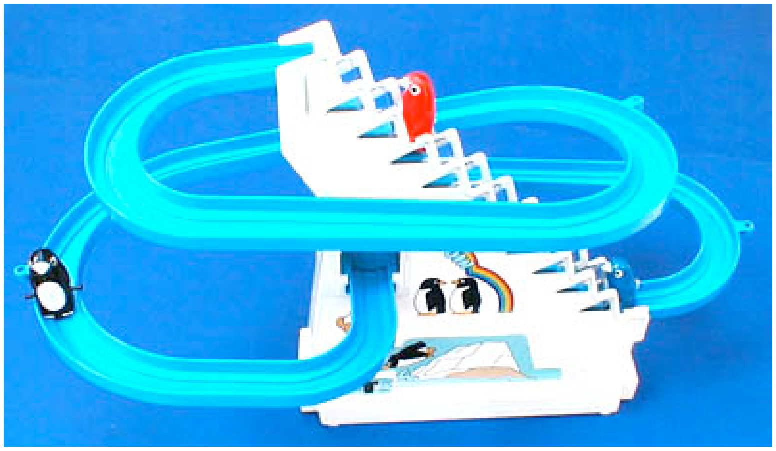
PENGUINS AND OTHER TOYS



Penguins

Jr. Jetway

The Penguin toy shown above comes in many versions that are essentially identical except for the décor and figures – e.g., seals, dogs, monsters, etc. There are also related toys that have different track configurations, mechanisms, and features – for example, the Jr. Jetway shown in Figure 2.

The activities below provide just a few examples of the many ways in which these toys can be used illustrate physics concepts such as work, potential energy, kinetic energy, friction, conservation of energy, efficiency, power, centripetal force, etc.

If you obtain a number of these toys, you can use them as a lab by setting them up as individual stations and having student groups rotate from one to the other at set intervals. Necessary equipment (balances, meter sticks, stop watches, etc.) should be supplied at each station as required.

PENGUINS

1. How much work is done in lifting a single penguin?

$W = F \times d = m \times g \times h$

=

2. How much power is expended?

$P = \frac{W}{t}$

=

3. One horsepower is approximately 750 watts. What is the horsepower involved in lifting a penguin?

JR. JETWAY

1. Why doesn't the plane fall off the upper and lower platforms? **Briefly** explain the mechanism that causes it to turn when it seems ready to fall off. (if necessary, continue on bottom of next page or on separate sheet)

2. Activating the levers on the upper and lower levels causes the plane to either remain on that level, or to climb or descend. **Briefly** explain how this works. (if necessary, continue on bottom of next page or on separate sheet)

SEALS

Match the items below with the numbered labels and signs on the apparatus. You may use numbers more than once.

______ a. mechanical work is transformed to gravitational potential energy as the seal travels in this region
______ b. gravitational potential energy is transformed to kinetic energy and heat as the seal travels in this region
______ c. electrical energy is transformed to mechanical energy here
______ d. work = force x distance; this distance would be used to calculate work **input**
______ e. work = force x distance; this distance would be used to calculate work **output**
______ f. kinetic energy is maximum here
______ g. gravitational potential energy is maximum here

DOLPHINS

1. Determine the electrical work input to lift a single dolphin.

$W_{in} = V \times I \times t =$

2. Determine the mechanical work output when a single dolphin is lifted.

$W_{out} = F \times d = m \times g \times h =$

3. Determine the % Efficiency for the machine lifting a single dolphin.

$\% \text{ Efficiency} = \frac{W_{out}}{W_{in}} \times 100 =$

Dolphins

Dogs

DOGS

1. Assuming no friction as a dog travels down the track, its loss of potential energy equals its gain of kinetic energy. The derivation shown below uses this relationship to determine the dog's maximum speed at the bottom of the track. Find this speed.

$PE_{loss} = KE_{gain}$ $\quad mgh = \frac{1}{2}mv^2$ $\quad v^2 = 2gh$ $\quad v = \sqrt{2gh}$

2. The equation for centripetal force is $F = mv^2/r$. Assuming the speed around the circular curve at the bottom is essentially the value calculated above, find the centripetal force on the dog in the curve.

TRAIN

NOTE: Please handle the locomotive carefully when you remove it from the tracks or turn it on or off. PLEASE DON'T FORCE ANYTHING IN SUCH A WAY AS TO CAUSE DAMAGE. Thanks.

1. Watch the locomotive run through a few complete cycles on the track layout.
2. Turn the locomotive over and notice the blue plastic tab near the front that extends downward.
   a. On what part of the track layout is this tab important?

   b. What would happen if the tab was not present?

   c. What does the tab do in its first interaction with the track layout?

   d. What feature of the track layout allows the train to get off the rotating track section and continue its journey?

3. Notice that the locomotive has two gears on one side, and only one on the other.
   a. Which of the gears turn, and which are fixed in place?

   b. What is the purpose of the larger gear?

BALL FACTORY

At first glance, the red circular section with the hole in the middle may seem to resemble a physical model of a "gravity well." The questions below compare the behavior of the balls in the red circular section with behavior in a gravity well. Circle the letter of the correct answer to each question.

1. The bottom surface of the red circular section
   a. rises notably upward toward the hole
   b. rises slightly upward toward the hole
   c. dips slightly downward toward the hole
   d. dips notably downward toward the hole

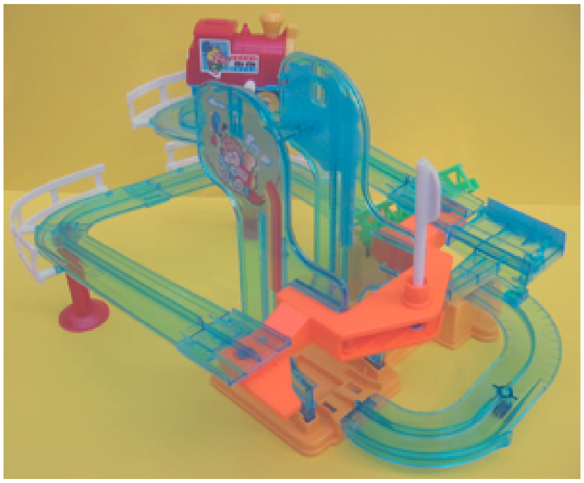
2. In the red circular section, the speed of a ball just before it falls into the hole seems
   a. greater than when it entered the red section
   b. less than when it entered the red section

3. In a model of a gravity well, it is usually obvious that the surface curves notably downward toward the hole. This means that as a ball rolling around the well approaches the hole, its gravitational potential energy is
   a. greater than when it was farther from the hole
   b. less than when it was farther from the hole

4. Considering conservation of energy, and also considering friction to be negligible, the answer to the previous question means that kinetic energy of the ball as it approaches the hole must be
   a. greater than when it was farther from the hole
   b. less than when it was farther from the hole

5. The answer to the previous question means that the speed of a ball just before it falls into the hole is
   a. greater than when it was farther from the hole
   b. less than when it was farther from the hole

6. Which of the following answers best explains the difference in behavior between the red circular section of the Ball Factory, and a model of a gravity well?
   a. The surface of the red circular section of the Ball Factory is so flat that loss of gravitational potential energy is very small, and the small gain in kinetic energy and speed is more than offset by frictional loss.
   b. Gravity wells are magic.



Train

Ball Factory

Apple Tree

APPLE TREE

1. In physics, there are six so-called ***simple machines***, which are listed below. Observe the mechanism which lifts the colored balls, and circle the letter of the machine to which you think you think the lifting mechanism might be most closely related.

a. lever	c. inclined plane	e. pulley
b. wedge	d. screw	f. wheel and axle

2. A screw is the most common choice, and the lifting mechanism is actually an example of an Archimedes Screw. A screw, however, can also be thought of as a variation of one of the other simple machines, a(n) _____ wrapped around a cylinder. Circle the letter of the answer which best seems to fill the blank in the preceding statetment.

a. lever	c. inclined plane	e. wheel and axle
b. wedge	d. pulley	

3. Note that there are several adjustments that can be made to affect the paths taken by the "apples" as they fall. Circle the letter of the correct statement below.
a. It may be possible to choose a path which gives an apple more kinetic energy just before it hits the bottom than it would have if it took other paths.
b. It may be possible to choose a path which gives an apple more gravitational potential energy just before it hits the bottom than it would have if it took other paths.