DEVIL PHYSICS

THE BADDEST CLASS ON CAMPUS

IB PHYSICS

LSN 6-6: MECHANICAL ENERGY AND ITS CONSERVATION
LSN 6-7: PROBLEM SOLVING USING CONSERVATION OF MECHANICAL ENERGY

Questions From Reading Activity?

Big Idea(s):

- Interactions between systems can result in changes in those systems.
- Changes that occur as a result of interactions are constrained by conservation laws.

Enduring Understanding(s):

- Interactions with other objects or systems can change the total energy of a system.
- The energy of a system is conserved.

Enduring Understanding(s):

- Certain quantities are conserved, in the sense that the changes of those quantities in a given system are always equal to the transfer of that quantity to or from the system by all possible interactions with other systems.

Essential Knowledge(s):

- The energy of a system includes its kinetic energy, potential energy, and microscopic internal energy. Examples should include gravitational potential energy, elastic potential energy, and kinetic energy.

Essential Knowledge(s):

- The internal energy of a system includes the kinetic energy of the objects that make up the system and the potential energy of the configuration of the objects that make up the system.
    - Since energy is constant in a closed system, changes in a system’s potential energy can result in changes to the system’s kinetic energy.
    - The changes in potential and kinetic energies in a system may be further constrained by the construction of the system.

Learning Objective(s):

- The student is able to calculate the total energy of a system and justify the mathematical routines used in the calculation of component types of energy within the system whose sum is the total energy.
- The student is able to predict changes in the total energy of a system due to changes in position and speed of objects or frictional interactions within the system.

Learning Objective(s):

- The student is able to describe and make predictions about the internal energy of systems.
- The student is able to calculate changes in kinetic energy and potential energy of a system, using information from representations of that system.

Introductory Video

[Conservation of Energy Song]

Conservation of Energy

- Energy cannot be created or destroyed.
- Instead, it is transformed into other forms of energy or even matter.
- Energy is said to be conserved.

Conservation of Energy

- When we say energy is “lost” due to friction or other resistance forces, we really mean it has been transformed into a form that is not usable.

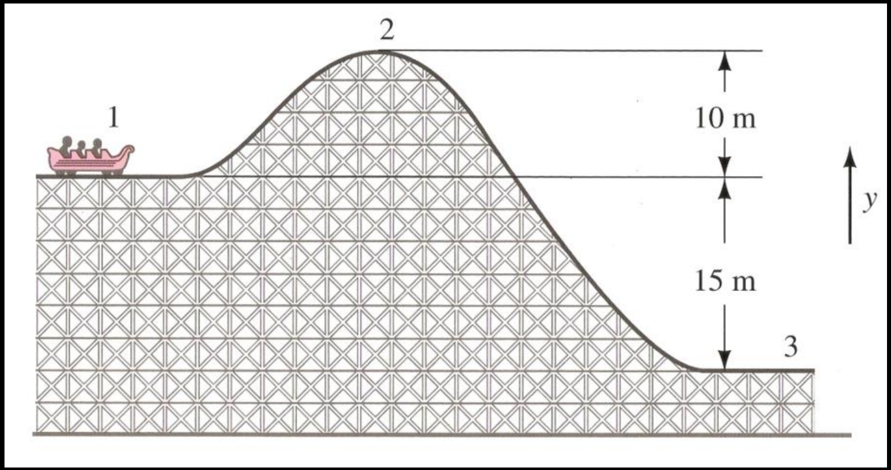
Conservation of Mechanical Energy

- ***Mechanical energy*** consists of kinetic and potential energy.
- Mechanical energy is a product of conservative forces.
- Mechanical energy is conserved if only conservative forces are involved.

$$KE_1 + PE_1 = KE_2 + PE_2$$

Conservation of Mechanical Energy

- For a given system, the total mechanical energy will be the same at all points.
  - Sometimes kinetic energy will be high and potential energy will be low.
  - Other times potential energy will be high and kinetic energy will be low
  - Their sum, however will always be the same



$$KE_1 + PE_1 = KE_2 + PE_2$$

Conservation of Mechanical Energy

$$KE_1 + PE_1 = KE_2 + PE_2$$

$$\frac{1}{2}mv_1^2 + mgh_1 = \frac{1}{2}mv_2^2 + mgh_2$$

$$\frac{1}{2}mv_1^2 + \frac{1}{2}kx_1^2 = \frac{1}{2}mv_2^2 + \frac{1}{2}kx_1^2$$

Sample Problem 1: You drop a 3-kg rock off a 30-m building. How fast is it going when it hits Jeremy's Dad's new car?

Kinematics	Conservation of Energy

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Kinematics

$$v_y^2 = v_{y_0}^2 + 2gy$$

$$v_y = \sqrt{2gy} = 24\,m/s$$

Conservation of Energy

$$\cancel{\frac{1}{2}mv_1^2} + mgh_1 = \frac{1}{2}mv_2^2 + \cancel{mgh_2}$$

$$mgh_1 = \frac{1}{2}mv_2^2$$

$$v_2 = \sqrt{2gh} = 24\,m/s$$

Sample Problem 2: A pole vaulter accelerates to 9.3 m/s on the run-up. What is the maximum height we can expect her to clear?

Kinematics

Conservation of Energy

Sample Problem 2: A pole vaulter accelerates to 9.3 m/s on the run-up. What is the maximum height we can expect her to clear?

Kinematics

$$v_x = 7.8\, m/s$$

$$y = ???$$

??????????

Conservation of Energy

$$\frac{1}{2}mv_1^2 + \cancel{mgh_1} = \cancel{\frac{1}{2}mv_2^2} + mgh_2$$

$$\frac{1}{2}mv_1^2 = mgh_2$$

$$\frac{v_1^2}{2g} = h_2 = 4.4m$$

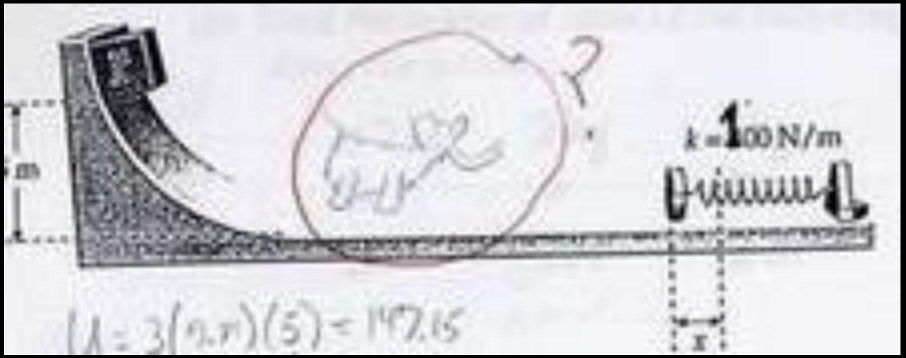
Sample Problem 2: A pole vaulter accelerates to 9.3 m/s on the run-up. What is the maximum height we can expect her to clear?

- *Is our answer valid since we failed to take into consideration the elasticity or "springyness" of the pole?*

Sample Problem 2: A pole vaulter accelerates to 9.3 m/s on the run-up. What is the maximum height we can expect her to clear?

- *Is our answer valid since we failed to take into consideration the elasticity or "springyness" of the pole?*
- *Sure it is!*
  - *All of the kinetic energy of the run was translated into elastic potential energy in bending the pole.*
  - *The elastic potential energy of the pole was then translated into kinetic energy going upward.*
  - *The kinetic energy upward was then translated into height gain to clear the bar.*
  - *Since mechanical energy is conserved, the final energy equals the initial energy no matter what happens in between.*

Sample Problem 3: The spring has a spring constant of 1250N/m. If the spring is compressed 2.5m, how fast will the 2000kg elephant be going when the spring is released and how high up the ramp will he travel?



Conservation of Energy

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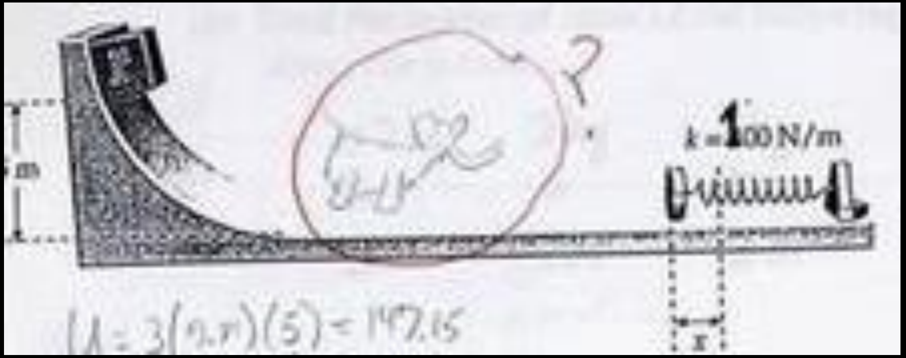

Conservation of Energy

$$\cancel{\frac{1}{2}mv_1^2} + \frac{1}{2}kx_1^2 = \frac{1}{2}mv_2^2 + \cancel{\frac{1}{2}kx_1^2}$$

$$\frac{1}{2}kx_1^2 = \frac{1}{2}mv_2^2$$

$$\frac{kx_1^2}{m} = v_2^2$$

$$\sqrt{\frac{kx_1^2}{m}} = v_2 = 1.98\,m/s$$

Sample Problem 3: The spring has a spring constant of 1250N/m. If the spring is compressed 2.5m, how fast will the 2000kg elephant be going when the spring is released and **how high up the ramp will he travel??**

Conservation of Energy

$$\frac{1}{2}mv_1^2 + \cancel{mgh_1} = \cancel{\frac{1}{2}mv_2^2} + mgh_2$$

$$\frac{1}{2}mv_1^2 = mgh_2$$

$$\frac{v_1^2}{2g} = h_2 = 0.20m$$

Sample Problem 4: Angela is standing on top of a building with a 5kg rock. She throws it up into the air at 5m/s. It goes up, then comes down and lands on a spring with a 350N/m spring constant that is 50m below Anna. The spring compresses and then extends sending the rock back at Angela at what velocity?

- *Your turn!!!*

Sample Problem 4: Angela is standing on top of a building with a 5kg rock. She throws it up into the air at 5m/s. It goes up, then comes down and lands on a spring with a 350N/m spring constant that is 50m below Anna. The spring compresses and then extends sending the rock back at Angela at what velocity?

- *Think before you act!*
- *Does the spring really matter*

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- *Think before you act!*
- *Does the spring really matter?*
- *No! If energy is conserved, the kinetic and potential energy at Angela's height will equal the kinetic energy at the top of the spring.*

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- *Think before you act!*
- *Do you need to use kinematic equations to find the rock's speed as it passes Angela on the way down?*

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- *Think before you act!*
- *Do you need to use kinematic equations to find the rock's speed as it passes Angela on the way down?*
- *No! It will be the same as it was going up only in the opposite direction!*

Sample Problem 4: Anna is standing on top of a building with a 5kg rock. She throws it up into the air at 5m/s. It goes up, then comes down and lands on a spring with a 350N/m spring constant that is 50m below Anna. The spring compresses and then extends sending the rock back at Anna at what velocity?

$$\frac{1}{2}mv_1^2 + mgh_1 = \frac{1}{2}mv_2^2 + \cancel{mgh_2}$$

$$\frac{1}{2}mv_1^2 + mgh_1 = \frac{1}{2}mv_2^2$$

$$v_1^2 + 2gh_1 = v_2^2$$

$$\sqrt{v_1^2 + 2gh_1} = v_2 = 32\,m/s$$

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QUESTIONS?

Homework

#33-44