. ground-penetrating radar

Correct Response and Explanation

B. This question requires the examinee to analyze the interrelationship between a technology used in offshore petroleum prospecting and the laws of physics. Prospecting for petroleum resources with seismic reflection takes advantage of the differential reflection of seismic waves as they encounter different layers of material beneath the ocean floor. Sensitive instruments towed behind a boat and located below the water surface record the time it takes for the various reflected seismic waves to arrive at the recording devices. A series of these measurements can be used to identify different layers and structures beneath the ocean floor, including petroleum traps where petroleum deposits accumulate.

Content Domain II: Geology

Competencies:

0004 Understand historical geology.

Descriptive Statements:

- » Demonstrate knowledge of relative dating and the use of technology in absolute dating to develop the geologic time scale.
- » Recognize causes and consequences of major events in Earth's geologic history.
- » Demonstrate knowledge of Earth's origin and the development of the atmosphere and hydrosphere.
- » Demonstrate knowledge of the origin and history of life, the fossil record, the process of fossil formation, and the theory of evolution.

Sample Item:

Which of the following statements describes the scientific basis of radiometric dating?

- A. The radioactivity of a rock sample is inversely related to the amount of time that has passed since the rock was exposed at Earth's surface.
- B. The proportion of alpha particles to beta particles given off by radioactive elements in a particular rock is a measure of the rock's age.
- C. The concentration of different types of radioactive isotopes in a rock indicates the geologic period in which the rock formed.
- D. The proportion of radioactive parent atoms to daughter atoms in a rock is used to calculate the time that has elapsed since the rock formed.

Correct Response and Explanation

D. This question requires the examinee to demonstrate knowledge of the absolute dating of geologic events using the breakdown of naturally occurring radioactive isotopes. This technique, known as radiometric dating, relies on the fact that different radioactive isotopes have different decay rates that are constant under conditions found in Earth's outer layers. As a radioactive isotope decays, it produces decay products, known as daughter products, at a rate specific to that isotope. The proportion of the original radioactive isotope in a rock to the daughter products that have formed over time provides a tool for measuring the time that has elapsed since the rock first formed.

0005 Understand plate tectonics and the rock cycle.

Descriptive Statements:

- » Analyze the landforms and geologic features that result from tectonic processes, and the evidence and methods used to establish the theory of plate tectonics.
- » Demonstrate knowledge of the causes, characteristics, and impacts of different types of volcanic activity and the nature of erupted materials.

- » Demonstrate knowledge of the causes, characteristics, and impacts of the geologic faulting and folding associated with earthquakes and mountain building.
- » Analyze the physical and chemical processes involved in the formation of metamorphic, igneous, and sedimentary rocks within the rock cycle.

Sample Item:

The upwelling of magma in an active volcano has the greatest potential for producing a dangerous pyroclastic flow if the magma:

- A. contains a high concentration of dissolved gases and a high silica content.
- B. is basaltic and contains very little water vapor.
- C. contains low levels of volatile gases and erupts at a relatively high temperature.
- D. is andesitic and has a relatively low viscosity.

Correct Response and Explanation

A. This question requires the examinee to demonstrate knowledge of the characteristics of different types of volcanic activity. Pyroclastic flows are associated with explosive eruptions from composite cones. Typically, the magma has a high silica content, making the magma relatively viscous, and a high concentration of dissolved gases. As the magma moves upward, the gases in it are unable to escape from the magma because of its high viscosity. Pressure builds within the volcano toward a sudden explosive eruption. Pyroclastic flows can be triggered by a lateral explosion from a composite volcano or, more commonly, from the collapse of a tall eruption column emitted during a major explosion from the top of the volcano's main vent. Pyroclastic flows consist of a mix of heated gases, incandescent ash, and rock fragments that move rapidly down the slopes of a volcano, often at speeds over 100 miles per hour.

0006 Understand Earth materials, geologic resources, and Earth's internal structure.

Descriptive Statements:

- » Demonstrate knowledge of the origin, characteristics, and classification of minerals, soil types, and rocks.
- » Analyze the formation, extraction, and use of geologic resources.
- » Demonstrate knowledge of Earth's interior and the evidence and methods used to study Earth's internal structure.

Sample Item:

Which of the following physical properties is used to classify minerals in Bowen's reaction series?

- A. crystallization temperature
- B. specific gravity
- C. crystal form
- D. hardness

Correct Response and Explanation

A. This question requires the examinee to demonstrate knowledge of the classification of minerals. Bowen's reaction series is a mineral classification scheme that describes the sequence in which minerals crystallize from a magma as the magma cools. For example, minerals containing iron, magnesium, and calcium crystallize first from the hot magma, depleting the remaining magma of these elements. As the magma cools, the very last minerals to form from the depleted magma are potassium feldspar, muscovite mica, and quartz.

0007 Understand the processes of weathering, erosion, and deposition.

Descriptive Statements:

- » Analyze the processes and effects of physical and chemical weathering.
- » Analyze erosional processes and the impacts of erosion.
- » Demonstrate knowledge of the physical properties of alpine and continental glaciers and the ways in which they alter the landscape.
- » Demonstrate knowledge of the processes of sediment transport and deposition in aquatic and terrestrial environments.
- » Demonstrate knowledge of how climatic and geographic conditions affect the landscape.

Sample Item:

The formation of karst topography in regions underlain by limestone occurs when:

- A. calcium carbonate combines with water molecules to form a hydrated compound that is easily dissolved.
- B. alkaline groundwater saturates and erodes cracks within the bedrock due to a rise in the elevation of the water table.
- C. carbonic acid in groundwater reacts with calcite, forming calcium bicarbonate, a soluble mineral.
- D. tectonic uplift exposes marine sediments to physical weathering that breaks up carbonate rocks along bedding planes.

Correct Response and Explanation

C. This question requires the examinee to analyze the process that produces karst topography in regions underlain by limestone deposits. The development of karst topography begins with the chemical weathering of limestone as it reacts with groundwater. The groundwater is slightly acidic because it contains carbonic acid. The carbonic acid in groundwater is produced by the interaction of precipitation with carbon dioxide in the atmosphere and in soils. The carbonic acid in groundwater reacts with calcium carbonate (calcite), the primary component of limestone, to produce calcium bicarbonate. Since the calcium bicarbonate is a mineral that is soluble in water, it is carried away in the groundwater. Over geologic time, this chemical weathering process produces the caverns, sinkholes, and caves associated with karst topography.

Content Domain III: Oceanography and Freshwater Systems

Competencies:

0008 Understand the hydrologic cycle and its interaction with other Earth systems.

Descriptive Statements:

- » Analyze the physical properties of water, including energy changes that occur in the hydrologic cycle.
- » Demonstrate knowledge of the chemical properties of water and how water chemistry changes during the hydrologic cycle.
- » Analyze the interrelationship of the hydrosphere and other Earth systems.

Sample Item:

During which of the following phase changes would the greatest amount of energy per gram of water be released to the environment?

- A. Water evaporates from a reservoir on a hot and dry day.
- B. On a cold fall morning, frost forms on a lawn.
- C. Ice sublimates on a very cold and dry day.
- D. On an early summer morning, dew forms on a field.

Correct Response and Explanation

B. This question requires the examinee to analyze the energy changes that occur as water changes phase. Energy must be added to water to vaporize liquid water or melt ice, however energy is given off by water when the processes are reversed. Frost is a particular case in which water vapor is converted to ice without passing through a liquid phase. It is because of this that the formation of frost releases more heat than the phase change from gas to liquid that occurs during the formation of dew.

0009 Understand the composition, structure, and properties of oceans.

Descriptive Statements:

- » Demonstrate knowledge of the origins and physical structures of ocean basins and different types of coastlines.
- » Analyze the physical and chemical characteristics of ocean water.
- » Demonstrate knowledge of the causes and characteristics of ocean currents, waves, and tides.
- » Analyze the characteristics, formation, management, and use of geologic and biological marine resources.

Sample Item:

The continental shelf of the East Coast of the United States comprises:

- A. thin deposits of marine mud overlying the remnants of ancient limestone reefs.
- B. salt deposits alternating with layers of basalt.
- C. shifting sandbars overlying the eroded remains of uplifted oceanic crust.
- D. thick layers of sand, silt, and mud overlying granitic crust.

Correct Response and Explanation

D. This question requires the examinee to demonstrate knowledge of the physical structure of the continental shelf. The continental shelf is the submerged, gently sloping section of the continental margin that stretches from the coastline to the beginning of the much steeper continental slope. Abundant sediments, primarily from the erosion of the adjacent continent, can accumulate to a thickness of several kilometers. These sediments typically range from coarser material that is deposited near the coastline to silt and mud that accumulate farther out on the continental shelf.

0010 Understand the characteristics and properties of freshwater systems.

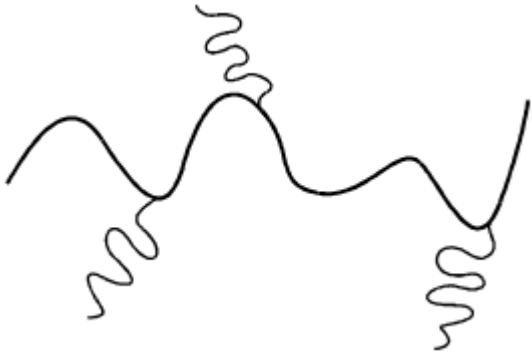
Descriptive Statements:

- » Demonstrate knowledge of the properties of surface water, factors affecting stream flow, the dynamics of drainage systems, and the functions of watersheds.
- » Demonstrate knowledge of the properties of groundwater, including factors affecting the movement, infiltration, extraction, and quality of groundwater resources.
- » Analyze geologic factors affecting the availability, use, and management of freshwater resources.

Sample Item:

A mature river system with a gentle grade flowing over coastal plain sediments is likely to have a configuration most similar to which of the following illustrations?

A.



B.



C.



D.



Correct Response and Explanation

A. This question requires the examinee to demonstrate knowledge of the characteristics of river drainage systems. A mature river flowing across a coastal plain composed of sediments will typically develop a meandering pattern due to the gentle slope of the coastal plain, the slow flow velocity of the river, and the nature of the fine-grained sediments through which it carves its channel.

Content Domain IV: The Atmosphere, Weather, and Climate

Competencies:

0011 Understand the structure and properties of the atmosphere.

Descriptive Statements:

- » Recognize the characteristics of the different layers and components of the atmosphere, and the role of gases and particulates in regulating conditions on Earth.
- » Analyze global wind patterns in relation to the Coriolis effect and the differential heating of Earth's surface by the sun.
- » Demonstrate knowledge of the causes and effects of changes to the atmosphere due to human or natural activities.

Sample Item:

In the year following the major eruption of the Mount Pinatubo volcano in the Philippines, a drop in mean global temperature was recorded. Which of the following factors was primarily responsible for this drop in global temperature?

- A. emission of sulfuric gases from the volcano into the lower stratosphere
- B. above-average precipitation in tropical regions
- C. ejection of particulates into the lower troposphere by the volcano
- D. increased levels of smog-forming nitrogen oxides in the troposphere

Correct Response and Explanation

A. This question requires the examinee to demonstrate knowledge of the effects of major volcanic eruptions on the climate system. The 1991 eruption of Mount Pinatubo in the Philippines provided an opportunity for scientists to evaluate the effects of a major eruption on climate. The eruption introduced over 25 million tons of sulfur dioxide into the stratosphere. The oxidation of the sulfur dioxide emitted by the volcano produced a haze of sulfuric acid droplets that spread throughout the stratosphere, significantly reducing the amount of sunlight reaching Earth's surface. This had the effect of lowering the average temperature of the troposphere by approximately 0.5°C following the eruption, while increasing the temperature of the stratosphere.

0012 Understand the characteristics of weather systems and the circumstances under which various weather conditions develop.

Descriptive Statements:

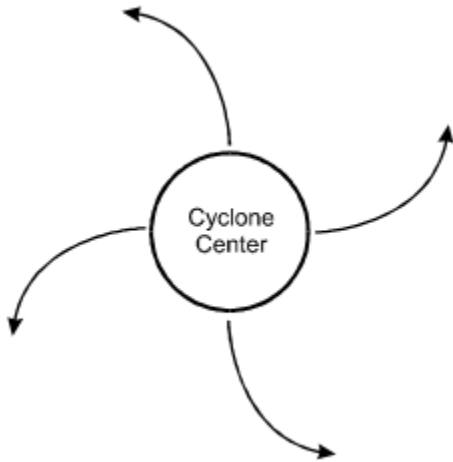
- » Demonstrate knowledge of the characteristics of high- and low-pressure systems, air masses, and fronts and the conditions under which these weather phenomena typically form.
- » Analyze the conditions that produce different types of clouds, precipitation, and weather, including the effects of the subtropical and polar front jet streams.

- » Analyze the effects of geography and/or bodies of water on weather formation, including severe weather.
- » Apply knowledge of weather maps and symbols and the instruments used to measure and predict weather conditions.

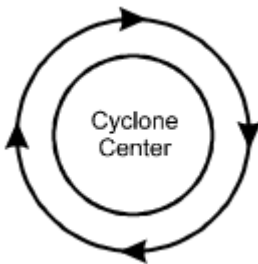
Sample Item:

A tropical cyclone in the Gulf of Mexico is moving slowly toward Florida. The flow of prevailing surface winds associated with the cyclone most closely resembles which of the following diagrams?

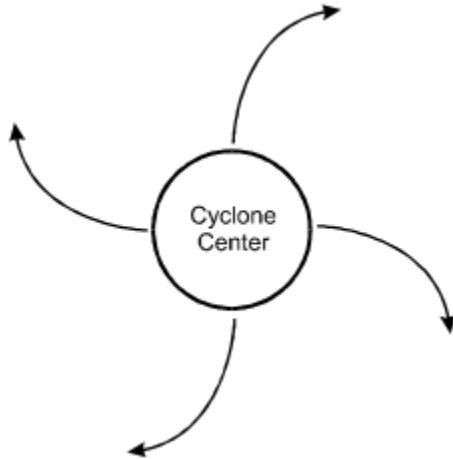
A.



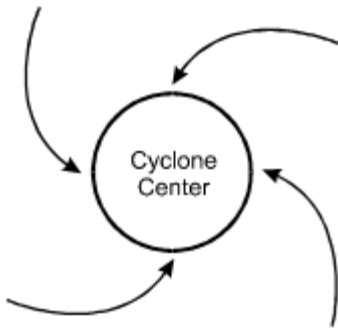
B.



C.



D.



Correct Response and Explanation

D. This question requires the examinee to demonstrate knowledge of the wind patterns associated with low-pressure systems in the northern hemisphere. A tropical cyclone is a large low-pressure system that rotates counterclockwise in the northern hemisphere due to the Coriolis effect, producing converging surface winds that pull in air from the surrounding region.

0013 Understand Earth's climate systems and the factors that influence climate.

Descriptive Statements:

- » Demonstrate knowledge of the biotic and abiotic characteristics of Earth's major climate regions.
- » Analyze the geographic factors and conditions responsible for unique climate phenomena, such as monsoons and the El Niño/Southern Oscillation (ENSO).
- » Demonstrate knowledge of the causes and effects of current and past changes in global climate, including the interrelationships of ecosystems, the hydrologic cycle, and human society.

Sample Item:

The once extensive grassland prairies of the upper Midwest typically did not include forests. Which of the following factors was primarily responsible for the absence of forests in this region?

- A. low annual precipitation
- B. winter and summer temperature extremes
- C. thin topsoil
- D. summer fires and strong winter winds

Correct Response and Explanation

A. This question requires the examinee to demonstrate knowledge of the limited rainfall that characterizes grasslands in general and the once extensive grassland prairies of the upper Midwest in particular. Although temperate grasslands have a fire ecology, grasses dominate in these regions primarily because the annual average rainfall is inadequate to sustain a forest ecosystem.

Content Domain V: Astronomy

Competencies:

0014 Understand the characteristics of stars, galaxies, and the universe.

Descriptive Statements:

- » Demonstrate knowledge of the sun's structure, life cycle, and energy production.
- » Demonstrate knowledge of the characteristics and evolution of different types of stars, including the process of nucleosynthesis.
- » Recognize the characteristics of the Milky Way Galaxy and other types of galaxies.
- » Analyze theories of the origin and nature of the universe and the characteristics of black holes, dark matter, supernovas, and quasars.
- » Demonstrate knowledge of the technology used to explore, and the evidence used to understand, the solar system, stars, extrasolar planets, galaxies, and the universe.

Sample Item:

Which of the following physical characteristics of a main-sequence star is the most important factor in determining its luminosity?

- A. total mass
- B. size of the corona
- C. chemical composition
- D. strength of the magnetic field

Correct Response and Explanation

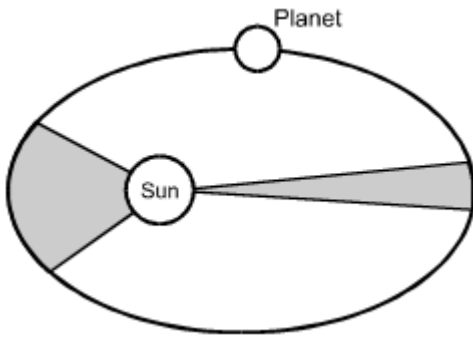
A. This question requires the examinee to demonstrate knowledge of the physical characteristics of stars. The luminosity of a star is a measure of the amount of energy it radiates each second. Based on research conducted during the 1920s, the astrophysicist A.S. Eddington discovered that the luminosity of a main-sequence star is determined by its mass. Eddington's discovery is the basis of the mass-luminosity relationship $L = M^3$, where the luminosity of a main-sequence star is equal to the star's mass cubed. Analysis of the energy emitted by a star continues to be an essential tool that astronomers use to deduce stellar properties, including composition, temperature, size, and mass.

0015 Understand characteristics and components of the solar system.

Descriptive Statements:

- » Demonstrate knowledge of the origin and structure of the solar system.
- » Recognize the position and characteristics of the planets and their satellites.
- » Recognize the origin and characteristics of comets, asteroids, and meteors.
- » Recognize the physical and mathematical models and laws that describe the motions of objects in the solar system.

Sample Item:



The diagram above shows the distance traveled by a planet at two different intervals in its solar orbit. The astronomer Johannes Kepler compared the two shaded gray areas of the ellipse in order to determine the:

- A. mass of planets with different orbital periods.
- B. diameter of the orbits of other planets.
- C. gravitational pull that the planet exerts on other objects.
- D. changing speeds at which a planet orbits the sun.

Correct Response and Explanation

D. This question requires the examinee to recognize the law developed by Johannes Kepler to describe the changing orbital speed of a planet as it travels around the sun. This law states that the orbital speed of a planet varies so that a line joining the sun and the planet will sweep over equal areas in equal time intervals. The graphic in the question represents the two equal areas that a hypothetical planet covers during two different but equal time periods in its elliptical orbit. Since the time periods are the same, but the distance covered during the two intervals is different, the orbital speed must be different.

0016 Understand the sun-moon-Earth system and the apparent motions of stars and planets.

Descriptive Statements:

- » Demonstrate knowledge of the physical characteristics of the moon and Earth, including theories on their origin and the evidence used to support those theories.
- » Analyze the interactions of the sun, moon, and Earth, including the effects of these interactions on Earth systems and the evolution of the sun-moon-Earth system.
- » Analyze the apparent motions of stars and planets relative to Earth, and the characteristics of the celestial sphere.

Sample Item:

The large dark areas of the moon known as maria are easily visible from Earth. Which of the following explains the presence of these dark areas?

- A. Massive volcanic eruptions emptied underlying magma caverns, causing their collapse and the formation of calderas.
- B. Shortly after the moon's formation, Earth's strong gravitational pull on the moon caused the release of magma from fissures in the crust.
- C. Large meteorites excavated huge craters that filled with low-viscosity basalt flowing from the fractures created in the underlying crust.
- D. When the moon was still semi-molten, thin areas of crust collapsed due to tectonic activity, creating low areas that trapped sediments.

Correct Response and Explanation

C. This question requires the examinee to demonstrate knowledge of the physical characteristics of the moon. The maria on the moon are large dark areas that formed when meteorites slammed into the moon, producing huge craters that then filled with basalt that flowed up into the craters through fractures in the moon's crust.

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