K-12 SCIENCE EDUCATION VISION

A K-12 Dublin City Schools science education engages *all students* in critical thinking and problem solving as they experience science and engineering. We believe that students can become scientifically literate citizens equipped with the knowledge and skills demanded by the ever-changing future, whether in the workforce or higher education.

We believe in developing our learners through high quality experiences that include:

- A challenging, collaborative and inquiry based environment.
- Opportunities to solve and investigate real-world problems that require critical and global thinking.
- Opportunities for students to build an identity as a scientist, able to interpret the natural world, participate productively in scientific practices and contribute to society in meaningful ways.
- Opportunities to research, generate and evaluate evidence and explanations that uphold or refute scientific data.

We believe these learning experiences will grow independent, confident students who will become creative, innovative adults that are capable of using informed scientific judgement to improve their world.

Instructional Agreements for Science Learning within the Dublin City Schools

1. Learning goals will be communicated to guide students through the expectations of science learning using a variety of instructional techniques and technology integration.
2. Teachers will ensure a safe, challenging learning environment focused on inquiry and science exploration.
3. Teachers will provide support to students as they learn to frame questions, assess and analyze data, and create and critique explanations – all important components of scientific and engineering practices.
4. Content standards will be learned in partnership with Ohio's Cognitive Demands for Science, Science and Engineering Practices and Nature of Science practices.

Dublin City Schools 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

Ohio's Cognitive Demands for Science	
Cognitive Demand	**Description**
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.

PHYSICAL SCIENCE

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	
Content Statement	**Content Elaboration**
PS.M.1: Classification of matter • Heterogeneous vs. homogeneous • Properties of matter • States of matter and its changes	● Heterogeneous vs. homogeneous ○ Solutes and Solvents ○ Impact of temperature on solubility ○ Separation of mixtures ○ Acids & bases (identify according to pH) ● Properties of matter ○ Physical Properties: Color, solubility, odor, hardness, density, conductivity, melting/boiling point, viscosity, malleability ○ Chemical Properties: reactivity, flammability, pH ● States of matter and its changes ○ Phase changes: changes in kinetic energy & particle spacing ○ Heating & cooling curves (graphing temperature vs. time) ○ Endothermic & Exothermic
PS.M.2: Atoms • Models of the atom (components) • Ions (cations and anions) • Isotopes	● Models of the atom (components) ○ Protons, neutrons, electrons and their location, charge & mass ○ Valence electrons, Bohr model ○ Atomic number, mass number, charge, element identity ● Ions (cations and anions) ○ Valence electrons are gained and lost to become anions & cations ● Isotopes

	○ Atoms of the same element have the same number of protons, but varying numbers of neutrons and so different masses
PS.M.3: Periodic trends of the elements • Periodic law • Representative groups	● Periodic law ○ Patterns are observed when elements are arranged by increasing atomic number ○ Trends of the periodic table: density, melting point, ionic charges within groups and families ● Representative groups ○ Identification of metals, non metals, metalloids, periods, groups or families, based on position on the periodic table
PS.M.4: Bonding and compounds • Bonding (ionic and covalent) • Nomenclature	● Bonding (ionic and covalent) ○ Ionic: oppositely charged ions, transfer of electrons ○ Covalent: usually nonmetals, sharing of electrons ● 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 • Nuclear reactions	● 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 AND WAVES

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

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: 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 center is massive black hole ● Hubble's law and observing a galaxies distance based on speed
PS.U.3: Stars ● Formation: stages of evolution ● Fusion in stars	● Formation: stages of evolution ○ Formation of stars, importance of H, He, fusion, and gravitational attraction ○ Classification of stars: color, size, luminosity ○ HR Diagrams ○ Life cycle of stars ● Fusion in stars ○
PS.EW.2: Transfer and transformation of energy (including work)	● Energy transfer briefly brought up in this section in relation to light, sound, thermal energy
PS.EW.3: Waves • Refraction, reflection, diffraction, absorption, superposition • Radiant energy and the electromagnetic spectrum • Doppler shift	● Refraction, reflection, diffraction, absorption, superposition ○ 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 (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)
PS.EW.4: Thermal energy	● Energy transfer briefly brought up in this section in relation to light, sound, thermal energy

ENERGY	
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 • Quantifying gravitational potential energy	● Quantifying kinetic energy ○ $E_k = ½ mv^2$ ● Quantifying gravitational potential energy ○ $E_g = mgh$ ● Opportunities to collect data in experimental situations to calculate conservation of energy (examples: swinging pendulum, car down an incline)
PS.EW.2: Transfer and transformation of energy (including work)	● $W = F\Delta x$ or ΔE ● Using pie graphs or bar graphs to represent energy transformations
PS.EW.4: Thermal energy	● Rates of thermal energy transfer/thermal equilibrium ● Conductors have higher rate of transfer than insulators ● Rate of thermal energy absorption impacted by: temperature, color, texture, exposed surface area
PS.EW.5: Electricity • Movement of electrons • Current • Electric potential (voltage) • Resistors and transfer of energy	● Movement of electrons ○ Conceptual relationship between current, voltage, and resistance ○ Conductors vs. insulators based on electron movement ● Current ○ Measured in Amps (1 C/s) ○ Convention: current is the rate at which positive charge flow through circuit

	○ In reality: negatively charged electrons move through circuit ● Electric potential (voltage) ○ Separation of charge impacts electron flow ○ Volt - unit of potential difference (1 J/C) ○ Power source supplies electron, impacts potential difference ● Resistors and transfer of energy ○ Resistors decrease current in a circuit ○ Electrical energy transferred into multiple other forms

FORCES AND MOTION	
Building upon content in elementary and middle school, major concepts of motion and forces are further developed. In middle school, speed was addressed conceptually, mathematically and graphically. The concepts that forces have both magnitude and direction and can be represented with force diagrams, that forces can be added to find a net force and that forces may affect motion have been addressed in middle school. At the high school level, mathematics (including graphing) is used when describing these phenomena, moving from qualitative understanding to one that is more quantitative. For this course, 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 • Displacement, velocity (constant, average and instantaneous) and acceleration • Interpreting position vs. time and velocity vs. time graphs	● 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 ● Interpreting position vs. time and velocity vs. time graphs

	○ Graphs limited to positive x-values and only constant velocity or constant acceleration ○ Collect data (motion detectors for graphing and analysis) ○ Calculate slope & use to interpret motion
PS.FM.2: Forces • Force diagrams • Types of forces (gravity, friction, normal, tension) • Field model for forces at a distance	● Force diagrams ○ $1N = 1kg*1m/s^2$ ○ Opportunities to measure force ● Types of forces (gravity, friction, normal, tension) ○ Conceptual introduction of normal/tension forces ○ Gravitational force (weight) calculated from mass, all other forces from force diagrams ○ $F_g = mg$ ($g = 9.8$ N/kg or m/s^2) ○ Only forces in one dimension ○ Conceptual introduction of sliding vs. kinetic friction ● Field model for forces at a distance ○ The stronger the field, the greater the force exerted on objects
PS.FM.3: Dynamics (how forces affect motion) • Objects at rest • Objects moving with constant velocity • Accelerating objects	● Focus is to understand the laws of motion, not name or recite memorized definitions ● Objects at rest/constant velocity ○ Balanced forces cause an object to remain at rest or experience constant velocity ○ When $F_{net} = 0$, object does not accelerate ● Accelerating objects Unbalanced forces cause objects to accelerate ○ $a = F_{net} = m$