Mendon High School Science Curriculum

Time Frame: September – December — Physics

Unit 1: Motion, Force, and Interactions

Next Generation Science Standards	Disciplinary Core Ideas	Essential Questions	Assessments	Vocabulary
Students who demonstrate understanding can: **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. [Clarification Statement: Examples of data could include tables or graphs of position or velocity as a function of time for objects subject to a net unbalanced force, such as a falling object, an object rolling down a ramp, or a moving object being pulled by a constant force.] [*Assessment Boundary: Assessment is limited to one-dimensional motion and to macroscopic objects moving at non-relativistic speeds.*] **HS-PS2-2** Use mathematical representations to support the claim that the total momentum of a system of	**PS2.A: Forces and Motion** Newton's second law accurately predicts changes in the motion of macroscopic objects. (HS-PS2-1) Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object. (HS-PS2-2) If a system interacts with objects outside itself, the total momentum of the system can change; however, any such change is balanced by changes in the momentum of objects outside the system. (HS-PS2-2),(HS-PS2-3) **PS2.B: Types of Interactions** Newton's law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict the effects of gravitational and	How can one explain and predict interactions between objects and within systems of objects? Why do physicists work in SI units? What is the role of uncertainty in physical measurement? What is the difference between speed and velocity? How can you determine velocity from a position-time graph? How can you determine acceleration from a velocity-time graph? How can a velocity-time graph be created from a position-time graph? How does force affect the motion of an object and how can the same magnitude of force cause a	**<u>Before</u>: HS-PS2-1** Pretest over the Newton's laws, velocity, acceleration, and data and graph analysis Discussions with the students. KWL **<u>During</u>: HS-PS2-1** Collecting data for objects in motion can be very simple so this is a great unit to begin with because students get introduced to data collection and analysis while also being introduced to velocity and acceleration. _ Depending on the difficulty of the lab you may want to give the lab before or after the material is lectured. Quick assessments should be used after lectures, e.g. response cards, daily assignments, think/pair/share, or quick writes. _ Conduct an experiment that collects data of an object with a constant velocity. _ Conduct an experiment that collects data of an object with a constant acceleration.	Acceleration due to gravity Accuracy Agent Apparent weight Average acceleration Average speed Average velocity Centripetal acceleration Centripetal force Closed system Coefficient of kinetic friction Coefficient of static friction Component Contact force Coordinate system Dependent variable Dimensional analysis Displacement Distance Drag force Equilibrant Equilibrium External force Field force Force Free fall Free-body diagram Gravitational force Gravitational mass Gravity Hypothesis

*Denotes a traditional science content integrated with engineering through a Practice or Disciplinary Core Idea.

Next Generation Science Standards	Disciplinary Core Ideas	Essential Questions	Assessments	Vocabulary
objects is conserved when there is no net force on the system. [Clarification Statement: Emphasis is on the quantitative conservation of momentum in interactions and the qualitative meaning of this principle.] [*Assessment Boundary: Assessment is limited to systems of two macroscopic bodies moving in one dimension.*] **HS-PS2-3** Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.* [Clarification Statement: Examples of evaluation and refinement could include determining the success of the device at protecting an object from damage and modifying the design to improve it. Examples of a device could include a football helmet or a parachute.] [*Assessment Boundary: Assessment is limited to qualitative evaluations and/or algebraic manipulations.*] **HS-PS2-4** Use mathematical representations of Newton's	electrostatic forces between distant objects. (HS-PS2-4) Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields. (HS-PS2-4),(HS-PS2-5) **PS3.A: Definitions of Energy** "Electrical energy" may mean energy stored in a battery or energy transmitted by electric currents.*(secondary to HS-PS2-5)* **ETS1.A: Defining and Delimiting an Engineering Problem** Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design	great change in motion? How do Newton's laws explain the horizontal acceleration of a projectile? How do Newton's laws explain the vertical acceleration of a projectile? Why is an object in uniform circular motion experiencing centripetal acceleration? Why does centrifugal force not actually exist? On what variables does the value of *g* depend? What factors do not affect it? How can a person's weight change depending on their location? How can you find net force using vector resolution? How does the angle of inclination change an object's normal force, friction force, and net force? Explain using an example how Newton's third law relates to conservation of	- Conduct an experiment that collects data of an object with a constant force and mass as the independent variable and acceleration as the dependent variable. **<u>After</u>: HS-PS2-1** The final test for this standard should include concepts and calculations for velocity, acceleration, forces, and Newton's laws. If possible, it is a good idea to add data analysis questions similar to questions found on the ACT or MME. **<u>Before</u>: HS-PS2-2** Pretest over concepts related to momentum. Discussions with the students. KWL **<u>During</u>: HS-PS2-2** Quick assessments should be used after lectures, e.g. response cards, daily assignments, think/pair/share, or quick writes. Practice problems involving impulse and change in momentum and the conservation of momentum. **<u>After</u>: HS-PS2-2**	Impulse Impulse-momentum theorem Independent variable Inertia Inertial mass Instantaneous Instantaneous acceleration Instantaneous velocity Interaction pair Internal force Inverse relationship Isolated system Kepler's second law Kinetic friction Law of conservation of momentum Line of best fit Linear relationship Magnitude Measurement Momentum Motion diagram Net force Newton's first law Newton's law of universal gravitation Newton's second law Newton's third law Normal force Origin Particle model Physics Position Position Position-time graph Precision Projectile Quadratic relationship

*Denotes a traditional science content integrated with engineering through a Practice or Disciplinary Core Idea.

Next Generation Science Standards	Disciplinary Core Ideas	Essential Questions	Assessments	Vocabulary
Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects. [Clarification Statement: Emphasis is on both quantitative and conceptual descriptions of gravitational and electric fields.] [*Assessment Boundary: Assessment is limited to systems with two objects.*] **HS-PS2-5** Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current. [*Assessment Boundary: Assessment is limited to designing and conducting investigations with provided materials and tools.*]	meets them. *(secondary to HS-PS2-3)* **ETS1.C: Optimizing the Design Solution** Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed. *(secondary to HS-PS2-3)*	momentum in collisions. How can a bullet have the same momentum as a truck? What conditions are necessary for an object to stay in orbit around the Earth? What is the relationship between work and energy?	The final test for this standard should include concepts on momentum and calculations for momentum, impulse, change in momentum, and conservation of momentum. If possible, it is a good idea to add data analysis questions similar to questions found on the ACT or MME. **Before**: **HS-PS2-3** Have a class discussion to gage student interest level for different project ideas. You may want to offer multiple ideas for students to choose from if the recourses are available. **During**: **HS-PS2-3** **S**tudents must complete a project that uses engineering practices to design or redesign an object that reduces the force experienced by the object during a collision. E.g. design an egg dropping apparatus, draw a diagram and explain the redesign of specific products such as football helmets or parachutes. **After**: **HS-PS2-3** Have students write a report about their project and why they used certain design features or have students answer a list of follow-up	Resultant Scalar Scientific law Scientific method Scientific theory Significant digits Static friction System Tension Terminal velocity Time interval Trajectory Uniform circular motion Vector Vector resolution Velocity-time graph Weightlessness

*Denotes a traditional science content integrated with engineering through a Practice or Disciplinary Core Idea.

Next Generation Science Standards	Disciplinary Core Ideas	Essential Questions	Assessments	Vocabulary
			questions. **<u>Before</u>: HS-PS2-4** Pretest over concepts related to gravitational force and electrical force. Discussions with the students. KWL **<u>During</u>**: HS**-PS2-4** Quick assessments should be used after lectures, e.g. response cards, daily assignments, think/pair/share, or quick writes. Practice problems involving Newton's Universal Law of Gravitation and Coulomb's Law. **<u>After</u>: HS-PS2-4** The final test for this standard should include concepts on gravity and electrostatic forces and calculations using Coulomb's Law and Newton's Law of Gravitation. If possible, it is a good idea to add data analysis questions similar to questions found on the ACT or MME. **<u>Before</u>: HS-PS2-5** Discussions with the students.	

*Denotes a traditional science content integrated with engineering through a Practice or Disciplinary Core Idea.

Next Generation Science Standards	Disciplinary Core Ideas	Essential Questions	Assessments	Vocabulary
			KWL **<u>During</u>: HS-PS2-5** Have students predict the outcome of demonstrations and analyze the results. E.g. Electric generator, electric motor. **<u>After</u>: HS-PS2-5** Have students design their own investigation that shows the relationship between electric current and magnetic force. E.g. place a compass around a current carrying wire or test what variables will increase the magnetic force of an electromagnet.	

*Denotes a traditional science content integrated with engineering through a Practice or Disciplinary Core Idea.

Mendon High School Science Curriculum Map

Time Frame: January – March
Physics
Unit 2: Energy

Next Generation Science Standards	Disciplinary Core Ideas	Essential Questions	Assessments	Vocabulary
Students who demonstrate understanding can: **HS-PS3-1** Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known. [Clarification Statement: Emphasis is on explaining the meaning of mathematical expressions used in the model.] [*Assessment Boundary: Assessment is limited to basic algebraic expressions or computations; to systems of two or three components; and to thermal energy, kinetic energy, and/or the energies in gravitational, magnetic, or electric fields.*] **HS-PS3-2** Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the	**PS3.A: Definitions of Energy** Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms. (HS-PS3-1),(HS-PS3-2) At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. (HS-PS3-2) (HS-PS3-3) These relationships are better understood at the microscopic scale, at which all of the different manifestations of energy can be modeled as a	What is the relationship between work, power and energy? What are different ways in which mechanical energy can be transferred and stored? How can the conservation of energy be maximized. What is the relationship between momentum and kinetic energy? When is momentum conserved and not kinetic energy? How does wave speed relate to wavelength and period? What is the relationship between the amplitude of a wave and the rate of energy transfer? What is the relationship between the amplitude of a wave and the rate of energy transfer? What is the difference between constructive and destructive interference?	**Before**: **HS-PS3-1** Pretest over energy transformation and conservation. **During**: **HS-PS3-1** Complete a lab that will show the conservation of mechanical energy. E.g. inelastic collisions lab or a rollercoaster lab **After**: **HS-PS3-1** Have students create their own equations for energy conservation based on the results from the lab. Have students use their energy equation to calculate changes in energy. **Before**: **HS-PS3-2** Have students brainstorm a list of different types of energy. Make a rubric for the diagram, drawing, or animation that will model the energy chosen by the students **During**: **HS-PS3-2** Depending on your resources,	Amplitude Amplitude Antinode Antinode Crest Efficiency Effort force Elastic collision Elastic potential energy Energy Frequency Frequency Gravitational potential energy Ideal mechanical advantage Inelastic collision Interference Interference Joule Kinetic energy Kinetic energy Law of conservation of energy Longitudinal wave Longitudinal wave Machine Mechanical advantage Mechanical energy Node Node

*Denotes a traditional science content integrated with engineering through a Practice or Disciplinary Core Idea.

Next Generation Science Standards	Disciplinary Core Ideas	Essential Questions	Assessments	Vocabulary
relative positions of particles (objects). [Clarification Statement: Examples of phenomena at the macroscopic scale could include the conversion of kinetic energy to thermal energy, the energy stored due to position of an object above the earth, and the energy stored between two electrically-charged plates. Examples of models could include diagrams, drawings, descriptions, and computer simulations.] **HS-PS3-3** Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.* [Clarification Statement: Emphasis is on both qualitative and quantitative evaluations of devices. Examples of devices could include Rube Goldberg devices, wind turbines, solar cells, solar ovens, and generators. Examples of constraints could include use of renewable energy forms and efficiency.] [*Assessment Boundary: Assessment for quantitative evaluations is limited to total output for a given input. Assessment is limited to devices constructed with materials*	combination of energy associated with the motion of particles and energy associated with the configuration (relative position of the particles). In some cases the relative position energy can be thought of as stored in fields (which mediate interactions between particles). This last concept includes radiation, a phenomenon in which energy stored in fields moves across space. (HS-PS3-2) **PS3.B: Conservation of Energy and Energy Transfer** Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system. (HS-PS3-1) Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. (HS-PS3-1),(HS-PS3-4) Mathematical expressions, which quantify how the stored energy in a system		have students complete a project described in the standard to the left. **<u>After</u>: HS-PS3-2** Have students share their projects. **<u>Before</u>: HS-PS3-3** Have students brainstorm project ideas that will demonstrate transforming of energy (Many ideas are listed in the standard). Have students choose an appropriate project. **<u>During</u>: HS-PS3-3** A big project like this should have check points for the students such as a materials list, a blue print, updates during construction, and the final project. **<u>After</u>: HS-PS3-3** Projects may be shared. If data can be collected from projects then students may use them to test variables and produce graphs. **<u>Before</u>: HS-PS3-4** Have students brainstorm ideas for conducting an experiment similar to the one described in	Period Period Periodic motion Periodic motion Power Reference level Refraction Refraction Resistance force Rotational kinetic energy Thermal energy Transverse wave Transverse wave Trough Trough Watt Wave Wave Wavelength Machine Work Work-energy theorem

*Denotes a traditional science content integrated with engineering through a Practice or Disciplinary Core Idea.

Next Generation Science Standards	Disciplinary Core Ideas	Essential Questions	Assessments	Vocabulary
provided to students.] **HS-PS3-4** Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics). [Clarification Statement: Emphasis is on analyzing data from student investigations and using mathematical thinking to describe the energy changes both quantitatively and conceptually. Examples of investigations could include mixing liquids at different initial temperatures or adding objects at different temperatures to water.] [*Assessment Boundary: Assessment is limited to investigations based on materials and tools provided to students.*] **HS-PS3-5** Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the	depends on its configuration (e.g. relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior. (HS-PS3-1) The availability of energy limits what can occur in any system. (HS-PS3-1) Uncontrolled systems always evolve toward more stable states—that is, toward more uniform energy distribution (e.g., water flows downhill, objects hotter than their surrounding environment cool down). (HS-PS3-4) **PS3.C: Relationship Between Energy and Forces** When two objects interacting through a field change relative position, the energy stored in the field is changed. (HS-PS3-5) **PS3.D: Energy in Chemical Processes** Although energy cannot be		the standard. **<u>During</u>: HS-PS3-4** The lab completed by students will depend on available materials. Have advanced students design their own data tables and graphs. **<u>After</u>: HS-PS3-4** Grade lab reports, share data and graphs. **<u>Before</u>: HS-PS3-5** Brainstorm project ideas (diagram, drawing, animation, etc.), that will represent one of the different forms of energy interaction listed in the standard. **<u>During</u>: HS-PS3-5** Check points should be set for the project. **<u>After</u>: HS-PS3-5** Share the projects with presentations.	

Next Generation Science Standards	Disciplinary Core Ideas	Essential Questions	Assessments	Vocabulary
objects due to the interaction. [Clarification Statement: Examples of models could include drawings, diagrams, and texts, such as drawings of what happens when two charges of opposite polarity are near each other.] [*Assessment Boundary: Assessment is limited to systems containing two objects.*]	destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment. (HS-PS3-3),(HS-PS3-4) **ETS1.A: Defining and Delimiting an Engineering Problem** Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. *(secondary to HS-PS3-3)*			

*Denotes a traditional science content integrated with engineering through a Practice or Disciplinary Core Idea.

Mendon High School Science Curriculum Map

Time Frame: March – June <u>Physics</u>

Unit 3: Waves and Electromagnetic Radiation

Next Generation Science Standards	Disciplinary Core Ideas	Essential Questions	Assessments	Vocabulary
Students who demonstrate understanding can: **HS-PS4-1** Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media. [Clarification Statement: Examples of data could include electromagnetic radiation traveling in a vacuum and glass, sound waves traveling through air and water, and seismic waves traveling through the Earth.] [Assessment Boundary: Assessment is limited to algebraic relationships and describing those relationships qualitatively.] **HS-PS4-2** Evaluate questions about the advantages of using a digital transmission and storage of information. [Clarification Statement:	**PS3.D: Energy in Chemical Processes** Solar cells are human-made devices that likewise capture the sun's energy and produce electrical energy. (secondary to HS-PS4-5) **PS4.A: Wave Properties** The wavelength and frequency of a wave are related to one another by the speed of travel of the wave, which depends on the type of wave and the medium through which it is passing. (HS-PS4-1) Information can be digitized (e.g., a picture stored as the values of an array of pixels); in this form, it can be stored reliably in computer memory and sent over long distances as a series of wave pulses. (HS-PS4-2),(HS-PS4-5) [From the 3–5 grade band endpoints] Waves can add or cancel one another as	What factors does the amount of current produced in a magnetic field depend on? How does a cathode ray tube work? Describe the orientation of the electric field, magnetic field, and direction of travel in an electromagnetic wave. How does a capacitor work? What are four factors that affect the resistance properties of a piece of metal wire? Why do wires heat up when a current flows in them? What does an ammeter measure? What does a voltmeter measure? How would you insert each in a circuit?	**<u>Before</u>: HS-PS4-1** KWL waves Pretest **<u>During</u>: HS-PS4-1** Use equations to solve for the speed, period, frequency, and wavelength for a variety of different waves traveling through various media. **<u>After</u>: HS-PS4-1** Posttest for wave calculations. **<u>Before</u>: HS-PS4-2** Discuss advantages and disadvantages of digital transmission of information. **<u>During</u>: HS-PS4-2** Research a current issue, positive or negative, with digital information. **<u>After</u>: HS-PS4-2** Share research reports with the class. **<u>Before</u>: HS-PS4-3** KWL	Ammeter Ampere Antenna Atomic mass unit Average power Battery Capacitance Capacitor Charging by conduction Charging by induction Circuit breaker Conductor Coulomb Coulomb's law Dielectrics Electric circuit Electric current Electric field Electric field lines Electric potential difference Electromagnetic induction Electromagnetic radiation Electromagnetic spectrum Electromagnetic wave Electromotive force Electrostatics Elementary charge Equipotential Equivalent resistance Fuse Ground-fault interrupter Grounding

Next Generation Science Standards	Disciplinary Core Ideas	Essential Questions	Assessments	Vocabulary
Examples of advantages could include that digital information is stable because it can be stored reliably in computer memory, transferred easily, and copied and shared rapidly. Disadvantages could include issues of easy deletion, security, and theft.] **HS-PS4-3** Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other. [Clarification Statement: Emphasis is on how the experimental evidence supports the claim and how a theory is generally modified in light of new evidence. Examples of a phenomenon could include resonance, interference, diffraction, and photoelectric effect.] [Assessment Boundary: Assessment does not include using quantum theory.] **HS-PS4-4** Evaluate the	they cross, depending on their relative phase (i.e., relative position of peaks and troughs of the waves), but they emerge unaffected by each other. (Boundary: The discussion at this grade level is qualitative only; it can be based on the fact that two different sounds can pass a location in different directions without getting mixed up.) (HS-PS4-3) **PS4.B: Electromagnetic Radiation** Electromagnetic radiation (e.g., radio, microwaves, light) can be modeled as a wave of changing electric and magnetic fields or as particles called photons. The wave model is useful for explaining many features of electromagnetic radiation, and the particle model explains other features. (HS-PS4-3) When light or longer wavelength electromagnetic radiation is absorbed in matter, it is generally converted into thermal energy (heat). Shorter wavelength electromagnetic radiation (ultraviolet, X-rays, gamma rays) can		Pretest **<u>During</u>: HS-PS4-3** Demonstrate or show many properties of mechanical waves that are shared by electromagnetic waves (diffraction, interference, Doppler effect, etc.). Discuss characteristics of electromagnetic waves that are similar to particles. Discuss how the idea of photons brings the two theories together. **<u>After</u>: HS-PS4-3** Posttest **<u>Before</u>: HS-PS4-4** Brainstorm ideas for research projects related to the standard. Create a rubric for how students should evaluate the published material. Evaluate the validity of an article with the class as an example. **<u>During</u>: HS-PS4-4** Have check points for the students' research paper. **<u>After</u>: HS-PS4-4**	Insulators Isotope Kilowatt-hour Mass spectrometer Neutral Parallel circuit Parallel connection Primary coil Receiver Resistance Resistor Series circuit Series connection Short circuit Step-down transformer Step-up transformer Superconductor Volt Voltmeter

*Denotes a traditional science content integrated with engineering through a Practice or Disciplinary Core Idea.

Next Generation Science Standards	Disciplinary Core Ideas	Essential Questions	Assessments	Vocabulary
validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter. [Clarification Statement: Emphasis is on the idea that photons associated with different frequencies of light have different energies, and the damage to living tissue from electromagnetic radiation depends on the energy of the radiation. Examples of published materials could include trade books, magazines, web resources, videos, and other passages that may reflect bias.] [Assessment Boundary: Assessment is limited to qualitative descriptions.] **HS-PS4-5** Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.* [Clarification Statement: Examples could include solar cells capturing light and converting it to	ionize atoms and cause damage to living cells. (HS-PS4-4) Photoelectric materials emit electrons when they absorb light of a high-enough frequency. (HS-PS4-5) **PS4.C: Information Technologies and Instrumentation** Multiple technologies based on the understanding of waves and their interactions with matter are part of everyday experiences in the modern world (e.g., medical imaging, communications, scanners) and in scientific research. They are essential tools for producing, transmitting, and capturing signals and for storing and interpreting the information contained in them. (HS-PS4-5)		Share research papers with the class and have discussions. **<u>Before</u>: HS-PS4-5** Brainstorm research ideas **<u>During</u>: HS-PS4-5** Students should complete research and a report on different uses for electromagnetic waves. **<u>After</u>: HS-PS4-5** Students should share their research with the class. The class should take notes or complete worksheets on the different uses of electromagnetic waves.	

*Denotes a traditional science content integrated with engineering through a Practice or Disciplinary Core Idea.

Next Generation Science Standards	Disciplinary Core Ideas	Essential Questions	Assessments	Vocabulary
electricity; medical imaging; and communications technology.] [Assessment Boundary: Assessments are limited to qualitative information. Assessments do not include band theory.]				

*Denotes a traditional science content integrated with engineering through a Practice or Disciplinary Core Idea.