Unit 3: Energy

UNIT PLAN

AP Physics 1

Unit # 3

Suggested Duration: 20-21 Days

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UNIT NARRATIVE

This unit begins with an Anchoring Event and Essential Question (day 01) that students will attempt to model and explain with their current physics knowledge. The Anchoring Event has been chosen because it can be modeled using Kinematics and Dynamics but is very difficult to explain properly with using concepts related to Mechanical Energy. Throughout the unit key understandings from individual lessons should be connected back to the Anchoring Event and Essential Question. After all new content has been covered in this unit students will craft Seamless Explanations for the Anchoring Event and Essential Question using the new concepts they have learning in the unit.

First students will explore the PhET Energy Skate Park Simulation (Day 02) as a re-introduction to kinetic and gravitational potential energies, which were first introduced in middle grade sciences. This lesson introduces students to Energy Bar (LOL) Charts as they use these graphs to qualitatively describe the relationships between mass, position, and velocity with kinetic and gravitational potential energy. Students will also describe the conservation of mechanical energy and the conditions required for the conservation of mechanical energy. Energy Bar (LOL) Charts should be created for EVERY physics energy scenario.

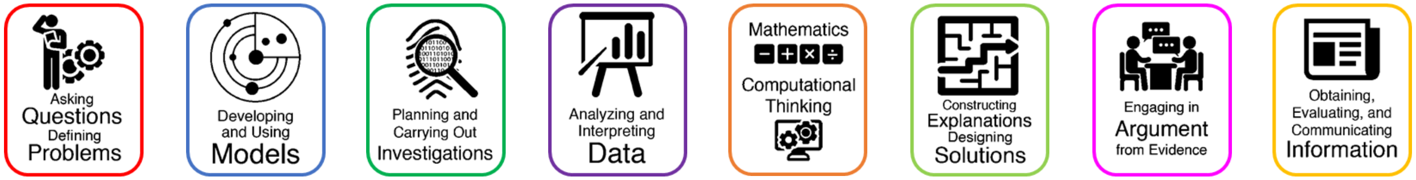
Students will then spend four days experimentally determining the variable relationships the define Work (Day 3), Gravitational Potential Energy (day 3-4), Kinetic Energy (Day 4) and Elastic Potential Energy (Day 6) and then describing the equations for each. Work is introduced early in this unit as a way for students to quantitatively "SEE" how the energy of a system changes. Next students will spend two days (Days 7-8) practicing creating LOL Charts and energy concepts and equations to calculate unknown variables for scenarios. Then students will analyze stopping distance (Day 9) by applying the Work-Energy relationship. This is scenario that can also be analyzed with Kinematics and/Dynamics but is more easily analyzing using Energy. Next students will apply Conservation of Energy to the specific Next students will analyze the scenario of "bungee jump" (Day 10) by taking measurements using a spring and mass and predicting the maximum fall distance when the mass is released from rest.

Next students will spend four days in a station rotation lab (Days 11-14) analyzing different real-world scenarios set up with lab equipment. Students will need to decide which scenarios are better analyzed with the Work-Energy relationship and which are better analyzed using the conservation of energy, make measurements of the required quantities and calculate an unknown variable/quantity. Then students are introduced to the concept of Power as the rate Work (Day15) is done by analyzing physics scenarios using the same procedure as the rest of the unit (modeling with LOL Charts, choosing Work-Energy or Conservation of Energy, setting up an energy equation to describe the scenario) with the added complexity of Power. Now that students have explored the fundamental physics concepts around Mechanical Energy and practiced applying them to analyze physics scenarios, they are ready to revise their initial modeling and thinking about the Anchoring Event and create Seamless Explanations (Day 16) to share with table partners.

The unit concludes with additional practice analyzing physics scenarios quantitatively with energy concepts. Students will spend two days answering, peer scoring, and revising College Board FRQs (Days 17-18) that require the use of conservation of energy concepts in combination with concepts from previous units, specifically projectile motion and circular motion. Most AP Physics Exam FRQ questions will include multiple big physics concepts, so it is important for students to get as much practice as possible with these types of FRQs. During the flex/review day students can use parts of the Progress Check on AP Classroom for additional review with College Board MCQ and/or FRQ This review should include time for students to compare their claims and justifications with table partners

Focus on Disciplinary Literacy

In science, disciplinary literacy is synonymous with the science and engineering practices. The SEPs are the context through which all science concepts should be taught. In the lessons, you will find the Science and Engineering practices icons when the SEPs are being explicitly used by students.



UNPACKED CONTENT STANDARDS

Below are the standards **taught** and **assessed** in this unit.

Topic		Learning Objective		Essential Knowledge	
3.1	Translational Kinetic Energy	3.1.A	Describe the translational kinetic energy of an object in terms of the object's mass and velocity.	3.1.A.1	An object's translational kinetic energy is given by the **equation** - $K = \frac{1}{2}mv^2$
				3.1.A.2	Translational kinetic energy is a scalar quantity.
				3.1.A.3	Different observers may measure different values of the translational kinetic energy of an object, depending on the observer's frame of reference.
3.2	Work	3.2.A	Describe the work done on an object or system by a given force or collection of forces.	3.2.A.1	Work is the amount of energy transferred into or out of a system by a force exerted on that system over a distance. i. The work done by a conservative force exerted on a system is path-independent and only depends on the initial and final configurations of that system. ii. The work done by a conservative force on a system—or the change in the potential energy of the system—will be zero if the system returns to its initial configuration. iii. Potential energies are associated only with conservative forces. iv. The work done by a nonconservative force is path independent. v. Examples of nonconservative forces are friction and air resistance.
				3.2.A.2	Work is a scalar quantity that may be positive, negative, or zero.
				3.2.A.3	The amount of work done on a system by a constant force is related to the components of that force and the displacement of the point at which that force is exerted. I. Only the component of the force exerted on a system that is parallel to the displacement of the point of application of the force will change the system's total energy. **Relevant equation -->** $W = F_{\|\|}d = fd\cos\theta$ ii. The component of the force exerted on a system perpendicular to the direction of the displacement of the system's center of mass can change the direction of the system's motion without changing the system's kinetic energy.
				3.2.A.4	The work-energy theorem state that the change in an object's kinetic energy is equal to the sum of the work (net work) being done by all forces exerted on the object. **Relevant equation-->** $\Delta K = \Sigma W = \Sigma F_{\|\|}d$ i. An external force may change the configuration of a system. The component of the external force parallel to the displacement times the displacement of the point of application of the force gives the change in kinetic energy of the system. ii. If the system's center of mass and the point of application of the force move the same distance when a force is exerted on a system, then the system may be modeled as an object, and only the system's kinetic energy can change. iii. The energy dissipated by friction is typically equated to the force of friction times the length of the path over which the force is exerted, **Derived equation -->**

					$\Delta E_{mech} = F_f d\cos\theta$
				3.2.A.5	Work is equal to the area under the curve of a graph of F as a function of displacement.
		BOUNDARY STATEMENT: *AP Physics 1 only expects students to analyze the transfer of mechanical energy (as defined in Unit 3, Topic 4: Conservation of Energy), although students should be aware that mechanical energy may be dissipated in the form of thermal energy or sound. In AP Physics 2, students will also study how thermal energy can be transferred between systems through heating or cooling.*			
3.3	Potential Energy	3.3.A	Describe the potential energy of a system.	3.3.A.1	A system composed of two or more objects has potential energy if the objects within that system only interact with each other through conservative forces.
				3.3.A.2	Potential energy is a scalar quantity associated with the position of objects within a system.
				3.3.A.3	The definition of zero potential energy for a given system is a decision made by the observer considering the situation to simplify or otherwise assist in analysis.
				3.3.A.4	The potential energy of common physical systems can be described using the physical properties of that system. i. The elastic potential energy of an ideal spring is given by the following equation, where Δx is the distance the spring has been stretched or compressed from its equilibrium length. **Relevant equation -->** $U_S = \frac{1}{2}k(\Delta x)^2$ ii. The general form for the gravitational potential energy of a system consisting of two approximately spherical distributions of mass (e.g., moons, planets or stars) is given by the **Relevant equation -->** $U_g = -G\frac{m_1 m_2}{r}$ iii. Because the gravitational field near the surface of a planet is nearly constant, the change in gravitational potential energy in a system consisting of an object with mass m and a planet with gravitational field of magnitude g when the object is near the surface of the planet may be approximated by the **Relevant equation -->** $U_g = mg\Delta y$
				3.3.A.5	The total potential energy of a system containing more than two objects is the sum of the potential energy of each pair of objects within the system.
3.4	Conservation of Energy	3.4.A	Describe the energies present in a system.	3.4.A.1	A system composed of only a single object can only have kinetic energy.
				3.4.A.2	A system that contains objects that interact via conservative forces or that can change its shape reversibly may have both kinetic and potential energies.
		3.4.B	Describe the behavior of a system using conservation of mechanical energy principles.	3.4.B.1	Mechanical energy is the sum of a system's kinetic and potential energies.
				3.4.B.2	Any change to a type of energy within a system must be balanced by an equivalent change of other types of energies within the system or by a transfer of energy between the system and its surroundings.
				3.4.B.3	A system may be selected so that the total energy of that system is constant.
				3.4.B.4	If the total energy of a system changes, that change will be equivalent to the energy transferred into or out of the system.
		3.4.C		3.4.C.1	Energy is conserved in all interactions.

			Describe how the selection of a system determines whether the energy of that system changes.	3.4.C.2	If the work done on a selected system is zero and there are no nonconservative interactions within the system, the total mechanical energy of the system is constant.
				3.4.C.3	If the work done on a selected system is nonzero, energy is transferred between the system and the environment.
		BOUNDARY STATEMENT: *AP Physics 1 expects students to know that mechanical energy can be dissipated as thermal energy or sound by nonconservative forces.*			
3.5	Power	3.5.A	Describe the transfer of energy into, out of, or within a system in terms of power.	3.5.A.1	Power is the rate at which energy changes with respect to time, either by transfer into or out of a system or by conversion from one type to another within a system.
				3.5.A.2	Average power is the amount of energy being transferred or converted, divided by the time it took for that transfer or conversion to occur. **Relevant equation-->** $\boldsymbol{P_{avg} = \frac{\Delta E}{\Delta t}}$
				3.5.A.3	Because Work is the change in energy of an object or system due to a force, average power is the total Work done, divided by the time during which that Work was done. **Relevant equation -->** $\boldsymbol{P_{avg} = \frac{\Delta W}{\Delta t}}$
				3.5.A.4	The instantaneous power delivered to an object by the component of a constant force parallel to the object's velocity can be described with the **derived equation -->** $\boldsymbol{P_{inst} = F_{\parallel} v = Fv\,cos\theta}$

KEY UNDERSTANDINGS AND QUESTIONS

Key Understandings

- ❑ Phenomena are events or processes ("things that happen") that are observable or detectable
- ❑ A scientific question is a question that may lead to a hypothesis and help us in answering the explanation for an observation or event
- ❑ Potential energy is the stored energy an object has due to its position or configuration
- ❑ Kinetic energy is the energy an object has due to its motion
- ❑ Mechanical energy is the energy an object possesses due to its motion AND position (the sum of the two)
- ❑ Work is the amount of energy transferred into or out of a system by a force exerted on that system over a distance.
- ❑ Work is a scalar quantity that may be positive, negative, or zero.
- ❑ $W = f_{||}\, d = Fdcos\theta$
- ❑ The work-energy theorem states that the change in an object's kinetic energy is equal to the sum of the work (net work) being done by all forces exerted on the object.
- ❑ $\Delta K = \Delta W_i = \Delta f_{||}\, d_i$
- ❑ Work is equal to the area under the curve of a graph of Force as a function of displacement.
- ❑ Potential energy is a scalar quantity associated with the position of objects within a system.
- ❑ The definition of zero potential energy for a given system is a decision made by the observer considering the situation to simplify or otherwise assist in analysis.
- ❑ The total potential energy of a system containing more than two objects is the sum of the potential energy of each pair of objects within the system.
- ❑ Mass and height have a linear relationship with gravitational potential energy
- ❑ $\Delta U_g = mg\Delta y$
- ❑
- ❑ Mass has a linear relationship with kinetic energy and velocity has a squared relationship with kinetic energy
- ❑ $K = \frac{1}{2}mv^2$
- ❑ Spring constant has a linear relationship with elastic potential energy
  - Spring displacement has a squared relationship with elastic potential energy
- ❑ $\Delta U_s = \frac{1}{2}k(\Delta x)^2$
- ❑ Energy is conserved in all interactions.
- ❑ Mechanical energy is the sum of a system's kinetic and potential energies.
- ❑ A system composed of only a single object can only have kinetic energy.
- ❑ A system that contains objects that interact via conservative forces or that can change its shape reversibly may have both kinetic and potential energies.

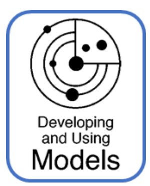
- ❑ Any change to a type of energy within a system must be balanced by an equivalent change of other types of energies within the system or by a transfer of energy between the system and its surroundings.
- ❑ If the total energy of a system changes, that change will be equivalent to the energy transferred into or out of the system.
- ❑ If the work done on a selected system is zero and there are no nonconservative interactions within the system, the total mechanical energy of the system is constant.
- ❑ If the work done on a selected system is nonzero, energy is transferred between the system and the environment.
- ❑ Negative work must be done in order to stop a moving object
- ❑ Negative work reduces mechanical energy (by converting to thermal energy)
- ❑ The amount of work done to stop a moving object is proportional to the kinetic energy of the object
- ❑ Power is the rate at which energy changes with respect to time, either by transfer into or out of a system or by conversion from one type to another within a system.
- ❑ Average Power is the rate of energy change, or the amount of work done or per unit of time
- ❑ $P_{avg} = \frac{W}{\Delta t} = \frac{\Delta E}{\Delta t}$
- ❑ The instantaneous power delivered to an object by the component of a constant force parallel to the object's velocity can de described by the equation: $P_{inst} = F_{\parallel} v = Fv\cos\theta$
- ❑ Revise original model based on evidence from Unit Lessons
- ❑ Making a Claim to explain the Anchoring Event and Essential Question
- ❑ Identifying evidence from Unit Lessons relevant to Anchoring Event and Essential Question
- ❑ Crafting a Seamless Explanation by connecting all relevant evidence to the claim using physics laws and principles

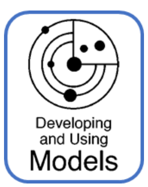
Key Questions

- How is Mechanical Energy different than total energy?
- Under what circumstances is the total mechanical energy of a system conserved?
- How can we make accurate predictions about the types of mechanical energy an system has at particular times and locations?
- How can we use energy relationships to make predictions about the movement of objects?
- How does Work affect the energy of a system?
- How is Power related to Work and Energy?

ROADMAP

AT A Glance: Unit #:				
Day	**Date**	**Lesson**	**Lesson Title**	**Lesson Notes**
1		01	Anchoring Event & Initial Modeling	
2		02	Intro to Energy – Energy Skate Park	
3		03	Work-Energy	
4		04	Gravitational Potential Energy	
5		05	Kinetic Energy	
6		06	Elastic Potential Energy	
7		07	Conservation of ME – Day 1	
8		08	Conservation of ME – Day 2	
9		09	Conservation of ME Challenge	
10		10	Stopping Distance	
11		11	Energy Stations – Day 1	
12		12	Energy Stations – Day 2	
13		13	Energy Stations – Day 3	
14		14	Energy Stations – Day 4	
15		15	Work & Power	
16		16	Anchoring Event–Seamless Explanations	
17		17	FRQ Practice – Basic Energy	
18		18	FRQ Practice – Energy & Projectile Motion	
19		19	Flex/Review	
20		20	**TX_SCI_APPhysics_S25_UE3**	
21		Success Day	Time Permitting – review the most missed MC and the entire FRQ using Success Day Lesson Plan	

Lesson	Objective(s) and Standard(s)	Instructional Notes	Resources
Day 01 **Anchoring Event & Modeling**	**STANDARD(s):** **Topic 3.2: Work** 3.2.A - Describe the work done on an object or system by a given force or collection of forces. **Topic 3.4: Conservation of Energy** 3.4.A - Describe the energies present in a system. 3.4.B - Describe the behavior of a system using conservation of mechanical energy principles. **SWBAT**: create an initial explanatory model for the anchoring event **DISCIPLINARY LITERACY FOCUS:** 	**KEY UNDERSTANDINGS CHECKLIST** ❑ **Phenomena are events or processes ("things that happen") that are observable or detectable** ❑ **A scientific question is a question that may lead to a hypothesis and help us in answering the explanation for an observation or event** **LESSON CONTEXT FOR LESSON MASTERY** This lesson introduces students to energy through a swinging pendulum from the ceiling. Students will be asked a question regarding an interactive, observable anchoring event. By playing with and making observations about the event, students form a hypothesis regarding the cause of the phenomenon. Their hypothesis will be tested and revised throughout the unit until a definitive conclusion is reached. **LOOK-FORS 🔍 (What to observe students doing or producing)** • Recording qualitative and quantitative observations and data • Create a model with annotations, questions, and ideas **LISTEN-FORS 🗣 (Examples of what students should be saying or explaining)** • Using prior knowledge to justify a hypothesis **COMMON MISCONCEPTIONS 🚩 (Historical/widespread misunderstandings)** ▪ Misconceptions will vary from student to student as this is their first exploration into energy and work. The key is to NOT dissuade these misconceptions as they will be addressed as they arise throughout the unit.	Materials Required: • Bocce Ball Pendulum Kit OR • Pendulum hung from classroom ceiling **TEACHER CONTENT BACKGROUND RESOURCES** • **Ceiling Pendulum Demo** • **Ambitious Science Teaching Overview**

Lesson	Objective(s) and Standard(s)	Instructional Notes	Resources
Day 02 **Energy Skate Park – Exploring Energy**	**STANDARD(s):** **Topic 3.1: Translational Kinetic Energy** 3.1.A Describe the translational kinetic energy of an object in terms of the object's mass and velocity. **Topic 3.3: Potential Energy** 3.3.A Describe the potential energy of a system. **Topic 3.4: Conservation of Energy** 3.4.A Describe the energies present in a system. 3.4.B Describe the behavior of a system using conservation of mechanical energy principles. **SWBAT** describe qualitatively the relationships between potential energy, kinetic energy, mechanical energy and friction using energy bar charts. **DISCIPLINARY LITERACY FOCUS:** 	**KEY UNDERSTANDINGS CHECKLIST** ❑ **Potential energy is the stored energy an object has due to its position or configuration** ❑ **Kinetic energy is the energy an object has due to its motion** ❑ **Mechanical energy is the energy an object possesses due to its motion AND position (the sum of the two)** **LESSON CONTEXT FOR LESSON MASTERY** Students are re-introduced to kinetic, potential, and mechanical energy after learning them in 8th grade science. This lesson introduces students how to account for energy in a "before" and "after" state using Energy Bar Charts (LOKL). Students should use Energy Bar Charts as a first step in analyzing ALL physics scenarios related to Mechanical Energy. **LOOK-FORS (What to observe students doing or producing)** • Summing energy at various states • Producing graphs with equal amounts of energy **LISTEN-FORS (Examples of what students should be saying or explaining)** • Using prior knowledge to justify a hypothesis **COMMON MISCONCEPTIONS (Historical/widespread misunderstandings)** ▪ Misconceptions will vary from student to student as this is their first exploration into energy and work. The key is to NOT dissuade these misconceptions as they will be addressed as they arise throughout the unit.	**PhET – Energy Skate Park** **TEACHER CONTENT BACKGROUND RESOURCES** • **PC – Mechanical Energy** • **Khan – Kinetic Energy** • **Khan – Potential Energy** • **Khan -Conservation of Energy** • **Khan – LOL Diagrams** • **PC – Bar Charts Diagrams**
Day 03	**STANDARD(s):** **Topic 3.2: Work**	**KEY UNDERSTANDINGS CHECKLIST** ❑ **Work is the amount of energy transferred into or out of a system by a force exerted on that system over a distance.**	**TEACHER CONTENT BACKGROUND RESOURCES**

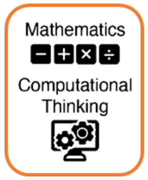
Lesson	Objective(s) and Standard(s)	Instructional Notes	Resources
Work-Energy	3.2.A Describe the work done on an object or system by a given force or collection of forces **SWBAT** experimentally discover the concept of the Work done on a system by measuring the amount of energy added to a system and comparing to a Force-distance graph. **DISCIPLINARY LITERACY FOCUS:** 	❑ **Work is a scalar quantity that may be positive, negative, or zero.** ❑ $W = f_{\|\|} d = Fd\cos\theta$ ❑ **The work-energy theorem states that the change in an object's kinetic energy is equal to the sum of the work (net work) being done by all forces exerted on the object.** ❑ $\Delta K = \Delta W_i = \Delta f_{\|\|} d_i$ ❑ **Work is equal to the area under the curve of a graph of Force as a function of displacement.** **LESSON CONTEXT FOR LESSON MASTERY** This lesson provides a bridge between two heavy hitting concepts: work and energy. This lesson introduces work as the area under a force-distance graph and also introduces the student to the work-energy theorem by experimentally comparing it to the energy added to a system. **LOOK-FORS 🔍 (What to observe students doing or producing)** • Collecting meaningful data by: ○ Measuring the height and distance of the inclined plane ○ Applying steady, controlled force while pushing ○ Performing multiple trials • Plotting force vs distance and calculating area under curve • Comparing calculated area to calculated theoretical work **LISTEN-FORS 🗣 (Examples of what students should be saying or explaining)** • Checking for inconsistencies in data • Hypothesizing that the work produced is related to force applied and / or distance pushed • Justifying that area under force-distance graph is the work done **COMMON MISCONCEPTIONS 🚩 (Historical/widespread misunderstandings)** ▪ "A greater incline will cause more work done because it takes more force to move the object". The student is only considering the magnitude of the force produced to raise the cart.	• **Khan – KE & Work** • **Khan – Work-KE Example** • **Khan – Force-displacement graphs** Materials (per group): • 1 student computer • Vernier track and dynamics cart • Vernier force sensor • 1 Vernier motion sensor • Books (to create incline) • Extra masses • String (shared) • Masking tape (shared)

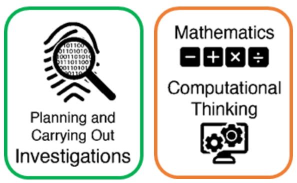
Lesson	Objective(s) and Standard(s)	Instructional Notes	Resources
Day 04 **Gravitational Potential Energy Formula** **Day 05** **Kinetic Energy Formula**	**STANDARD(s):** **Topic 3.1: Translational Kinetic Energy** 3.1.A Describe the translational kinetic energy of an object in terms of the object's mass and velocity. **Topic 3.3: Potential Energy** 3.3.A Describe the potential energy of a system. **SWBAT** design, execute and analyze experiments to determine the variable relationships that define gravitational potential energy and kinetic energy (U_G, KE). **DISCIPLINARY LITERACY FOCUS:** Planning and Carrying Out Investigations	**KEY UNDERSTANDINGS CHECKLIST** ❑ **Potential energy is a scalar quantity associated with the position of objects within a system.** ❑ **The definition of zero potential energy for a given system is a decision made by the observer considering the situation to simplify or otherwise assist in analysis.** ❑ **The total potential energy of a system containing more than two objects is the sum of the potential energy of each pair of objects within the system.** ❑ **Mass and height have a linear relationship with gravitational potential energy** ❑ $\Delta U_g = mg\Delta y$ ❑ **Mass has a linear relationship with kinetic energy and velocity has a squared relationship with kinetic energy** ❑ $K = \frac{1}{2}mv^2$ **LESSON CONTEXT FOR LESSON MASTERY** This lesson allows students to experimentally uncover the equations for potential energy and kinetic energy and continues to give students valuable data collection and analysis time. This lesson offers students a more in-depth look into equations they will be referring back to for the remainder of the unit. **LOOK-FORS 🔍 (What to observe students doing or producing)** • Collecting meaningful data by: ○ Measuring and varying the mass of objects ○ Measure the height ○ Performing multiple trials **LISTEN-FORS 🗣 (Examples of what students should be saying or explaining)** • Checking for inconsistencies in data • Hypothesizing which variables cause an effect in potential or kinetic energy • Identifying relationships: ○ Linear for m, h and U_g	**TEACHER CONTENT BACKGROUND RESOURCES** • Khan – Kinetic Energy • Khan – Potential Energy Materials Required (per group): • 1 student computer • Vernier track and dynamics cart • Vernier force sensor • 1 Vernier motion sensor • Books (to create incline) • Extra masses • String (shared) • Masking tape (shared)

Lesson	Objective(s) and Standard(s)	Instructional Notes	Resources
		○ Linear for m and K but squared for v and K **COMMON MISCONCEPTIONS 🚩 (Historical/widespread misunderstandings)** ▪ "All energy relationships are linear" ▪ "Heavier objects have more kinetic energy so they should have greater speed when they fall than lighter objects".	
Day 06 **Elastic Potential Energy Formula**	**STANDARD(s):** **Topic 3.3: Potential Energy** 3.3.A Describe the potential energy of a system. **SWBAT** collect experimental data to derive the equation for spring/elastic potential energy. **DISCIPLINARY LITERACY FOCUS:** 	**KEY UNDERSTANDINGS CHECKLIST** ❑ **Spring constant has a linear relationship with elastic potential energy** ❑ **Spring displacement has a squared relationship with elastic potential energy** ❑ $\Delta U_s = \frac{1}{2}k(\Delta x)^2$ **LESSON CONTEXT FOR LESSON MASTERY** This lesson allows students to experimentally uncover the equations for elastic potential and continues to give students valuable data collection and analysis time. This lesson offers students a more in-depth look into equations they will be referring back to for the remainder of the unit. **LOOK-FORS 🔍 (What to observe students doing or producing)** • Collecting meaningful data by: ○ Measuring and varying the mass of objects (to act as the constant downward force) OR ○ Measuring and varying the force needed to stretch a spring a specific distance ○ Measuring the displacement of the springs from equilibrium ○ Performing multiple trials **LISTEN-FORS 🗣 (Examples of what students should be saying or explaining)** • Checking for inconsistencies in data • Hypothesizing which variables cause an effect in elastic potential energy • Identifying relationships: ○ Linear for k ○ Squared for x	**TEACHER CONTENT BACKGROUND RESOURCES** • PC – Potential Energy • Khan – Potential Energy

Lesson	Objective(s) and Standard(s)	Instructional Notes	Resources
		COMMON MISCONCEPTIONS 🚩 (Historical/widespread misunderstandings) ▪ Confusing spring force equation (Hooke's law) with elastic potential energy ▪ Assuming the equilibrium point is where the hanging mass rests ▪ Not recognizing that displacement from the equilibrium in either direction will result in the same elastic potential energy	
Day 07 **Conservation of Energy – 1** **Day 08** **Conservation of Energy – 2**	**STANDARD(s):** **Topic 3.4: Conservation of Energy** 3.4.A Describe the energies present in a system. 3.4.B Describe the behavior of a system using conservation of mechanical energy principles. **SWBAT** apply the concept of conservation of energy to make qualitative and quantitative predictions about physics scenarios. **DISCIPLINARY LITERACY FOCUS:** Mathematics Computational Thinking	**KEY UNDERSTANDINGS CHECKLIST** ❑ **Energy is conserved in all interactions.** ❑ **Mechanical energy is the sum of a system's kinetic and potential energies.** ❑ **A system composed of only a single object can only have kinetic energy.** ❑ **A system that contains objects that interact via conservative forces or that can change its shape reversibly may have both kinetic and potential energies.** ❑ **Any change to a type of energy within a system must be balanced by an equivalent change of other types of energies within the system or by a transfer of energy between the system and its surroundings.** ❑ **If the total energy of a system changes, that change will be equivalent to the energy transferred into or out of the system.** ❑ **If the work done on a selected system is zero and there are no nonconservative interactions within the system, the total mechanical energy of the system is constant.** ❑ **If the work done on a selected system is nonzero, energy is transferred between the system and the environment.** **LESSON CONTEXT FOR LESSON MASTERY** This lesson allows students to practice each equation for the different types of energies they have learned over the past week. Students will become familiar with identifying initial and final states for a scenario and practice one of the most important concepts for this unit: conservation of energy. **LOOK-FORS 🔍 (What to observe students doing or producing)** • Clearly labeling initial and final states of the system • Sketching "before" and "after" bar charts	**TEACHER CONTENT BACKGROUND RESOURCES** • **Khan – Conservation of Energy** • Khan – Conversation of Energy Examples • PC – Conserved Energy Examples

Lesson	Objective(s) and Standard(s)	Instructional Notes	Resources
		• Applying appropriate energy equation based on key phrases in the narrative: ○ U_g for an object with height ○ K for an object in motion ○ U_s for a stretched spring **LISTEN-FORS 🗣 (Examples of what students should be saying or explaining)** • Identifying where the maximum and minimum amount of energy are at initial and final states • Describing how the energy totals must remain the same from the initial to final state **COMMON MISCONCEPTIONS 🚩 (Historical/widespread misunderstandings)** ▪ "Objects at rest have no energy" ▪ "Doubling the speed will double the kinetic energy"	
Day 09 **Lab Practicum: Conservation of Energy Challenge**	**STANDARD(s):** **Topic 3.4: Conservation of Energy** 3.4.A Describe the energies present in a system. 3.4.B Describe the behavior of a system using conservation of mechanical energy principles. **SWBAT** apply conservation of energy concepts to predict the minimum height of a bungee jump.	**KEY UNDERSTANDINGS CHECKLIST** ❑ **Energy is conserved in all interactions.** ❑ **Mechanical energy is the sum of a system's kinetic and potential energies.** ❑ **A system composed of only a single object can only have kinetic energy.** ❑ **A system that contains objects that interact via conservative forces or that can change its shape reversibly may have both kinetic and potential energies.** ❑ **Any change to a type of energy within a system must be balanced by an equivalent change of other types of energies within the system or by a transfer of energy between the system and its surroundings.** ❑ **If the total energy of a system changes, that change will be equivalent to the energy transferred into or out of the system.** ❑ **If the work done on a selected system is zero and there are no nonconservative interactions within the system, the total mechanical energy of the system is constant.** ❑ **If the work done on a selected system is nonzero, energy is transferred between the system and the environment.** **LESSON CONTEXT FOR LESSON MASTERY**	**TEACHER CONTENT BACKGROUND RESOURCES** • **Khan – Conservation of Energy** • Khan – Conversation of Energy Examples • PC – Conserved Energy Examples Materials (per group): • 1 lab/ring stand • 1 clamp • 1 index card • 1 meterstick • Extra masses Shared • Various masses

Lesson	Objective(s) and Standard(s)	Instructional Notes	Resources
	DISCIPLINARY LITERACY FOCUS:  	This activity tests students ability to apply the theoretical concepts of energy they have learned thus far. Students must utilize gravitational potential, elastic potential, kinetic energy, and conservation of energy concepts. **LOOK-FORS 🔍 (What to observe students doing or producing)** • Clearly labeling initial and final states of the system • Sketching "before" and "after" bar charts • Measuring the natural length of the spring • Testing different drop heights • Performing multiple trials **LISTEN-FORS 🗣 (Examples of what students should be saying or explaining)** • Identifying where the maximum and minimum amount of energy are at initial and final states • Describing how the energy totals must remain the same from the initial to final state **COMMON MISCONCEPTIONS 🚩 (Historical/widespread misunderstandings)** Misconceptions will vary from student to student	
Day 10 **Stopping Distance**	**STANDARD(s):** **Topic 3.2: Work** 3.2.A Describe the work done on an object or system by a given force or collection of forces **Topic 3.4: Conservation of Energy** 3.4.A Describe the energies present in a system. 3.4.B Describe the behavior of a system using conservation of mechanical energy principles.	**KEY UNDERSTANDINGS CHECKLIST** ❑ **If the work done on a selected system is nonzero, energy is transferred between the system and the environment.** ❑ **Negative work must be done in order to stop a moving object** ❑ **Negative work reduces mechanical energy (by converting to thermal energy)** ❑ **The amount of work done to stop a moving object is proportional to the kinetic energy of the object** **LESSON CONTEXT FOR LESSON MASTERY** At this point in the lesson, students have now learned about energy quantities, the Law of Conservation of Energy, and the Work-Kinetic Energy Theorem. This lab simulation allows students the opportunity to make predictions using these two important concepts by introducing heat as a form of "negative" work.	**Stopping Distance Activity** **TEACHER CONTENT BACKGROUND RESOURCES** • **Khan – Energy dissipated by friction**

Lesson	Objective(s) and Standard(s)	Instructional Notes	Resources
	SWBAT experimentally determine the variable relationships that define stopping distance using a virtual simulation. **SWBAT** make predictions about the stopping distance of a car using Conservation of Energy and/or the Work-Kinetic Energy relationship. **DISCIPLINARY LITERACY FOCUS:**  	Additionally, this also sets students up for the following topics in later units: Conservation of Momentum, energy lost during simple harmonic motion, and energy lost during rotational motion. **LOOK-FORS 🔍 (What to observe students doing or producing)** • Adjusting the initial height of the ramp to alter the starting conditions • Recording speed and skid distance in a table • Plotting data to create multiple representations of variable relationships **LISTEN-FORS 🗣 (Examples of what students should be saying or explaining)** • Students are making predictions or connections during the data collection phase • Students form connections during the data analysis phase by applying the Law of Conservation of Energy • Students identify friction as a source of negative work being performed during the skid section of the simulation **COMMON MISCONCEPTIONS 🚩 (Historical/widespread misunderstandings)** • Students may struggle applying the quadratic relationships between the distance and initial velocity of an object	
Day 11 **Energy Lab Stations Day 1** **Day 12** **Energy Lab Stations Day 2**	**STANDARD(s):** **Topic 3.2: Work** 3.2.A Describe the work done on an object or system by a given force or collection of forces **Topic 3.4: Conservation of Energy** 3.4.A Describe the energies present in a system.	**KEY UNDERSTANDINGS CHECKLIST** ❑ **Potential energy is the stored energy an object has due to its position or configuration** ❑ **Kinetic energy is the energy an object has due to its motion** ❑ **Mechanical energy is the energy an object possesses due to its motion, position, or both** ❑ **Negative work reduces mechanical energy (converts to thermal energy)** **LESSON CONTEXT FOR LESSON MASTERY**	**TEACHER CONTENT BACKGROUND RESOURCES** • Khan – KE & Work • Khan – Work-KE Example • Khan – Conservation of Energy

Lesson	Objective(s) and Standard(s)	Instructional Notes	Resources
Day 13 **Energy Lab Stations Day 3** **Day 14** **Energy Lab Stations Day 4**	3.4.B Describe the behavior of a system using conservation of mechanical energy principles. **SWBAT** select between conservation of energy and Work-Energy to use to make qualitative predictions about various lab stations/scenarios. **DISCIPLINARY LITERACY FOCUS:** Mathematics Computational Thinking	Students will implement all key understandings learned this far in a station rotation activity by interacting with real-world set ups. These lessons require students to utilize energy bar charts, Law of Conservation of Energy, and / or Work-Kinetic Energy Theorem. This practice sets up students for preparing for topics in future units: momentum and collisions, making predictions about simple harmonic motion, and rotational mechanical energy. **LOOK-FORS (What to observe students doing or producing)** • Drawing energy bar charts representing specific lab scenarios • Interpreting negative work appropriately when present • Applying Law of Conservation of Energy or Work-Energy theorem as needed to make a prediction **LISTEN-FORS (Examples of what students should be saying or explaining)** • Discussing which forms of energy are present and how to calculate them • Comparing the energy before and after the scenario and discussing how it changed within the system • Making predictions by using equations / relationships **COMMON MISCONCEPTIONS (Historical/widespread misunderstandings)** Student misconceptions may vary based on the specific lab station the student is working at. See prior misconceptions list based on the particular station (e.g. negative work, elastic potential energy, etc.)	• Khan – Conversation of Energy Examples • PC – Conserved Energy Examples **Materials (stations):** • Student whiteboards • Dynamics carts and tracks • Various masses • Motion detector • Rulers • Loop spring or cart launcher • Sticky notes • Bouncy ball • Spring scales or force sensors • Pulleys • String • Metersticks • Lever fulcrum
Day 15 **Work & Power**	**STANDARD(s):** **Topic 3.5: Power** 3.5.A Describe the transfer of energy into, out of, or within a system in terms of power. **SWBAT** make qualitative predictions about the amount of Work and Power in physics scenarios.	**KEY UNDERSTANDINGS CHECKLIST** ❑ **Power is the rate at which energy changes with respect to time, either by transfer into or out of a system or by conversion from one type to another within a system.** ❑ **Average Power is the rate of energy change, or the amount of work done or per unit of time** ❑ $P_{avg} = \frac{W}{\Delta t} = \frac{\Delta E}{\Delta t}$	**TEACHER CONTENT BACKGROUND RESOURCES** • Khan - Power • PC - Power

Lesson	Objective(s) and Standard(s)	Instructional Notes	Resources
	DISCIPLINARY LITERACY FOCUS: Mathematics Computational Thinking	❑ **The instantaneous power delivered to an object by the component of a constant force parallel to the object's velocity can de described by the equation:** $P_{inst} = F_{\parallel}v = Fv\cos\theta$ **LESSON CONTEXT FOR LESSON MASTERY** This lesson gives students the opportunity to continue practicing energy bar charts, conservation of energy, work-energy theorem and also tie these concepts to power. Students perform a series of at-bat style problems. **LOOK-FORS 🔍 (What to observe students doing or producing)** • Drawing energy bar charts representing specific lab scenarios • Interpreting negative work appropriately when present • Applying Law of Conservation of Energy or Work-Energy theorem as needed to make a prediction **LISTEN-FORS 🗣 (Examples of what students should be saying or explaining)** • Discussing which forms of energy are present and how to calculate them • Comparing the energy before and after the scenario and discussing how it changed within the system • Making predictions by using equations / relationships **COMMON MISCONCEPTIONS 🚩 (Historical/widespread misunderstandings)** Student misconceptions may vary based on the concept the student is attempting to apply. See prior misconceptions list based on the particular station (e.g. negative work, elastic potential energy, etc.)	
Day 16 **Anchoring Event Seamless Explanation**	**STANDARD(s):** **Topic 3.2: Work** 3.2.A - Describe the work done on an object or system by a given force or collection of forces. **Topic 3.4: Conservation of Energy**	**KEY UNDERSTANDINGS CHECKLIST** ❑ **Revise original model based on evidence from Unit Lessons** ❑ **Making a Claim to explain the Anchoring Event and Essential Question** ❑ **Identifying evidence from Unit Lessons relevant to Anchoring Event and Essential Question** ❑ **Crafting a Seamless Explanation by connecting all relevant evidence to the claim using physics laws and principles**	**TEACHER CONTENT BACKGROUND RESOURCES** ❑

Lesson	Objective(s) and Standard(s)	Instructional Notes	Resources
	3.4.A - Describe the energies present in a system. 3.4.B - Describe the behavior of a system using conservation of mechanical energy principles. **SWBAT:** write a paragraph length justification about how a cup full of water can be spun in a vertical circle without spilling the water. **DISCIPLINARY LITERACY FOCUS:** 	**LESSON CONTEXT FOR LESSON MASTERY** Students use graphic organizers and reviewing summary tables to create a seamless explanation of the anchoring event. Students are given time to have whole group discussion and draw evidence from multiple sources to answer an essential question from the anchoring event. Being able to answer essential questions using discussion and evidence is a foundational skill for both Physics and other science courses. **LOOK-FORS 🔍 (What to observe students doing or producing)** • Citing evidence from their summary tables • Including scientific reasoning to connect the evidence with the Claim **LISTEN-FORS 🗣 (Examples of what students should be saying or explaining)** • Providing feedback to partners using the Accountable Talk Moves for Scholars and asking clarifying questions **COMMON MISCONCEPTIONS 🚩 (Historical/widespread misunderstandings)** • Moving object stop on their own (without a net force stopping them).	❑ 5 Mini Lessons to Improve Written Explanations ❑ Explanation Tool – Graphic Organizer
Day 17 **FRQ Practice: Basic Energy & Work**	**STANDARD(s):** **Topic 3.2: Work** 3.2.A Describe the work done on an object or system by a given force or collection of forces. **Topic 3.4: Conservation of Energy** 3.4.A Describe the energies present in a system. 3.4.B Describe the behavior of a system using conservation of mechanical energy principles.	**KEY UNDERSTANDINGS CHECKLIST** ❑ **See all previous lessons from this unit** **LESSON CONTEXT FOR LESSON MASTERY** Students use all key understandings for Unit 3 to engage with FRQ style questions. FRQ writing is a foundational skill for both AP Physics, future science courses, and life skills for careers. This FRQ begins with content from Unit 1: Kinematics to provide spiral review about v-t graphs and help students make connections between units. **LOOK-FORS 🔍 (What to observe students doing or producing)** • Students using AP Physics Table to identify relevant equations • Deriving equations as need using proper algebraic techniques • Using notes and previous practice to help answer questions	

Lesson	Objective(s) and Standard(s)	Instructional Notes	Resources
	SWBAT: demonstrate mastery of Work & Energy concepts on College Board FRQs **DISCIPLINARY LITERACY FOCUS:** Mathematics Computational Thinking	• Using relevant evidence and reasoning to support claims that directly answer each question **LISTEN-FORS (Examples of what students should be saying or explaining)** • Justifying claim or evidence / reasoning choice with peers **COMMON MISCONCEPTIONS (Historical/widespread misunderstandings)** • Reading/analyzing the graph as a p-t graph (not reding the x and y axis first) • Thinking that larger magnitude of negative velocity is slower • Thinking that Work cannot be compared because object A has a non-linear graph (but it can still be estimated and compared qualitatively)	
Day 18 **FRQ Practice: Energy and Projectile Motion**	**STANDARD(s):** **Topic 3.4: Conservation of Energy** 3.4.A - Describe the energies present in a system. 3.4.B - Describe the behavior of a system using conservation of mechanical energy principles. **Topic 2.9: Circular Motion** 2.9.A Describe the motion of an object traveling in a circular path. **SWBAT:** combine energy concepts with projectile motion and/or circular motion concepts to make qualitative claims and predictions with evidence and reasoning	**KEY UNDERSTANDINGS CHECKLIST** ❑ **See all previous lessons from this unit** **LESSON CONTEXT FOR LESSON MASTERY** Students use all key understandings for Unit 3 to engage with FRQ style questions. FRQ writing is a foundational skill for both AP Physics, future science courses, and life skills for careers. These FRQ choices ask students to analyze scenarios using both Energy concepts AND projectile motion concepts. **LOOK-FORS (What to observe students doing or producing)** • Students using AP Physics Table to identify relevant equations • Deriving equations as need using proper algebraic techniques • Using notes and previous practice to help answer questions • Using relevant evidence and reasoning to support claims that directly answer each question **LISTEN-FORS (Examples of what students should be saying or explaining)** • Justifying claim or evidence / reasoning choice with peers **COMMON MISCONCEPTIONS (Historical/widespread misunderstandings)** ❑ Not drawing LOL charts to begin analyzing a physics scenario using Mechanical Energy/Conservation of Energy.	

Lesson	Objective(s) and Standard(s)	Instructional Notes	Resources
	DISCIPLINARY LITERACY FOCUS: Mathematics Computational Thinking Engaging in Argument from Evidence	❑ Forgetting that spring potential energy has a squared relationship with elastic potential energy ❑ The time of flight for a horizontal projectile depends on the initial velocity of the projectile.	
Day 19	**Flex/review** – Students can complete & review the College Board Unit 4 – Energy Progress Check in AP Classroom. Students should take the MC part of the Progress Check (part 1 and 2). There are 32 questions in total and per AP Exam timing of 1.8 min/question students should be given. Shorten as needed for your classes. Students should review their answers to the Progress Check MC. They should provide justification for the correct answers AND incorrect answers. How do they know each answer choice is correct or incorrect.		
Day 20	**TX_SCI_APPhysics_S26_UE3** **All Student should have access to the AP Physics 1 Equation Table during the exam**		ap-physics-1-Equation Table - 2024.pdf

VERTICAL STANDARDS for Texas

This section details the **progression** of key student standards in the courses **before** this course. This will help you understand what **prior knowledge skills to build upon**.

5th Grade Science	6/7 Grade Hybrid Science	8th Grade Science
3-5(7) Force, motion, and energy. The student knows the nature of forces and the patterns of their interactions. The student is expected to: 5.7A investigate and explain how equal and unequal forces acting on an object cause patterns of motion and transfer of energy. **3-5(8) Force, motion, and energy. The student knows that energy is everywhere and can be observed in cycles, patterns, and systems. The student is expected to:** 5(8)(A) investigate and describe the transformation of energy in systems such as energy in a flashlight battery that changes from chemical energy to electrical energy to light energy; 5(8)(B) demonstrate that electrical energy in complete circuits can be transformed into motion, light, sound, or thermal energy and identify the requirements for a functioning electrical circuit; and	**6(8) Force, motion, and energy. The student knows that the total energy in systems is conserved through energy transfers and transformations. The student is expected to:** 6(8)(A) compare and contrast gravitational, elastic, and chemical potential energies with kinetic energy; 6(8)(B) describe how energy is conserved through transfers and transformations in systems such as electrical circuits, food webs, amusement park rides, or photosynthesis; and **7(8) Force, motion, and energy. The student understands the behavior of thermal energy as it flows into and out of systems. The student is expected to:** 7(8)(A) investigate methods of thermal energy transfer into and out of systems, including conduction, convection, and radiation; 7(8)(B) investigate how thermal energy moves in a predictable pattern from warmer to cooler until all substances within the system reach thermal equilibrium; and 7(8)(C) explain the relationship between temperature and the kinetic energy of the particles within a substance.	None

VOCABULARY GLOSSARY

Domain-specific words and definitions for this unit.

Key Content Vocabulary

Energy Bar Chart – a model to represent the energy transformations and movement in a scenario.

Mechanical Energy – the sum of potential energy and kinetic energy of an object or system of objects.

$$ME = KE + U_G + U_S$$

Gravitational Potential Energy – the potential energy and object possess due to its position relative to the Earth.

$$U_G = mgh$$

Kinetic Energy – the energy that an object possesses due to its motion.

$$KE = \frac{1}{2}.mv^2$$

Conservation of Energy - states that the total energy of an isolated system remains constant; it is said to be *conserved* over time.

Work - the energy transferred to or from an object/system via the application of force along a displacement.

$$W = Fdcos\theta$$

Power – the rate of doing Work or the rate of energy transfer, units: Joules/sec = Watt

$$P = \frac{\Delta W}{t} \text{ or } P = \frac{\Delta E}{t}$$

Spring Force (Hooke's Law) - a law of physics that states that the force (*F*) needed to extend or compress a spring by some distance (*x*) scales linearly with respect to that distance.

$$F_s = -kx$$
$$k = spring\ constant$$
$$x = displacement\ of\ spring\ from\ equilibrium\ position$$

Spring Constant – a measure the of the stiffness of a spring. Larger numbers indicate a stiffer spring. Often measured in N/m.

Spring/Elastic Potential Energy - the mechanical potential energy stored in the configuration of a material or physical system as it is subjected to elastic deformation by work performed upon it.

$$U_S = \frac{1}{2}k\Delta x^2$$

Related Vocabulary

Thermal Energy				