



DUBLIN
CITY SCHOOLS

K-12 SCIENCE
Graded Course of Study
2025



Dublin City Schools K-12 Science Graded Course of Study

A K-12 Dublin City Schools science education aims to create lifelong learners who are curious, critical thinkers, and effective collaborators, equipped with the scientific knowledge and skills necessary to navigate and shape a complex and ever-changing world.

Our vision is to inspire students to develop a deep appreciation for science and its applications, empowering them to:

- Ask questions, seek answers, and explore the natural world with a sense of wonder and curiosity.
- Think critically and creatively to solve problems and make informed decisions as a scientifically literate citizen.
- Communicate and collaborate effectively in our diverse community and beyond to address common challenges and create innovative solutions.
- Build their own identity as a scientist in order to apply scientific concepts and methods to understand and address real-world issues competently and confidently.
- Develop the resilience, adaptability, and perseverance needed to succeed in a rapidly evolving world.

Instructional Agreements for Science Learning within the Dublin City Schools

- Teachers will provide opportunities for students to engage in hands-on experiences, projects, and real-world simulations to provide context and relevance to science concepts.
- Teachers will create an environment that emphasizes the importance of effort, perseverance, and reflection in order to learn and grow from both success and failure.
- Content standards will be learned in conjunction with best practices regarding science education.

Together, we will cultivate resourceful, adaptable, and collaborative individuals with the ability to tackle real-world challenges with resilience and innovation.



Dublin City Schools
K-12 Science Graded Course of Study

Nature of Science

One goal of science education is to help students become scientifically literate citizens able to use science as a way of knowing about the natural and material world. All students should have sufficient understanding of scientific knowledge and scientific processes to enable them to distinguish what is science from what is not science and to make informed decisions about career choices, health maintenance, quality of life, community and other decisions that impact both themselves and others.

Scientific Inquiry, Practice and Applications

All students must use these scientific processes with appropriate laboratory safety techniques to construct their knowledge and understanding in all science content areas.

Science is a Way of Knowing

Science assumes the universe is a vast single system in which basic laws are consistent. Natural laws operate today as they did in the past and they will continue to do so in the future. Science is both a body of knowledge that represents a current understanding of natural systems and the processes used to refine, elaborate, revise and extend this knowledge.

Science is a Human Endeavor

Science has been, and continues to be, advanced by individuals of various races, genders, ethnicities, languages, abilities, family backgrounds and incomes.

Scientific Knowledge is Open to Revision in Light of New Evidence

Science is not static. Science is constantly changing as we acquire more knowledge.

Scientific and Engineering Practices:

1. Asking questions (for science) and defining problems (for engineering)
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations (for science) and designing solutions (for engineering)
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information



Dublin City Schools
K-12 Science Graded Course of Study

Ohio's Cognitive Demands for Science

Educators will refer to "Ohio's Cognitive Demands for Science" to create experiences for students to engage in science content and demonstrate understanding of scientific concepts in ways that align with current research about how people learn.

**DESIGNING TECHNOLOGICAL/
ENGINEERING SOLUTIONS
USING SCIENCE CONCEPTS**

Requires students to solve science-based engineering or technological problems through application of scientific inquiry. Within given scientific constraints, propose or critique solutions, analyze and interpret technological and engineering problems, use science principles to anticipate effects of technological or engineering design, find solutions using science and engineering or technology, consider consequences and alternatives, and/or integrate and synthesize scientific information.

**DEMONSTRATING SCIENCE
KNOWLEDGE**

Requires students to use scientific practices and develop the ability to think and act in ways associated with inquiry, including asking questions, planning and conducting investigations, using appropriate tools and techniques to gather and organize data, thinking critically and logically about relationships between evidence and explanations, constructing and analyzing alternative explanations, and communicating scientific arguments. (Slightly altered from National Science Education Standards)

**INTERPRETING AND
COMMUNICATING SCIENCE
CONCEPTS**

Requires students to use subject-specific conceptual knowledge to interpret and explain events, phenomena, concepts and experiences using grade-appropriate scientific terminology, technological knowledge and mathematical knowledge. Communicate with clarity, focus and organization using rich, investigative scenarios, real-world data and valid scientific information.

**RECALLING ACCURATE
SCIENCE**

Requires students to provide accurate statements about scientifically valid facts, concepts and relationships. Recall only requires students to provide a rote response, declarative knowledge or perform routine mathematical tasks. This cognitive demand refers to students' knowledge of science fact, information, concepts, tools, procedures (being able to describe how) and basic principles.



Dublin City Schools
K-12 Science Graded Course of Study

Grade 8

Course Goals

Students in Grade 8 will focus on using scientific inquiry to discover patterns, trends, structures and relationships that may be inferred from simple principles. These principles are related to the properties or interactions within and between systems. Students will learn about physical earth, forces and motion, and species and reproduction.

Strand Connections

Systems can be described and understood by analysis of the interaction of their components. Energy, forces and motion combine to change the physical features of Earth. The changes of the physical Earth and the species that have lived on Earth are found in the rock record. For species to continue, reproduction must be successful.

PHYSICAL SCIENCE (PS)	
Topic: Forces and Motion This topic focuses on forces and motion within, on and around the Earth and within the universe.	
Content Statement	Content Elaboration
8.PS.1: Objects can experience a force due to an external field such as magnetic, electrostatic, or gravitational fields.	This content statement involves a basic introduction to the field model. • A field model can be used to explain how two objects can exert forces on each other without touching. • Details about the field model are not required other than the idea that a field is a concept that is used to understand forces that act at a distance. • An object is thought to have a region of influence, called a field, surrounding it. • When a second object with an appropriate property is placed in this region, the field exerts a force on and can cause changes in the motion of the object. • In grade 8, content will focus on connecting and organizing prior knowledge using the field model. • Three types of fields should be investigated: gravitational, electric and magnetic. Magnetic, electrical and gravitational forces can act at a distance. • These forces can act to change the motion of objects. • Every object with mass exerts a gravitational force on every other object with mass.



Dublin City Schools
K-12 Science Graded Course of Study

	• These forces are hard to detect unless at least one of the objects is very massive (e.g., sun, planets). ◦ The gravitational force increases with the mass of the objects, decreases rapidly with increasing distance and points toward the center of objects. ■ Weight is the force that a mass experiences in a gravitational field. Weight is often confused with mass. ■ Weight is proportional to mass, but depends upon the gravitational field at a particular location. ■ An object will have the same mass when it is on the moon as it does on Earth. ■ However, the weight (force of gravity) will be different at these two locations. ◦ Electrostatic fields exist around objects with a net charge. ■ If a second object with a net charge is placed in the field, the two objects experience electric forces that can attract or repel them, depending on the sign of the charges involved. ◦ Magnetic fields exist around magnetic objects. ■ If a second magnetic object is placed in the field, the two objects experience magnetic forces that can attract or repel them, depending on the orientation of the objects involved. ■ Magnetic field lines can be seen when iron filings are sprinkled around a magnet. ■ Electricity is related to magnetism. • In some circumstances, magnetic fields can produce electrical currents in conductors. • Electric currents produce magnetic fields. • Electromagnets are temporary magnets that lose their magnetism when the electric current is turned off. • Building an electromagnet to investigate magnetic properties and fields can demonstrate this concept. • Note 1: Magnetic poles are often confused with electric charges. It is important to emphasize the differences. Note 2: Mathematics is not used to describe fields at this level.
8.PS.2: Forces can act to change the motion of objects.	When multiple forces act on an object, their combined effort is what influences the object's motion (speed and direction). • The motion of an object is always measured with respect to a reference point.



Dublin City Schools
K-12 Science Graded Course of Study

- The new force on an object is the sum of all of the forces acting on the object.
- Forces can cancel to a net force of zero if they are equal in strength and act in opposite directions.
 - Such forces are said to be balanced and the object will maintain its current motion (both speed and direction).
 - This means if the object is stationary, it will remain stationary.
 - If the object is moving, it will continue moving in the same direction and at the same speed.
- When the net force is nonzero, the forces are unbalanced and the object's motion will change.
 - The forces acting on an object can be modeled by a force diagram.
 - Forces are represented by arrows drawn on an isolated picture of the object.
 - The direction of each arrow shows the direction of the force.
 - The length of each arrow represents the magnitude of the force.
- The effect of the net force on the motion of an object can be predicted from a force diagram.
 - The direction and relative size of the net force can be identified from force diagrams involving multiple forces.
 - Diagrams with forces in both the horizontal and vertical directions can be considered.
 - At this grade level, there should be unbalanced forces in only one of these dimensions.
- Forces can also act to change the direction of objects.
 - If a force on an object acts toward a single center, the object's path may curve into an orbit around the center.

Kinetic friction and drag are forces that act in a direction opposite the relative motion of objects.

- Kinetic friction is a force that opposes sliding between two surfaces.
 - For surfaces that are sliding relative to each other, the force on an object always points in the direction opposite the relative motion of the object.
- Drag is a force that opposes the motion of an object when a solid object moves through a fluid (e.g., gas, liquid).
- Kinetic friction and drag affect the motion of objects and may even cause moving objects to slow to a stop unless another force is exerted in the direction of motion.
- A lack of understanding of friction can lead to the misconception that objects require



Dublin City Schools
K-12 Science Graded Course of Study

	a sustained force to continue moving. • Experimentation with objects that have limited friction (e.g., a puck on an air hockey table, dry ice on a surface) can address this misconception. • In grade 8, friction will only be calculated from force diagrams. Static friction, as well as the equations for static and kinetic friction, are found in Physics.
7.PS.1: Elements can be organized by properties.	All substances are composed of one or more elements. • Elements are organized into groups based on their properties (including melting and/or boiling points). • Elements with similar properties are grouped together on the periodic table. ◦ These groups include metals, non-metals and metalloids and can be organized by similar properties such as color, solubility, hardness, density, conductivity, melting point and boiling point, viscosity, and malleability. ■ Most metals are malleable, have high melting points, are usually solid at room temperature and are good conductors of heat and electricity. ■ Nonmetals are poor conductors of heat and electricity and tend to be dull and brittle in the solid state. • Depending on the element, they may be solid, liquid or gas at room temperature. ■ Metalloids demonstrate some properties of both metals and non-metals. Note: This is the conceptual introduction of the Periodic Table of Elements and should be limited to classifications based on observable properties; it should not include the names of the families.

EARTH AND SPACE SCIENCE (ESS)

Topic: Physical Earth

This topic focuses on the physical features of Earth and how they formed. This includes the interior of Earth, the rock record, plate tectonics and landforms.

Content Statement	Content Elaboration
8.ESS.1: The composition and properties of Earth's interior are identified by the	It is important to provide background knowledge regarding how scientists know about the structure and composition of the interior of Earth (without being able to see it).



Dublin City Schools
K-12 Science Graded Course of Study

behavior of seismic waves.

- Seismic data, graphics, charts, digital displays and cross sections can be used to study Earth's interior.
- **Note 1:** At this grade level, analyzing seismograms (e.g., amplitude and lag time) and reading a travel time curve are not the focus. At this grade the properties of seismic waves should be addressed.

Earth has a core, a mantle, and a crust.

- Earth and other planets in the solar system formed as heavier elements (primarily iron and nickel) coalesced in their centers and formed planetary cores.
- The less dense, lighter elements (potassium and sodium for example) remained closer to the planetary surface.
- This is planetary differentiation, a process through which distinct layers with characteristic chemical and/or physical properties are formed.

Earth is differentiated into distinct chemical and physical layers.

- They correspond in the following way [the chemical layer is stated first, followed by the physical layers in parentheses]: the crust (upper lithosphere), the mantle (lower lithosphere, asthenosphere, mesosphere) and the core (outer and inner).
- The refraction and reflection of seismic waves, as they travel through the lithosphere to the inner core, is used to identify the different physical layers of Earth's interior.
- The thicknesses of each layer of Earth can vary and be transitional, depending on composition, density, temperature and pressure, rather than uniform and distinct as often depicted in textbooks.

In addition to the composition of Earth's interior, the history of the formation of Earth and relationships among energy transfer, energy transformation and convection currents within the mantle and crust are essential in understanding sources of energy.

- Impacts during planetary formation generated heat.
- These impacts converted gravitational potential energy to heat.
- Earth's core is also able to generate its own thermal energy because of decaying atoms.
- This continuously releases thermal energy.
- Thermal energy generated from Earth's core drives convection currents in the asthenosphere.
- **Note 2:** Radioactive decay is not the focus; this will be discussed in Physical Science and Chemistry.



Dublin City Schools
K-12 Science Graded Course of Study

8.ESS.2: Earth’s lithosphere consists of major and minor tectonic plates that move relative to each other.	Historical data and observations such as fossil distribution, paleomagnetism, continental drift and seafloor spreading contributed to the theory of plate tectonics. • Historical data related to the modern-day theory of plate tectonics, which led to theories of continental drift (Wegener), convection theory (Holmes) and seafloor spreading (Hess, Deitz) is introduced. • The data supporting these theories include paleontological data, paleoclimate data, paleomagnetic data and the continental “puzzle-like-fit” noticed as early as Magellan and by other mapmakers and explorers. • Contemporary data is introduced, including seismic data, GPS/GIS data (documenting plate movement and rates of movement), robotic studies of the sea floor and further exploration of Earth’s interior. Physical world maps, cross sections, models (virtual or 3D) and data are used to identify plate boundaries, movement at the boundary and the resulting feature or event. • The relationship between heat from Earth’s interior, convection in the magma and plate movement is explored. • World distribution of tectonic activity of possible interest should be investigated (e.g., Ring of Fire, San Andreas Fault, Mid-Atlantic Ridge, Mariana Trench, Hawaiian Islands, New Madrid Fault System). Volcanic activity, earthquakes, tsunamis, geysers, hot springs, faults, oceanic vents, island arcs, hot spots and rift valleys are included in the identification of plates and plate boundaries. • There are three main types of plate boundaries: divergent, convergent and transform. ◦ Each type of boundary results in specific motion and causes events (such as earthquakes or volcanic activity) or features (such as mountains or trenches) that are indicative of the type of boundary. • The focus is on the cause of plate movement, the type and direction of plate movement and the result of the plate movement, not on memorizing plate names. ◦ The rigid tectonic plates move with the molten rock and magma beneath them in the upper mantle. ◦ Convection currents in the asthenosphere cause movements of the lithospheric plates. ■ The energy that forms convection currents comes from deep within the Earth.
8.ESS.3: A combination of constructive and	Earth’s surface is formed from a variety of different geologic processes, including but not



Dublin City Schools
K-12 Science Graded Course of Study

destructive geologic processes formed Earth's surface.	limited to plate tectonics. • The interactions between the hydrosphere and lithosphere are studied as they relate to erosional events (e.g., flooding, mass movement). • The characteristics of rocks and soil, climate, location, topography and geologic process are studied. • Distinguishing between major geologic processes (e.g., tectonic activity, erosion, deposition) and the resulting feature on the surface of Earth is the focus of this content statement. • Factors that affect the patterns and features associated with streams and floodplains (e.g., discharge rates, gradients, velocity, erosion, deposition), glaciers (e.g., moraines, outwash, tills, erratics, kettles, eskers), tectonic activity (includes the features listed in the previous content statement), coastlines, flooding and deserts should be studied.
8.ESS.4: Evidence of the dynamic changes of Earth's surface through time is found in the geologic record.	Earth history is based on observations of the geologic record and the understanding that processes observed at present day are similar to those that occurred in the past (uniformitarianism). • Earth is approximately 4.6 billion years old. ◦ Representations of the age of Earth should include a graphic demonstration of the immensity of geologic time, as this is a very difficult concept to grasp. • There are different methods to determine relative and absolute age of some rock layers in the geologic record. ◦ In grade 8, the concept of index fossils is a way to build toward understanding relative dating. ◦ Superposition, cross-cutting relationships and index fossils play an important role in determining relative age. ■ Within a sequence of undisturbed sedimentary rocks, the oldest rocks are at the bottom (superposition). ◦ Radiometric dating plays an important role in absolute age. ◦ The inclusion of new advances and studies is important in learning about the geologic record. • Uniformitarianism can be an important key in understanding how scientists have interpreted the environmental conditions that existed throughout Earth's history. ◦ Fossil evidence also can indicate specific environments and climate conditions that help interpret the geologic record. ◦ Environmental and climate conditions can also be documented through the cryosphere as seen through ice cores. ◦ Relating Earth's climate history to present-day climate issues should include



Dublin City Schools
K-12 Science Graded Course of Study

evidence from ice core sampling as well as evidence from the geologic record.

Using actual data to generate geologic maps of local or statewide formations can connect to the real world.

- Field studies or geologic research (virtual/digital) can help identify local formations and interpret the environment that existed at the time they were formed.
- Analyzing and interpreting the data to draw conclusions about geologic history is an important part of this content statement.

LIFE SCIENCE (LS)

Topic: Species and Reproduction

This topic focuses on continuation of the species.

Content Statement	Content Elaboration
8.LS.1: Diversity of species, a result of variation of traits, occurs through the process of evolution and extinction over many generations.	Combining data from the geologic record and the fossil record, Earth's living history can be interpreted. • The fossil records provide evidence that changes have occurred in number and types of species. • Fossils provide important evidence of how life and environmental conditions have changed. Evidence from the geologic and fossil record can be used to infer what the environment was like at the time of deposition. • Changes in environmental conditions can affect how beneficial a trait will be for the survival and reproductive success of an organism or an entire species. • Throughout Earth's history, extinction of a species has occurred when the environment changes and the individual organisms of that species do not have the traits necessary to survive and reproduce in the changed environment. • Most species (approximately 99 percent) that have lived on Earth are now extinct. Data and evidence from the fossil record can be used to further develop the concepts of extinction, biodiversity and the diversity of species. • Diversity in a species increases the likelihood that some individuals will have characteristics suitable to survive and reproduce when conditions change.



Dublin City Schools
K-12 Science Graded Course of Study

	○ Diversity can result from sexual reproduction. ■ The sorting and combination of genes result in different genetic combinations, which allow offspring to be similar to, yet different from, their parents and each other (this statement connects to the grade 8 Life Science content statement on reproduction and Mendelian Genetics). ● The variations that exist in organisms can accumulate over many generations, so organisms can be very different in appearance and behavior from their distant ancestors. ○ The term “transitional form” is used to describe intermediate organisms between ancestral forms and their descendants. ■ Some examples of transitional forms were fossilized and found in the fossil record. ■ Other transitional forms are missing from the fossil record. Note 1: Molecular clocks are not appropriate at this grade level. Note 2: Population genetics and the ability to use statistical mathematics to predict changes in a gene pool are reserved for high school Biology.
8.LS.2: Every organism alive today comes from a long line of ancestors who reproduced successfully every generation.	The ability to reproduce defines living things and refers to the transfer of genetic information from one generation to the next. ● Organisms reproduce either sexually or asexually and some organisms are capable of both. ● Asexual reproduction involves the transfer of genes from one individual to the next generation. (Mitosis was introduced in grade 6) ○ In asexual reproduction, all genes come from a single parent, resulting in offspring genetically identical to their parent. ○ At this grade level, the end products of mitotic and meiotic cell divisions are compared as they relate to asexual and sexual reproduction. ○ Mitosis and meiosis are addressed in preparation for the study of Mendelian genetics in 8.LS.3. ● Sexual reproduction involves the mixing of genes from two individual organisms. ○ A single specialized cell from a female (egg) merges with a specialized cell from a male (sperm). ○ Half of the nuclear genes come from each parent. ○ The fertilized cell, carrying genetic information from each parent, multiplies



Dublin City Schools
K-12 Science Graded Course of Study

	forming the genetically complete organism. - Each cell of an organism contains the same genetic information. - As opposed to asexual reproduction, sexual reproduction results in offspring with new combinations of traits which may increase or decrease their chances for survival.
8.LS.3: The characteristics of an organism are a result of inherited traits received from parent(s).	Expression of all traits is determined by genes and environmental factors to varying degrees. - During reproduction, genetic information deoxyribonucleic acid (DNA) is transmitted between parent and offspring. - Traits are determined by instructions encoded in DNA, which forms genes. - Many genes influence more than one trait, and many traits are influenced by more than one gene. - Genes have different forms called alleles. - In asexual reproduction, the lone parent contributes DNA to the offspring. - In sexual reproduction, both parents contribute DNA to the offspring. The principles of Mendelian genetics are introduced by reviewing Mendel's work. - Mendel's two laws provide the theoretical base for future study of modern genetics. - Mendel's first law, the Law of Segregation, and his second law, the Law of Independent Assortment, should be demonstrated and illustrated in a variety of organisms. The concepts of dominant and recessive genes are appropriate at this grade level. - Codominant traits such as roan color in horses and cows may be useful to provide further validation of the theory and to help dispel some misconceptions. - Pedigree analysis is appropriate for this grade level when limited to dominant, recessive or the codominance of one trait. - The Law of Independent Assortment should only be explored in simple cases of dominant and recessive traits. - Incomplete dominance is not suggested for this grade level to help avoid the misconception of "blending of traits." - Codominance is encouraged because both traits are expressed in the resulting offspring. - Dihybrid crosses and sex-linked traits also are reserved for high school. A long-term investigation to analyze and compare characteristics passed on from parent to offspring through sexual and asexual reproduction can be conducted. - These investigations can lead to questions about the phenotypes that appear in the



Dublin City Schools
K-12 Science Graded Course of Study

resulting generations and what they infer about genotypes of the offspring.

Note 1: The focus should be the link between DNA and traits without being explicit about the mechanisms involved.

Note 2: The ways in which bacteria reproduce is beyond the scope of this content statement.

Note 3: The molecular structure of DNA is not appropriate at this grade level.



Dublin City Schools
K-12 Science Graded Course of Study

Physical Science

Course Goals

Physical science introduces students to key concepts and theories that provide a foundation for further study in other sciences and advanced science disciplines. Physical science comprises the systematic study of the physical world as it relates to fundamental concepts about matter, energy and motion. A unified understanding of phenomena in physical, living, Earth and space systems is the culmination of all previously learned concepts related to chemistry, physics, and Earth and space science, along with historical perspective and mathematical reasoning.

STUDY OF MATTER	
Matter was introduced in the elementary grades and the learning progression continued through middle school to include differences in the physical properties of solids, liquids and gases. Elements, compounds, mixtures, molecules, kinetic and potential energy and the particulate nature of matter were introduced. Content in Chemistry (e.g., electron configuration, molecular shapes, bond angles) will build on concepts in this course.	
Content Statement	Content Elaboration
PS.M.1: Classification of matter	Heterogeneous vs. homogeneous • Solutes and Solvents • Acids & bases (identify according to pH) Properties of matter • Physical Properties: color, solubility, odor, hardness, conductivity, melting/boiling point, viscosity, malleability • Chemical Properties: reactivity, flammability, pH States of matter and its changes • Phase changes • Endothermic and Exothermic
PS.M.2: Atoms	Atoms • Components of atoms (protons, neutrons, electrons)



Dublin City Schools K-12 Science Graded Course of Study

	• Ions (cations and anions) • Isotopes
PS.M.3: Periodic trends of the elements	The Periodic Table • Arranged by group or family • Periodic law
PS.M.4: Bonding and compounds	Chemical components • Bonding (ionic and covalent) • 3D Lattice Nomenclature • Ionic: Formulas of ionic compounds from groups 1, 2, 17, H & O • Covalent: use prefixes 1-10
PS.M.5: Reactions of matter	Chemical reactions • Transfer of thermal energy (endothermic & exothermic) • Chemical equations are balanced to reflect the Law of Conservation of matter Nuclear reactions • Changes to nucleus, larger energy than chemical reactions • Strong nuclear force greater than repulsive electrical forces (imbalance leads to unstable nucleus) • Radioisotopes undergo alpha or beta decay, resulting nuclear reaction can be written • Half life graphs (amount of radioisotope vs. time) • Whole number integers of half-life only • Fission, fusion reactions • Using nuclear reactions for energy

THE UNIVERSE

In early elementary school, observations of the sky and space are the foundation for developing a deeper knowledge of the solar system. In late elementary school, the parts of the solar system are introduced, including characteristics of the sun and planets, orbits and celestial bodies. At the middle school level, energy, waves, gravity and density are emphasized in the physical sciences, and characteristics and patterns within the solar system are explored. In this course, the universe and galaxies are introduced, building upon the knowledge about space and the solar system from earlier grades



Dublin City Schools
K-12 Science Graded Course of Study

Content Statement	Content Elaboration
PS.U.1: History of the universe	Big bang theory is accepted explanation for origin & evolution of the universe Supporting evidence for the expansion of the known universe: Hubble's law, red shift, cosmic background radiation Roles of telescopes, space probes, accelerators & technology in simulating and computing data
PS.U.2: Galaxies	Classification of galaxies by size and shape: elliptical, spiral, irregular Milky Way galaxy classification and characteristics - Spiral galaxy - Center is a massive black hole Hubble's law and its relationship to Red Shift/Doppler Shift
PS.U.3: Stars	Live cycles of stars - Formation of stars, importance of Hydrogen, Helium, fusion, and gravitational attraction - Focus is on the interpretation of data and NOT memorization of the names of stars and names of evolutionary stages Fusion in stars - Basis of all elements beyond hydrogen, helium, and lithium

ENERGY AND WAVES

Building upon knowledge gained in elementary and middle school, major concepts about energy are further developed. Conceptual knowledge will move from qualitative understandings of energy to ones that are more quantitative using mathematical formulas, manipulations and graphical representations.

Content Statement	Content Elaboration
PS.EW.1: Conservation of energy	Quantifying kinetic energy $E_k = \frac{1}{2} mv^2$



Dublin City Schools
K-12 Science Graded Course of Study

	Quantifying gravitational potential energy $E_g = mgh$ Calculating conservation of energy within open and closed systems - Collecting data in experimental situations (examples: swinging pendulum, roller coaster with multiple heights and velocities, Skateboard vert ramp)
PS.EW.2: Transfer and transformation of energy	Representations of Work $W = F\Delta x$ or ΔE Energy transformations - Conceptual understanding of kinetic energy, potential energy and work combined with the law of conservation of energy - Using pie graphs or bar graphs to represent energy transformations within both open and closed systems
PS.EW.3: Waves	Refraction, reflection, diffraction, absorption, superposition (constructive and destructive interference) - Understanding the conceptual nature of each type of wave interaction Radiant energy and the electromagnetic spectrum - Radiant energy does not require a medium, wide range of frequencies - Light energy radiates in all directions - Electromagnetic spectrum (relative position of radio to gamma) - Differences in wave behavior based on material (opaque, transparent materials) Doppler shift - Change in wavelength & frequency based on location of observer & wave source - Connect to expansion of the universe (red-shift) - Calculations to measure the apparent change in frequency or wavelength are not appropriate for this course
PS.EW.4: Thermal energy*	Rates of thermal energy transfer/thermal equilibrium Graph changes in temperature to compare insulators ability to insulate Conductors have higher rate of transfer than insulators



Dublin City Schools K-12 Science Graded Course of Study

	Conductive capacity as a comparative measure between different objects/matter Rate of thermal energy absorption impacted by: temperature, color, texture, exposed surface area and elaborate on phase of matter change as a result
PS.EW.5: Electricity*	Movement of electrons - Define and measure current, voltage, and resistance - Conceptual understanding between current, voltage, and resistance in a circuit - Identify conductors and insulators based on electron movement

*This standard is not addressed in Grade 8/Telescoped Physical Science

FORCES AND MOTION

Building upon content in elementary and middle school, major concepts of motion and forces are further developed. In this course, mathematics (including graphing) is used when describing these phenomena, moving from qualitative understanding to one that is more quantitative. Motion is limited to segments of uniform motion (e.g., at rest, constant velocity, constant acceleration) in a straight line either horizontally, vertically, up an incline or down an incline. Motions of two objects may be compared or addressed simultaneously (e.g., when or where would they meet).

Content Statement	Content Elaboration
PS.FM.1: Motion	Introduction to one-dimensional vectors - Frame of reference described in terms of: distance, position, displacement, speed, velocity, acceleration, time - Drawing motion diagrams for position & velocity Displacement, velocity (constant, average and instantaneous) and acceleration - Displacement: $\Delta x = x_f - x_i$ - Provide examples where distance does not equal displacement $v_{avg} = (x_f - x_i) / (t_f - t_i)$ - Provide examples where avg speed is not the same as avg velocity - Position, displacement, velocity, acceleration all vector (magnitude and direction) $a_{avg} = (v_f - v_i) / (t_f - t_i)$ - Acceleration can be negative, but specific examples of +/- acceleration addressed in physics



Dublin City Schools
K-12 Science Graded Course of Study

	- Constant acceleration Interpreting position vs. time and velocity vs. time graphs - Graphs include objects at rest, moving at a constant velocity and moving at a constant acceleration, both positive and negative - Calculate slope & use to interpret motion - Collect data (motion detectors for graphing and analysis)
PS.FM.2: Forces	Forces, measuring and representing $1\text{N} = 1\text{kg}\cdot 1\text{m}/\text{s}^2$ - Opportunities to measure force - Force diagrams are constructed and interpreted Types of forces (gravity, friction, normal, tension, applied) - Conceptual introduction of normal/tension forces - Gravitational force (weight) calculated from mass, all other forces from force diagrams $F_g = mg$ ($g = 9.8 \text{ N/kg}$ or m/s^2) - Forces in one dimension are analyzed - Conceptual introduction of sliding vs. kinetic friction - Net force is determined through vector addition Field model for forces at a distance (Magnetic, Electric and Gravitational) - The stronger the field, the greater the force exerted on objects
PS.FM.3: Dynamics	Understand and apply Newton's Three Laws of Motion Unbalanced forces cause changes in motion (acceleration) whereas balanced forces do not. - When $F_{\text{net}} = 0$, object does not accelerate $F_{\text{net}} = ma$ - Accelerating objects