Unit 2: Momentum and Energy

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Title Section

Department of Curriculum and Instruction

Belleville Public Schools

Curriculum Guide

Unit 2

Momentum and Energy

Belleville Board of Education

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Unit Overview

In this unit, students will be able to describe and explain the ways that motion is affected during collisions and other interactions with other systems. Students will apply the concepts of momentum and energy to motion problems in order to conceptualize and quantify intersystem interactions. Prior knowledge will be used to build new connections to mathematical relationships and interconnected quantities of motion, momentum, and energy.

NJSLS

CCC.1	Patterns.
CCC.2	Cause and effect: Mechanism and explanation.
CCC.4	Systems and system models.
CCC.5	Energy and matter: Flows, cycles, and conservation.
SCI.HS-PS3-1	Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.
SCI.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 position of particles (objects).
SCI.HS-PS2-6	Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.
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-PS2-5	Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current.
SCI.HS-PS3-4	Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).
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-PS3-5	Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.

Exit Skills

By the end of Unit 2 Students will:

1. Relate Kepler's laws to the law of universal gravitation.
2. Calculate orbital speeds and periods.
3. Describe the importance of Cavendish's experiment.
4. Solve orbital motion problems.
5. Relate weightlessness to objects in free fall.
6. Describe gravitational fields.
7. Compare views on gravitation.
8. Describe angular displacement.
9. Calculate angular velocity.
10. Calculate angular acceleration.
11. Solve problems involving rotational motion.
12. Describe torque and the factors that determine it.
13. Calculate net torque.
14. Calculate the moment of inertia.
15. Define center of mass.
16. Explain how the location of the center of mass affects the stability of an object.
17. Define the conditions for equilibrium.
18. Describe how rotating frames of reference give rise to apparent forces.
19. Define the momentum of an object.
20. Determine the impulse given to an object.
21. Define the angular momentum of an object.
22. Relate Newton's third law to conservation of momentum in collisions and explosions.
23. Recognize the conditions under which momentum is conserved.
24. Solve conservation of momentum problems in two dimensions.
25. Describe the relationship between work and energy.
26. Calculate work.
27. Calculate the work done by a variable force.
28. Calculate the power used.
29. Demonstrate knowledge of the usefulness of simple machines.
30. Differentiate between ideal and real machines in terms of efficiency.
31. Analyze compound machines in terms of simple machines.

32. Calculate efficiencies for simple and compound machines.
33. Use a model to relate work and energy.
34. Calculate kinetic energy.
35. Determine the gravitational potential energy of a system.
36. Identify how elastic potential energy is stored.
37. Solve problems using the law of conservation of energy.
38. Analyze collisions to find the change in kinetic energy.

Enduring Understanding

Unit Enduring Understandings:

• 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:

What are the different ways energy and momentum affect the motion of objects?
How do physicists describe collisions?
How do physicists describe machines and mechanical systems in terms of work, power and energy?
Will students be able to find real life uses for simple machines?
Are students able to explain leverage in simple machines?

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

Students will be able to...

Define the momentum of an object.
Determine the impulse given to an object.
Relate Newton's third law to conservation of momentum in collisions and explosions.
Recognize the conditions under which momentum is conserved.
Define the conditions for equilibrium.
Describe how rotating frames of reference give rise to apparent forces.
Define the momentum of an object.
Determine the impulse given to an object.
Define the angular momentum of an object.
Relate Newton's third law to conservation of momentum in collisions and explosions.
Recognize the conditions under which momentum is conserved.
Solve conservation of momentum problems in two dimensions.
Describe the relationship between work and energy.
Calculate work.
Calculate the work done by a variable force.
Calculate the power used.
Use a model to relate work and energy.
Calculate kinetic energy.
Determine the gravitational potential energy of a system.
Identify how elastic potential energy is stored.
Analyze collisions to find the change in kinetic energy.
Describe the force in an elastic spring.
Determine the energy stored in an elastic spring.

Solve problems using the law of conservation of energy.
Demonstrate knowledge of the usefulness of simple machines.
Differentiate between ideal and real machines in terms of efficiency.
Analyze compound machines in terms of simple machines.
Calculate efficiencies for simple and compound machines.
Compare simple harmonic motion and the motion of a pendulum.
Describe the force in an elastic spring.
Determine the energy stored in an elastic spring.

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:

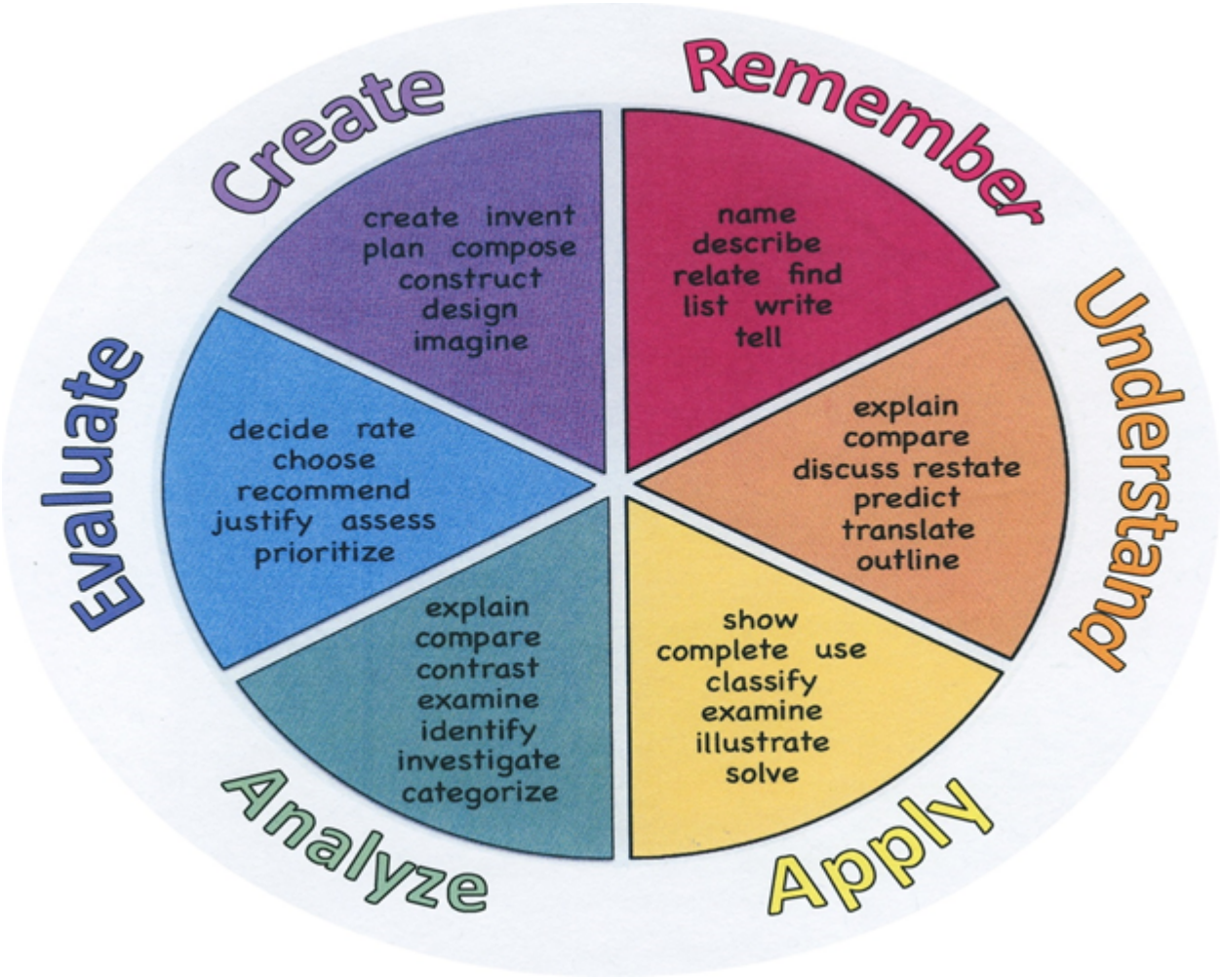
- **Identify** nutrients found in common food sources via the product's nutrition label
- Use computer dietary analysis to assess a 2-day dietary intake and **summarize** results
- **Locate** nutrition-related information on the Internet and use **evaluative** criteria to **identify** reliability of 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 Count Draw Outline Point Quote Recall Recognize Repeat Reproduce	Infer Match Paraphrase Represent Restate Rewrite Select Show Summarize Tell Translate Associate Compute Convert Discuss Estimate Extrapolate Generalize Predict	Solve Use Add Calculate Change Classify Complete Compute Discover Divide Examine Graph Interpolate Manipulate Modify Operate Subtract	Breakdown Combine Detect Diagram Discriminate Illustrate Outline Point out Separate	Measure Rank Rate Support Test	Produce Role Play Drive Devise Generate Integrate Prescribe Propose Reconstruct Revise Rewrite Transform



Interdisciplinary Connections

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

MA.S-ID.A.1	Represent data with plots on the real number line (dot plots, histograms, and box plots).
MA.K-12.2	Reason abstractly and quantitatively.
MA.A-SSE.A.1	Interpret expressions that represent a quantity in terms of its context.
MA.K-12.4	Model with mathematics.
MA.A-SSE.B.3	Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression.
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.
MA.F-IF.C.7	Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases.
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.11-12.7	Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.
MA.A-CED.A.1	Create equations and inequalities in one variable and use them to solve problems.
MA.A-CED.A.2	Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales.
MA.A-CED.A.4	Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations.
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.WHST.11-12.8	Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation.
LA.WHST.11-12.9	Draw evidence from informational texts to support analysis, reflection, and research.
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: