CAPE-tech Physics Laboratory Activity — Penguins - Work & Energy

Purpose: _____

Materials & Procedures:

1. Measure the mass of a single penguin.
2. Determine the total change in height of a penguin as it moves from the bottom of the stairs to the top of the stairs.
3. Time the penguin's trip up the stairs and then down the slide.
4. Measure the distance the penguins travel down the slide.

Data:

Mass of penguin ( )	Height of stairs ( )	Time up stairs ( )	Time down slide ( )	Distance down slide ( )

Calculations & Questions: Show all equations used and your work. Results

1. Compute the weight of a single penguin. 1. _____

2. Determine the potential energy of a penguin at the top of the stairs relative to the bottom of the stairs. 2. _____

3. Find the average speed of the penguins going down the slide. 3. _____

4. If you assume the penguins maintain a constant speed down the ramp, what is the final speed of the penguin at the bottom of the slide? 4. _____

5. What happens to your answer to #4 if you assume the penguins undergo constant acceleration?

_____

_____

Why is that so? _____

_____

_____

6. What did your group decide and why? _____

_____

_____

7. How much kinetic energy does each penguin have at the bottom of the slide? 7. _____

8. What percent of the potential energy that the penguin has at the top is converted into kinetic energy at the bottom? 8. _____

9. What is the average thermal energy dissipated as the penguin moves down the slide? 9. _____

10. Assuming no friction, how much work was done on three penguins to get them from the bottom to the top of the stairs? 10. _____

11. If the answer to #10 is the work done by the motor lifting all three penguins to the top, how powerful must the motor be? 11. _____

12. . If the penguin went off the bottom of the slide like a ski jumper and landed on the ground 1.2 meters below the bottom of slide, how far out (i.e., range) would the penguin land? Show work! 12. _____

Conclusion: _____

_____

Date Printed: September 5, 1999

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Purpose: *Find percentage of initial potential energy converted to kinetic energy at the bottom of apparatus.*

Materials & Procedures:

1. Measure the mass of a single penguin.
2. Determine the total change in height of a penguin as it moves from the bottom of the stairs to the top of the stairs.
3. Time the penguin's trip up the stairs and then down the slide.
4. Measure the distance the penguins travel down the slide.

Data:

Mass of penguin (*grams*)	Height of stairs (*centimeters*)	Time up stairs (*seconds*)	Time down slide (*seconds*)	Distance down slide (*centimeters*)
7.96	*19.4*	*7.03*	*4.56*	*146.8*

Calculations & Questions: Show all equations used and your work.

Results

1. Compute the weight of a single penguin.
   1. *Weight = mg = 0.00796 * 9.8 = 0.0782 N*
2. Determine the potential energy of a penguin at the top of the stairs relative to the bottom of the stairs.
   2. *PE = mgh = 0.00796 * 9.8 * 0.194 = 0.0152 J*
3. Find the average speed of the penguins going down the slide.
   3. *v = d/t = 1.468/4.56 = 0.322 m/s*
4. If you assume the penguins maintain a constant speed down the ramp, what is the final speed of the penguin at the bottom of the slide?
   4. *If speed is constant for most of trip, thus final speed equals average speed or 0.322 m/s*
5. What happens to your answer to #4 if you assume the penguins undergo constant acceleration?
   If the acceleration is constant, each penguin will increase in speed at a steady rate. If the initial speed is zero, then the final speed of the penguin will be twice the average speed or 0.644 m/s. This would result in a large final kinetic energy, and less energy coverted to thermal energy.
   Why is that so? *With constant acceleration, the average speed is the sum of initial speed plus final speed divide by two. Another way to look at this is the average speed is the speed at the middle of the total time of travel.*
6. What did your group decide and why? *Answers will vary. Accept any answer that is reasonable*
7. How much kinetic energy does each penguin have at the bottom of the slide?
   7. *KE = 1/2 * (mv^2) = 0.5 * 0.00796 * 0.32^2 = 0.000412 J*
8. What percent of the potential energy that the penguin has at the top is converted into kinetic energy at the bottom?
   8. *Percent = (0.00041/0.015) * 100 = 2.71%*
9. What is the average thermal energy dissipated as the penguin moves down the slide?
   Since the total energy is conserved, the difference between the potential energy at the top and the kinetic energy at the end will be the energy converted to thermal energy. In this case that is 0.0152 J - 0.000412 J or 0.0148 J.
10. Assuming no friction, how much work was done on three penguins to get them from the bottom to the top of the stairs?
    10. *W = Fd = 3 * 0.00796 * 9.8 * 0.194 = 0.0454 J*
11. If the answer to #10 is the work done by the motor lifting all three penguins to the top, how powerful must the motor be?
    11. *P = W/t = 0.045/7.03 = 0.00646 W (*) At least*
12. If the penguin went off the bottom of the slide like a ski jumper and landed on the ground 1.2 meters below the bottom of slide, how far out (i.e., range) would the penguin land? Show work!
    12. *$d_V = (1/2) * g * t^2$ thus t = 0.49 s*
    *0.322 * 0.49 = 0.16 m*

Conclusion: *If students assume constant speed the majority of the energy will be converted to thermal energy with very little left as kinetic energy by the time the penguins reach the bottom of the slide.*

(*) Teacher Note: Since the battery power supply must also move ramp etc., the calculation for power will give a minimum power needed. In addition three penguins are not necessarily on the ramp at one time, thus the students might be asked to discuss what value for time should be used in the calculation for power.