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| **Task-level phenomenon:**  Students watch a video showing a slinky falling in slow motion and a video showing a how a light powered by gravity works.  **Synopsis of high-quality task:**  Students observe phenomena regarding energy transformation and share questions they have. Students then observe, interact, and describe energy change with energy transformation setups. Students explain energy changes shown in pictures and calculate kinetic and potential (both gravitational and elastic) energy.  This lesson could serve as the start of a unit on energy, or this lesson could serve as a follow up to lessons on energy issues (e.g., designing and building a renewably powered device), or discussion and activity on mechanical work.  This lesson is best followed by discussions on power and energy, calculating power, and using conservation of energy.  **Anticipated student time spent on task:** 2 class sessions, 55 min each  **Type of Task (check one):**  \_x\_\_ 1. **Investigation/experimentation/design challenge**  \_\_\_\_ 2. Data representation, analysis, and interpretation  \_\_\_\_ 3. Explanation  **Student task structure(s):** Small group/individual/whole class. |
| **STE Standards and Science and Engineering Practices:**  **Standards:**  **HS-PS3-1.** Use algebraic expressions and the principle of energy conservation to calculate the change in energy of one component of a system when the change in energy of the other component(s) of the system, as well as the total energy of the system including any energy entering or leaving the system, is known. Identify any transformations from one form of energy to another, including thermal, kinetic, gravitational, magnetic, or electrical energy, in the system.  Clarification Statement:   * Systems should be limited to two or three components and to thermal energy; kinetic energy; or the energies in gravitational, magnetic, or electric fields.   **Science and Engineering Practices:**   * Constructing explanations & designing solutions * Using Mathematics and Computational Thinking |
| **Prior Knowledge:**  Previous Standard from [Strand Map](http://www.doe.mass.edu/stem/standards/StrandMaps.html):  **HS-PS3-2.** Develop and use a model to illustrate that energy at the macroscopic scale can be accounted for as either motions of particles and objects or energy stored in fields.  Clarification Statements:   * Examples of phenomena at the macroscopic scale could include evaporation and condensation, the conversion of kinetic energy to thermal energy, the gravitational potential energy stored due to position of an object above the earth, and the stored energy (electrical potential) of a charged object’s position within an electrical field. * Examples of models could include diagrams, drawings, descriptions, and computer simulations.   **HS-PS3-3.** Design and evaluate a device that works within given constraints to convert one form of energy into another form of energy.\*  Clarification Statements:   * Emphasis is on both qualitative and quantitative evaluations of devices. * Examples of devices could include Rube Goldberg devices, wind turbines, solar cells, solar ovens, and generators. * Examples of constraints could include use of renewable energy forms and efficiency.   State Assessment Boundary:   * Quantitative evaluations will be limited to total output for a given input in state assessment.   Previous Topics:   * Kinematics (motion) * Forces * Momentum |
| **Connections to the real-world:**   * The gravity light is an interesting invention that can be used when there is no power, such as a hurricane or a camping trip. * All devices that use energy leverage energy transfers from one form to another. |
| **Mastery Goals:**  Learning Objective:   * Make observations and construct an explanation that describes the different types of energy transformation. * Calculate the amount of energy transformed.   Performance Objective:   * Observe pictures and videos of energy phenomena and generate a list of questions. * Using mathematical computation and thinking, calculate the energy transformation in a bungee cord.   Language Objective:   * Orally discuss and then write an explanation of energy transfers. |
| **Teacher instructions:**  **Day 1:**   1. Show Introductory Phenomena video of slinky dropping (https://www.ngssphenomena.com/new-gallery-1/3mw481bgv3bag2zbo39y97d6yyjezf). Students record in their lab book what they see happen, questions they have and begin to describe what they think about the energy behind what they saw and record it. 2. Show Introductory Phenomena video of the Gravity Light: https://thewonderofscience.com/phenomenon/2018/7/9/the-gravity-light. Students record in their lab book what they see happen, questions they have and begin to describe the energy behind what they saw and record it. 3. Students brainstorm various forms of energy (not kinetic and potential energy) and record the energy forms in their lab book. 4. Students visit each energy transformation station and record the forms of energy being transformed in the stations in their lab book. Use the form: “Energy form 1 -> Energy Form 2 -> Energy Form 3”. The order of the stations is not important. Stations could include hot plate heating beaker of water, battery-powered fan, solar panel-powered light, robot, battery-powered light. 5. Ask students to decide how to arrange the data into a model that describe how energy is transferred.   **Day 2:**   1. Remind students of the various scenarios involving energy transformations from Day 1 and have them break into small groups to organize their data collected and compare. 2. Students explain their energy transfer explanations and models with the larger group. 3. Students add or modify their explanations or models according to their discussion. 4. Students now tackle three energy transfer problems:    * Show clip of Empire Strikes Back video: <https://www.youtube.com/watch?v=E4hb7NcrJzQ> . Ask students to calculate the energy necessary for Yoda to lift the X-wing on planet Dagobah in The Empire Strikes Back. Students will need the following info:  Yoda’s planet = Dagobah,  Mass of x-wing = 5600 kg   Acceleration due to gravity on Dagobah = 0.9g (g = acceleration due to gravity on Earth)  Height x-wing is lifted = 1.4 m   * + Ask students to calculate the kinetic energy (KE) of Usain Bolt, an electron, a F22 Fighter, a F1 car, or the Earth at their fastest recorded speeds.   + Students are provided with a simulation (<https://www.geogebra.org/m/aBRsx86n>) that graphs the gravitational potential energy, kinetic energy, elastic potential energy, and total energy of someone bouncing on a bungee cord. Students use evidence from the simulation to answer the following prompt: As part of a fundraiser, you want the new dean to bungee jump from a crane. The jump will be made from 44 m above a 2.5 m deep pool of Jell-O. A 30 m long bungee cord would be attached to the dean's ankle. You must convince the dean that your plan is safe for a person of his mass, 70 kg. As the bungee cord stretches, it will exert a force with the same properties as the force exerted by a spring. Your plan has the dean stepping off a platform and being in free fall for the 30 m before the cord begins to stretch. You must determine the elastic constant of the bungee cord so that it stretches only 12 m, which will keep the dean's head just out of the Jell-O.  1. After completing the different scenarios, ask students to draw a chart in their notebook with three columns – Notice, Think, and Wonder. Give students 5 minutes to review their work and see what they notice across the scenarios from both Day 1 and Day 2 (Notice), explain why they think it is occurring (Think), and pose additional questions (Wonder). Record their findings on a class chart. Use the questions from their wonderings to look at your scope and sequence to see where their questions may best fit with your curriculum. |
| **Instructional Materials/Resources/Tools:**  **Materials:**  Lab notebook  Energy Transformation stations   * hot plate * batteries and battery pack * beaker * alligator clips * robot (e.g., Lego Mindstorms) * light bulb * Vex robot, or any other robot that moves * light bulb socket * 12 V fan * solar panel (needs to be sufficient power to power lights) |
| **Task Sources:**  The Ambassador would like to recognize Paul Muller for his contributions to the development of this task. |
| **Accessibility and Supports:**  Provide a reference sheet for students to with example of how to calculate energy  Key academic vocabulary: elastic potential energy, gravitational potential energy, kinetic energy, voltage, current, electrical power, electrical energy, mechanical work, torque, efficiency |