2022-2023, 9-12, Astronomy, Quarter 1

Big Ideas/Key Concepts

- Comprehending distance and mass on a cosmic scale is immensely difficult and requires scaling methods.
- Our understanding of the relationship between the earth, moon, sun and celestial bodies has evolved gradually over time.
- The night sky has always served mankind for the purposes of navigation, time keeping, culture and spiritual meaning.
- The are basic observational skills and techniques that allow virtually anyone to navigate the night sky.

Standards	Student Friendly "I Can" Statements
<u>Earth's Place in the Cosmos</u> The student will express distance and time on several scales and relate them. The student will relate the relative motion of the earth, moon and sun into time-keeping methodologies and relate them to our seasons. The student will describe the circumstances that give rise to solar and lunar eclipses.	**<u>Earth's Place in the Cosmos</u>** *I can use appropriate units and scaling to compare the relative distances between astronomical objects and the relative masses of astronomical objects. *I can describe the gravitational relationship between the earth and the moon and how this relationship affects each body. *I can provide the causality of the lunar phase cycle and the geometric relationship between the earth, moon and sun during each phase. *I can explain how the properties of the period of rotation and revolution for a celestial object give rise to definitions of times and seasons.

The student will describe the lunar cycle of phases.	*I can develop a model to show the spatial relationships between the earth, moon and sun and the shadows cast during both lunar eclipses and solar eclipses.
The student will construct a model using astronomical distances to explain the spatial relationships and physical interactions among planetary systems, stars, multiple-star systems, star clusters, galaxies, and galactic groups in the universe.	*I can locate various celestial locations on the celestial sphere using the right ascension and declination coordinate system. *I can create an accurate and realistic scale model of distance between a known group of celestial objects given the actual average distances between those objects.
<u>Historical Astronomy</u>	**<u>Historical Astronomy</u>**
The student will explain how our model of the universe has progressed from a Ptolemaic view all the way to big bang cosmology	*I can describe the origin and evolution of the study of the sky over time and how it influenced mankind’s understanding and behavior.
The student will explore the contributions of other great fathers of astronomy such as Galileo, Copernicus, Brahe and others.	*I can explain the concept of a solar system as it has adapted over time from simple geocentric models to the present heliocentric model *I can describe how fundamental queries such as “how big is the earth” were answered thousands of years ago by scientists such as Erathosthenes, etc.
The student will state and apply Kepler’s laws of planetary motion to describe the elliptical motion of celestial bodies	*I can prove that the mathematical foundations laid by Kepler and Newton allow us to make precise astronomical predictions and have shown us how to escape the gravity of our own planet.
The student will cite Newton’s law of universal gravitation and Einstein’s theories of general and special relativity to form a more complete understanding of gravity.	*I can use a conceptual description of Einsteinian relativity to differentiate between Newton’s concept of gravity and the more complete explanation of mass curving space as given by Einstein. *I can apply graphical techniques to determine the eccentricity and period of an orbit given the periapsis and apoapsis of the orbit.

Observational Astronomy I: "Backyard Astronomy"	Observational Astronomy I: "Backyard Astronomy"
The student will learn how to make unaided observations of the constellations visible in the northern hemisphere The student will learn how to use technology (star-finding apps and conventional maps) to locate celestial objects in the sky The student will know how to identify and seek out the optimal conditions for successful observation, including negating light pollution to the best of their ability.	* I can distinguish between constellations and asterisms. *I can identify all the circumpolar and common constellations in the northern hemisphere and use those constellations to "navigate" to others as the ancients did. *I can identify the ecliptic in the sky by the usage of traditional zodiac constellations. *I can use basic observational techniques such as averted vision, dark adaptation and "red light rules" to ensure greatest success during field observations *I can use handheld software applications to assist in the location of various celestial objects in the sky, to include manmade objects such as the International Space Station *I can use valid "dark sky maps" based on the Bortle Index to select the most appropriate observation sites.

2022-2023, 9-12, Astronomy, Quarter 2

Big Ideas/Key Concepts

- The great majority of energy in the universe cannot be detected by direct or visible observations.
- By studying a composite of the electromagnetic energies given off by an object, we gain a much more complete image of that object.
- The basic purpose of telescopes is to gather as much light as possible with the biggest objective device possible; not to magnify.
- The Hubble Space Telescope and other similar observatories have completely redefined our view and understanding of the cosmos.
- Terrestrial planets have great bulk similarities but vary wildly in atmospheric nature; Jovian planets appear to have great similarity.
- Exoplanets are being discovered at an extraordinary rate, including some that have significant similarities to our planet.

Standards	Student Friendly "I Can" Statements
<u>Observational Astronomy II: "Light and Telescopes"</u>	**<u>Observational Astronomy II: "Light and Telescopes"</u>**
The student will learn the various means of detecting energy in the universe given off in the EM spectrum that is not visible to the human eye	*I can distinguish between the various forms of electromagnetic energy and differentiate between those that can penetrate the atmosphere from those that are absorbed or reflected by the atmosphere.
The student will communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.	*I can describe some of the difficulties in making observations of high energy waves and exotic measurements such as the mapping of dark matter, etc. *I can explain how astronomers create "false color" imagery in order to provide people with a visual representation of energy not in the visible wavelength.
The student will learn the fundamental differences between refracting and reflecting telescopes, and how to make basic operations with simple telescopes in observation.	*I can verbally and graphically demonstrate understanding of the optics of both a simple refracting telescope and a simple reflecting telescope. *I can provide some of the strengths and weaknesses of both reflectors and refractors and give means of correction for those respective weaknesses.

The student will explain how observatories and large digital telescopes are used to image deep space objects and to track various threats to our survival and benefits to society.	*I can identify the criteria and characteristics that go into the building and placement of the world's most successful radio and optical telescopes. *I can provide data and historical context to prove that the Hubble Space Telescope has had a profound impact on society and altered our view of the universe.
<u>Planetary Astronomy</u>	**<u>Planetary Astronomy</u>**
The student will make fundamental comparisons between the physical properties of terrestrial planets and Jovian planets.	*I can explain and model relative motion of planets in the sky relative to those of distant stars by means of parallax. *I can provide the tenants of the definition of a planet as proposed by the I.A.U. in 2006, and thus define the "dwarf planet" classification
The student will compare and contrast the terrestrial planets of our solar system.	*I can explain that slight variance in magnetic field and atmosphere lead to the significant variations of surface conditions present on our terrestrial planets. *I can provide the many physical similarities that Jovian planets share, including their chemical composition being very similar to that of stars.
The student will compare and contrast the Jovian planets of our solar system.	*I can characterize the more massive moons of our solar system, and explain their relative interest to us in our search for organic materials and resources (including moons like Europa, Titan, Enceladus, etc.)
The student will examine the physical characteristics of the Jovian moons and relate those to inner planet characteristics.	*I can describe how telescopes such as the Kepler Observatory find and confirm exoplanets around distant stars by observing a change in the "light curve" of the star as the exoplanet transits the star.
The student will determine how exoplanets are discovered and explain the significance of those discovered in the habitable zones of their host stars.	*I can categorize exoplanets into various categories based on their potential size, temperature, and relative habitability.

The student will analyze and interpret data to compare, contrast, and explain the characteristics of objects in the solar system including the sun, planets and their satellites, planetoids, asteroids, and comets. Characteristics include: mass, gravitational attraction, diameter, and composition.	*I can use data from Kepler and other ground observatories to refine our estimation for the number of planets that may exist in our galaxy.

2022-2023, 9-12, Astronomy, Quarter 3

Big Ideas/Key Concepts

- Solar systems are filled with debris from collisions and failed protoplanets that orbit their stars at varying distances.
- Asteroids and comets pose humanity with the dangers of mass extinction but also with the promise of incredible wealth and resource.
- Various strategies for protecting the earth from impact have been proposed and engineering a better solution seems necessary.
- The “race to the moon” was initially fueled by political aspiration but has since become part of mankind’s common heritage.
- Exploration of space so far has been severely limited by the cost, technology of propulsion, duration, and risk to human life involved.
- The rise of the private sector in exploration in collaboration with NASA may be giving rise to a new age of “space race” in our time.
- The exploration of space exerts significant influence on global technologies, economies, militaries and politics.

Standards	Student Friendly “I Can” Statements
Planetary Debris (Asteroids, Meteors, Comets, etc.)	**Planetary Debris (Asteroids, Meteors, Comets, etc.)**
The student will differentiate between asteroids, meteoroids and comets in composition and behavior.	*I can differentiate between meteors, meteorites, meteoroids, asteroids and comets.
The student will determine how previous impact craters that have been weathered and eroded with time can be experimentally validated as previous impacts.	*I can describe the various lines of evidence used to validate former impact sites and how the age and the relative size of the impactor can be determined.
The student will apply scientific reasoning and evidence from ancient Earth materials, meteorites, and other planetary surfaces to construct an account of Earth’s formation and early history.	*I can explain the differences in composition, orbital mechanics and relative velocity between asteroids and comets.
The student will examine the bulk characteristics of the asteroid belt, the Kuiper Belt and the Oort Cloud.	*I can use data acquired from earth’s surface, the lunar surface and Martian meteorites to help inform a model of planetary and lunar formation.

The student will examine the physical difficulties that would be encountered in the event of an impact and examine close calls such as the 2013 Chelyabinsk incident.	*I can describe multiple strategies for the mitigation of threat from an earthbound impactor, to include the gravity tractor, kinetic impactor, standoff blast, solar ablation and others.
The student will explore mitigation strategies that might be implemented as a means of circumventing possible disaster in case of certain earth impact.	*I can characterize the potential opportunity in asteroid mining (especially in rare earth metals and water) that might allow mankind to extend their presence further into the solar system.
The student will identify potential resources that mankind might be able to utilize from asteroids if they could be deliberately accessed.	*I can describe methods of asteroid detection and programs (such as the Near Earth Object program) who actively search for NEOs.
Space Exploration	**Space Exploration**
The student will explore the circumstances that gave rise to the "space race" between the United States and the Soviet Union in the 1960's.	*I can provide the scientific and political motivations that propelled the initial manned exploration of the heavens, and why progress in this endeavor has slowed dramatically from its initial pace. *I can describe the necessary steps that were required for a successful manned lunar landing and the safe return of those individuals to earth.
The student will examine the successes and failures of the Mercury, Gemini, Apollo and Space Shuttle programs in America's exploration of space.	*I can document the successes of the space shuttle program but also its ultimate demise due to the expenses involved in the refurbishing and reusing the vehicle. *I can make scientific arguments for the advantageous nature of both unmanned robotic exploration and for manned exploration of the solar system.
The student will compare and contrast the benefits of manned exploration versus the exploration done by probes and rovers.	*I can name technological benefits derived from the world's space programs, to include microcomputers, global communications, GPS, aerodynamics improvements, solar and weather forecasting, etc.
The student will look at direct and indirect benefits of space exploration to the scientific stimulation and the economy of a nation.	

	*I can explain the basic orbital mechanics of a launch, how orbit is achieved, and how a trajectory to another body may be most effectively achieved (to include gravitational assists).
The student will research potential targets for future missions involving exploration and debate the merits of returning to the moon or directly pursuing a Mars landing.	*I can summarize the current and short-term goals of NASA and the goals of predominant private space enterprises and how they are attempting to fulfill those goals. *I can propose possible solutions to difficulties that may await humans if they leave earth and become a multi-planet species.
The student will evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural and environmental impacts.	*I can communicate understanding of contemporary events involving astronomy and space exploration and describe how they influence various aspects of modern society.

2022-2023, 9-12, Astronomy, Quarter 4

Big Ideas/Key Concepts

- The sun is our key to survival and provides the ultimate blueprint for energy, and yet poses life-threatening risks to mankind as well.
- Our understanding of solar dynamics and the sun's complex magnetic field are necessary to maintain our current way of life.
- Stars, through different processes, can create all the elements that make up conventional matter.
- Mass is the critical physical property of a star that determines how the star "lives" and eventually how it "dies".
- A star will undergo complex changes during its evolution that will eventually lead to its cataclysmic demise.
- Cosmology examines time and space on the largest possible scales and leads to many new unanswered and exciting questions.
- Despite all of mankind's innovation and learning, scientists are still unsure as to what composes most of the matter in the universe.

Standards	Student Friendly "I Can" Statements
<u>Stellar Properties and Evolution</u> The student will learn the bulk physical characteristics of the sun and the critical role it plays in preserving life on earth. The student will communicate scientific ideas to explain the nuclear fusion process and how elements with an atomic number greater than helium have been formed in stars, supernova explosions, or exposure to cosmic rays. The student will develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fusion in the sun's core to release energy that eventually reaches Earth in the form of radiation.	**<u>Stellar Properties and Evolution</u>** *I can characterize the internal structure of the sun and the relative variance in temperature from core moving out to the corona. *I can describe the sudden release of energy from the sun (in the forms of flares, prominences, coronal mass ejections, etc.) and how it relates to the changes in the sun's magnetic field. *I can explain how a star achieves hydrostatic equilibrium and the internal consequences to the star when it goes out of equilibrium. *I can create a model of the proton-proton fusion chain and explain how the sun creates energy and releases light in the form of photons.

The student will learn the importance of the earth’s magnetic field as it relates to the protection from solar wind and radiation. The student will explain how stars are classified by spectral class and by luminosity. The student will analyze and interpret data about the mass of a star to predict its composition, luminosity, and temperature across its life cycle, including an explanation for how and why it undergoes changes at each stage. The student will explain the “main sequence” and place stars on a Hertzsprung-Russell diagram based on their luminosity and temperature. The student will describe the various “death” possibilities for stars or a stellar system based upon their mass and interactions, to include planetary nebulae and supernovae processes, and eventually ending with their remnants as white dwarves, neutron stars or black holes.	*I can explain nucleosynthesis and the conditions under which it occurs in stars. *I can describe the role the earth’s magnetosphere plays in protecting earth from solar radiation and how it gives rise to aurora. *I can explain how the stellar property of mass determines the luminosity, temperature, color and the life span of a star. *Given a star’s brightness, temperature and relative size, I can classify stars into the appropriate spectral class and luminosity class. *I can explain stellar evolution as a star exits the “main sequence” through its final state, describing the changes that the star undergoes at each step. *I can create a Hertzsprung-Russell diagram for known stars and explain the significance of this diagrams “main sequence” to the evolution of the stars plotted. *Given a star’s mass, I can predict how the estimated time that the star will undergo regular fusion, how the “life” of the star will come to an end, and what remnants will remain after fusion ceases.

Galaxies and Cosmology	**Galaxies and Cosmology**
The student will describe the bulk structure of galactic distribution of stars.	*I can distinguish between the nature of stars in the galactic disc, galactic bulge and the galactic halo.
The student will differentiate between spirals, barred spirals, ellipticals and irregular galaxies.	*I can classify galaxies into class and subclass based upon their appearances and describe the approximate distribution of galaxies into each category.
The student will explore the nature of interstellar space and explore the birth of stars from within nebulae	*I can explain the formation of some irregular galaxies based upon the interactions or “collisions” of two or more galaxies.
The student will explore the science of cosmology and describe the tenants of the big bang theory	*I can explain the process by which a new protostar might emerge from the clouds and dust within a stellar nebula.
	*I can state and apply the cosmological principle as it applies to observations and descriptions of the entire observable universe.
	*I can explain the concept of “critical density”, and how this concept relates to the possible “geometry” of the universe.
The student will describe the potential fates of the universe given our current understanding of dark energy and dark matter	*I can hypothesize an eventual fate of the universe based upon our understanding of the quantity of “dark energy” compared to the quantity of “dark matter” in the universe.
The student will construct an explanation regarding the rapid expansion of the universe based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe.	*I can explain the tenants of cosmic inflation and the fundamentals of the “big bang” theory as a cosmological model for universal origin.
	*I can describe experimental evidence that lends support to the concept of inflation and expansion.
The student will give criteria and methodologies that may allow us to detect extrasolar life.	*I can explain the methods by which space agencies and private corporations have searched for extrasolar life to this point in time, and why these groups have special interest in certain regions of space.

	*I can describe the parameters set forth in the Drake equation predicting extrasolar intelligence and explain why the final answer that it yields may deviate significantly from individual to individual.