Unit Lesson Plan – Gravitation			
Teacher:	**<Teacher>**	**Time Frame:**	**8 or 9 days**
Grade:	**9**	**School:**	**<School>**
Subject:	**PSI Algebra Based Physics**		

NGSS 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:	• 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. • Enduring Understanding 2.B: A gravitational field is caused by an object with mass. • Essential Knowledge 2.B.1: A gravitational field g at the location of an object with mass m causes a gravitational force of magnitude mg to be exerted on the object in the direction of the field. a. On the Earth, this gravitational force is called weight. b. The gravitational field at a point in space is measured by dividing the gravitational force exerted by the field on a test object at that point by the mass of the test object and has the same direction as the force. c. If the gravitational force is the only force exerted on the object, the observed free-fall acceleration of the object (in meters per second squared) is numerically equal to the magnitude of the gravitational field (in newtons/kilogram) at that location. • Learning Objective (2.B.1.1):The student is able to apply F=mg to calculate the gravitational force on an object with mass m in a gravitational field of strength g in the context of the effects of a net force on objects and systems. • Essential Knowledge 2.B.2: The gravitational field caused by a spherically symmetric object with mass is radial and, outside the object, varies as the inverse square of the radial distance from the center of that object. a. The gravitational field caused by a spherically symmetric object is a vector whose magnitude outside the object is equal to GM/r^2 . • b. Only spherically symmetric objects will be considered as sources of the gravitational field. • Learning Objective (2.B.2.1):The student is able to apply $g=GM/r^2$ to calculate the gravitational field due to an object with mass M, where the field is a vector directed toward the center of the object of mass M.

Note that this **exact** Smart Notebook presentation has not been used in the classroom, although all of the material has. The pacing below is approximate based on a 40-45 minute class period. Feel free to adjust as necessary and please provide your feedback!

	• Learning Objective (2.B.2.2):The student is able to approximate a numerical value of the gravitational field (g) near the surface of an object from its radius and mass relative to those of the Earth or other reference objects.

Essential Questions

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

1. How are mass, separation, and gravitational force related?
2. How does the mass of a planet relate to its gravitational force?
3. How do we explain the apparent weightlessness of orbiting objects?

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:
• Newton's Law of Universal Gravitation • That the motion of an object in orbit is under the influence of gravitational forces	• Determine the force that one spherically symmetrical mass exerts on another. • Determine the strength of the gravitational field at a specified point outside a spherically symmetrical mass. • Recognize that the motion does not depend on the object's mass • Describe qualitatively how the velocity, period of revolution, and centripetal acceleration depend upon the radius of the orbit • Derive expressions for the velocity and period of revolution in such an orbit.

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.

- Universal Gravitation 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**
Optional	Scientific Notion	Review Scientific Notation presentation	N/A

1	Gravitational Force	Presentation to slide 17	Problems #6-9
2	Gravitational Force	Problems #1-5	Problems #10-15
3	Gravitational Field	Presentation to slide #34	Problems #16-20 & MC #1-10
4	Gravitational Field	Problems #21-23	Problems #24-31 & MC #10-15
5	Orbital Motion	Presentation to end & problems #32-34	Problems #35-41
6	General Problems	Problem 42	Problems 43 & 44 & MC #16-25
7	Review MC	Review	Study for Test
8	Gravitation 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.