Physics Lab 6 (Online Simulation)

ENERGY

Mechanics

Unit 6

TA name: Vivek Khichar

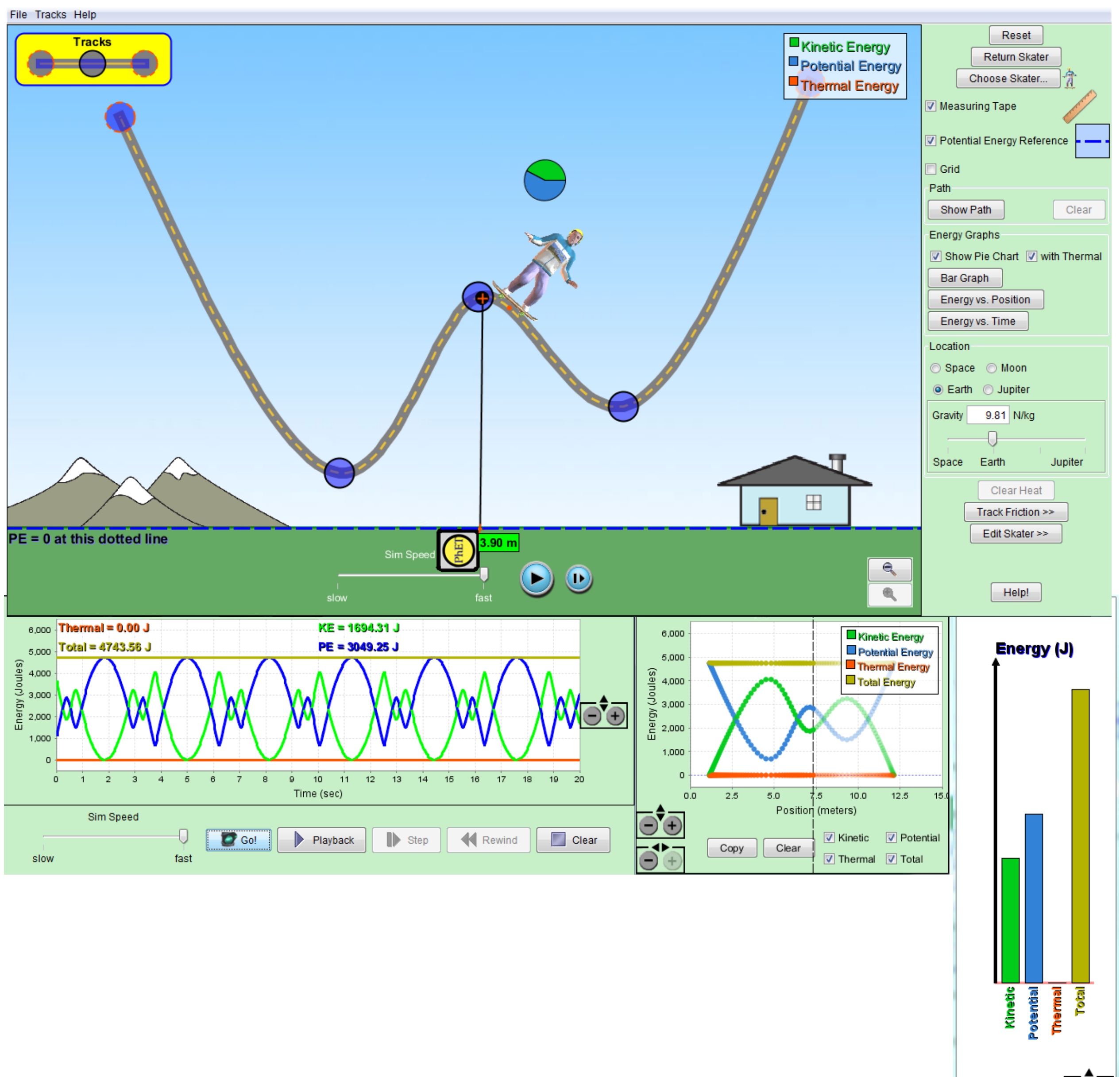
Due Date: 3/30/21

Student Name: Landon Moon

Student ID: 1001906270

Simulation Activity #4: Energy Skate Park

Simulation created by the Physics Education Technology Project (PhET)
c/o The University of Colorado at Boulder http://phet.colorado.edu/



Investigating Energy Exchanges: Kinetic Energy and Gravitational Potential Energy

Objective:
This activity is intended to enhance your physics education. We offer it as a virtual lab online. We think it will help you make connections between predictions and conclusions, concepts and actions, equations and practical activities. We also think that if you give this activity a chance, it will be fun! This is an opportunity to learn a great deal. Answer all questions as you follow the procedure in running the simulation.

Learn about conservation of energy with a skater dude! Build tracks, ramps and jumps for the skater and view the kinetic energy, potential energy and friction as he moves. You can also take the skater to different planets or even space!

Take some time and play with the skater and his track. It helps you to practice with the following features and controls.
Track selector: click on *Tracks* and select from the drop down menu. For example, the “Double well (Roller Coaster)” shown above.
Reset: This rests the simulation to default values and sets the track to friction parabola track.
Skater selector: clicking on *Choose skater…* will allows you to choose a skateboarder with a different mass.
Measuring Tape: Check the Measuring Tape Box when you want to make measurements. Drag the left end of the tape measure to where you start your measurement, and then drag the right end to the final location. To make a reference horizontal line to your measurement, check the *potential energy reference* box and drag the blue line you see on the screen to the initial position.
Graph Selector: If you would like to observe graphs that depicts the relationships among potential, kinetic, and thermal energy of the simulation, click buttons under the Energy Graphs. The types of graphs are shown above. You can also add pie graph by checking the *show pie chart* box. These graphs can be shown with or without the Thermal energy.
Gravity: you may change the gravitational force by changing the location or the sliding bar underneath Gravity box.
Additional Features: Clicking the C*lear Heat* makes the track frictionless. You can also edit the track friction and the skater mass using *Track friction* and *Edit Skater* buttons. You can also control the speed of the skater using the slide bar under the screen.

Introduction:
The law of conservation of energy states that the total amount of energy in an isolated system remains constant. As a consequence of this law, we can say that energy neither created nor destroyed, but can change its form.
The total energy E of a system (the sum of its mechanical energy and its internal energies, including thermal energy) can change only by amounts of energy that are transferred to or from the system. If work W is done on the system, then
$W = \Delta E = \Delta E_{mech} + \Delta E_{th} + \Delta E_{int}$
If the system is isolated ($W = 0$), this gives

Physics Lab 6 (Online Simulation)

$\Delta E_{mech} + \Delta E_{th} + \Delta E_{int} = 0$

The skate park is an excellent example of the conservation of energy. For the isolated skate-track-Earth system, the law of conservation of energy equation has the form
$\Delta E_{mech} + \Delta E_{th} = 0$
Mechanical Energy: The mechanical energy E_{mech} of a system is the sum of its kinetic energy K and its potential energy U: $E_{mech} = K + U$
The conservation of mechanical energy can be written as
$\Delta E_{mech} = \Delta K + \Delta U = 0$. It can also rewritten as $K_1 + U_1 = K_2 + U_2$
In which the subscript refer to different instants during an energy transfer process.
Gravitational Potential Energy: The potential energy associated with a system consisting of Earth and a nearby particle is gravitational potential energy. If the particle moves from y_1 to height y_2 , the change in gravitational potential energy of the particle-Earth system is
$\Delta U = mg(y_2 - y_1)=mg\Delta y$
Kinetic Energy: The kinetic energy is associated with the state of motion of an object. If an object changes its speed from v_1 to v_2 , the change in kinetic energy is
$\Delta K = K_2 - K_1 = \frac{1}{2} mv_2^2 - \frac{1}{2} mv_1^2$

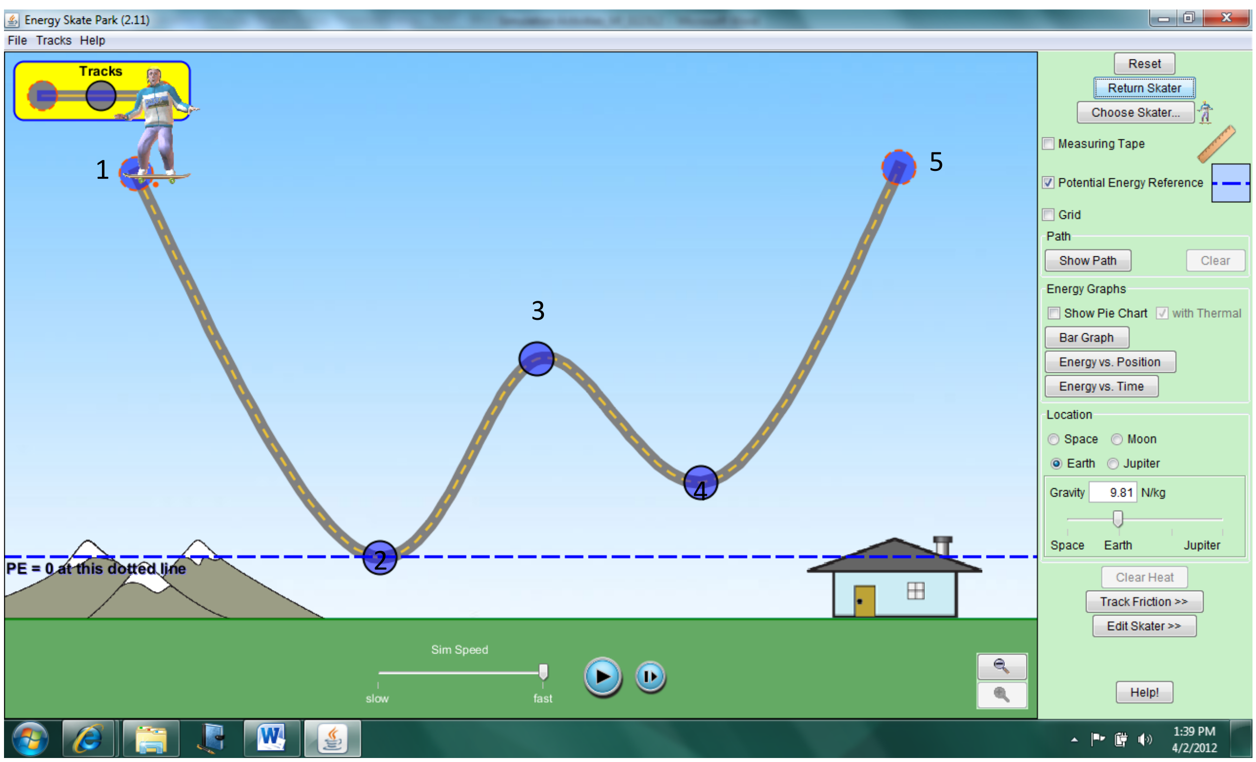
Procedure: *Open Energy Skate Park*
http://phet.colorado.edu/simulations/sims.php?sim=Energy_Skate_Park

Part I: Friction Parabola Track

1. Click Reset and observe the energy bars as the skater moves back and forth. As the skater descends his kinetic energy (green) increases and his potential energy (blue) decreases. The total energy bar stays the same.
2. Considering the bottom of the parabola as a reference line, measure the maximum height (h) the skater climb. h = 5.8m
3. The gravitational potential energy at the maximum height is equal to 3487.8Joules.
4. The skaters speed at the minimum point of the parabola is equal to 10.71m/s
5. Change the skateboarder (say Bulldog) and repeat steps 2, 3, and 4. Cannot change skateboarder and measure PE in same mode. I changed the skateboarder's mass instead.
    a. h = 5.8m
    b. gravitational potential energy = 2331.6 Joules
    c. speed = 10.77m/s
6. Is the law of conservation of energy affected by the mass of the skater? Yes/no
   No. The law itself does not change but the mass of the skater changed the total energy. This energy is then distributed about their mass resulting in no change in speed compared to the original mass.
7. Now click *Reset* and observe the Energy versus Position graph as the skater moves back and forth. Do not forget to put the reference line at the minimum point of the parabola
    a. Pause the simulation at the bottom of the parabola.
        i. Kinetic energy = 2250Joules
        ii. Potential energy = 0Joules
    b. Run the simulation again, and then pause it at the maximum height.
        i. Kinetic energy = 0Joules
        ii. Potential energy = 2250Joules

8. Apply the following settings for the simulation to answer the proceeded questions.
    a. Stop the simulation
    b. Click *Reset* then *return skater* buttons
    c. Adjust the coefficient of friction to one-eighth mark on the slide
    d. Open the Energy versus Time graph
    e. Run the simulation for 20 seconds
9. What are the energies at 12 seconds and 17 seconds
    a. at 12 seconds: K = <u>500J</u> U = <u>1100J</u> E_{th} = <u>600J</u>
    b. at 17 seconds: K = <u>100J</u> U = <u>1400J</u> E_{th} = <u>700J</u>
10. Calculate the change and total energies
    a. ΔK = <u>-400J</u> ΔU = <u>300J</u> ΔE_{th} = <u>100J</u>
    b. Total energy: $\Delta E = \Delta K + \Delta U + \Delta E_{th}$ = <u>0J. This is the change in total energy not simply total energy.</u>

Part II: Double Well (Roller Coaster)



1. Click Reset and return skater buttons and put the reference line as shown above. Measure height of each control point from the reference line and calculate the potential (U), kinetic (K), and total (E) energies.
    a. At point 1: h_1 = <u>4.0m</u>. U_1 = <u>2352J</u> K_1 = <u>0J</u> E_1 =<u>2352J</u>
    b. At point 2: h_2 = <u>0m.</u> U_2 = <u>0J</u> K_2 = <u>2352J</u> E_2 = <u>2352J</u>
    c. At point 3: h_3 = <u>1.7m</u>. U_3 = <u>999.6J</u> K_3 = <u>1352.4J</u> E_3 = <u>2352J</u>
    d. At point 4: h_4 = <u>1.0m</u>. U_4 = <u>588J</u> K_4 = <u>1763J</u> E_4 = <u>2352J</u>

2. Calculate the speeds at control points 3 and 4 using the kinetic energies result you calculated in the previous step.

   a. The skaters speed at point 3: v_3 = 6.71m/s
   b. The skaters speed at point 4: v_4 = 7.66m/s

3. Now open the Energy vs position graph and read the potential (U), kinetic(K), and total (E) energies at the control points
   a. At point 1: U_1 = 2250J K_1 = 0J E_1 = 2250J
   b. At point 2: U_2 = 0J K_2 = 2250J E_2 = 2250J
   c. At point 3: U_3 = 1000J K_3 = 1250J E_3 = 2250J
   d. At point 4: U_4 = 500J K_4 = 1750J E_4 = 2250J
4. Calculate the heights at each of the control points using the information from step 3.
   a. h_1 = 3.82m, h_2 = 0m, h_3 = 1.7m, h_4 = .85m, h_5 = 3.82m.
5. How the shape of potential and kinetic energies do related to the shape of the track?
   a. Potential energy to the track matches the shape of the track.
   b. Kinetic energy to the track is the inverse shape of the track.
6. If you change the location to Moon instead of Earth, will the shape the energies change? If not, what is changed? The shapes stay the same but the magnitude of all energies are reduced.
7. Apply the following settings for the simulation to answer the proceeded questions.
   a. Stop the simulation
   b. Click *Reset* then *return skater* buttons
   c. Adjust the coefficient of friction to one-eighth mark on the slide
   d. Open the Energy versus Time graph
   e. Run the simulation for 20 seconds
8. What are the energies at 9 seconds and 16 seconds
   a. at the 9th second: K = 900J U = 600J E_{th} = 750J
   b. at the 16th second: K = 100J U = 950J E_{th} = 1200J
9. Calculate the change and total energies. E_{th} is thermal energy
   a. ΔK = -800J ΔU = 350J ΔE_{th} = 450J
   b. Total energy: $\Delta E = \Delta K + \Delta U + \Delta E_{th}$ = 0J. like before this is not the total energy but ΔE which is the change in energy.

Follow up Questions:

1. At the highest point kinetic energy is **zero**/maximum while the potential energy is zero /**maximum**.
2. At the lowest point kinetic energy is zero/**maximum** while potential energy is **zero** /maximum.
3. Mass affects / **does not** affect the conservation of energy.
4. How much potential energy does the 60. kg skater have before she starts her ride, 12 m above the ground? 7056J
5. How much kinetic energy does a 60.0 kg skater have traveling with a velocity of 4 m/s? 480J
6. How fast must a 20. kg skater travel to have a kinetic energy of 360 Joules? 6m/s
7. How high must a 2.0 kg basketball be thrown so it has a potential energy of 160 J? 8.163m
8. How fast must the 2.0 kg basketball be thrown upward to achieve the same 160 J? 12.64m/s

9. If a 75kg skater starts his skate at 8.0m, at his lowest point, he will have a velocity of 12.52m/s
10. In the above question, all the potential energy became kinetic energy. How much work was done? 5880J