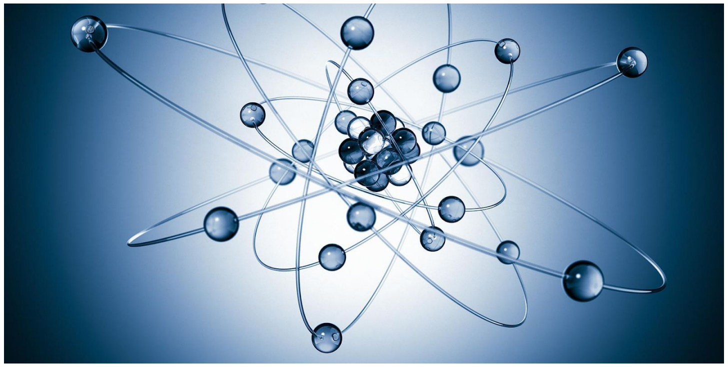
Secaucus Board of Education

PSI Physics

Course Code: 4121, 4131, 6450, 4800

Science Department



Born on August 2016
Aligned to the NJSLS – Science (2014), Technology (2014), 21st Century Life and Careers (2014), ELA (2016) and Mathematics (2016)
Adopted by the Secaucus Board of Education on August 25, 2016

District Equity Statement

The Board of Education directs that all students enrolled in the schools of this district shall be afforded equal educational opportunities in strict accordance with the law. No students shall be denied access to or benefit from any educational program or activity or from a co-curricular or athletic activity on the basis of the student's race, color, creed, religion, national origin, ancestry, age, marital status, affectional or sexual orientation, gender, gender identity or expression, socioeconomic status, or disability. The Board directs the Superintendent to allocate faculty, administrators, support staff members, curriculum materials, and instructional equipment supplies among and between the schools and classes of this district in a manner that ensures equivalency of educational opportunity throughout this district. The school district's curricula in the following areas will eliminate discrimination, promote mutual acceptance and respect among students, and enable students to interact effectively with others, regardless of race, color, creed, religion, national origin, ancestry, age, marital status, affectional or sexual orientation, gender, gender identity or expression, socioeconomic status, or disability:

1. School climate/learning environment
2. Courses of study, including Physical Education
3. Instructional materials and strategies
4. Library materials
5. Software and audio-visual materials
6. Guidance and counseling
7. Extra-curricular programs and activities
8. Testing and other assessments.

Excerpt from Secaucus Board of Education, Policy 5750, Edited September 2016

Course Description

This course represents the first year of Physics that could lead to AP 1, AP 2 or AP C Physics. The course covers Mechanics, which is studied for the first 40% of the year; Electricity and Magnetism, which is studied for the next 40%; and, finally, Simple Harmonic Motion, Waves, Light and the Bohr model of the Hydrogen atom for the last 20%.

The pacing, topics, and teaching methodology presented in this curriculum may be modified at the teacher's discretion on the basis of, but not limited to, academic level of the course, student performance, student needs, and school schedule.

The order of the topics has been geared to use and reinforce the mathematics that the students are studying. For this reason, this course is geared towards reinforcing skills in algebra and requires no trigonometry. This is accomplished by restricting the course to problems that can be simplified to one-dimensional form. While vectors are introduced, they are only added and subtracted in one dimension at a time. This allows students to do about 90% of the Physics AP 1 and AP 2 topics. Connections are also developed between the analysis of motion and graphical analysis, collision problems and the solving of systems of equations, etc.

Students will be involved in problem-solving activities on an individual, small group and large group basis. Through this process the ability to read and understand problems, break them down into their component parts and then create and present solutions will be developed.

Students who have successfully completed this course may elect to move onto Physics AP 1, AP 2 or AP C. In order to provide a smooth transition to these higher level physics courses, and to show a greater level of detail on the material being covered, the College Board AP Physics 1 and 2 Standards are listed underneath the NJSLS – Science standards. Students will not be tasked with completing the 10% of the standards that requires trigonometry.

Course Outline

1. One- Dimensional Kinematics

a. Motion in one dimension
b. Vectors vs. scalars
c. Displacement vs. Distance
d. Velocity vs. Speed
e. Using the four kinematics equations to solve problems:
    a. $x = xo + v_o t + \frac{1}{2} at^2$
    b. $v = v^o + at$
    c. $v^2 = v_o^2 + 2ax$
    d. $v_{avg} = (v + v_o)/2$
f. Graphical interpretation of motion

2. Dynamics

a. Aristotelian World View
b. Galilean view
c. Newton's Laws
d. Free body Diagrams
e. Gravity near the earth's surface and "g"
f. Mass versus weight (W = mg)
g. Use ΣF = ma and free body diagrams to solve problems in one dimension
h. Surface Forces: Normal Force and Friction

i. Apparent weight
e. Static and Kinetic Friction

2. **Uniform Circular Motion and Universal Gravitation**

1. Net force required for circular motion ($a = mv^2/r$)
2. Application of Free Body diagrams and Newton's Laws to circular motion problems
3. Universal gravitation
4. Solve problems with universal gravitation ($F = GMm/r^2$)
5. Satellites and 'weightless"
6. Kepler's Laws and Newton's Synthesis

5. Linear Momentum

a. Momentum ($p = mv$)
b. Impulse ($I = Ft = p$)
c. Momentum and its relation to force ($F = p/t$)
d. Conservation of momentum ($p = p'$)
e. Collision and Impulse Problems
f. Elastic collisions in one dimension ($v_1 - v_2 = v_2' - v_1'$)
g. Perfectly inelastic collisions in one dimension ($m' = m_1 + m_2$)
h. Inelastic collisions in one dimension

6. Work and Energy

a. Work done by a constant force ($W = Fd_{parallel}$)
b. Conservation of Energy ($E_o + W = E_f$)
c. Kinetic Energy ($KE = ½ mv^2$)
d. Gravitational Potential Energy ($GPE = mgh$)
e. Elastic Potential Energy ($EPE = ½ kx^2$)
f. Internal Energy and Joule's Principle

g. Conservative and nonconservative forces
h. Problem solving with the Principle of Conservation of Energy

7. Electric Charge and Electric Field

a. Electric charge and its conservation
b. Interactions of charges
c. Induced charges; the electroscope
d. Coulomb's Law ($F = kq_1q_2/r^2$)
e. Electric field ($E = kq/r^2$)
f. Superposition of forces
g. Superposition of electric fields
h. Calculation of net force and/or field due to multiple charges

8. **Electric Potential**

a. Electric potential and potential difference ($V = kq/r$)
b. Relation between electric potential and field ($V = Ed$)
c. Equipotential lines
d. Calculation of net electric potential due to multiple charges
e. Calculation of potential energy of a charge in at a voltage
f. Calculation of the potential energy of an assembly of charges

9. Electric Currents

a. The electric battery
b. Electric current ($I = q/t$
c. Ohm's Law ($I = V/R$)
d. Resistivity $R = L/A$
e. Superconductivity
f. Joule's Law and Electric Power ($P=V^2/R = IV = I^2R$)

10. DC Circuits

a. Resistors in series ($R_{series} = R_1 + R_2 +...$)
b. Adding resistors in parallel ($1/R_{parallel} = 1/R_1 + 1/R_2 +...$)
c. Equivalent Circuit resistance
d. Calculating current in circuits and circuit branches
e. Calculating power in circuits and circuit branches
f. EMF and terminal voltage (VT = E - Ir
g. EMF's in series and in parallel

11. Magnetism

a. Magnets and magnetic fields
b. Electric currents produce magnetic fields
c. Force on an electric current in a magnetic field ($F = LIB_{perpendicular}$)
d. Force on a charged particle in a magnetic field ($F = qvB_{perpendicular}$)
e. Magnetic field due to a current carrying wire $B = {}_oI/2r$
f. Force between parallel wires $F = {}_oI_1I_2/2r$
g. Direction of force between two parallel wires
h. Mass spectrometry ($r = mv/(qB)$)
i. Velocity selection ($v = E/B$)

12. Electromagnetic Induction

a. Magnetic Flux ($_B = BA_{parallel}$)
b. Magnitude of Induced EMF (E = -N
c. Lenz's Law
d. EMF induced in a moving conductor $E = BvL_{perpendicular}$
e. Changing magnetic flux produces an electric field
f. Electric generators
g. Conversion of mechanical to electric energy and its importance

13. Simple Harmonic Motion, Waves and Sound Waves

a. Period and frequency
b. Mass-spring systems
c. The simple pendulum
d. Wave Motion
e. Wavelength, frequency and wave velocity
f. Interference
g. Refraction
h. Diffraction
i. Standing Waves

14. Electromagnetic Radiation and the Wave Nature of Light

a. Changing electric fields produce magnetic fields
b. Production of EM Waves
c. The Wave Nature of Light
d. Visible Spectrum
e. Dispersion
f. The Speed of Light
g. The Double slit Experiment

15. Quantum Physics, Atomic and Nuclear Physics

a. Alpha particle scattering and the Rutherford model of the atom
b. Photons and the photoelectric effect
c. Wave-particle duality
d. Bohr model of the atom
e. Quantum Mechanics revolution
f. Nuclear models
g. Binding Energy

Labs

1. Graphical analysis of the motion of an object
2. Position, velocity, acceleration
3. Kinetic friction
4. Inertia
5. Centripetal force
6. Conservation of momentum
7. Electric charge
8. Electric field
9. Ohm's Law
10. Series and parallel circuits
11. Resistivity
12. Magnetic field maps
13. SHM spring-mass oscillating system

Course Modifications (ELLs, Special Education, Gifted and Talented)

The course instructor will determine, with the assistance of guidance counselors, teacher assistant/aides, and/or special education teachers, what modifications will be made for his/her students. Such examples of modifications can include, but not be limited to:

- Extended time as needed
- Modification of tests and quizzes
- Preferential seating
- Alternative/Formative assessment (projects)
- Effective teacher questioning (ranging from simple recall to higher order critical thinking questions)
- Supplemental materials
- Cooperative learning
- Teacher tutoring
- Peer tutoring
- Differentiated Instruction

Interdisciplinary Connections

The following NJSLS for ELA, Mathematics, College and Career Readiness, and Technology depict what standards align to the science standards taught in this PSI Physics Course.

NJSLS - ELA/Literacy:

- RST.9-10.1. Accurately cite strong and thorough evidence from the text to support analysis of science and technical texts, attending to precise details for explanations or descriptions.
- RST.9-10.2. Determine the central ideas, themes, or conclusions of a text; trace the text's explanation or depiction of a complex process, phenomenon, or concept; provide an accurate summary of the text.
- RST.9-10.3. Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.
- RST.9-10.4. Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to *grades 9-10 texts and topics*.
- RST.9-10.5. Analyze the relationships among concepts in a text, including relationships among key terms (e.g., *force, friction, reaction force, energy*).
- RST.9-10.6. Determine the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, defining the question the author seeks to address.
- RST.9-10.7. Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.
- RST.9-10.8. Determine if the reasoning and evidence in a text support the author's claim or a recommendation for solving a scientific or technical problem.
- RST.9-10.9. Compare and contrast findings presented in a text to those from other sources (including their own experiments), noting when the findings support or contradict previous explanations or accounts.
- RST.9-10.10. By the end of grade 10, read and comprehend science/technical texts in the grades 9-10 text complexity band independently and proficiently.
- WHST.9-10.1. Write arguments to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant sufficient textual and non-textual evidence.

- WHST.9-10.2. Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.

NJSLS - Mathematics:

- A.SSE.1 Interpret expressions that represent a quantity in terms of its context.
- A.SSE.2 Use the structure of an expression to identify ways to rewrite it.
- A.SSE.3 Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression.
- A.APR.1 Understand that polynomials form a system analogous to the integers, namely, they are closed under the operations of addition, subtraction, and multiplication; add, subtract, and multiply polynomials.
- A.CED.1 Create equations and inequalities in one variable and use them to solve problems. Include equations arising from linear and quadratic functions, and simple rational and exponential functions.
- A.CED.2 Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales.
- A.CED.4 Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations.
- A.REI.4 Solve quadratic equations in one variable
- A.APR.3 Identify zeros of polynomials when suitable factorizations are available, and use the zeros to construct a rough graph of the function defined by the polynomial.
- N.RN.1 Explain how the definition of the meaning of rational exponents follows from extending the properties of integer exponents to those values, allowing for a notation for radicals in terms of rational exponents.
- N.RN.2 Rewrite expressions involving radicals and rational exponents using the properties of exponents.
- N.RN.3 Explain why the sum or product of two rational numbers is rational; that the sum of a rational number and an irrational number is irrational; and that the product of a non-zero rational number and an irrational number is irrational.
- F.IF.4 For a function that models a relationship between two quantities, interpret key features of graphs and tables in terms of the quantities, and sketch graphs showing key features given a verbal description of the relationship.
- F.IF.5 Relate the domain of a function to its graph and, where applicable, to the quantitative relationship it describes.
- F.IF.6 Calculate and interpret the average rate of change of a function (presented symbolically or as a table) over a specified interval.
- F.IF.7 Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases.
- F.LE.1 Distinguish between situations that can be modeled with linear functions and with exponential functions.

- ❖ F.IF.8 Write a function defined by an expression in different but equivalent forms to reveal and explain different properties of the function.
- ❖ F.IF.9 Compare properties of two functions each represented in a different way (algebraically, graphically, numerically in tables, or by verbal descriptions)
- ❖ F.BF.1 Write a function that describes a relationship between two quantities.
- ❖ F.BF.3 Identify the effect on the graph of replacing f(x) by f(x) + k, k f(x), f(kx), and f(x + k) for specific values of k (both positive and negative); find the value of k given the graphs.
- ❖ F.LE.1 Distinguish between situations that can be modeled with linear functions and with exponential functions.
- ❖ F.LE.2 Construct linear and exponential functions, including arithmetic and geometric sequences, given a graph, a description of a relationship, or two input-output pairs (include reading these from a table).
- ❖ F.LE.3 Observe using graphs and tables that a quantity increasing exponentially eventually exceeds a quantity increasing linearly, quadratically, or (more generally) as a polynomial function.
- ❖ F.LE.5 Interpret the parameters in a linear or exponential function in terms of a context.
- ❖ S.ID.1 Represent data with plots on the real number line (dot plots, histograms, and box plots).
- ❖ S.ID.2 Use statistics appropriate to the shape of the data distribution to compare center (median, mean) and spread (interquartile range, standard deviation) of two or more different data sets.
- ❖ S.ID.3 Interpret differences in shape, center, and spread in the context of the data sets, accounting for possible effects of extreme data points (outliers).
- ❖ S.ID.4 Use the mean and standard deviation of a data set to fit it to a normal distribution and to estimate population percentages
- ❖ S.ID.5 Summarize categorical data for two categories in two-way frequency tables. Interpret relative frequencies in the context of the data (including joint, marginal, and conditional relative frequencies). Recognize possible associations and trends in the data.
- ❖ S.ID.6 Represent data on two quantitative variables on a scatter plot, and describe how the variables are related.
- ❖ S.ID.7 Interpret the slope (rate of change) and the intercept (constant term) of a linear model in the context of the data.
- ❖ S.ID.8 Compute (using technology) and interpret the correlation coefficient of a linear fit.
- ❖ S.ID.9 Distinguish between correlation and causation.

NJSLS – Technology:

- ❖ 8.1.12.A.1 Create a personal digital portfolio which reflects personal and academic interests, achievements, and career aspirations by using a variety of digital tools and resources.

- 8.1.12.A.2 Produce and edit a multi-page digital document for a commercial or professional audience and present it to peers and/or professionals in that related area for review.
- 8.1.12.A.3 Collaborate in online courses, learning communities, social networks or virtual worlds to discuss a resolution to a problem or issue.
- 8.1.12.A.4 Construct a spreadsheet workbook with multiple worksheets, rename tabs to reflect the data on the worksheet, and use mathematical or logical functions, charts and data from all worksheets to convey the results.
- 8.1.12.A.5 Create a report from a relational database consisting of at least two tables and describe the process, and explain the report results.

NJSLS – 21st Century Life and Careers:

- CRP1. Act as a responsible and contributing citizen and employee.
- CRP2. Apply appropriate academic and technical skills.
- CRP4. Communicate clearly and effectively and with reason.
- CRP5. Consider the environmental, social and economic impacts of decisions.
- CRP6. Demonstrate creativity and innovation.
- CRP7. Employ valid and reliable research strategies.
- CRP8. Utilize critical thinking to make sense of problems and persevere in solving them.
- CRP11. Use technology to enhance productivity.
- CRP12. Work productively in teams while using cultural global competence.

<table>
<tr><th colspan="4">Unit 1 – Kinematics</th></tr>
<tr><td>Teacher:</td><td>Science Dept</td><td>Time Frame:</td><td>19 days</td></tr>
<tr><td>Grade:</td><td>8/9</td><td>School:</td><td>SHS</td></tr>
<tr><td>Subject:</td><td colspan="3">PSI Algebra Based Physics</td></tr>
<tr><td colspan="2">NJSLS-Science DCI:</td><td colspan="2">This unit provides necessary background and skills for the following practices.</td></tr>
<tr><td colspan="2">Standards: None specifically.</td><td colspan="2">Science Practice 1: The student can use representations and models to communicate scientific phenomena and solve scientific problems.
Science Practice 2: The student can use mathematics appropriately.
Science Practice 3: The student can engage in scientific questioning to extend thinking or to guide investigations within the context of the AP course.
Science Practice 4: The student can plan and implement data collection strategies in relation to a particular scientific question.</td></tr>
<tr><th colspan="4">Essential Questions</th></tr>
<tr><td colspan="4">How vectors are used to analyze motion?
What is the difference between speed and velocity?
What are the relationships between position, velocity, and acceleration?</td></tr>
<tr><th colspan="4">Knowledge & Skills</th></tr>
<tr><td colspan="2">By the end of this unit, students will:
understand the general relationships among position, velocity, and acceleration for the motion of a particle along a straight line.
understand the special case of motion with constant acceleration.</td><td colspan="2">By the end of this unit, students will be able to:
solve problems specifically by first writing out all variables present, determining the appropriate equation to use, solving the equation for the variable needed, inserting numbers into the equation, and finally performing calculations with a scientific calculator.</td></tr>
</table>

• understand the relationship among words, equations and graphs for motion in on dimension.	• apply the qualitative definition of acceleration (speeding up, or slowing down, and/or changing direction) to determine if an object is accelerating. • Students will be able to determine velocity by taking the slope of a position-time graph, and determine acceleration from the slope of a velocity-time graph, as well as the displacement by calculating the area under the curve. • Students will correlate negative and positive slopes with positive and negative velocities and accelerations.

Assessment

During the Smart Notebook lesson designed to introduce concepts, students will be continually questioned on these concepts using a combination of class work/homework questions and the SMART Response system. Classwork and Homework questions will be discussed as a class and misconceptions will be addressed by the teacher prior to the formal evaluations listed below.

Average Speed Quiz
Equation 1 Quiz
Equation 2 Quiz
Equation 3 Quiz
Mixed Equations Quiz
Kinematics Test

Other assessments on the NJCTL website are optional and can be used as needed.

Pacing Guide

Day	Topic	Classwork	Homework**
1	Speed, Distance and Time	Slides 1-21 Problems 1-8	Problems 9-16

	$s = \frac{d}{t}$		
2	Average Speed $S_{ave} = \frac{d_1 + d_2 + d_3 + \cdots}{t_1 + t_2 + t_3 + \cdots}$	Slides 22-35 Problems 17-19	MC 1-6 & Problems 20-28
3	Average Speed Quiz + Reference Frames, Position, Displacement and Velocity	Average Speed Quiz Slides 36-61	MC 16-21
4	Position, Displacement and Velocity $v = \frac{\Delta x}{\Delta t}$	Slides 62-90 Problems 29-30	Problems 31-34
5	Motion with a constant acceleration/first kinematics equation $v = v_o + at$	Slides 91-113 Problems 35-41	Problems 42-49
6	Motion with a constant acceleration/first kinematics equation continued + Graphing	Review HW problems Slides 114-121	MC 7-15 & 22-30
7	Bowling Ball Lab*	Lab	Lab questions/write up
8	Free Fall	Slides 122-133 Problems 50-54	Problems 55-59

9	First Kinematics Equation Quiz + Second kinematics equation: Position vs. time $x = x_0 + v_0 t + \frac{1}{2}at^2$	First Quiz Slides 134-148	Problems 70-73 MC 31-34
10	Second kinematics equation: Position vs. time continued	Problems 60-69	Problems 74-76 MC 35-39
11	Stomp Rocket Lab*	Lab	Lab questions/write up
12	Second Equation Quiz + Third kinematics equation $v^2 = v_0{}^2 + 2a(x - x_0)$	Second Quiz Slides 149-157	Problems 83-85 MC 40-44
13	Third kinematics equation continued	Problems 77-82	Problems 86-88 MC 45-50
14	Third Equation Quiz + Three kinematics equations problem solving	Third Quiz Slides 158-161 Problems 89-104	Problems 104-117
15	Three Equations Quiz + Graphing Practice	Slides 162-182 Problems 118-121	Problems 122-124

16	Graphing Practice	Problems 125-128	Problems 129-130
17	Hopper Lab*	Lab	Lab questions/write up
18	Review MC	Review MC	Study for test
19	Kinematics Test	Test	N/A

* It may not be possible to complete labs in the order stated due to lab schedules. Other labs on the NJCTL website are option and can be used as needed.

**HW Problems are currently not scaffolded from least to most difficult, but are instead listed in order of topic. Teacher should pay special attention at the end of each class period when assigning HW so that only problems related to the topic that was taught are being assigned.

<u>The above two notes apply to every unit.</u>

Unit 2 – Dynamics			
Teacher:	**Science Dept**	**Time Frame:**	**16 days**
Grade:	**8/9**	**School:**	**SHS**
Subject:	**PSI Algebra Based Physics**		
NJSLS - Science DCI:	● 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 nonrelativistic speeds.] ● 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. [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.]		
AP Physics 1 & 2 Standards:	● Essential Knowledge 3.A.2: Forces are described by vectors. a. Forces are detected by their influence on the motion of an object. b. Forces have magnitude and direction. ● Learning Objective (3.A.2.1):The student is able to represent forces in diagrams or mathematically using appropriately labeled vectors with magnitude, direction, and units during the analysis of a situation. ● Essential Knowledge 3.A.3: A force exerted on an object is always due to the interaction of that object with another object.		

	a. An object cannot exert a force on itself. b. Even though an object is at rest, there may be forces exerted on that object by other objects. c. The acceleration of an object, but not necessarily its velocity, is always in the direction of the net force exerted on the object by other objects. ● Learning Objective (3.A.3.1):The student is able to analyze a scenario and make claims (develop arguments, justify assertions) about the forces exerted on an object by other objects for different types of forces or components of forces. ● Learning Objective (3.A.3.2):The student is able to challenge a claim that an object can exert a force on itself. ● Learning Objective (3.A.3.3):The student is able to describe a force as an interaction between two objects and identify both objects for any force. ● Essential Knowledge 3.A.4: If one object exerts a force on a second object, the second object always exerts a force of equal magnitude on the first object in the opposite direction. ● Learning Objective (3.A.4.1):The student is able to construct explanations of physical situations involving the interaction of bodies using Newton's third law and the representation of action-reaction pairs of forces. ● Learning Objective (3.A.4.2):The student is able to use Newton's third law to make claims and predictions about the action-reaction pairs of forces when two objects interact. ● Learning Objective (3.A.4.3):The student is able to analyze situations involving interactions among several objects by using free-body diagrams that include the application of Newton's third law to identify forces. ● Essential Knowledge 3.B.1: If an object of interest interacts with several other objects, the net force is the vector sum of the individual forces. ● Learning Objective (3.B.1.1):The student is able to predict the motion of an object subject to forces exerted by several objects using an application of Newton's second law in a variety of physical situations with acceleration in one dimension. ● Learning Objective (3.B.1.2):The student is able to design a plan to collect and analyze data for motion (static, constant, or accelerating) from force measurements and carry out an analysis to determine the relationship between the net force and the vector sum of the individual forces. ● Learning Objective (3.B.1.3):The student is able to reexpress a free-body diagram representation into a mathematical representation and solve the mathematical representation for the acceleration of the object. ● Learning Objective (3.B.1.4):The student is able to predict the motion of an object subject to forces exerted by several objects using an application of Newton's second law in a variety of physical situations. ● Essential Knowledge 3.B.2: Free-body diagrams are useful tools for visualizing forces being exerted on a single object and writing the equations that represent a physical situation.

a. An object can be drawn as if it was extracted from its environment and the interactions with the environment identified.
b. A force exerted on an object can be represented as an arrow whose length represents the magnitude of the force and whose direction shows the direction of the force.
c. A coordinate system with one axis parallel to the direction of the acceleration simplifies the translation from the free-body diagram to the algebraic representation.

- Learning Objective (3.B.2.1):The student is able to create and use free-body diagrams to analyze physical situations to solve problems with motion qualitatively and quantitatively.

Essential Questions

4. How can an object be made to accelerate?
5. How do forces interact?
6. How do objects respond to multiple forces acting on them?

Knowledge & Skills

By the end of this unit, students will know:

- How to apply the concept of inertia to determine the motion of an object experiencing a net force and zero net force.
- How to algebraically manipulate and utilize the following equations:

  $\mathbf{F = ma}$
  $\mathbf{f_k = {}_k F_N}$
  $\mathbf{f_s < {}_s F_N}$
  $\mathbf{w = mg}$

- How to solve problems specifically by first sketching the setup, drawing a free body diagram, determining the forces present, aligning coordinate axes, solving the equation

By the end of this unit, students will be able to:

- Describe inertia using Newton’s First Law.
- Relate force, mass and acceleration using Newton’s Second Law.
- Solve problems using Newton’s Second Law.
- Describe inertial reference frames.
- Differentiate between weight and mass.
- Describe weight as a force in terms of mass and gravitational acceleration.
- Describe the normal force and understand the conditions in which it exists.
- Identify a reaction force if given an action force.

for the variable needed, inserting numbers into the equation, and finally performing calculations with a scientific calculator. ● How to determine the weight of objects in settings with vertical accelerations and determine the difference between true weight and apparent weight (normal force). ● How apply Newton's Third Law (for every action force, there is an equal and opposite reaction force) to determine action/reaction pairs. ● How to identify when friction must be considered in a problem and when it can be ignored, determine the type of friction present, and the point at which the static friction is overcome to result in kinetic friction. ● How to identify all the different types of force present in a problem. They will draw the relative magnitudes and directions of the forces on a free body diagram and note the direction of acceleration ● How to, after drawing a free body diagram, students will apply Newton's Second Law to a problem, determining the net force acting on an object. They will solve for net forces and forces specific to the problem. ● How to identify the following forces and illustrate their relative magnitudes and directions when problem solving: o Applied Force o Normal Force	● Determine whether a frictional force is kinetic (moving) or static (not moving). ● Solve problems involving static and kinetic friction. ● Identify and solve for tension force. ● Draw free body diagrams. ● Solve problems involving multiple forces and accelerations not restricted to one axis of motion.

o Weight (Gravitational Force) o Apparent Weight o Tension o Friction (Kinetic and Static) ● How to solve Atwood machine type problems.	

Assessment

During the Smart Notebook lesson designed to introduce concepts, students will be continually questioned on these concepts using a combination of class work/homework questions and the SMART Response system. Classwork and Homework questions will be discussed as a class and misconceptions will be addressed by the teacher prior to the formal evaluations listed below.

- Newton's Second Law Quiz
- Weight and Mass Quiz
- Friction Quiz (Either one at discretion of teacher.)
- Dynamics Test

Other assessments on the NJCTL website are optional and can be used as needed.

Pacing Guide

Day	Topic	Classwork	Homework**
1	Dynamics Thought Experiment, Inertial Reference Frames and Newton's First Law	Review Presentation	MC #1-11
2	Newton's Second Law	Problems #1-9	Problems #10-19
3	Review Newton's Second Law + Newton's Second Law Quiz	Review & Quiz	N/A

4	Mass, Weight and Normal Force & Newton's Third Law	Problems #20-25	Problems #26-31 & MC #12-20
5	Mass & Weight Quiz + Free Body Diagrams	Problems #32-34	Problems #35-37 & MC #21-34
5	Inertia Lab HT	Lab	Finish Lab & Study for Lab Quiz
6	Inertia Lab Quiz + Kinetic Friction	Problems #38-46	Problems #47-54
7	Static Friction	Problems #55-62	Problems #63-66
8	Tension + Apparent Weight	Problems #67-70	Problems #71-74
9	Review + Friction Quiz (either one)	Review & Quiz	MC #35-38
10	Friction Lab or Mu Shoe Lab	Lab	Finish Lab and Study for Lab Quiz
11	Friction Lab Quiz or Mu Shoe Lab Quiz + General Problems	Problem #75 & 77	Problem #76 & 78
12	General Problems	Problems #79 & 81	Problems #80, 82, 83
13	Hooke's Law Lab	Lab	Finish Lab and Study for Lab Quiz

14	Hooke's Law Quiz + General Problems	Problems #84	Problem #85 + MC #39-50
15	Review	Review MC	Study for Test
16	Dynamics Test	Test	N/A

Unit 3 – Uniform Circular Motion			
Teacher:	**Science Dept**	**Time Frame:**	**7 days**
Grade:	**8/9**	**School:**	**SHS**
Subject:	**PSI Algebra Based Physics**		
NJSLS - Science DCI:	The topics in this unit are an essential part of understand the later units and of physics as a whole.		
AP Physics 1 and 2 Standards:	● This essential knowledge does not produce a specific learning objective but serves as a foundation for other learning objectives in the course.		

Essential Questions

7. How do we use Free Body diagrams and Newton's Laws to solve circular motion problems?
8. What are the applications of circular motion?
9. How does apparent weight vary during circular motion?

Knowledge & Skills

By the end of this unit, students will know:	By the end of this unit, students will be able to:
● How to relate the radius of the circle and the speed or rate of revolution of the particle to the magnitude of the centripetal acceleration. ● How to describe the direction of the particle's velocity and acceleration at any instant during the motion. ● How to analyze situations in which an object moves with specified acceleration under the	● Learn various concepts and ideas related to circular motion. They will use the following equations in solving problems. o $a= v^2/r$ o $v = 2\pi r/T$ o $T= 1/f$ o $F = ma$

influence of one or more forces so they can determine the magnitude and direction of the net force, or of one of the forces that makes up the net force, in situations such as the following: (1) Motion in a horizontal circle (e.g., mass on a rotating merry-go-round, or car rounding a banked curve). (2) Motion in a vertical circle (e.g., mass swinging on the end of a string, cart rolling down a curved track, rider on a Ferris wheel).	

Assessment

During the Smart Notebook lesson designed to introduce concepts, students will be continually questioned on these concepts using a combination of class work/homework questions and the SMART Response system. Classwork and Homework questions will be discussed as a class and misconceptions will be addressed by the teacher prior to the formal evaluations listed below.

- Uniform Circular Motion Test

Other assessments on the NJCTL website are optional and can be used as needed.

Pacing Guide

Day	Topic	Classwork	Homework**
1	Period and Frequency	Presentation to slide 23 Problems 1-3	Problems 4-6
2	Velocity and Acceleration	Presentation slide 24-51 Problems 7,8	Problems 9,10 MC 1-6
3	Dynamics of UCM	Presentation slide 52-61 Problems 11-16	Problems 17-22 MC 7-20
4	Bucket on a string	Presentation 75-86 Problems 23, 24	Problems 25, 26 MC 21-30
5	Free Response Problems	Problems 27-31 & 37	Problems 32-36 & 38
6	Review MC	Review	Study for test
7	Test	Test	N/A

<table>
<tr><th colspan="4">Unit 4 – Energy</th></tr>
<tr><td>Teacher:</td><td>Science Dept</td><td>Time Frame:</td><td>14 days</td></tr>
<tr><td>Grade:</td><td>8/9</td><td>School:</td><td>SHS</td></tr>
<tr><td>Subject:</td><td colspan="3">PSI Algebra Based Physics</td></tr>
<tr><td>NJSLS - Science DCI:</td><td colspan="3">
● 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-PS3-3. Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.</td></tr>
<tr><td>AP Physics 1 and 2 Standards:</td><td colspan="3">
● Enduring Understanding 3.E: A force exerted on an object can change the kinetic energy of the object.
● Essential Knowledge 3.E.1: The change in the kinetic energy of an object depends on the force exerted on the object and on the displacement of the object during the interval that the force is exerted.
a. Only the component of the net force exerted on an object parallel or antiparallel to the displacement of the object will increase (parallel) or decrease (antiparallel) the kinetic energy of the object.
b. The magnitude of the change in the kinetic energy is the product of the magnitude of the displacement and of the magnitude of the component of force parallel or antiparallel to the displacement.
c. The component of the net force exerted on an object perpendicular to the direction of the displacement of the object can change the direction of the motion of the object without changing the kinetic energy of the object. This should include uniform circular motion and projectile motion.
● Learning Objective (3.E.1.1):The student is able to make predictions about the changes in kinetic energy of an object based on considerations of the direction of the net force on the object as the object moves.
● Learning Objective (3.E.1.2):The student is able to use net force and velocity vectors to determine qualitatively whether kinetic energy of an object would increase, decrease, or remain unchanged.
● Learning Objective (3.E.1.3):The student is able to use force and velocity vectors to determine qualitatively or quantitatively the net force exerted on an object and qualitatively whether kinetic energy of that object would increase, decrease, or remain unchanged.
● Learning Objective (3.E.1.4):The student is able to apply mathematical routines to determine the change in kinetic energy of an object given the forces on the object and the displacement of the object.</td></tr>
</table>

	• Enduring Understanding 4.C: Interactions with other objects or systems can change the total energy of a system. • Essential Knowledge 4.C.2: Mechanical energy (the sum of kinetic and potential energy) is transferred into or out of a system when an external force is exerted on a system such that a component of the force is parallel to its displacement. The process through which the energy is transferred is called work. a. If the force is constant during a given displacement, then the work done is the product of the displacement and the component of the force parallel or antiparallel to the displacement. b. Work (change in energy) can be found from the area under a graph of the magnitude of the force component parallel to the displacement versus displacement. • Learning Objective (4.C.2.1):The student is able to make predictions about the changes in the mechanical energy of a system when a component of an external force acts parallel or antiparallel to the direction of the displacement of the center of mass. • Learning Objective (4.C.2.2):The student is able to apply the concepts of Conservation of Energy and the Work-Energy theorem to determine qualitatively and/or quantitatively that work done on a two-object system in linear motion will change the kinetic energy of the center of mass of the system, the potential energy of the systems, and/or the internal energy of the system. • Big Idea 5: Changes that occur as a result of interactions are constrained by conservation laws. • Enduring Understanding 5.A: Certain quantities are conserved, in the sense that the changes of those quantities in a given system are always equal to the transfer of that quantity to or from the system by all possible interactions with other systems. • Essential Knowledge 5.A.1: A system is an object or a collection of objects. The objects are treated as having no internal structure. • Essential Knowledge 5.A.2: For all systems under all circumstances, energy, [charge, linear momentum, and angular momentum] are conserved. For an isolated or a closed system, conserved quantities are constant. An open system is one that exchanges any conserved quantity with its surroundings. • Essential Knowledge 5.A.3: An interaction can be either a force exerted by objects outside the system or the transfer of some quantity with objects outside the system. • Essential Knowledge 5.A.4: The boundary between a system and its environment is a decision made by the person considering the situation in order to simplify or otherwise assist in analysis. • Enduring Understanding 5.B: The energy of a system is conserved. • Essential Knowledge 5.B.1: Classically, an object can only have kinetic energy since potential energy requires an interaction between two or more objects.

	● Learning Objective (5.B.1.1):The student is able to set up a representation or model showing that a single object can only have kinetic energy and use information about that object to calculate its kinetic energy. ● Learning Objective (5.B.1.2):The student is able to translate between a representation of a single object, which can only have kinetic energy, and a system that includes the object, which may have both kinetic and potential energies. ● Essential Knowledge 5.B.2: A system with internal structure can have internal energy, and changes in a system's internal structure can result in changes in internal energy. ● Essential Knowledge 5.B.3: A system with internal structure can have potential energy. Potential energy exists within a system if the objects within that system interact with conservative forces. ● a. The work done by a conservative force is independent of the path taken. The work description is used for forces external to the system. Potential energy is used when the forces are internal interactions between parts of the system. ● Essential Knowledge 5.B.4: The internal energy of a system includes the kinetic energy of the objects that make up the system and the potential energy of the configuration of the objects that make up the system. a. Since energy is constant in a closed system, changes in a system's potential energy can result in changes to the system's kinetic energy. b. The changes in potential and kinetic energies in a system may be further constrained by the construction of the system. ● Learning Objective (5.B.4.1):The student is able to describe and make predictions about the internal energy of systems. ● Learning Objective (5.B.4.2):The student is able to calculate changes in kinetic energy and potential energy of a system, using information from representations of that system. ● Essential Knowledge 5.B.5: Energy can be transferred by an external force exerted on an object or system that moves the object or system through a distance; this energy transfer is called work. Energy transfer in mechanical or electrical systems may occur at different rates. Power is defined as the rate of energy transfer into, out of, or within a system.

Essential Questions
10. How do we determine the work done on a physical system when the net force acting on it and its displacement are known? 11. How do we use the work/energy theorem to determine the motion of an object?

12. How do we apply energy conservation to determine the position and motion of an object?

Knowledge & Skills	
By the end of this unit, students will know: ● Definition of work, including when it is positive, negative, or zero. ● How to apply the work-energy theorem. ● The concept of a conservative force. ● The concept of potential energy. ● The concepts of mechanical energy and of total energy. ● Conservation of energy. ● The definition of power.	By the end of this unit, students will be able to: ● Calculate the work done by a specified constant force on an object that undergoes a specified displacement. ● Relate the work done by a force to the area under a graph of force as a function of position, and calculate this work in the case where the force is a linear function of position. ● Use the scalar product operation to calculate the work performed by a specified constant force F on an object that undergoes a displacement in a plane. ● Calculate the change in kinetic energy or speed that results from performing a specified amount of work on an object. ● Calculate the work performed by the net force, or by each of the forces that make up the net force, on an object that undergoes a specified change in speed or kinetic energy. ● Apply the theorem to determine the change in an object's kinetic energy and speed which results from the application of specified forces, or to determine the force that is required in order to bring an object to rest in a specified distance. ● Describe examples of conservative forces and non-conservative forces. ● Write an expression for the force exerted by an ideal spring and for the potential energy of a stretched or compressed spring. ● Calculate the potential energy of one or more objects in a uniform gravitational field. ● State and apply the relation between the work performed on an object by non-conservative forces and the change in an object's mechanical energy.

	• Describe and identify situations in which mechanical energy is converted to other forms of energy. • Analyze situations in which an object's mechanical energy is changed by friction or by a specified externally applied force. • Identify situations in which mechanical energy is or is not conserved. • Apply conservation of energy in analyzing the motion of systems of connected objects, such as an Atwood's machine. • Apply conservation of energy in analyzing the motion of objects that move under the influence of springs. • Recognize and solve problems that call for application both of conservation of energy and Newton's Laws. • Calculate the power required to maintain the motion of an object with constant acceleration (e.g., to move an object along a level surface, to raise an object at a constant rate, or to overcome friction for an object that is moving at a constant speed). • Calculate the work performed by a force that supplies constant power, or the average power supplied by a force that performs a specified amount of work.

Assessment

During the Smart Notebook lesson designed to introduce concepts, students will be continually questioned on these concepts using a combination of class work/homework questions and the SMART Response system. Classwork and Homework questions will be discussed as a class and misconceptions will be addressed by the teacher prior to the formal evaluations listed below.

- Work and Energy Quiz
- Power Quiz
- Energy Test

Other assessments on the NJCTL website are optional and can be used as needed.

Pacing Guide			
Day	Topic	Classwork	Homework**
1	Conservation of Energy and Work & Gravitational Potential Energy	Presentation to slide 39 & Problems 1-7 & 12-19	Problems 8-11 & 20-24 MC 1-15
3	Kinetic Energy & Elastic Potential Energy	Presentation to slide 82 Problems 25-30 & 37-43	Problems 31-36 & 44-48 MC 16-25
4	Mixed Problems	Problems 49-54	Problems 55-61
5	Review Homework & MC Work and Energy Quiz	Review & Quiz	N/A
6	Marble Launcher Lab	Lab	Finish lab and study for lab quiz
7	Marble Launcher Lab Quiz & Conservation of Energy	Quiz & Presentation to end & Problems 79-86	Problems 62-78 & 87-91 Finish MC
8	General Problems	Problems 92 & 94	Problems 93 & 95
9	Power Quiz & General Problems	Quiz & Problem 96 & 98	Problems 97 & 99

10	Review for Test	Review	Study
11	Energy Test	Test	N/A

Unit 5 – Momentum			
Teacher:	**Science Dept**	**Time Frame:**	**11 days**
Grade:	**8/9**	**School:**	**SHS**
Subject:	**PSI Algebra Based Physics**		
NJSLS - Science DCI:	● 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 scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.		
AP Physics 1 and 2 Standards:	● Enduring Understanding 3.D: A force exerted on an object can change the momentum of the object. ● Essential Knowledge 3.D.1: The change in momentum of an object is a vector in the direction of the net force exerted on the object. ● Learning Objective (3.D.1.1): The student is able to justify the selection of data needed to determine the relationship between the direction of the force acting on an object and the change in momentum caused by that force. ● Essential Knowledge 3.D.2: The change in momentum of an object occurs over a time interval. a. The force that one object exerts on a second object changes the momentum of the second object (in the absence of other forces on the second object). b. The change in momentum of that object depends on the impulse, which is the product of the average force and the time interval during which the interaction occurred. ● Learning Objective (3.D.2.1):The student is able to justify the selection of routines for the calculation of the relationships between changes in momentum of an object, average force, impulse, and time of interaction. ● Learning Objective (3.D.2.2):The student is able to predict the change in momentum of an object from the average force exerted on the object and the interval of time during which the force is exerted. ● Learning Objective (3.D.2.3):The student is able to analyze data to characterize the change in momentum of an object from the average force exerted on the object and the interval of time during which the force is exerted.		

	● Learning Objective (3.D.2.4):The student is able to design a plan for collecting data to investigate the relationship between changes in momentum and the average force exerted on an object over time.

Essential Questions

13. How do we determine the impulse on a physical system when the forces on the system, and the time interval these forces act, are known?
14. What is the difference between elastic and inelastic collisions?

Knowledge & Skills

By the end of this unit, students will know:	By the end of this unit, students will be able to:
● relationship between certain physics quantities related to impulse and momentum. ● fundamental law of physics -conservation of momentum.	● use the following equations in solving problems: P = mv Momentum I = Δp = mv Impulse

Assessment

During the Smart Notebook lesson designed to introduce concepts, students will be continually questioned on these concepts using a combination of class work/homework questions and the SMART Response system. Classwork and Homework questions will be discussed as a class and misconceptions will be addressed by the teacher prior to formal evaluations. Other assessments on the NJCTL website are optional and can be used as needed.

Pacing Guide

Day	Topic	Classwork	Homework**

1	Momentum & Momentum Change and Impulse	Presentation to slide 26 Problems 1-6 & 13-21	Problems 7-12 & 22-28
2	Momentum of a System of Objects & Conservation of Momentum	Presentation to slide 39 Problems 29-31	Problems 32-34 MC 1-10
3	Review Problems & Momentum Quiz and/or Impulse Quiz	Review & Quiz	MC 11-20
4	Perfectly Inelastic Collisions & Explosions	Presentation to slide 52 Problems 35-41	Problems 42-49
5	Elastic Collisions	Presentation to end Problems 50-57 (Optional 66-68)	Problems 58-65 (Optional 69-71)
6	Momentum HT Lab (or other lab)	Lab	Finish Lab and study for Quiz
7	Lab Quiz & General Problems	Quiz & Problem 72	Problem 78 MC 21-25
8	General Problems	Problems 73, 74, 79	Problems 75, 76, 77
9	Review	Review for test	Study for Test

10	Momentum Test	Test	N/A

Unit 6 – Electric Charge and Force			
Teacher:	**Science Dept**	**Time Frame:**	**7 days**
Grade:	**8/9**	**School:**	**SHS**
Subject:	**PSI Algebra Based Physics**		
NJSLS - Science DCI:	● 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.		
AP Physics 1 and 2 Standards:	● Essential Knowledge 1.A.4: Atoms have internal structures that determine their properties. a. The number of protons in the nucleus determines the number of electrons in a neutral atom. b. The number and arrangements of electrons cause elements to have different properties. ● Enduring Understanding 1.B: Electric charge is a property of an object or system that affects its interactions with other objects or systems containing charge. ● Essential Knowledge 1.B.1: Electric charge is conserved. The net charge of a system is equal to the sum of the charges of all the objects in the system. ● Learning Objective (1.B.1.1):The student is able to make claims about natural phenomena based on conservation of electric charge. ● Essential Knowledge 1.B.2: There are only two kinds of electric charge. Neutral objects or systems contain equal quantities of positive and negative charge, with the exception of some fundamental particles that have no electric charge. ● Learning Objective (1.B.2.1): The student is able to construct an explanation of the two-charge model of electric charge based on evidence produced through scientific practices. ● Learning Objective (1.B.2.2):The student is able to make a qualitative prediction about the distribution of positive and negative electric charges within neutral systems as they undergo various processes. ● Learning Objective (1.B.2.3):The student is able to challenge claims that polarization of electric charge or separation of charge must result in a net charge on the object.		

	● Essential Knowledge 1.B.3: The smallest observed unit of charge that can be isolated is the electron charge, also known as the elementary charge. a. The magnitude of the elementary charge is equal to $1.6x10^{19}$ coulombs. b. Electrons have a negative elementary charge; protons have a positive elementary charge of equal magnitude, although the mass of a proton is much larger than the mass of an electron.

Essential Questions

15. How many types of electric charge are there? What are they named?
16. Which particle of an atom carries a positive charge? Which carries the negative charge?
17. Why is it that when you take off a sweater in a dark room you can see tiny sparks and hear a crackling sound?
18. Compare and contrast Coulomb's Law with Newton's Law of Universal Gravitation.
19. A student touches an electroscope with his hand at the same time he brings a positively charged rod close to the electroscope without touching. When he removes his hand first and then moves the rod away from the electroscope the leaves move apart. Why? What type of charge is on the leaves?

Knowledge & Skills

By the end of this unit, students will know:
- The two types of electric charges
- The law of conservation of charge
- How charges interact
- How to charge various object using conduction and induction

By the end of this unit, students will be able to:
- Use Coulomb's Law to solve problems
- Make predictions about charges

Assessment

During the Smart Notebook lesson designed to introduce concepts, students will be continually questioned on these concepts using a combination of class work/homework questions and the SMART Response system. Classwork and Homework questions will be discussed as a class and misconceptions will be addressed by the teacher prior to the formal evaluations listed below.

- Electric Charge Lab Quiz
- Electric Charge and Force Test

Other assessments on the NJCTL website are optional and can be used as needed.

Pacing Guide

Day	Topic	Classwork	Homework**
1	Electric Charge	Electric Charge Lab/Demo Presentation to slide 12 Questions 1-4	Questions 5-7
2	Atomic Structure	Lab Quiz Presentation to Slide 28 Questions #8-11	Questions 12-15
3	Conduction & Induction; Electroscope	Presentation to Slide 65 Problems 16-18	Questions 19-22
4	Electric Force	Presentation to Slide 81 Problems 1-5 General Problem 13-14	Problems 6-12 General Problem 15
5	Number Line Problems	Coulomb's Law Quiz Finish Presentation General Problems 16-17	General Problems 18

6	Review	Review MC	Study for test
7	Electric Charge and Force Test	Test	N/A

Unit 7 – Electric Field and Potential			
Teacher:	**Science Dept**	**Time Frame:**	**8 days**
Grade:	**8/9**	**School:**	**SHS**
Subject:	**PSI Algebra Based Physics**		
NJSLS – Science DCI:	Exceeds standards		
AP Physics 1 and 2 Standards:	● Essential Knowledge 1.E.4: Matter has a property called electric permittivity. a. Free space has a constant value of the permittivity that appears in physical relationships. b. The permittivity of matter has a value different from that of free space. ● Enduring Understanding 2.A: A field associates a value of some physical quantity with every point in space. Field models are useful for describing interactions that occur at a distance (long-range forces) as well as a variety of other physical phenomena. ● Essential Knowledge 2.A.1: A vector field gives, as a function of position (and perhaps time), the value of a physical quantity that is described by a vector. a. Vector fields are represented by field vectors indicating direction and magnitude. b. When more than one source object with mass or electric charge is present, the field value can be determined by vector addition. c. Conversely, a known vector field can be used to make inferences about the number, relative size, and location of sources. ● Essential Knowledge 2.A.2: A scalar field gives, as a function of position (and perhaps time), the value of a physical quantity that is described by a scalar. In Physics 2, this should include electric potential. a. Scalar fields are represented by field values. b. When more than one source object with mass or charge is present, the scalar field value can be determined by scalar addition. c. Conversely, a known scalar field can be used to make inferences about the number, relative size, and location of sources. ● Enduring Understanding 2.C: An electric field is caused by an object with electric charge.		

	• Essential Knowledge 2.C.1: The magnitude of the electric force F exerted on an object with electric charge q by an electric field E is F=qE. The direction of the force is determined by the direction of the field and the sign of the charge, with positively charged objects accelerating in the direction of the field and negatively charged objects accelerating in the direction opposite the field. This should include a vector field map for positive point charges, negative point charges, spherically symmetric charge distribution, and uniformly charged parallel plates. • Learning Objective (2.C.1.1):The student is able to predict the direction and the magnitude of the force exerted on an object with an electric charge q placed in an electric field E using the mathematical model of the relation between an electric force and an electric field: F=q E; a vector relation. • Learning Objective (2.C.1.2):The student is able to calculate any one of the variables — electric force, electric charge, and electric field — at a point given the values and sign or direction of the other two quantities. • Essential Knowledge 2.C.2: The magnitude of the electric field vector is proportional to the net electric charge of the object(s) creating that field. This includes positive point charges, negative point charges, spherically symmetric charge distributions, and uniformly charged parallel plates. • Learning Objective (2.C.2.1):The student is able to qualitatively and semiquantitatively apply the vector relationship between the electric field and the net electric charge creating that field. • Essential Knowledge 2.C.3: The electric field outside a spherically symmetric charged object is radial and its magnitude varies as the inverse square of the radial distance from the center of that object. Electric field lines are not in the curriculum. Students will be expected to rely only on the rough intuitive sense underlying field lines, wherein the field is viewed as analogous to something emanating uniformly from a source. a. The inverse square relation known as Coulomb’s law gives the magnitude of the electric field at a distance r from the center of a source object of electric charge Q as $E = \frac{kQ}{r^2}$ b. This relation is based on a model of the space surrounding a charged source object by considering the radial dependence of the area of the surface of a sphere centered on the source object. • Learning Objective (2.C.3.1):The student is able to explain the inverse square dependence of the electric field surrounding a spherically symmetric electrically charged object. • Essential Knowledge 2.C.4: The electric field around dipoles and other systems of electrically charged objects (that can be modeled as point objects) is found by vector addition of the field of each individual object. Electric dipoles are treated qualitatively in this course as a teaching analogy to facilitate student understanding of magnetic dipoles.

	a. When an object is small compared to the distances involved in the problem, or when a larger object is being modeled as a large number of very small constituent particles, these can be modeled as charged objects of negligible size, or "point charges." b. The expression for the electric field due to a point charge can be used to determine the electric field, either qualitatively or quantitatively, around a simple, highly symmetric distribution of point charges. ● Learning Objective (2.C.4.1):The student is able to distinguish the characteristics that differ between monopole fields (gravitational field of spherical mass and electrical field due to single point charge) and dipole fields (electric dipole field and magnetic field) and make claims about the spatial behavior of the fields using qualitative or semi quantitative arguments based on vector addition of fields due to each point source, including identifying the locations and signs of sources from a vector diagram of the field. ● Learning Objective (2.C.4.2):The student is able to apply mathematical routines to determine the magnitude and direction of the electric field at specified points in the vicinity of a small set (2–4) of point charges, and express the results in terms of magnitude and direction of the field in a visual representation by drawing field vectors of appropriate length and direction at the specified points. ● Essential Knowledge 2.C.5: Between two oppositely charged parallel plates with uniformly distributed electric charge, at points far from the edges of the plates, the electric field is perpendicular to the plates and is constant in both magnitude and direction. ● Learning Objective (2.C.5.1):The student is able to create representations of the magnitude and direction of the electric field at various distances (small compared to plate size) from two electrically charged plates of equal magnitude and opposite signs, and is able to recognize that the assumption of uniform field is not appropriate near edges of plates. ● Learning Objective (2.C.5.2):The student is able to calculate the magnitude and determine the direction of the electric field between two electrically charged parallel plates, given the charge of each plate, or the electric potential difference and plate separation. ● Learning Objective (2.C.5.3):The student is able to represent the motion of an electrically charged particle in the uniform field between two oppositely charged plates and express the connection of this motion to projectile motion of an object with mass in the Earth's gravitational field.
Essential Questions	
20. What is the definition of the Electric Field and what equation was used to derive this concept? 21. Why can Electric Field lines never cross or touch each other? Do Electric Field lines exist? 22. What is the significance of the density of the electric field lines about a charge?	

23. How is the Electric Potential derived from the Electric Potential Energy?
24. What is an equipotential line? How does it relate to an Electric Field line?

Knowledge & Skills

By the end of this unit, students will know:

- How to define electric fields and how they relate to electric force.
- The relationship between electric potential, voltage and potential energy.
- How charged objects respond to electric fields and potential differences.

By the end of this unit, students will be able to:

- Use the following equations to solve problems:

$E = \frac{kQ}{r^2}$ $E = \frac{kQ}{r^2}$ $F = qE$ $F = qE$ $V = \frac{kQ}{r}$ $V = \frac{kQ}{r}$ $U_E = qV$ $U_E = qV$

$E = \frac{\Delta V}{x}$ $E = \frac{\Delta V}{x}$

Assessment

During the Smart Notebook lesson designed to introduce concepts, students will be continually questioned on these concepts using a combination of class work/homework questions and the SMART Response system. Classwork and Homework questions will be discussed as a class and misconceptions will be addressed by the teacher prior to the formal evaluations listed below.

- Electric Field and Potential Test

Other assessments on the NJCTL website are optional and can be used as needed.

Pacing Guide

Day	Topic	Classwork	Homework**

1	Electric Field	Presentation to slide 26 Problems 1-4 & 10-12	Problems 5-9 & 13-15
2	Electric Field of Multiple Charges and Net Electric Field	Presentation to slide 41 Problems 16-18 & 22, 23	Problems 19-21 & 24, 25 MC 1-5
3	Electric Potential Energy and Electric Potential	Presentation to slide 75 Problems 26-29 & 34-41	Problems 30-33 & 42-50
4	Uniform Electric Fields	Presentation to end Problems 51-58	Problems 59-66 & MC 6-10
5	Electric Field Shapes Lab	Lab	Finish Lab & MC 11-22
6	General Problems	General problems 1-4	General Problems 5-8
7	Review	Review MC and general problems	Study for test
8	Electric Field and Potential Test (or other assessment depending on topics covered)	Test	N/A

<table>
<tr><th colspan="4">Unit 8 – Current and Circuits</th></tr>
<tr><td>Teacher:</td><td>Science Dept</td><td>Time Frame:</td><td>12 days</td></tr>
<tr><td>Grade:</td><td>8/9</td><td>School:</td><td>SHS</td></tr>
<tr><td>Subject:</td><td colspan="3">PSI Algebra Based Physics</td></tr>
<tr><td>NJSLS - Science DCI:</td><td colspan="3">This unit provides necessary background and skills for the following units.</td></tr>
<tr><td>AP Physics 1 and 2 Standards:</td><td colspan="3">
Essential Knowledge 1.B.1: Electric charge is conserved. The net charge of a system is equal to the sum of the charges of all the objects in the system.
a. An electrical current is a movement of charge through a conductor.
b. A circuit is a closed loop of electrical current.
Learning Objective (1.B.1.2):The student is able to make predictions, using the conservation of electric charge, about the sign and relative quantity of net charge of objects or systems after various charging processes, including conservation of charge in simple circuits.
Essential Knowledge 1.E.2: Matter has a property called resistivity.
a. The resistivity of a material depends on its molecular and atomic structure.
b. The resistivity depends on the temperature of the material.
Learning Objective (1.E.2.1):The student is able to choose and justify the selection of data needed to determine resistivity for a given material.
Essential Knowledge 4.E.4: The resistance of a resistor, and the capacitance of a capacitor, can be understood from the basic properties of electric fields and forces, as well as the properties of materials and their geometry.
a. The resistance of a resistor is proportional to its length and inversely proportional to its cross-sectional area. The constant of proportionality is the resistivity of the material.
b. The capacitance of a parallel plate capacitor is proportional to the area of one of its plates and inversely proportional to the separation between its plates. The constant of
</td></tr>
</table>

	proportionality is the product of the dielectric constant, κ, of the material between the plates and the electric permittivity, ε_o. c. The current through a resistor is equal to the potential difference across the resistor divided by its resistance R. The magnitude of charge of one of the plates of a parallel plate capacitor is directly proportional to the product of the potential difference across the capacitor and the capacitance. The p lates have equal amounts of charge of opposite sign. ● Learning Objective (4.E.4.1):The student is able to make predictions about the properties of resistors and/or capacitors when placed in a simple circuit, based on the geometry of the circuit element and supported by scientific theories and mathematical relationships. ● Learning Objective (4.E.4.2):The student is able to design a plan for the collection of data to determine the effect of changing the geometry and/or materials on the resistance or capacitance of a circuit element and relate results to the basic properties of resistors and capacitors. ● Learning Objective (4.E.4.3):The student is able to analyze data to determine the effect of changing the geometry and/or materials on the resistance or capacitance of a circuit element and relate results to the basic properties of resistors and capacitors. ● Essential Knowledge 4.E.5: The values of currents and electric potential differences in an electric circuit are determined by the properties and arrangement of the individual circuit elements such as sources of emf, resistors, and capacitors. physics ● Learning Objective (4.E.5.1):The student is able to make and justify a quantitative prediction of the effect of a change in values or arrangements of one or two circuit elements on the currents and potential differences in a circuit containing a small number of sources of emf, resistors, capacitors, and switches in series and/or parallel. ● Learning Objective (4.E.5.2):The student is able to make and justify a qualitative prediction of the effect of a change in values or arrangements of one or two circuit elements on currents and potential differences in a circuit containing a small number of sources of emf, resistors, capacitors, and switches in series and/or parallel. ● Learning Objective (4.E.5.3):The student is able to plan data collection strategies and perform data analysis to examine the values of currents and potential differences in an electric circuit that is modified by changing or rearranging circuit elements, including sources of emf, resistors, and capacitors.

	• Essential Knowledge 5.B.9: Kirchhoff 's loop rule describes conservation of energy in electrical circuits. The application of Kirchhoff's laws to circuits is introduced in Physics 1 and further developed in Physics 2 in the context of more complex circuits, including those with capacitors. a. Energy changes in simple electrical circuits are conveniently represented in terms of energy change per charge moving through a battery and a resistor. b. Since electric potential difference times charge is energy, and energy is conserved, the sum of the potential differences about any closed loop must add to zero. c. The electric potential difference across a resistor is given by the product of the current and the resistance. d. The rate at which energy is transferred from a resistor is equal to the product of the electric potential difference across the resistor and the current through the resistor. e. Energy conservation can be applied to combinations of resistors and capacitors in series and parallel circuits. • Learning Objective (5.B.9.1):The student is able to construct or interpret a graph of the energy changes within an electrical circuit with only a single battery and resistors in series and/or in, at most, one parallel branch as an application of the conservation of energy (Kirchhoff 's loop rule). • Learning Objective (5.B.9.2):The student is able to apply conservation of energy concepts to the design of an experiment that will demonstrate the validity of Kirchhoff's loop rule ($\sum \Delta V = 0$) in a circuit with only a battery and resistors either in series or in, at most, one pair of parallel branches. • Learning Objective (5.B.9.3):The student is able to apply conservation of energy (Kirchhoff 's loop rule) in calculations involving the total electric potential difference for complete circuit loops with only a single battery and resistors in series and/or in, at most, one parallel branch.

Essential Questions
25. What are voltage, current, and resistance? 26. How are voltage, current, and resistance related? 27. What factors affect resistivity?

Knowledge & Skills

By the end of this unit, students will know:

- That current is defined as charge over time
- The relationship between voltage, current, and resistance
- Ohm's Law
- Kirchoff's Rules (the rules will not be named but they will be applied)
- The relationship between voltage/current/resistance and power in circuits
- The relationship between emf and terminal voltage

By the end of this unit, students will be able to:

- Use the following equations to solve problems with simple DC circuits:

$$I = \frac{Q}{t}\; I = \frac{Q}{t} \quad R = \frac{\rho L}{A}\; R = \frac{\rho L}{A} \qquad I = \frac{V}{R}\; I = \frac{V}{R} \qquad P = IV = \frac{V^2}{R} = I^2 R$$

$$P = IV = \frac{V^2}{R} = I^2 R$$

$$R_{eq\ in\ series} = R_1 + R_2 + R_3 + \cdots$$

$$\frac{1}{R_{eq\ in\ parallel}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \cdots$$

$$V_T = \varepsilon - Ir$$

Assessment

(What is acceptable evidence to show desired results (rubrics, exam, etc.)? Attach Copy

During the Smart Notebook lesson designed to introduce concepts, students will be continually questioned on these concepts using a combination of class work/homework questions and the SMART Response system. Classwork and Homework questions will be discussed as a class and misconceptions will be addressed by the teacher prior to the formal evaluations listed below.

- Ohm's Law Lab Quiz
- Series and Parallel Lamp Circuit Lab Quiz
- Current and Circuits Test

Other assessments on the NJCTL website are optional and can be used as needed.

(What is the sequence of activities, learning experiences, etc, that will lead to desired results (the plan)?

Day	Topic	Classwork	Homework**
1	Current and Ohm’s Law	Presentation to slide 30 Problems 1-3 & 7-9	Problems 4-6 & 10-12
2	Ohm’s Law Lab	Lab	Finish lab and prepare for quiz
3	Ohm’s Law Lab Quiz + Power	Quiz & Presentation to slide 44 + Problems 21-26	Problems 27-32
4	Resistivity and Resistance	Presentation to slide 56 + Problems 13-16	Problems 17-20 & MC 1-9
5	Resistors in Series	Presentation to slide 76 + Problems 33-37	Problems 38-42
6	Resistors in Parallel	Presentation to slide 90 + Problems 43-44	Problems 45-52
7	Series and Parallel Lamp Circuit Lab	Lab	Finish lab and prepare for quiz
8	Series and Parallel Lab Quiz + Measurement and Electromotive Force	Quiz & Finish Presentation + Problems 53-58	Problems 59-64 & MC 10-20
9	General Problems	Problems 1, 2, 5, 6	Problems 3, 4, 7

10	General Problems	Problems 8, 9, 12, 13	Problems 10, 11, 14, 15 (harder problems can be left out and replace with simpler extra practice problems from the website)
11	Review MC	Review MC	Study for test
12	Current and Circuits Test	Test	N/A

Unit 9 – Magnetism			
Teacher:	**Science Dept**	**Time Frame:**	**7 days**
Grade:	**8/9**	**School:**	**SHS**
Subject:	**PSI Algebra Based Physics**		
NJSLS – Science DCI:	● 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-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. **[**		
AP Physics 1 and 2 Standards:	● Essential Knowledge 1.E.5: Matter has a property called magnetic permeability. a. Free space has a constant value of the permeability that appears in physical relationships. b. The permeability of matter has a value different from that of free space. ● Enduring Understanding 2.A: A field associates a value of some physical quantity with every point in space. Field models are useful for describing interactions that occur at a distance (long-range forces) as well as a variety of other physical phenomena. ● Enduring Understanding 2.D: A magnetic field is caused by a magnet or a moving electrically charged object. Magnetic fields observed in nature always seem to be produced either by moving charged objects or by magnetic dipoles or combinations of dipoles and never by single poles. ● Essential Knowledge 2.D.1: The magnetic field exerts a force on a moving electrically charged object. That magnetic force is perpendicular to the direction of velocity of the object and to the magnetic field and is proportional to the magnitude of the charge, the magnitude of the velocity and the magnitude of the magnetic field. It also depends on the angle between the velocity, and the magnetic field vectors. Treatment is quantitative for angles of 0°, 90°, or 180° and qualitative for other angles. ● Learning Objective (2.D.1.1): The student is able to apply mathematical routines to express the force exerted on a moving charged object by a magnetic field. ● Essential Knowledge 2.D.2: The magnetic field vectors around a straight wire that carries electric current are tangent to concentric circles centered on that wire. The field has no component toward the current-carrying wire.		

	a. The magnitude of the magnetic field is proportional to the magnitude of the current in a long straight wire. b. The magnitude of the field varies inversely with distance from the wire, and the direction of the field can be determined by a right-hand rule. ● Learning Objective (2.D.2.1): The student is able to create a verbal or visual representation of a magnetic field around a long straight wire or a pair of parallel wires. ● Essential Knowledge 2.D.3: A magnetic dipole placed in a magnetic field, such as the ones created by a magnet or the Earth, will tend to align with the magnetic field vector. a. A simple magnetic dipole can be modeled by a current in a loop. The dipole is represented by a vector pointing through the loop in the direction of the field produced by the current as given by the right-hand rule. b. A compass needle is a permanent magnetic dipole. Iron filings in a magnetic field become induced magnetic dipoles. c. All magnets produce a magnetic field. Examples should include magnetic field pattern of a bar magnet as detected by iron filings or small compasses. d. The Earth has a magnetic field. ● Learning Objective (2.D.3.1):The student is able to describe the orientation of a magnetic dipole placed in a magnetic field in general and the particular cases of a compass in the magnetic field of the Earth and iron filings surrounding a bar magnet. ● Essential Knowledge 2.D.4: Ferromagnetic materials contain magnetic domains that are themselves magnets. a. Magnetic domains can be aligned by external magnetic fields or can spontaneously align. b. Each magnetic domain has its own internal magnetic field, so there is no beginning or end to the magnetic field — it is a continuous loop. c. If a bar magnet is broken in half, both halves are magnetic dipoles in themselves; there is no magnetic north pole found isolated from a south pole. ● Learning Objective (2.D.4.1):The student is able to use the representation of magnetic domains to qualitatively analyze the magnetic behavior of a bar magnet composed of ferromagnetic material. ● Essential Knowledge 3.C.3: A magnetic force results from the interaction of a moving charged object or a magnet with other moving charged objects or another magnet. a. Magnetic dipoles have “north” and “south” polarity. b. The magnetic dipole moment of an object has the tail of the magnetic dipole moment vector at the south end of the object and the head of the vector at the north end of the object. c. In the presence of an external magnetic field, the magnetic dipole moment vector will align with the external magnetic field.

d. The force exerted on a moving charged object is perpendicular to both the magnetic field and the velocity of the charge and is described by a right-hand rule.

- Learning Objective (3.C.3.1):The student is able to use right-hand rules to analyze a situation involving a current-carrying conductor and a moving electrically charged object to determine the direction of the magnetic force exerted on the charged object due to the magnetic field created by the current-carrying conductor.
- Learning Objective (3.C.3.2):The student is able to plan a data collection strategy appropriate to an investigation of the direction of the force on a moving electrically charged object caused by a current in a wire in the context of a specific set of equipment and instruments and analyze the resulting data to arrive at a conclusion.
- Essential Knowledge 3.G.2: Electromagnetic forces are exerted at all scales and can dominate at the human scale.
- Learning Objective (3.G.2.1):The student is able to connect the strength of electromagnetic forces with the spatial scale of the situation, the magnitude of the electric charges, and the motion of the electrically charged objects involved.
- Enduring Understanding 4.E: The electric and magnetic properties of a system can change in response to the presence of, or changes in, other objects or systems.

Essential Questions

28. Both Electric and Magnetic Forces will cause objects to repel and attract each other. What is a difference in the origin of these forces?
29. A Magnet has a north and a south pole. If you cut the magnet in half, describe what happens to each end of the two pieces.
30. Can you find a magnet with just a north pole?
31. What Field circles a current carrying wire?

Knowledge & Skills

By the end of this unit, students will know:	By the end of this unit, students will be able to:
• How to determine the direction of the magnetic field created by a current carrying wire. • How to determine the force exerted by a magnetic field on a moving charged particle or current carrying wire.	• Find the magnitude of the magnetic field created by a current carrying wire using: $B = \frac{\mu_0 I}{2\pi r}$ • Find the magnitude of the force exerted by a magnetic field on a current carrying wire using: $F_B = ILB$

	• Find the magnitude of the force exerted by a magnetic field on a moving charge: $F_B = qvB$ • Find the magnitude of the force between tow current carrying wires using: $F_B = \frac{\mu_0 I_1 I_2 l}{2\pi r}$

Assessment

During the Smart Notebook lesson designed to introduce concepts, students will be continually questioned on these concepts using a combination of class work/homework questions and the SMART Response system. Classwork and Homework questions will be discussed as a class and misconceptions will be addressed by the teacher prior to the formal evaluations listed below.

- Magnetism Test

Other assessments on the NJCTL website are optional and can be used as needed.

Pacing Guide

Day	Topic	Classwork	Homework**
1	Magnetic Fields and Right Hand Rule	Presentation to slide 41	Problems 1-16
2	Magnetic Force on a Moving Charge	Presentation to slide 56 Problems 17-20	Problems 21-24 + MC 1-9

3	Magnetic Force on a Current Carrying Wire	Presentation to slide 99 Problems 25-28	Problems 29-32 MC 10-14
4	Magnetic Fields Due to a Long Straight Wire and Magnetic Force Between Two Current Carrying Wires	Finish Presentation Problems 33, 34, 37, 38	Problems 35, 36, 39, 40 MC 15-20
5	Magnetic Fields Map Lab + Free Response Problems	Lab	Finish Lab + General Problems 1, 2
6	Free Response Problems + Review	General problems 3-5 Review MC	Study for test
7	Magnetism Test	Test	N/A

Unit 10 – EM Induction			
Teacher:	**Science Dept**	**Time Frame:**	**6 days**
Grade:	**8/9**	**School:**	**SHS**
Subject:	**PSI Algebra Based Physics**		
NJSLS – Science DCI:	● 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-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.		
AP Physics 1 and 2 Standards:	● Essential Knowledge 4.E.2: Changing magnetic flux induces an electric field that can establish an induced emf in a system. a. Changing magnetic flux induces an emf in a system, with the magnitude of the induced emf equal to the rate of change in magnetic flux. b. When the area of the surface being considered is constant, the induced emf is the area multiplied by the rate of change in the component of the magnetic field perpendicular to the surface. c. When the magnetic field is constant, the induced emf is the magnetic field multiplied by the rate of change in area perpendicular to the magnetic field. d. The conservation of energy determines the direction of the induced emf relative to the change in the magnetic flux.		

	• Learning Objective (4.E.2.1):The student is able to construct an explanation of the function of a simple electromagnetic device in which an induced emf is produced by a changing magnetic flux through an area defined by a current loop (i.e., a simple microphone or generator) or of the effect on behavior of a device in which an induced emf is produced by a constant magnetic field through a changing area.

Essential Questions

32. What did Michael Faraday's experiment demonstrate?
33. Using Faraday's Law of Induction, explain how a constant magnetic field can still generate an EMF in a closed loop.
34. What is Lenz's Law?

Knowledge & Skills

By the end of this unit, students will know:

- That an electric current induces a magnetic field.
- That a changing magnetic field induces an EMF.
- How to determine the direction of the induced current.

By the end of this unit, students will be able to:

- Determine the flux, induced EMF, and current using the equations:

  $\Phi = BA$

  $\varepsilon = -N\frac{\Delta\Phi}{\Delta t}$

  $\varepsilon = Blv$

  $I = \frac{\varepsilon}{R}$
- Determine the direction of the induced current using Lenz's Law.

Assessment

During the Smart Notebook lesson designed to introduce concepts, students will be continually questioned on these concepts using a combination of class work/homework questions and the SMART Response system. Classwork and Homework questions will be discussed as a class and misconceptions will be addressed by the teacher prior to the formal evaluations listed below.

- Electromagnetic Induction Test

Other assessments on the NJCTL website are optional and can be used as needed.

Pacing Guide			
Day	Topic	Classwork	Homework**
1	Flux and Induced EMF	Presentation to slide 33 Problems 1-3 & 7-11	Problems 4-6 & 12-16
2	Lenz's Law	Presentation to slide 43 Problems 17-22	Problems 23-28 & MC 1-6
3	EMF induced in a moving conductor + Induction Demos or Lab	Presentation to end Problems 29-31	Problems 32-34 & MC 7-12
4	General Problems	General Problems 1, 3, 5	General Problems 2, 4, 6 & MC 13-18
5	Review	Review MC	Study for test
6	Test	EM Induction Test	N/A

<table>
<tr><th colspan="4">Unit 11 – Simple Harmonic Motion</th></tr>
<tr><td>Teacher:</td><td>Science Dept</td><td>Time Frame:</td><td>6 days</td></tr>
<tr><td>Grade:</td><td>8/9</td><td>School:</td><td>SHS</td></tr>
<tr><td>Subject:</td><td colspan="3">PSI Algebra Based Physics</td></tr>
<tr><td>NJSLS – Science DCI:</td><td colspan="3">● 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 motions of particles (objects) and energy associated with the relative position of particles (objects).</td></tr>
<tr><td>AP Physics 1 and 2 Standards:</td><td colspan="3">● Essential Knowledge 3.B.3: Restoring forces can result in oscillatory motion. When a linear restoring force is exerted on an object displaced from an equilibrium position, the object will undergo a special type of motion called simple harmonic motion.
a. For a spring that exerts a linear restoring force the period of a mass-spring oscillator increases with mass and decreases with spring stiffness.
b. For a simple pendulum oscillating the period increases with the length of the pendulum.
c. Minima, maxima, and zeros of position, velocity, and acceleration are features of harmonic motion. Students should be able to calculate force and acceleration for any given displacement for an object oscillating on a spring.
● Learning Objective (3.B.3.1):The student is able to predict which properties determine the motion of a simple harmonic oscillator and what the dependence of the motion is on those properties.
● Learning Objective (3.B.3.2): The student is able to design a plan and collect data in order to ascertain the characteristics of the motion of a system undergoing oscillatory motion caused by a restoring force.
● Learning Objective (3.B.3.3):The student can analyze data to identify qualitative or quantitative relationships between given values and variables (i.e., force, displacement, acceleration, velocity, period of motion, frequency, spring constant, string length, mass) associated with objects in oscillatory motion to use that data to determine the value of an unknown.</td></tr>
</table>

	• Learning Objective (3.B.3.4):The student is able to construct a qualitative and/or a quantitative explanation of oscillatory behavior given evidence of a restoring force.

Essential Questions

35. What is simple harmonic motion?
36. How do we determine the energy, position, speed, acceleration, frequency, and period of a physical system?

Knowledge & Skills

By the end of this unit, students will know:	By the end of this unit, students will be able to:
• How energy changes from potential to kinetic during simple harmonic motion • How a spring pendulum works • How a simple pendulum work	• Use the following equations to solve problems involving a simple pendulum or a spring pendulum: $T = \frac{t}{n} = \frac{1}{f} \qquad f = \frac{n}{t} = \frac{1}{T}$ $T = 2\pi\sqrt{\frac{L}{g}}\, T = 2\pi\sqrt{\frac{L}{g}} \qquad T = 2\pi\sqrt{\frac{m}{k}}\, T = 2\pi\sqrt{\frac{m}{k}}$ $KE = \frac{1}{2}mv^2 \quad GPE = mgh \quad EPE = \frac{1}{2}kx^2$

Assessment

During the Smart Notebook lesson designed to introduce concepts, students will be continually questioned on these concepts using a combination of class work/homework questions and the SMART Response system. Classwork and Homework questions will be discussed as a class and misconceptions will be addressed by the teacher prior to the formal evaluations listed below.

- Simple Harmonic Motion Test

Other assessments on the NJCTL website are optional and can be used as needed.			
Pacing Guide			
Day	Topic	Classwork	Homework**
1	Period & Frequency, SHM & UCM	Presentation to slide 22 Problems 1-5	Problems 6-10 & MC1-3
2	Spring Pendulum	Presentation to slide 54 Problems 11, 12, 15, 16, 19-22	Problems 13, 14, 17, 18, 23-26 & MC 4-10
3	Simple Pendulum	Finish Presentation Problems 27-30, 35, 36,	Problems 31-34, 37, 38 & MC 11-20
4	General Problems	General Problems 1, 3, 5	General Problems 2, 4, 6
5	Review	Review MC	Study for Test
6	SHM Test	Test	Test

Unit 12 – Waves and Sound			
Teacher:	**Science Dept**	**Time Frame:**	**9 days**
Grade:	**8/9**	**School:**	**SHS**
Subject:	**PSI Algebra Based Physics**		
NJSLS Science - DCI:	● HS-PS4-1. Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.		
AP Physics 1 and 2 Standards:	● Big Idea 6: Waves can transfer energy and momentum from one location to another without the permanent transfer of mass and serve as a mathematical model for the description of other phenomena. ● Enduring Understanding 6.A: A wave is a traveling disturbance that transfers energy and momentum. ● Essential Knowledge 6.A.1: Waves can propagate via different oscillation modes such as transverse and longitudinal. a. Mechanical waves can be either transverse or longitudinal. Examples should include waves on a stretched string and sound waves. b. Electromagnetic waves are transverse waves. c. Transverse waves may be polarized. ● Learning Objective (6.A.1.1): The student is able to use a visual representation to construct an explanation of the distinction between transverse and longitudinal waves by focusing on the vibration that generates the wave. ● Learning Objective (6.A.1.2): The student is able to describe representations of transverse and longitudinal waves. ● Learning Objective (6.A.1.3):The student is able to analyze data (or a visual representation) to identify patterns that indicate that a particular mechanical wave is polarized and construct an explanation of the fact that the wave must have a vibration perpendicular to the direction of energy propagation. ● Essential Knowledge 6.A.3: The amplitude is the maximum displacement of a wave from its equilibrium value.		

	- Learning Objective (6.A.3.1): The student is able to use graphical representation of a periodic mechanical wave to determine the amplitude of the wave. - Learning Objective (6.A.4.1):The student is able to explain and/or predict qualitatively how the energy carried by a sound wave relates to the amplitude of the wave, and/or apply this concept to a real-world example. - Enduring Understanding 6.B: A periodic wave is one that repeats as a function of both time and position and can be described by its amplitude, frequency, wavelength, speed, and energy. Essential Knowledge 6.B.1: For a periodic wave, the period is the repeat time of the wave. The frequency is the number of repetitions of the wave per unit time. - Learning Objective (6.B.1.1):The student is able to use a graphical representation of a periodic mechanical wave (position versus time) to determine the period and frequency of the wave and describe how a change in the frequency would modify features of the representation. - Essential Knowledge 6.B.2: For a periodic wave, the wavelength is the repeat distance of the wave. - Learning Objective (6.B.2.1):The student is able to use a visual representation of a periodic mechanical wave to determine wavelength of the wave. - Essential Knowledge 6.B.4: For a periodic wave, wavelength is the ratio of speed over frequency. - Learning Objective (6.B.4.1):The student is able to design an experiment to determine the relationship between periodic wave speed, wavelength, and frequency and relate these concepts to everyday examples. - Essential Knowledge 6.B.5: The observed frequency of a wave depends on the relative motion of source and observer. This is a qualitative treatment only. - Essential Knowledge 6.C.1: When two waves cross, they travel through each other; they do not bounce off each other. Where the waves overlap, the resulting displacement can be determined by adding the displacements of the two waves. This is called superposition. - Learning Objective (6.C.1.1):The student is able to make claims and predictions about the net disturbance that occurs when two waves overlap. Examples should include standing waves. - Learning Objective (6.C.1.2):The student is able to construct representations to graphically analyze situations in which two waves overlap over time using the principle of superposition. - Essential Knowledge 6.A.1: Waves can propagate via different oscillation modes such as transverse and longitudinal. a. Mechanical waves can be either transverse or longitudinal. Examples should include waves on a stretched string and sound waves.

- Essential Knowledge 6.A.2: For propagation, mechanical waves require a medium, while electromagnetic waves do not require a physical medium. Examples should include light traveling through a vacuum and sound not traveling through a vacuum.
- Learning Objective (6.A.2.1): The student is able to describe sound in terms of transfer of energy and momentum in a medium and relate the concepts to everyday examples
- Essential Knowledge 6.A.4: Classically, the energy carried by a wave depends upon and increases with amplitude. Examples should include sound waves.
- Learning Objective (6.C.4.1):The student is able to predict and explain, using representations and models, the ability or inability of waves to transfer energy around corners and behind obstacles in terms of the diffraction property of waves in situations involving various kinds of wave phenomena, including sound and light.
- Essential Knowledge 6.D.3: Standing waves are the result of the addition of incident and reflected waves that are confined to a region and have nodes and antinodes. Examples should include waves on a fixed length of string, and sound waves in both closed and open tubes.

Essential Questions

37. What are the properties of waves?
38. How do we distinguish the difference between longitudinal and transverse waves, and give at least one example of each?
39. What happens when two waves overlap?
40. How do we define the nature of sound waves?
41. How do different musical instruments such at open and closed tubes create sound?
42. What happens when two sound waves interact?
43. What happens when either the source of a sound or the observer moves?

Knowledge & Skills

By the end of this unit, students will know:

- Various concepts dealing with vibrations and waves.
- The difference between longitudinal and transverse waves.
- What happens when waves interact?
- the properties of sound

By the end of this unit, students will be able to:

- Solve problems involving waves using the following equations:

$$v = \frac{\lambda}{T} = \lambda f$$

$$v = \sqrt{\frac{F_T}{\mu}}$$

- sound wave interference and diffraction - how open and closed tubes create sound - how the Doppler effect changes how we hear sounds	$\lambda = \frac{2L}{n}\ (n = 1,2,3\ldots)\ for\ open\ tubes$ $\lambda = \frac{4L}{n}\ (n = 1,3,5\ldots)\ for\ closed\ tubes$

Assessment

During the Smart Notebook lesson designed to introduce concepts, students will be continually questioned on these concepts using a combination of class work/homework questions and the SMART Response system. Classwork and Homework questions will be discussed as a class and misconceptions will be addressed by the teacher prior to the formal evaluations listed below.

- Waves and Sound Test

Other assessments on the NJCTL website are optional and can be used as needed.

Pacing Guide

Day	Topic	Classwork	Homework**
1	Speed, Frequency, and Wavelength for a wave on a string	Presentation to slide 15 Problems 1-4, 9-11	Problems 5-8, 12-14
2	Reflection, Transmission & Interference and Standing Waves on Strings	Finish Presentation Problems 15-17, 21, 22	Problems 18-20, 23, 24
3	General Problems	General Problems 1-4	All Waves Multiple Choice

4	Sound and Open Tubes Problems	Presentation to slide 32 + optional simulations or lab demos	Problems #1-10 & MC 1-8
5	Closed Tubes, Interference, Beat Frequency and Doppler Effect	Finish Presentation	Problems #11-23 & MC 9-16
6	General Problems	General Problems #1 & 3 + Lab Demos & Simulations	General Problems #2 & 4 + MC 17-20
7	Review	Review Waves MC	Study For Test
8	Review	Review Sound MC	Study For Test
9	Test	Sound and Waves Test	N/A

Unit 13 – EM Waves			
Teacher:	**Science Dept**	**Time Frame:**	**7 days**
Grade:	**8/9**	**School:**	**SHS**
Subject:	**PSI Algebra Based Physics**		

NJSLS - Science DCI:	● 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 a digital transmission and storage of information. ● 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. ● 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.
AP Physics 1 and 2 Standards:	● Essential Knowledge 6.A.1: Waves can propagate via different oscillation modes such as transverse and longitudinal. b. Electromagnetic waves are transverse waves. ● Essential Knowledge 6.A.2: For propagation, mechanical waves require a medium, while electromagnetic waves do not require a physical medium. Examples should include light traveling through a vacuum and sound not traveling through a vacuum. ● Learning Objective (6.A.2.2): The student is able to contrast mechanical and electromagnetic waves in terms of the need for a medium in wave propagation. ● Essential Knowledge 6.C.2: When waves pass through an opening whose dimensions are comparable to the wavelength, a diffraction pattern can be observed.

	- Essential Knowledge 6.C.3: When waves pass through a set of openings whose spacing is comparable to the wavelength, an interference pattern can be observed. Examples should include monochromatic double-slit interference. - Learning Objective (6.C.3.1):The student is able to qualitatively apply the wave model to quantities that describe the generation of interference patterns to make predictions about interference patterns that form when waves pass through a set of openings whose spacing and widths are small compared to the wavelength of the waves. - Essential Knowledge 6.C.4: When waves pass by an edge, they can diffract into the "shadow region" behind the edge. Examples should include hearing around corners, but not seeing around them, and water waves bending around obstacles. - Learning Objective (6.C.4.1):The student is able to predict and explain, using representations and models, the ability or inability of waves to transfer energy around corners and behind obstacles in terms of the diffraction property of waves in situations involving various kinds of wave phenomena, including sound and light. - Essential Knowledge 6.F.1: Types of electromagnetic radiation are characterized by their wavelengths, and certain ranges of wavelength have been given specific names. These include (in order of increasing wavelength spanning a range from picometers to kilometers) gamma rays, x-rays, ultraviolet, visible light, infrared, microwaves, and radio waves. - Learning Objective (6.F.1.1):The student is able to make qualitative comparisons of the wavelengths of types of electromagnetic radiation. - Essential Knowledge 6.F.2: Electromagnetic waves can transmit energy through a medium and through a vacuum. a. Electromagnetic waves are transverse waves composed of mutually perpendicular electric and magnetic fields that can propagate through a vacuum. b. The planes of these transverse waves are both perpendicular to the direction of propagation. - Learning Objective (6.F.2.1):The student is able to describe representations and models of electromagnetic waves that explain the transmission of energy when no medium is present.
Essential Questions	

44. How does light behave like a wave?
45. How do we identify the electromagnetic spectrum?
46. How does wave speed relate to frequency?

Knowledge & Skills

By the end of this unit, students will know:

- The wave properties of light
- The double slit and single slit experiments
- How light changes speed and direction when entering a new medium

By the end of this unit, students will be able to:

- Solve various problems relating to light in double slit experiments and thin films using the following equations:

$$c = \lambda f$$

$$n = \frac{c}{v}$$

$$x = \frac{m\lambda L}{d}$$

$$2t = m\lambda \ \ and \ \ 2t = (m + \frac{1}{2})\lambda$$

Assessment

During the Smart Notebook lesson designed to introduce concepts, students will be continually questioned on these concepts using a combination of class work/homework questions and the SMART Response system. Classwork and Homework questions will be discussed as a class and misconceptions will be addressed by the teacher prior to the formal evaluations listed below.

- EM Wave Test

Other assessments on the NJCTL website are optional and can be used as needed.

Pacing Guide			
Day	Topic	Classwork	Homework**
1	Introduction to Light, Reflection, Refraction, Dispersion	Problems 1-5	Problems 6-10
2	Diffraction and Single and Double Slit Experiments	Problems 11-17	Problems 22-28
3	Interference by Thin Films + Properties of Electromagnetic Spectrum	Problems 18-21 & 33-36	Problems 29-32 & 37-40
4	General Problems + Lab Demos	General Problem 1	General Problem 2 & MC 1-13
5	General Problems	General Problems 3 & 5	General Problems 4 & 6 & MC 14-25
6	Review	Review MC	Study for test
7	Test	EM Waves Test	N/A

Unit 14 – Quantum Physics and Atomic Modeling			
Teacher:	**Science Dept**	**Time Frame:**	**8 days**
Grade:	**8/9**	**School:**	**SHS**
Subject:	**PSI Algebra Based Physics**		

NJSLS - Science DCI:	● 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. ● 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.
AP Physics 1 and 2 Standards:	● Essential Knowledge 6.F.3: Photons are individual energy packets of electromagnetic waves, with Ephoton = hf, where h is Planck's constant and f is the frequency of the associated light wave. ● a. In the quantum model of electromagnetic radiation, the energy is emitted or absorbed in discrete energy packets called photons. Discrete spectral lines should be included as an example. b. For the short-wavelength portion of the electromagnetic spectrum, the energy per photon can be observed by direct measurement when electron emissions from matter result from the absorption of radiant energy. c. Evidence for discrete energy packets is provided by a frequency threshold for electron emission. Above the threshold, emission increases with the frequency and not the intensity of absorbed radiation. The photoelectric effect should be included as an example. ● Learning Objective (6.F.3.1)The student is able to support the photon model of radiant energy with evidence provided by the photoelectric effect. ● Essential Knowledge 6.F.4: The nature of light requires that different models of light are most appropriate at different scales. a. The particle-like properties of electromagnetic radiation are more readily observed when the energy transported during the time of the measurement is comparable to Ephoton.

	b. The wavelike properties of electromagnetic radiation are more readily observed when the scale of the objects it interacts with is comparable to or larger than the wavelength of the radiation. ● Learning Objective (6.F.4.1) The student is able to select a model of radiant energy that is appropriate to the spatial or temporal scale of an interaction with matter. ● Essential Knowledge 6.G.1: Under certain regimes of energy or distance, matter can be modeled as a classical particle. ● Learning Objective (6.G.1.1)The student is able to make predictions about using the scale of the problem to determine at what regimes a particle or wave model is more appropriate. ● Essential Knowledge 6.G.2: Under certain regimes of energy or distance, matter can be modeled as a wave. The behavior in these regimes is described by quantum mechanics. a. A wave model of matter is quantified by the de Broglie wavelength that increases as the momentum of the particle decreases. b. The wave property of matter was experimentally confirmed by the diffraction of electrons in the experiments of Clinton Joseph Davisson, Lester Germer, and George Paget Thomson. ● Learning Objective (6.G.2.1) The student is able to articulate the evidence supporting the claim that a wave model of matter is appropriate to explain the diffraction of matter interacting with a crystal, given conditions where a particle of matter has momentum corresponding to a deBroglie wavelength smaller than the separation between adjacent atoms in the crystal. ● Learning Objective (6.G.2.2) The student is able to predict the dependence of major features of a diffraction pattern (e.g., spacing between interference maxima), based upon the particle speed and de Broglie wavelength of electrons in an electron beam interacting with a crystal. (de Broglie wavelength need not be given, so students may need to obtain it.)

Essential Questions

47. Who determined the charge on an electron, and what was the name of the experiment?

48. What assumption did Max Planck make to solve the Blackbody radiation problem?

49. What properties of the Photoelectric effect could not be explained by the wave theory of light?

50. How did Albert Einstein explain the Photoelectric effect? Who first postulated that light was made up of particles?

51. Describe the Thomson Plum Pudding model of the atom.

52. What experiment was performed by Ernest Rutherford? How did it change the Thomson model?

53. How did Neils Bohr resolve the problems with the Rutherford model?

Knowledge & Skills

By the end of this unit, students will know:

- The Oil Drop Experiment
- Rutherford's Experiment
- The Cathode Ray Tube Experiment
- The Photoelectric Effect
- The Bohr Model of the Atom

By the end of this unit, students will be able to:

- Solve problems using the following equations:

$E = hf$ $\quad hf = \emptyset + KE$

$KE = eV_0$ $\quad \lambda = \frac{h}{p}$

Assessment

During the Smart Notebook lesson designed to introduce concepts, students will be continually questioned on these concepts using a combination of class work/homework questions and the SMART Response system. Classwork and Homework questions will be discussed as a class and misconceptions will be addressed by the teacher prior to the formal evaluations listed below.

- Quantum Physics and Atomic Modeling Test

Other assessments on the NJCTL website are optional and can be used as needed.

Pacing Guide

Day	Topic	Classwork	Homework**

1	Electrons, X-rays, & Radioactivity	Presentation to slide 77 Problems 1-2	Problems 3-4
2	Blackbody Radiation and the Photoelectric Effect	Presentation to slide 118 Problems 5-13	Problems 14-22
3	Atomic Models	Presentation to slide 164 Problems 23-24	Problems 25-26
4	Waves and Particles	Presentation to slide 178 (the rest is optional) Problems 27-28	Problems 29-30
5	General Problems	General Problems # 1, 3, 5	General Problems # 2 & 4 + MC #1-13
6	General Problems	General Problem # 6	General Problem # 7 + MC #14-26 (the rest are optional)
7	Review MC	Review MC	Study for Test
8	Test	Quantum Physics and Atomic Modeling Test	N/A

Unit 15 – Nuclear Physics			
Teacher:	**Science Dept**	**Time Frame:**	**6 days**
Grade:	**8/9**	**School:**	**SHS**
Subject:	**PSI Algebra Based Physics**		
NJSLS Science DCI:	● 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-PS1-8. Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay**.**		
AP Physics 1 and 2 Standards:	● Essential Knowledge 3.G.3: The strong force is exerted at nuclear scales and dominates the interactions of nucleons. ● Learning Objective (3.G.3.1):The student is able to identify the strong force as the force that is responsible for holding the nucleus together. ● Essential Knowledge 4.C.4: Mass can be converted into energy and energy can be converted into mass. a. Mass and energy are interrelated by E m= c2 b. Significant amounts of energy can be released in nuclear processes. ● Learning Objective (4.C.4.1):The student is able to apply mathematical routines to describe the relationship between mass and energy and apply this concept across domains of scale. ● Essential Knowledge 5.C.1: Electric charge is conserved in nuclear and elementary particle reactions, even when elementary particles are produced or destroyed. Examples should include equations representing nuclear decay. ● Learning Objective (5.C.1.1):The student is able to analyze electric charge conservation for nuclear and elementary particle reactions and make predictions related to such reactions based upon conservation of charge. ● Essential Knowledge 5.G.1: The possible nuclear reactions are constrained by the law of conservation of nucleon number.		

	● Learning Objective (5.G.1.1):The student is able to apply conservation of nucleon number and conservation of electric charge to make predictions about nuclear reactions and decays such as fission, fusion, alpha decay, beta decay, or gamma decay. ● Essential Knowledge 7.C.3: The spontaneous radioactive decay of an individual nucleus is described by probability. a. In radioactive decay processes, we cannot predict when any one nucleus will undergo a change; we can only predict what happens on the average to a large number of identical nuclei. b. In radioactive decay, mass and energy are interrelated, and energy is released in nuclear processes as kinetic energy of the products or as electromagnetic energy. c. The time for half of a given number of radioactive nuclei to decay is called the half-life. d. Different unstable elements and isotopes have vastly different half-lives, ranging from small fractions of a second to billions of years. ● Learning Objective (7.C.3.1):The student is able to predict the number of radioactive nuclei remaining in a sample after a certain period of time, and also predict the missing species (alpha, beta, gamma) in a radioactive decay.

Essential Questions

54. What particles make up the nucleus? What is the general term for them? What are those particles composed of?
55. What is the definition of the atomic number? What is its symbol?
56. What is the definition of the atomic mass number? What is its symbol?
57. What is the definition of mass defect?
58. What is the definition of binding energy?
59. What is the spontaneous emission of radiation from nuclei called? What are the three types?
60. What is nuclear fusion and where does it occur?

Knowledge & Skills	
By the end of this unit, students will know: ● Mass defect and binding energy ● Alpha decay ● Beta decay ● Gamma Radiation ● Fission ● Fusion	By the end of this unit, students will be able to: ● Solve problems using the following equation: $E = \Delta mc^2$ ● Solving problems involving nuclear reactions

Assessment
During the Smart Notebook lesson designed to introduce concepts, students will be continually questioned on these concepts using a combination of class work/homework questions and the SMART Response system. Classwork and Homework questions will be discussed as a class and misconceptions will be addressed by the teacher prior to the formal evaluations listed below. ● Nuclear Physics Test Other assessments on the NJCTL website are optional and can be used as needed.

Pacing Guide			
Day	Topic	Classwork	Homework**
1	Nuclear Structure, Radius and Atomic Mass	Presentation to slide 29 Problems 1-6	Problems 7-12 & MC 1-10
2	Binding Energy and Mass Defect	Presentation to slide 40 Problems 13-15	Problems 16-18 & MC 11-20

3	Radioactivity and Half Life	Presentation to slide 60 Problems 19-21 & 25-27	Problems 22-24 & 28-30 & MC 21-30
4	Nuclear Reactions, Fission and Fusion	Presentation to end Problems 31-38 & 47-49	Problems 39-46 & 50-52 & MC 31-32
5	Review	Review MC	Study for Test
6	Test	Nuclear Physics Test	N/A