Lesson 6 Worksheet: Using Efficiency to Calculate Energy Transfer

% Efficiency = (Output Energy / Input Energy) x 100

Ep (Gravitational Potential Energy) = mgh

m = mass (kg)

g = acceleration due to gravity (9.8 m/s/s)

h = height (m)

Ek (Kinetic Energy) = $1/2mv^2$

m = mass (kg)

v = velocity (m/s)

Questions:

1.

A 5 kg ball is dropped from a height of 10 meters. The energy transformation from potential to kinetic energy is 60% efficient. Due to air resistance, what speed does the ball reach just before hitting the ground?

-What is the ball's potential energy (Ep) at the initial height?

-What is its kinetic energy (Ek) just before it hits the ground?

2.
A roller coaster with a mass of 1000 kg starts from rest at a height of 40 meters. The roller coaster has 80% efficiency in its energy transformation.

-What is the roller coaster's initial potential energy (Ep)?

-What is the roller coaster's kinetic energy (Ek) at the bottom of the hill?

-What is the roller coaster's speed at the bottom of the hill?

3.
A pendulum bob with a mass of 0.2 kg is released from an initial height where it has 1 J of potential energy. The pendulum has a 90% efficiency in its energy transformation.

-What is the bob's kinetic energy (Ek) at its lowest point?

-What is the bob's speed at its lowest point?

4.
A 2 kg block slides down a ramp from a height of 3 meters. The block reaches a speed of 5 m/s at the bottom.

-What is the block's potential energy (Ep) at the top of the ramp?

-What is the block's kinetic energy (Ek) at the bottom of the ramp?

-What is the efficiency of the energy transformation?

5.
A child on a swing is pulled back to a height where they have 50 J of potential energy. The swing is 75% efficient.

-What is the child's kinetic energy (Ek) at the lowest point of the swing?

-What is the child's mass at the lowest point of the swing if they have a speed of 4.0m/s?

6.
A 0.5 kg projectile is launched vertically upwards. Air resistance causes the projectile to reach a maximum height of 9 meters, where it has 40 J of potential energy. The projectile is 85% efficient.

-What was the projectile's initial kinetic energy?

7.
A basketball player jumps vertically upwards to dunk a basketball. The player is 60% efficient and reaches a maximum height of 0.9 meters. The player has a mass of 80 kg.

-What is the player's potential energy (Ep) at their maximum height?

-What is the player's initial kinetic energy?

8.
A 1 kg object is thrown horizontally off a cliff with an initial velocity of 5 m/s. The cliff is 20 meters high. The object has a 90% efficiency in energy transformation.

-What is the object's total energy at the top of the cliff? (Hint: Consider both potential and kinetic energy).

-What is the object's kinetic energy just before it hits the ground?

-What is the object's speed just before it hits the ground?

Worksheet Answer Key: Calculating Energy Transfers with Efficiency

Here's an answer key for the edited worksheet, demonstrating how to use the provided efficiency values to calculate energy transfers:

Question 1

- The ball's potential energy (Ep) at the initial height: **$Ep = mgh = (5\ kg)(9.8\ m/s^2)(10\ m) = 490\ J$**
- The efficiency is given as 60%, meaning 60% of the initial potential energy is converted into kinetic energy: **$Ek = 0.60 * Ep = 0.60 * 490\ J = 294\ J$**
- Solving for the ball's speed just before hitting the ground using the kinetic energy formula: **$Ek = 1/2mv^2 \rightarrow 294\ J = (1/2)(5\ kg)v^2 \rightarrow v = \sqrt{(294\ J * 2 / 5\ kg)} \approx 10.84\ m/s$**

Question 2

- The roller coaster's initial potential energy: **$Ep = mgh = (1000\ kg)(9.8\ m/s^2)(40\ m) = 392{,}000\ J$**
- With 80% efficiency, the kinetic energy at the bottom of the hill is 80% of the initial potential energy: **$Ek = 0.80 * Ep = 0.80 * 392{,}000\ J = 313{,}600\ J$**
- The roller coaster's speed at the bottom of the hill: **$Ek = 1/2mv^2 \rightarrow 313{,}600\ J = (1/2)(1000\ kg)v^2 \rightarrow v = \sqrt{(313{,}600\ J * 2 / 1000\ kg)} \approx 25.07\ m/s$**

Question 3

- The pendulum has 90% efficiency, meaning its kinetic energy at the lowest point is 90% of its initial potential energy: **$Ek = 0.90 * Ep = 0.90 * 1\ J = 0.9\ J$**
- The bob's speed at its lowest point: **$Ek = 1/2mv^2 \rightarrow 0.9\ J = (1/2)(0.2\ kg)v^2 \rightarrow v = \sqrt{(0.9\ J * 2 / 0.2\ kg)} = 3\ m/s$**

Question 4

- The block's potential energy at the top of the ramp: **$Ep = mgh = (2\ kg)(9.8\ m/s^2)(3\ m) = 58.8\ J$**
- The block's kinetic energy at the bottom of the ramp: **$Ek = 1/2mv^2 = (1/2)(2\ kg)(5\ m/s)^2 = 25\ J$**
- The efficiency of the energy transformation: **$\%\ Efficiency = (Output\ Energy / Input\ Energy) \times 100 = (25\ J / 58.8\ J) \times 100 \approx 42.52\%$**

Question 5

- The swing is 75% efficient, meaning the child's kinetic energy at the lowest point is 75% of their initial potential energy: **$Ek = 0.75 * Ep = 0.75 * 50\ J = 37.5\ J$**
- The child's speed at the lowest point of the swing: **$Ek = 1/2mv^2 \rightarrow 37.5\ J = (1/2)m(4\ m/s)^2 \rightarrow m = 37.5\ J * 2 / (4\ m/s)^2 = 4.69\ kg$**. The child's mass was not given in the problem, but can be determined from the provided information.

Question 6

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The projectile is 85% efficient, meaning its initial kinetic energy was greater than its potential energy at its maximum height: **Ek(initial) = Ep / 0.85 = 40 J / 0.85 ≈ 47.06 J**

Question 7

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The player has a mass of 80 kg and reaches a maximum height of 0.9 meters: **Ep = mgh = (80 kg)(9.8 m/s²)(0.9 m) = 705.6 J**
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With 60% efficiency, the player's initial kinetic energy was greater than their potential energy at maximum height: **Ek(initial) = Ep / 0.60 = 705.6 J / 0.60 = 1176 J**

Question 8

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The object's total energy at the top of the cliff is the sum of its potential and kinetic energy: **Ep = mgh = (1 kg)(9.8 m/s²)(20 m) = 196 J; Ek = 1/2mv² = (1/2)(1 kg)(5 m/s)² = 12.5 J; Total Energy = Ep + Ek = 196 J + 12.5 J = 208.5 J**
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With 90% efficiency, the object's kinetic energy just before hitting the ground is 90% of its total initial energy: **Ek(final) = 0.90 * Total Energy = 0.90 * 208.5 J = 187.65 J**
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The object's speed just before hitting the ground: **Ek = 1/2mv² → 187.65 J = (1/2)(1 kg)v² → v = √(187.65 J * 2 / 1 kg) ≈ 19.37 m/s**