School District of Marshfield Course Syllabus

Course Name: Physics
Length of Course: Year
Credit: 1 Credit

Program Goal:

The School District of Marshfield K-12 Science Program will prepare and motivate learners to explore, problem solve and collaborate with their classmates to interpret science and explain the world around them. Learners will acquire knowledge and evidence that promotes creative solutions through the evaluation and understanding of scientific theories and evidence. Learners will collect, analyze and reason with scientific data through investigations that ultimately allow for the generation of scientific explanations. Critical thinking skills will elevate natural curiosity, make sense of scientific data and promote scientific literate citizens.

Course Description:

Discover the physical laws of nature, including motion, dynamics, energy, waves and modern physics. Learners will study the interactions among science, technology and society along with the history of Physicists and scientific myth busting. At least 25 percent of instructional time will be spent on hands-on laboratory work with an emphasis on inquiry-based investigations. Students will learn how to develop equations that model the behaviors in the above areas.

Wisconsin Standards for Science (SCI)	
Crosscutting Concepts (CC)	
CC1: Students use science and engineering practices, disciplinary core ideas, and ***patterns*** to make sense of phenomena and solve problems.	
Patterns	CC1.h: Students observe patterns in systems at different scales and cite patterns as empirical evidence for causality in supporting their explanations of phenomena. They recognize classifications or explanations used at one scale may not be useful or need revision using a different scale, thus requiring improved investigations and experiments. They use mathematical representations to identify and analyze patterns of performance in order to reengineer a designed system.
CC2: Students use science and engineering practices, disciplinary core ideas, and ***cause and effect*** relationships to make sense of phenomena and solve problems.	
Cause and Effect	CC2.h: Students understand empirical evidence is required to differentiate between cause and correlation and to make claims about specific causes and effects. They suggest cause and effect relationships to explain and predict behaviors in complex natural and designed systems. They also propose causal relationships by examining what is known about smaller scale mechanisms within the system. They recognize changes in systems may have various causes that may not have equal effects.
CC3: Students use science and engineering practices, disciplinary core ideas, and an understanding of ***scale, proportion and quantity*** to make sense of phenomena and solve problems.	
Scale, Proportion, and Quantity	CC3.h: Students understand the significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. They recognize patterns observable at one scale may not be observable or exist at other scales, and some systems can only be studied indirectly as they are too small, too large, too fast, or too slow to observe directly. They use orders of magnitude to understand how a model at one scale relates to a model at another scale. They use algebraic thinking to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth).
CC4: Students use science and engineering practices, disciplinary core ideas, and an understanding of ***systems and models*** to make sense of phenomena and solve problems.	

Systems and System Models	CC4.h: Students investigate or analyze a system by defining its boundaries and initial conditions, as well as its inputs and outputs. They use models (e.g., physical, mathematical, computer models) to simulate the flow of energy, matter, and interactions within and between systems at different scales. They also use models and simulations to predict the behavior of a system, and recognize that these predictions have limited precision and reliability due to the assumptions and approximations inherent in the models. They also design systems to do specific tasks.
CC5: Students use science and engineering practices, disciplinary core ideas, and an understanding of ***energy and matter*** to make sense of phenomena and solve problems.	
Energy and Matter	CC5.h: Students understand that the total amount of energy and matter in closed systems is conserved. They describe changes of energy and matter in a system in terms of energy and matter flows into, out of, and within that system. They also learn that energy cannot be created or destroyed. It only moves between one place and another place, between objects and/or fields, or between systems. Energy drives the cycling of matter within and between systems. In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved.
CC6: Students use science and engineering practices, disciplinary core ideas, and an understanding of ***structure and function*** to make sense of phenomena and solve problems.	
Structure and Function	CC6.h: Students investigate systems by examining the properties of different materials, the structures of different components, and their interconnections to reveal the system’s function and solve a problem. They infer the functions and properties of natural and designed objects and systems from their overall structure, the way their components are shaped and used, and the molecular substructures of their various materials.
CC7: Students use science and engineering practices, disciplinary core ideas, and an understanding of ***stability and change*** to make sense of phenomena and solve problems.	
Stability and Change	CC7.h: Students understand much of science deals with constructing explanations of how things change and how they remain stable. They quantify and model changes in systems over very short or very long periods of time. They see some changes are irreversible, and negative feedback can stabilize a system, while positive feedback can destabilize it. They recognize systems can be designed for greater or lesser stability.
Science and Engineering Practices (SEP)	
SEP1: Students ***ask questions and define problems***, in conjunction with using crosscutting concepts and disciplinary core ideas, to make sense of phenomena and solve problems.	

<table>
<tr><td>Asking Questions
SEP1.A</td><td>SEP1.A.h:
Students ask questions to formulate, refine, and evaluate empirically testable questions. This includes the following:

Ask questions that arise from careful observation of phenomena, or unexpected results, to clarify and seek additional information.

Ask questions that arise from examining models or theories to clarify and seek additional information and relationships.

Ask questions to determine relationships, including quantitative relationships, between independent and dependent variables.

Ask questions to clarify and refine a model or an explanation.

Evaluate a question to determine if it is testable and relevant.

Ask questions that can be investigated within the scope of the school laboratory, research facilities, or field (e.g., outdoor environment) with available resources and, when appropriate, frame a hypothesis based on a model or theory.

Ask and evaluate questions that challenge the premise(s) of an argument, the interpretation of a data set, or the suitability of the design.</td></tr>
<tr><td>Defining Problems
SEP1.B</td><td>SEP1.B.h:
Students formulate, refine, and evaluate design problems using models and simulations. This includes the following:

Define a design problem that involves the development of a process or system with interacting components and criteria and constraints that may include social, technical, and environmental considerations.

Clarify and refine an engineering problem.</td></tr>
<tr><td colspan="2">SEP2: Students develop and use models, in conjunction with using crosscutting concepts and disciplinary core ideas, to make sense of phenomena and solve problems.</td></tr>
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Developing Models SEP2.A	SEP2.A.h: Students use, synthesize, and develop models to predict and show relationships among variables and between systems and their components in the natural and designed world. This includes the following: Evaluate merits and limitations of two different models of the same proposed tool, process, mechanism, or system in order to select or revise a model that best fits the evidence or design criteria. Design a test of a model to ascertain its reliability. Develop, revise, and use models based on evidence to illustrate and predict the relationships between systems of between components of a system. Develop and use multiple types of models to provide mechanistic accounts and predict phenomena. Move flexibly between these model types based on merits and limitations. Develop a complex model that allows for manipulation and testing of a proposed process or system. Develop and use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and solve problems.
SEP3: Students ***plan and carry out investigations***, in conjunction with using crosscutting concepts and disciplinary core ideas, to make sense of phenomena and solve problems.	
Planning and Conducting Investigations SEP3.A	SEP3.A.h: Students plan and carry out investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models: This includes the following: Individually and collaboratively plan an investigation or test a design to produce data that can serve as evidence to build and revise models, support explanations for phenomena, and refine solutions to problems. Consider possible variables or effects and evaluate the investigation's design to ensure variables are controlled. Individually and collaboratively plan and conduct an investigation to produce data to serve as the basis for evidence. In the design: decide on types, how much, and accuracy of data needed to produce reliable measurements. Consider limitations on the precision of the data (e.g., number of trials, cost, risk, time) and refine the design accordingly.

	Plan and conduct an investigation or test a design solution in a safe and ethical manner including considerations of environmental, social, and personal impacts. Select appropriate tools to collect, record, analyze, and evaluate data. Make directional hypotheses that specify what happens to a dependent variable when an independent variable is manipulated. Manipulate variables and collect data about a complex model of a proposed process or system to identify failure points, or to improve performance relative to criteria for success.
SEP4: Students ***analyze and interpret data***, in conjunction with using crosscutting concepts and disciplinary core ideas, to make sense of phenomena and solve problems.	
Analyze and Interpret Data SEP4.A	SEP4.A.h: Students engage in more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data. This includes the following: Analyze data using tools, technologies, and models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. Apply concepts of statistics and probability to scientific and engineering questions and problems, using digital tools when feasible. Concepts should include determining the fit of functions, slope, and intercepts to data, along with correlation coefficients when the data is linear. Consider and address more sophisticated limitations of data analysis (e.g., sample selection) when analyzing and interpreting data. Compare and contrast various types of data sets (e.g., self-generated, archival) to examine consistency of measurements and observations. Evaluate the impact of new data on a working explanation or model of a proposed process or system. Analyze data to optimize design features or characteristics of system components relative to criteria for success.
SEP5: Students ***mathematics and computational thinking***, in conjunction with using crosscutting concepts and disciplinary core ideas, to make sense of phenomena and solve problems.	

Qualitative and Quantitative Data SEP5.A	SEP5.A.h: Students use algebraic thinking and analysis, a range of linear and nonlinear functions (including trigonometric functions, exponentials, and logarithms), and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. This includes the following: Decide if qualitative or quantitative data are best to determine whether a proposed object or tool meets criteria for success. Create and/or revise a computational model or simulation of a phenomenon, designed device, process, or system. Use mathematical, computational, and algorithmic representations of phenomena or design solutions to describe and support claims and explanations. Apply techniques of algebra and functions to represent and solve scientific and engineering problems. Use simple limit cases to test mathematical expressions, computer programs, algorithms, or simulations of a process or system to see if a model "makes sense" by comparing the outcomes with what is known about the real world. Apply ratios, rates, percentages, and unit conversions in the context of complicated measurement problems involving quantities with derived or compound units (such as mg/mL, kg/m^3, acre-feet, and others).
SEP6: Students ***construct explanations and design solutions***, in conjunction with using crosscutting concepts and disciplinary core ideas, to make sense of phenomena and solve problems.	
Construct an Explanation SEP6.A	SEP6.A.h: Students create explanations that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. This includes the following: Make quantitative and qualitative claims regarding the relationship between dependent and independent variables. Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources, including students' own investigations, models, theories, simulations, and peer review. Explanations should reflect the assumption that theories and laws that describe the

	natural world operate today as they did in the past and will continue to do so in the future. Apply scientific ideas, principles, and evidence to provide an explanation of phenomena taking into account possible, unanticipated effects.
Design Solutions SEP6.B	SEP6.B.h: Students create designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. This includes the following: Design, evaluate, and refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, and prioritized criteria. Consider trade-offs. Apply scientific ideas, principles, and evidence to solve design problems, taking into account possible unanticipated effects.
SEP7: Students ***engage in argument from evidence***, in conjunction with using crosscutting concepts and disciplinary core ideas, to make sense of phenomena and solve problems.	
Argue from Evidence SEP7.A	SEP7.A.h: Students use appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world. Arguments may also come from current scientific or historical episodes in science. This includes the following: Compare and evaluate competing arguments or design solutions in light of currently accepted explanations, new evidence, limitations (e.g., trade-offs), constraints, and ethical issues. Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments. Respectfully provide and receive critiques on scientific arguments by probing reasoning and evidence, by challenging ideas and conclusions, by responding thoughtfully to diverse perspectives, and by determining what additional information is required to resolve contradictions. Construct, use, and present oral and written arguments or counterarguments based on data and evidence.

	Make and defend a claim based on evidence about the natural world or the effectiveness of a design solutions that reflects scientific knowledge and student-generated evidence. Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and logical arguments. Consider relevant factors (e.g. economic, societal, environmental, and ethical considerations).
SEP8: Students will ***obtain, evaluate and communicate information***, in conjunction with using crosscutting concepts and disciplinary core ideas, to make sense of phenomena and solve problems.	
Obtain, Evaluate, and Communicate Information SEP8.A	SEP8.A.h: Students evaluate the validity and reliability of claims, methods, and designs. This includes the following: Critically read scientific literature adapted for classroom use to determine the central ideas or conclusions, and to obtain scientific and technical information. Summarize complex evidence, concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms. Compare, integrate, and evaluate sources of information presented in different media or formats (e.g., visually, quantitatively, or text-based) in order to address a scientific question or solve a problem. Gather, read, and evaluate scientific and technical information from multiple authoritative sources, assessing the evidence and usefulness of each source. Synthesize and evaluate the validity and reliability of multiple claims, methods, or designs that appear in scientific and technical texts or media reports. Verify the data when possible. Communicate scientific and technical information in multiple formats, including orally, graphically, textually, and mathematically. Examples of information could include ideas about phenomena or the design and performance of a proposed process or system.
Physical Science (PS)	
PS1: Students use science and engineering practices, crosscutting concepts, and an understanding of ***matter and its interactions*** to make sense of phenomena and solve problems.	
Structures and Properties of Matter PS1.A	PS1.A.h: The sub-atomic structural model and interactions between electric charges at the atomic scale can be used to explain the structure and interactions of matter, including chemical reactions and nuclear processes. Repeating

	patterns of the periodic table reflect patterns of outer electrons. A stable molecule has less energy than the same set of atoms separated; one must provide at least this energy to take the molecule apart.
PS2: Students use science and engineering practices, crosscutting concepts, and an understanding of ***forces, interactions, motion and stability*** to make sense of phenomena and solve problems.	
Forces and Motion PS2.A	PS2.A.h: Motion and changes in motion can be quantitatively described using concepts of speed, velocity, and acceleration (including speeding up, slowing down, and/or changing direction). Newton's second law of motion (F=ma) and the conservation of momentum can be used to predict changes in the motion of macroscopic objects. If a system interacts with objects outside itself, the momentum of the system can change; however, any such change is balances by changes in the momentum of objects outside the system.
Types of Interactions PS2.B	PS2.B.h: Forces at a distance are explained by fields that can transfer energy and can be described in terms of the arrangement and properties of the interacting objects and the distance between them. These forces can be used to describe the relationship between electrical and magnetic fields. Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects.
Example Three-Dimensional Performance Indicators PS2	HS-PS2-1: Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration. HS-PS2-2: Use mathematical representations (qualitative and quantitative) to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system. HS-PS2-3: Apply scientific and engineering ideas to design, evaluated, and refine a device that minimizes the force on a macroscopic object during a collision. HS-PS2-4: Use mathematical representations (qualitative and quantitative) of Newton's law of gravitation and Coulomb's law to describe and predict the gravitational and electrostatic forces between objects. HS-PS2-6: Communicate scientific and technical information about why the molecular-level structure is important in the functions of designed materials.

PS3: Students use science and engineering practices, crosscutting concepts, and an understanding of ***energy*** to make sense of phenomena and solve problems.	
Definitions of Energy PS3.A	PS3.A.h: Systems move towards more stable states.
Conservation of Energy and Energy Transfer PS3.B	PS3.B.h: The total energy within a system is conserved. Energy transfer within and between systems can be described and predicted in terms of energy associated with the motion or configuration of particles (objects).
Relationships Between Energy and Forces PS3.C	PS3.C.h: Fields contain energy that depends on the arrangement of the objects in the field.
Energy in Chemical Processes and Everyday Life PS3.D	PS3.D.h: Photosynthesis is the primary biological means of capturing radiation from the sun; energy cannot be destroyed, but it can be converted to less useful forms.
PS4: Students use science and engineering practices, crosscutting concepts, and an understanding of ***waves and their applications in technologies for information transfer*** to make sense of phenomena and solve problems.	
Wave Properties PS4.A	PS4.A.h: The wavelength and frequency of a wave are related to one another by the speed of the wave, which depends on the type of wave and the medium through which it is passing. Waves can be used to transmit information and energy.
Electromagnetic Radiation PS4.B	PS4.B.h: Both an electromagnetic wave model and a photon model explain features of electromagnetic radiation broadly and describe common applications of electromagnetic radiation.
Information Technologies and Instrumentation PS4.C	PS4.C.h: Large amounts of information can be stored and shipped around as a result of being digitized.
Earth and Space Science (ESS)	
ESS1: Students use science and engineering practices, crosscutting concepts, and an understanding of ***Earth's place in the universe*** to make sense of phenomena and solve problems.	
Earth and the Solar System ESS1.B	ESS1.B.h: Kepler's laws describe common features of the motions of orbiting objects. Observations from astronomy and space probes provide evidence for explanations of solar system formation. Cyclical changes in Earth's tilt and orbit, occurring over tens to hundreds of thousands of years, cause cycles of ice ages and other gradual climate changes.
ESS2: Students use science and engineering practices, crosscutting concepts, and an understanding of ***Earth's systems*** to make sense of phenomena and solve problems.	
Weather and Climate ESS2.D	ESS2.D.h: The role of radiation from the sun and its interactions with the atmosphere, ocean, and land are the foundation for the global climate system. Global climate models are used to predict future changes, including changes influenced by human behavior and natural factors.
Engineering, Technology, and the Application of Science (ETS)	

<table>
<tr><td colspan="2">ETS1: Students use science and engineering practices, crosscutting concepts, and an understanding of engineering design to make sense of phenomena and solve problems.</td></tr>
<tr><td>Developing Possible Solutions
ETS1.B</td><td>ETS1.B.h: When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts.

Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical. They are also useful in making a persuasive presentation to a client about how a given design will meet his or her needs.</td></tr>
<tr><td colspan="2">ETS2: Students use science and engineering practices, crosscutting concepts, and an understanding of links among Engineering, Technology, Science, and Society to make sense of phenomena and solve problems.</td></tr>
<tr><td>Developing Possible Solutions
ETS2.A</td><td>ETS2.A.h: Science and engineering complement each other in the cycle known as research and development (R&D).

Many research and development projects may involve scientists, engineers, and others with wide ranges of expertise.</td></tr>
<tr><td>Influence of Engineering, Technology, and Science on Society and the Natural World
ETS2.B</td><td>ETS2.B.h: Modern civilization depends on major technological systems, such as agriculture, health, water, energy, transportation, manufacturing, construction, and communications.

Engineers continuously modify these systems to increase benefits while decreasing costs and risks.

New technologies can have deep impacts on society and the environment, including some that were not anticipated.

Analysis of costs and benefits is a critical aspect of decisions about technology.</td></tr>
<tr><td colspan="2">ETS3: Students use science and engineering practices, crosscutting concepts, and an understanding of the nature of science and engineering to make sense of phenomena and solve problems.</td></tr>
<tr><td>Science and Engineering Are Human Endeavors
ETS3.A</td><td>ETS3.A.h: Individuals from diverse backgrounds bring unique perspectives that are valuable to the outcomes and processes of science and engineering.

Scientists’ and engineers’ backgrounds, perspectives, and fields of endeavor influence the nature of questions they ask, the definition of problems, and the nature of their findings and solutions.</td></tr>
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	Some cultures have historically been marginalized in science and engineering discourse. Scientists and engineers embrace skepticism and critique as a community. Deliberate deceit in science is rare and is likely exposed through the peer review process. When discovered, intellectual dishonesty is condemned by the scientific community.
Science and Engineering Are Unique Ways of Thinking with Different Purposes ETS3.B	ETS3.B.h: Science is both a body of knowledge that represents current understanding of natural systems and the processes used to refine, elaborate, revise and extend this knowledge. These processes differentiate science from other ways of knowing. Science knowledge has a history that includes the refinement of, and changes to, theories, ideas and beliefs over time. Science and engineering innovations may raise ethical issues for which science and engineering, by themselves, do not provide answers and solutions.
Science and Engineering Use Multiple Approaches to Create New Knowledge and Solve Problems ETS3.C	ETS3.C.h: Scientists use a variety of methods, tools and techniques to develop theories. A scientific theory is an explanation of some aspect of the natural word, based on evidence that has been repeatedly confirmed through observation, experimentation (hypothesis-testing), and peer review. The certainty and durability of science findings varies based on the strength of supporting evidence. Theories are usually modified if they are not able to accommodate new evidence. Engineers use a variety of approaches, tools, and techniques to define problems and develop solutions to those problems. Successful engineering solutions meet stakeholder needs and safety requirements and are economically viable. Trade-offs in design aspects balance competing demands.

Key Vocabulary:			
motion	displacement	speed	velocity
acceleration	force	balanced force	unbalanced force
net force	friction	gravity	free fall

Law of Conservation of Energy	elastic potential energy	Centripetal Acceleration	Centripetal Force
Gravitational Force	G’s	energy	work
kinetic energy	terminal velocity	inertia	potential energy
momentum	impulse	volume	pressure
density	volume flow rate	reference point	distance
Sound wave	electromagnetic wave	electric field	magnetic field
circuit	resistor	amplitude	frequency
lens	mirror	reflection	refraction
dispersion	diffraction	focal length	magnification
neutrino	atom	proton	neutron
electron	shock wave	photoelectric effect	fission
fusion	binding energy	ice cube telescope	special relativity

Topics/Content Outline- Units and Themes:

Quarter 1:

- Linear Motion and Forces

Quarter 2:

- 2D Motion, Circular Motion and Gravitation

Quarter 3:

- Energy, Momentum, Fluid Mechanics

Quarter 4:

- Waves and Optics, Atomic and Nuclear Physics

Primary Resource(s):

PhET Interactive Simulations: University of Colorado Boulder