DREYFOUS

Subject Guide

PHYSICS
Dreyfous

TABLE OF CONTENTS

Course Description

The Dreyfous Secondary Level Science series offers courses in which students are able to appreciate science as part of their daily lives and not simply as a school subject that is unrelated to them or their environment. The usefulness and application of scientific concepts become evident throughout these lessons. The series features an interdisciplinary approach based on projects and research that demonstrates how the topics are integrated and work together in real life. This series seeks to develop evaluative, research, and problem-solving skills by adopting the 4Cs of 21st-century education: *Creativity, Collaboration, Critical Thinking, and Communication*.

Each course in the series provides for the development of a group project, which will be worked on as the lessons advance and will connect the topics studied to the real world. Special sections will also be introduced to help students appreciate the integration and usefulness of science in the real world. Each lesson includes *supplementary documents* that will be helpful to both the teacher and the students to work on the unit lessons. These documents consist of a descriptive log, vocabulary, worksheets containing concept and application exercises along with their answer keys, laboratories, and study guide. Finally, suggested links to online resources are included in order to expand the content and provide fun facts related to the topics being studied.

Course Framework

The Physics course comprises eight units carefully structured into different lessons. The number of lessons per unit varies depending on the scope and depth with which the different topics are discussed and developed. Each lesson contains an interactive presentation that outlines and explains the content of the topic to be studied. Each presentation includes concept definitions, specific examples, explanations, and multiple examples and applications of concepts, as well as daily life skills.

Each unit begins with a section titled *Superphysics*, which acts as the unit's opening. This section can be found in the first lesson of each unit. It introduces everyday situations or issues related to the main topic of the unit under study. In addition to introducing the topic at hand, this section is intended to guide students through the process of creating their group project. For this project, students will create a *comic book* featuring a new superhero whose powers will be applications of physics to real life. Students will work on the comic book throughout the course

and present it at the end. The teacher may use different teaching strategies to guide students in the development of this project.

This is followed by a short introductory activity titled *Explore and Learn*. The main objective of this activity is to explore the students' prior knowledge about the lesson's topic. The activity may be performed as a written exercise or a MiniLab. This is activity is followed by the lesson content, presented in the form of text, diagrams, examples, animations, interactive activities, and videos, among others. Following the content is the *Laboratory*, which supplements the conceptualization process.

Finally, the lesson closes with one of the following special sections:

Myth or Reality? – Activity, demonstration or video testing people's beliefs regarding everyday physics phenomena. It is recommended that students design an activity to test the myth.

Techno-Physics – Shows a video or text article about commonly used technological applications related to the topic studied in the lesson, as well as a brief follow-up activity.

Science Connections – Shows videos or texts that demonstrate how the topic studied in the lesson is integrated with other sciences.

Lessons also include two worksheets: *I Understand!* and *Applying What I Know*. These worksheets reinforce the concepts studied in each lesson. The activities are varied and flexible, with the purpose of addressing the particular needs and interests of each student. Practice activities are designed to make students aware of the strengths and weaknesses in their knowledge of the content, so they can gradually take control of their own learning process. The teacher, as an integral and essential part of this process, will be responsible for stimulating, mentoring, guiding, and periodically evaluating each student's learning progress. Lessons also include a *study guide*, which presents the main ideas and the vocabulary studied, along with its definitions.

Lessons

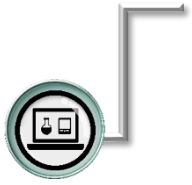
Each unit is made up of different lessons, divided into topics, macro concepts and skills. In turn, each lesson consists of five key elements: course presentation or content, digital format (PDF) documents, internet links, special sections, and a descriptive log.

- **Descriptive Log.** This is the detailed lesson plan. It includes the lesson's specific objectives, standards, and expectations, teaching strategies and resources, keywords, internet links, and references, among others. The teacher will have sole access to the lesson descriptive logs.
- **Presentation (*Lesson Content*).** Each presentation contains detailed explanations of the lesson's concepts and skills, as established by the objectives. In addition, it contains the following elements, which systematically contribute to the development of the intended learning outcomes for students:

▪ **Activity.** It includes a series of carefully selected activities to allow the student to practice the skills and concepts discussed. The Activity is designed to periodically assess the learning progress of students before moving on to other topics and skills.

▪ **Demonstration / Steps.** It features formal demonstrations of the processes to be followed in an activity or in solving a problem.

▪ **Animation.** It gives access to explanations, procedures, or graphics that provide a visual portrayal of the concepts and skills discussed in the section. It helps address the students' conceptual understanding and development.



▪ **Tabs.** These can be found on the right or left side of the presentation. Tabs can be expanded to show flowcharts, biographies, notes, photos, explanations, suggestions, reminders, or necessary background knowledge.

▪ **Photograph or image.** A particular explanation is connected to a photo or image, which will be likely accessed by internet.

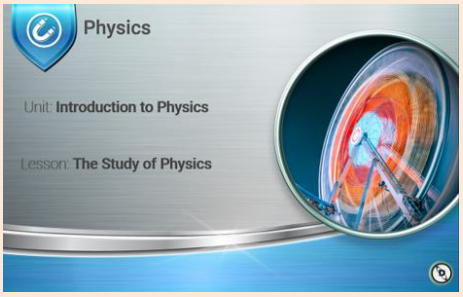
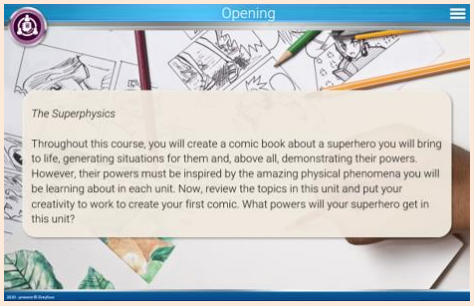
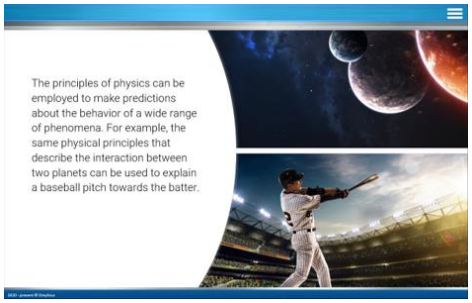
- **Video.** Access to a short video related to the topic.

- **Internet.** A direct link to a site or internet portal closely related to the topic.

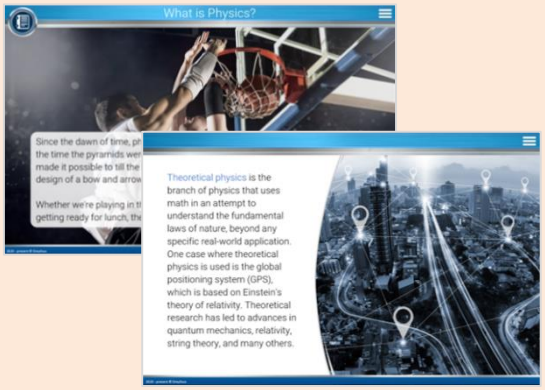
Each of the sections included in the presentation is connected to a particular identifying icon, as shown in the explanation provided. Clicking on the icon will take the presentation immediately to the specific section it represents.

- **PDF Documents.** These documents include a copy of the practice exercises, laboratories, and lesson activities. The documents may be printed out for students to work on.
- **Internet Links.** These links provide a direct connection to the internet and may be accessed directly from the presentation. They include additional explanations, examples, applications or demonstrations that facilitate the students' conceptual development in the skills and topics discussed.

Course Framework: Curricular Components

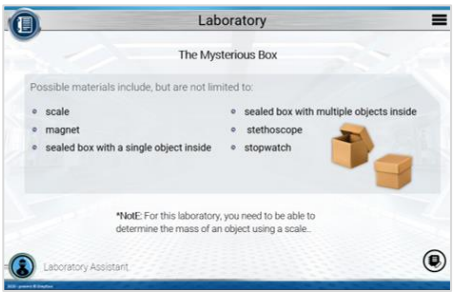
Lesson content	
Cover  	This is the introduction for the course and the lesson. It identifies the course, unit, and lesson. It contains: ○ Course title ○ Unit and lesson title ○ Image ○ Credits
Directory  	It displays the lesson sections. Each button has a hyperlink to the section it represents. From the second lesson onwards, there is no *Opening* section.
Unit Opening  	This section may only be found in the first lesson of each unit.
Explore and Learn  	This section is included in every lesson.

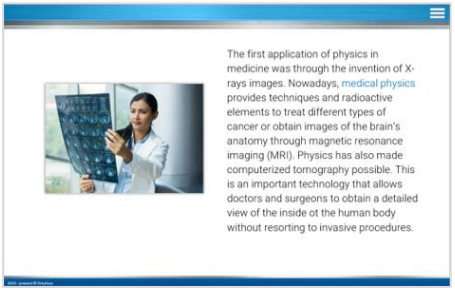
Topics (content)

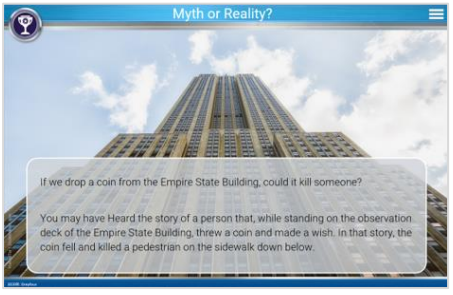


Development of the content, along with definitions, explanations, examples, and demonstrations.

Special sections





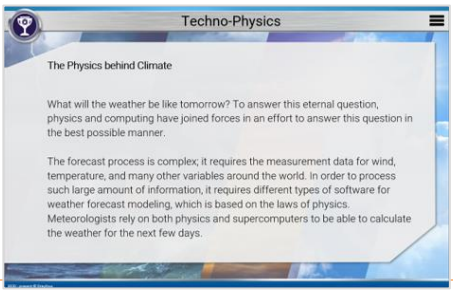


These sections expand on the students' learning experiences.

Laboratory. This laboratory activity is included to supplement the conceptualization process.

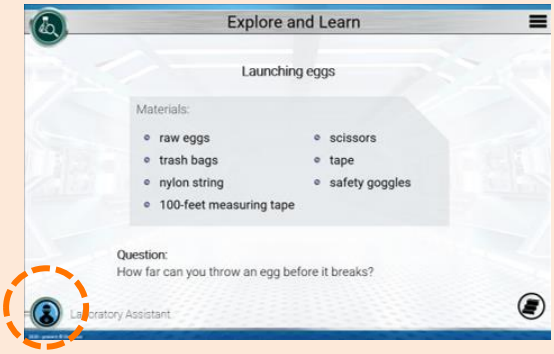
Science Connections It includes videos or text articles that show how the topic studied in the lesson is integrated with other sciences.

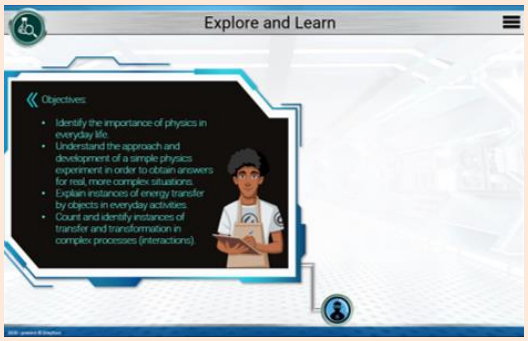
Myth or Reality? Popular beliefs regarding everyday physics phenomena are put to the test.



Techno-Physics Common technological applications related to the lesson's topic.

Laboratory Assistant





When students click on the Laboratory Assistant tab located in the lower right or left corner of some of the *Lesson Content* templates, they will be able to see important notes to complete the laboratory activities.

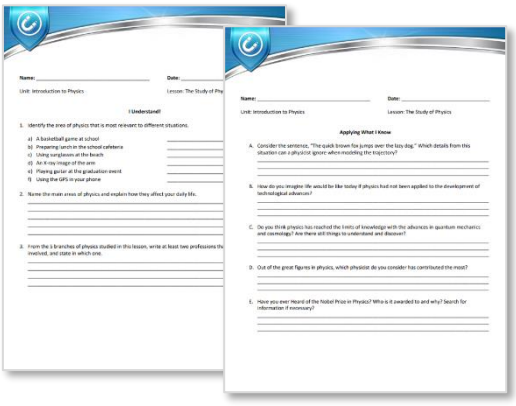
Button Directory			
Navigation			
	Close		Credits
	Slide		Back
General			
	Information		Video
	Laboratory Assistant		Review
	Reason		Image
	Group Project		Steps
	Question		Web
	Concept Map		Calculator
	Map		Music
	Objectives		Observe
 	Zoom in or out of image	 	Reading

Special sections

	Laboratory		Science Connections
	Techno-Physics		Myth or Reality?

Worksheets

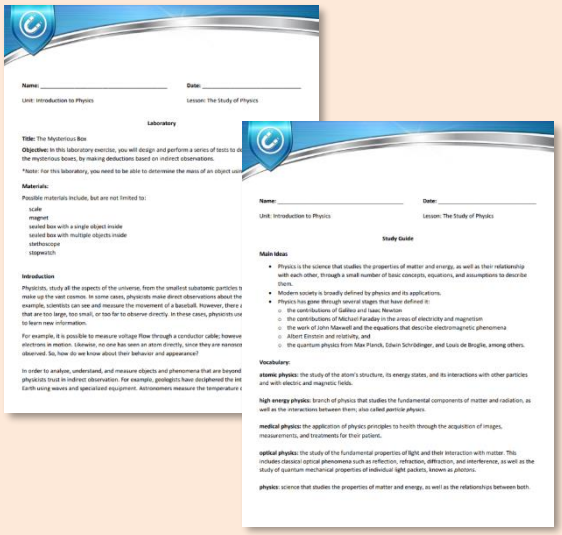
Objective Exercises



These activities are featured in every lesson, including the answer key for the teacher.

- I Understand!
- Applying What I Know

Other documents



These are included in every lesson.

- Laboratory
- Study Guide

Unit Breakdown

Below we have included a breakdown of each unit into lessons, outlining the titles of each unit, as well as the titles, codes, objectives, topics, and concepts of each lesson.

Unit 0. Introduction

At the end of this unit, the students will have accomplished the objectives established in the following lessons.

Lesson 0. Guide for the Development of Scientific Research

Code: C432G0SU00L00

Appendix

- Guide for the Development of Scientific Research

Concepts

- Science fair
- Scientific research

Lesson 1. Scientific Knowledge

Code: C432G0SU00L01

Objectives

By the end of this lesson, students will:

- identify information as either a scientific or a non-scientific fact;
- distinguish between science and pseudoscience.

Topics

- Common knowledge or scientific knowledge
- Science and pseudoscience

Concepts

- common knowledge
- empirical knowledge
- observation
- pseudoscience
- reliability
- science
- scientific knowledge
- scientific method

Lesson 2. The Scientific Method

Code: C432G0SU00L02

Objectives

By the end of this lesson, students will:

- describe the history and origin of the scientific method;
- explain the role of Galileo in the development of modern science;
- describe the characteristics of the scientific method;
- explain the steps of the scientific method;
- conduct a simple investigation following the scientific method.

Topics

- History and origin
- Definition and characteristics
- Stages

Concepts

- experimental method
- logical method
- scientific method

Lesson 3. Scientific Research

Code: C432G0SU00L03

Objectives

By the end of this lesson, students will:

- identify the most recent technological advances in the field of science;
- describe how recent technological advances have benefited scientific research;
- identify and describe examples of scientific fraud;
- distinguish reliable sources of information from unreliable ones;
- identify the different classifications into which scientific research can be grouped;
- identify the main characteristics of scientific research.

Topics

- Introduction
- Research and science
- Types of research
- Technology and mathematics
- Validity and reliability
- Scientific fraud

Concepts

- objectivity
- reliability
- research
- scientific fraud
- scientific knowledge
- validity

Lesson 4. Developing Scientific Research

Code: C432G0SU00L04

Objectives

By the end of this lesson, students will:

- identify the dependent, independent, and control variables in different research scenarios;
- identify the different steps in a scientific research;
- develop the first step of a possible scientific research.

Topics

- Stage 1: The beginning
- Stage 2: Research
- Stage 3: Finding meaning
- Stage 4: Publication

Concepts

- APA format
- challenging the hypothesis
- conclusions
- control variable
- data analysis
- dependent variable
- experimental methods
- independent variable
- rationale
- theoretical framework
- variables

Lesson 5. Practice Sheets

Code: C432G0SU00L05

Objectives

By the end of this lesson, students will:

- correctly draft a research question and hypothesis for a scientific research project;
- use questions to analyze the data represented through tables or graphs;
- reach and draft conclusions based on data analysis;
- create and draft an original experimental design for a potential formal research project.

Topics

- Research draft
- Question and hypothesis
- Hypothesis: If..., then...
- Data analysis
- Experiment

Lesson 6. Mathematics: The Language of Science

Code: C432G0SU00L06

Objectives

By the end of this lesson, students will:

- explain the importance of the International System of Units;
- mention and describe the units of the International System of Units;
- convert measurements to scientific notation;
- distinguish between accuracy and precision in measurements;
- use significant figures in measurements and calculations;
- determine the correct units to use for certain measurements.

Topics

- The International System of Units
- Prefixes of the International System of Units
- Scientific Notation
- Measurements in the experiment

Concepts

- accuracy
- ampere
- candela
- international measurement system
- kelvin
- kilogram
- meter
- mole
- precision
- prefix
- scientific notation
- significant figures

Lesson 7. Getting to Know the Science Laboratory

Code: C432G0SU00L07

Objectives

By the end of this lesson, students will:

- identify safety symbols in the laboratory and determine what they mean;
- identify the most common laboratory equipment and its uses;
- prevent accidents in the laboratory.

Topics

- Safety in the Laboratory
- Laboratory equipment and its uses

Concepts

- carcinogenic
- contamination
- corrosive
- irritating
- meniscus
- MSDS
- pollution
- radiation
- safety
- toxic

Unit 1. Introduction to Physics

At the end of this unit, the students will have accomplished the objectives established in the following lessons.

Lesson 1. The Study of Physics

Code: C432G0SU01L01

Objectives

By the end of this lesson, students will:

- describe the characteristics of physics;
- distinguish physics from the other branches of science;
- describe the importance of the study of physics for humanity;
- point out and describe the events that led to the study and development of physics;
- identify the applications of the different branches of physics in everyday life.

Topics

- What is physics?
- The importance of physics
- History of physics

Concepts

- atomic physics
- electromagnetism
- high energy physics
- mechanics
- medical physics
- optical physics
- physics
- quantum mechanics
- relativity
- theoretical physics
- thermodynamics
- vibrations and wave phenomena

Lesson 2. Measuring

Code: C432G0SU01L02

Objectives

By the end of this lesson, students will:

- explain the importance of correctly using the International System of Units in science;
- correctly use the common metric prefixes in unit conversion;
- solve mathematical operations using the correct scientific notation.

Topics

- Physical quantity and measurement
- International System of Units (SI)
- Unit conversion
- Scientific notation

Concepts

- base unit
- conversion factor method
- dimension
- International System (SI) of Units
- kilogram
- meter
- metric system
- scientific notation
- second
- unit

Lesson 3. Uncertainty in Measuring

Code: C432G0SU01L03

Objectives

By the end of this lesson, students will:

- distinguish between precision and accuracy;
- determine the precision of measured amounts with significant figures;
- perform arithmetic operations with significant figures.

Topics

- Errors
- Precision and accuracy
- Significant figures

Concepts

- accuracy
- instrument error
- mean (average)
- median
- method error
- mode
- percent error
- precision
- significant figures

Unit 2. Kinematics

At the end of this unit, the students will have accomplished the objectives established in the following lessons.

Lesson 1. Motion

Code: C432G0SU02L01

Objectives

By the end of this lesson, students will:

- use a particle model to represent particle movement;
- distinguish between speed and velocity;
- distinguish between scalar and vector quantities;
- use the process of vector decomposition to find the vector components;
- establish and use a graph to represent the sum of two vectors.

Topics

- Particles
- Coordinate system
- One-dimensional vectors
- Speed and velocity

Concepts

- coordinate system
- direction
- displacement
- frame of reference
- magnitude
- motion
- motion diagram
- particle model
- scalar
- speed
- vector
- velocity

Lesson 2. One-Dimensional Motion

Code: C432G0SU02L02

Objectives

By the end of this lesson, students will:

- compare and contrast the concepts of *velocity* and *acceleration*;
- solve velocity and acceleration problems using equations of motion;
- describe the meaning of gravitational acceleration;
- define the magnitude of gravitational acceleration as a positive quantity and establish the sign of acceleration within the chosen coordinates system;
- use equations of motion to solve problems that involve free-falling objects.

Topics

- Average velocity
- Instantaneous velocity
- Acceleration and constant acceleration
- Free fall

Concepts

- acceleration
- average acceleration
- average speed
- average velocity
- constant acceleration
- free fall
- instantaneous acceleration
- instantaneous velocity

Lesson 3. Graphical Analysis of Motion

Code: C432G0SU02L03

Objectives

By the end of this lesson, students will:

- create and interpret graphs featuring position vs. time for a particle in motion to determine its velocity and acceleration;
- explain and describe the information shown in the graphs;
- create a graph showing velocity vs. time, and determine the velocity of an object at a specific time;
- interpret a graph of velocity vs. time to find the time in which an object has a specific velocity;
- calculate the displacement of an object based on the area under a velocity vs. time curve.

Topics

- Uniform Motion
- Position vs. Time
- Velocity vs. Time
- Acceleration vs. time

Concepts

- uniform motion

Lesson 4. Two-Dimensional Motion

Code: C432G0SU02L04

Objectives

By the end of this lesson, students will:

- calculate the force that would produce equilibrium when three forces act on a body;
- analyze the movement of an object on an inclined plane without friction;

- recognize that a projectile's vertical and horizontal movements are independent from each other;
- draw a relationship between the height, air time, and initial vertical velocity of a projectile using its vertical motion, and then determine its range;
- explain how the trajectory of a moving object depends on the point of reference from which it is observed.

Topics

- Two-dimensional vectors
- Adding and subtracting vectors
- Projectile motion
- Relative Motion

Concepts

- parabola
- projectile motion
- Pythagorean Theorem
- relative motion
- scalar quantity
- vector quantity

Unit 3. Dynamics

At the end of this unit, the students will have accomplished the objectives established in the following lessons.

Lesson 1. Force and Newton's Laws

Code: C432G0SU03L01

Objectives

By the end of this lesson, students will:

- compare and contrast the different types of force;
- identify and provide everyday examples of Newton's laws of motion;
- describe the mathematical relation between net force applied to an object and the object's mass and acceleration;
- optimize existing designs.

Topics

- What is force?
- Newton's First Law
- Newton's second law
- Newton's Third Law
- Friction and the Inclined Plane

Concepts

- buoyancy
- dynamics
- electric force
- external force
- force
- frictional force
- gravitational force
- inclined plane
- inertia
- magnetic force
- mass
- normal force
- tension
- weight

Lesson 2. Applying Newton's Laws of Motion

Code: C432G0SU03L02

Objectives

By the end of this lesson, students will:

- describe how the weight and mass of an object are related;
- differentiate between the weight caused by the force of gravity and what is experienced as apparent weight;
- define frictional force and distinguish between static friction and kinetic friction;
- research Hooke’s law and its applications;
- calculate the coefficient of friction, friction force, mass and weight;
- analyze free body diagrams.

Topics

- Static and kinetic friction
- Weight force
- Hooke's Law

Concepts

- coefficient of friction
- dyne
- force
- Hooke's law
- kinetic friction
- mass
- static friction
- weight

Lesson 3. Circular Motion and Gravitation

Code: C432G0SU03L03

Objectives

By the end of this lesson, students will:

- explain the acceleration of an object that moves in a circular motion at a constant speed;
- describe how centripetal acceleration depends on the object's speed and the circle radius;
- recognize the direction of the force causing centripetal acceleration;
- explain how the rate of circular motion changes when torque is applied;
- establish the relation between Newton's law of gravitation and Kepler's law of planetary motion;
- use the mathematical equations for calculating centripetal acceleration, tangential velocity, mass, distance and gravitational force;
- describe Kepler’s laws both experimentally and mathematically.

Topics

- Centripetal acceleration
- Centripetal force
- Law of universal gravitation
- Kepler's laws

Concepts

- centripetal acceleration
- centripetal force
- Kepler's first law
- Kepler's second law
- Kepler's third law
- law of universal gravitation
- tangential acceleration
- uniform circular motion

Unit 4. Momentum and Circular Motion

At the end of this unit, the students will have accomplished the objectives established in the following lessons.

Lesson 1. Impulse and Linear Momentum

Code: C432G0SU04L01

Objectives

By the end of this lesson, students will:

- compare a system of particles before and after an event in momentum exercises;
- determine the momentum of an object;
- determine the impulse applied to an object;
- use the impulse-momentum theorem to calculate mass, initial velocity and final velocity.

Topics

- Momentum and impulse
- Elastic and inelastic collisions

Concepts

- elastic collision
- impulse
- impulse-momentum theorem
- inelastic collision
- linear momentum
- momentum

Lesson 2. Description of Rotational Motion

Code: C432G0SU04L02

Objectives

By the end of this lesson, students will:

- distinguish between angular velocity and angular acceleration;
- use equations to calculate angular acceleration, angular velocity, angular displacement, tangential velocity, linear velocity, or time;
- describe the relationship between the velocity of an object in circular motion, the circle's radius, and the centripetal acceleration.

Topics

- Angular displacement
- Angular velocity
- Angular acceleration
- Rotational kinematics

Concepts

- angular acceleration
- angular displacement
- angular velocity
- linear velocity
- radian
- tangential velocity

Lesson 3. Torque and Angular Momentum

Code: C432G0SU04L03

Objectives

By the end of this lesson, students will:

- compare and contrast angular momentum and linear momentum;
- explain how circular motion is affected by torque;
- calculate the moment of inertia, torque, angular momentum and angular acceleration;
- describe the angular impulse-angular momentum theorem.

Topics

- Torque
- Inertia and Newton's second law
- Angular momentum and Lineal momentum

Concepts

- angular momentum
- lever arm
- moment of inertia
- rolling motion
- torque

Unit 5. Energy

At the end of this unit, the students will have accomplished the objectives established in the following lessons.

Lesson 1. The Different Forms of Energy

Code: C432G0SU05L01

Objectives

By the end of this lesson, students will:

- define the concept of energy from the atomic to the macroscopic scale;
- describe the different types of energy that exist, specify their uses and sources, and classify them into either kinetic or potential;
- compare and contrast the different types of energy;
- use the formula for work to calculate distance, mass, force or work.

Topics

- What is energy?
- Types of energy
- Uses and sources

Concepts

- chemical energy
- electromagnetic energy
- energy
- gravitational energy
- kinetic energy
- mechanical energy
- nuclear energy
- potential energy
- sonic energy
- theorem
- thermal energy
- work

Lesson 2. Energy and Work

Code: C432G0SU05L02

Objectives

By the end of this lesson, students will:

- describe the relation between work and energy;
- demonstrate their ability to calculate the work performed by a force;
- identify the force that performs the work;
- establish the difference between work and power, and calculate the power used;
- create a model that illustrates the relation between work and energy;
- calculate the kinetic energy of an object in motion.

Topics

- Potential energy
- Kinetic energy
- The work-energy theorem

Concepts

- elastic potential energy
- gravitational potential energy
- kinetic energy
- work-energy theorem

Lesson 3. Types of Machines

Code: C432G0SU05L03

Objectives

By the end of this lesson, students will:

- use the concepts of force and motion to explain how simple machines are useful or solve everyday problems;
- explain the mechanical advantage in ideal and real machines;
- analyze compound machines and describe them in terms of simple machines;
- calculate the work done by a machine;
- classify the machines that surround them;
- calculate the efficiencies for simple and compound machines.

Topics

- Simple machines
- Compound machines

Concepts

- compound machine
- efficiency
- inclined plane
- lever
- mechanical advantage (MA)
- pulley
- screw
- simple machine
- wedge
- wheel and axle

Lesson 4. Conservation of Energy

Code: C432G0SU05L04

Objectives

By the end of this lesson, students will:

- describe the principle of conservation of energy;
- solve problems using of the principle of conservation of energy;
- analyze collisions to establish changes in kinetic energy;
- create a prototype of a machine.

Topics

- The principle of conservation of energy and its applications

Concepts

- conservation
- conservation of energy
- mechanical energy

Lesson 5. Thermodynamics

Code: C432G0SU05L05

Objectives

By the end of this lesson, students will:

- explain the relation between work and heat;
- describe the nature of thermal energy;
- define the concept of temperature and distinguish it from thermal energy;
- use the Celsius and Kelvin temperature scales and convert one into the other;
- define the concept of specific heat and calculate heat transfer;
- describe the laws of thermodynamics;
- define the concepts of heat engine, cooler, and heat pump;
- define the concept of entropy;
- use the second law of thermodynamics to explain what happens when two components with different temperatures are combined within a closed system.

Topics

- Basic concepts
- The laws of thermodynamics
- Machines and thermal efficiency

Concepts

- Celsius scale
- entropy
- external combustion engine
- Fahrenheit scale
- first law of thermodynamics
- heat
- internal combustion engine
- Kelvin scale
- second law of thermodynamics
- temperature
- thermal efficiency
- thermometer
- third law of thermodynamics
- zeroth law of thermodynamics

Lesson 6. The Solid State

Code: C432G0SU05L06

Objectives

By the end of this lesson, students will:

- describe solids, liquids, gases, and plasma at a microscopic level, and draw a relationship between their properties and their structures;

- explain why solids expand and contract when the temperature changes;
- calculate the expansion of solids and analyze the problems caused by this expansion;
- analyze the effect of temperature on matter;
- build a system model of thermal expansion.

Topics

- States of matter
- Thermal expansion

Concepts

- boiling point
- Bose-Einstein condensate
- coefficient of thermal expansion
- condensation
- deposition
- evaporation
- freezing point
- isotropic
- linear expansion
- matter
- melting point
- plasma
- sublimation
- superficial expansion
- triple point
- volumetric expansion

Lesson 7. Fluids

Code: C432G0SU05L07

Objectives

By the end of this lesson, students will:

- describe and distinguish between hydrostatics and hydrodynamics;
- describe how fluids create pressure and link the Pascal principle to everyday events;
- apply the principles of Archimedes and Bernoulli;
- calculate the buoyancy, area, pressure, volume and weight of a fluid;
- explain how the forces within liquids cause surface tension and capillary action;
- explain the relation between the kinetic model and evaporation and condensation.

Topics

- Fluids at rest
- Fluids in motion

Concepts

- Archimedes' principle
- Bernoulli's principle
- density
- fluid
- Pascal's principle
- pressure
- volumetric flow

Unit 6. Electricity and Magnetism

At the end of this unit, the students will have accomplished the objectives established in the following lessons.

Lesson 1. Static Electricity

Code: C432G0SU06L01

Objectives

By the end of this lesson, students will:

- explain the relationship between forces and charges;
- describe how an electroscope detects electrical charge;
- recognize that charged objects exert forces, both of attraction and repulsion;
- demonstrate that the charge is the separation—not the creation—of electric charges;
- describe the differences between conductors and insulators and provide examples for each one;
- determine the value of an electric charge and an electric force;
- explain how to charge by conduction and by induction;
- use Coulomb's law to solve problems related to electric force;
- develop a model to describe the way in which charged objects can attract a neutral object.

Topics

- Electric charges
- Conductors and insulators
- Electric forces

Concepts

- conductor
- Coulomb's law
- electric charge
- electric dipole
- electron
- insulator
- neutron
- polarization
- proton
- superposition principle

Lesson 2. Electric Fields

Code: C432G0SU06L02

Objectives

By the end of this lesson, students will:

- define and measure an electric field;
- solve problems related to charge, electric fields, and forces;
- diagram electric field lines;
- calculate the magnitude and direction of an electric field, capacitance, change in potential energy and kinetic energy;

- define the term electric potential and solve related problems;
- determine where the charges reside in solids and in hollow conductors;
- describe the capacity of capacitors (condensers) and solve related problems.

Topics

- Electric field and electric potential
- Capacitance

Concepts

- capacitance
- capacitor
- dielectric
- electric field
- electric field line
- electric potential
- electric potential energy
- farad

Lesson 3. Currents and Circuits

Code: C432G0SU06L03

Objectives

By the end of this lesson, students will:

- define an electric current and the ampere;
- describe the conditions that determine the current in an electric circuit;
- draw circuits and describe closed loops;
- create a series circuit and a parallel circuit;
- establish the power in electric circuits;
- use Ohm’s law to calculate the resistance and the voltage in a circuit;
- define the concept of resistance;
- describe Ohm’s law;
- describe Watt’s law;
- identify and describe examples where different types of circuits are used.

Topics

- Electric current
- Resistance and Ohm's law
- Series circuits
- Parallel circuits
- Combined circuits
- Generation and Transfer of Electric Energy

Concepts

- combination circuit
- electric current
- electric power
- electromotive force
- kilowatt-hour
- Ohm’s law
- parallel circuit
- resistance
- series circuit
- Watt’s law

Lesson 4. Magnetism

Code: C432G0SU06L04

Objectives

By the end of this lesson, students will:

- describe the properties of magnets and the origin of magnetism in materials;
- identify commonly used magnetic materials;
- describe Weber's theory;
- classify magnets according to their characteristics.

Topics

- Magnets
- Theory of magnetism
- Magnetic materials

Concepts

- Bohr magneton
- diamagnetism
- ferromagnetism
- magnet
- magnetism
- paramagnetic
- spin
- Weber's theory

Lesson 5. Magnetic Fields and the Earth

Code: C432G0SU06L05

Objectives

By the end of this lesson, students will:

- compare different types of magnetic fields;
- relate magnetic induction with the direction and sense of a force on a live wire in a magnetic field;
- solve problems involving the intensity of the magnetic field and the forces on live wires and on charged moving particles within magnetic fields;
- describe the importance of Johann Karl, Friedrich Gauss, and William Gilbert in the study of Earth's magnetism;
- explain the behavior of Earth's magnetic field over time and the phenomena related to Earth's magnetism.

Topics

- Magnetic Fields and Flows
- Terrestrial Magnetism

Concepts

- geomagnetic field
- magnetic declination
- magnetic field
- magnetosphere
- right-hand rule

Lesson 6. Electromagnetic Induction

Code: C432G0SU06L06

Objectives

By the end of this lesson, students will:

- explain how a variable magnetic field produces an electric current;
- define the concept of electromotive force (EMF);
- solve electromotive induction problems;
- describe how an electric generator works and how it differs from an engine;
- recognize the difference between peak voltage and current and effective voltage and current;
- use Lenz's law to explain electromotive force (EMF) and how it affects the operation of engines and generators;
- explain the nature of self-inductance and its effect on circuits;
- describe the design and operation of an electric engine;
- describe the function of a transformer;
- solve problems with voltage, current, and turns ratio.

Topics

- Current Induction and Applications
- Faraday's Law
- Electric Motors

Concepts

- electromagnetic induction
- generator
- incremental transformer
- magnetic flux
- reducing transformer
- transformer

Unit 7. Waves: Light and Sound

At the end of this unit, the students will have accomplished the objectives established in the following lessons.

Lesson 1. Wave Properties and Behavior

Code: C432G0SU07L01

Objectives

By the end of this lesson, students will:

- describe and create diagrams of examples of oscillatory and periodic motion;
- identify how waves transfer energy without transferring matter;
- contrast transversal waves and longitudinal waves;
- calculate the acceleration, length and frequency of a wave;
- relate the wave velocity with the medium through which it travels;
- identify the types of waves according to their medium of travel.

Topics

- Simple harmonic motion and pendulums
- Resonance
- Types of waves

Concepts

- electromagnetic waves
- frequency
- gravitational waves
- longitudinal wave
- pendulum
- period
- resonance
- simple harmonic motion
- tone
- transverse wave
- wave

Lesson 2. Sound

Code: C432G0SU07L02

Objectives

By the end of this lesson, students will:

- demonstrate knowledge about the nature of sound waves;
- identify the properties that sound shares with other waves;
- solve problems related to frequency, wavelength, and speed of sound;
- establish the relationship between the physical properties of sound waves and the way we perceive sound;
- define the Doppler effect and identify some of its applications;
- describe the origin of the sound.

Topics

- Perception
- Acoustic Waves
- Doppler effect
- Resonance

Concepts

- Doppler effect
- hearing
- p waves
- rarefaction
- s waves
- tone
- wavelength

Lesson 3. Light

Code: C432G0SU07L03

Objectives

By the end of this lesson, students will:

- recognize that light is the visible part of the full range of electromagnetic frequencies;
- describe the light spectrum model;
- solve problems that involve the speed of light;
- calculate the angle and refractive index;
- explain the law of reflection and provide examples;
- distinguish between reflection and diffuse reflection providing examples;
- explain total internal reflection;
- define critical angle;
- explain the effects caused by light refraction in a medium with varying refractive indexes;
- explain the dispersion of light in terms of refractive index;
- analyze the properties of light;
- explain the formation of color by light and by pigments or dyes;
- describe methods of polarized light production.

Topics

- How does light behave on a boundary?
- Applications of Light Reflection and Refraction
- Snell's law
- Light and Color

Concepts

- complementary colors
- incident ray
- law of reflection
- law of refraction
- light, polarization
- primary colors
- primary pigments
- ray
- refracted ray
- refraction
- refractive index
- secondary colors
- secondary pigments
- Snell's law
- spectrum
- total internal reflection

Lesson 4. Mirrors

Code: C432G0SU07L04

Objectives

By the end of this lesson, students will:

- explain how concave, convex, and plane mirrors form images;
- locate images using ray diagrams;
- calculate the location and size of images using equations;
- explain the cause of spherical aberration and how this effect can be corrected;
- identify different types of mirrors;
- explain what mirror neurons are;
- describe the uses of parabolic mirrors.

Topics

- Plane mirrors
- Spherical mirrors

Concepts

- concave mirror
- convex mirror
- mirror
- parabolic mirror
- plane mirror
- spherical aberration

Lesson 5. Lenses

Code: C432G0SU07L05

Objectives

By the end of this lesson, students will:

- describe how convex and concave lenses form real and virtual images;
- locate the image using a ray diagram and find the location and size of the image using a mathematical model;
- define chromatic aberration and explain how it can be reduced;
- classify lenses according to their curvature;
- determine the focal length between a lens and the height of an object;
- know the uses of lens in the field of ophthalmological medicine;
- explain how optical instruments, such as telescopes and microscopes, work.

Topics

- Types of lenses
- Lens Equations
- Microscope and Telescope

Concepts

- chromatic aberrations
- concave lens
- convex lens
- lens
- microscope
- telescope

Lesson 6. Interference and Diffraction

Code: C432G0SU07L06

Objectives

By the end of this lesson, students will:

- establish a relationship between the diffraction of light and its wave characteristics;
- explain how light passing through two narrow slits produces a pattern of interference;
- calculate the focal length of the lens;
- apply geometric models to explain diffraction in single-slit and double-slit interference patterns;
- explain how diffraction gratings form interference patterns and are used in grating spectrometers;
- analyze how diffraction limits the capacity of a lens to distinguish two very close objects;
- calculate the angle of observation.

Topics

- Coherent and incoherent light
- Interference
- Diffraction

Concepts

- coherent light
- constructive interference
- destructive interference
- diffraction
- incoherent light
- interference
- phase

Unit 8. Modern Physics

At the end of this unit, the students will have accomplished the objectives established in the following lessons.

Lesson 1. Quantum Physics

Code: C432G0SU08L01

Objectives

By the end of this lesson, students will:

- describe continuous and discontinuous spectrums;
- detect alpha and beta particle residue in an experimental manner;
- describe the origin of modern physics;
- calculate the De Broglie wavelength of several particles;
- calculate the energy of a photon, wavelength and frequency;
- analyze the paradox of Schrodinger's cat;
- explain what the photoelectric effect is and how it works;
- describe experiments that demonstrate the properties of particles that have electromagnetic radiation;
- describe the evidence of the wavy nature of matter and solve problems that relate wavelength with particle momentum;
- recognize the dual nature of both waves and particles and the importance of the Heisenberg uncertainty principle.

Topics

- What is quantum physics?
- Waves behave like particles
- Particles behave like waves

Concepts

- black body
- De Broglie wavelength
- emissivity
- photons
- Planck constant
- quantum mechanics

Lesson 2. The Atom

Code: C432G0SU08L02

Objectives

By the end of this lesson, students will:

- explain the structure of the atom;
- establish the difference between the atomic models of J. Thompson, E. Rutherford and N. Bohr;

- explain the behavior of alpha particles in the E. Rutherford experiment;
- distinguish between a continuous spectrum and a line spectrum;
- differentiate the emission spectrum from the absorption spectrum;
- calculate the energy of a photon;
- calculate the wavelength of a photon in different levels of energy;
- explain the flaws of the Bohr atomic model;
- describe the quantum model of the atom.

Topics

- Bohr's atomic model
- Quantum model of the atom

Concepts

- atomic orbital
- electron spin
- radial node
- Schrödinger equation
- wave mechanics

Lesson 3. Conduction in Solids

Code: C432G0SU08L03

Objectives

By the end of this lesson, students will:

- describe the motion of electrons in conductors and semiconductors;
- identify the characteristics in direct and indirect polarization of a diode;
- experiment the conductivity of several objects;
- identify different insulators;
- create a battery using vegetables as electrolytic sources;
- describe the motion of an electron in conductors and semiconductors;
- compare and contrast n-type and p-type semiconductors;
- describe how diodes limit current motion in a single direction;
- explain how a transistor can amplify or increase voltage changes;
- identify and describe everyday examples of conduction in solids.

Topics

- Electronic devices
- Robotics

Concepts

- conductor
- crystalline solid
- diode
- insulator
- resistivity
- robotics
- semiconductors

Lesson 4. Radiation

Code: C432G0SU08L04

Objectives

By the end of this lesson, students will:

- identify patterns in radioactive particles;
- determine the number of neutrons and protons in atomic nuclei;
- describe three types of radioactive decay;
- explain the principle of solar cells;
- identify the proportional relationship between voltage values, current and temperature in an experimental manner;
- determine the radioactive period and calculate the amount of material and its residual activity after a given number of radioactive periods.

Topics

- Theories
- Photoelectric effect

Concepts

- β^- decay
- β^+ decay
- Compton scattering
- photoelectric effect
- pitchblende
- radioactivity

Lesson 5. Nuclear Physics

Code: C432G0SU08L05

Objectives

By the end of this lesson, students will:

- define how radioactive isotopes can be artificially produced and used;
- complete nuclear reaction equations;
- define the concepts of nuclear fission and chain reaction and describe how they are related;
- define the liquid drop model of nuclear fission;
- describe the process of nuclear fusion;
- describe X-rays;
- establish the pros and cons of X-rays for human health;
- evaluate the effects of using radioactive materials on human health.

Topics

- Nuclear energy
- X-rays

Concepts

- critical mass
- fission
- fusion
- nucleosynthesis
- X-ray diffraction
- X-rays