**PHYSICS 2021 - 22 Lab & Activity**

**Egg Bungee Jump Lab**

How safe is bungee jumping? It depends on those in charge of setting up the bungee cord. Bungee jumps might look simple to set up, but they involve a tremendous number of physics and mathematical calculations. The thrill of bungee jumping is to see how close the participant can come to the ground without actually contacting the ground. How can this be achieved?

**Goal:** Use multiple measurements to correctly predict the number of rubber bands needed to provide a “safe and thrilling jump” from a specific height. ( \_\_\_\_ m)

**Long-term goal:** Gather data to be used in future calculations for forces, energy, Hooke’s Law, etc.

**Materials:**

Ring Stand

Clamp

Raw egg (unaltered)

Plastic Bag

Rubber Bands

Paper Clip

Meter Stick Camera

**Write a set of procedures to obtain and record the following data:**

* Mass (g) of Egg
* Unstretched elastic band length (cm)
* Stretched elastic band length (cm)
* Initial Height (cm) of drop
* Total distance fallen (cm) after drop using 1 rubber band.
* Total distance fallen (cm) after drop using 2 rubber bands.
* Total distance fallen (cm) after drop using 3 rubber bands.
* Total distance fallen (cm) after drop using 4 rubber bands.
* Have 3 trials every time you add a rubber band.

**Create a data table to organize all of your data.**

**Analyze your data by creating a graph comparing the number of rubber bands to the total distance fallen** (HINT: which is the independent (x) variable and the dependent (y) variable?)

**Based on your graph, predict the number of rubber bands that will be needed to successfully accomplish your goal.** (HINT: think equations from math class) You MUST show your calculations **neatly**!!

**Testing Your Model:**

We will now put your measurements to the test. You will be given a height from which your participant is to make the leap. Using only your measurements, your group will then drop your egg. No practice jumping allowed. This jump will be videotaped for further analysis in the future. How much do you trust your measurements?!

**Scoring will be as follows for *Successful Jumps:***

 100 The “jump” is within 5 cm of the ground

 95 The “jump” is 5 to 10 cm from the ground

 90 The “jump” is 10 to 20 cm from the ground

 85 The “jump” is 20 to 30 cm from the ground

 80 The “jump” is 30 to 40 cm from the ground

 75 The “jump” is more than 40 cm from the ground

**Scoring will be as follows for *Unsuccessful Jumps:***

85 Minor impact is made with ground (Small crack or can hear it touch)

70 Impact with the ground that results in a fairly large crack, but the egg is still pretty much intact.

 50 Impact that results in egg *shattering*

\*Your challenge is two-fold:

1) Using the information gleaned from the lab above, determine the number of rubber bands you will need to…

2) Create an egg bungee system that can be successfully thrown out (two tries) of the Science Lab’s window, soar past Mr. Beland’s door, and come to a distance from the ground, as indicated on the list above.

Bungee-Jumping Egg

**SCIENTIFIC**

***FAX!***

***SCIENCE***

# Introduction

Bungee jumping would not be as “safe” as it appears to be without relying on some basic physics principles, such as the conservation of energy and Hooke’s law for springs. A safe bungee

jump occurs when no one is injured. An exhilarating bungee jump is one in which no one is injured, the free fall lasts as long a time as possible, and the bungee jumper comes as close to the ground as possible without touching it. In this activity, the law of conservation of energy and Hooke’s law will be used to build a safe *and* exhilarating model bungee jump of an egg!

**Concepts**

 • Hooke’s law for springs • Acceleration of gravity • Conservation of energy

# Background

The law of conservation of energy states that energy cannot be created or destroyed, only converted between one form and another. During a bungee jump, the stored, potential energy (PE) of the jumper on a tall platform (*PE = mgh*) is converted into kinetic energy (KE) during the fall (*KE = 1/2mv2*). This kinetic energy is converted back into potential energy as the bungee cord (rubber band chain) stretches. At the bottom of the “ride,” when the jumper momentarily stops, all the kinetic energy has been converted into spring potential energy—the energy stored in the stretched bungee cord (PEspring = 1/2kx2). An instant later, the bungee jumper is flung upward as the bungee cord relaxes, thereby converting the spring potential energy back into kinetic energy. An egg will simulate the bungee jumper in this experiment.

In order to determine the appropriate length of string needed to make the bungee cord long enough for a safe and exhilarating ride, five quantities are needed—(1) the total height of the jump that is desired, (2) the initial length of the unstretched rubber band chain, (3) the spring constant of the rubber band chain, (4) the mass of the egg, and (5) the length of the basket (see Figure 1). The total height of the jump (*h*) is the height above the ground at which the jump begins (*PH*) *minus* the separation distance between the egg and the ground at the bottom of the ride (Equation 1).

 *PH – d = h = SL + UL + BL + X* *Equation 1*

 *PH* = Platform height above the floor *h* = Total height of the jump

 *SL* = String length

 *UL* = Unstretched rubber band chain length

 *BL* = Egg basket length

 *X* = Stretch distance of rubber band chain during jump *d* = Separation distance between egg and floor at the bottom of the ride (2 cm)

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Ceiling Support

d

PH

h

SL

X

BL

UL

Rubber Band Chain

Egg in Bag Basket

**Bungee-Jumping Egg**

# Materials

|  |  |
| --- | --- |
| Balance, 0.1-g precision  | Rubber bands, 3–4 long, 1⁄16 thick, 10 |
| C-clamp  | Sandwich bag, plastic |
| Ceiling hook or rod support  | Scissors |
| Egg, raw (or hard boiled)  | Step-stool |
| Marker, ink  | String, thin, 150 cm |
| Mass with hook, 100-g or 50-g  | Tape measure |
| Meter stick  | Trough or catch bucket (optional) |
| Paper towels  | Water |

**Safety Precautions**

*Wear safety glasses. If an egg cracks on the floor, clean up the spill immediately to reduce the risk of a slippery surface. Please follow all laboratory safety guidelines.*

# Procedure

1. Obtain ten long, thin rubber bands.
2. Link two rubber bands together with a “looping knot” as shown in Figure 2.
3. Make a chain of ten rubber bands using the “looping knot” method.
4. Hold the rubber band chain by one end and allow it to hang vertically. Measure the unstretched length with a meter stick. It may be necessary to pull the chain slightly in order to uncurl and **Figure 2.** untwist some of the rubber bands and get a more accurate “unstretched” length. Record the unstretched length to the nearest 0.1 centimeter.

 Unstretched Rubber Band Chain Length (UL): \_\_\_\_\_\_\_\_\_\_\_\_\_.

1. Add a 100-g or 50-g hooked mass to one end of the rubber band chain.
2. Hold the other end of the rubber band chain and allow the mass to hang vertically.
3. With the meter stick, measure the length of the stretched rubber band chain. Record the stretched length to the nearest 0.1 centimeter.

 Stretched Rubber Band Chain Length (S): \_\_\_\_\_\_\_\_\_\_\_\_\_.

1. Calculate the spring constant, *k,* for the rubber band chain using the following equation:

 *k* = (mass of weight)(981 cm/s2)/(S – UL) Spring Constant *(k)*: \_\_\_\_\_\_\_\_\_\_\_\_\_.

1. Place an egg into a sandwich bag.
2. Measure the mass of the egg and sandwich bag using a balance. Record the mass to the nearest 0.1 g.

 Mass of Egg and Sandwich Bag (M) \_\_\_\_\_\_\_\_\_\_\_\_\_.

1. Tie the sandwich bag closed with a free end of the rubber band chain. Use the same “looping knot” that was used to link the rubber bands together to connect the bag to the chain (Figures 1 and 2).

## Bungee-Jumping Egg

1. With a meter stick, measure the length of the egg basket from the end of the rubber band looping knot to the bottom of the bag. Record this measurement to the nearest 0.1 centimeter.

 Egg Basket Length (BL): \_\_\_\_\_\_\_\_\_\_\_\_\_.

1. *(For the teacher)* With a tape measure, measure, to the nearest 0.1 centimeter, the height above the ground of the ceiling hook or support rod, from which the bungee jump will begin. *Caution:* Take extreme care when standing on a step-stool.

 Platform Height (PH): \_\_\_\_\_\_\_\_\_\_\_\_\_.

1. Calculate the stretch distance of the rubber band chain using the following equation: X = 2 M (981 cm/s2)(PH–2 cm)

 ———————————

 K

 Stretch Distance, (X): \_\_\_\_\_\_\_\_\_\_\_\_\_.

1. Calculate the length of additional string that is necessary to successfully complete the jump safely (refer to the *Background* section). SL = h – UL – BL – X

 String Length (SL): \_\_\_\_\_\_\_\_\_\_\_\_\_.

1. Measure the string to the necessary length with a meter stick. Use scissors to cut the string about 10 cm beyond the necessary length to allow for excess string at each end for clamping and tying the string to the support rod and rubber band chain, respectively.
2. Securely tie one end of the string to the free end of the rubber band chain. Tie as close to the end of the string as possible.
3. Measure the string length from the end tied to the bag. Use an ink marker to mark the end point of the true, functional string length (calculated in step 15). Leave at least 5 cm of excess string at the end.
4. *(Optional)* Fill a trough with water to act as the pool or lake below the bungee-jump site. Place it beneath the “jump” location.
5. Double check the total length of the bungee cord and egg basket. Make sure to lift the egg basket slightly until the rubber band chain begins to have some slack to determine the approximate unstretched length of the bungee cord.
6. Did the egg survive the bungee jump? Was it the most exhilarating ride possible? If not, what are some possible sources of error that may be corrected?

# Tips

* Double check all the calculations before bungee jumping.
* Make sure the bungee cord does not get tangled up or twisted together before the release. Have a partner hold string apart and to the side before the drop. Let go of the string immediately when the egg is released.
* The *Background* section infers previous knowledge about the conservation of energy and Hooke’s law. Please refer to your physics or physical science textbooks for more information about these topics.
* Plastic eggs filled with water with the two halves loosely connected may be used instead of real eggs. Place tape on one side to act as a hinge.
* A thin elastic band may be used instead of a rubber band chain. Cut the band so its length is 1⁄4 to 1⁄3 the platform height.