Unit Lesson Plan – Dynamics			
Teacher:	**<Teacher>**	**Time Frame:**	**16 days**
Grade:	**9**	**School:**	**<School>**
Subject:	**PSI Algebra Based Physics**		

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

1. How can an object be made to accelerate?

2. How do forces interact?

3. How do objects respond to multiple forces acting on them?

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

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:

$$\Sigma F = ma$$
$$f_k = \mu_k F_N$$
$$f_s < \mu_s F_N$$
$$w = mg$$

- 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 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

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.

- 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.

specific to the problem.

- How to identify the following forces and illustrate their relative magnitudes and directions when problem solving:
    - Applied Force
    - Normal Force
    - Weight (Gravitational Force)
    - Apparent Weight
    - Tension
    - Friction (Kinetic and Static)
- How to solve Atwood machine type problems.

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.

- 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.

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

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	Hook's Law Lab	Lab	Finish Lab and Study for Lab Quiz
14	Hook'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

* 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.