

Energy Skate Park Activities

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Clicker questions can be downloaded at <https://phet.colorado.edu/en/contributions/view/3016>

The activities can also be found in the PhET Teaching Ideas in Microsoft office format if you would like to edit them go to:

Activity 1: <https://phet.colorado.edu/en/contributions/view/2856>

Activity 2: <https://phet.colorado.edu/en/contributions/view/2992>

Activity 3: <https://phet.colorado.edu/en/contributions/view/3008>

Activity 4: <https://phet.colorado.edu/en/contributions/view/3109>

All of my activities are posted under the Creative Commons - Attribution license

(<http://creativecommons.org/licenses/by/3.0/>), so please acknowledge that they were

developed by Trish Loeblein and PhET Team, and provide a link back to the main phet

website (<http://phet.colorado.edu>).

Non-obvious controls:

- Use the **Save** feature in the **File** menu to save a track and Skater position for lecture or homework.
- You can resize the windows when you open the graphs and charts to make them fit.
- **Return Character** or **Bring Back the Skater** (*name changes with the character*) buttons do the same thing. The Skater is returned to the place where the user last placed it.
- You can **Pause** the sim and then put the Skater wherever you like easily. Then the **Return Character** (or **Bring Back the ..**) will let you rerun the scenario.
- The **Energy Position Graph** has a few subtle features. It erases as the sim Plays, but you can **Pause** the simulation and the graph will not change. The **Copy** button will let you freeze the graph to compare different scenarios, but it cannot be saved as a file. If you **Zoom**, the graph clears; you can make a new graph by rerunning your scenario using **Return Character**.
- If you use the **Show Path** feature, you can click on the purple dots and show quantitative information. Height refers to height from Potential Energy Reference line. Click again to hide.
- **Step** is a good way to incrementally analyze. It is very useful to have the students make predictions. The button next to **Play** in the large window moves the character forward in time. The button in the **Energy Time** window moves the vertical cursor on the graph (Steps through the Playback).
- If you are doing a lecture demonstration, you should set your screen resolution to 1024x768 so the simulation will fill the screen and be seen easily.

Important modeling notes / simplifications:

- When the Skater lands on the track, the vertical component of his kinetic energy is converted to thermal energy. You can do experiments where there is no energy loss to thermal (only PE and KE conversions) by making sure he doesn't leave the track. (No jumps or use the roller coaster mode).

Insights into student use / thinking:

- If the students open too many windows, they have a difficult time focusing on learning and tend to just play with the Skater.

Suggestions for sim use:

- The simulations have been used successfully with homework, lectures, in-class activities, or lab activities. Use them for introduction to concepts, learning new concepts, reinforcement of concepts, as visual aids for interactive demonstrations, or with in-class clicker questions. To read more, see [Teaching Physics using PhET Simulations](#)
- Inquiry strategies take advantage of the simulation design. Invite the students to **play** with the simulation without any instruction. Use a **guided inquiry** approach to learning or ask **concept questions**. For help with creating effective guided inquiry activities or questions, see: [Guidelines for Contributions](#) or [Concept Questions](#)
- For activities and lesson plans written by the PhET team and other teachers, see: [Teacher Ideas & Activities](#)

I have written a series of activities and here are the learning goals for all four. Each activity can be downloaded from the Teaching Ideas section of the PhET website.

Activity 1: Introduction to Conservation of Mechanical Energy

Students will be able to

- Explain the Conservation of Mechanical Energy concept using kinetic and gravitational potential energy.
- Design a skate park using the concept of Mechanical energy

Activity 2: Relating Graphs, Position and Speed (no time graphs)

Students will be able to:

- Describe Energy -Position, -Bar, and -Pie Charts from position or selected speeds. *My thoughts about “selected” are zero, maximum, 1/2 max, etc*
 1. Explain how changing the Skater affects the situations above. *The simulation treats all the objects the same (the same contact area and center of mass is one the track), so changing the type only changes the mass.*
 2. Explain how changing the surface friction affects the situations above.
- Predict position or estimate of speed from Energy -Position, -Bar, and -Pie Charts
- Look at the position of an object and use the Energy -Position, -Bar, and -Pie charts to 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.*

Activity 3: Calculating Speed and Height (no time graphs)

Students will be able to

- Calculate speed or height from information about a different position.
- Describe how different gravity fields effect the predictions.
- Describe how changing the PE reference effects the predictions. *I decided to leave this goal out of the students’ directions and either discuss it with the class or omit it.*

Activity 4: Calculations with Conservation of Mechanical Energy using time graphs

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
- Predict energy distribution for tracks with and without friction.

Lesson plan for *Energy Skate Park Activity 1: Introduction to Conservation of Mechanical Energy*

Time for activity 50 minutes <http://phet.colorado.edu>

Learning Goals: Students will be able to

- Explain the Conservation of Mechanical Energy concept using kinetic and gravitational potential energy.
- Design a skate park using the concept of Mechanical energy

Background:

Students, in general, know about conservation of energy. For example, they can tell you that energy comes from the sun and is converted by plants into food. It is unlikely that my students have done any quantitative analysis. In class lecture, kinetic, elastic potential, and gravitational potential energy will be defined accompanied by common demonstrations. This is the first of 4 Energy Skate Park activity and I also used an activity with Masses and Springs. My students are familiar with Excel and so I decided to use the term “chart” for the graphs and chart like it does.

PreLesson: There are some Pre-lesson questions (see the power point associated with this lesson) adapted from Karen King’s lesson published in the activity database.

1. Say: “Draw pictures showing something that has a lot of potential energy and something that does not.” Display the ppt that goes with this lesson. (slide 1)
 2. Explain why you think the object on the left has more potential energy. (slide 2)
 3. Now draw pictures for kinetic energy. (slide 3)
 4. Explain why you think the object on the left has more kinetic energy. (slide 4)
- (The other slides are clicker questions for after the students do the lab)

Energy Skate Park Introduction:

I think I’ll show how to add track and the **Return Skater** and **Clear Heat** buttons are really handy for repeating experiments or running an experiment once the Skater doesn’t leave the track. Also, if you can resize the windows when you open the graphs and charts, to make them fit.

Energy Skate Park Helpful hints for teachers:

1. I often make a track that I want to project for class discussion and then save it.
2. You can Pause the sim and then put the Skater wherever you like easily. Then the **Return Skater** will let you rerun the scenario.
3. When the Skater lands on the track, the vertical component of his kinetic energy is converted to thermal energy. You can do experiments where there is only PE and KE by making sure he doesn’t leave the track. One way to do that is to right click on a track, you can make in into roller coaster mode.
4. The thermal energy can be “zeroed” using the **Clear Heat** button.
5. **Return Skater** and **Bring Back the Skater** (*name changes with the character*) buttons puts the character at the location that the user last let go.
6. The **Energy Position Graph** erases, but you can **Pause** the simulation and the graph will not change. The **Copy** button will let you freeze the graph to compare different scenarios, but it cannot be saved as a file. If you **Zoom**, the graph clears; you can make a new graph by rerunning your scenario using **Return Skater**.

Lesson plan for *Energy Skate Park Activity 1: Introduction to Conservation of Mechanical Energy*

Time for activity 50 minutes <http://phet.colorado.edu>

7. **Step** is a good way to incrementally analyze. It is very useful to have the students make predictions. The button next to **Play** in the large window moves the character forward in time. The button in the **Energy Time** window moves the vertical cursor on the graph (Steps through the Playback).
8. If you use the **Show Path** feature, then you can click on the purple dots and show quantitative information about the energies. Click again to hide. Height refers to height from Potential Energy Reference line.

Lesson: Have the students use the lab sheet for guidance. The activity took my honors physics students about 40 minutes.

Post lesson:

I have written some clicker questions. I saved the tracks that are in the questions so I can easily prove the answers. Go through questions 1-4 and then show the answers using the saved track. Go through 5-7, then show the answers using the second saved track.

Next lesson: Energy Skate Park activity 2. The learning goals are specific to chart interpretation and chart prediction.

Student directions *Energy Skate Park* activity 1:
Introduction to Conservation of Mechanical Energy
<http://phet.colorado.edu>

Learning Goals: Students will be able to

- Explain the Conservation of Mechanical Energy concept using kinetic and gravitational potential energy.
 - Design a skate park using the concept of Mechanical energy
1. Investigate what affects the skater's path and discuss your ideas with your partner. You should try adding some track, changing shapes or building jumps. (There's no friction on the track)
 2. Explain how you could use your investigation to plan a track that is fun, challenging and one that is relatively safe. You might think for example: When does he: fly off an end? make it to the top a hill? or land a jump?
 3. Build a good track and sketch it. Then use the Energy Graphs to study the Skater's energy.
 - Decide which graphs or chart best helps you understand what makes your track successful
 - Look in your textbook to find out what the Conservation of Mechanical Energy means and explain it in your own words.
 - Explain why your track is successful in terms of Conservation of Mechanical Energy. Include drawings of the Chart or Graphs to help explain your reasoning.
 4. Using the Law of Conservation of Mechanical Energy, explain what things need to be considered when designing **any** successful track.

Lesson plan for *Energy Skate Park* Activity 2:
Relating Graphs, Position and Speed (no time graphs)

Time for activity 100 minutes

Learning Goals

Students will be able to:

1. Describe Energy -Position, -Bar, and -Pie Charts from position or selected speeds. *My thoughts about "selected" are zero, maximum, $\frac{1}{2}$ max, etc*
 - a. Explain how changing the Skater affects the situations above. *The simulation treats all the objects the same (the same contact area and center of mass is one the track), so changing the type only changes the mass.*
 - b. Explain how changing the surface friction affects the situations above.
2. Predict position or estimate of speed from Energy -Position, -Bar, and -Pie Charts
3. Look at the position of an object and use the Energy -Position, -Bar, and -Pie charts to 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.*

Possible Extension: How does changing PE affect chart?

Background:

My students will have done Energy Skate Park Activity 1 and some concept questions from the text.

Energy Skate Park Introduction:

Since my students will have done my first lesson, I won't have to show much how to use the simulation. I'll show a track with the Energy-Position chart and discuss the purpose of the vertical line. If you use Pause and Step this is easy to explain. In the first lesson plan, there are some hints that might be useful. My students are familiar with Excel and so I decided to use the term "chart" for the graphs and chart like it does.

Pre-Lesson: I projected clicker questions 1-3 to have the students think about their present understanding, but I wouldn't go over the answers until the post-lesson. The track is saved under CQ 1-3.

Lesson:

Have the students use the lab sheet for guidance. The activity took my honors physics students about 100 minutes.

Post lesson: Use the clicker questions with the simulation during discussion of the answers. I would open Skater and the track for questions 1-3 before class and change the character to the female one because the track saves with the male skater. The blue dots on the questions were drawn in paint and I couldn't make the same track using track pieces to get the blue dots. The track for the next questions are saved too.

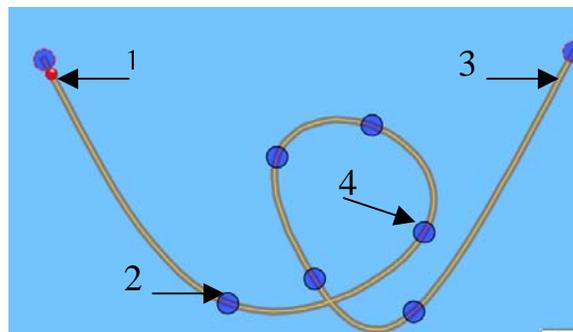
Next lesson: I have the students design an experiment to determine how well the relationship between Potential Energy of a cart at the top of a ramp and the Kinetic Energy of the cart at a lower height compares to the predicted equation. We use high quality physics carts and Vernier Photogate timers to find the speed of the cart. The students are able to predict that the relationship should be linear with a slope of one and we generally get good accuracy and precision. Then, we continue our study with Energy Skate Park 3 Speed and Height calculations.

Student directions *Energy Skate Park Activity 2:*
 Relating Graphs, Position and Speed (no time graphs)
<http://phet.colorado.edu>

Learning Goals: Students will be able to:

1. Describe Energy -Pie, -Bar, and -Position Charts from position or selected speeds.
 - a. Explain how changing the Skater affects the situations above.
 - b. Explain how changing the surface friction affects the situations above.
2. Predict position or estimate of speed from Energy -Pie, -Bar, and -Position Charts
3. Look at the position of an object and use the Energy -Pie, -Bar, and -Position charts to predict direction of travel or change in speed.

1. Josie made a *frictionless* hot wheel track that looks like the one shown. She placed a red rubber ball on the left top of track at 1.
 - a. Make a data table like the one below
 - b. Fill in the Prediction column by sketching what you think the Pie chart will look like for the ball at points 1-4.
 - c. Use the **Loop Track** with the **Ball Skater** to test your ideas and make any adjustments

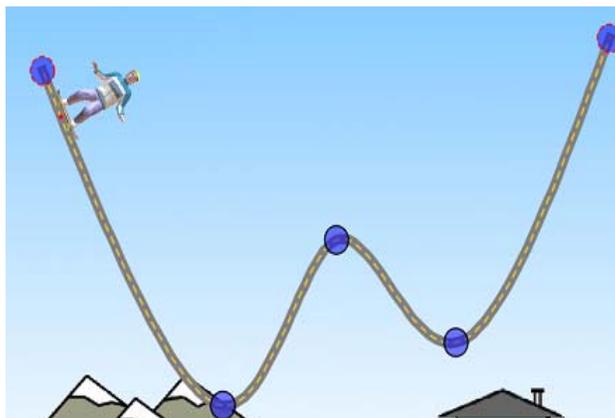


Pie chart			
	Prediction	Simulation	Explain differences
1			
2			
3			
4			

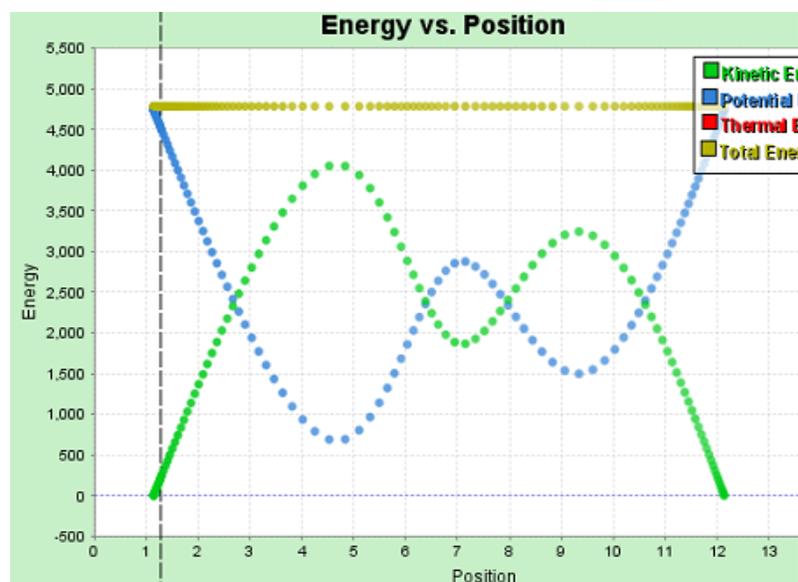
2. Pretend that Josie can magically change the ball to different things like the simulation can.
 - a. What do you think would change about the Pie Charts?
 - b. Explain why you think the charts would similar or different.
 - c. Check your reasoning using the simulation and make corrections if necessary.
3. Josie has a friend, Phillip that can magically change the friction on the track like the simulation can.
 - a. What do you think would change about the Pie Charts?
 - b. Explain why you think the charts would similar or different.
 - c. Check your reasoning using the simulation and make corrections if necessary.
4. Work with your partner to build a track and sketch it.
 - a. Make a table like the one you did for question 1.
 - b. Predict what you think the charts will look like.
 - c. Use the simulation to check your ideas.
 - d. Test your ideas from questions 2 and 3. Make changes to your answers if necessary.
5. Explain how you can use what you understand about pie charts to predict bar charts.

Student directions *Energy Skate Park Activity 2:*
 Relating Graphs, Position and Speed (no time graphs)
<http://phet.colorado.edu>

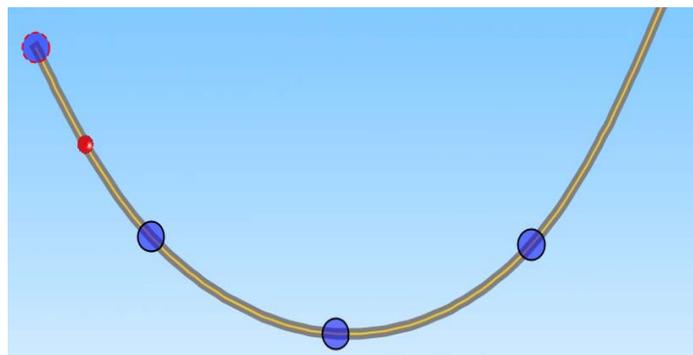
6. Sketch this track and label where the 5 spots could be.
- He is at his maximum speed
 - He is stopped
 - He is going his average speed
 - He is going slow
 - He is going fast



7. Sketch this energy-position graph and label where you think the same 5 spots are.
- Test your ideas using the **Double Well Roller Coaster** track.
 - If one of your friends in the class asked you for help making sense of this type of graph, what would you say?



8. Talk about how you could use the Energy -Pie, -Bar, and -Position charts to predict direction of the ball is rolling.
- Check your ideas using the simulation.
 - Talk about how you could tell if the ball is going to be moving faster, the same, or slower.
 - Pretend you are writing a test for this unit.
 Type a question that includes at least one type of graph and a Skater on a different track.
 Then, give it to another group to see if they can predict the direction and changing speed of the ball.
 Make sure to attach your question.



Lesson plan for *Energy Skate Park* Activity 3:
Calculating Speed and Height (no time graphs)

Time for activity

Learning Goals:

Students will be able to

- Calculate speed or height from information about a different position.
- Describe how different gravity fields effect the predictions.
- Describe how changing the PE reference effects the predictions. *I decided to leave this goal out of the students' directions and either discuss it with the class or omit it.*

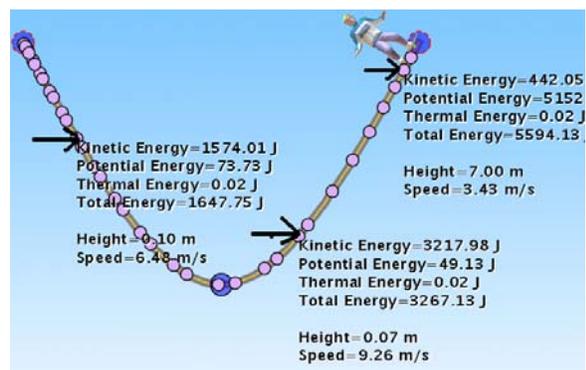
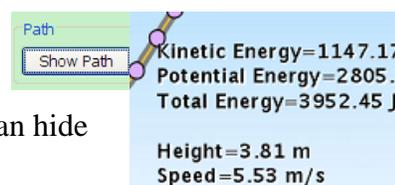
Background:

My students will have done Energy Skate Park Activity 1 & 2 and some concept questions from the text.

Pre-Lesson: I projected clicker questions 1-4 to have the students think about their present understanding, but I wouldn't go over the answers until the post-lesson.

Lesson: Have the students use the lab sheet for guidance. You may want to show the students how to get data from the Skater by using the **Show Path** button. Then they can **Right Click** on any purple spot to see measurements about the Energy, Height (relative to the PE reference line), and speed. You can hide the data by **Right Click** on the dot again.

Simulation hints: The data recorded at the purple dot is in reference to the PE reference line with the variables that have been selected like mass; the data does not change if you make changes. The example here was made by showing the path, and then I paused the sim and moved the PE line, paused and moved the line again. The data does not make sense if you do not pay attention to the changes. I advised the students to clear the path if they want to look at how variables effect the measurements or take careful notes. Remember that changing the Skater only changes the mass.



Post lesson: Use the clicker questions with the simulation during discussion of the answers. I would open Skater and the track for questions 1-3 before class and change the character to the female one because the track saves with the male skater. The blue dots on the questions were drawn in paint and I couldn't make the same track using track pieces to get the blue dots. Also, I have included some clicker questions that I adapted from those used at University of Colorado for the first year algebra based course.

I may have a class discussion around the last learning goal. I did include a challenge to find the PE reference in the Masses and Springs activity that I will be using on the following class period.

Next lesson: I also have a conservation of energy homework activity using *Masses and Springs*. I think it is better to use after the students are familiar with PE gravitational and KE.

Student directions *Energy Skate Park* activity 3: Calculating Speed and Height (no time graphs)
50 minutes untested

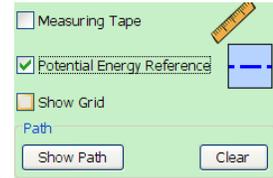
Learning Goals: Students will be able to

- Calculate speed or height from information about a different position.
- Describe how different gravity fields effect the predictions.

Helpful hints: You can take measurements by using the **Show Path** button, then click on any purple dot to see the values. Make sure if you change any variables (like mass, location, character, etc) that you clear the path to get new purple points.

1. Play with the features shown to the right and the purple dot data to understand what the data means. Then,

- a. Explore how the values change when you move the **PE reference line**.



- b. Explore how the values change when you change the **Skater**. Remember that changing the Skater only changes the mass.



2. Explain what is meant by the value called **Height** .

Height = 10.10 m
Speed = 1.42 m/s

3. Consider the following situation: You put the Skater on a track, **Show Path** and display the purple dot data. How could you predict the values for another place on the track?

- a. Describe what you would have to measure.
- b. Show an example of your proposed calculations for each value: KE, PE, TE, speed.
- c. Test your ideas and include a screen capture with the purple dot data shown for both points that show that your calculations are correct. *Show a corrected example of calculations if the data didn't match your ideas.*

4. Describe what you think will change in your calculations if you move the Skater to Jupiter.

- a. Describe what you would have to measure.
- b. Show an example of your proposed calculations for each value: KE, PE, TE, speed.
- c. Test your ideas and include a screen capture with the purple dot data shown to support your calculation or show corrected examples.
- d. How do your calculations change if you take the Skater to the moon? Test your ideas and correct if necessary.

**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.

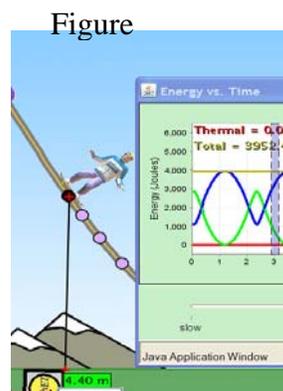
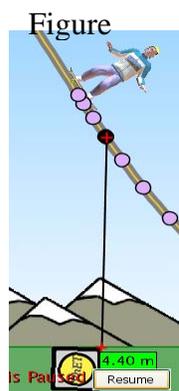
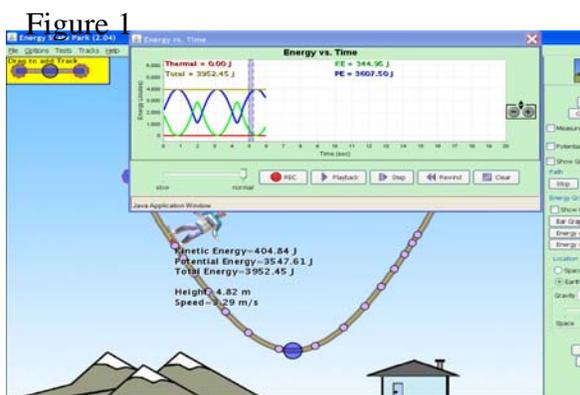
In activity 2, one of the goals was: Predict direction of travel or change in speed. *By “change in speed” I mean increasing or decreasing if for example the graph shows increasing PE, decreasing KE etc.” I decided not to repeat this goal because I want to avoid making the activities feel repetitive. 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)



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.

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

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.



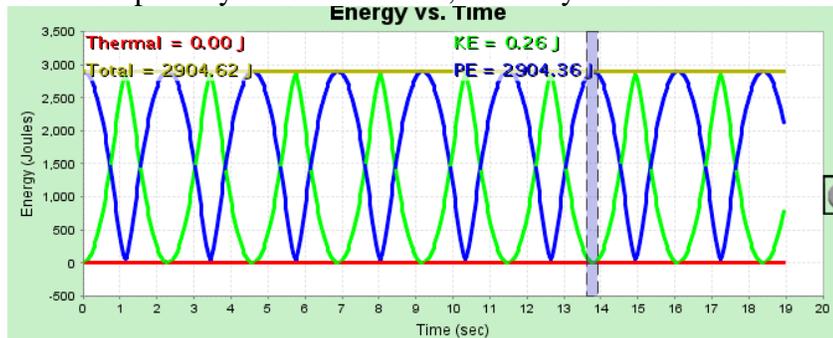
Answers: (I'm expecting estimates the first time around and then more exact when they do #2). The picture on the student directions shows total energy at 2918J. When the students sun their trials, the **Total Energy** will vary a little depending on where they put the **PE Reference** line. I used acceleration = 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 ($KE = 2918 = 1/2mv^2 = .5*75*v^2$); at 5s= 3.6m/s ($KE = 500 = 1/2*75*3.6^2$)

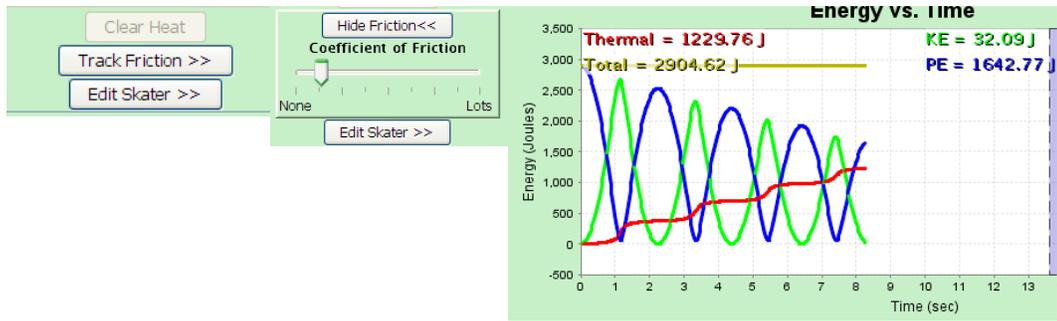
2d. a complete cycle is about 4. 7s, so the cycle should restart bout 14s.



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

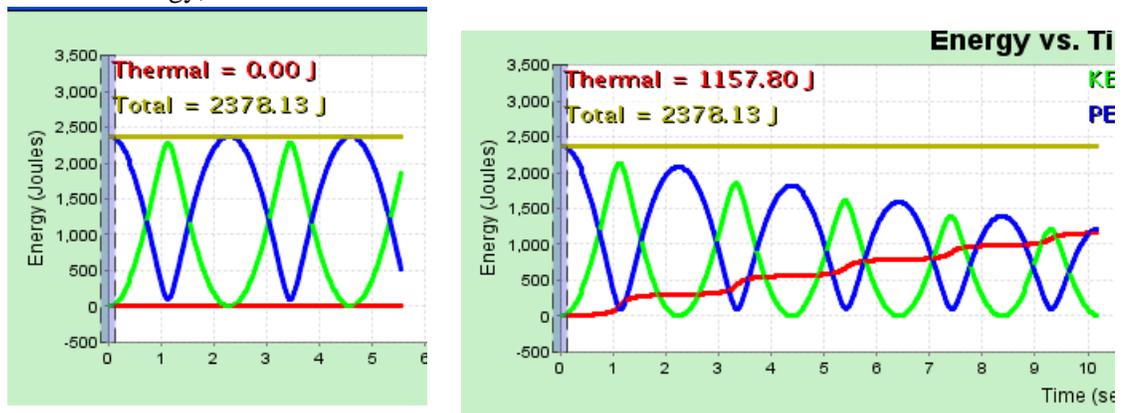
Time for activity

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)

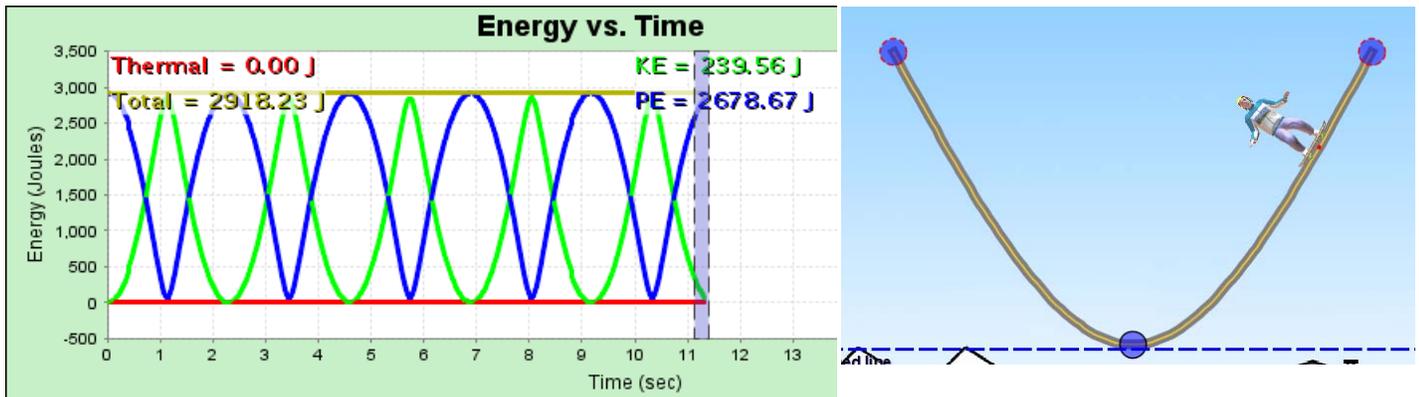
**Student directions *Energy Skate Park* activity 4:
Calculations with Conservation of Mechanical Energy using time graphs**

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
- Predict energy distribution for tracks with and without friction.

Directions:

1. This graph was made with the 75 kg Skater Guy riding on the track shown. Without using the simulation, talk with your partner to predict the answers to these questions. Record your predictions!



- a. Where was he at time zero? At 7 seconds? At 8 seconds? 5 seconds?
 - b. If his maximum height is 4 m, what is his height at time zero? At 7 seconds? At 8 seconds? 5 seconds?
 - c. What is his speed at time zero? At 7 seconds? At 8 seconds? 5 seconds?
 - d. Sketch what the graph would look like between 13 and 15 seconds.
2. Use the Skate Park simulation to check your answers and make corrections. *Show examples of calculations by giving the formula and substitution.*
 3. Without using the simulation, talk with your partner to predict the answers to these questions about the same Track, Skater and Starting point as #1. Record your predictions!
 - a. Sketch what the graph might look like between 0 and 9 seconds if the **Track Friction** was turned on.
 - b. How do you think his location will be affected? Think about both horizontal and vertical location.
 - c. How do you think his speed on the track will be affected?
 - d. Test your ideas using the simulation and make corrections to your predictions.
 4. Consider if the 60kg Skater Gal rode on the same Frictionless Track and Starting point.
 - a. How do you think her position, speed and energy will compare to the Guy's?
 - b. Sketch what the graph might look like between 0 and 5 seconds.
 - c. If you used the same amount of track friction, how would your answers to question three compare?
 - d. Test your ideas using the simulation and make corrections to your predictions.