# UNIT 3: Thermal Physics

Content Area: **Science**
Course(s): **IB physics, SL**
Time Period: **Second Marking period**
Length: **3 Weeks**
Status: **Published**

## Unit Overview

This unit introduces the concepts of temperature, heat, internal energy and thermal equilibrium. Thermal physics deftly demonstrates the links between the macroscopic measurements essential to many scientific models with the microscopic properties that underlie these models. The properties of ideal gases allow scientists to make predictions of the behavior of real gases.

## STAGE 1- DESIRED RESULTS

### 2020 New Jersey Student Learning Standards- Science

| | |
|---|---|
| SCI.9-12.HS.E | Energy |
| SCI.9-12.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.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. |
| SCI.9-12.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.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 motions of particles (objects) and energy associated with the relative position of particles (objects). |

## 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
- 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

PS3 A: Definitions of Energy

PS3 B: Conservation of Energy and Energy Transfer

## 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

- What is the relationship between temperature and internal energy?
- Why temperature of ice does not change while melting?
- How does air within winter clothing keep you warm on cold winter days?
- Why do we sweat in summer?
- In what two ways can the internal energy of a system be increased?
- What are the key characteristics of gas pressure?
- How are the concepts of moles and molar mass useful when measuring quantities of matter?

## Enduring Understanding

Our perception of hot or cold is related to differences in temperature (average kinetic energy), but also to the capacity of substances to soak up energy in rotations, internal vibrations and bond stretching (specific heat capacity).

## Students will know...

- Molecular theory of solids, liquids and gases
- Temperature and absolute temperature
- Internal energy
- Specific heat capacity
- Phase change
- Specific latent heat
- Pressure
- Equation of state for an ideal gas
- Kinetic model of an ideal gas
- Mole, molar mass and the Avogadro constant
- Differences between real and ideal gases

**Possible Misconceptions**

The temperature of an object depends on its size.

A cold body contains no heat.

Different materials hold the same amount of heat.

## Students will be able to...

- Describe temperature change in terms of internal energy.
- Use Kelvin and Celsius temperature scales and converting between them.
- Apply the calorimetric techniques of specific heat capacity or specific latent heat experimentally.
- Describe phase change in terms of molecular behavior.
- Sketch and interpret phase change graphs.
- Calculate energy changes involving specific heat capacity and specific latent heat of fusion and vaporization.
- Solve problems using the equation of state for an ideal gas and gas laws.
- Sketch and interpret changes of state of an ideal gas on pressure–volume, pressure–temperature and volume–temperature diagrams.
- Investigate at least one gas law experimentally.

## STAGE 2- EVIDENCE OF LEARNING

## Formative Assessment

Observation

Homework

Class participation

Journal entry

Questions and answers

- 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

Sketch and interpret graphs: Phase change graphs, Changes of state of an ideal gas on P-V, P-T and V-T diagrams

**Worksheets on** Specific heat capacity and latent heat. Equation of state for an ideal gas and gas laws

**Lab Activity -** Calorimetric techniques of specific heat capacity and latent heat.

Investigating at least one gas law.

Quizzes and tests

## Benchmark Assessments

Unit Test

Past IB 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.
- Have students make idea maps for heat, temperature, and thermal energy. Encourage students to add to and modify these maps as they progress through the chapter.
- Internal energy is taken to be the total intermolecular potential energy + the total random kinetic energy of the molecules.
- Explain how the specific heat capacity of a substance affects its response to heat.
- Identify the principles of calorimetry.
- Students will use the principle of thermal equilibrium to determine the specific heats of metals. They will also determine the composition of an unknown substance.
- Challenge students to explain in terms of specific heat capacity why a pond might be warmer in October than it is in July, even though the weather is much warmer in July.
- Explain how evaporation cools a surface.
- Define latent heat and describe what happens to the temperature of a system as it undergoes a phase change.

- Phase change graphs may have axes of temperature versus time or temperature versus energy.
- The effects of cooling should be understood qualitatively but cooling correction calculations are not required.
- Use beads in a jar to model how gas particles exert force on the walls of a container.
- Calculate the pressure of a gas using the ideal gas law and describe how changing different factors changes the pressure of a gas.
- Explain how molar mass relates the number of particles in a sample to the mass of the sample.
- Students should be aware of the assumptions that underpin the molecular kinetic theory of ideal gases.
- Gas laws are limited to constant volume, constant temperature, constant pressure and the ideal gas law.
- Students should understand that a real gas approximates to an ideal gas at conditions of low pressure, moderate temperature and low density.

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    - Lab work on power of heater , specific latent heat of fusion ice, specific heat capacity of copper etc.
        - transfer of energy due to temperature difference; calorimetric investigations;
        - energy involved in phase changes;
        - verification of gas laws;
        - calculation of the Avogadro constant;
        - virtual investigation of gas law parameters not possible within a school laboratory setting.

## 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

Differentiation Strategies for Gifted and Talented Students

- 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

Nineth Grade Biology

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://www.pbs.org/wgbh/nova/physics/sense-of-scale-absolute-zero.html

http://www.tutorvista.com/physics/animations/change-of-state-and-specific-latent-heat-animation

http://phet.colorado.edu/en/simulation/gas-properties

gas laws animated tutorials