UNIT 2: Mechanics

Content Area: **Science**
Course(s): **IB physics, SL**
Time Period: **First Marking Period**
Length: **22 hours**
Status: **Published**

Unit Overview

The ideas of motion are fundamental to many areas of physics, providing a link to the consideration of forces and their implication. The kinematic equations for uniform acceleration were developed through careful observations of the natural world. Classical physics requires a force to change a state of motion, as suggested by Newton in his laws of motion. The fundamental concept of energy lays the basis upon which much of science is built. Conservation of momentum is an example of a law that is never violated.

STAGE 1- DESIRED RESULTS

2020 New Jersey Student Learning Standards- Science

SCI.9-12.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 motion of particles (objects) and energy associated with the relative position of particles (objects).
SCI.9-12.HS-PS2	Motion and Stability: Forces and Interactions
SCI.9-12.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.9-12.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.9-12.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.
SCI.9-12.HS-PS3-3	Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.

Science and Engineering Practices

- Analyzing and Interpreting Data
- Asking Questions and Defining Problems

- Constructing Explanations and Designing Solutions
- Developing and Using Models
- Engaging in Argument from Evidence
- Obtaining, Evaluating, and Communicating Information
- Planning and Carrying Out Information
- Using Mathematics and Computational Thinking

Cross Cutting Concepts

Cause and Effect

Systems and System Models

- Cause and Effect
- Energy and Matter
- Influence of Engineering, Technology, and Science on Society and the Natural World
- Interdependence of Science, Engineering, and Technology
- Patterns
- Scale, Proportion, and Quantity
- Stability and Change
- Structure and Functions
- Systems and System Models

Disciplinary Core Ideas

PS2 A: Forces and Motion

PS3 A: Definitions of Energy

Physical Sciences

- PS1A: Structure and Properties of Matter
- PS1B: Chemical Reactions
- PS1C: Nuclear Processes
- PS2A: Forces and Motion
- PS2B: Types of Interaction
- PS3A: Definitions of Energy
- PS3B: Conservation of Energy and Energy Transfer
- PS3C: Relationship Between Energy and Forces
- PS3D: Energy in Chemical Processes and Everyday Life
- PS4A: Wave Properties
- PS4B: Electromagnetic Radiation
- PS4C: Information Technologies and Instrumentation

Earth and Space Sciences

- ESS1A: The Universe and its Stars
- ESS1B: Earth and the Solar System
- ESS1C: The History of Planet Earth
- ESS2A: Earth Materials and Systems
- ESS2B: Plate Tectonics and Large-Scale Systems
- ESS2C: The Role of Water in Earth's Surface Processes
- ESS2D: Weather and Climate
- ESS2E: Biogeology
- ESS3A: Natural Resources
- ESS3B: Natural Hazards
- ESS3C: Human Impacts on Earth Systems
- ESS3D: Global Climate Change

Engineering. Technology. and Applications of Science

- ETS1A: Defining and Delimiting an Engineering Problem
- ETS1B: Developing Possible Solutioins
- ETS1C: Optimizing the Design Solution

Essential Questions

- How can an object's motion and change in motion be represented physically, graphically, and mathematically?
- How are Newton's laws of motion applied to describe the motion of an object or system?
- How can an object's momentum be represented graphically and mathematically?
- How does work done on a system affect the total energy of the system?

Enduring Understanding

Motion may be described and analyzed by the use of graphs and equations. Classical physics requires a force to change a state of motion, as suggested by Newton in his Laws of Motion. The fundamental concept of energy lays the basis upon which much of science is built. Conservation of momentum is an example of a law that is never violated.

Students will know…

- Distance and displacement
- Speed and velocity
- Acceleration
- Graphs describing motion
- Equations of motion for uniform acceleration
- Projectile motion
- Fluid resistance and terminal speed
- Objects as point particles
- Free-body diagrams
- Translational equilibrium
- Newton’s laws of motion
- Solid friction
- Kinetic energy
- Gravitational potential energy
- Elastic potential energy
- Work done as energy transfer
- Power as rate of energy transfer
- Principle of conservation of energy
- Efficiency
- Newton’s second law expressed in terms of rate of change of momentum
- Impulse and force–time graphs
- Conservation of linear momentum
- Elastic collisions, inelastic collisions and explosion

Possible Misconceptions

A force is needed to keep an object moving with a constant speed.

If an object is at rest, no forces are acting on the object.

Large objects exert a greater force than small objects.

Velocity is another word for speed. An object's speed and velocity are always the same.

Students will be able to...

- Determine instantaneous and average values for velocity, speed and acceleration.
- Solve problems using equations of motion for uniform acceleration.
- Sketch and interpret motion graphs.
- Determine the acceleration of free-fall experimentally.
- Analyze projectile motion, including the resolution of vertical and horizontal components of acceleration, velocity and displacement.
- Qualitatively describe the effect of fluid resistance on falling objects or projectiles, including reaching terminal speed.
- Represent forces as vectors.
- Sketch and interpret free-body diagrams.
- Describe the consequences of Newton's first law for translational equilibrium.
- Use Newton's second law quantitatively and qualitatively.
- Identify force pairs in the context of Newton's third law.
- Solve problems involving forces and determine resultant force.
- Describe solid friction (static and dynamic) by coefficients of friction.
- Discuss the conservation of total energy within energy transformations.
- Sketch and interpret force–distance graphs.
- Determine work done including cases where a resistive force acts.
- Solve problems involving power.
- Quantitatively describe efficiency in energy transfers.
- Apply conservation of momentum in simple isolated systems including (but not limited to) collisions, explosions, or water jets.
- Use Newton's second law quantitatively and qualitatively in cases where mass is not constant.
- Sketch and interpret force–time graphs.
- Determine impulse in various contexts including (but not limited to) car safety and sports.
- Qualitatively and quantitatively compare situations involving elastic collisions, inelastic collisions and explosions.

STAGE 2- EVIDENCE OF LEARNING

Lab reports

Question and Answer

Quizzes

Unit Test

Formative Assessment

- 3- Minute Pause
- A-B-C Summaries
- Analogy Prompt
- Choral Response
- Debriefing
- Exit Card / Ticket
- Hand Signals
- Idea Spinner
- Index Card Summaries
- Inside-Outside Circle Discussion (Fishbowl)
- Journal Entry
- Misconception Check
- Observation
- One Minute Essay
- One Word Summary
- Portfolio Check
- Questions & Answers
- Quiz
- Self-Assessment
- Student Conference
- Think-Pair-Share
- Web or Concept Map

Authentic Assessments

Worksheets on: Equations of motion for uniform acceleration, projectile motion, forces and resultant force, friction, work,energy, power, efficiency, law of conservation of momentum, elastic and inelastic collisions.

Lab Activity: Determine the acceleration of free fall

Investigate motion on slopes

Investigate friction

Quizzes

Benchmark Assessments

Unit Test

STAGE 3- LEARNING PLAN

Instructional Map

- Students will be given the details of the learning outcome of the unit in the beginning of the unit. Every day at the beginning of the class, expected questions/goal will be written on the board.
- Ask students to list real life examples that demonstrate each of Newton's Laws of Motion.
- Encourage students to illustrate these examples and concepts using free-body diagrams.
- Explain how Newton's second law relates force, mass, and acceleration.
- Ask students to define friction in their own words and share their responses with the class.
- Calculations will be restricted to those neglecting air resistance.
- Projectile motion will only involve problems using a constant value of *g* close to the surface of the Earth.
- The equation of the path of a projectile will not be required.
- Students should label forces using commonly accepted names or symbols (for example: *weight* or *force of gravity* or *mg*).
- Free-body diagrams should show scaled vector lengths acting from the point of application.
- Examples and questions will be limited to constant mass.
- *mg* should be identified as weight.
- Calculations relating to the determination of resultant forces will be restricted to one- and two-dimensional situations.
- Let students recognize that the amount of force that does work on an object depends on the angle

between the force on and the displacement of the object.
- Cases where the line of action of the force and the displacement are not parallel should be considered.
- Examples should include force–distance graphs for variable forces.
- Students should be aware that $F = ma$ is equivalent to $F = \Delta p / \Delta t$ only when mass is constant.
- Solving simultaneous equations involving conservation of momentum and energy in collisions will not be required.
- Calculations relating to collisions and explosions will be restricted to one-dimensional situations.
- A comparison between energy involved in inelastic collisions (in which kinetic energy is not conserved) and the conservation of (total) energy should be made.
- Discuss how work and energy are related to bungee jumping.
- Have students use the power formula, $P = Fv$, to calculate the maximum force that a car with a 185-horsepower engine can apply at different speeds.

Lab work

Experiments, including use of data logging,

determination of *g*,

estimating speed using travel timetables, analyzing projectile motion,

investigating motion through a fluid,

verification of Newton's second law,

investigating forces in equilibrium;

determination of the effects of friction,

relationship of kinetic and gravitational potential energy for a falling mass;

power and efficiency of mechanical objects;

comparison of different situations involving elastic potential energy;

analysis of collisions with respect to energy transfer;

investigate elastic and inelastic collisions.

Phet simulation

Modification/Differentiation of Instruction

Differentiation Strategies for Special Education Students

- Remove unnecessary material, words, etc., that can distract from the content

- Use of off-grade level materials
- Provide appropriate scaffolding
- Limit the number of steps required for completion
- Time allowed
- Level of independence required
- Tiered centers, assignments, lessons, or products
- Provide appropriate leveled reading materials
- Deliver the content in “chunks”
- Varied texts and supplementary materials
- Use technology, if available and appropriate
- Varied homework and products
- Varied questioning strategies
- Provide background knowledge
- Define key vocabulary, multiple-meaning words, and figurative language.
- Use audio and visual supports, if available and appropriate
- Provide multiple learning opportunities to reinforce key concepts and vocabulary
- Meet with small groups to reteach idea/skill
- Provide cross-content application of concepts
- Ability to work at their own pace
- Present ideas using auditory, visual, kinesthetic, & tactile means
- Provide graphic organizers and/or highlighted materials
- Strategy and flexible groups based on formative assessment
- Differentiated checklists and rubrics, if available and appropriate

<u>Differentiation Strategies for Gifted and Talented Students</u>

- Increase the level of complexity
- Decrease scaffolding
- Variety of finished products
- Allow for greater independence
- Learning stations, interest groups
- Varied texts and supplementary materials
- Use of technology
- Flexibility in assignments
- Varied questioning strategies
- Encourage research
- Strategy and flexible groups based on formative assessment or student choice
- Acceleration within a unit of study
- Exposure to more advanced or complex concepts, abstractions, and materials
- Encourage students to move through content areas at their own pace
- After mastery of a unit, provide students with more advanced learning activities, not more of the same activity
- Present information using a thematic, broad-based, and integrative content, rather than just single-subject areas

Differentiated Strategies for ELL Students

- Remove unnecessary materials, words, etc., that can distract from the content
- Provide appropriate scaffolding
- Limit the number of steps required for completion
- Gradually increase the level of independence required
- Tiered centers, assignments, lessons, or products
- Provide appropriate leveled reading materials
- Deliver the content in “chunks”
- Varied texts and supplementary materials, including visuals
- Use technology, if available and appropriate
- Differentiate homework and products
- Varied questioning strategies
- Provide background knowledge
- Define key vocabulary, multiple-meaning words, and figurative language.
- Use audio and visual supports, if available and appropriate
- Provide multiple learning opportunities to reinforce key concepts and vocabulary
- Meet with small groups to reteach idea/skill
- Provide cross-content application of concepts
- Allow students to work at their own pace
- Presenting ideas through auditory, visual, kinesthetic, & tactile means
- Role play
- Provide graphic organizers, highlighted materials
- Strategy and flexible groups based on formative assessment

Differentiation Strategies for At Risk Students

- Remove unnecessary materials, words, etc., that can distract from the content
- Provide appropriate scaffolding
- Limit the number of steps required for completion
- Gradually increase the level of independence required
- Tiered centers, assignments, lessons, or products
- Provide appropriate leveled reading materials
- Deliver the content in “chunks”
- Varied texts and supplementary materials
- Use technology, if available and appropriate
- Differentiate homework and products
- Varied questioning strategies
- Provide background knowledge
- Define key vocabulary, multiple-meaning words, and figurative language

- Use audio and visual supports, if available and appropriate
- Provide multiple learning opportunities to reinforce key concepts and vocabulary
- Meet with small groups to reteach idea/skill
- Provide cross-content application of concepts
- Presenting ideas through auditory, visual, kinesthetic, & tactile means
- Provide graphic organizers and/or highlighted materials
- Strategy and flexible groups based on formative assessment

504 Plans

Students can qualify for 504 plans if they have physical or mental impairments that affect or limit any of their abilities to:

- walk, breathe, eat, or sleep
- communicate, see, hear, or speak
- read, concentrate, think, or learn
- stand, bend, lift, or work

Examples of accommodations in 504 plans include:

- preferential seating
- extended time on tests and assignments
- reduced homework or classwork
- verbal, visual, or technology aids
- modified textbooks or audio-video materials
- behavior management support
- adjusted class schedules or grading
- verbal testing
- excused lateness, absence, or missed classwork
- pre-approved nurse's office visits and accompaniment to visits
- occupational or physical therapy

Peer Tutoring

Repeated Drill and Practice

Cooperative Grouping

Teacher notes

Use of additional reference materials

Modification Strategies

- Cooperative Grouping
- Extended Time
- Frequent Breaks
- Highlighted Text
- Interactive Notebook
- Modified Test
- Oral Directions
- Peer Tutoring
- Preferential Seating
- Re-direct
- Repeated Drill and Practice
- Shortened Assisgnment
- Teacher Notes
- Tutorials
- Use of Additional Reference Materials
- Use of Audio Resources

Differentiation Strategies

High Preparation

- Alternative Assessments
- Choice Boards
- Games and Tournaments
- Group Investigations
- Guided Reading
- Independent Research / Project
- Interest Groups
- Learning Contracts
- Leveled Rubrics
- Literature Circles
- Multiple Intelligence Options

- Multiple Texts
- Personal Agendas
- Project Based Learning (PBL)
- Stations / Centers
- Think-Tac-Toe
- Tiered Activities / Assignments
- Varying Graphic Organizers

Low Preparation

- Choice of Book / Activity
- Cubing Activities
- Exploration by Interest (using interest inventories)
- Flexible Grouping
- Goal Setting With Student
- Homework Options
- Jigsaw
- Mini Workshops to Re-teach or Extend Skills
- Open-ended Activities
- Think-Pair-Share by Readiness, Interest, or Learning Style
- Use of Collaboration
- Use of Reading Buddies
- Varied Journal Prompts
- Varied Product Choice
- Varied Supplemental Materials
- Work Alone / Together

Horizontal Intergration- Interdisciplinary Connections

See Appendix

Vertical Integration- Discipline Mapping

Physics IB SL course is offered during the Junior and Senior years of High School. At this point in their studies, students will have been exposed to the Performance Expectations of the NGSS in Middle school. This course will allow the student to further expand and develop a deeper understanding of the physics concepts taught in earlier years.

Tenth grade Chemistry

Eighth Grade - Chemical Interactions

Seventh Grade - Electromagnetic Force and Gravity and Kinetic Energy

Sixth Grade - Waves

Additional Materials

Internet resources:

Khan Academy

Physicsclassroom.com

Youtube videos

Phet.colorado.edu

http://vcephysics.com/content/

https://phet.colorado.edu/en/simulation/forces-and-motion-basics

https://phet.colorado.edu/en/simulation/forces-and-motion

https://phet.colorado.edu/en/simulation/mass-spring-lab

https://phet.colorado.edu/en/simulation/energy-skate-park-basics

https://phet.colorado.edu/en/simulation/energy-skate-park

https://phet.colorado.edu/en/simulation/collision-lab

https://phet.colorado.edu/en/simulation/friction

https://phet.colorado.edu/en/simulation/projectile-motion

https://phet.colorado.edu/en/simulation/gravity-force-lab

https://phet.colorado.edu/en/simulation/gravity-and-orbits