LEE ACADEMY

Lee, Maine USA

Official Curriculum

Physics

Revised, Summer 2011

Course description

This course is intended to give students experience with the fundamentals of physics, including: motion in one and two dimensions, forces (Newton's Laws of Motion), rotational and periodic motion, gravitation, work, energy, and power, waves, sound, and light, and electricity and magnetism. This is an inquiry, lab-based course. Laboratory experiments account for the greatest percentage of the student's grade and serve as either formative or summative assessments in each unit. All lab reports are to be completed in the lab notebook and are scored using the attached lab report guide and rubric. In most labs, students are given only a problem and they must then develop their own procedures. Unit tests and major projects will also be given periodically to assess student learning.

Primary text(s) and other major resources:

Conceptual Physics, Paul G. Hewitt
9th Edition 2001, College Edition,
ISBN 0321052021

Conceptual Physics—Lab Manual
2002, High School Edition,
ISBN 0130542571

Note:
Because of their universal applicability in physics, learning of the following Maine Learning Results (http://www.maine.gov/education/lres/pei/index.html) is ongoing in each unit:

Student will:

A1a *analyze a system using the principles of boundaries, subsystems, inputs, outputs, feedback, or the system's relation to other systems and design solutions to a system problem.*
A1b *explain and provide examples that illustrate how it may not always be possible to predict the impact of changing some part of a manmade or natural system.*
A2 *evaluate the effectiveness of a model by comparing its predictions to actual observations from the physical setting, the living environment, and the technological world.*
A3 *identify and analyze examples of constancy and change that result from varying types and rates of change in physical, biological, and technological systems with and without counterbalances.*
A4a *describe how large changes of scale may change how physical and biological systems work and provide examples.*
A4b *mathematically represent large magnitudes of scale.*

B1a *identify questions, concepts, and testable hypotheses that guide scientific investigations.*
B1b *design and safely conduct methodical scientific investigations, including experiments with controls.*
B1c *use statistics to summarize, describe, analyze, and interpret results.*
B1d *formulate and revise scientific investigations and models using logic and evidence.*
B1e *use a variety of tools and technologies to improve investigations and communications.*
B1f *recognize and analyze alternative explanations and models using scientific criteria.*
B1g *communicate and defend scientific ideas.*

B2a *identify new problems or a current design in need of improvement.*
B2b *generate alternative design solutions.*
B2c *select the design that best meets established criteria.*
B2d *use models and simulations as prototypes in the design planning process.*
B2e *implement the proposed design solution.*
B2f *evaluate the solution to a design problem and the consequences of that solution.*
B2g *present the problem, design process, and solution to a design problem including models, diagrams, and demonstrations.*

C2a *provide an example that shows how science advances with the introduction of new technologies and how solving technological problems often impacts new scientific knowledge.*
C2b *provide examples of how creativity, imagination, and a good knowledge base are required to advance scientific ideas and technological design.*
C2c *provide examples that illustrate how technological solutions to problems sometimes lead to new problems or new fields of inquiry.*

~Unit length & MLRs	Objectives	Essential Questions	Labs & Assessments
Unit 1 5 weeks Chapters 2-4, 10 Motion in One and Two Dimensions **D4a** Describe the contribution of Newton to our understanding of force and motion, and give examples of and apply Newton's three laws of motion and his theory of gravitation. **D4b** Explain and apply the ideas of relative motion and frame of reference.	Student will: ✓ explain that all motion is relative and that a reference point is needed to describe motion. ✓ explain the difference between scalar and vector quantities. ✓ calculate velocity in one direction. ✓ calculate acceleration in one direction. ✓ calculate displacement and velocity by applying the equations of constant acceleration. ✓ describe and calculate resultant displacement in two dimensions. ✓ describe and calculate resultant velocity in two dimensions. ✓ describe and calculate resultant acceleration in two dimensions. ✓ apply the concept of universal gravitation in two-dimensional motion problems. ✓ describe the factors that affect the magnitude of gravitational acceleration on the earth's surface.	✓ Why is motion relative? ✓ How do we use direction to describe motion? ✓ What are speed and velocity and how are they calculated? ✓ What is acceleration and how is it calculated? ✓ How is displacement calculated when motion occurs in more than one direction in one dimension? ✓ How is velocity calculated when motion occurs in more than one direction in one dimension? ✓ How is acceleration calculated when motion occurs in more than one direction in one dimension? ✓ What is gravitational acceleration (on the earth's surface)? ✓ How is displacement calculated in two dimensions? ✓ How is velocity calculated in two dimensions? ✓ How is acceleration calculated in two dimensions?	**Lab:** Motion in one dimension **Part I:** **Problem—**Determine the displacement, speed, and velocity of an object moving in one dimension. **Part II:** **Problem—**Determine the acceleration of an object moving in one dimension. **Part III:** **Problem—**Use acceleration to determine velocity and displacement. **Equipment:** tape measure, stop watch, wind up car **Lab:** Acceleration Due to Gravity **Problem:** How do the final velocities and average accelerations of different objects dropped from the same height compare? **Equipment:** tape measure, watch, balls **Lab:** Projectile Motion **Problem:** Determine the vertical displacement and final horizontal and vertical velocities of a ball by graphically analyzing a data set. **Equipment:** baseballs, pitching machine, stopwatch, tape measure *Introduce astronomy journals. (See note at end.) Test: Unit 1
Unit 2 3 Weeks Ch 2-4 Forces **D4a** Describe the contribution of	Student will:: ✓ explain what a force is ✓ explain how forces are produced ✓ explain the causes of the following forces: ✓ tension ✓ compression	✓ What is a force? ✓ Where do forces come from? ✓ What types of forces are there and how do they behave differently? ✓ What happens when more than one force acts on an object? ✓ How can we show the forces acting on an	**Lab:** Forces on Materials **Problem:** How do different forces affect the integrity of spaghetti? **Equipment:** weights, stands, spring scales, uncooked spaghetti **Lab:** Torque Comparison

Newton to our understanding of force and motion, and give examples of and apply Newton's three laws of motion and his theory of gravitation. **D4b** Explain and apply the ideas of relative motion and frame of reference.	✓ load ✓ torsion ✓ shearing ✓ torque ✓ friction ✓ describe the effects on an object of the following forces: ✓ tension ✓ compression ✓ load ✓ torsion ✓ friction ✓ torque ✓ calculate torque on objects under different conditions. ✓ calculate the net force of an object in one dimension. ✓ calculate the net force on an object in two dimensions. ✓ calculate the magnitude and direction of a frictional force acting on an object. ✓ draw a free body diagram and explain how it represents the forces acting on an object.	object?	**Problem:** How does varying the amount and location of mass affect the torque of a meter stick? **Equipment:** meter sticks, meter stick balancing stands, weight sets **Lab:** Friction **Problem:** Determine the amount of frictional force between different surfaces. **Project:** Balsa Wood Bridges Students will design and build balsa wood bridges to support a given load.
Unit 3 3 weeks Ch 2-4 Newton's Laws of Motion **D4a** Describe the contribution of Newton to our understanding of force and motion, and give examples of and apply Newton's three laws of motion and his theory of gravitation.	Student will: ✓ state and explain *Newton's First Law of Motion.* ✓ provide a descriptive example of *Newton's First Law of Motion*. ✓ explain what inertia is. ✓ explain how mass determines inertia. ✓ explain that mass is not weight. ✓ state and explain *Newton's Second Law of Motion.* ✓ provide a descriptive example of *Newton's Second Law of Motion.* ✓ explain that weight is a force. ✓ calculate the magnitude of a single force acting on an object based on its mass and acceleration ✓ calculate the acceleration of an object acted on by a frictional force.	✓ What is *Newton's First Law of Motion*? ✓ What is inertia? ✓ What is mass? ✓ How are mass and inertia related? ✓ What is *Newton's Second Law of Motion*? ✓ How are force and acceleration related? ✓ How are mass and acceleration related? ✓ What is Newton's Third Law of Motion? ✓ What is equilibrium and how does it affect the motion of an object? ✓ How is the concept of equilibrium applied?	**Lab:** Inertia Lab **Problem:** Compare the inertias of different objects and how this affects their acceleration by launching projectiles with different masses. **Equipment:** physics cart, small dolls or clay, ramps, tape measure, stop watches or photo-gate timers **Lab:** Effect of Mass on Acceleration **Problem:** How does changing the mass on a cart change the acceleration of the cart? **Equipment:** physics cart, weight set, ramp, tape measure, stop watches or photo-gate timers. **Lab:** Equilibrium **Problem:** Use a series of carts, pulleys,

D4b Explain and apply the ideas of relative motion and frame of reference.	✓ state and explain Newton's Third Law of Motion. ✓ provide a descriptive example of Newton's Third Law of Motion. ✓ determine if a system is in equilibrium by calculating net force.		and masses to create a system that is in equilibrium (moves at constant velocity). **Equipment:** pulleys, weight set, ramp, physics cart, stop watches or photo-gate timers, tape measure **Project:** Egg Drop **Problem:** Design and construct a crate that keeps an egg from breaking when dropped from a given height. **Equipment:** stopwatch, tape measure, materials for crate (see attachment) Test: Units 2 and 3
Unit 4 2 weeks Ch 6 Momentum **D4b** Explain and apply the ideas of relative motion and frame of reference.	Student will: ✓ explain what momentum is. ✓ calculate the net momentum of a system. ✓ predict and calculate changes in momentum. ✓ explain and provide examples for the *Law of Conservation of Momentum*. ✓ explain what happens during elastic and inelastic collisions. ✓ apply the *Law of Conservation of Momentum* to elastic and inelastic collisions.	✓ What is momentum? ✓ What factors determine the total momentum of a system? ✓ How is momentum changed? ✓ How is momentum conserved? ✓ What happens during collisions?	**Lab:** "Train Wreck" **Problem:** Is momentum conserved? Compare initial and final velocity of "Thomas" trains before and after collisions. **Equipment:** "Thomas" trains, train tracks, ramp, photo-gate timers or stop watches, tape measure
Unit 5 3 weeks Ch 7, 16, 18 Energy **D3i** Explain the relationship between kinetic and potential energy and apply the knowledge to solve problems.	Student will: ✓ state and explain the *Law of Conservation of Energy*. ✓ provide a descriptive example of the Law of Conservation of Energy. ✓ explain how energy is conserved. ✓ give examples of different forms of energy. ✓ explain how energy changes forms. ✓ calculate kinetic energy. ✓ calculate potential energy. ✓ apply the *Law of Conservation of Energy* to calculate energy changes. ✓ relate work, power, and energy.	✓ What does the *Law of Conservation of Energy state*? ✓ How is energy conserved? ✓ What are the different forms of energy? ✓ How does energy change forms? ✓ How is the *Law of Conservation of Energy* applied? ✓ What are work and power? ✓ How are energy, work, and power related?	**Lab:** Sledding Lab **Problem:** Determine the magnitude of the frictional force on a person sledding down a hill. Determine if energy is conserved during this process. **Equipment:** sled, stopwatch, tape measure or gps (See attachment.) **Project:** Energy Changes **Problem:** Determine how the kinetic and potential energy of a marble changes on a marble roller coaster. **Equipment:** marbles, cardboard tubes,

D3j Describe how in energy transformations the total amount of energy remains the same, but because of inefficiencies (heat, sound, and vibration) useful energy is often lost through radiation or conduction. **D3k** Apply an understanding of energy transformations to solve problems.	✓ calculate work. ✓ calculate power.		materials to support tubes, meter sticks, stop watches (See attachment.)
Unit 6 3 weeks Ch 8, 10 Circular, Rotational, and Periodic Motion **D4a** Describe the contribution of Newton to our understanding of force and motion, and give examples of and apply Newton's three laws of motion and his theory of gravitation. **D4b** Explain and apply the ideas of relative motion	Student will: ✓ describe the factors that determine the period of a pendulum ✓ state and apply Hooke's Law ✓ compare and contrast rotation and revolution and provide examples of each. ✓ explain how linear and rotational speed are related. ✓ apply the relationship between rotational and linear speed to calculate each. ✓ compare and contrast centripetal and centrifugal forces and provide examples of their effects. ✓ explain what the center of gravity and center of mass are and how they affect rotation. ✓ compare the rotation of objects of different sizes and shapes. ✓ explain how the size and shape of an object affect its rotational inertia. ✓ explain how rotational inertia affects rotational motion.	✓ How are rotation and revolution different? ✓ How are rotational and linear speed related? ✓ What are centripetal and centrifugal forces and how do they affect objects? ✓ What are center of gravity and center mass and what are their importance to the rotation of an object? ✓ What is rotational inertia and what determines the rotational inertia of an object? ✓ How does the rotational inertia of an object affect its rotational motion?	**Lab:** Pendulums **Problem:** What determines the period of a pendulum? **Equipment:** ring stands, string, pendulum bobs, meter sticks, stop watches **Lab:** Hooke's Law **Problem:** Graphically determine Hooke's constant for different springs. **Equipment:** ring stand, variety of springs, weight set, meter stick, stop watches **Lab:** Center of Gravity/Center of Mass **Problem:** Compare the center of gravity and center of mass of different people. **Equipment:** students, meter sticks Test: Units 4, 5, and 6

and frame of reference.			
Unit 7 1 week Ch 9, 35 and supplemental materials Gravity and Space **D1a** Explain why the unit of light years can be used to describe distances to objects in the universe and use light years to describe distances. **D1b** Explain the role of gravity in forming and maintaining planets, stars, and the solar system. **D1c** Outline the age, origin, and process of formation of the universe as currently understood by science. **D1d** Describe the major events that have led to our current understanding of the universe and	Student will: ✓ explain what gravity is. ✓ explain how mass and distance affect gravity. ✓ give examples of variations in gravitational force. ✓ explain what causes satellite motion and describe the factors that affect satellite motion. ✓ describe the formation of the universe as currently understood by astronomers. ✓ explain how distance is measured in space. ✓ describe how astronomers have developed their current understanding of the universe. ✓ explain how light is used to determine the distance to objects in space. ✓ explain how evidence that supports the Big Bang Theory has been collected. ✓ explain how scientists have been able to arrive at the idea that the universe is expanding.	✓ What is gravitational force? ✓ What factors affect the strength of a gravitational force? ✓ What is satellite motion and what factors affect satellite motion? ✓ How was the universe formed and how has it changed? ✓ How do we know how far away things are in space? ✓ How do astronomers study the universe? ✓ How big is the universe and how do we know? ✓ How old is the universe and how do we know? ✓ How do we know that the universe is expanding?	**Planetarium Presentations:** Students will use information from their astronomy journals to give a short presentation about the local night sky, using the school planetarium. (This assignment will be scored as a lab.) **Project:** Space Probe Project Students will research, design, and construct a model of a space probe to carry out a specific mission.

the current technologies used to further our understanding.			

Unit 8
2 weeks
Ch 19
 	
Waves
 	
D4d Describe and apply characteristics of waves including wavelength, frequency, and amplitude.
 	
D4e Describe and apply an understanding of how waves interact with other waves and with materials including reflection, refraction, and absorption.
 	
D4f Describe kinetic energy (the energy of motion), potential energy (dependent on relative position), and energy contained by a field (including electromagnetic waves) and apply these understandings to energy problems.
	Student will:
	✓ explain how vibrations and waves are related.
	✓ explain that waves are the transference of energy.
	✓ compare and contrast longitudinal and transverse waves.
	✓ determine the period, wave length, and frequency of different transverse and longitudinal waves.
	✓ compare and contrast the properties of waves as they move through different materials.
	✓ describe and provide examples of:
	  ✓ interference
	  ✓ standing waves
	  ✓ the Doppler effect
	  ✓ bow waves
	  ✓ shock waves
	  ✓ reflection and refraction
	✓ calculate wavelength, speed, and frequency.
		✓ How are vibrations and energy related?
		✓ What are waves and what are the properties of waves?
		✓ What are the properties of the different types of waves?
		✓ What happens when waves move through different mediums?
		✓ What happens when waves interact with each other?
			Lab: Comparing Waves
			Problem: How does the movement of transverse and longitudinal waves compare as they move through different materials (“slinky”, different springs, different types of rope)?
			Equipment: string/rope, springs, tape measure, stopwatch
			
			Lab: Wave Interactions
			Problem: Use “slinky”, springs and rope to model: 1) standing waves, 2) reflection, 3) refraction, and 4) interference.
			Equipment: string/rope, springs

Unit 9 2 week Ch 20, 26, 28, 29 Sound and Light **D4e** Describe and apply an understanding of how waves interact with other waves and with materials including reflection, refraction, and absorption.	Student will: ✓ explain that sound is a type of electromagnetic radiation caused by vibrations of different materials. ✓ explain how sound is affected by the medium through which it moves. ✓ explain how and why sounds vary. ✓ provide examples of technological applications of sound. ✓ compare the wave and particle theories of light. ✓ compare and contrast visible and UV light. ✓ compare and contrast how light behaves as it travels through or is absorbed or reflected by different materials. ✓ explain how light is polarized. ✓ explain why different colors are visible. ✓ compare reflection and refraction. ✓ compare and contrast different types of lenses.	✓ What causes sound? ✓ What factors affect and change sounds? ✓ How can sound be applied through technology? ✓ What is light? ✓ How does light vary within the electromagnetic spectrum? ✓ Why do we see things the way we do? ✓ What is polarization and how does it occur? ✓ How do lenses work? ✓ How do reflection and refraction affect light?	**Lab:** Comparing Sounds **Problem:** How do the sounds produced by the vibrations of different materials compare? **Equipment:** tuning forks **Lab:** Prisms **Problem:** How does the shape of a prism affect the light that passes through it? **Equipment:** prisms, colored pencils **Project:** Pin-hole Cameras Students will design and build their own pin-hole cameras to create photographic images (see attachment). Test: Units 7 and 8
Unit 10 7 weeks Ch 22-25 Electricity and Magnetism **D4c** Describe the relationship between electric and magnetic fields and forces, and give examples of how this relationship is used in modern	Student will: ✓ explain that electrical forces are produced by an uneven distribution of charge. ✓ apply *Coulombe's Law* to calculate electrical forces. ✓ compare and contrast conductors, semi-conductors, and insulators. ✓ demonstrate induction, charge by friction, charge by contact and polarization. ✓ explain how electric fields result around electric charges. ✓ draw an electric field. ✓ explain how electric current is produced and moves. ✓ explain how resistance is produced	✓ What are electric forces and what produces them? ✓ How does *Coulombe's Law* help us determine the strength of electrical forces? ✓ How do electrons behave in different materials? ✓ What is an electric field and what produces it? ✓ How do we represent electric fields? ✓ What is electric potential? ✓ How does a battery work? ✓ How is electric current produced? ✓ What causes resistance? ✓ How is *Ohm's Law* applied? ✓ How are alternating and direct current different?	**Lab:** Electrostatics **Problem:** Compare the static charge produced by friction between two objects. **Equipment:** different fabrics, plastics, foil **Lab:** Electromagnets **Problem:** Create a basic electromagnet with a battery, nail, and wire. **Equipment:** iron nail, copper wire, 9 volt battery **Lab:** Series vs. Parallel Circuits **Problem:** Compare the amount of current and voltage that flow through series and parallel circuits.

technologies. **D3j** Describe how in energy transformations the total amount of energy remains the same, but because of inefficiencies (heat, sound, and vibration) useful energy is often lost through radiation or conduction. **D3k** Apply an understanding of energy transformations to solve problems.	and how it affects current. ✓ compare and contrast current flow and resistance in parallel and series circuits. ✓ apply Ohm's Law across parallel and series circuits. ✓ construct circuits to perform specific tasks. ✓ compare and contrast AC and DC current. ✓ explain how electric power and energy can be produced and provide several descriptive examples. ✓ explain what a magnetic field is and how it is produced.	✓ How are electric power and energy produced? ✓ How do series and parallel circuits affect current flow and resistance? ✓ How is a magnetic field produced? ✓ How can magnets be used to produce electrical currents?	**Equipment:** power source or batteries, wires, light bulbs, switches, circuit boards **FINAL ASSESSMENT:** Wind Turbines (see attachment) **Note:** All projects will be scored as a test grade, except for the final assessment, which will be waited as two test grades. **Note:** Students will use the astronomy journals to keep weekly observations of the local night sky.