Physics is the fundamental science of the natural world. In this course, students will study the topics of kinematics, mechanics, waves, light, electricity, and magnetism. The basic concepts and fundamental principles introduced in the course serve as a foundation for advanced work in this or any other physical science. Laboratory experiments serve to illustrate the fundamentals more clearly and to acquaint the student with the use of equipment and technology.

This course meets the graduation requirements of a Physical Science (if student did not take Physical Science) or an Advanced Science (if student did complete Physical Science). Upon completion of this course, students who did not take Physical Science and have completed Chemistry are then prepared to take the end of course exam for Physical Science. Students who elect to take General Chemistry in lieu of the full Physical Science course must also complete Physics or the second semester of Physical Science before taking the end of course exam for Physical Science.

Science Inquiry and Application Standards

During the years of grades 9 through 12 all students must use the following scientific processes with appropriate laboratory safety techniques to construct their knowledge and understanding in all science content areas. These are ongoing skills that will be developed and intertwined within the content of each course.

- Identify questions and concepts that guide scientific investigations
- Design and conduct scientific investigations
- Use technology and mathematics to improve investigations and communications
- Formulate and revise explanations and models using logic and evidence (critical thinking)
- Recognize and analyze explanations and models
- Communicate and support a scientific argument
English Language Arts Standards for Science & Technical Subjects

I. Key Ideas and Details
   A. 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.
   B. 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.
   C. 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.

II. Craft and Structure
   A. 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.
   B. Analyze how the text structures information or ideas into categories or hierarchies, demonstrating understanding of the information or ideas.
   C. 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.

III. Integration of Knowledge and Ideas
   A. 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.
   B. 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.
   C. 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.

IV. Range of Reading and Level of Text Complexity
   A. By the end of grade 12, read and comprehend science/technical texts in the grades 11–12 text complexity band independently and proficiently.
Writing Standards for Science & Technical Subjects

I. Text Types and Purposes Standard 1
   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.

II. Text Types and Purposes Standard 2
   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).
### III. Production and Distribution of Writing

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

B. 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.

C. 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.

### IV. Research to Build and Present Knowledge

A. 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.

B. 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.

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

### V. Range of Writing

A. 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.
Content Standards

I Motion

A Graph Interpretations

1 Position, Velocity and Acceleration vs. Time

(a) Construct and interpret graphs of position, velocity and acceleration versus time.
(b) Compare graphical representations of accelerated and non-accelerated motions.
(c) Solve problems using graphs of position, velocity and acceleration versus time.

B Problem Solving

1 Uniform acceleration including free-fall

(a) Apply kinematic equations to calculate distance, time or velocity under conditions of constant acceleration.
(b) Relate the motion of a freely falling body to motion with constant acceleration.
(c) Calculate displacement, velocity, and time at various points in the motion of a freely falling object.

C Vectors

1 Vector Concepts

(a) Distinguish between a scalar and a vector.
(b) Describe motion using the concepts of vectors

2 Graphical Manipulation of Vectors

(a) Draw scale diagrams to represent vector addition of 2-dimensional force, velocity or displacement vectors.

3 Mathematical Manipulation of Vectors

(a) Calculate components for vectors at any angle.
(b) Calculate the sum or difference of two or more vectors at any angle.
D  Projectiles

1  Concepts of Projectile Motion
   (a) Recognize the independence of horizontal and vertical motion
   (b) Describe the path of a projectile as a parabola, under the influence of no forces other than gravity, when near Earth’s surface.

2  Problem-Solving involving horizontally launched projectiles
   (a) Apply the kinematic equations to horizontally launched projectiles

3  Problem-Solving involving projectiles launched at any angle
   (a) Apply kinematic equations to projectiles launched at an angle

II  Forces

A  Applications of Newton’s Laws

1  Force Concepts
   (a) Distinguish between contact forces, such as friction, tension and normal forces, and field forces, such as gravity.
   (b) Relate the concept of a field to the behavior of some forces to act at a distance.
   (c) Calculate the force of gravity on an object in a uniform gravitational field.
   (d) Interpret and construct force diagrams.

2  Dynamics
   (a) Calculate the force required to bring an object into static or dynamic equilibrium.
   (b) Apply Newton’s Laws to accelerated systems and other complex problems.

3  Additional Forces
   (a) Demonstrate the ways in which frictional forces influence the motion of objects.
   (b) Describe air resistance as a form of friction.
Newton’s Laws on Inclined Planes

Application of Newton’s Laws

(a) Analyze the dynamics of objects on inclined surface using a rotated reference frame.

Conservation Laws

Work and Energy

Conservation of Energy

(a) Identify different forms of energy (e.g., electrical, mechanical, chemical, thermal, nuclear, radiant and acoustic).
(b) Demonstrate that mechanical energy can be considered to be either kinetic (motion) or potential (stored).
(c) Explain how an object’s kinetic energy depends to its mass and speed relative to a frame of reference.
(d) Explain how an object’s gravitational energy depends to its mass, the gravitational field and height relative to a reference.
(e) Calculate forces from springs and relate spring forces to other elastic forces.
(f) Calculate the elastic potential energy stored in a spring.

Work and Power

(a) Define work, relating it to force and displacement.
(b) Relate work to transfers of mechanical energy.
(c) Apply the work-kinetic energy theorem to solve problems.
(d) Describe work done by friction to changes in thermal energy.
(e) Apply the definition of power as a rate of energy transfer to a variety of systems.

Momentum

Momentum in relation to impulse

(a) Describe changes in momentum in terms of force and time.

Momentum conserved in interactions
(a) Describe the interaction between two objects in terms of the change in momentum of each object.
(b) State the law of conservation of momentum.
(c) Predict the final velocities of objects after an interaction, given their initial velocities.

IV Periodic Motion, Waves and Light

A Circular Motion and Gravitation

1 Centripetal acceleration and centripetal force
   (a) Solve problems involving centripetal acceleration.
   (b) Calculate the force that maintains circular motion.

2 Gravitation and orbits
   (a) Describe how gravitational forces act between all masses and always create a force of attraction. Recognize that the strength of the force is proportional to the masses and weakens rapidly with increasing distance between them.
   (b) Apply Newton’s law of gravity to the circular motion of orbiting bodies.

B Simple Harmonic Motion and Waves

1 Periodic motion
   (a) State the conditions, which are necessary for general periodic motion.
   (b) State the conditions, which are necessary for simple harmonic motion.
   (c) Apply to concepts of simple harmonic motion to the behavior of pendulums and masses on a spring.

2 Conservation of energy
   (a) Apply the principle of conservation of energy to objects in simple harmonic motion.

3 Waves
   (a) Demonstrate that vibrations in materials may produce waves that spread away from the source in all directions (e.g., earthquake waves, sound waves).
(b) Identify the amplitude of vibration.
(c) Recognize the relationship between period and frequency.
(d) Distinguish local particle vibrations from overall wave motion.
(e) Differentiate between pulse waves and periodic waves.
(f) Interpret waveforms of transverse and longitudinal waves.
(g) Apply the relationship among wave speed, frequency, and wavelength to solve problems.
(h) Relate energy and amplitude.
(i) Demonstrate that waves (e.g., sound, seismic, water, light) have energy and waves can transfer energy when they interact with matter.
(j) Show how the properties of a wave depend on the properties of the medium through which it travels.
(k) Recognize that electromagnetic waves can be propagated without a medium.
(l) Apply the superposition principle.
(m) Differentiate between constructive and destructive interference.
(n) Describe how waves can superimpose on one another when propagated in the same medium.
(o) Predict whether specific traveling waves will produce a standing wave.
(p) Identify nodes and antinodes of a standing wave.
(q) Analyze conditions in which waves can bend around corners, reflect off surfaces, are absorbed by materials they enter, and change direction and speed when entering a different material.
(r) Relate such wave behavior to the terms reflection, refraction and diffraction.
(s) Predict when a reflected wave will be inverted.
(t) Describe how the observed wavelength of a wave depends upon the relative motion of the source and the observer (Doppler effect). If either is moving towards the other, the observed wavelength is shorter; if either is moving away, the observed wavelength is longer (e.g., weather radar, bat echoes, police radar).

C Light and Reflection

1 Properties of light

(a) Demonstrate that electromagnetic radiation is a form of energy. Recognize that light acts as a wave. Show that visible light is a part of the electromagnetic spectrum (e.g., radio waves, microwaves, infrared, visible light, ultraviolet, X-rays, and gamma rays).
(b) Show how the properties of a wave depend on the properties of the medium through which it travels. Recognize that electromagnetic waves can be propagated without a medium.
(c) Identify the components of the electromagnetic spectrum.
(d) Calculate the frequency or wavelength of electromagnetic radiation.
(e) Recognize that light has a finite speed.
(f) Distinguish between specular and diffuse reflection of light.
(g) Apply the law of reflection for flat mirrors.
(h) Describe the nature of images formed by flat mirrors.

2 Ray diagrams for curved mirrors

(a) Calculate distances and focal lengths using the mirror equation for concave and convex spherical mirrors.
(b) Draw ray diagrams to find the image distance and magnification for concave and convex spherical mirrors.
(c) Distinguish between real and virtual images.
(d) Describe how parabolic mirrors differ from spherical mirrors.

3 Color

(a) Relate wavelength and frequency in the visible spectrum to perception of color.
(b) Recognize how additive colors affect the color of light.
(c) Recognize how pigments affect the color of reflected light.
(d) Explain how linearly polarized light is formed and detected.

D Refraction, Interference and Diffraction

1 Snell’s Law

(a) Recognize situations in which refraction will occur.
(b) Identify which direction light will bend when it passes from one medium to another.
(c) Solve problems using Snell’s Law.
(d) Recognize atmospheric conditions that cause refraction.
(e) Explain dispersion and phenomena such as rainbows in terms of the relationship between the index of refraction and the wavelength.

2 Ray diagrams for lenses

(a) Use ray diagrams to find the position of an image produced by a converging or diverging lens, and identify the image as real or virtual.
(b) Solve problems using the thin-lens equation.
(c) Calculate the magnification of images.
(d) Predict whether light will be refracted or undergo total internal reflection.

3 Interference and Diffraction

(a) Relate constructive and destructive interference of other kinds of waves to those same phenomena in light.
(b) Describe the interference patterns that result from different sources, including single slit, double slit and diffraction gratings.

V The Universe

A Stars

1 Describe the processes of star formation.
2 Find patterns in and graph the observable physical features of stars, specifically surface temperature and luminosity.
3 Relate the observed types of stars to the stages of stellar evolution.
4 Relate the observed types of stars to the stages of stellar evolution.
5 Discuss the relationship between observed nuclear abundances in the universe to the processes of nuclear fusion in stars.
6 Examine the process of fusion and the role it plays in star formation.

B Galaxies and Cosmology

1 Describe the basic characteristics of galaxies.
2 Discuss the observed Doppler shifts of galaxies to Hubble's Law and the expansion of the universe.
3 Relate the expansion of the universe to the Big Bang theory and the earliest stages in the history of the universe.

VI Electricity and Magnetism

A Electrostatics

1 Charging objects

(a) Understand the basic properties of electric charge.
(b) Differentiate between conductors and insulators.
(c) Distinguish between the processes of charging by friction, conduction and induction.
2 Coulomb’s Law

(a) Calculate electric force using Coulomb’s Law.
(b) Compare electric force with gravitational force.

3 Electric Fields, Electric potential, and electric potential energy

(a) Calculate electric field strength.
(b) Define electric potential energy.
(c) Distinguish between electric potential energy, electric potential, and potential difference.

B DC Circuits

1 Simple circuits

(a) Describe the basic properties of electric current.
(b) Solve problems with current, charge and time.
(c) Calculate resistance, current and potential difference using Ohm’s Law.
(d) Distinguish between Ohmic and non-Ohmic materials.
(e) Know what factors affect resistance.
(f) Recognize that at low temperatures some materials become superconducting and offer little to no resistance to the flow of electrons.
(g) Relate electric power to the rate at which electric energy is converted to other forms of energy.
(h) Calculate electric power.
(i) Calculate the cost of running electrical appliances.
(j) Interpret and construct circuit diagrams.
(k) Identify circuits as open or closed.
(l) Deduce the potential difference across the circuit load, given the potential difference across the battery’s terminals.

2 Complex circuits

(a) Calculate the equivalent resistance for a circuit of resistors in series, and find the current in and potential difference across each resistor in the circuit.
(b) Calculate the equivalent resistance for a circuit of resistors in parallel, and find the current in and potential difference across each resistor in the circuit.
(c) Calculate the equivalent resistance for a complete circuit involving both series and parallel portions.
(d) Calculate the current in and potential difference across individual elements within a complex circuit.
(e) Use the junction and loop rules to apply conservation of charge and conservation of energy to electric circuits.

C Magnetism

1 Permanent magnets

(a) Draw magnetic fields created by various shapes of permanent magnets.
(b) Describe the mechanism by which permanent magnets create magnetic fields.
(c) Recognize that positioning permanent magnets at various distances can store potential energy.

2 Electro-magnetic Interactions

(a) Compute the magnetic field created by a given current.
(b) Compute the force that a current or moving charge feels from a given magnetic field.
(c) Describe the way that a changing electric field can create a changing magnetic field, which can then create a changing electric field, and how this system can self-propagate through empty space.