Curriculum Map: Principles of Technology

Course: PHYSICS Sub-topic: Physics

Grade(s): 11

Course Description:	Principles of Technology is a Physics based class that studies four basics energy systems of Mechanical, Fluid, Electrical, and Thermal. There is a small math basis of the class, but the majority class is concept based. Topics that are discussed are: Force, pressure, voltage, temperature difference, work, motion, friction, ohm's law, energy, and power.
Course Textbooks, Workbooks, Materials Citations:	Physics in Context Cord Communications, 2010

Unit: Mathematical Review

Timeline: Week 1 to 2

Unit Description:	This unit is designed as a review of the basic math concepts that we will be using during the school year. These concepts include: Basic Math, Order of Operations, Basic Algebra, Geometry, and Solving Word Problems.
Unit Essential Questions:	How is mathematics used to quantify, compare, represent, and model numbers? How can mathematics support effective communication? How are relationships represented mathematically? What does it mean to estimate or analyze numerical quantities? How can expressions, equations and inequalities be used to quantify, solve, model and/or analyze mathematical situations? What makes a tool and/or strategy appropriate for a given task? How can patterns be used to describe relationships in mathematical situations? How are spatial relationships, including shape and dimension, used to draw, construct, model, and represent real situations or solve problems?
Unit Big Ideas:	Mathematical relationships among numbers can be represented, compared, and communicated. Mathematical relationships can be represented as expressions, equations and inequalities in mathematical situations. Mathematical relations and functions can be modeled through multiple representations and analyzed to raise and answer questions. Geometric relationships can be described, analyzed, and classified based on spatial reasoning and/or visualization.
Unit Materials:	Textbook Calculator Various Worksheets Math Preview Test
Unit Assignments:	The students will be assigned a math review worksheet for each topic of the Math Review. The students will have time in class to start the assignment and then complete the remainder of the assignment on their own time. At the end of the unit there will be a Math Review test on the concepts learned during this review.
Unit Key Terminology & Definitions :	Absolute Value Additive Inverse

Arithmetic Sequence

Associative Property

Bar Graph

Communative Property

Equivalent

Exponential

Geometric Sequence

Inverse

Multiplicative Sequence

Complementary Angles

Supplementary Angles

STANDARDS:

STANDARDS

STATE: PA Core Standards (2014)

CC.2.1.HS.F.2 (Advanced)	Apply properties of rational and irrational numbers to solve real world or mathematical problems.
CC.2.1.HS.F.4 (Advanced)	Use units as a way to understand problems and to guide the solution of multi-step problems.
CC.2.1.HS.F.6 (Advanced)	Extend the knowledge of arithmetic operations and apply to complex numbers.
CC.2.2.HS.C.1 (Advanced)	Use the concept and notation of functions to interpret and apply them in terms of their context.
CC.2.2.HS.C.3 (Advanced)	Write functions or sequences that model relationships between two quantities.
CC.2.2.HS.C.5 (Advanced)	Construct and compare linear, quadratic, and exponential models to solve problems.
CC.2.2.HS.D.2 (Advanced)	Write expressions in equivalent forms to solve problems.
CC.2.2.HS.D.9 (Advanced)	Use reasoning to solve equations and justify the solution method.
CC.2.3.HS.A.1 (Advanced)	Use geometric figures and their properties to represent transformations in the plane.
CC.2.3.HS.A.8 (Advanced)	Apply geometric theorems to verify properties of circles.
CC.2.3.HS.A.14 (Advanced)	Apply geometric concepts to model and solve real world problems.

(* standards consolidated from Topic level)

Topic: Basic Math

Minutes for Topic: 44

STANDARDS

STATE: PA Core Standards (2014)

CC.2.1.HS.F.2 (Advanced)	Apply properties of rational and irrational numbers to solve real world or mathematical problems.
CC.2.1.HS.F.6 (Advanced)	Extend the knowledge of arithmetic operations and apply to complex numbers.

Topic: Order of Operations

Minutes for Topic: 44

STANDARDS

STATE: PA Core Standards (2014)

CC.2.1.HS.F.6 (Advanced)	Extend the knowledge of arithmetic operations and apply to complex numbers.

CC.2.2.HS.C.1 (Advanced)	Use the concept and notation of functions to interpret and apply them in terms of their context.

Topic: Algebra Review

Minutes for Topic: 88

STANDARDS

STATE: PA Core Standards (2014)

CC.2.2.HS.C.1 (Advanced)	Use the concept and notation of functions to interpret and apply them in terms of their context.
CC.2.2.HS.C.3 (Advanced)	Write functions or sequences that model relationships between two quantities.
CC.2.2.HS.C.5 (Advanced)	Construct and compare linear, quadratic, and exponential models to solve problems.
CC.2.2.HS.D.2 (Advanced)	Write expressions in equivalent forms to solve problems.
CC.2.2.HS.D.9 (Advanced)	Use reasoning to solve equations and justify the solution method.

Topic: Geometry Review

Minutes for Topic: 44

STANDARDS

STATE: PA Core Standards (2014)

CC.2.3.HS.A.1 (Advanced)	Use geometric figures and their properties to represent transformations in the plane.
CC.2.3.HS.A.8 (Advanced)	Apply geometric theorems to verify properties of circles.
CC.2.3.HS.A.14 (Advanced)	Apply geometric concepts to model and solve real world problems.

Topic: Word Problems Review

Minutes for Topic: 44

STANDARDS

STATE: PA Core Standards (2014)

CC.2.1.HS.F.4 (Advanced)	Use units as a way to understand problems and to guide the solution of multi-step problems.

Unit: Forces as Prime Movers

Timeline: Week 3 to 8

Unit Description: In this unit we will be discussing the topics as Force as a Prime Mover. A Prime Mover is defined as a force like quantity that causes motion. The sequence of the class is to discuss the force like quantities in their specific energy systems one at a time. Mechanical: Force and Torque, Fluid: Pressure, Electrical: Voltage, and Thermal: Temperature Difference.

Unit Essential Questions: How can one explain and predict interactions between objects within systems?

Unit Big Ideas: Interactions between any two objects can cause changes in one or both of them.

Unit Materials: Textbook and associated curriculum

Lab equipment

Unit Assignments: Classwork will be vocabulary, general questions about each topic, and a mathematical application of each topic.

Each topic will consist of a lab experiment that coinsides with each topic.

Unit Key Terminology & Definitions :

Force

System

Mass

Net Force

Pressure

Voltage

Temperature Difference

STANDARDS:

STANDARDS

NGSS Arranged by Topic - Science (2013)

HS-PS2-1 (Advanced)	Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.

Topic: Force and Torque

Minutes for Topic: 352

STANDARDS

NGSS Arranged by Topic - Science (2013)

HS-PS2-1 (Advanced)	Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.

Topic: Pressure in Fluid Systems

Minutes for Topic: 308

STANDARDS

NGSS Arranged by Topic - Science (2013)

HS-PS2-1 (Advanced)	Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.

Topic: Voltage in Electrical Systems

Minutes for Topic: 308

STANDARDS

NGSS Arranged by Topic - Science (2013)

HS-PS2-4 (Advanced)	Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects.
HS-PS3-4 (Advanced)	Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).

Topic: Temperature Difference in Thermal Systems

Minutes for Topic: 352

STANDARDS

NGSS Arranged by Topic - Science (2013)

HS-PS2-4 (Advanced)	Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects.
HS-PS3-4 (Advanced)	Plan and conduct an investigation to provide evidence that the transfer of thermal

energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).

Unit: Work

Timeline: Week 9 to 12

Unit Description: In this unit we will discuss the scientific defintion of work and how the use of Prime Movers creates work in the scientific definition.

Unit Essential Questions: How is energy transferred and conserved?

Unit Big Ideas: Interactions of objects or systems of objects can be predicted and explained using the concept of energy transfer and conservation.

Unit Materials: Textbook and associated curriculum

Lab equipment

Unit Assignments: Classwork will be vocabulary, general questions about each topic, and a mathematical application of each topic.

Each topic will consist of a lab experiment that coinsides with each topic.

Unit Key Terminology & Definitions :

Force

System

Mass

Net Force

Displacement

Electrostatic Force

Gravitational Force

STANDARDS:

STANDARDS

NGSS Arranged by Topic - Science (2013)

HS-PS3-1 (Advanced)	Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.
HS-PS3-2 (Advanced)	Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative position of particles (objects).
HS-PS3-4 (Advanced)	Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).

(* standards consolidated from Topic level)

Topic: Work in Linear and Rotational Systems

Minutes for Topic: 440

STANDARDS

NGSS Arranged by Topic - Science (2013)

HS-PS3-1 (Advanced)	Create a computational model to calculate the change in the energy of one

	component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.
HS-PS3-2 (Advanced)	Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative position of particles (objects).
HS-PS3-4 (Advanced)	Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).

Topic: Work in Fluid Systems

Minutes for Topic: 220

STANDARDS

NGSS Arranged by Topic - Science (2013)

HS-PS3-1 (Advanced)	Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.
HS-PS3-2 (Advanced)	Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative position of particles (objects).
HS-PS3-4 (Advanced)	Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).

Topic: Work in Electrical Systems

Minutes for Topic: 220

STANDARDS

NGSS Arranged by Topic - Science (2013)

HS-PS3-1 (Advanced)	Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.
HS-PS3-2 (Advanced)	Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative position of particles (objects).
HS-PS3-4 (Advanced)	Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).

Unit: Rates

Timeline: Week 13 to 18

Unit Description:	In this unit we will discuss the concept of Rates and how it applies to the four different energy systems.
Unit Essential Questions:	How can one explain and predict interactions between objects within systems?
Unit Big Ideas:	Interactions between any two objects can cause changes in one or both of them. Interactions of objects or systems of objects can be predicted and explained using the concept of energy transfer and conservation.
Unit Materials:	Textbook and associated curriculum materials Lab equipment.
Unit Assignments:	Classwork will be vocabulary, general questions about each topic, and a mathematical application of each topic.

Each topic will consist of a lab experiment that coinsides with each topic.

Unit Key Terminology & Definitions : Force System Velocity Acceleration Mass Net Force

STANDARDS:

STANDARDS

NGSS Arranged by Topic - Science (2013)

HS-PS2-6 (Advanced)	Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.
HS-PS2-1 (Advanced)	Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.
HS-PS2-5 (Advanced)	Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current.
HS-PS3-4 (Advanced)	Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).
HS-PS3-5 (Advanced)	Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.

(* standards consolidated from Topic level)

Topic: Speed, Velocity, and Acceleration

Minutes for Topic: 440

STANDARDS

NGSS Arranged by Topic - Science (2013)

HS-PS2-1 (Advanced)	Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.

Topic: Fluid and Mass Flow Rate

Minutes for Topic: 220

Topic: Electric Current and Frequency

Minutes for Topic: 396

STANDARDS

NGSS Arranged by Topic - Science (2013)

HS-PS2-6 (Advanced)	Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.
HS-PS2-5 (Advanced)	Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current.
HS-PS3-5 (Advanced)	Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.

Topic: Heat Flow Rate

Minutes for Topic: 264

STANDARDS

NGSS Arranged by Topic - Science (2013)

HS-PS3-4 (Advanced)	Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).

Unit: Resistance

Timeline: Week 19 to 25

Unit Description: In this unit we will discuss the concept of resistance forces in each of the four different energy systems.

Unit Essential Questions: How can one explain and predict interactions between objects within systems?

Unit Big Ideas: Interactions between any two objects can cause changes in one or both of them.

Unit Materials: The textbook and associated curriculum.

Lab Equipment.

Unit Assignments: Classwork will be vocabulary, general questions about each topic, and a mathematical application of each topic.

Each topic will consist of a lab experiment that coinsides with each topic.

Unit Key Terminology & Definitions : Force

System

Mass

Net Force

STANDARDS:

STANDARDS

NGSS Arranged by Topic - Science (2013)

HS-PS2-6 (Advanced)	Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.
HS-PS2-1 (Advanced)	Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.
HS-PS2-4 (Advanced)	Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects.
HS-PS3-5 (Advanced)	Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.

(* standards consolidated from Topic level)

Topic: Friction

Minutes for Topic: 220

STANDARDS

NGSS Arranged by Topic - Science (2013)

HS-PS2-1 (Advanced)	Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.

HS-PS2-4 (Advanced)	Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects.

Topic: Fluid Resistance and Drag

Minutes for Topic: 440

STANDARDS

NGSS Arranged by Topic - Science (2013)

HS-PS2-1 (Advanced)	Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.
HS-PS2-4 (Advanced)	Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects.

Topic: Ohm's Law, Resistors in Series and Parallel

Minutes for Topic: 660

STANDARDS

NGSS Arranged by Topic - Science (2013)

HS-PS2-6 (Advanced)	Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.
HS-PS2-1 (Advanced)	Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.
HS-PS3-5 (Advanced)	Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.

Topic: Thermal Resistance

Minutes for Topic: 220

STANDARDS

NGSS Arranged by Topic - Science (2013)

HS-PS3-5 (Advanced)	Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.

Unit: Energy

Timeline: Week 26 to 31

Unit Description:	In this Unit will be discussing the concept of energy and its conservation in the four different energy systems. Topics will include: Kinetic Energy, Potential Energy, Electrical Energy, and Thermal Energy.
Unit Essential Questions:	How is energy transferred and conserved?
Unit Big Ideas:	Interactions of objects or systems of objects can be predicted and explained using the concept of energy transfer and conservation.
Unit Materials:	Textbook and associated curriculum Lab Equipment
Unit Assignments:	Classwork will be vocabulary, general questions about each topic, and a mathematical application of each topic. Each topic will consist of a lab experiment that coinsides with each topic.

Unit Key Terminology & Definitions : Kinetic energy Mechanical energy Potential energy Energy transfer Model System Conservation of energy Evidence Investigation

STANDARDS:

STANDARDS

NGSS Arranged by Topic - Science (2013)

HS-PS2-4 (Advanced)	Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects.
HS-PS2-5 (Advanced)	Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current.
HS-PS3-3 (Advanced)	Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.
HS-PS3-4 (Advanced)	Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).
HS-PS3-5 (Advanced)	Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.

(* standards consolidated from Topic level)

Topic: Kinetic Energy

Minutes for Topic: 264

STANDARDS

NGSS Arranged by Topic - Science (2013)

HS-PS3-3 (Advanced)	Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.
HS-PS3-4 (Advanced)	Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).
HS-PS3-5 (Advanced)	Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.

Topic: Potential Energy and Conservation of Energy

Minutes for Topic: 396

STANDARDS

NGSS Arranged by Topic - Science (2013)

HS-PS3-3 (Advanced)	Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.
HS-PS3-4 (Advanced)	Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).
HS-PS3-5 (Advanced)	Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.

Topic: Electrical Energy in Capacitors and Inductors

Minutes for Topic: 308

STANDARDS

NGSS Arranged by Topic - Science (2013)

HS-PS2-4 (Advanced)	Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects.
HS-PS2-5 (Advanced)	Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current.
HS-PS3-5 (Advanced)	Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.

Topic: Thermal Resistance and Insulation

Minutes for Topic: 352

STANDARDS

NGSS Arranged by Topic - Science (2013)

HS-PS3-4 (Advanced)	Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).

Unit: Power

Timeline: Week 32 to 36

Unit Description: In this topic we will be discussing the concept of Power as it related to each of the four different systems.

Unit Essential Questions: How is energy transferred and conserved?

Unit Big Ideas: Interactions of objects or systems of objects can be predicted and explained using the concept of energy transfer and conservation.

Unit Materials: Textbook and associated curriculum

Lab equipment

Unit Assignments: Classwork will be vocabulary, general questions about each topic, and a mathematical application of each topic.

Each topic will consist of a lab experiment that coinsides with each topic.

Unit Key Terminology & Definitions : Force

System

Mass

Net Force

STANDARDS:

STANDARDS

NGSS Arranged by Topic - Science (2013)

HS-PS2-1 (Advanced)	Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.
HS-PS2-4 (Advanced)	Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects.
HS-PS2-5 (Advanced)	Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a

changing magnetic field can produce an electric current.

HS-PS3-5 (Advanced)	Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.

(* standards consolidated from Topic level)

Topic: Linear and Rotational Power

Minutes for Topic: 440

STANDARDS

NGSS Arranged by Topic - Science (2013)

HS-PS2-1 (Advanced)	Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.
HS-PS2-4 (Advanced)	Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects.

Topic: Fluid Power

Minutes for Topic: 264

STANDARDS

NGSS Arranged by Topic - Science (2013)

HS-PS2-1 (Advanced)	Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.
HS-PS2-4 (Advanced)	Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects.

Topic: Electrical Power

Minutes for Topic: 396

STANDARDS

NGSS Arranged by Topic - Science (2013)

HS-PS2-4 (Advanced)	Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects.
HS-PS2-5 (Advanced)	Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current.
HS-PS3-5 (Advanced)	Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.