Warren County School District

PLANNED INSTRUCTION

COURSE DESCRIPTION

Course Title: _AP Physics 1____

Course Number: ____

Course Prerequisites: appropriate algebra course work_______________________

Course Description: (Include "no final exam" or "final exam required")

AP Physics 1 is an algebra-based, introductory college-level physics course that explores topics such as Newtonian mechanics (including rotational motion); work, energy, and power; mechanical waves and sound; and introductory, simple circuits. Through inquiry-based learning, students will develop scientific critical thinking and reasoning skills.

Suggested Grade Level: ______10, 11 ,12_____

Length of Course: ______ One Semester ___x___ Two Semesters ______Other (Describe)

Units of Credit: _______1______ (Insert ***NONE*** if appropriate.)

PDE *Certification and Staffing Policies and Guidelines (CSPG)* Required Teacher Certification(s) (Insert certificate title and CSPG#) **___Physics_______**

Certification verified by WCSD Human Resources Department:

___x___ Yes _______ No

Board Approved Textbooks, Software, Materials:
Title:

TEXTBOOK:

- **Etkina, Eugenia, Michael Gentile, and Alan Van Heuvelen. College Physics. San Francisco, CA: Pearson, 2014. [CR1]**

TEACHING RESOURCES:

- **Christian, Wolfgang, and Mario Belloni. Physlet® Physics: Interactive Illustrations, Explorations and Problems for Introductory Physics. Upper Saddle River, NJ: Prentice Hall, 2004.**

- **Hieggelke, Curtis, David Maloney, and Stephen Kanim. Newtonian Tasks Inspired by Physics Education Research: nTIPERs. Upper Saddle River, NJ: Pearson, 2012.**

- **Hieggelke, Curtis, David Maloney, Tomas O'Kuma, and Stephen Kanim. E&M TIPERs: Electricity & Magnetism Tasks. Upper Saddle River, NJ: Pearson, 2006.**

- **Knight, Randall D., Brian Jones, and Stuart Field. College Physics: A Strategic Approach. 2nd ed., AP® ed. Boston: Pearson, 2013.**

Publisher:
ISBN #:
Copyright Date:
Date of WCSD Board Approval:

BOARD APPROVAL:

Date Written: 7/2014

Date Approved:______________

Implementation Year: 2014-2015

SPECIAL EDUCATION AND GIFTED REQUIREMENTS

The teacher shall make appropriate modifications to instruction and assessment based on a student's Individual Education Plan (IEP) or Gifted Individual Education Plan (GIEP).

SPECIFIC EDUCATIONAL STANDARDS, ESSENTIAL QUESTIONS, CONTENT, & SKILLS

Course Syllabus AP Physics 1

INSTRUCTIONAL STRATEGIES

The AP Physics 1 course is conducted using **inquiry-based instructional strategies** that focus on experimentation to develop students' conceptual understanding of physics principles. The students begin studying a topic by making observations and discovering patterns of natural phenomena. The next steps involve developing, testing and applying models. Throughout the course, the students construct and use multiple representations of physical processes, solve multi-step problems, design investigations, and reflect on knowledge construction through self-assessment rubrics.

In most labs, the students use probeware technology in data acquisition. In the classroom, they use graphing calculators and digital devices for interactive simulations, Physlet-based exercises, collaborative activities and formative assessments.

COURSE SYLLABUS

UNIT 1. KINEMATICS [CR2a]

- Kinematics in one-dimension: constant velocity and uniform accelerated motion
- Vectors: vector components and resultant
- Kinematics in two-dimensions: projectile motion

Big Idea 3

Learning Objectives: 3.A.1.1, 3.A.1.2, 3.A.1.3

UNIT 2. DYNAMICS [CR2b]

- Forces, types and representation (FBD)
- Newton's First Law
- Newton's Third Law
- Newton's Second Law
- Applications of Newton's 2nd Law
- Friction
- Interacting objects: ropes and pulleys

Big Ideas 1, 2, 3, 4

Learning Objectives: 1.C.1.1, 1.C.1.3, 2.B.1.1, 3.A.2.1, 3.A.3.1, 3.A.3.2, 3.A.3.3, 3.A.4.1, 3.A.4.2, 3.A.4.3, 3.B.1.1, 3.B.1.2, 3.B.1.3, 3.B.2.1, 3.C.4.1, 3.C.4.2, 4.A.1.1, 4.A.2.1, 4.A.2.2, 4.A.2.3, 4.A.3.1, 4.A.3.2

UNIT 3. CIRCULAR MOTION AND GRAVITATION [CR2c]

- Uniform circular motion
- Dynamics of uniform circular motion
- Universal Law of Gravitation

Big Ideas 1, 2, 3, 4

Learning Objectives: 1.C.3.1, 2.B.1.1, 2.B.2.1, 2.B.2.2, 3.A.3.1, 3.A.3.3, 3.B.1.2, 3.B.1.3, 3.B.2.1, 3.C.1.1, 3.C.1.2, 3.C.2.1, 3.C.2.2, 3.G.1.1, 4.A.2.2

UNIT 4. ENERGY [CR2f]

- Work
- Power
- Kinetic energy
- Potential energy: gravitational and elastic
- Conservation of energy

Big Ideas 3, 4, 5

Learning Objectives: 3.E.1.1, 3.E.1.2, 3.E.1.3, 3.E.1.4, 4.C.1.1, 4.C.1.2, 4.C.2.1, 4.C.2.2, 5.A.2.1, 5.B.1.1, 5.B.1.2, 5.B.2.1, 5.B.3.1, 5.B.3.2, 5.B.3.3, 5.B.4.1, 5.B.4.2, 5.B.5.1, 5.B.5.2, 5.B.5.3, 5.B.5.4, 5.B.5.5, 5.D.1.1, 5.D.1.2, 5.D.1.3, 5.D.1.4, 5.D.1.5, 5.D.2.1, 5.D.2.3

UNIT 5. MOMENTUM [CR2e]

- Impulse
- Momentum
- Conservation of momentum
- Elastic and inelastic collisions

Big Ideas 3, 4, 5

Learning Objectives: 3.D.1.1, 3.D.2.1, 3.D.2.2, 3.D.2.3, 3.D.2.4, 4.B.1.1, 4.B.1.2, 4.B.2.1, 4.B.2.2, 5.A.2.1, 5.D.1.1, 5.D.1.2, 5.D.1.3, 5.D.1.4, 5.D.1.5, 5.D.2.1, 5.D.2.2, 5.D.2.3, 5.D.2.4,5.D.2.5, 5.D.3.1

UNIT 6. SIMPLE HARMONIC MOTION [CR2d]

- Linear restoring forces and simple harmonic motion
- Simple harmonic motion graphs
- Simple pendulum
- Mass-spring systems

Big Ideas 3, 5

Learning Objectives: 3.B.3.1, 3.B.3.2, 3.B.3.3, 3.B.3.4, 5.B.2.1, 5.B.3.1, 5.B.3.2, 5.B.3.3, 5.B.4.1, 5.B.4.2

UNIT 7. ROTATIONAL MOTION [CR2g]

- Torque
- Center of mass
- Rotational kinematics
- Rotational dynamics and rotational inertia
- Rotational energy
- Angular momentum
- Conservation of angular momentum

Big Ideas 3, 4, 5
Learning Objectives: 3.F.1.1, 3.F.1.2, 3.F.1.3, 3.F.1.4, 3.F.1.5, 3.F.2.1, 3.F.2.2, 3.F.3.1, 3.F.3.2, 3.F.3.3, 4.A.1.1, 4.D.1.1, 4.D.1.2, 4.D.2.1, 4.D.2.2, 4.D.3.1, 4.D.3.2, 5.E.1.1, 5.E.1.2, 5.E.2.1

UNIT 8. MECHANICAL WAVES [CR2j]

- Traveling waves
- Wave characteristics
- Sound
- Superposition
- Standing waves on a string
- Standing sound waves

Big Idea 6
Learning Objectives: 6.A.1.1, 6.A.1.2, 6.A.1.3, 6.A.2.1, 6.A.3.1, 6.A.4.1, 6.B.1.1, 6.B.2.1, 6.B.4.1, 6.B.5.1, 6.D.1.1, 6.D.1.2, 6.D.1.3, 6.D.2.1, 6.D.3.1, 6.D.3.2, 6.D.3.3, 6.D.3.4, 6.D.4.1, 6.D.4.2, 6.D.5.1

UNIT 9. ELECTROSTATICS [CR2h]

- Electric charge and conservation of charge
- Electric force: Coulomb's Law

Big Ideas 1, 3, 5
Learning Objectives: 1.B.1.1, 1.B.1.2, 1.B.2.1, 1.B.3.1, 3.C.2.1, 3.C.2.2, 5.A.2.1

UNIT 10. DC CIRCUITS [CR2i]

- Electric resistance
- Ohm's Law
- DC circuits
- Series and parallel connections
- Kirchhoff's Laws

Big Ideas 1, 5
Learning Objectives: 1.B.1.1, 1.B.1.2, 1.E.2.1, 5.B.9.1, 5.B.9.2, 5.B.9.3, 5.C.3.1, 5.C.3.2, 5.C.3.3

LABORATORY INVESTIGATIONS AND THE SCIENCE PRACTICES

The AP Physics 1 course devotes over **25% of the time** to laboratory investigations **[CR5].**
The laboratory component of the course allows the students to demonstrate the seven **science practices** through a variety of investigations in all of the foundational principles.

The students use **guided inquiry (GI)** or **open inquiry (OI)** in the design of their laboratory investigations. Some labs focus on investigating a physical phenomenon without having expectations of its outcomes. In other experiments, the student has an expectation of its outcome based on concepts constructed from prior experiences. In application experiments, the students use acquired physics principles to address practical problems.

All investigations are reported in a **laboratory journal**. Students are expected to record their observations, data, and data analyses. Data analyses include identification of the sources and effects of experimental uncertainty, calculations, results and conclusions, and suggestions for further refinement of the experiment as appropriate. **[CR7]**

UNIT	**LAB INVESTIGATION OBJECTIVE(S) CR6a** (Investigation identifier: Guided Inquiry: **GI** Open Inquiry: **OI**) **[CR6b]**	**SCIENCE PRACTICES [CR6b]**
UNIT 1. KINEMATICS	**1. Meeting Point (OI)** To predict where two battery-powered cars will collide if they are released from opposite ends of the lab table at different times.	1.1, 1.2, 1.4, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.1, 5.2, 5.3, 6.1, 6.2, 6.4, 7.2
	2. Match the Graph (GI) To determine the proper placement of an air track, a glider, and a motion detector to produce a motion that matches a set of given graphs: position, velocity and acceleration versus time.	1.2, 1.5, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.1, 5.3, 6.1, 6.4, 7.2
	3. Free-Fall Investigation (OI) To determine and compare the acceleration of two objects dropped simultaneously.	1.4, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.1, 5.3, 6.1, 6.4, 7.2
	4. Vector Addition (GI) To determine the value of a resultant of several vectors, and then compare that value to the values obtained through graphical and analytical methods.	1.1, 1.2, 1.4, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.3, 6.1, 6.4, 7.2
	5. Shoot the Target (OI) To determine the initial velocity of a projectile, the angle at which the maximum range can be attained and predict where the projectile will	1.4, 1.5, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.3, 6.1, 6.4, 7.2

	land.	
	6. Chase Scenario (OI) *Lab Practicum:* Students use a battery- cart and a fan cart to recreate a chase scenario (police-thief) to predict the position where the "'thief"' will be caught and the final speeds of both cars.	1.1, 1.2, 1.4, 1.5, 2.1, 2.2, 3.1, 3.2, 3.3, 4.1, 4.2, 4.3, 5.1, 5.2, 5.3, 6.1, 6.2, 6.4, 7.2
UNIT 2. DYNAMICS	**7. Inertial and Gravitational Mass (GI)** To determine the difference (if any) between inertial mass and gravitational mass.	1.4, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.3, 6.1, 6.4, 7.2
	8. Forces Inventory (GI) Qualitative and quantitative investigation on a variety of interactions between objects.	1,1, 1.4, 1.5, 2.1, 2.2, 3.3, 4.1, 4.2, 4.3, 5.1, 6.1, 6.2, 6.4, 7.2
	9. Static Equilibrium Challenge (OI) To determine the mass of a hanging object in a setup with three strings at various angles.	1.1, 1.4, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.1, 5.3, 6.1, 6.4, 7.2
	10. Newton's Second Law (OI) To determine the variation of the acceleration of a dynamics cart in two scenarios: (1) the total mass of the system is kept constant while the net force varies, and (2) the net force is kept constant while the total mass of the system varies.	1.1, 1.4, 1.5, 2.1, 2.2, 3.1, 3.2, 3.3, 4.1, 4.2, 4.3, 5.1, 5.2, 5.3, 6.1, 6.2, 6.4, 7.2
	11. Coefficient of Friction (OI) To determine the maximum coefficient of static friction between a shoe and a wooden plank.	1.1, 1.4, 1.5, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.3, 6.1, 6.4, 7.2
	12. Atwood's Machine (GI) To determine the acceleration of a hanging mass and the tension in the string.	1.1, 1.4, 1.5, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.3, 6.1, 6.4, 7.2
UNIT 3. CIRCULAR MOTION AND GRAVITATION	**13. Flying Toy (GI)** To determine the tension in the string and the centripetal acceleration of the flying toy.	1.1, 1.2, 1.4, 1.5, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.3, 6.1, 6.4, 7.2
UNIT 4. ENERGY	**14. Roller Coaster Investigation (OI)** To design a simple roller coaster using	1.1, 1.2, 1.3, 1.4, 1.5, 2.1, 2.2, 3.1, 4.1, 4.2,

	provided materials to test whether the total energy of the system is conserved if there are no external forces exerted on it by other objects.	4.3, 5.3, 6.1, 6.2, 6.4, 7.2
	15. Work Done in Stretching a Spring (GI) To determine the work done on the spring from force-versus-distance graph of the collected data.	1.1, 1.2, 1.3, 1.4, 1.5, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.3, 6.1, 6.4, 7.2
	16. Energy and Non-Conservative Forces (GI) To determine the energy dissipated by friction of a system consisting of a modified Atwood's machine.	1.1, 1.2, 1.3, 1.4, 1.5, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.3, 6.1, 6.4, 6.5, 7.2
UNIT 5. MOMENTUM	**17. Bumper Design (OI)** To design a paper bumper that will soften the impact of the collision between a cart and a fixed block of wood. Their designs are evaluated by the shape of an acceleration-versus-time graph of the collision.	1.4, 2.1, 2.2, 3.1, 3.2, 4.1, 4.2, 4.3, 5.1, 5.2, 5.3, 6.1, 6.2, 6.4, 7.2
	18. Impulse and Change in Momentum (GI) To measure the change in momentum of a dynamics cart and compare it to the impulse received.	1.1, 1.2, 1.3, 1.4, 1.5, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.1, 5.3, 6.1, 6.4, 7.2
	19. Elastic and Inelastic Collisions (OI) To investigate conservation of momentum and conservation of energy using a ballistic pendulum to determine the type of collision.	1.1, 1.2, 1.3, 1.4, 1.5, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.1, 5.2, 5.3, 6.1, 6.2, 6.4, 7.2
	20. Forensic Investigation (OI) *Lab Practicum:* Apply principles of conservation of energy, conservation of momentum, the work-energy theorem, and a linear model of friction to find the coefficient of kinetic friction.	1.1, 1.2, 1.4, 1.5, 2.1, 2.2, 3.1, 3.2, 3.3, 4.1, 4.2, 4.3, 5.1, 5.2, 5.3, 6.1, 6.2, 6.4, 7.2
UNIT 6. SIMPLE HARMONIC MOTION	**21. Finding the Spring Constant (OI)** To design two independent experiments to determine the spring constants of various	1.1, 1.4, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.3, 6.1, 6.4, 7.2

	springs of equal length.	
	22. Graphs of an Oscillating System (GI) To analyze graphs of position, velocity, and acceleration versus time for an oscillating system to determine how velocity and acceleration vary at the equilibrium position and at the endpoints.	1.1, 1.2, 1.4, 1.5, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.1, 5.3, 6.1, 6.4, 7.2
	23. Simple Pendulum Investigation (OI) To investigate the factors that affect the period of a simple pendulum and test whether the period is proportional to the pendulum's length, the square of its length, or the square root of its length.	1.2, 1.4, 2.1, 2.2, 2.3, 3.1, 3.2, 3.3, 4.1, 4.2, 4.3, 5.1, 5.3, 6.1, 6.4, 7.2
UNIT 7. ROTATIONAL MOTION	**24. Torque and the Human Arm (OI)** To design and build an apparatus that replicates the forearm and biceps muscle system to determine the biceps tension when holding an object in a lifted position.	1.1, 1.2, 1.4, 1.5, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.1, 5.2, 5.3, 6.1, 6.2, 6.4, 7.1, 7.2
	25. Rotational Inertia (GI) To determine the rotational inertia of a cylinder from the slope of a graph of an applied torque versus angular acceleration.	1.1, 1.2, 1.4, 1.5, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.1, 5.3, 6.1, 6.4, 7.2
	26. Conservation of Angular Momentum (GI) To investigate how the angular momentum of a rotating system responds to changes in the rotational inertia.	1.1, 1.2, 1.4, 1.5, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.1, 5.3, 6.1, 6.4, 7.2
UNIT 8. MECHANICAL WAVES	**27. Mechanical Waves (OI)** To model the two types of mechanical waves with a spring toy to test whether or not these characteristics affect the speed of a pulse: frequency, wavelength and amplitude.	1.2, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.1, 5.3, 6.1, 6.2, 6.4, 7.2
	28. Speed of Sound (OI) Design two different procedures to determine the speed of sound in air.	1.1, 1.2, 1.4, 1.5, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.3, 6.1, 6.4, 7.2
	29. Wave Boundary Behavior (GI)	1.4, 3.1, 4.1, 4.2, 4.3,

	To compare what happens to the phase of a transverse wave on a spring toy when a pulse is reflected from a boundary and when it is reflected and transmitted from various boundaries (spring to string).	5.1, 6.1, 6.4, 7.2
	30. Standing Waves (GI) Given a specified tension, students predict the length of the string necessary to generate the first two harmonics of a standing wave on the string. Then they perform the experiment and compare the outcome with their prediction.	1.1, 1.2, 1.4, 1.5, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.1, 5.3, 6.1, 6.4, 7.2
UNIT 9. ELECTROSTATICS	**31. Static Electricity Interactions (GI)** Students use sticky tape and a variety of objects to make qualitative observations of the interactions when objects are charged, discharged, and recharged.	1.2, 3.1, 4.1, 4.2, 5.1, 6.2, 7.2
	32. Coulomb's Law (OI) To estimate the charge on two identical, equally charged spherical pith balls of known mass.	1.1, 1.2, 1.4, 1.5, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.1, 5.3, 6.1, 6.4, 7.2
UNIT 10. DC CIRCUITS	**33. Brightness Investigation (GI)** To make predictions about the brightness of light bulbs in a variety of series and parallel circuits when some of the bulbs are removed.	1.2, 3.1, 4.1, 4.2, 4.3, 5.3, 6.1, 6.4, 7.2
	34. Voltage and Current (GI) To determine the relationship between the current through a resistor and the voltage across the resistor.	1.1, 1.2, 1.4, 1.5, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.1, 5.3, 6.1, 6.4, 7.2
	35. Resistance and Resistivity (OI) To investigate the effects of cross-sectional area and length on the flow of current through a roll of Play-Doh.	1.4, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.1,5.3, 6.1, 6.4, 7.2
	36. Series and Parallel Circuits (OI) To investigate the behavior of resistors in series, parallel, and series-parallel circuits. The	1.1, 1.2, 1.4, 1.5, 2.1, 2.2, 3.1, 4.1, 4.2, 4.3, 5.1, 5.2, 5.3, 6.1, 6.4,

	lab should include measurements of voltage and current.	7.2

INSTRUCTIONAL ACTIVITIES

Throughout the course the students engage in a variety of activities designed to build the students' reasoning skills and deepen their conceptual understanding of physics principles. Students conduct activities and projects that enable them to connect the concepts learned in class to real world applications. Examples of activities are described below.

1. PROJECT DESIGN [CR3]
Students engage in hands-on activities outside of the laboratory experience that support the connection to more than one Learning Objective.

ACTIVITY: Roller Coaster Investigation
DESCRIPTION:
Working in groups of three, students design a simple roller coaster using provided materials (a track with a vertical loop and toy cars) to test whether the total energy of a car-Earth system is conserved if there are no external forces exerted on it by other objects. Students include multiple representations of energy to provide **evidence** for their **claims**. Students use a bar chart, the mathematical expression of conservation of energy represented by the graph, and the corresponding calculations to evaluate whether the outcome of the experiment supports the idea of energy conservation**.**

Learning Objective 5.B.3.1
The student is able to describe and make qualitative and/or quantitative predictions about everyday examples of systems with internal potential energy.
Learning Objective 5.B.3.2
The student is able to make quantitative calculations of the internal potential energy of a system from a description or diagram of that system.
Learning Objective 5.B.3.2
The student is able to apply mathematical reasoning to create a description of the internal potential energy of a system from a description or diagram of the objects and interactions in that system.
Learning Objective 5.B.4.2
The student is able to calculate changes in kinetic energy and potential energy of a system, using information from representations of that system.
Learning Objective 4.C.1.1
The student is able to calculate the total energy of a system and justify the mathematical routines used in the calculation of component types of energy within the system whose sum is the total energy.
Learning Objective 4.C.1.2

The student is able to predict changes in the total energy of a system due to changes in position and speed of objects or frictional interactions within the system.

DESCRIPTION:

Working in groups of three, students design a simple roller coaster using provided materials (a track with a vertical loop and toy cars) to test whether the total energy of a car-Earth system is conserved if there are no external forces exerted on it by other objects. Students include multiple representations of energy to provide **evidence** for their **claims**. Students use a bar chart, the mathematical expression of conservation of energy represented by the graph, and the corresponding calculations to evaluate whether the outcome of the experiment supports the idea of energy conservation**.**

2. REAL WORLD APPLICATION

ACTIVITY: Torque and the Human Arm [CR4]

DESCRIPTION:

This activity provides an opportunity for students to make an **interdisciplinary connection** to biological systems by investigating the structure and function of a major muscle (biceps) in the human body.

Students design and build an apparatus that replicates the forearm and biceps muscle system. The objective is to determine the biceps tension when holding an object in a lifted position. Students may use the Internet to research the structure of the biceps muscle. They can use readily available materials in the classroom, such as a meter stick, a ring stand, weight hangers, an assortment of blocks, and a spring scale. In their lab journal, students are required to document the different stages of their design. Required elements include design sketches, force diagrams, mathematical representations of translational and rotational equilibrium, and numerical calculations.

Learning Objective 3.F.1.1

The student is able to use representations of the relationship between force and torque.

Learning Objective 3.F.1.2

The student is able to compare the torques on an object caused by various forces.

Learning Objective 3.F.1.3

The student is able to estimate the torque on an object caused by various forces in comparison to other situations.

Learning Objective 3.F.1.4

The student is able to design an experiment and analyze data testing a question about torques in a balanced rigid system.

Learning Objective 3.F.1.5

The student is able to calculate torques on a two-dimensional system in static equilibrium, by examining a representation or model (such as a diagram or physical construction).

3. SCIENTIFIC ARGUMENTATION

In the course, students become familiar with the three components of **scientific argumentation**. The first element is the claim, which is the response to a prediction. A claim provides an explanation for why or how something happens in a laboratory investigation. The second component is the evidence, which supports the claim and consists of the analysis of the data collected during the investigation. The third component consists of questioning, in which students examine and defend one another's claims. Students receive explicit instruction in posing meaningful questions that include questions of clarification, questions that probe assumptions, and questions that probe implications and consequences. As a result of the scientific argumentation process, students are able to revise their claims and make revisions as appropriate**. [CR8]**

ACTIVITY 1: Formative Assessment: Changing Representations in Energy
DESCRIPTION:
Students work in pairs to create exercises that involve translation from one representation to another. Some possible translations are:

- from a bar chart to a mathematical representation
- from a physical situation diagram to a bar chart
- from a given equation to a bar chart

Each pair of students exchanges their exercises with another pair. After the students work through the exercises they received, the pairs meet and offer constructive criticism (**peer critique**) on each other's solutions.

Learning Objective 5.B.4.1
The student is able to describe and make predictions about the internal energy of everyday systems.
Learning Objective 5.B.4.2
The student is able to calculate changes in kinetic energy and potential energy of a system, using information from representations of that system.

ACTIVITY 2. Laboratory Investigation: Speed of Sound
DESCRIPTION:
Working in small groups, students design two different procedures to determine the speed of sound in air. They brainstorm their approaches and write them on the whiteboard. Each of the teams presents their ideas to the class. They receive feedback from their peers and then conduct their experiments. They record the revised procedures in their lab journals. During the post-lab discussion, the students discuss their results (**evidence**) by examining and defending one another's **claims**. Then as a class we reach consensus about the estimated value for the speed of sound.

Learning Objective 6.A.2.1
The student is able to describe sound in terms of transfer of energy and momentum in a medium and relate the concepts to everyday examples.
Learning Objective 6.A.4.1
The student is able to explain and/or predict qualitatively how the energy carried by a sound wave relates to the amplitude of the wave, and/or apply this concept to a real-world example.
Learning Objective 6.B.4.1

The student is able to design an experiment to determine the relationship between periodic wave speed, wavelength, and frequency and relate these concepts to everyday examples.

AP Physics 1

Content Outline

Big Idea 1: Objects and systems have properties such as mass and charge. Systems may have internal structure.

Enduring Understanding 1.A: The internal structure of a system determines many properties of the system.

Essential Knowledge 1.A.1: A system is an object or a collection of objects. Objects are treated as having no internal structure.

a. A collection of particles in which internal interactions change little or not at all, or in which changes in these interactions are irrelevant to the question addressed, can be treated as an object.
b. Some elementary particles are fundamental particles (e.g., electrons). Protons and neutrons are composed of fundamental particles (i.e., quarks) and might be treated as either systems or objects, depending on the question being addressed.
c. The electric charges on neutrons and protons result from their quark compositions.

Essential Knowledge 1.A.5: Systems have properties determined by the properties and interactions of their constituent atomic and molecular substructures. In AP Physics, when the properties of the constituent parts are not important in modeling the behavior of the macroscopic system, the system itself may be referred to as an *object*. **Phy 1 and 2**

Learning Objective (1.A.5.1): The student is able to model verbally or visually the properties of a system based on its substructure and to relate this to changes in the system properties over time as external variables are changed. [See Science Practices 1.1 and 7.1]

Enduring Understanding 1.B: Electric charge is a property of an object or system that affects its interactions with other objects or systems containing charge. **Phy 1 and 2**

Essential Knowledge 1.B.1: Electric charge is conserved. The net charge of a system is equal to the sum of the charges of all the objects in the system.
a. An electrical current is a movement of charge through a conductor.
b. A circuit is a closed loop of electrical current.

Learning Objective (1.B.1.1): The student is able to make claims about natural phenomena based on conservation of electric charge.
[See Science Practice 6.4]

Learning Objective (1.B.1.2): The student is able to make predictions, using the conservation of electric charge, about the sign and relative quantity of net charge of objects or systems after various charging processes, including conservation of charge in simple circuits.
[See Science Practices 6.4 and 7.2]

Essential Knowledge 1.B.2: There are only two kinds of electric charge. Neutral objects or systems contain equal quantities of positive and negative charge, with the exception of some fundamental particles that have no electric charge.
a. Like-charged objects and systems repel, and unlike charged objects and systems attract.
b. Charged objects or systems may attract neutral systems by changing the distribution of charge in the neutral system.

Learning Objective (1.B.2.1): The student is able to construct an explanation of the two-charge model of electric charge based on evidence produced through scientific practices. [See Science Practice 6.2]

Essential Knowledge 1.B.3: The smallest observed unit of charge that can be isolated is the electron charge, also known as the elementary charge.
a. The magnitude of the elementary charge is equal to 1.6×10^{-19} coulombs
b. Electrons have a negative elementary charge; protons have a positive elementary charge of equal magnitude, although the mass of a proton is much larger than the mass of an electron.

Learning Objective (1.B.3.1): The student is able to challenge the claim that an electric charge smaller than the elementary charge has been isolated. [See Science Practices 1.5, 6.1, and 7.2]

Enduring Understanding 1.C: Objects and systems have properties of inertial mass and gravitational mass that are experimentally verified to be the same and that satisfy conservation principles.

Essential Knowledge 1.C.1: Inertial mass is the property of an object or a system that determines how its motion changes when it interacts with other objects or systems.

Learning Objective (1.C.1.1): The student is able to design an experiment for collecting data to determine the relationship between the net force exerted on an object, its inertial mass, and its acceleration.
[See Science Practice 4.2]

Essential Knowledge 1.C.2: Gravitational mass is the property of an object or a system that determines the strength of the gravitational interaction with other objects, systems, or gravitational fields.
a. The gravitational mass of an object determines the amount of force exerted on the object by a gravitational field.
b. Near the Earth's surface, all objects fall (in a vacuum) with the same acceleration, regardless of their inertial mass.

Essential Knowledge 1.C.3: Objects and systems have properties of inertial mass and gravitational mass that are experimentally verified to be the same and that satisfy conservation principles.

Learning Objective (1.C.3.1): The student is able to design a plan for collecting data to measure gravitational mass and to measure inertial mass, and to distinguish between the two experiments.
[See Science Practice 4.2]

Enduring Understanding 1.E: Materials have many macroscopic properties that result from the arrangement and interactions of the atoms and molecules that make up the material.

Essential Knowledge 1.E.2: Matter has a property called resistivity.

a. The resistivity of a material depends on its molecular and atomic structure.
b. The resistivity depends on the temperature of the material.

Learning Objective (1.E.2.1): The student is able to choose and justify the selection of data needed to determine resistivity for a given material. [See Science Practice 4.1]

Big Idea 2: Fields existing in space can be used to explain interactions.

Enduring Understanding 2.A: A field associated a value of some physical quantity with every point in space. Field models are useful for describing interactions that occur at a distance (long-range forces) as well as a variety of other physical phenomena.

Essential Knowledge 2.A.1: A vector field gives, as a function of position (and perhaps time), the value of a physical quantity that is described by a vector.
a. Vector fields are represented by field vectors indicating direction and magnitude.
b. When more than one source object with mass or electric charge is present, the field value can be determined by vector addition.
c. Conversely, a known vector field can be used to make inferences about the number, relative size, and location of sources.

Enduring Understanding 2.B: A gravitational field is caused by an object with mass.

Essential Knowledge 2.B.1: A gravitational field equal to g at the location of an object with mass m causes a gravitational force of magnitude mg to be exerted on the object in the direction of the field.
a. On the Earth, this gravitational force is called weight.
b. The gravitational field at a point in space is measured by dividing the gravitational force exerted by the field on a test object at that point by the mass of the test object and has the same direction as the force.
c. If the gravitational force is the only force exerted on the object, the observed free-fall acceleration of the object (in meters per second squared) is numerically equal to the magnitude of the gravitational field (in Newtons/kilogram) at that location.

Learning Objective (2.B.1.1): The student is able to apply $F_w = mg$ to calculate the gravitational force on an object with mass m in a gravitational field of strength g in the context of the effects of a net force on objects and systems. [See Science Practices 2.2 and 7.2]

Essential Knowledge 2.B.2: The gravitational field caused by a spherically symmetric object with mass is radial and, outside the object varies as the inverse square of the radial distance from the center of that object.
a. The gravitational field caused by a spherically symmetric object is a vector whose magnitude outside the object is equal to GM/r^2.
b. Only spherically symmetric objects will be considered as sources of the gravitational field.

Learning Objective (2.B.2.1): The student is able to apply $g = GM/r^2$ to calculate the gravitational field due to an object with mass m, where the field is a vector directed toward the center of the object of mass M. [See Science Practice 2.2]

Learning Objective (2.B.2.2): The student is able to approximate a numerical value of the gravitational field (g) near the surface of an object from its radius and mass relative to those of the Earth or other reference objects. [See Science Practice 2.2]

Big Idea 3: The interactions of an object with other objects can be described by forces.

Enduring Understanding 3.A: All forces share certain common characteristics when considered, by observers in inertial reference frames.

Essential Knowledge 3.A.1: An observer in a particular reference frame can describe the motion of an object using such quantities as position, displacement, distance, velocity, speed, and acceleration.
a. Displacement, velocity, and acceleration are all vector quantities.
b. Displacement is change in position. Velocity is the rate of change of position with time. Acceleration is the rate of change of velocity with time. Changes in each property are expressed by subtracting initial values from final values.
c. A choice of reference frame determines the direction and the magnitude of each of these quantities.

Learning Objective (3.A.1.1): The student is able to express the motion of an object using narrative, mathematical, and graphical, representations.
[See Science Practices 1.5, 2.1, and 2.2]

Learning Objective (3.A.1.2): The student is able to design an experimental investigation of the motion of an object. [See Science Practice 4.2]

Learning Objective (3.A.1.3): The student is able to analyze experimental data describing the motion of an object, and is able to express the results of the analysis using narrative, mathematical, and graphical, representations. [See Science Practice 5.1]

Essential Knowledge 3.A.2: Forces are described by vectors.

a. Forces are detected by their influence on the motion of an object.
b. Forces have magnitude and direction.

Learning Objective (3.A.2.1): The student is able to represent forces in diagrams or mathematically using appropriately labeled vectors with magnitude, direction and units during the analysis of a situation. [See science practice 1.1]

Essential knowledge 3.A.3: A force exerted on an object is always due to the interaction of that object with another object.

a. An object cannot exert a force on itself.
b. Even though an object is at rest, there may be forces exerted on that object by other objects.
c. The acceleration of an object, but not necessarily its velocity, is always in the direction of the net force exerted on the object by other objects.

Learning objective (3.A.3.1): The student is able to analyze a scenario and make claims (develop arguments, justify assertions) about the forces exerted on an object by other objects for different types of forces or components of forces. [See science practices 6.4 and 7.2]

Learning objective (3.A.3.2): The student is able to challenge a claim that an object can exert a force on itself. [See science practice 1.4]

Learning objective (3.A.3.3): The student is able to make claims about the force on an object due to the presence of other objects with the same property; mass, electrical charge. [See science practices 6.1 and 6.4]

Essential knowledge 3.A.4: If one object exerts a force on a second object, the second object always exerts a force of equal magnitude on the first object and in the opposite direction.

Learning objective (3.A.4.1): The student is able to construct explanations of physical situations involving the interaction of bodies using Newton's third law and the representation of action-reaction pairs of forces. [See science practices 1.4 and 6.2]

Learning objective (3.a.4.2): The student is able to use Newton's third law to make claims and predictions about the action-reaction pairs of forces when two objects interact. [See science practices 6.4 and 7.2]

Learning objective (3.a.4.3): The student is able to analyze situations involving interactions among several objects by using free body diagrams that include the application of Newton's third law to identify forces. [See science practice 1.4]

Enduring Understanding 3.B: Classically, the acceleration of an object interacting with other objects can be predicted by using

$$a = \frac{\sum F}{m}$$

Essential knowledge 3.B.1: If an object of interest interacts with several other objects, the net force is the vector sum of the individual forces.

Learning objective (3.B.1.1): The student is able to predict the motion of an object subject to forces exerted by several objects using and application of Newton's second law in a variety of situations with acceleration in one dimension. [See science practices 6.4 and 7.2]

LO (3.b.1.2): The student is able to design a plan to collect and analyze data for motion (static, constant or accelerating) from force measurements and carry out an analysis to determine the relationship between the net force and the vector sum of the individual forces.
[See science practices 4.2 and 5.1]

LO (3.B.1.3): The student is able to re-express a free body diagram representation into a mathematical representation and solve the mathematical representation for the acceleration of the object. [See science practices 1.5 and 2.2]

Essential knowledge 3.B.2: Free-body diagrams are useful tools for visualizing forces being exerted on a single object and writing the equations that represent the physical situation.

a. An object can be drawn as if it was extracted from its environment and the interactions with the environment identified.
b. A force exerted on an object can be represented as an arrow whose length represents the magnitude of the force and whose direction shows the direction of the force.
c. A coordinate system with one axis parallel to the direction of the acceleration simplifies the translation from the free-body diagram to the algebraic representation.
d.

LO (3.B.2.1): The student is able to create and use free-body diagrams to analyze physical situations to solve problems with motion qualitatively and quantitatively. [See science practices 1.1, 1.4, and 2.2]

Essential knowledge 3.B.3 Restoring forces can result in oscillatory motion. When a linear restoring force is exerted on an object displaced from an equilibrium position, the object will undergo a special type of motion called simple harmonic motion. Examples should include gravitational force exerted by the earth on a simple pendulum, mass spring oscillator.

a. For a spring that exerts a linear restoring force the period of a mass spring oscillator increases with mass and decreases with spring stiffness.
b. For a simple pendulum oscillating the period increases with length of the pendulum.

c. Minima, maxima, and zeros of position, velocity, and acceleration are features of harmonic motion. Students should be able to calculate force and acceleration for any given displacement for and object oscillating on a spring.

LO (3.B.3.1): The student is able to predict which properties determine the motion of a simple harmonic oscillator and what dependence of the motion is on those properties. [See science practices 6.4 and 7.2]

LO(3.B.3.2): The student is able to design a plan and collect data in order to ascertain the characteristics of the motion of a system undergoing oscillatory motion caused by a restoring force. [See science practices 4.2]

LO(3.B.3.3): The student can analyze data to identify qualitative or quantitative relationships between given values and variables (i.e., force, displacement, acceleration, velocity, period of motion, frequency, spring length, mass) associated with the objects in oscillatory motion to use that data to determine the value of an unknown. [See science practices 2.2 and 5.1]

LO (3.B.3.4): The student is able to construct a qualitative and/or quantitative explanation of oscillatory behavior given evidence of a restoring force. [See science practices 2.2 and 6.2]

Enduring understanding 3.C: At the macroscopic level, forces can be categorized as either long-range (action at a distance) forces or contact forces.

Essential Knowledge 3.C.1: Gravitational force describes the interaction of one object that has mass with another object that has mass.

a. The gravitational force is always attractive
b. The magnitude of force between two spherically symmetric objects of mass m_1 and m_2 *is* Gm_1m_2/r^2 where r is the center to center distance between the objects.
c. In a narrow range of heights above the Earth's surface, the local gravitational field, g, is approximately constant.

LO (3.C.1.1): The student is able to use Newton's law of gravitation to calculate the gravitational force the two objects exert on each other and use that force in contexts other than orbital motion. [See science practice 2.2]

LO (3.C.1.2): The student is able to us Newton's law of gravitation to calculate the gravitational force between two objects and use that force in contexts involving orbital motion (for circular orbital in Physics 1). [See science practice 2.2]

Essential Knowledge 3.C.2: Electric forces results from interaction of one object that has an electric charge with another object that has an electric charge.

a. Electric forces dominate the properties of the objects in our everyday experiences. However, the large number of particle interactions that occur make it more convenient to treat everyday forces in terms of non-fundamental forces called contact forces, such as normal force, friction and tension.
b. Electric forces may be attractive or repulsive, depending upon the charges on the objects involved.

LO (3.C.2.1): The student is able to use Coulomb's law to qualitative and quantitatively make predictions about the interaction between two electric point charges (interactions between collections of electric point charges are not covered in Physics 1).

LO(3.C.2.2): The student is able to connect the concepts of gravitational force and electric force to compare similarities and differences between the forces. [See science practice 7.2]

Essential Knowledge 3.C.4: Contact forces result from the interaction of one object touching another object and they arise from interatomic electric forces. These forces include tension, friction, normal force, and spring.

LO (3.C.4.1): The student is able to make claims about various contact forces between objects based on the microscopic cause of those forces.
[See science practice 6.1]

LO (3.C.4.2): The student is able to explain contact forces (tension, friction, normal, spring) as arising from interatomic electric forces and that they therefore have certain direction. {See Science Practice 6.2]

Enduring understanding 3.D: A force exerted on an object can change the momentum of the object.

Essential Knowledge 3.D.1: The change in momentum of an object is a vector in the direction of the net force on the object.

LO (3.D.1.1): The student is able to justify the selection of data needed to determine the relationship between the direction of the force acting on an object and the change in momentum caused by that force.
[Sci Pr 4.1]

Essential Knowledge 3.D.2: The change in momentum of an object occurs over a time interval.

a. The force that one object exerts on a second object changes the momentum of the second object (in the absence of other forces on the second object).
b. The change in momentum of that object depends on the impulse, which is the product of the average force and the time interval during which the interaction occurred.

LO (3.D.2.1): The student is able to justify the selection of routines for the calculation of the relationships between changes in momentum of an object, average force, impulse, and the time of interaction. [Sci Pr 2.1]

LO (3.D.2.2): The student is able to predict the change in momentum of an object from the average force exerted on the object and the interval of time during which the force is exerted. [Sci Pr 6.4]

LO (3.D.2.3): The student is able to analyze data to characterize the change in momentum of an object from the average force exerted on the object and the interval of time during which the force is exerted. [Sci Pr 5.1]

LO (3.D.2.4): The student is able to design a plan for the collecting of data to investigate the relationship between changes in momentum and the average force exerted on an object over time. [Sci pr 4.2]

Enduring Understanding 3.E: A force exerted on an object can change the kinetic energy of the object.

Essential Knowledge 3.E.1: The change in the kinetic energy of an object depends on the force exerted on the object and on the displacement of the object during the interval that the force is exerted.
a. Only the component of the net force exerted on an object parallel or antiparallel to the displacement of the object will increase (parallel) or decrease (antiparallel) the kinetic energy of the object.
b. The magnitude of the change in the kinetic energy is the product of the magnitude of the displacement and the magnitude of the component of force parallel or antiparallel to the displacement.
c. The component of the net force exerted on an object perpendicular to the direction of the displacement of the object can change the direction of the motion of the object without changing the kinetic energy of the object. This should include uniform circular motion and projectile motion.

LO (3.E.1.1): The student is able to make predictions about the changes in kinetic energy of an object based on the consideration of the direction of the net force on the object as the object moves. [Sci Pr 6.4 and 7.2]

LO (3.E.1.2): The student is able to use net force and velocity vectors to determine qualitatively whether kinetic energy of an object would increase, decrease or remain unchanged. **[Sci Pr 1.4]**

LO (3.E.1.3): The student is able to use force and velocity vectors to determine qualitative or quantitatively the net force on an object and qualitatively whether kinetic energy of that object would increase, decrease, or remain unchanged. [Sci Pr 1.4 and 2.2]

LO (3.E.1.4): The student is able to apply mathematical routines to determine the change in kinetic energy of an object given the forces on the object and the displacement of the object. [Sci Pr 2.2]

Enduring Understanding 3.F: A force exerted on an object can cause a torque on that object.

Essential Knowledge 3.F.1: Only the force component perpendicular to the line connecting the axis of rotation and the point of application of the force results in a torque about that axis.

a. The lever arm is the perpendicular distance from the axis of rotation or revolution to the line of application of the force.
b. The magnitude of the torque is the product of the magnitude of the lever arm and the magnitude of the force.
c. The net torque on a balanced system is zero.

LO (3.F.11): The student is able to use representations of the relationship between force and torque.[Sci Pr 1.4]

LO (3.F.1.2): The student is able to compare the torques on an object caused by various forces. [Sci Pr 1.4]

LO (3.F.1.3): The student is able to estimate the torque on an object caused by various forces in comparison to other situations. [Sci Pr 2.3]

LO (3.F.1.4): The student is able to design an experiment and analyze data testing a question about torques in a balanced rigid system.
[Sci Pr 4.1, 4.2, and 5.1]

LO (3.F.1.5): The student is able to calculate torques on a two dimensional system in static equilibrium, by examining a representation or model (such as a diagram or physical construction)
[Sci Pr 1.4 and 2.2]

Essential Knowledge 3.F.2: The presence of a net torque along any axis will cause a rigid system to change its rotational motion or an object to change its rotational motion about that axis.

a. Rotational motion can be described in terms of angular displacement, velocity and acceleration about a fixed axis.

b. Rotational motion of a point can be related to linear motion of the point using the distance of the point from the axis of rotation.
c. The angular acceleration of an object or rigid system can be calculated from the net torque and the rotational inertia of the object or rigid system

LO (3.F.2.1): The student is able to make predictions about the change in the angular velocity about an axis for an object when forces exerted on the object cause a torque about that axis. [Sci Pr 6.4]

LO (3.F.2.2): The student is able to plan data collection and analysis strategies designed to test the relationship between a torque exerted on an object and the change in angular velocity of that object about an axis. [Sci Pr 4.1, 4.2, and 5.1]

Essential Knowledge 3.F.3: A torque exerted on an object can change the angular momentum of an object.

a. Angular momentum is a vector quantity, with its direction determined by the right hand rule.
b. The magnitude of angular momentum of a point object about an axis can be calculated by multiplying the perpendicular distance from the axis of rotation to the line of motion by the magnitude of linear momentum
c. The magnitude of angular momentum of an extended object can also be found by multiplying the rotational inertia by the angular velocity.
d. The change in angular momentum of an object is given by the product of the average torque and the time the torque is exerted.

LO (3.F.3.1): The student is able to predict the behavior of rotational collision situation by the same processes that are used to analyze linear collision situations using an analogy between impulse and change of linear momentum and angular impulse and change of angular momentum. [Sci Pr 6.4 and 7.2]

LO (3.F.3.2): In an unfamiliar context or using representations beyond equations, the student is able to justify the selection of a mathematical routine to solve for the change in angular momentum of an object caused by torques exerted on the object. [Sci Pr 2.1]

LO (3.F.3.3): The student is able to plan data collection and analysis strategies designed to test the relationship between torques exerted on an object and the change in angular momentum of that object. [Sci Pr 4.1, 4.2, 5.1, and 5.3]

Enduring Understanding 3.G: Certain types of forces are considered fundamental.

Essential Knowledge 3.G.1: Gravitational forces are exerted at all scales and dominate at the largest distance and mass scales.

LO (3.G.1.1): The student is able to articulate situations when the gravitational force is the dominant force and when the electromagnetic, weak, and strong forces can be ignored. [Sci Pr 7.1]

Big Idea 4: Interactions between systems can result in changes in those systems.

Enduring Understanding 4.A: The acceleration of the center of mass of a system is related to the net force exerted on the system, where $a = \frac{\sum F}{m}$.

Essential Knowledge 4.A.1: The linear motion of a system can be described by the displacement, velocity, and acceleration of its center of mass.

LO (4.A.1.1): The student is able to use representation of the center of mass of an isolated two-object system to analyze the motion of the system qualitatively and semi-quantitatively. [Sci Pr 1.2, 1.4, 2.3,and 6.4]

Essential knowledge 4.A.2: The acceleration is equal to the rate of change in velocity with time, and velocity is equal to the rate of change of position with time.

a. The acceleration of the center of mass if a system is directly proportional to the net force exerted on it by all objects interacting with the system and inversely proportional to the mass of the system.
b. Force and acceleration are both vectors, with acceleration in the same direction as the net force.

LO (4.A.2.1): The student is able to make predictions about the motion of a system based on the fact that acceleration is equal to the change in velocity per unit time, and velocity is equal to the change in position per unit time. [Sci Pr 6.4]

LO (4.A.2.2): The student is able to evaluate using given data whether all the forces on a system or whether all the parts of a system have been identified. [Sci Pr 5.3]

LO (4.A.2.3): The student is able to create mathematical models and analyze graphical relationships for acceleration, velocity, and position of the center of mass of a system and use them to calculate properties of the motion of the center of mass of a system. [Sci Pr 1.4 and 2.2]

Essential Knowledge 4.A.3: Forces that systems exert on each other are due to interactions between objects in the systems. If the interacting objects are parts of the same system, there will be no change in the center of mass velocity of that system.

LO (4.A.3.1): The student is able to apply Newton's second law to systems to calculate the change in the center-of-mass velocity when an external force is exerted on the system. [Sci Pr 2.2]

LO (4.A.3.2): The student is able to use the visual or mathematical representations of the forces between objects in a system to predict whether or not there will be a change in the center-of-mass velocity of that system. [Sci Pr 1.4]

Enduring Understanding 4.B: Interactions with other objects or systems can change the total linear momentum of a system.

Essential Knowledge 4.B.1: The change in linear momentum for a constant-mass system is the product of the mass of the system and the change in velocity of the center of mass.

LO (4.B.1.1): The student is able to calculate the change in linear momentum of a two object system with constant mass in linear motion from a representation of the system. (data, graphs, etc.)

LO (4.B.1.2): The student is able to analyze data to find the change in linear momentum for a constant-mass-system using the product of the mass and the change in velocity of the center of mass.
[Sci Pr 5.1]

Essential knowledge 4.B.2: The change in linear momentum of the system is given by the product of the average force on that system and the time interval during which the force is exerted.

a. The units for momentum are the same as the units of the area under the curve of a force vs. time graph.
b. The changes in linear momentum and force are both vectors in the same direction.

LO (4.B.2.1): The student is able to apply mathematical routines to calculate the change in momentum of a system by analyzing the average force exerted over a certain time on the system. [Sci Pr 2.2]

Lo (4.B.2.2): The student is able to perform analysis on data presented as a force-time graph and predict the change in momentum of a system.
[Sci Pr 5.1]

Enduring Understanding 4.C: Interactions with other objects or systems can change the total energy of a system.

Essential Knowledge 4.C.1: The energy of a system includes its kinetic energy, potential energy, and microscopic internal energy. Examples should include gravitational potential energy, elastic potential energy, and kinetic energy.

LO (4.C.1.1): The student should be able to calculate the total energy of a system and justify the mathematical routines used in the calculation of component types of energy within the system whose sum is the total energy. [Sci Pr 1.4, 2.1, and 2.2]

LO (4.C.1.2): The student is able to predict changes in the total energy of a system due to changes in position and speed of objects or frictional interactions within the system. [Sci Pr 6.4]

Essential Knowledge 4.C.2: Mechanical energy (the sum of kinetic and potential energy) is transferred into or out of a system when an external force is exerted on the system such that a component of the force is parallel to its displacement. The process through which energy is transferred is called work.

a. If the force is constant during a given displacement, then the work done is the product of the displacement and the component of the force parallel or anti-parallel to the displacement.
b. Work (change in energy) can be found from the area under a graph of the magnitude of the net force component parallel to the displacement versus displacement.

LO (4.C.2.1): The student is able to make predictions about the changes in mechanical energy of a system when a component of an external force acts parallel or anti-parallel to the direction of the displacement of the center of mass. [Sci Pr 6.4]

LO (4.C.2.2): The student is able to apply the concepts of Conservation of Energy and the Work-Energy theorem to determine qualitatively and/or quantitatively that work done on a two object system in linear motion will change the kinetic energy of the center of mass of the system, and/or, the internal energy of the system. [Sci Pr 1.4, 2.2, 7.2]

Enduring Understanding 4.D: A net torque exerted on a system by other objects of systems will change the angular momentum of the system.

Essential Knowledge 4.D.1: Torque, angular velocity, angular acceleration and angular momentum are vectors and can be characterized as a positive or negative depending upon whether they give rise to or correspond to counterclockwise or clockwise rotation with respect to an axis.

LO (4.D.1.1): The student is able to describe a representation and use it to analyze a situation in which several forces exerted on a rotation system of rigidly connected objects change the angular velocity and angular momentum of the system. [Sci Pr 1.2 and 1.4]

LO (4.D.1.2): The student is able to plan data collection strategies designed to establish that torque, angular velocity, angular acceleration, and angular momentum can be predicted accurately when the variables are treated as being clockwise or counterclockwise with respect to a well-defined axis of rotation, and refine the research question based on the examination of data.
[Sci Pr 3.2, 4.1, 4.2, 5.1, and 5.3]

Essential Knowledge 4.D.2: The angular momentum of a system may change due to interactions with other systems of objects.

a. The angular momentum of a system with respect to an axis of rotation is the sum of the angular momenta, with respect to that axis, of the objects that make up the system
b. The angular momentum of an object about a fixed axis can be found by multiplying the momentum of the particle by the perpendicular distance from the axis to the line of motion of the object.
c. Alternatively, the angular momentum of a system can be found form the product of the system's rotational inertia and its angular velocity.

LO (4.D.2.1): The student is able to describe a model of a rotational system and use that model to analyze a situation in which angular momentum changes due to interaction with other objects or systems.
[Sci Pr 1.2 and 1.4]

LO (4.D.2.2): The student is able to plan a data collection and analysis strategy to determine the change in angular momentum of a system and relate it to interactions with other objects and systems. [Sci Pr 4.2}

Essential Knowledge 4.D.3: The change in angular momentum is given by the product of the average torque and the time interval during which the torque is exerted.

LO (4.D.3.1): The student is able to use appropriate mathematical routines to calculate values for initial or final angular momentum, or change in angular momentum of a system, or average torque or time during which the torque is exerted in analyzing a situation involving torque and angular momentum. [Sci Pr 2.2]

LO (4.D.3.2): The student is able to plan a data collection strategy designed to test the relationship between the change in angular momentum of a system and the product of the average torque applied to the system and the time the torque is exerted. [Sci 4.1 and 4.2]

Big Idea 5: Changes that occur as the result of interaction are constrained by conservation laws.

Enduring Understanding 5.A: Certain quantities are conserved, in the sense that they changes of those quantities in a given system are always equal to the transfer of that quantity to or from the system by all possible interactions with other systems.

Essential Knowledge 5.A.1: A system is an object of a collection of objects. The objects are treated as having no internal structure.

Essential Knowledge 5.A.2: For all systems under all circumstances, energy, charge, linear momentum, and angular momentum are conserved. For an isolated or closed system, conserved quantities are constant. An open system is one that exchanges any conserved quantity with its surroundings.

LO (5.A.2.1): The student is able to define open and closed systems for everyday situations and apply conservation concepts for energy, charge, and linear momentum to those situations. [Sci Pr 6.4 and 7.2]

Essential Knowledge 5.A.3: An interaction can be either a force exerted by objects outside the system or the transfer of some quantity with objects outside the system.

Essential Knowledge 5.A.4: The boundary between a system and its environment is a decision made by the person considering the situation in order to simplify or otherwise assist in analysis.

Enduring Understanding 5.B: The energy of a system is conserved.

Essential Knowledge 5.B.1: Classically, an object can only have kinetic energy since potential energy requires an interaction between two or more objects.

LO (5.B.1.1): The student is able to set up a representation or model showing that a single object can only have kinetic energy and use information about the object to calculate its kinetic energy.

[Sci Pr 1.4 and 2.2]

LO (5.B.1.2): The student is able to translate between a representation of a single object, which can only have kinetic energy, and a system that includes the object, which may have both potential and kinetic energy.
[Sci Pr 1.5]

Essential knowledge5.B.2: A system with internal structure can have internal energy, and changes in a system's internal structure can result in changes in internal energy. (Phy I mass spring oscillators and simple pendulums).

LO (5.B.2.1): The student is able to calculate the expected behavior of a system using the object model (i.e. by ignoring changes in internal structure) to analyze a situation. Then when the model fails, the student can justify the use of conservation of energy due to changes in internal structure because the object is actually a system.
[Sci Pr 1.4 and 2.1]

Essential Knowledge 5.B.3: A system with internal structure can have potential energy. Potential energy exists within a system if the objects within that system interact with conservative forces.

a. The work done by a conservative force is independent of the path taken. The work description is used for forces external to the system. Potential energy is used when forces are internal interactions between parts of the system.
b. Changes in the internal structure can result in changes in potential energy. Examples include mass-spring oscillators and objects falling in a gravitational field.
c. The change in electric potential is the change in potential energy per unit charge. (Context of circuits)

LO (5.B.3.1): The student is able to describe and make qualitative and/or quantitative predictions about everyday examples of systems with internal potential energy. [Sci Pr 2.2, 6.4, and 7.2]

LO (5.B.3.2): The student is able to make quantitative calculations of the internal potential energy of a system from a description of that system.
[Sci Pr 1.4 and 2.2]

LO (5.B.3.3): The student is able to apply mathematical reasoning to create a description of the internal potential energy of as system from a description of the objects and interactions in that system.
[Sci Pr 1.4 and 2.2]

Essential knowledge 5.B.4: The internal energy of a system includes the kinetic energy of the objects that make up the system and the potential energy of the configuration of the objects that make up the system.

a. Since energy is constant in a closed system, changes in a system's potential energy can result in changes to the system's kinetic energy.
b. The changes in potential and kinetic energies in a system may be further constrained by the construction of the system.

LO (5.B.4.1): The student is able to describe and make predictions about the internal energy of systems. [Sci Pr 6.4 and 7.2]

LO (5.B.4.2): The student is able to calculate changes in kinetic energy and potential energy of a system, using information from representations of that system. [Sci Pr 1.4, 2.1, and 2.2]

Essential Knowledge 5.B.5: Energy can be transferred by an external force exerted on an object or system that moves the object or system through a distance; this energy transfer is called work. Energy transfer in mechanical or electrical systems may occur at different rates. Power is defined as the rate of energy transfer into, out of, or within a system.

LO (5.B.5.1): The student is able to design an experiment and analyze data to examine how a force exerted on an object or system does work on the object or system as it moves through a distance. [Sci Pr 4.2 and 5.1]

LO (5.B.5.2): The student is able to design an experiment to analyze graphical data in which interpretations of the area under a force distance curve are needed to determine the work done on or by an object or system. [Sci Pr 4.2 and 5.1]

LO (5.B.5.3): The student is able to predict and calculate from graphical data the energy transfer to or work done on an object or system from information about a force exerted on the object or system through a distance. [Sci Pr 1.4, 2.2, and 6.4]

LO (5.B.5.4): The student is able to make claims about the interaction between a system and its environment in which the environment exerts a force on the system, thus doing work on the system and changing the energy of the system (kinetic plus potential energy). [Sci Pr 6.4 and 7.2]

LO (5.B.5.5): The student is able to predict and calculate the energy transfer to (i.e. the work done on) an object or system from information about a force exerted on the object or system through a distance. [Sci 2.2 and 6.4]

Essential Knowledge 5.B.9: Kirchhoff's loop rule describes conservation of energy in electrical circuits.

a. Energy changes in simple electrical circuits are conveniently represented in terms of energy change per charge moving through a battery or resistor.
b. Since electric potential difference times charge is energy, and energy is conserved, the sum of the potential differences about any closed loop must add to zero.
c. The electric potential difference across a resistor is given by the product of the current and the resistance.
d. The rate at which energy is transferred from a resistor is equal to the product of the electric potential difference across the resistor and the current through the resistor.

LO (5.B.9.1): The student is able to construct or interpret a graph of the energy changes within an electrical circuit with only a single battery and resistors in series and/or at most one parallel branch as an application of the conservation of energy (Kirchhoff's loop rule).
[Sci Pr 1.1 and 1.4]

LO (5.B.9.2): The student is able to apply conservation of energy concepts to the design of an experiment that will demonstrate the validity of Kirchhoff's loop rule ($\sum \Delta V = 0$) in a circuit with only one battery and resistors either in series or in, at most, one pair of parallel branches. [Sci Pr 4.2, 6.4, and 7.2]

LO (5.B.9.3): The student is able to apply conservation of energy (Kirchhoff's loop rule) in calculations involving the total electrical potential difference for complete circuit loops with only a single battery and resistors in series and/or in, at most, on parallel branch
[Sci Pr 2.2, 6.4, and 7.2]

Enduring Understanding 5.C: The electric charge of a system is conserved.

Essential knowledge 5.C.3: Kirchhoff's junction rule describes the conservation of electric charge in electrical circuits. Since charge is conserved, current must be conserved at each junction in a circuit. Examples should include circuits that combine resistors in series and parallel. (Physics I circuits with resistors in series and at most one parallel branch and one battery).

LO (5.C.3.1): The student is able to apply conservation of electric charge (Kirchhoff's junction rule) to the comparison of electric current in various segments of an electrical circuit with a single battery and resistors in series and in, at most, one parallel branch and predict how those values would change if configurations of the circuits are changed.
[Sci Pr 6.4 and 7.2]

LO (5.C.3.2): The student is able to design an investigation of an electrical circuit with one or more resistors in which evidence of conservation of electric charge can be collected and analyzed.
[Sci Pr 4.1, 4.2, and 5.1]

LO (5.C.3.3): The student is able to use a description or schematic diagram of an electrical circuit to calculate unknown values of current in various segments or branches of the circuit. [Sci Pr 1.4 and 2.2]

Enduring Understanding 5.D: The linear momentum of a system is conserved.

Essential Knowledge 5.D.1: In a collision between objects, linear momentum is conserved. In an elastic collision, kinetic energy is the same before and after.

a. In a closed system, the linear momentum is constant throughout the collision.
b. Ina closed system, the kinetic energy after an elastic collision is the same as the kinetic energy before the collision.

LO (5.D.1.1): The student is able to make qualitative predictions about natural phenomena based on conservation of linear momentum and restoration of kinetic energy in elastic collisions. [Sci Pr 6.4 and 7.2]

LO (5.D.1.2): The student is able to apply the principles of conservation of momentum and restoration of kinetic energy to reconcile a situation that appears to be isolated and elastic, but in which data indicate that linear momentum and kinetic energy are not the same after the interaction, by refining a scientific question to identify interactions that have not been considered. Students will be expected to solve qualitatively and/or quantitatively for one-dimensional situations and only qualitatively in two-dimensional situations.
[Sci Pr 2.2, 2.3, 5.1, and 5.3]

LO (5.D.1.3): The student is able ot apply mathematical routines appropriately to problems involving elastic collisions in one dimension and justify the selection of those mathematical routines based on conservation of momentum and restoration of kinetic energy.
[Sci Pr 2.1 and 2.2]

LO (5.D.1.4): The student is able to design an experimental test of an application of the principle of the conservation of linear momentum, predict an outcome of the experiment using the principle, analyze data generated by that experiment whose uncertainties are expressed numerically, and evaluate the match between the prediction and the outcome. [Sci Pr 4.2, 5.1, 5.3, and 6.4]

LO (5.D.1.5): The student is able to classify a given collision situation as elastic or inelastic, justify the selection of conservation of linear momentum and restoration of kinetic energy as the appropriate principles for analyzing an elastic collision, solve for missing variables and calculate their values. [Sci Pr 2.1 and 2.2]

Essential Knowledge 5.D.2: In a collision between objects, linear momentum is conserved. In an inelastic collision, kinetic energy is not the same before and after the collision.

a. In a closed system, the linear momentum is constant throughout the collision.
b. In a closed system, the kinetic energy after in inelastic collision is different from the kinetic energy before the collision.

LO (5.D.2.1): The student is able to qualitatively predict, in terms of linear momentum and kinetic energy, how the outcome of a collision between two objects changes depending on whether the collision is elastic or inelastic. [Sci Pr 6.4 and 7.2]

LO (5.D.2.2): The student is able to plan data collection strategies to test the law of conservation of momentum in a two object collision that is elastic or inelastic and analyze the resulting data graphically. [Sci Pr 4.1, 4.2, and 5.1]

LO (5.D.2.3): The student is able to apply the conservation of linear momentum to a closed system of objects involved in an inelastic collision to predict the change in kinetic energy. [Sci Pr 6.4 and 7.2]

LO (5.D.2.4): The student is able to analyze data that verify the conservation of momentum in collisions with and without an external friction force. [Sci Pr 4.1, 4.2, 4.4 5.1, and 5.3]

LO (5.D.2.5): The student is able to classify a given collision situation as elastic or inelastic, justify the selection of conservation of linear momentum as the appropriate solution method for an inelastic collision, recognize that there is a common final velocity for the colliding objects in the totally inelastic case, solve for missing variables, and calculate their values. [Sci Pr 2.1 and 2.2]

Essential knowledge 5.D.3: The velocity of the center of mass of the system cannot be changed by an interaction within the system. (Phy I students are expected to be able to locate the center of mass of highly symmetric mass distributions, such as a uniform rod or cube of uniform density, or two spheres of equal mass).

a. The center of mass of a system depends upon the masses and positions of the objects in the system. In an isolated system (a system with no external forces), the velocity of the center of mass does not change.
b. When objects in a system collide, the velocity of the center of mass of the system will not change unless an external force is exerted on the system.

LO (5.D.3.1): The student is able to predict the velocity of the center of mass of a system when there is no interaction outside of the system but there is an interaction within the system (i.e. The student simply recognizes that interactions within the system do not affect the center of mass motion of the system and is able to determine that there is no external force). [Sci Pr 6.4]

Enduring Understanding 5.E: The angular momentum of a system is conserved.

Essential Knowledge 5.E.1: If the net external torque exerted on the system is zero, the angular momentum of the system does not change.

LO (5.E.1.1): The student is able to make qualitative predictions about the angular momentum of a system for a situation in which there is no net external torque. [Sci Pr 6.4 and 7.2]

LO (5.E.1.2): The student is able to make calculation of quantities related to the angular momentum of a system when the net external torque on a system is zero. [Sci Pr 2.1 and 2.2]

Essential Knowledge 5.E.2: The angular momentum of a system is determined by the location and velocities of the objects that make up the system. The rotational inertia of an object or system depends upon the distribution of mass within the object or system. Changes in the radius of a system of in the distribution of mass within the system result in changes in the system's rotational inertia, and hence its angular velocity and linear speed for a given angular momentum. Examples should include elliptical orbits in an earth-satellite system. Mathematical expressions for the moments of inertia will be provided where needed. Students will not be expected to know the parallel axis theorem.

LO (5.E.2.1): The student will be able to describe or calculate the angular momentum and rotational inertia of a system in terms of the locations and velocities of objects that make up the system. Students are expected to do qualitative reasoning with compound objects. Students are expected to do calculations with a fixed set of extended objects and oint masses. [Sci Pr 2.2]

Bid Idea 6: Waves can transfer energy and momentum from one location to another without the permanent transfer of mass and serve as a mathematical model for the description of other phenomena.

Enduring Understanding 6.A: A wave is a travelling disturbance that transfers energy and momentum.

Essential Knowledge 6.A.1: Waves can propagate via different oscillation modes such as transvers and longitudinal.

a. Mechanical waves can be either transvers or longitudinal. Examples should include waves on a stretched string and sound waves.

LO (6.A.1.1): The student is able to use a visual representation to construct an explanation of the distinction between transverse and longitudinal waves by focusing on the vibration that generates the wave. [Sci Pr 6.2]

LO (6.A.1.2): The student is able to describe representations of transverse and longitudinal waves. [Sci Pr 1.2]

Essential Knowledge 6.A.2: For propagation, mechanical waves require a medium, while electromagnetic waves do not require a physical medium. Examples: Light travelling through a vacuum while sound does not.

LO (6.A.2.1): The student is able to describe sound in terms of transfer of energy and momentum in a medium and relate the concept to everyday examples. [Sci Pr 6.4 and 7.2]

Essential Knowledge 6.A.3: The amplitude is the maximum displacement of a wave from its equilibrium value.

LO (6.A.3.1): The student is able to use graphical representation of a periodic mechanical wave to determine the amplitude of the wave.
[Sci Pr 1.4]

Essential Knowledge 6.A.4: Classically, the energy carried by a wave depends upon and increase with amplitude. Examples should include sound waves.

LO (6.A.4.1): The student is able to explain and/or predict qualitatively how the energy carried by a sound wave relates to the amplitude of the wave and/or apply this concept to a real world example. [Sci Pr 6.4]

Enduring Understanding 6.B: A periodic wave is one that repeats as a function of both time and position and can be described by its amplitude, frequency, wavelength, speed and energy.

Essential Knowledge 6.B.1: For a periodic wave, the period is the repeat time of the wave. The frequency is the number of repetitions of the wave per unit time.

LO (6.B.1.1): The student is able to use a graphical representation of a periodic mechanical wave (position vs. time) to determine the period and frequency of the wave and describe how a change in the frequency would modify features of the representation. [Sci Pr 1.4 and 2.2]

Essential Knowledge 6.B.2: For aperiodic wave, the wavelength is the repeat distance of the wave.

LO (6.B 2.1): The student is able to use a visual representation of a periodic mechanical wave to determine wavelength of the wave.
[Sci Pr 1.4]

Essential Knowledge 6.B.4: For a periodic wave, wavelength is the ratio of speed over frequency.

LO (6.B.4.1): The student is able to design an experiment to determine the relationship between periodic wave speed, wavelength, and frequency and relate these concepts to everyday examples.
[Sci Pr 4.2, 5.1, and 7.2]

Essential Knowledge 6.B.5: The observed frequency of a wave depends on the relative motion of source an observer. This is a qualitative treatment only.

LO (6.B.5.1): The student is able to create or use a wave front diagram to demonstrate or interpret qualitatively the observed frequency of a wave, dependent upon the relative motions of source and observer. [Sci Pr 1.4]

Enduring Understanding 6.D: Interference and superposition lead to standing waves and beats.

Essential Knowledge 6.D.1: Two or more wave pulses can interact in such a way as to produce amplitude variations in the resultant wave. When two pulses cross, they travel through each other; they do not bounce off each other. Where pulses overlap, the resulting displacement can be determined by adding the displacements of the two pulses. This is called superposition.

LO (6.D.1.1): The student is able to use representations of individual pulses and construct representations to model the interaction of two wave pulses. {Sci Pr 1.1 and 1.4]

LO (6.D.1.2): The student is able to design a suitable experiment and analyze data illustrating the superposition of mechanical waves (only for wave pulses or standing waves). [Sci Pr 4.2 and 5.1]

LO (6.D.1.3): The student is able to design a plan for collecting data to quantify the amplitude variations when two or more travelling waves or wave pulses interact in a given medium. [Sci Pr 4.2]

Essential Knowledge 6.D.2: Two or more travelling waves can interact in such a way as to produce amplitude variations in the resultant wave.

LO (6.D.2.1): The student is able to analyze data or observations or evaluate evidence of the interaction of two or more travelling waves in one or two dimensions (i.e. circular wave fronts) to evaluate variations in resultant amplitudes. [Sci 5.1]

Essential Knowledge 6.D.3: Standing waves are the result of the addition of incident and reflected waves that are confined to a region and have node and antinodes. Examples should include waves on a fixed length of string, and sound waves in both closed and open tubes.

LO (6.D.3.1): The student is able to refine a scientific question related to standing waves and design a detailed plan for the experiment that can be conducted to examine the phenomenon qualitatively or quantitatively. [Sci Pr 2.1, 3.2, and 4.2]

LO (6.D.3.2): The student is able to predict properties of standing waves that result from the addition of incident and reflected waves that are confined to a region and nodes and antinodes. [Sci Pr 5.4]

LO (6.D.3.3): The student is able to plan data collection strategies, predict the outcome based on the relationship under test, perform data analysis, evaluate evidence compared to the prediction, explain any discrepancy and, if necessary, revise the relationship among variables responsible for establishing standing waves on a string or in a column of air. [Sci 3.2, 4.1, 5.1, 5.2, and 5.3]

LO (6.D.3.4): The student is able to describe representations and models of situation in which standing waves result from the addition of incident and reflected waves confined to a region. [Sci Pr 1.2]

Essential Knowledge 6.D.4: The possible wavelengths of a standing wave are determined by the size of the region to which it is confined.

a. A standing wave with zero amplitude at both ends can only have certain wavelengths. Examples should include fundamental frequencies and harmonics.
b. Other boundary conditions or other regions sizes will result in different sets of possible wavelengths.

LO (6.D.4.1): The student is able to challenge with evidence the claim that the wavelength of standing waves are determined by the frequency of the source regardless of the size of the region. [Sci Pr 1.5 and 6.1]

LO (6.D.4.2): The student is able to calculate wavelengths and frequencies (if given wave speed) of standing waves based on boundary condition and length of region within which the wave is confined, and calculate numerical values of wavelengths and frequencies. Examples should include musical instruments. [Sci Pr 2.2]

Essential Knowledge 6.5.D: Beats arise from the addition of waves slightly different frequency.

a. Because of the different frequencies, the two waves are sometimes in phase and sometimes out of phase. The resulting regularly spaced amplitude changes are called beats. Examples should include the tuning of an instrument.
b. The beat frequency is the difference in frequency between the two waves.

LO (6.D.5.1): The student is able to use a visual representation to explain how waves of slightly different frequency give rise to the phenomenon of beats. [Sci Pr 1.2]

ASSESSMENTS

Suggested Formative Assessments: The teacher will develop and use standards-based assessments throughout the course.

- Pre-Assessments of prior knowledge (e.g. entrance cards or KWL chart)
- Labs/lab reports
- Bell ringers/Problems of the Day(PODs)
- Discussions
- Teacher observation/Questioning
- Graphic organizers (e.g. Venn diagrams, word mapping, webbing, KWL chart, etc.)
- Summarizing
- Retelling
- Notetaking
- Problem-based learning modules
- Authentic assessment
- Oral presentations
- Outlining
- Journaling
- Student presentations/projects
- Open-ended response
- Classroom Performance System (CPS)

Suggested Summative Assessments:

- Essays
- Open-Ended Responses

- Projects
- Quizzes/tests
- Student presentations
- Portfolios

District Approved Assessment Instruments

- Any district approved assessment instrument

Portfolio Assessment: ______ Yes __x___ No

District-wide Final Examination Required: ______ Yes __x___ No

Course Challenge Assessment (Describe): none

WRITING TEAM:

WCSD STUDENT DATA SYSTEM INFORMATION

1. Is there a required final examination? __X___ Yes ______ No
2. Does this course issue a mark/grade for the report card?

   __X___Yes ______ No
3. Does this course issue a Pass/Fail mark? ______Yes __X___ No
4. Is the course mark/grade part of the GPA calculation?

   __X___Yes ______ No
5. Is the course eligible for Honor Roll calculation? __X___ Yes ______ No
6. What is the academic weight of the course?

   ______ No weight/Non credit ______ Standard weight

   __X___ Enhanced weight (Describe) as per current school board policy