Phoenixville Area School District Understanding by Design (UbD) Science Template

Grade Level &/or HS Subject: Physics **Unit Name: Gravity + Motion**

Plain English Summary: This unit is focused on two gravity-driven motions, parabolic motion near the surface of the Earth and circular motion when the acceleration is not constant (when the distance between the objects doesn't change). The problem-solving techniques for those motion types are different and treating them both around the same time allows for the reasons behind those differences to be examined. In particular, reasons for circular motion *other than* by gravity can also be considered. The performance task will allow students to go behind just circular orbits, if desired, to model the motion of planets, moons or satellites using spreadsheets or other programming languages.

<table>
<tr><th colspan="3">Stage 1 Desired Results</th></tr>
<tr><td rowspan="4">Overarching NGSS & PA Standards:

HS-PS2-1

Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.

HS-PS2-4

Use mathematical representations</td><td colspan="2">Transfer</td></tr>
<tr><td colspan="2">Students will be able to independently use their learning to…

Ask questions and define problems
Develop and use models
Plan and carry out experiments
Analyze and interpret data using computational thinking
Obtain, evaluate, and communicate information (supported by evidence)
Construct explanations and design solutions

(Choose the appropriate content-specific transfer goals)</td></tr>
<tr><td colspan="2">Meaning-Making</td></tr>
<tr><td>Students will understand that…

Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.

Mathematical representations of Newton's Law of Gravitation can be used to describe and predict the gravitational forces between objects.

Mathematical or computational representations can be used to predict the motion of orbiting objects in the solar system

Models can be developed and used 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 positions of particles (objects).</td><td>ESSENTIAL QUESTIONS
Students will keep considering...

How do masses interact with each other?

How can one predict an object's motion, change in motion and stability?

How is energy transferred and conserved?</td></tr>
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<tr>
<td rowspan="4">of Newton’s Law of Gravitation and Coulomb’s Law to describe and predict the gravitational and electrostatic forces between objects

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 positions of particles (objects).

HS-ESS1-4

Use mathematical or computational</td>
<td>Constant fields, such as gravity near Earth’s surface, can be modeled with motion paths other than circles and ellipses, such as parabolas.</td>
<td></td>
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<tr>
<td colspan="2">Knowledge and Skills Acquisition</td>
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<td>UNDERSTANDINGS
Students will know…

Kepler’s laws describe common features of the motions of orbiting objects, including their elliptical paths around the sun. Orbits may change due to the gravitational effects from, or collisions with, other objects in the solar system.

Newton’s law of universal gravitation provides the mathematical model to describe and predict the effects of gravitational and forces between distant objects.

Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields.

Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system’s total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms.

The potential energy between two masses is the result of the relative position of the masses and the fields mediating their interactions.

Objects can accelerate without changing speed. The sum of forces that change direction without changing speed is called Centripetal Force and gives rise to circular motion.</td>
<td rowspan="2">Students will be skilled at…

Apply scientific ideas to solve a design problem, taking into account possible unanticipated effects.

Use mathematical representations of phenomena to describe explanations.

Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution.</td>
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<tr>
<td>KEY VOCABULARY

Newton’s Law of Universal Gravitation
Centripetal Force
Centripetal or Radial Acceleration
Period
Radius
Parabola
Projectile</td>
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<tr><td>representations to predict the motion of orbiting objects in the solar system

Which branch(es) of science apply:

PS ESS</td><td></td><td></td></tr>
<tr><th colspan="3">Stage 2 – Evidence</th></tr>
<tr><th>Evaluative Criteria</th><th colspan="2">Assessment Evidence</th></tr>
<tr><td>Accurate simulation; Easy to interpret; successful completion of goal</td><td>PERFORMANCE TASK(S):

Solar System Simulation

Goal: Students will construct a simulation of the solar system using a spreadsheet and graph(s) to recreate planetary orbits. Once the basic solar system is generated, students should attempt to create one of the following: a probe launch from Earth to another planet; a stable orbit between two planets; a comet-like path; or interactions between Earth or Mars and Jupiter. Other possibilities also exist.
Role: Student-generated, but default would be a Probe Launch programmer.
Audience: Again, student-generated but in the default case, Mission Control.
Situation: Default case: you need to design the initial launch conditions for a probe to go from Earth to some other planet. To do so, you first must design a functioning solar system. Once you have figured out a pathway, you can present your results to Mission Control. Students can work in pairs.
Product/Purpose: The product will be the simulation and graph(s).
Standards: See left</td><td>Differentiation Considerations:

Students have choice in what they do beyond the basic simulation and what their role/audience might be. For some students/pairs, a more basic solar system (2 planets and the sun) might be a more achievable task, so the project can be adjusted to make the time work for all students.</td></tr>
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Accuracy of answers and explanations; lab/inquiry process skills	OTHER EVIDENCE: • HW – these will consist of a range of questioning goals, from basic things like vocab understanding to conceptual understanding to application • Lab – Projectile Competition – students experiment with launch angle effect on distance, then construct an equation allowing them to hit any distance from the launcher (within max range of the launcher). • Quizzes – MC or FR where work is required; similar to HW, could be fact recall, conceptual understanding or application being assessed. • Test – 1 for the unit, will contain a mix of recall and application focused on the understandings and knowledge from Stage 1 (What evidence will be collected to determine whether Stage 1 goals were achieved?)	Differentiation Considerations: • Notes allowed on some assessments • Partial credit + test corrections