LOWER CAPE MAY REGIONAL SCHOOL DISTRICT

TITLE OF COURSE: College Bound Physics

DEPARTMENT: Science **DATE REVISED: 9/2014**

GRADE: 12

I. COURSE ORGANIZATION

Length: Full year
Credits: 5

Periods per Week: There are two period lengths during the week. The shorter 42 minutes and the longer period is at least 87 minutes and held one or two times per week. **Weighted**: CB

Prerequisite: Physical Science, College Bound Chemistry, Successful completion of Algebra 2

II. COURSE DESCRIPTION; Physics is the study of matter and energy. The purpose of this course is to study classical Newtonian mechanics, the behavior of fluids, thermodynamics, waves, and provide an introduction to the study of electricity.

III. COURSE MISSION: To provide the student with an introduction to the study of matter and energy and the interactions between them.

IV. DEPARTMENT MISSION:

The primary goal of the Science Department of Lower Cape May Regional High School is to support and prepare students to lead successful lives by helping them to:

- Communicate Effectively
- Think critically and creatively
- Solve problems resourcefully
- Use technology effectively
- Work cooperatively
- Develop as self-directed learners

VI. COURSE LEVEL ASSESSMENTS & BENCH MARKS

- Students will become cognizant of the importance of the study of physical interactions and be able to predict the outcome of physical events by the application of formula and mathematical constants.

- The student will understand the relationship of past discoveries in science to present discoveries and how new studies build upon the past while sometimes completely eclipsing prior understanding.
- Students will learn to use mathematics to interpret physical behaviors. Since the focus is on application, calculators may be used freely.
- Students will participate in classroom activities that include problem solving and group work.
- Students will complete a minimum of 14 formal written laboratories during the school year

VII. POSSIBLE ASSESSMENT TASKS

Daily problem solving, written tests, formal laboratories involving group work

VIII. CONTENT/SUGGESTED INSTRUCTIONAL TIME

Quarter One

Introduction to Physics

Objectives:

Identify activities and fields that involve major areas in physics

Processes of the scientific method

The role of diagrams in physics

Basic SI units

Accuracy and Precision

Significant figures

Interpret data

Dimensional analysis

Content:

What is Physics?

Measurements

Motion in One Dimension

Objectives:

Describe motion in terms of frames of reference

Calculate displacement

Describe motion in terms of changing velocity

Apply kinematic equations to calculate distance, time, and velocity under conditions of constant acceleration

Relate the motion of a freely falling body to motion with constant acceleration

Content:

Speed and Velocity

Acceleration

Falling Objects

Two Dimensional Motion and Vectors

Objectives:

Distinguish between a scalar and a vector

Add, subtract, multiply and divide vectors

Identify appropriate coordinate systems

Apply the Pythagorean Theorem to calculate the magnitude and direction of a vector

Resolve vector into sine and cosine components
Add nonperpendicular vectors
Describe the path of a projectile as a parabola
Resolve vectors into components and apply the kinematic equations to solve problems involving parabolic motion
Describe situations in terms of frames of reference
Solve problems involving relative velocity

Content:

- Vectors
- Projectile Motion
- Relative Motion

Forces

Objectives:
Describe how a force affects an object
Interpret and construct free body diagrams
Describe the relationship between the motion of an object and the net external force acting on it
Determine net external forces
Calculate the force required to bring an object into equilibrium
Describe an object's acceleration in terms of the mass and net force acting on it
Predict the direction and magnitude caused by a net force
Identify action reaction pairs
Mass and weight
The normal force
Air resistance as a form of friction
Use coefficients of friction to calculate the frictional force
Content:

- Changes in motion
- Newton's First Law
- Newton's Second Law
- Newton's Third Law

Quarter Two

Work and Energy

Objectives:
The difference between ordinary work and scientific work
Define work as related to a force and a displacement
Identify where work is being performed
Calculate net work
Identify forms of energy
Calculate kinetic energy
Apply the work-kinetic energy theorem to solve problems
Distinguish between kinetic and potential energy
Classify different types of potential energy
Calculate potential energy related to an object's position
Relate energy, time and power

Calculate power in multiple ways
Explain the effect of machines on work and power
Content:
- Work
- Energy and Its Conservation
- Power

Momentum and Collisions

Objectives:
Compare the momentum of different moving objects
Compare the momentum of the same object moving with different velocities
Identify examples of change in the momentum of an object
Describe the changes in momentum in terms of force and time
Describe the interaction between two objects in terms of the change in momentum
Compare the total momentum of an object before and after a collision
State the Law of Conservation of Momentum
Predict final velocities after collisions given the initial velocities
Identify different types of collisions
Determine the changes in kinetic energy during perfectly inelastic collisions
Compare Conservation of Momentum with Conservation of Kinetic Energy in perfectly elastic and inelastic collisions
Find the final velocity of an object in perfectly elastic and inelastic collisions
Content:
- Momentum and Impulse
- Conservation of Momentum
- Elastic and Inelastic Collisions

Circular Motion and Gravitation

Objectives:
Solve problems involving centripetal acceleration
Solve problems involving centripetal force
Explain inertia
Explain how Newton's Law of Universal Gravitation accounts for various phenomena including satellite motion, orbits, and tides
Apply Newton's Law of Universal Gravitation to solve problems
Describe Kepler's Laws of Planetary Motion
Relate Newton's law of gravitational force to the elliptical orbits proposed by Kepler
Solve problems involving orbital speed and period
Distinguish between torque and force
Calculate the magnitude of a torque
Identify the six types of machines
Calculate mechanical advantage
Content:
- Circular Motion
- Newton's Law of Universal Gravitation
- Torque and Simple Machines

Quarter Three

Fluid Mechanics

Objectives:

Define a fluid

Distinguish a gas from a liquid

Determine the magnitude of a buoyant force

Explain why some objects float and others sink

Calculate the pressure exerted by a fluid

Calculate how pressure varies with depth

Examine the motion of a fluid by using the continuity equation

Recognize the effects of Bernoulli's principle on fluid motion

Content:

- Fluids and Buoyant Force
- Fluid Pressure
- Fluids in Motion

Heat

Objectives:

- Relate temperature to kinetic energy of atoms and molecules
- Describe the temperature changes in objects reaching thermal equilibrium
- Identify different temperature scales and convert from one to another
- Explain heat as energy
- Relate heat and temperature to particle motion
- Apply the principle of energy conservation to calculate changes in potential, kinetic, and internal energy
- Perform calculations with specific heat capacity
- Interpret various sections of a heating curve
- Content:
  - Temperature and Thermal Equilibrium
  - Heat
  - Changes in Temperature and Phase

Thermodynamics

Objectives:

- Recognize that a system can absorb or release energy as heat in order for work to be done on or by a system
- Compute the amount of work done by a thermodynamic process
- Distinguish between isovolumetric, isothermal, adiabatic thermodynamic processes
- Illustrate how the First Law of Thermodynamics is a statement of energy conservation
- Calculate heat, work, and change in internal energy
- Apply the First Law of Thermodynamics to describe cyclic processes
- Recognize why the Second Law of Thermodynamics requires two bodies at different temperatures for work to be done
- Calculate the efficiency of a heat engine
- Relate disorder of a system to the ability to do work
- Content:

Relationship between Heat and Work
First Law of Thermodynamics
Second Law of Thermodynamics

Vibrations and Waves

Objectives:
Identify the conditions of SHM
Explain how force, velocity, and acceleration change as an object vibrates with SHM
Calculate the spring force using Hooke's law
Identify the amplitude of a vibration
Recognize the relation between period and frequency
Calculate period and frequency of an object vibrating with SHM
Differentiate between pulse waves and periodic waves
Apply the relationship among speed, frequency and wavelength to solve problems
Relate energy and amplitude
Apply the superposition principle
Differentiate between constructive and destructive interference
Identify nodes and antinodes
Content:
Simple Harmonic Motion
Properties of Waves
Wave Interactions

Sound

Objectives:
Explain how sound waves are produced
Relate frequency to pitch
Compare the speed of sound in various media
Relate plane waves to spherical waves
Recognize the Doppler effect
Calculate intensity of sound waves
Relate intensity to decibel level and perceived loudness
Explain why resonance occurs
Distinguish between the harmonic series of open and closed pipes
Calculate the harmonics of vibrating springs
Relate harmonics and timbre
Relate the frequency difference between two waves to the number of beats heard per second
Content:
Sound Waves
Intensity and Resonance
Harmonics

Light and Reflection

Objectives:
Identify components of the electromagnetic spectrum
Calculate frequency or wavelength of electromagnetic radiation
Recognize that light has a finite speed

Describe how brightness of a light source is affected by distance
Distinguish between specular and diffuse reflection
Apply the law of reflection for flat mirrors
Describe the nature of images formed by flat mirrors
Calculate distance and focal length for concave and convex mirrors
Draw ray diagrams to find image distance and magnification
Distinguish between real and virtual images
Recognize how additive colors affect the color of light
Recognize how pigments affect the color of reflected light
Explain how linearly polarized light is formed and detected
Content:
- Characteristics of Light
- Flat Mirrors
- Curved Mirrors
- Color and Polarization

Refraction and Diffraction

Objectives:

Recognize situations where refraction will occur
Identify which direction light will bend when going from one medium to another
Solve problems using Snell's law
Use ray diagrams to find the position of an image produced by a diverging or converging lens
Solve problems using the thin lens equation
Calculate the magnification of lenses
Predict whether light will be refracted or undergo total internal reflection
Explain dispersion and phenomena such as rainbows in terms of the relationship between the index of refraction and wavelength
Describe how light waves interfere with each other to produce bright and dark fringes
Identify the conditions required for interference to occur
Content:
- Refraction
- Thin Lenses
- Interference
- Diffraction
- Lasers

Quarter Four

Electric Forces and Fields

Objectives:

Understand the basic properties of electric charge
Differentiate between conductors and insulators
Distinguish charging by contact, induction, or polarization
Calculate electric force using Coulomb's law
Compare electric force with gravitational force
Apply the superposition principle to find the resultant force on a charge and to find the position at which the net force on the charge is zero

Calculate electric field strength
Draw and interpret field lines
Identify the four properties associated with a conductor in electrostatic equilibrium
Content:
Electric Charge
Electric Force
Electric Field

Electrical Energy and Current

Objectives:
Distinguish between electrical potential energy, electric potential, and potential difference
Solve problems involving electrical energy and potential difference
Describe the energy conversions that occur in a battery
Relate capacitance to the storage of electrical potential energy in the form of separated charges
Calculate the capacitance of various charges
Calculate the energy stored in a capacitor
Describe the basic properties of electric current and solve problems relating current, charge, and time
Distinguish between the drift speed of a charge carrier and the average speed of a charge carrier between collisions
Calculate resistance, current, and potential difference by using the definition of resistance
Distinguish between ohmic and nonohmic materials and learn what factors affect resistance
Differentiate between direct and alternating current
Relate electric power to the rate at which electrical energy is converted to other forms of energy
Content:
Electric Potential
Capacitance
Current and Resistance

Circuits and Circuit Elements

Objectives:
Interpret and construct circuit diagrams
Identify circuits as open or closed
Deduce the potential difference across the circuit load
Calculate the equivalent resistance for a circuit of resistors connected in series
Calculate the equivalent resistance for a circuit of resistors connected in parallel
Calculate the equivalent resistance of a complex circuit involving both series and parallel portions
Content:
Schematic Diagrams and Circuits
Resistors in Series and Parallel
Complex Resistor Combinations

Magnetism

Objectives:

For a given situation, predict whether magnets will attract or repel

Describe the magnetic field around a permanent magnet

Describe the orientation of earth's magnetic field

Describe the magnetic field produced by a current in a straight conductor and in a solenoid

Use the right hand rule to determine the direction of the magnetic field in a current carrying wire

Given the force on a charge in a magnetic field, determine the strength of the magnetic field

Use the right hand rule to find the direction of the force on a charge moving in an electric field

Determine the magnitude and direction of the force on a wire carrying current in a magnetic field

Content:

Magnets and Magnetic Fields

Magnetism from Electricity

Magnetic Force

Electromagnetic Induction

Objectives:

Recognize that relative motion between a conductor and a magnetic field induces an emf in the conductor

Apply Lenz's law and Faraday's law of induction to solve problems involving induced emf and current

Describe how generators and motors operate

Explain the energy conversions that place in generators and motors

Describe how mutual induction occurs in circuits

Apply the transformer equation to solve problems involving step-up and step-down transformers

Describe what electromagnetic waves are and how they are produced

Recognize that electricity and magnetism are two aspects of a single electromagnetic force

Describe various applications of electromagnetic waves

Content:

Electricity from Magnetism

Generators, Motors, and Mutual Inductance

Electromagnetic Waves

Content Pacing Guide & Standards

Unit One: Mechanics		
Content	**Standards**	**Time Frame**
Introduction to Physics Measurements Activities: Graph matching, Measuring the Height of the Auditorium	5.1.12.A.1-3 5.1.12.B.1-2 5.1.12.C.2 5.1.12.D.1 RST.11-12.1-5, 10 WHST.11-12.1.a, d, e	1 Weeks
Motion in One Dimension Speed and Velocity Acceleration Falling Objects Activities/Lab: Using LoggerPro software Picket Fence Free fall, Determining "g" on an Incline Benchmark assessment: Chapter Test, 1-2	5.1.12.A.1-3 5.1.12.B.1-2 5.1.12.C.1-2 5.1.12.D.1 5.2.12.E.1 RST.11-12.1-5, 10 WHST.11-12.1.a, d, e WHST.11-12.2.a, e	2 Weeks
Two Dimensional Motion and Vectors Vectors Projectile Motion Relative Motion Activities/Lab: Projectile Motion Benchmark assessment: Chapter Test	5.1.12.A.1-3 5.1.12.B.1-2 5.1.12.C.1-2 5.1.12.D.1-2 5.2.12.E.1 RST.11-12.1, 3, 5, 8, 9, 10 WST.11-12.1.a, d, e WST.11-12.2.a, b, c, e	2 weeks
Forces Changes in motion Newton's First Law Newton's Second Law Newton's Third Law Activities/Lab: Newton's 2nd Law, Air Resistance Benchmark assessment: Chapter Test	5.1.12.A.1-3 5.1.12.B.1-2 5.1.12.C.1-2 5.1.12.D.1-2 5.2.12.D.1 5.2.12.E.1-4 RST.11-12.1, 3, 8, 9, 10 WST.11-12.1.a, b, e WST.11-12.2.a, b, e	3 weeks
Work and Energy Work Energy and Its Conservation Power Activities/Lab: Momentum and Energy Benchmark assessment: Chapter Test	5.1.12.A.1-3 5.1.12.B.1-2 5.1.12.C.1-2 5.1.12.D.1 5.2.12.D.1 and 4 5.2.12.E.1-4 RST.11-12.4, 7, 8, 9 WHST.11-12. 1, b, e WHST.11-12.a, b, e	2 weeks

Momentum and Collisions Momentum and Impulse Conservation of Momentum Elastic and Inelastic Collisions Activities/Lab: Impulse and Momentum Benchmark Assessment Chapter Test	5.1.12.A.1-3 5.1.12.B.1-4 5.1.12.C.1-2 5.1.12.D.1 5.2.12.D.1 and 4 5.2.12.E.1-4 RST.11-12.4, 7, 8, 9 WHST.11-12. 1.A, b, e WHST.11-12.2.a, b, e	3 weeks
Circular Motion and Gravitation Circular Motion Newton's Law of Universal Gravitation Torque and Simple Machines Activities/Lab: Centripetal Acceleration Benchmark Assessment: At this point every student should be able to set up a lab setup with computer, proper interface, and probeware while using the software to collect and analyze data Benchmark assessment: Chapter Test	5.1.12.A.1-3 5.1.12.B.1-4 5.1.12.C.1-2 5.1.12.D.1 5.2.12.D.1 and 4 5.2.12.E.1-4 RST.11-12.1, 2, 3, 7, 8, 9 WHST.11-12.1.a, b, e WHST11-12.2.d, e WHST.11-12.4, 5, 6, 8, 9	2 weeks

Unit Two: Fluids and Thermodynamics		
Content	**Standards**	Time Frame
Fluid Mechanics Fluids and Buoyant Force Fluid Pressure Fluids in Motion Activities/Lab Density and Displacement Benchmark assessment: Chapter Test	5.1.12.A.1-3 5.1.12.B.1-4 5.1.12.C.1-2 5.1.12.D.1 5.2.12.A.2 5.2.12.D.1 and 4 5.2.12.E.1-2 RST.11-12.1, 2, 3, 7, 8, 9 WHST.11-12.a, b, e WHST.11-12. a, b, d, e WHST.11-12.4, 5, 6, 8, 9	2 weeks
Heat Temperature and Thermal Equilibrium Heat Changes in Temperature and Phase Activities Newton's Law of Cooling Benchmark assessment: Chapter Test	5.1.12.A.1-3 5.1.12.B.1-4 5.1.12.C.1-2 5.1.12.D.1 5.2.12.A.2 5.2.12.C.1-2 5.2.12.D.1 and 4 5.2.12.E.1-2 RST.11-12.1, 2, 3, 7, 8, 9 WHST.11-12.a, b, e WHST.11-12. a, b, d, e WHST.11-12.4, 5, 6, 8, 9	2 weeks
Thermodynamics Relationship Between Heat and Work First Law of Thermodynamics Second Law of Thermodynamics Activities: The Zeroth Law Benchmark assessment: Chapter Test	5.1.12.A.1-3 5.1.12.B.1-4 5.1.12.C.1-2 5.1.12.D.1 5.2.12.D.1 and 4 5.2.12.E.1-2 5.2.12.A.2 5.2.12.C.1-2 RST.11-12.1, 2, 3, 7, 8, 9 RST.11-12.1, 2, 3, 7, 8, 9 WHST.11-12.a, b, e WHST.11-12. a, b, d, e WHST.11-12.4, 5, 6, 8, 9	2 weeks

Unit Three: Waves and Optics		
Content	**Standards**	**Time Frame**
Vibrations and Waves Simple Harmonic Motion Properties of Waves Wave Interactions Activities/Lab: Energy in SHM Benchmark assessment: Chapter Test	5.1.12.A.1-3 5.1.12.B.1-4 5.1.12.C.1-2 5.1.12.D.1 5.2.12.A.2 5.2.12.C.1-2 5.2.12.D.4 5.2.12.E.1-2 RST.11-12.1, 2, 3, 7, 8, 9 RST.11-12.1, 2, 3, 7, 8, 9 WHST.11-12.a, b, e WHST.11-12. a, b, d, e WHST.11-12.4, 5, 6, 8, 9	2 weeks
Sound Sound Waves Intensity and Resonance Harmonics Activities/Lab: The Speed of Sound Sound Waves and beats Benchmark assessment: Chapter Test	5.1.12.A.1-3 5.1.12.B.1-4 5.1.12.C.1-2 5.1.12.D.1 5.2.12.A.2 5.2.12.C.1-2 5.2.12.D.4 5.2.12.E.1-2 RST.11-12.1, 2, 3, 7, 8, 9, WHST.11-12.a, b, e WHST.11-12. a, b, d, e WHST.11-12.4, 5, 6, 8, 9	2 weeks
Light and Reflection Characteristics of Light Flat Mirrors Curved Mirrors Color and Polarization Activity/Lab: Calculating *f* in a mirror Benchmark assessment: Chapter Test	5.1.12.A.1-3 5.1.12.B.1-4 5.1.12.C.1-2 5.1.12.D.1 5.2.12.A.2 5.2.12.C.1-2 5.2.12.D.4 5.2.12.E.1-2 RST.11-12.1, 2, 3, 7, 8, 9,	2 weeks

	WHST.11-12.a, b, e WHST.11-12. a, b, d, e WHST.11-12.4, 5, 6, 8, 9	
Refraction and Diffraction Refraction Thin Lenses Interference Diffraction Lasers Activity/Lab: f in a thin lens Benchmark assessment: Chapter Test	5.1.12.A.1-3 5.1.12.B.1-4 5.1.12.C.1-2 5.1.12.D.1 5.2.12.A.2 5.2.12.C.1-2 5.2.12.D.4 5.2.12.E.1-2 RST.11-12.1, 2, 3, 7, 8, 9, WHST.11-12.a, b, e WHST.11-12. a, b, d, e WHST.11-12.4, 5, 6, 8, 9	2 weeks

Unit Four: Electricity and Magnetism		
Content	**Standards**	**Time Frame**
Electric Forces and Fields Electric Charge Electric Force Electric Field Activity: Coulomb's law Benchmark assessment: Chapter Test	5.1.12.A.1-3 5.1.12.B.1-4 5.1.12.C.1-2 5.1.12.D.1 5.2.12.C.1 5.2.12.D.5 5.2.12.E.1, 2 and 4 RST.11-12.1, 2, 3, 7, 8, 9, WHST.11-12.a, b, e WHST.11-12. a, b, d, e WHST.11-12.4, 5, 6, 8, 9	2 weeks

Electrical Energy and Current Electric Potential Capacitance Current and Resistance Activity: Capacitors Benchmark assessment: Chapter Test	5.1.12.A.1-3 5.1.12.B.1-4 5.1.12.C.1-2 5.1.12.D.1 5.2.12.C.1 5.2.12.D.5 5.2.12.E.1, 2 and 4 WHST.11-12.a, b, e WHST.11-12. a, b, d, e WHST.11-12.4, 5, 6, 8, 9	2 weeks
And if time allows, the following material may be covered		
Circuits and Circuit Elements Schematic Diagrams and Circuits Resistors in Series and Parallel Complex Resistor Combinations Activity: Series and Parallel Circuits Benchmark assessment: Chapter Test	5.1.12.A.1-3 5.1.12.B.1-4 5.1.12.C.1-2 5.1.12.D.1 5.2.12.C.1 5.2.12.D.5 5.2.12.E.1, 2 and 4 RST.11-12.1, 2, 3, 7, 8, 9, WHST.11-12.a, b, e WHST.11-12. a, b, d, e WHST.11-12.4, 5, 6, 8, 9	2 weeks
Magnetism Magnets and Magnetic Fields Magnetism from Electricity Magnetic Force Activity: magnetic Field in a Slinky Benchmark assessment: Chapter Test	5.1.12.A.1-3 5.1.12.B.1-4 5.1.12.C.1-2 5.1.12.D.1 5.2.12.C.1 5.2.12.D.5 5.2.12.E.1, 2 and 4 RST.11-12.1, 2, 3, 7, 8, 9, WHST.11-12.a, b, e WHST.11-12. a, b, d, e WHST.11-12.4, 5, 6, 8, 9	2 weeks

Electromagnetic Induction Electricity from Magnetism Generators, Motors, and Mutual Inductance Electromagnetic Waves Benchmark assessment: Chapter Test	5.1.12.A.1-3 5.1.12.B.1-4 5.1.12.C.1-2 5.1.12.D.1 5.2.12.C.1 5.2.12.D.5 5.2.12.E.1, 2 and 4 RST.11-12.1, 2, 3, 7, 8, 9, WHST.11-12.a, b, e WHST.11-12. a, b, d, e WHST.11-12.4, 5, 6, 8, 9	2 weeks
Final Exam is taken by all students and includes content from text, labs, and readings		

IX. MODIFICATIONS: INCLUSION TECHNIQUES/ENRICHMENTS

Possible instructional techniques may include but may not be limited to the following:

- **Resource Center –** A course of study will be modified to accommodate the specific needs of a special education student as outlined in his/her IEP.
- **Inclusion –** Peer tutoring, computer software, oral tests, visual organizers, study guides, and cooperative learning activities
- **Enrichments –** Field trips, guest speakers, brochure design, simulations, drama, and poetry

Students are provided with a basic text and/or supplemental curricular materials that are used for assigned readings, discussion, and information gathering. Through teacher-directed instructional activities, students are asked to acquire knowledge, develop an understanding of content, apply information to their own lives, analyze data, synthesize material, and make evaluative judgments.

When planning each lesion, teachers select specific objectives, organize material to achieve maximum understanding, make associations, and check for understanding at frequent intervals. Technology materials are used when appropriate. Suggestions for specific assignments and student activities are found in the teacher's resource guide of the approved textbook series.

X. INTERDISCIPLINARY CONNECTIONS/MULTICULTURAL MATERIALS

XI. MATERIALS/TECHNOLOGY

Textbook: Holt Physics- Serway and Faughn 2009

All labs use experiments designed to be executed using Vernier software, interfaces and probeware.

Computers are used to analyze and interpret data.

Java applets are used for concept enhancement.

Teacher website is to be utilized for assignments, announcements and additional resources.

Videos: The Mechanical Universe series from PBS 1986 54 ½ hour videos detailing concept in physics

The Elegant Universe NOVA 2004

The Fabric of the Cosmos NOVA 2011

Magnetic Storm NOVA 2003

New Jersey Core Curriculum Standards for Physics

5.1 Science Practices All students will understand that science is both a body of knowledge and an evidence-based, model-building enterprise that continually extends, refines, and revises knowledge. The four Science Practices strands encompass the knowledge and reasoning skills that students must acquire to be proficient in science.

A. Understand Scientific Explanations: Students understand core concepts and principles of science and use measurement and observation tools to assist in categorizing, representing, and interpreting the natural and designed world.

5.1.12.A.1 Refine interrelationships among concepts and patterns of evidence found in different central scientific explanations.

5.1.12.A.2 Develop and use mathematical, physical, and computational tools to build evidence-based models and to pose theories.

5.1.12.A.3 Use scientific principles and theories to build and refine standards for data collection, posing controls, and presenting evidence.

B. Generate Scientific Evidence Through Active Investigations: Students master the conceptual, mathematical, physical, and computational tools that need to be applied when constructing and evaluating claims.

5.1.12.B.1 Design investigations, collect evidence, analyze data, and evaluate evidence to determine measures of central tendencies, causal/correlational relationships, and anomalous data.

5.1.12.B.2 Build, refine, and represent evidence-based models using mathematical, physical, and computational tools.

5.1.12.B.3 Revise predictions and explanations using evidence, and connect explanations/arguments to established scientific knowledge, models, and theories.

5.1.12.B.4 Develop quality controls to examine data sets and to examine evidence as a means of generating and reviewing explanations.

C. Reflect on Scientific Knowledge: Scientific knowpledge builds on itself over time.

5.1.12.C.1 Reflect on and revise understandings as new evidence emerges.

5.1.12.C.2 Use data representations and new models to revise predictions and explanations.

5.1.12.C.3 Consider alternative theories to interpret and evaluate evidence-based arguments.

D. Participate Productively in Science: The growth of scientific knowledge involves critique and communication, which are social practices that are governed by a core set of values and norms.

5.1.12.D.1 Engage in multiple forms of discussion in order to process, make sense of, and learn from others' ideas, observations, and experiences.

5.1.12.D.2 Represent ideas using literal representations, such as graphs, tables, journals, concept maps, and diagrams.

5.1.12.D.3 Demonstrate how to use scientific tools and instruments and knowledge of how to handle animals with respect for their safety and welfare.

5.2 Physical Science: All students will understand that physical science principles, including fundamental ideas about matter, energy, and motion, are powerful conceptual tools for making sense of phenomena in physical, living, and Earth systems science.

A. Properties of Matter: All objects and substances in the natural world are composed of matter. Matter has two fundamental properties: matter takes up space, and matter has inertia.

5.2.12.A.1 Use atomic models to predict the behaviors of atoms in interactions.

5.2.12.A.2 Account for the differences in the physical properties of solids, liquids, and gases.

5.2.12.A.3 Predict the placement of unknown elements on the Periodic Table based on their physical and chemical properties.

5.2.12.A.4 Explain how the properties of isotopes, including half-lives, decay modes, and nuclear resonances, lead to useful applications of isotopes.

5.2.12.A.5 Describe the process by which solutes dissolve in solvents.

B. Changes in Matter: Substances can undergo physical or chemical changes to form new substances. Each change involves energy.

5.2.12.B.1 Model how the outermost electrons determine the reactivity of elements and the nature of the chemical bonds they tend to form.

5.2.12.B.2 Describe oxidation and reduction reactions, and give examples of oxidation and reduction reactions that have an impact on the environment, such as corrosion and the burning of fuel.

5.2.12.B.3 Balance chemical equations by applying the law of conservation of mass.

C. Forms of Energy: Knowing the characteristics of familiar forms of energy, including potential and kinetic energy, is useful in coming to the understanding that, for the most part, the natural world can be explained and is predictable.

5.2.12.C.1 Use the kinetic molecular theory to describe and explain the properties of solids, liquids, and gases.

5.2.12.C.2 Account for any trends in the melting points and boiling points of various compounds.

D. Energy Transfer and Conservation: The conservation of energy can be demonstrated by keeping track of familiar forms of energy as they are transferred from one object to another.

5.2.12.D.1 Model the relationship between the height of an object and its potential energy.

5.2.12.D.2 Describe the potential commercial applications of exothermic and endothermic reactions.

5.2.12.D.3 Describe the products and potential applications of fission and fusion reactions.

5.2.12.D.4 Measure quantitatively the energy transferred between objects during a collision.

5.2.12.D.5 Model the change in rate of a reaction by changing a factor.

E. Forces and Motion: It takes energy to change the motion of objects. The energy change is understood in terms of forces.

5.2.12.E.1 Compare the calculated and measured speed, average speed, and acceleration of an object in motion, and account for differences that may exist between calculated and measured values.

5.2.12.E.2 Compare the translational and rotational motions of a thrown object and potential applications of this understanding.

5.2.12.E.3 Create simple models to demonstrate the benefits of seatbelts using Newton's first law of motion.

5.2.12.E.4 Measure and describe the relationship between the force acting on an object and the resulting acceleration.

Reading Standards for Literacy in Science and Technical Subjects 11–12

Key Ideas and Details

1. Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
2. Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.
3. Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.

Craft and Structure

4. Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 11–12 texts and topics.
5. Analyze how the text structures information or ideas into categories or hierarchies, demonstrating understanding of the information or ideas.
6. Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, identifying important issues that remain unresolved.

Integration of Knowledge and Ideas

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.
8. Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.
9. Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.

Range of Reading and Level of Text Complexity

10. By the end of grade 12, read and comprehend science/technical texts in the grades 11–CCR text complexity band independently and proficiently.

College and Career Readiness Anchor Standards for Writing

The grades 6–12 standards on the following pages define what students should understand and be able to do by the end of each grade span. They correspond to the College and Career Readiness (CCR) anchor standards below by number. The CCR and grade-specific standards are necessary complements—the former providing broad standards, the latter providing additional specificity—that together define the skills and understandings that all students must demonstrate.

Text Types and Purposes*

1. Write arguments to support claims in an analysis of substantive topics or texts using valid reasoning and relevant and sufficient evidence.
2. Write informative/explanatory texts to examine and convey complex ideas and information clearly and accurately through the effective selection, organization, and analysis of content.

3. Write narratives to develop real or imagined experiences or events using effective technique, well-chosen details and well-structured event sequences.

Production and Distribution of Writing

4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

5. Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach.

6. Use technology, including the Internet, to produce and publish writing and to interact and collaborate with others.

Research to Build and Present Knowledge

7. Conduct short as well as more sustained research projects based on focused questions, demonstrating understanding of the subject under investigation.

8. Gather relevant information from multiple print and digital sources, assess the credibility and accuracy of each source, and integrate the information while avoiding plagiarism.

9. Draw evidence from literary or informational texts to support analysis, reflection, and research.

Range of Writing

10. Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of tasks, purposes, and audiences.

*These broad types of writing include many subgenres. See Appendix A for definitions of key writing types.

Note on range and content of student writing

For students, writing is a key means of asserting and defending claims, showing what they know about a subject, and conveying what they have experienced, imagined, thought, and felt. To be college and career ready writers, students must take task, purpose, and audience into careful consideration, choosing words, information, structures, and formats deliberately. They need to be able to use technology strategically when creating, refining, and collaborating on writing. They have to become adept at gathering information, evaluating sources, and citing material accurately, reporting findings from their research and analysis of sources in a clear and cogent manner. They must have the flexibility, concentration, and fluency to produce high-quality first draft text under a tight deadline and the capacity to revisit and make improvements to a piece of writing over multiple drafts when circumstances encourage or require it. To meet these goals, students must devote significant time and effort to writing, producing numerous pieces over short and long time frames throughout the year.

Writing Standards for Literacy in History/Social Studies, Science, and Technical Subjects 11–12

The standards below begin at grade 6; standards for K–5 writing in history/social studies, science, and technical subjects are integrated into the K–5 Writing standards. The CCR anchor standards and high school standards in literacy work in tandem to define college and career readiness expectations—the former providing broad standards, the latter providing additional specificity.

Grades 11–12 students:

Text Types and Purposes

1. Write arguments focused on discipline-specific content.

    a. Introduce precise, knowledgeable claim(s), establish the significance of the claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that logically sequences the claim(s), counterclaims, reasons, and evidence.

b. Develop claim(s) and counterclaims fairly and thoroughly, supplying the most relevant data and evidence for each while pointing out the strengths and limitations of both claim(s) and counterclaims in a discipline-appropriate form that anticipates the audience's knowledge level, concerns, values, and possible biases.

c. Use words, phrases, and clauses as well as varied syntax to link the major sections of the text, create cohesion, and clarify the relationships between claim(s) and reasons, between reasons and evidence, and between claim(s) and counterclaims.

d. Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing.

e. Provide a concluding statement or section that follows from or supports the argument presented.

2. Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.

a. Introduce a topic and organize complex ideas, concepts, and information so that each new element builds on that which precedes it to create a unified whole; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension.

b. Develop the topic thoroughly by selecting the most significant and relevant facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audience's knowledge of the topic.

c. Use varied transitions and sentence structures to link the major sections of the text, create cohesion, and clarify the relationships among complex ideas and concepts.

d. Use precise language, domain-specific vocabulary and techniques such as metaphor, simile, and analogy to manage the complexity of the topic; convey a knowledgeable stance in a style that responds to the discipline and context as well as to the expertise of likely readers.

e. Provide a concluding statement or section that follows from and supports the information or explanation provided (e.g., articulating implications or the significance of the topic).

3. (See note; not applicable as a separate requirement)

Note: Students' narrative skills continue to grow in these grades. The Standards require that students be able to incorporate narrative elements effectively into arguments and informative/explanatory texts. In history/social studies, students must be able to incorporate narrative accounts into their analyses of individuals or events of historical import. In science and technical subjects, students must be able to write precise enough descriptions of the step-by-step procedures they use in their investigations or technical work that others can replicate them and (possibly) reach the same results.

Production and Distribution of Writing

4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

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.

6. Use technology, including the Internet, to produce, publish, and update individual or shared writing products in response to ongoing feedback, including new arguments or information.

Research to Build and Present Knowledge

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.
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.
9. Draw evidence from informational texts to support analysis, reflection, and research.

Range of Writing

10. Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.