Lesson plan for *Energy Skate Park* Activity 4:
Calculations with Conservation of Mechanical Energy using time graphs

Time for activity

Learning Goals:

Students will be able to use **Energy-Time** graphs to… at a given time.

- Estimate a location for the Skater on a track.
- Calculate the speed or height of the Skater *Friction and frictionless.*
- Predict energy distribution for tracks with and without friction.

In activity 2, one of the goals was*:* Predict direction of travel or change in speed. *By "change in speed" I mean increasing or decreasing if for example the graph shows increasing PE, decreasing KE etc." I decided not to repeat this goal because I want to avoid making the activities feel repetitive. I think it would be ok to use these ideas for clicker questions*

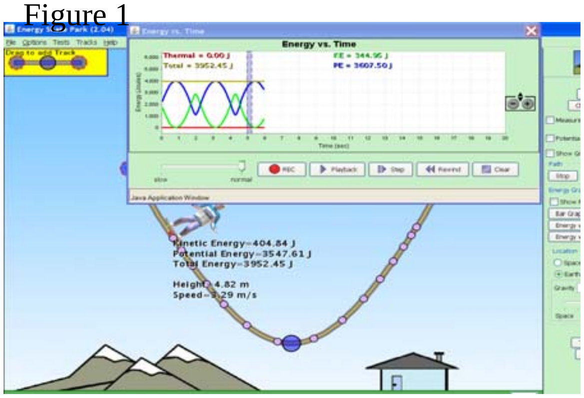
Background:

My students will have done my Energy Skate Park Activity 1, 2, 3 and some reading and questions from the text. The students will have used conservation of energy equations to solve text problems after having done activity 3. In a textbook, the learning goals for Activity 3 and 4 are often taught concurrently because using equations to solve energy/motion problems is the predominate goal. I feel like the ability to relate the time graph to the play space requires complex visualization, so I wanted a separate activity.

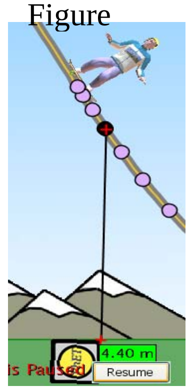
Simulation hints: Make sure to read the hints in Activity 3. *If you have trouble getting a purple dot to show data, you can* ***Pause*** *the sim and move the* ***PE line*** *and track out of the way. The values shown reflect the settings when the dot was made.*

To make the figures below: I started the sim (or **Reset)** then **Paused,** moved the **PE Reference** line to the bottom of the track, opened the **Energy-Time Graph,** and **Show Path ,** then **Play.** After getting one cycle, **Pause** again and click on the Purple dot (figure 1)

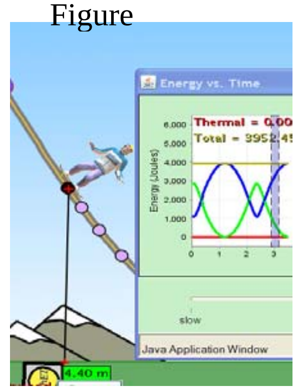
Figure 1



Figure



Figure



The **Total Energy** will vary a little depending on where you put the **PE Reference** line.

You can **Clear** the graph before you run a trial to use a different situation; if you put the Skater where you want before you press **Play**, you'll be able to simplify your graph like mine.

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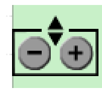
To relate the data to the **Energy-Time** graph, (remember the window can be moved to help viewing) I selected a purple dot to get the Height and Speed then I used the **Measuring Tape** to mark the dot's location. (figure 2). Then I moved the vertical bar so that the Skaters red dot was on top of the tape (figure 3).

Lesson: Have the students use the lab sheet for guidance. I handed out the directions and had them make predictions.

For question 1, I opened the simulation, **Paused**. Then I moved the **PE line** to the bottom of the track, pressed **Return Skater**, selected the **Energy-Time** graph and zoomed so 3500 was the max y value. Then I pressed **Play** and let the sim run 11 seconds and then **Paused**. *One of the nice things about using the default track and initial Skater position is that it is very quick to rerun trials with variation by* ***Return Skater.*** His place on the track is at the time shown by the vertical bar on the graph.



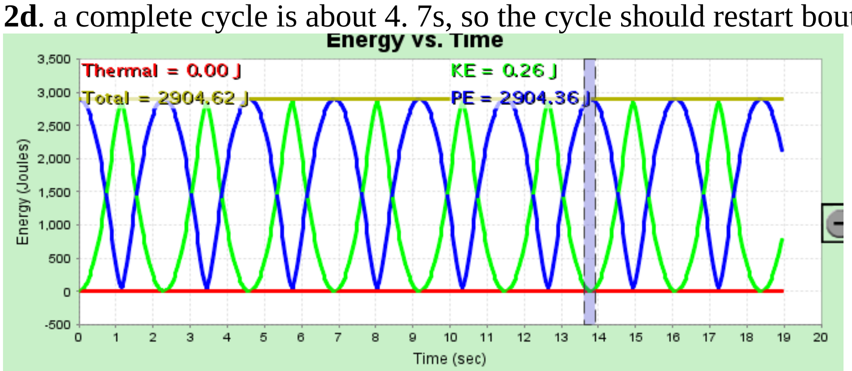
Answers: (I'm expecting estimates the first time around and then more exact when they do #2). The picture on the student directions shows total energy at 2918J. When the students sun their trials, the **Total Energy** will vary a little depending on where they put the **PE Reference** line. I used acceleration = 9.81 m/s^2 in my calculations.

2a. 0 =left side, same height; 7s=same place; 8s=bottom; 5s= on way back down from right side at about 80% of original height (PE = 2500 which is about 2500/2918 =85% of max)

2b. 0 and 7s = 4m; 8s=0; 5s= 3.4m (85% of 4m)

2c. 0 and 7s = 0; 8s= 8.8m/s (KE= 2918= $1/2mv^2$= $.5*75*^2$); at 5s= 3.6m/s (KE=500=$1/2*75*3.6^2$)

2d. a complete cycle is about 4. 7s, so the cycle should restart bout 14s.



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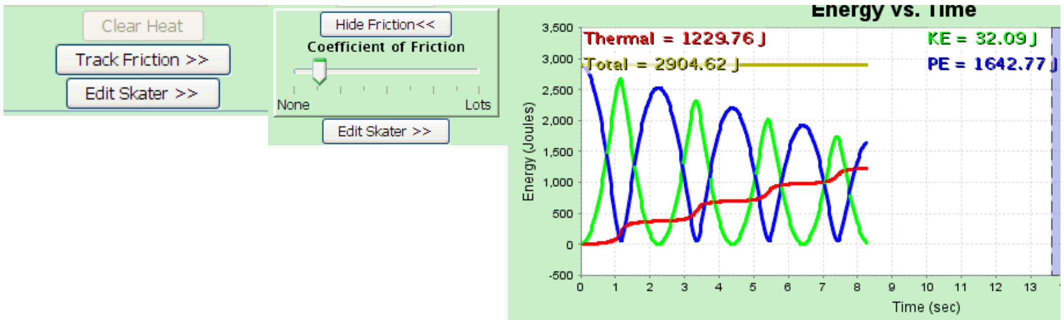
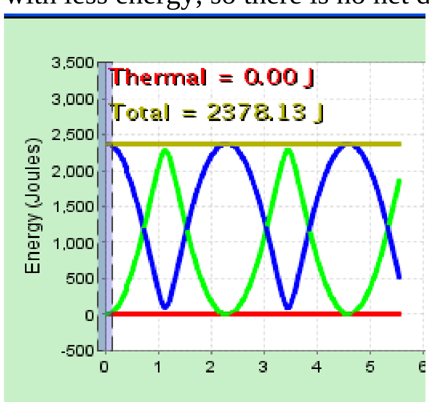
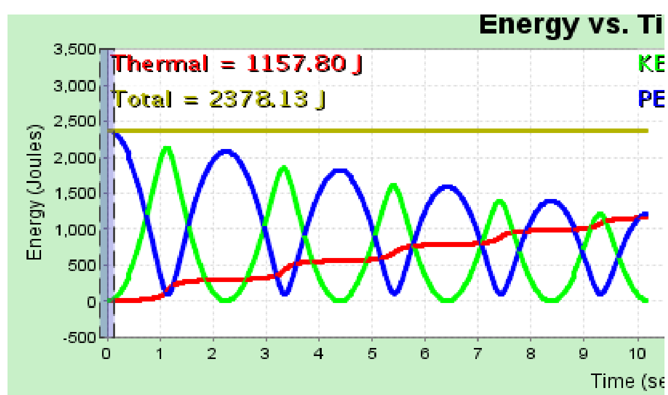
3. I made this graph by setting the **Friction** on the first tick. The only thing that changes on the graph is that **Total Energy** decreases along with max PE and KE.



Notice that the max, min points are still at the same time, so the Skater is at the same horizontal location, but not going as high. The calculations for speed and height should reflect the lower PE and KE values. I didn't give answers because the amount of friction that the students use will matter.

4. If you use the **Return Skater** button after changing the Skater (which really only changes the mass), the only thing that changes is that **Total Energy,** max PE and KE are less. It may be important to help students see that the time for max and min are still the same and that both the horizontal and vertical location at any time is the same whether there is friction or not. Students make think Track Friction that she will go higher or faster because the Skater has less mass and therefore less Friction force, but she started with less energy, so there is no net difference.





Post lesson: Use clicker questions (yet to be written)