2017 - 2018 HS Physics: T2, U4

Physics, Term 2, Unit 4
Topic: Newton's Laws
Duration: approximately 17 days

Eligible Content

This is what the State of Pennsylvania wants your students to know and be able to do by the end of the unit.

S11.C.3.1.2 Design or evaluate simple technological or natural systems that incorporate the principles of force and motion (e.g., simple machines, compound machines).
S11.C.3.1.3 Describe the motion of an object using variables (i.e., acceleration, velocity, displacement).

Performance Objectives

These are examples, created by SDP teachers, of how you may translate the eligible content into learning goals for your classroom.

1. **SWBAT** understand Newton's Laws of Motion **IOT** qualitatively describe situations involving forces.
2. **SWBAT** analyze free body diagrams and use vector addition **IOT** determine the net force on an object.
3. **SWBAT** design and conduct investigations **IOT** analyze and calculate forces such as friction and gravity.
4. **SWBAT** analyze physical situations and equations **IOT** solve problems using net force, mass and acceleration.

Key Terms and Definitions:

1. **Force** - A push or pull on an object - measured in Newtons [N]
2. **Inertia** - an object's resistance to changes in its motion
3. **Mass** - the measure of the inertia of an object - measured in kilograms [kg]
4. **Weight** - The force of gravity on an object
5. **Gravity** - An attractive force between two massive bodies
6. **Friction** - A force that acts to resist sliding between two surfaces. Can be kinetic (if the objects move relative to one another) or static (if the objects are at rest relative to one another).
7. **Net Force** - The vector sum of all the forces acting on an object
8. **Normal Force** - The force exerted on an object perpendicular to a surface it is in contact with
9. **Free-Body Diagram** - a diagram used to depict the relative magnitudes and directions of the forces acting on a single object

Starting Points

An overview of how the content and skills of this unit connect to students' prior knowledge.

Prerequisite knowledge for this unit includes all of the knowledge from Term 1. Students will need to be extremely comfortable with kinematic quantities, solving kinematic equations, properly identifying variables and graphing. Additional required prerequisite knowledge revolves around comfort performing trigonometric and vector calculations. Students should be able to decompose vectors, add the components and find resultants as well as properly label diagrams with both magnitude and direction of vectors.

When using forces to explain motion, students will be able to apply Newton's Laws to put their observations in context. Newton's Second Law will become their main problem-solving tool to quantitatively describe observed changes in motion. Finally, students will identify, describe, measure and use a variety of forces, including gravity, friction and the normal force. This all will set the stage for their understanding of momentum and energy.

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Instructional Resources Aligned with Performance Objectives and related Key Terms
An overview of how the content and skills of this unit connect to students' prior knowledge.

1. **SWBAT** understand Newton's Laws of Motion **IOT** qualitatively describe situations involving forces. (PA Standards: 3.2.P.B1, 3.2.10.B1).
(Key Terms: force, inertia, friction, net force, free-body diagram)

Suggested Activities:
- PhET Forced and Motion: https://phet.colorado.edu/en/simulation/forces-and-motion-basics
- https://phet.colorado.edu/en/simulation/trig-tour

Worksheets
- Newton's Third Law Thinksheet: http://www.physicsclassroom.com/curriculum/newtlaws/Newton-s-Third-Law

Suggested Reading
- Newton's Laws of Dynamics - From *The Feynman Lectures on Physics, Volume 1*: http://www.feynmanlectures.caltech.edu/I_09.html

General Resource Sites That Are Searchable and Provide Labs, Worksheets
- Pretty Good Physics Community: https://prettygoodphysics.wikispaces.com/
- Pretty Good Physics Secure Community: https://prettygoodphysics.wikispaces.com/Secure-PGP (Free registration required)
- Yale National Initiative Curriculum Units: http://teachers.yale.edu/curriculum/search/start
- Teachers Institute of Philadelphia Curriculum Units: http://theteachersinstitute.org/content/curriculum-unit-guide

2. **SWBAT** analyze free body diagrams and use vector addition **IOT** determine the net force on an object. (PA Standards: 3.2.P.B1, 3.2.10.B1).
(*Key Terms: force, mass, weight, gravity, friction, net force, normal force, free-body diagram*)

Suggested Activities
- PhET Forces and Motion: https://phet.colorado.edu/en/simulation/legacy/forces-and-motion
- PhET Forced and Motion (Ramp): https://phet.colorado.edu/en/simulation/legacy/ramp-forces-and-motion

Worksheets
- Free Body Diagrams: http://www.physicsclassroom.com/curriculum/newtlaws/Free-Body-Diagrams

Suggested Reading:
- Drawing Free Body Diagrams: http://www.physicsclassroom.com/class/newtlaws/Lesson-2/Drawing-Free-Body-Diagrams

General Resource Sites That Are Searchable and Provide Labs, Worksheets
- Pretty Good Physics Community: https://prettygoodphysics.wikispaces.com/
- Pretty Good Physics Secure Community: https://prettygoodphysics.wikispaces.com/Secure-PGP (Free registration required)
- Yale National Initiative Curriculum Units: http://teachers.yale.edu/curriculum/search/start
- Teachers Institute of Philadelphia Curriculum Units: http://theteachersinstitute.org/content/curriculum-unit-guide

3. **SWBAT** design and conduct investigations **IOT** analyze and calculate forces such as friction and gravity. (PA Standards: 3.2.P.B1, 3.2.10.B1).
(*Key Terms: force, mass, weight, gravity, friction, net force, normal force*)

Suggested Activities
- PhET Masses and Springs: https://phet.colorado.edu/en/simulation/legacy/mass-spring-lab
- PhET Friction: https://phet.colorado.edu/en/simulation/friction
- PhET Gravity Force Lab: https://phet.colorado.edu/en/simulation/gravity-force-lab

Worksheets
- Friction Worksheet: http://www.physicsclassroom.com/curriculum/newtlaws/Friction

Suggested Reading:

- Characteristics of Force - From *The Feynman Lectures on Physics, Volume 1*: http://www.feynmanlectures.caltech.edu/I_09.html http://www.feynmanlectures.caltech.edu/I_12.html

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- Pretty Good Physics Secure Community: https://prettygoodphysics.wikispaces.com/Secure-PGP (Free registration required)
- Yale National Initiative Curriculum Units: http://teachers.yale.edu/curriculum/search/start
- Teachers Institute of Philadelphia Curriculum Units: http://theteachersinstitute.org/content/curriculum-unit-guide

4. **SWBAT** analyze physical situations and equations **IOT** solve problems using net force, mass and acceleration. (PA Standards: 3.2.P.B1, 3.2.10.B1).
(*Key Terms: force, mass, weight, gravity, friction, net force, normal force, free-body diagram*)

Suggested Activity

- The Physics Classroom Push It!: http://www.physicsclassroom.com/NGSS-Corner/Activity-Descriptions/Push-It-Description

Worksheets

- Newton's 2nd Law and Problem Solving: http://www.physicsclassroom.com/curriculum/newtlaws/Newton-s-Second-Law-and-Problem-Solving

Suggested Reading

- Solving Newton's 2nd Law Problems: https://www.cpp.edu/~ajm/materials/n2.html
- Solving Newton's 2nd Law Problems: http://canyonphysics.com/tools/second_law_how_to/Second_Law_how_to.htm

PDESAS Sample Lesson Plan(s) & Web Resources

- *Newton's 2nd Law and Determining the Net Force*. An online resource from PDESAS to help students understand forces.. https://www.pdesas.org/ContentWeb/Content/Content/20047/Lesson%20Plan

General Resource Sites That Are Searchable and Provide Labs, Worksheets

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- Pretty Good Physics Secure Community: https://prettygoodphysics.wikispaces.com/Secure-PGP (Free registration required)
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Enrichment

Enroll your students into a Philadelphia tradition - Carver Science Fair www.carversciencefair.org [General Science Fair Guide for Students] https://go.hrw.com/resources/go_sc/hst/HSTGP221.PDF

Textbook References

Serway, Raymond A., and Jerry S. Faughn. Holt Physics. Orlando: Holt, Rinehart and Winston, 2006.*

The Feynman Lectures on Physics. http://www.feynmanlectures.caltech.edu/

The Physics Hypertextbook. http://physics.info/

**Note: Must login to SchoolNet in order to access online textbook*

Essential Questions

1. How do you combine quantities that point in different directions?

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2. How does 2D motion relate to 1D motion and how can we describe 2D motion in terms of 1D motion?
3. What effect does an observer's frame of reference have on their perception of 2D motion?
4. What observations lead to the conclusion that a net force is acting on an object?
5. How do Newton's Laws add new perspective to common observations?

PA Standards

These are the PA Standards that underly the Eligible Content in this unit.

3.1.P.B: Physics	**3.2.P.B1.** Differentiate among translational motion, simple harmonic motion, and rotational motion in terms of position, velocity, and acceleration. Use force and mass to explain translational motion or simple harmonic motion of objects. Relate torque and rotational inertia to explain rotational motion. **3.2.10.B1.** Analyze the relationships among the net forces acting on a body, the mass of the body, and the resulting acceleration using Newton's Second Law of Motion. Use Newton's Third Law to explain forces as interactions between bodies.

Common Core Standards for Science and Technical Subjects

These are Common Core Standards that are related to the Eligible Content in this unit.

CC.3.5.11-12.A: Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.

CC.3.5.11-12.C: Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.

CC.3.5.11-12.H: Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.

CC.3.6.11-12.B:

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

CC.3.6.11-12.C: Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

CC.3.6.11-12.H: Draw evidence from informational texts to support analysis, reflection, and research.

Common Core Standards for Mathematical Practice

- MP3: Construct viable arguments and critique the reasoning of others.
- MP5: Use appropriate tools strategically.
- MP6: Attend to precision.

Next Generation Science Standards

These are Next Generation Science Standards that are related to the Eligible Content in this unit.

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.