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Elective 5: Modifying for Levels of Inquiry

I. Content

- The resource that I am using to help my students support their learning of forces and motion the PhET simulation, Masses and Springs
https://phet.colorado.edu/sims/html/masses-and-springs/latest/masses-and-springs_en.html
- I selected this resource because of the variety of ways that the springs can be manipulated and show not only the spring constant and Hooke's Law but also the vectors associated with objects moving up and down in the vertical direction. The introduction tab allows the students time to explore how springs move by comparing 2 next to each other and showing how varying the mass and spring constant affect the motion of the spring. They can also manipulate the gravity to be different than the gravity on earth either greater or smaller. This feature can be manipulated on all tabs of the simulation as well. After students have time to familiarize themselves with this screen they can tab to the next one on vectors, which provides a review for gravity, acceleration, velocity, and the net force on the spring. There is a slow motion feature that allows the students to visualize how the direction of the forces change as the spring extends and compresses due to the mass and the spring constant. Additionally, this tap doesn't have friction so the spring will continue to move and show the selected vectors until the student changes the parameters. They can then tab to the energy section of the simulation and see how the total energy of the spring system remains constant but how there are changes to the elastic potential, gravitational potential, kinetic and heat energy. This tab also shows the spring starting and then slowing down, so there is the input of friction into the simulation. This is a great feature because it helps the students to visualize what the sum of the energies are and how they change as the spring goes from rest, to moving and back to rest again. The last tab of the simulation is the actual experimentation tab where the students can combine all of the information learned in the first 3 tabs to analyze a spring's motion based on all of the different view points (energies, vectors, and spring constants).
- The various physics contents that connects to this simulation are: vectors, motion in the vertical direction due to gravity, springs and spring constants, Hooke's Law, sum of the total energy in a system, conservation of energy, and transformation of energy. The NYSSLS (NGSS adapted for NYS) standards that this simulation connects to are:

- o HS-PS3-1: Energy Change in Components of a System: **Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known. (Systems and System Models)**
- o HS-PS3-3: Energy Conversion Device Design: **Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy. (Energy and Matter)**
- o HS-PS2-1: Newton's Second Law of Motion: **Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration. (Cause and Effect)**
- The pros of utilizing this simulation resource are that students can investigate the different effects that spring constants and mass have on the movement of a spring, the total and individual components of the energy of the spring, and analyze the vectors of motion for the spring. Additionally, they can modify the gravity (gravitational constant) to see how the simulation would differ if the gravity affecting the springs were either increased or decreased. This helps reinforce that things on Earth behave a certain way because of the gravity on Earth. The cons of using this simulation resource are that there is no data to collect that would allow the students the opportunity to calculate the energies only view the energies on the graph along the side of the simulation. At the lab tab, there is only one spring so they would not be able to make a side-by-side comparison of their manipulations to see how they respond as they can in the first 2 tabs of the simulation. Additionally, the spring constants are not provided they are only able to manipulate between “small and large”. The fact that the values are not provided means that the students can't obtain quantitative data to determine their own calculations but can practice manipulating the variables in the equations by increasing/decreasing/halving/etc. to see how the spring responds. This is a pro and a con, because both ways of analyzing equations is important to understanding the motion of the springs.

II. Modification

- To modify this simulation for a low Level of Inquiry, Discovery Learning I allow the students time to get familiar with just the

first tab of the simulation, the Intro section by “playing” with the simulation. I would give them about 5 minutes to see what they discovered by being able to manipulate the simulation. As a class we would come back together and summarize what happened when we manipulated the springs in certain ways and develop some conclusions together about these manipulations. Then we would generate some of the “rules” that springs follow and what factors would affect spring motion. Then the students would have a written out instructional process to follow about the vectors manipulation tab that walks them through analysis of each vector and what factors affect it. As mentioned, this would be guided with a follow along sheet designed by me to guide them through the vector and spring learning process. Then we would come together again and discuss the springs in terms of the vector components. I would repeat this pattern for the energy tab as well, instructing them what to manipulate, what variables to pay attention to, and what to focus on when analyzing the motion of the springs. We would then come back together as a class and add the energy information into the images/notes of the springs intro and vectors so we continue to build on the spring information as we investigate the tabs further. Lastly I would have the students complete a lab I made walking them through the spring manipulations and ask them to analyze its motion based on masses, spring constants, energies and vectors. This lab would be done with partners and would build upon the discovery learning we did with each of the 3 prior tabs and culminate in their explanation of springs and spring motion. This is a great way to introduce students to springs while not overwhelming them with the large amounts of information that can obtain throughout this simulation. These guided steps are also helpful for students and classes that struggle with mathematical operations and predictions of manipulated variables. By breaking it down step wise and coming together as a class after each tab I can ensure that the students comprehending and building upon the various ways springs can change based on the manipulations we add.

- To modify this simulation for a high Level of Inquiry, or full Inquiry lab I would present the students with the following scenario: “You are an architect who has to design a building in an Earthquake prone region that has limited access to resources and it needs to withstand a magnitude 7 Earthquake. In order to do that you discovered that springs are an excellent, cost effective resource that allows buildings rebound and withstand Earthquake destruction. Make a design for your building, describe the types of springs you would want to use and where they would be in the construction, and explain what features of the springs are

important when choosing a spring material.” In order for my students to complete this assignment they would need to investigate the properties of springs, their transfers of energy, and their spring constants so their building would be able to withstand a magnitude 7 Earthquake. The students would be evaluated on how well they explained the features of their springs relevant to the construction of the building. For example, would the springs need to be loose, stiff, or a combination, how does the varying mass affect its movement, how would the rest of the building respond as the springs moved, where would you want the springs (throughout the building, at one level, at the corners, etc.), is the information gained from the simulation scaled to the size of a building properly, and does the building meet the engineering and design standards for their proposed solution. The purpose of changing the outcome of the task but still incorporating the simulation changes what the students need to use the simulation for. In this scenario the students will need to freely explore the simulation at their own paces to understand the motion of springs. But then they need to take the content that they learned through the simulation and apply it to the engineering and design task, which takes the content they learned through the simulation and applies it. I think that this higher LoI is more in alignment with 3-D thinking and learning as well as incorporating one of the Engineering and Design Standards from the NYSSLS (NGSS). After the students complete their spring exploration, guidelines and tasks to complete would be formally assigned after each group checks in with me. This way each group can move at their own pace, not be overwhelmed with the entire task at once, and it can be chunked for more manageable expectations. This LoI is also something that could be done at all grade levels, not only High School. The outcome of the product would look slightly different but the project should be tailored to the grade level standards and then chunked according to how much the students should be working on at one time before checking in with the teacher. Also, rubrics for the final assessment or check lists for what to include for the minimum passing grade would be handed out so there is no confusion about what is explicitly being assessed in the final building design.