Unit 1: Introduction to Mechanics

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Title Section

Department of Curriculum and Instruction

Belleville Public Schools

Curriculum Guide

Unit 1

Introduction to Mechanics

Belleville Board of Education

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Unit Overview

In this unit, students will be introduced to the world through the eyes of a physicist, whose principle goal is to study the underlying nature of everyday processes and to investigate the structure of the universe in terms of scientific analysis. Using the sciences of kinematics, or study of motion, and dynamics, or the study of forces, this unit requires the students to put into practice previously learned skills of hypothesis creation, experimental design, data collection and analysis in order to investigate how objects move through space. The quantities to be investigated include base units such as mass, length, and time, as well as derived units such as velocity and acceleration. The interrelation of these quantities will be discussed and problems will be solved using kinematics formulas. In addition, Newton's Laws of Motion will be used to analyze changes in motion, and Newton's Law of Universal Gravitation will be investigated.

NJSLS

CCC.1	Patterns.
CCC.2	Cause and effect: Mechanism and explanation.
CCC.4	Systems and system models.
SEP.3	Planning and Carrying Out Investigations
SEP.4	Analyzing and Interpreting Data

SEP.5	Using Mathematics and Computational Thinking
SEP.6	Constructing Explanations and Designing Solutions
SCI.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.
SCI.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.
SCI.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.
SCI.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.

Exit Skills

By the end of Unit 1 Students will:

• Develop a particle model to represent a moving object
• Define coordinate systems for motion problems.
• Recognize that the chosen coordinate system affects the signs of the objects' positions.
• Define Displacement.
• Determine a time interval.
• Develop position-time graphs for moving objects.
• Use a position-time graph to interpret an object's position or displacement.
• Define velocity.
• Differentiate between speed and velocity.
• Create pictorial, physical, and mathematical models of motion problems.
• Define acceleration.
• Relate velocity and acceleration to the motion of objects.
• Create velocity-time graphs.
• Determine mathematical relationships among position, velocity, acceleration, and time.
• Define acceleration due to gravity.
• Solve problems involving objects in free fall.
• Define force.
• Use Newton's second law to solve problems.
• Explain the meaning of Newton's first law.
• Describe how the weight and the mass of an object are related.
• Differentiate between actual weight and apparent weight.
• Define Newton's third law.
• Explain the tension in ropes and strings in terms of Newton's third law.
• Define the Normal Force.
• Determine the value of the normal force by applying Newton's second law.
• Define Friction Force.
• Distinguish between static and kinetic friction.
• Relate the height, time in the air, and initial vertical velocity of a projectile using its vertical motion
• Explain how the trajectory of the projectile depends upon the frame of reference from which it observed.
• Explain why an object moving in a circle at a constant speed is accelerated.
• Describe how centripetal acceleration depends up on the object's speed and the radius of the circle.
• Identify the force that causes centripetal acceleration.

• Use the Law of Universal Gravitation to solve problems.

Enduring Understanding

Unit Enduring Understanding:

Students will relate to their world in a more detailed and scientific manner.
Students will identify how their new understandings can be applied to real-world phenomena

Definition: *Enduring Understandings*

Enduring understandings are statements summarizing important ideas and core processes that are central to a discipline and have lasting value beyond the classroom. They synthesize what students should understand—not just know or do—as a result of studying a particular content area. Moreover, they articulate what students should "revisit" over the course of their lifetimes in relationship to the content area.

Enduring understandings:

1. Frame the big ideas that give meaning and lasting importance to such discrete curriculum elements as facts and skills
2. Can transfer to other fields as well as adult life
3. "Unpack" areas of the curriculum where students may struggle to gain understanding or demonstrate misunderstandings and misconceptions
4. Provide a conceptual foundation for studying the content area and
5. Are deliberately framed as declarative sentences that present major curriculum generalizations and recurrent ideas.

Example:

Reading/Literature

This is an Enduring Understanding

Reading is a process by which we construct meaning about the information being communicated by an author within a print or non-print medium.

This is an Essential Question

How is reading a process of constructing meaning from text?

Essential Questions

Unit Essential Questions:

How does the Scientific Method apply to physics?
How does Mathematics play a role in physics
What are the various forms of motion?
How do physicists describe and quantify motion?
How does one describe motion of an object in two dimensions?
What is the difference between weight and mass?

Essential Question: A question that lies at the heart of a subject or a curriculum and one that promotes inquiry and the discovery of a subject.

•They can help students discover patterns in knowledge and solve problems.
•They support inductive teaching—guiding students to discover meaning, which increases motivation to learn.
•They are one of the most powerful tools for helping students think at more complex levels.
•They engage the personal intellect—something that traditional objectives usually fail to do.
•Have no obvious "right" answer
•Raise other important questions, often across subject-area boundaries
•Address a concept
•Raise other important questions
•Naturally and appropriately recur
•Stimulate critical, ongoing rethinking
•Are framed to provoke and sustain student interest

What makes a Questions "Essential?"
•Continues throughout all our lives
•Refers to core ideas and inquiries within a discipline
•Helps students effectively ask questions and make sense of important and complex ideas, knowledge, and know-how
•Engages a specific and diverse set of learners

Two Types of Essential Questions:
•Overarching: The overall "Big Idea"
- •More general, broader
- •Point beyond specific topics or skills
- •Promote the transfer of understanding

•Topical: Unit or lesson specific but still promotes inquiry
- •Unit or lesson specific - used to guide individual units or lessons
- •Promote inquiry
- •Resist obvious answers
- •Require explanation and justification

Examples:
•What is a true friend?
•What makes an artist amazing?

•In what sense is the body a system?
•What is the law of nature, and how is it like or unlike social laws?
•To what extent is US history a history of progress?
•In what ways do diet and exercise affect health?
•Must heroes be flawless?
•How do effective writers hook and hold their readers?
•How do cultures affect one another?
•Does practice make perfect?
•What is healthy eating? Healthy living?
•How and when do we use mathematics?
•How does something acquire value?

Learning Objectives

The student will be able to..

Develop a particle model to represent a moving object.
Define coordinate systems for motion problems.
Recognize that the chosen coordinate system affects the signs of the objects' positions.
Define Displacement.
Determine a time interval.
Develop position-time graphs for moving objects.
Use a position-time graph to interpret an object's position or displacement.
Define velocity.
Differentiate between speed and velocity.
Create pictorial, physical, and mathematical models of motion problems.
Recognize that the chosen coordinate system affects the signs of the objects' positions.
Create pictorial, physical, and mathematical models of motion problems.
Draw motion diagrams to describe motion.
Develop a particle model to represent a moving object.
Define coordinate systems for motion problems.
Define Displacement.
Determine a time interval.
Use a motion diagram to answer questions about an object's position or displacement.
Develop position-time graphs for moving objects.
Use a position-time graph to interpret an object's position or displacement.
Make motion diagrams, pictorial representations, and position time graphs that are equivalent representations describing an object's motion.
Define velocity.
Differentiate between speed and velocity.
Create pictorial, physical, and mathematical models of motion problems. (NPS) Define acceleration.
Relate velocity and acceleration to the motion of objects.
Create velocity-time graphs.
Determine mathematical relationships among position, velocity, acceleration, and time.
Define acceleration due to gravity.
Solve problems involving objects in free fall.
Define force.

Use Newton's second law to solve problems.
Explain the meaning of Newton's first law.
Describe how the weight and the mass of an object are related.
Differentiate between actual weight and apparent weight.
Define Newton's third law.
Explain the tension in ropes and strings in terms of Newton's third law.
Define the Normal Force.
Determine the value of the normal force by applying Newton's second law.
Interpret position-time graphs for motion with constant acceleration.
Apply graphical and mathematical relationships to solve constant –acceleration problems.
Differentiate between actual weight and apparent weight.
Determine the value of the normal force by applying Newton's second law.
Evaluate the sum of two or more vectors in two dimensions, graphically.
Determine the components of vectors.
Solve for the sum of two or more vectors, algebraically, by adding the components of the vectors.
Define Friction Force.
Distinguish between static and kinetic friction.
Relate the height, time in the air, and initial vertical velocity of a projectile using its vertical motion.
Explain how the trajectory of the projectile depends upon the frame of reference from which it observed.
Determine the force that produces equilibrium when two to three forces act on an object.
Analyze the motion of an object on an inclined plane with and without friction.
Recognize that the vertical and horizontal motions of a projectile are independent.
Relate the height, time in the air, and initial vertical velocity of a projectile using its vertical motion, and then determine the range using the horizontal motion.
Explain how the trajectory of the projectile depends upon the frame of reference from which it observed.
Solve relative velocity problems.
Explain why an object moving in a circle at a constant speed is accelerated.
Describe how centripetal acceleration depends up on the object's speed and the radius of the circle.
Identify the force that causes centripetal acceleration.
Describe angular displacement.
Calculate angular velocity.
Calculate angular acceleration.
Solve problems involving rotational motion.
Describe torque and the factors that determine it.
Calculate net torque.
Calculate the moment of inertia.
Define center of mass.
Use Newton's law of universal gravitation to solve problems.
Describe the importance of Cavendish's experiment.
Solve orbital motion problems.
Relate weightlessness to objects in free fall.
Describe gravitational fields.
Relate Kepler's laws to the law of universal gravitation.
Calculate orbital speeds and periods.
Describe the importance of Cavendish's experiment.
Solve orbital motion problems.
Relate weightlessness to objects in free fall.
Describe gravitational fields.
Compare views on gravitation.

Tips on Writing Good Learning Objectives

Bloom's Taxonomy

Applying Bloom's Taxonomy to Learning Objectives

Effective learning objectives need to be observable and/or measureable, and using action verbs is a way to achieve this. Verbs such as "identify", "argue," or "construct" are more measureable than vague or passive verbs such as "understand" or "be aware of". As you develop your syllabus focus on articulating clear learning objectives and then use these objectives to guide class assignments, exams and overall course assessment questions.

Sample Learning Objectives for a Lower Division Course

After completing Nutrition 101 *Humans and Food*, students will be able to:

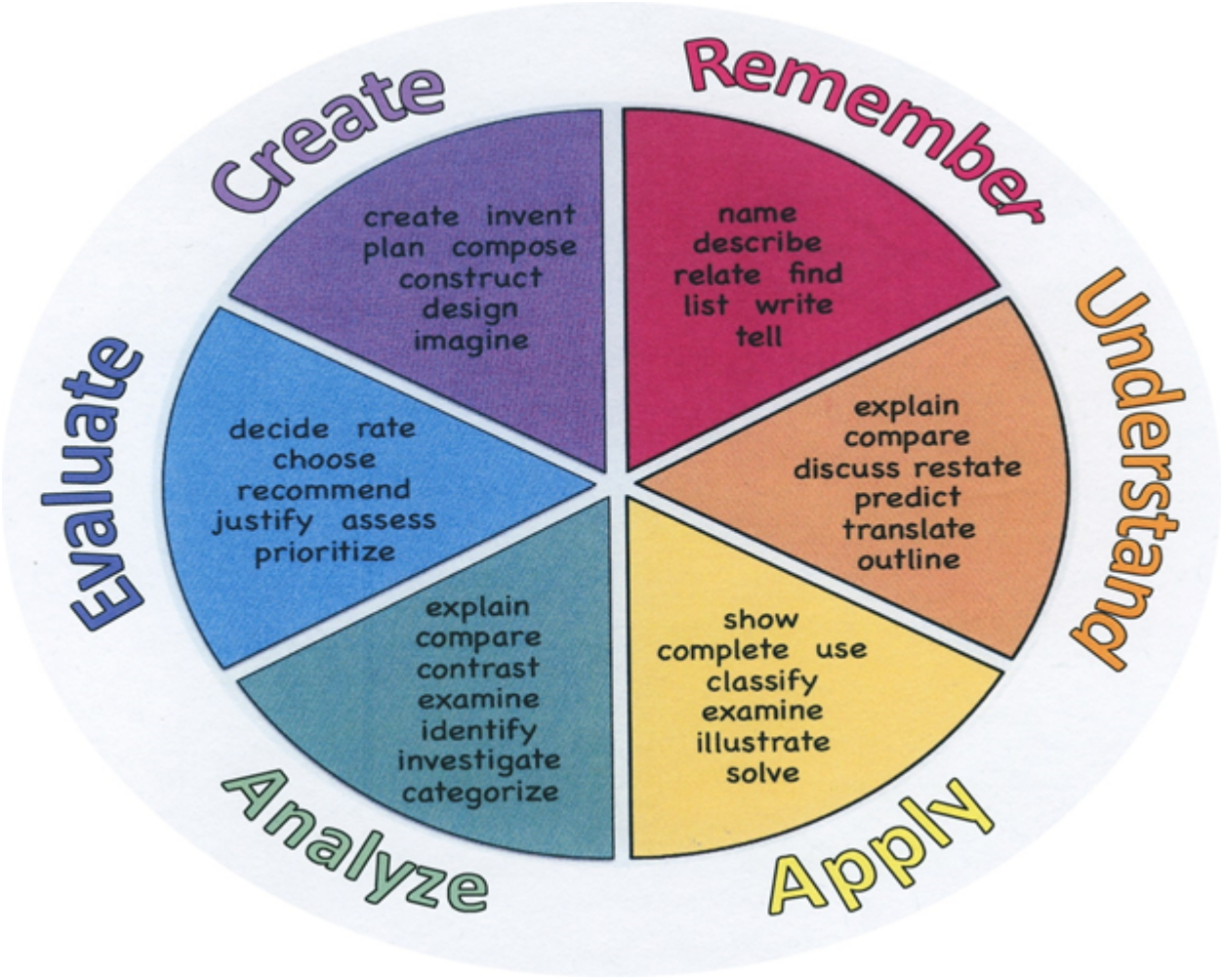
- **Identify** nutrients found in common food sources via the product's nutrition label
- Use computer dietary analysis to assess a 2-day dietary intake and **summarize** results
- **Locate** nutrition-related information on the Internet and use **evaluative** criteria to **identify** reliability of the information

Action Verbs

Below are examples of action verbs associated with each level of the Revised Bloom's Taxonomy. These are useful in writing learning objectives, assignment objectives and exam questions.

Remember	Understand	Apply	Analyze	Evaluate	Create
Choose	Classify	Choose	Categorize	Appraise	Combine
Describe	Defend	Dramatize	Classify	Judge	Compose
Define	Demonstrate	Explain	Compare	Criticize	Construct
Label	Distinguish	Generalize	Differentiate	Defend	Design
List	Explain	Judge	Distinguish	Compare	Develop
Locate	Express	Organize	Identify	Assess	Formulate
Match	Extend	Paint	Infer	Conclude	Hypothesize
Memorize	Give Examples	Prepare	Point out	Contrast	Invent
Name	Illustrate	Produce	Select	Critique	Make
Omit	Indicate	Select	Subdivide	Determine	Originate
Recite	Interrelate	Show	Survey	Grade	Organize
Select	Interpret	Sketch	Arrange	Justify	Plan
State	Infer	Solve	Breakdown	Measure	Produce
Count	Match	Use	Combine	Rank	Role Play
Draw	Paraphrase	Add	Detect	Rate	Drive
Outline	Represent	Calculate	Diagram	Support	Devise
Point	Restate	Change	Discriminate	Test	Generate
Quote	Rewrite	Classify	Illustrate		Integrate
Recall	Select	Complete	Outline		Prescribe
Recognize	Show	Compute	Point out		Propose
Repeat	Summarize	Discover	Separate		Reconstruct
Reproduce	Tell	Divide			Revise
	Translate	Examine			Rewrite

	Associate Compute Convert Discuss Estimate Extrapolate Generalize Predict	Graph Interpolate Manipulate Modify Operate Subtract			Transform



Interdisciplinary Connections

Please list all and any cross-curricular content standards that link to this Unit.

MA.K-12.2	Reason abstractly and quantitatively.
MA.K-12.4	Model with mathematics.
MA.N-Q.A.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.
MA.N-Q.A.2	Define appropriate quantities for the purpose of descriptive modeling.

MA.N-Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.
LA.RST.11-12.1	Accurately cite strong and thorough evidence from the text to support analysis of science and technical texts, attending to precise details for explanations or descriptions.
LA.RST.11-12.2	Determine the central ideas, themes, or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.
LA.WHST.11-12.2	Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.
LA.WHST.11-12.5	Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.
LA.WHST.11-12.7	Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.
LA.SL.11-12.4	Present information, findings and supporting evidence clearly, concisely, and logically. The content, organization, development, and style are appropriate to task, purpose, and audience.
LA.SL.11-12.5	Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest.

Alignment to 21st Century Skills & Technology

Key SUBJECTS AND 21st CENTURY THEMES

Mastery of key subjects and 21st century themes is essential for all students in the 21stcentury.

Key subjects include:

- English, reading or language arts
- World languages
- Arts
- Mathematics
- Economics
- Science
- Geography
- History
- Government and Civics

21st Century/Interdisciplinary Themes

- Civic Literacy
- Environmental Literacy
- Financial, Economic, Business and Entrepreneurial Literacy

- Global Awareness
- Health Literacy

21st Century Skills

- Communication and Collaboration
- Creativity and Innovation
- Critical thinking and Problem Solving
- ICT (Information, Communications and Technology) Literacy
- Information Literacy
- Life and Career Skills
- Media Literacy

Technology Infusion

What technology can be used in this unit to enhance learning?



Differentiation

As a Reminder:

The basis of good differentiation in a lesson lies in differentiating by content, process, and/or product.

Resources:

- NJDOE: Instructional Supports and Scaffolds for Success in Implementing the Common Core State Standards http://www.state.nj.us/education/modelcurriculum/success/math/k2/

Special Education

- printed copy of board work/notes provided
- additional time for skill mastery
- assistive technology
- behavior management plan
- Center-Based Instruction
- check work frequently for understanding
- computer or electronic device utilizes
- extended time on tests/ quizzes
- have student repeat directions to check for understanding
- highlighted text visual presentation
- modified assignment format
- modified test content
- modified test format
- modified test length
- multi-sensory presentation
- multiple test sessions
- preferential seating
- preview of content, concepts, and vocabulary
- reduced/shortened reading assignments
- Reduced/shortened written assignments
- secure attention before giving instruction/directions
- shortened assignments
- student working with an assigned partner
- teacher initiated weekly assignment sheet
- Use open book, study guides, test prototypes

ELL

- teaching key aspects of a topic. Eliminate nonessential information

- using videos, illustrations, pictures, and drawings to explain or clarif
- allowing products (projects, timelines, demonstrations, models, drawings, dioramas, poster boards, charts, graphs, slide shows, videos, etc.) to demonstrate student's learning;
- allowing students to correct errors (looking for understanding)
- allowing the use of note cards or open-book during testing
- decreasing the amount of workpresented or required
- having peers take notes or providing a copy of the teacher's notes
- modifying tests to reflect selected objectives
- providing study guides
- reducing or omitting lengthy outside reading assignments
- reducing the number of answer choices on a multiple choice test
- tutoring by peers
- using computer word processing spell check and grammar check features
- using true/false, matching, or fill in the blank tests in lieu of essay tests

Intervention Strategies

- allowing students to correct errors (looking for understanding)
- teaching key aspects of a topic. Eliminate nonessential information
- allowing products (projects, timelines, demonstrations, models, drawings, dioramas, poster boards, charts, graphs, slide shows, videos, etc.) to demonstrate student's learning
- allowing students to select from given choices
- allowing the use of note cards or open-book during testing
- collaborating (general education teacher and specialist) to modify vocabulary, omit or modify items to reflect objectives for the student, eliminate sections of the test, and determine how the grade will be determined prior to giving the test.
- decreasing the amount of workpresented or required
- having peers take notes or providing a copy of the teacher's notes
- marking students' correct and acceptable work, not the mistakes
- modifying tests to reflect selected objectives
- providing study guides
- reducing or omitting lengthy outside reading assignments
- reducing the number of answer choices on a multiple choice test
- tutoring by peers
- using authentic assessments with real-life problem-solving
- using true/false, matching, or fill in the blank tests in lieu of essay tests
- using videos, illustrations, pictures, and drawings to explain or clarify

Evidence of Student Learning-CFU's

Please list ways educators may effectively check for understanding in this secion.

- Admit Tickets
- Anticipation Guide
- Common benchmarks
- Compare & Contrast
- Create a Multimedia Poster
- Define
- Describe
- Evaluate
- Evaluation rubrics
- Exit Tickets
- Explaining
- Fist- to-Five or Thumb-Ometer
- Illustration
- Journals
- KWL Chart
- Newspaper Headline
- Outline
- Question Stems
- Quickwrite
- Quizzes
- Red Light, Green Light
- Self- assessments
- Socratic Seminar
- Study Guide
- Teacher Observation Checklist
- Think, Pair, Share
- Think, Write, Pair, Share
- Top 10 List
- Unit tests

Primary Resources

Textbook
Internet
Science Department Video Library

Ancillary Resources

Teacher Prepared Materials
Lab Materials
Study Guide Materials
United Streaming Videos
The Physics Classroom: www.thephysicsclassroom.com
STEM Lab

Sample Lesson

One Lesson per Curriculum must bein this lesson plan template. I.e. one lesson in one unit

Unit Name:

NJSLS:

Interdisciplinary Connection:

Statement of Objective:

Anticipatory Set/Do Now:

Learning Activity:

Student Assessment/CFU's:

Materials:

21st Century Themes and Skills:

Differentiation/Modifications:

Integration of Technology: