# Pequannock Township School District
# Curriculum Syllabus

***STEM Physics / Grade 11-12***

## Course Description:

The STEM Physics course outlined in this curriculum represents a comprehensive full year of Algebra-based HONORS level Physics. The course is divided into eleven main units which span the entirety of classical physics. The first three units form the foundation of physics and the rest of the course builds on them. The primary emphasis of this course is in the application of physical principles with particular emphasis on mechanical and electrical engineering applications. The unit sequence has been designed to interchange principles of electricity and magnetism with principles of mechanics, and students will be learning a diverse set of topics and applications including but not limited to: simple and compound machines, passive and active electronic components, integrated circuits, automobile engines, motors, generators, transformers, and rockets.

## Course Standards:

The following is a list of NJSLS that describe what students are expected to know and be able to do as a result of successfully completing this course. The following NJSLS are the basis of the assessment of student achievement. The learner will demonstrate mastery of:

HS-PS1-1: Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.

HS-PS1-2: Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.

HS-PS1-3: Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.

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 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 science and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.

HS-PS2-4: Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between 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.

HS-PS2-6: Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.

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.

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 motion of particles (objects) and energy associated with the relative positions of particles (objects).

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.

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).

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 objects due to the interaction.

HS-PS4-1: Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.

HS-PS4-2: Evaluate questions about the advantages of using digital transmission and storage of information.

HS-PS4-3: Evaluate the claims, evidence, and the 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.

HS-PS4-4: Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter.

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.

HS-ETS1-2: Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

HS-ETS1-4: Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.

HS-ESS1-4: Use mathematical or computational representations to predict the motion of orbiting objects in the solar system.

# Scope and Sequence

The course content is organized into units. The units have been arranged in a sequence which alternates applications of mechanics with principles and applications of electromagnetic theory. The crosscutting concepts of cause and effect, systems and systems models, energy and matter, and the influence of science, engineering, and technology on society and the natural world are further developed in the performance expectations. Students are expected to demonstrate proficiency in developing and using models, planning and carrying out investigations, using computational thinking and designing solutions, and they are expected to use these practices to demonstrate understanding of core ideas.

| **Units** | **Pacing** | **Unit Description** |
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| Unit 1: Kinematics and Dynamics Along a Line of Action | Sep.<br><br>16-20 days<br><br>Q1 | Students are expected to plan and conduct investigations, analyze data and use math to support claims, and apply scientific ideas to solve design problems in order to develop an understanding of ideas related to why objects move with specific speed/velocity and how time affects an object's rate of acceleration. Students will also build an understanding of forces and Newton's second law. They will represent the applied forces on an object within a coordinate system through the use of free body diagrams. Students are also able to apply science and engineering ideas to design, evaluate, and refine a device to minimize the effects of frictional force on a macroscopic object in motion. Students are also able to apply science and engineering ideas to design, evaluate, and refine experiments to determine the velocity, time, and distance travelled of an object using basic laboratory equipment and materials. |

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| | | Unit 1 culminates with an Assembly Line Project which will link the various pieces of the unit together. |
| Unit 2: Energy | Oct.<br><br>10-13 days<br><br>Q1 | In this unit of study, students develop and use models, plan and carry out investigations, use computational thinking and design solutions as they make sense of the disciplinary core idea. The disciplinary core idea of Energy is broken down into subcore ideas: definitions of energy, conservation of energy and energy transfer, and the relationship between energy and forces. Energy is understood as a quantitative property of a system that depends on the motion and interactions of matter, and the total change of energy in any system is equal to the total energy transferred into and out of the system. Students also demonstrate their understanding of engineering principles when they design, build, and refine devices associated with the conversion of energy.<br>Unit 2 culminates with a Roller Coaster Project which will link the various pieces of the prior 2 units together which will be carried out during Unit 3. |
| Unit 3: Force Fields and Flux | Oct.-Nov.<br><br>9-13 days<br><br>Q1 | Unit 3 begins the study of electromagnetic phenomena at a fundamental level, introducing students to the concepts of electric charge, electric force, and electric field and potential.<br>Students will use the concept of equipotential lines to visualize the electric field and make connections between the isolines on topographic maps for gravitational fields and equipotential lines for the electric field. This unit will also help students better understand that interactions between systems result in changes within those systems—allowing students to further apply energy conservation principles in later units. Students are encouraged to apply what they know when learning about fields (gravitational and electric), how fields interact, and the complex concepts of static and dynamic electricity. This will help students better understand energy conservation principles, as well as develop the science practice of data analysis. Data analysis is essential in identifying patterns and relationships between variables and helps students become better prepared to engage in and craft scientific arguments that describe a mechanism through which a phenomenon occurs. |
| Unit 4: DC Circuits | Nov- Dec | In this unit, students will examine how that charge can move through an object. Conductors, Capacitors and |

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| | 16-19 days<br><br>Q2 | Resistors are presented to demonstrate that a charge's movement is dependent on an object's material. In electronics, each of these are important based on the type of movement or desired object behavior.<br><br>Unit 4 serves to illuminate how, and why, our various appliances function by exploring the nature and importance of electric currents, circuits, and resistance. Students will also analyze the relationships that exist between current, resistance, and power, in addition to exploring and applying Ohm's Law and Kirchhoff's Rules. Students should be provided with opportunities (laboratory investigations or activities) to describe and examine the function of each of these elements, along with capacitors. The end of the unit entails thorough investigation of breadboards, and an introduction to modern electrical components.<br><br>Unit 4 culminates with two projects: building an Automatic Night Light Project and building a Variable DC Power Supply. The two projects will be carried out during Unit 5 and Unit 6 respectively. |
| Unit 5: Rotations | Dec- Jan<br><br>12-15 days<br><br>Q2 | In this unit, students will apply Newton's 2nd law to a polar coordinate system and investigate torque and rotational statics, kinematics, and dynamics to gain an in-depth and comprehensive understanding of rotation. Students are provided with opportunities to make connections between the content and models explored in the first four units, as well as with opportunities to demonstrate the analogy between translational and rotational kinematics. |
| Unit 6: Fluids and Simple Machines | Jan<br><br>10-13 days<br><br>Q2 | Fluids and Machines play a vital role in many aspects of everyday life. A fluid is any substance that can flow; we use the term for both liquids and gases. A machine eases the load by changing either the magnitude or the direction of a force to match the force to the capability of the machine or the person.<br><br>We begin our study with fluid statics, the study of fluids at rest in equilibrium situations. Like other equilibrium situations, it is based on Newton's first and third laws. We will explore the key concepts of density, pressure, and buoyancy. Fluid dynamics, the study of fluids in motion, is much more complex; indeed, it is one of the |

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| | | most complex branches of mechanics. Fortunately, we can analyze many important situations using simple idealized models and familiar principles such as Newton's laws and conservation of energy. Students will then draw their attention to a class of machines called Simple Machines where they will learn about mechanical advantage and efficiency. Students will then apply the concepts of mechanical advantage and efficiency to compound machines.<br><br>Unit 6 culminates with a Switch Activated Trebuchet Project which will link the various pieces of the first 6 units together and will be carried out during Unit 7. |
| Unit 7: Semiconductors: Active Electronic Components | Feb<br><br>10-13 days<br><br>Q3 | Nearly all electronic devices today use semiconductors. The most common are silicon (Si) and germanium (Ge) which acquire properties useful for electronics when a tiny amount of impurity is introduced into the crystal structure. This is called doping the semiconductor. In this unit students will learn about the two types of semiconductors n-type and p-type and how these two types can be arranged to create diodes, NPN transistors, PNP transistors, thyristors, and Field Effect Transistors (FET). In Unit 4-6 students were acquiring hands on experience building projects with the semiconductive devices above purely from understand their operative function. In this unit students will learn to qualitatively explain why these devices function the way they do and in addition provide a hydraulic analog associated with each. The unit ends with the introduction to SR flip flop and the 555 integrated circuit.<br><br>Unit 7 culminates with three projects that apply the function of the 555 timer: The first is to build a Pulse Width Modulation PWM DC Motor Speed Controller which will take place in Unit 8. The second is to build a Continuity Tester which will take place during Unit 9. The third is to build a Tone Generator which will also take place during Units 9 and 10. |
| Unit 8: Magnetism and Electromagnetic Induction | Feb - Mar<br><br>13-16 days<br><br>Q3 | In previous units, students discovered that the electric and gravitational fields allows objects with mass and charge to interact without contact. Unit 8 introduces students to magnetism and how magnetic fields are generated, behave, and relate to electricity. Students will learn how magnetic fields impact motion and interact with other |

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| | | magnetic fields.Unit 8 then examines electromagnetism through the concept of electromagnetic induction. Through activities and detailed laboratory investigations, students will study, apply, and analyze the concept of induction, as well as investigate the relationship between Faraday's Law and Lenz's Law. Additionally, students are expected to call upon their knowledge obtained in earlier units—particularly that of charges, currents, and electric and magnetic fields to be able to demonstrate, as well as reason with, how these fields are generated. In this unit students will learn the underlying physics of how motors function.<br><br>Unit 8 culminates with students building a low power Transformer which will apply the concepts from this and will be carried out during Unit 10. |
| Unit 9: Thermal Physics and Engines | Mar - Apr<br><br>13-16 days<br><br>Q3 | In Unit 9, students will continue to investigate what they cannot see by examining heat, temperature, and thermal energy in practical contexts such as heat engines, heat pumps, and refrigerators. The focus of this unit is the study of relationships and change, so it's important that students can discuss—in addition to calculate—what happens when a physical scenario changes, such as the consequences of adding heat to, or removing heat from a system.<br>Throughout this unit, students will use representations and models (PV diagrams, energy bar charts, or free-body diagrams) to construct evidence-based explanations and help them make predictions and justify claims about new phenomena. In particular, students will learn about three specific engine cycles: Carnot, Otto, and Diesel and how they relate to PV diagrams and physical construction of the Otto and Diesel engines. Unit 9 also acquaints students with the second law of thermodynamics and how it is not possible to build a perfectly efficient engine. |
| Unit 10: Oscillations, Waves, Sound and Light | Apr-May<br><br>20-23 days<br><br>Q4 | Unit 10 pays close attention to the type of motion we experience when we talk or listen to music, and the light that we can see and not see. Through the concept of oscillations, students are introduced to the model of simple harmonic motion (SHM) for springs. Students will discover why some objects repeat their motions with a regular pattern. They will also apply the model of SHM, define the three kinematic characteristics (displacement, velocity, and acceleration), and practice representing |

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| | | them graphically and mathematically. During their study of oscillations, students will gain a more in-depth understanding of motion, making them better equipped to apply their knowledge of forces and motion to waves.<br><br>Students will extend the main themes of the previous units and learn about mechanical and electromagnetic waves. Although concepts like oscillation, energy, and motion carry over into the study of waves, students will be introduced to new tools to communicate scientific phenomena and solve scientific models. For example, students will learn the underlying physics of how ac electric generators and speakers work. how resistors, inductors, and capacitors behave in circuits with sinusoidally varying voltages and currents. A key concept in this Unit is electrical resonance.<br><br>Unit 10 culminates with students applying the concepts of waves, and electromagnetic induction to build a Two Transistor Oscillator and Crystal Radio which will be carried out during this Unit and the last unit. |
| Unit 11: Momentum and Rockets | May - Jun<br><br>10-13 days<br><br>Q4 | Unit 11 introduces students to these factors through the concepts of impulse and momentum, and the conservation of linear momentum. Students will learn the relationship between impulse and momentum via application or calculations. The conservation of linear momentum and how it's applied to collisions and rocket propulsion is also addressed. Unit 11 offers a complete picture of the motion of a system, which is explored primarily through impulse and changes in momentum. Rocket propulsion offers a typical and interesting example of this kind of analysis. A rocket is propelled forward by rearward ejection of burned fuel that initially was in the rocket<br>(which is why rocket fuel is also called propellant). The forward force on the rocket is the reaction to the backward force on the ejected material. The total mass of the system is constant, but the mass of the rocket itself decreases as material is ejected.<br><br>Unit 11 culminates with students applying the concepts this unit with building a Rocket which will be carried out during this Unit. |

# Assessments
Evaluation of student achievement in this course will be based on the following:

**Assessment Types**

a. Projects, Lab, Reading Quizzes, Homework Quizzes, Review Quizzes, Unit Exams.

b. **Labs**
All lab work and lab reports will be done **legibly** inside your Quadruled composition lab notebook during your lab block using pencil, no typed labs. Your lab notebook will be submitted at the end of the lab period and returned to you at the start of the next lab day. Labs do not go home to be completed. Labs may require 1, 2 or 3 lab periods to complete depending on the complexity of the experiment.

**Assessment Policy**
Each assignment is assigned a certain number of points, which varies. The Final Grade is determined by Number of Points Earned Divided by Total Points.

# Curriculum Resources

***Primary Textbooks:*** Glencoe Science - Physics: Principles and Problems– 2007 by Paul W Zitzewitz; Physics: Principles with Applications, 6th Edition by Douglas Giancoli

***Supplemental Textbooks:*** Practical Electronics for Inventors - 4th Edition by Paul Scherz and Simon Monk;

# Home and School Connection
The following are suggestions and/or resources that will help parents support their children:

Solve assigned homework problems for every unit.

Invest in study/review time on a daily basis. Take the reading and projects seriously.

Online video resources: Khan Academy Physics, How to Mechatronics VLOG, All About Circuits Video Lectures