MIDDLE SCHOOL PHYSICAL SCIENCE CURRICULUM MAP AND PACING GUIDE

This pacing guide is based on NGSS performance standards and gives a basic outline of the material to cover in a middle school setting.

Class periods are based on projected time requirements by major subject area using various text resources.

Class period allotments acount for 155-180 instructional days, teacher's discretion on actual instructional days per unit is expected.

Listed under assessment/resources are labs from the Argument-Driven Inquiry in Life Science lab book (will be provided to interested schools) and links to resources to help structure activities and labs to meet performance expectations.

Vocabulary shown is based on key vocab in related text sources and may be expanded/edited as needed to meet lesson goals.

Vocabulary listed is shown for the entire "unit" and may not be specifically tied to the individual standard as it appears in this pacing guide.

Class Periods	Standard	Performance Expectation	Clarification	Disciplinary Core Ideas	Key Vocabulary	Assessment/ Resources links	Catholic Identity
SCIENTIFIC METHOD							
7-10 class periods			Examine the steps used by scientists to investigate the natural world.	There is no set "formula" for conducting scientific research, but there are universally accepted steps that can help define, organize, conduct experiments, and to collect and analyze data to help researchers stay on track.	hypothesis, dependent variable, independent variable, quantitative data, qualitative data	Students will be assessed as they construct and carry out their labs and research throughout the year.	Roger Bacon (c. 1214-1294) - Francisan friar who is described as the forerunner to the modern scientific method.
STRUCTURE AND PROPERTIES OF MATTER							
MS-PS1-1, MS-PS1-3, MS-PS1-4, MS-PS1-7, MS-PS1-8; 30-35 class periods	**MS-PS1-1**	Develop models to describe the atomic composistion of simple molecules and extended structures	Students will develop models of varying complexity. Examples of simple models (i. e. H20, NH3) and extended models (NaCl, Diamonds). Various methods of modeling may be used such as drawings, 3D "ball and stick," and/or computer generated.	**PS1.A -** Structures and Properties of Matter - Sustances may be single atoms or combinations of different atoms. Atoms are individual particles that can combine to form larger particles, two to thousands of atoms in size. Solids may be formed from molecules, or may consist of repeating units (extended structures) such as crystals.	element, compound, molecule, matter, mixture, diatomic, polyatomic, substance, physical property, chemical property, atom, density	Molecule building lab: http://static.nsta.org/connections/elementaryschool/200801BrownBlankWorksheet.pdf	
	MS-PS1-3	Gather and make sense of information to describe that synthetic materials come from natural resources and impact society	Students will be able to explain how synthetic materials result from chemical processes used on natural substances. Examples could include, but not limited to, medicines, alternate fuels, clothing, and foods.	**PS1.A -** Structures and Properties of Matter - All substances have characteristic physical and chemical properties that can be used to identify them. **PS1.B -** Chemical Reactions - Substances react chemically in characteristic ways. Atoms of a substance (reactants) undergo chemical processes and are regrouped creating new substances (products). These products have different properties from the reactants from which they are formed.	weight, physical change, chemical change, solid, liquid, gas, surface tension, viscosity, cyrstalline, amorphous, thermal energy, temperature, freezing point, melting point, boiling point, evaporation	The impact of synthetic materials: https://www.sciencedirect.com/topics/earth-and-planetary-sciences/synthetic-material	United States Catholic Catechism for Adults: Appreciation and respect for the laws of nature

	MS-PS1-4	Develop a model that predicts and describes changes in particle motion, temperature, and phase (state) of a substance when thermal energy is added or removed.	Students will be able to show how kinetic energy of the molecules of the phases of matter increases/decreases as thermal energy is added/removed. This includes the energy gain/loss that results in the change from one phase (solid, liquid, gas) to another.	**PS1.A -** Structures and Properties of Matter - The arrangement of particles in solids, liquids, and gases are different in relation to spacing and ease of movement. Changes in thermal energy and/or pressure can affect these properties and lead to changes from one state to another. Models can be used to describe and predict how these changes occur. **PS3.A -** Definitions of Energy - The term "heat" used in everyday language refers to both the motion of particles (thermal energy) and the transfer of that energy from one substance to another. In scientific context, heat is only used to describe the energy transfer due to temperature differences between two objects. Temperature is not a form of energy but a measurement of the average kinetic enery of the particles of a substance.	vaporization, condensation, deposition, Charles's Law, Boyle's Law, heterogeneous mixture, homogeneous mixture, solution, suspension	**Phase change of water lab**: https://betterlesson.com/lesson/633397/phase-change-lab **Argument-Driven Inquiry in Physical Science** Lab 1 - Thermal energy and matter: What happens at the molecular level when thermal energy is added to a substance? (also aligns to MS-PS3-4)	
	MS-PS1-7	Use evidence to illustrate that density is a property that can be used to identify samples of matter.	Emphasis should be placed on determining the density and identifying a material using measurements of mass and volume for regular and irregular shaped objects.	**PS1.A -** Structures and Properties of Matter - All substances have characteristic physical and chemical properties that can be used to identify them.		7 labs in density: https://newyorksciencetea cher.com/sci/files/topic-media.php?media=Lab&subject=earth+science&subtopic=Density	
	MS-PS1-8	Plan and conduct an investigation to demonstrate that mixtures are combinations of substances.	Emphasis should be on analyzing the physical changes that occur as mixtures are formed and/or separated. Methods should be limited to separation by evaporation, filtration, and magnetism.	**PS1.A -** Structures and Properties of Matter - Mixtures are physical combinations of one or more substances and can be separated by physical means.		AACT lab exercises related to mixtures/solutions: https://teachchemistry.org/classroom-resources/topics/chemistry-basics?q%5Bresource_topics_topic_id_eq%5D=3	

CHEMICAL REACTIONS							
MS-PS1-2, MS-PS1-5, MS-PS1-6; 35-40 class periods	**MS-PS1-2**	Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.	Examples of chemical reactions could include burning a wooden splint, souring of milk, decomposition of sodium bicarbonate. Limit analysis and assessment to properties of density, melting/freezing points, solubility, flammability, color change, gas production, and odor.	**PS1.A -** Structures and Properties of Matter - All substances have characteristic physical and chemical properties that can be used to identify them. **PS1.B -** Chemical Reactions - Substances react chemically in characteristic ways. Atoms of a substance (reactants) undergo chemical processes and are regrouped creating new substances (products). These products have different properties from the reactants from which they are formed.	mixture, colloid, suspenion, solution, solvent, solute, solubility, hypertonic, hypotonic, saturated, unsaturated, hypersaturated, physical change, chemical change, reactant, product	**8 experiments on chemical reactions**: https://owlcation.com/stem/hands-on-experiments-to-learn-about-chemistry **Argument-Driven Inquiry in Physical Science** Lab 2 - Chemical and physical changes: What set of rules should we use to distinguish between chemical and physical changes in matter?	
	MS-PS1-5	Develop and use a model to describe how the total number of atoms does not change is a chemical reaction and thus mass is conserved.	Emphasis is on the Law of the Conservation of Matter and the models that represent them.	**PS1.B -** Chemical Reactions - Substances react chemically in characteristic ways. Atoms of a substance (reactants) undergo chemical processes and are regrouped creating new substances (products). These products have different properties from the reactants from which they are formed. The total number of each type of atom present is conserved, and the mass does not change.	exothermic reaction, endothermic reaction, open system, closed system, Law of Conservation of Mass, polymer, synthetic, natural resource, atom, electron, nucleus	**Conservation of mass lab activity**: https://ngss.nsta.org/Resource.aspx?ResourceID=1099 **Argument-Driven Inquiry in Physical Science** Lab 4 - Conservation of mass: How does the total mass of the substances formed as a result of a chemical change compare with the total mass of the original substances?	

	MS-PS1-6	Undertake a design project to construct, test, and modify a device that either releases or absorbs thermal energy during a chemical and/or physical process.	Design emphasis is on controlling the transfer of energy by manipulating the type and amounts of a substance used. Assessment and analysis should be limited to substance amounts, measurement of reaction time, and observed temperature changes.	**PS1.B -** Chemical Reactions - Some chemical reactions release energy (exothermic), and others absorb energy (endothermic). **ETS1.B -** Developing Possible Solutions - A solution needs to be tested, and then modified on the basis of test results, in order to improve it. **ETS1.C -** Optimizing the Design Solution - One design may not work for all situations. Identifying those characteristics that perform best in each test provide useful information and be used in the project redesign. The iterative process of testing the most promising solution and modifying it based on test results leads to greater refinement and ultimately to an optimal solution.	atomic number, isotope, mass number, atomic mass, periodic table, chemical symbol, period, group, compound, valence electron, reactivity, malleable, ductile, luster, semiconductor, ion, polyatomic, ionic bond, covalent bond, polar bond, nonpolar bond, acid, corrosive, indicator, base, neutralization, salt	**Engineering lab on heat transfer**: https://www.teachengineering.org/lessons/view/uoh_magic_lesson01 **Argument-Driven Inquiry in Physical Science** Lab 5 - Design challenge: Which design will cool a soda the best? (also aligns to MS-PS3-3 and performance expectations for engineering design)	
FORCES AND INTERACTIONS							
MS-PS2-1, MS-PS2-2, MS-PS2-3, MS-PS2-4, MS-PS2-5; 16-20 class periods	**MS-PS2-1**	Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects.	Emphasis should be placed on practical problems that could include collisions/ impact of two objects and the changes in vertical and/or horizontal motion.	**PS2.A -** Forces and Motion - When any two objects interact, the force of the first object on the second is equal in strength to the force that the second object exerts on the first, but opposite in direction.	motion, reference point, relative motion, force, newton, friction, gravity, balanced force, unbalanced force, net force	NSTA hockey lab - Newton's three laws: https://ngss.nsta.org/Resource.aspx?ResourceID=320	United States Catholic Catechism for Adults: appreciation and respect for the laws of nature
	MS-PS2-2	Plan and conduct an investigation to provide evidence that the change in an object's motion depends on the sum of forces on the object and the mass of the object.	Emphasize Newton's First Law, balanced and unbalanced forces, and make qualitative comparisons of force, mass, and changes in motion (Newton's Second Law). Units of measure and a frame of reference to changes in inertia in one dimension, and in one variable at a time.	**PS2.A -** Forces in Motion - The motion of an object is determined by the sum of the forces acting on it. If the total of the forces is not zero, its motion will change. The greater the object's mass, the greater the force needed to achieve the same change in motion is required. For any given object, the larger force causes a larger change in motion. In order to share information, all positions of objects and the directions of forces and motions must be described in a common, shared reference frame and units of size/ measure.	acceleration, inertia, weight, slope	**Related video, investigations, and lab**: https://ngss.nsta.org/Resource.aspx?ResourceID=372 **Argument-Driven Inquiry in Physical Science** Lab 7 - Mass and free fall: How does mass affect the amount of time it takes for an object to fall to the ground?	

	MS-PS2-3	Ask questions about data to determine the factors that affect the strength of electric and magnetic forces.	Examination of devices that use electric and magnetic forces (e.g. electric motors, generators, electromagnets). Data analysis could include number of turns of wire related to electromagnetic strength, number and/or strenth of magnets on the speed of an electric motor. Limit assessment to proportional reasoning and algebraic thinking.	**PS2.B -** Types of Interactions - Electric and magnetic (electromagnetic) forces can attract or repel. The effect of the forces depend on the magnetude of the charges or the magnetic strength involved, and the distance between the interacting objects.	Electricity, magnetism, electromagnetism	**Electromagnetism lab exercise**: https://ngss.nsta.org/Resource.aspx?ResourceID=230 **Argument-Driven Inquiry in Physical Science** Lab 10 - Magnetic force: How is the strength of an electromagnet affected by the number of turns of wire in a coil? (also aligns to MS-PS2-5)	
	MS-PS2-4	Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects and the distance between them.	Evidence could include data generated from simulations or digital tools. Presentation in various forms (charts, tables, etc.) relating mass, strength of interaction, distance from the Sun, orbital periods of solar system objects found during research.	**PS2.B -** Types of Interactions - Gravitational forces are always attractive. There is a gravitational force between any two masses, but it is very small except when one or both of the objcts have large masses (e.g. the Earth and Sun).	Gravity	**Interactice gravity force lab**: https://www.stem.org.uk/resources/elibrary/resource/36003/gravity-force-lab **Argument-Driven Inquiry in Physical Science** Lab 6 - Strength of gravitational force: How does the gravitational force that exists between two objects relate to their masses and the distance between them?	
	MS-PS2-5	Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact.	Examples could include the interactions of magnets, electrically charged strips of tape, and electrically-charged pith balls. These could be first-hand experiments or through simulations. Emphasize the direction of forces using symbols.	**PS2.B -** Types of Interactions - Forces that act at a distance (electric, magnetic, and gravitational) can be explained by fields that extend through space and can be mapped by theif affect on a test object (a charged object, a ball)	Magnets, magnetic fields, electricity	**NSTA interaction of forces lab**: https://ngss.nsta.org/DisplayStandard.aspx?view=topic&id=26 **Argument-Driven Inquiry in Physical Science** Lab 10 - Magnetic force: How is the strength of an electromagnet affected by the number of turns of wire in a coil? (also aligns to MS-PS2-3)	

ENERGY							
MS-PS3-1, MS-PS3-2, MS-PS3-3, MS-PS3-4, MS-PS3-5, MS-PS3-6; 30-35 class periods	**MS-PS3-1**	Construct and interpret graphical displays of data to describe the relationship of kinetic energy to the mass of an object and to the speed of an object.	Emphasize descriptive relationships between kinetic energy and mass, which is different than kinetic energy and the object's speed. Examples could include rolling different sized rocks down hill, getting struck by a wiffle ball versus a tennis ball, or riding a bike at different speeds. Evaluations can include both qualitative and quantitative assessments.	**PS3.A -** Definitions of Energy - Kinetic energy is the energy of motion and it is proportional to the mass of the moving object and grows with the square of its speed.	energy, motion, force, work, power, kinetic energy, potential energy, gravitational potential energy, elastic potential energy, mechanical energy, nuclear energy, thermal energy	**Newton's second law lab exercises**: https://ngss.nsta.org/Resource.aspx?ResourceID=371 **Argument-Driven Inquiry in Physical Science** Lab 13 - Kinetic energy: How do the mass and velocity of an object affect its kinetic energy?	
	MS-PS3-2	Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system.	Emphasize the relative, not calculated, amounts of potential energy. Systems interacting at different distances may include: Earth and roller coasters, objects on shelves, changing a magnet's direction/orientation, a static-charged balloon in relation to a person's hair. Examples may be demonstrations, representations, diagrams, pictures. and/or written descriptions.	**PS3.A -** Definitions of Energy - A system of objects may also contain stored (potential) energy depending on their relative positions. **PS3.C-** Relationship Between Energy and Forces - When two objects interact, each one exerts a force on the other that can cause energy to be trasferred to or from the object.	energy, electrical energy, electromagnetic radiation, Law of Conservation of Energy, heat, temperature, conduction, convection, radiation, convection current, conductor, insulator, specific heat	**Various videos, investigations, and labs related to Newton's 1st and 3rd laws**: https://ngss.nsta.org/Resource.aspx?ResourceID=372 **Argument-Driven Inquiry in Physical Science** Lab 14 - Potential energy: How can you make an action figure jump higher? **Diocese of Buffalo STREAM Academy "Rockin Roller Coaster"**	
	MS-PS3-3	Apply scientific principles to design, contruct, and test a device that either minimzes or maximizes thermal transfer of energy.	Examples could include an insulated container, constructing a solar cooker, a styrofoam cup, and alumninum pans/foil.	**PS3.A -** Definitions of Energy - Temperature is a measure of the average kinetic energy of particles of matter. This relationship between temperature and the total energy of a system depends on the types, phases (states), and the amount of matter present. **PS3.B -** Conservation of Energy and Energy Transfer - Energy is spontaneously transferred out of hotter regions or objects and into colder ones. **ETS1.A -** Defining and Delimiting an Engineering problem - The more precisely a design task's criteria and constraints are defined the more likely the designed solution will be successful.Specifications of constraints includes consideration of scientific priciples and other relevant knowledge that may limit possible solutions. **ETS1.B -** Developing Possible Solutioins **-** A solution needs to be tested, and then modified based on test results in order to improve it. There are systematic processes to evaluate solutions related to meeting crieteria and constraints of a problem.	thermal expansion	**Thermal energy transfer lab**: https://ngss.nsta.org/Resource.aspx?ResourceID=229 **Argument-Driven Inquiry in Physical Science** Lab 5 - Design challenge: Which design will cool a soda the best? (also aligns to MS-PS1-6 and performance expectations for engineering design)	

	MS-PS3-4	Plan and conduct an investigation to determine the relationship amony the energy transferred, the type of matter, the mass, and the change in temperature of the sample matter.	Investigations could include comparing final temperatures after different masses of ice are melted in the same volume and temperature of water, the temperature change in different materials of the same mass exposed to heat/cooling, or the same material with different masses when a specific amount of energy is added. Do not include calculations of total thermal energy transferred.	**PS3.A -** Definitions of Energy - Temperature is a measure of the average kinetic energy of particles of matter. This relationship between temperature and the total energy of a system depends on the types, phases (states), and the amount of matter present. **PS3.B -** Conservation of Energy and Energy Transfer - The amount of energy transfer needed to change the temperature of a matter sample by a given amount depends on the nature of the matter, the mass of the sample, and the environment.	Thermal energy	Argument-Driven Inquiry in Physical Science Lab 1 - Thermal energy and matter: What happens at the molecular level when thermal energy is added to a substance? (also aligns to MS-PS1-4)	
	MS-PS3-5	Construct, use, and present an argument to support the claim that when work is done on or by a system, the energy of the system changes as energy is transferred to or from the system.	Empirical evidence used could include an inventory or other representation of the energy before and after the transfer as observed in temperature change or change in motion of the object. Argument may include the calculations of work and energy.	**PS3.B -** Conservation of Energy and Energy Transfer - When the motion energy of an object changes, there is inevitably some other change in energy at the same time.		Exploring energy in systems exercises: https://www.teachengineering.org/curricularunits/view/ucd_energy_unit	
	MS-PS3-6	Make observations to provide evidence that energy can be transferred by electric currents.	Emphasize the arrangement of components in both series and parallel circuits	**PS3.B -** Conservation of Energy and Energy Transfer - An electric circuit is a closed path in which an electric current can exist.	electric circuit, electric current, series circuit, parallel circuit	**Electric current and light lab**: https://ngss.nsta.org/Resource.aspx?ResourceID=48 **Argument-Driven Inquiry in Physical Science** Lab 16 - Electrical energy and lightbulbs: How does the arrangment of lightbulbs that are connected to a battery affect the brightness of a single bulb in that circuit?	

WAVES AND ELECTROMAGNETIC RADIATION - INFORMATION TECHNOLOGIES							
MS-PS4-1, MS-PS4-2, MS-PS4-3; 50-55 class periods	**MS-PS4-1**	Develop a model and use mathematical representations to describe waves that includes frequency, wavelength, and how the amplitude of a wave is related to the energy in a wave.	Emphasize describing waves in both qualitative and quantitative terms/thinking. Comparisons of waves are of similar types, either transverse/transverse or longitudinal/longitudinal.	**PS4.A -** Wave Properties - A simple wave has a repeating pattern with a specific wavelength, frequency, and amplitude.	wave, mechanical wave, medium, electromagnetic radiation, transverse wave, longitudinal wave	**Waves and electromagnetic radiation exercises**: https://ngss.nsta.org/DisplayStandard.aspx?view=topic&id=28 **Argument-Driven Inquiry in Physical Science Lab 19** - Wave properties: How do frequency, amplitude, and wavelength of a transverse wave affect its energy?	
	MS-PS4-2	Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials.	Emphasize both light and mechanical waves. Modeling could include drawings, ray diagrams, simulations, and written descriptions and focus on the qualitative applications of light and mechanical waves.	**PS4.A -** Wave Properties - A sound wave needs a medium through which it is transmitted. **PS4.B -** Electromagnetic Radiation - When light shines on an object, it is reflected, absorbed, or transmitted through the object. This depends on the object's material and the light's frequency (color). Light travels in straight lines except when it hits the surface of two different materials at an angle which causes the path of the light to bend (refract). A wave model of light helps explain brightness, color, and the bending of light at a surface between media. Because light can travel through space and does not require a medium, it cannot be a mechanical wave.	amplitude, frequency, wavelength, reflection, refraction, diffraction, absorption, interference, standing wave, resonance, loudness, intensity, decibel, pitch, Doppler effect, electromagnetic (em) wave, em spectrum, radio waaves, microwaves, infrared rays, visible light, ultraviolet rays, X-rays, gamma rays	**Light properties exercises**: https://ngss.nsta.org/DisplayStandard.aspx?view=pe&id=171 **Argument-Driven Inquiry in Physical Science** Lab 20 - Reflection and refraction: How can you predict where a ray of light will go when it comes in contact with different types of transparent materials?	
	MS-PS4-3	Integrate qualitative scientific and technical information to support the claim that digitized signals are a more reliable way to encode and transmit information that analog signals.	Emphasize that waves can be used for communication purposes, such as fiber optics to transmit light pulses, radio wave pulses for wifi, and binary patterns to create sound/text in computers.	**PS4.C -** Information Technologies and Instrumentation - Digitized signals sent as wave pulses are a more reliable wat to encode and transmit information.	transparent, translucent, opaque, reflection, convex, concave, focal point, electron, electric force/ field/current, conductor, static electricity, charge, neutral, magnet, magnetism, magnetic force/ pole/field, electromagnetism, electromagnet, galvanometer, electric motor, generator, transformer, information technology, software, noise, bandwidth, wave pulse, analog signal, digital signal, pixel, circuit, voltage, resistance, Ohm's Law, series circuit, parallel circuit	NOVA Series Cybersecurity: https://ny.pbslearningmedia.org/resource/nvcy-doc-cyberlplan/nova-cybersecurity-lab-lesson-plan/	

ENGINEERING DESIGN (TO INCLUDE IN ALL MIDDLE SCHOOL SCIENCE CLASSES) - Incorporate engineering design throughout the school year. One example lab is provided below ("Design challenge: Which design will cool a soda the best?"). Flinn Scientific also sells many STEM design challenge labs for Physical Science.

	MS-ETS1-1	Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.	No clarification statement provided with performance expectation.	**ETS1.A -** The more precisely a design task's critera and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions.			Lab 5 - Design challenge: Which design will cool a soda the best?
	MS-ETS1-2	Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.	No clarification statement provided with performance expectation.	**ETS1.B -** There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem.			Lab 5 - Design challenge: Which design will cool a soda the best?
	MS-ETS1-3	Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.	No clarification statement provided with performance expectation.	**ETS1.B -** Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. **ETS1.C -** Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process.			Lab 5 - Design challenge: Which design will cool a soda the best?
	MS-ETS1-4	Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.	No clarification statement provided with performance expectation.	**ETS1.B -** (1) A solution needs to be tested, and then modified on the basis of the test reults, in order to improve it. (2) Models of all kinds are important for testing solutions. **ETS1. C -** The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution.			Lab 5 - Design challenge: Which design will cool a soda the best?