Unit Lesson Plan – Energy			
Teacher:	**<Teacher>**	**Time Frame:**	**14 days**
Grade:	**9**	**School:**	**<School>**
Subject:	**PSI Algebra Based Physics**		

NGSS DCI:	• 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.
AP Physics 1 and 2 Standards:	• 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. • 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

(What questions will the student be able to answer as a result of the instruction?)

1. How do we determine the work done on a physical system when the net force acting on it and its displacement are known?

2. How do we use the work/energy theorem to determine the motion of an object?

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

Knowledge & Skills

(What skills are needed to achieve the desired results?)

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

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	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
(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.

- Work and Energy Quiz
- Power Quiz
- Energy 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	Conservation of Energy and Work	Presentation to slide 28 & Problems 1-7	Problems 8-11 MC 1-10
2	Gravitational Potential Energy	Presentation to slide 39 & Problems 12-19	Problems 20-24 MC 11-15
3	Kinetic Energy	Presentation to slide 55 Problems 25-30	Problems 31-36 MC 16-19
4	Elastic Potential Energy	Presentation to slide 82 Problems 37-43	Problems 44-48 MC 20-25
5	Mixed Problems	Problems 49-54	Problems 55-61
6	Review Homework & MC Work and Energy Quiz	Review & Quiz	N/A
7	Marble Launcher Lab	Lab	Finish lab and study for lab quiz
8	Marble Launcher Lab Quiz & Conservation of Energy	Quiz & Presentation to slide 99	Problems 62-71
9	Review Conservation of energy & Power	Review + Presentation to end + Problems 79-86	Problems 72-78 & 87-91 Finish MC
10	General Problems	Problems 92 & 94	Problems 93 & 95

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11	Power Quiz & General Problems	Quiz & Problem 96	Problems 97
12	General Problems	Problem 98	Problem 99
13	Review for Test	Review	Study
14	Energy 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.