How to Trap the Road Runner

Prepared by:

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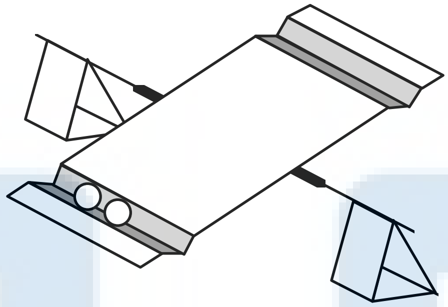
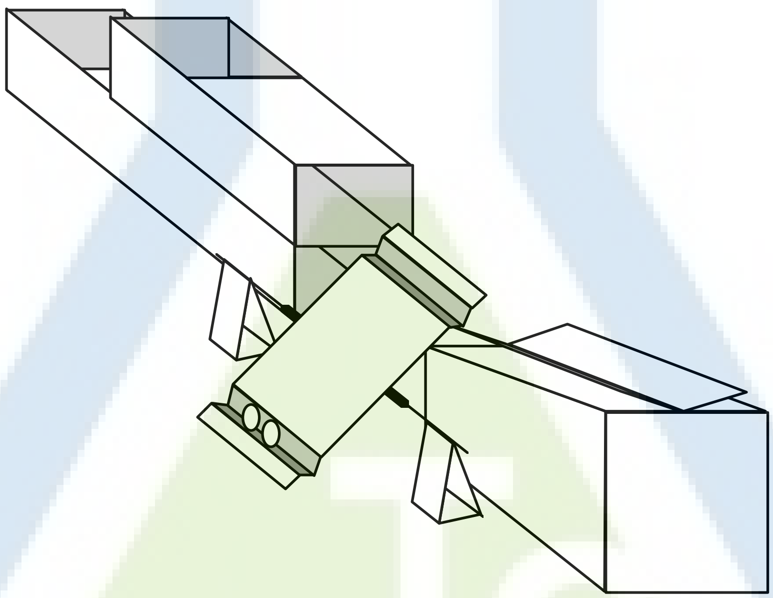


Line up the boxes, see-saw and ramp. Roll a small marble down the ramp. It rolls across the gutter into the upper box. Now try a large marble.



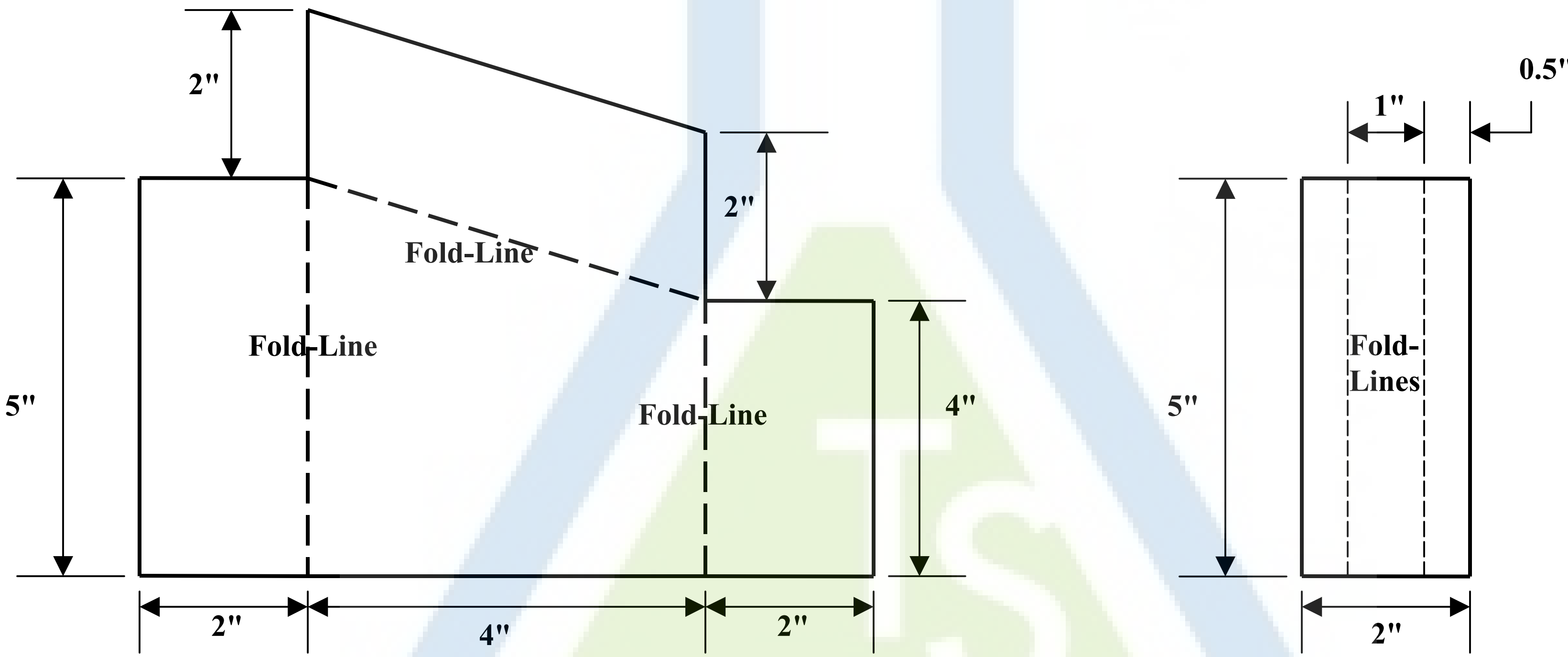
Questions:

1) What other things could you sort with this type of machine?

2) How could you improve this design?

(See Appendix for further building instructions)

Ramp Assembly

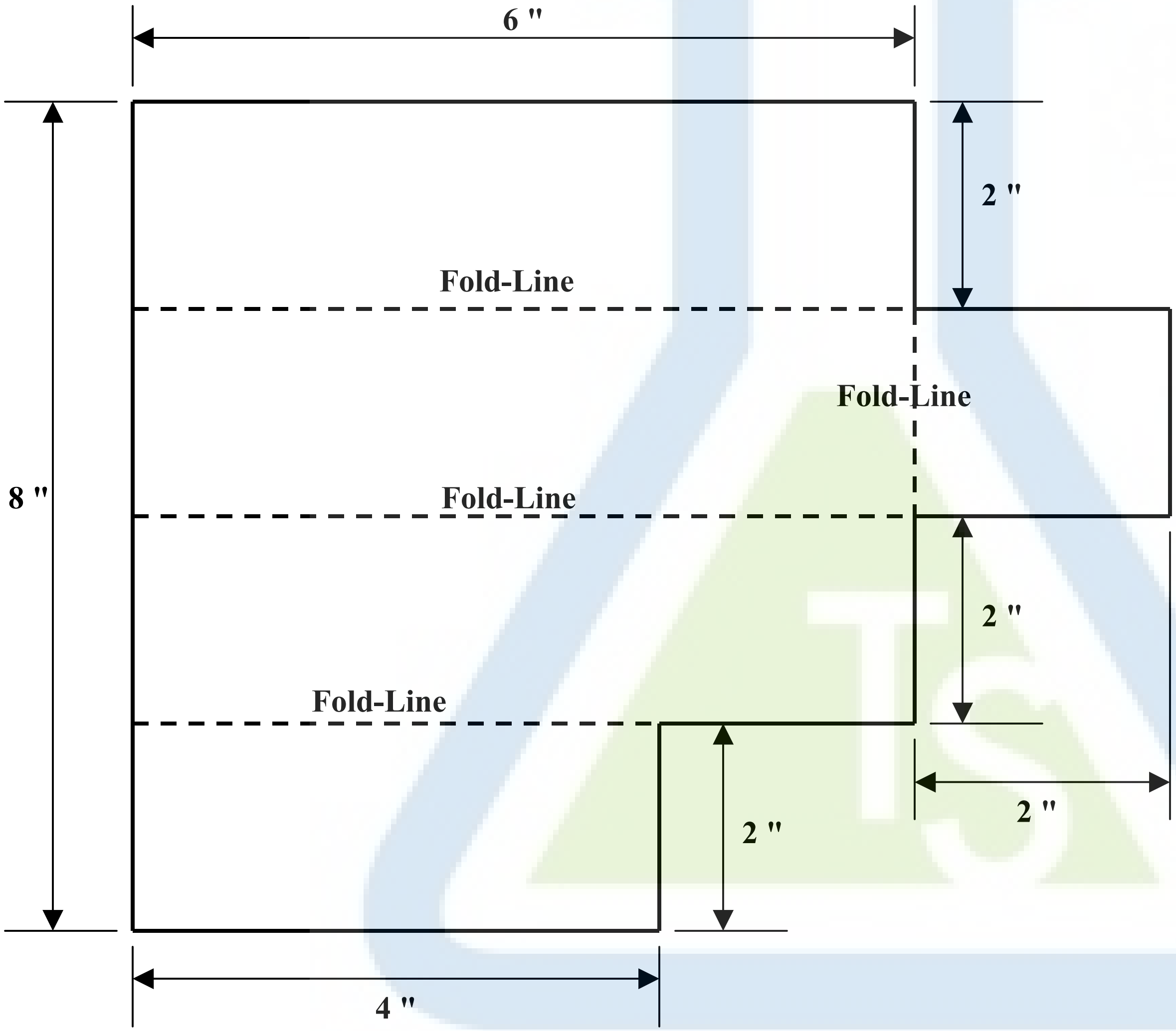


Stand (two pieces)

Ramp

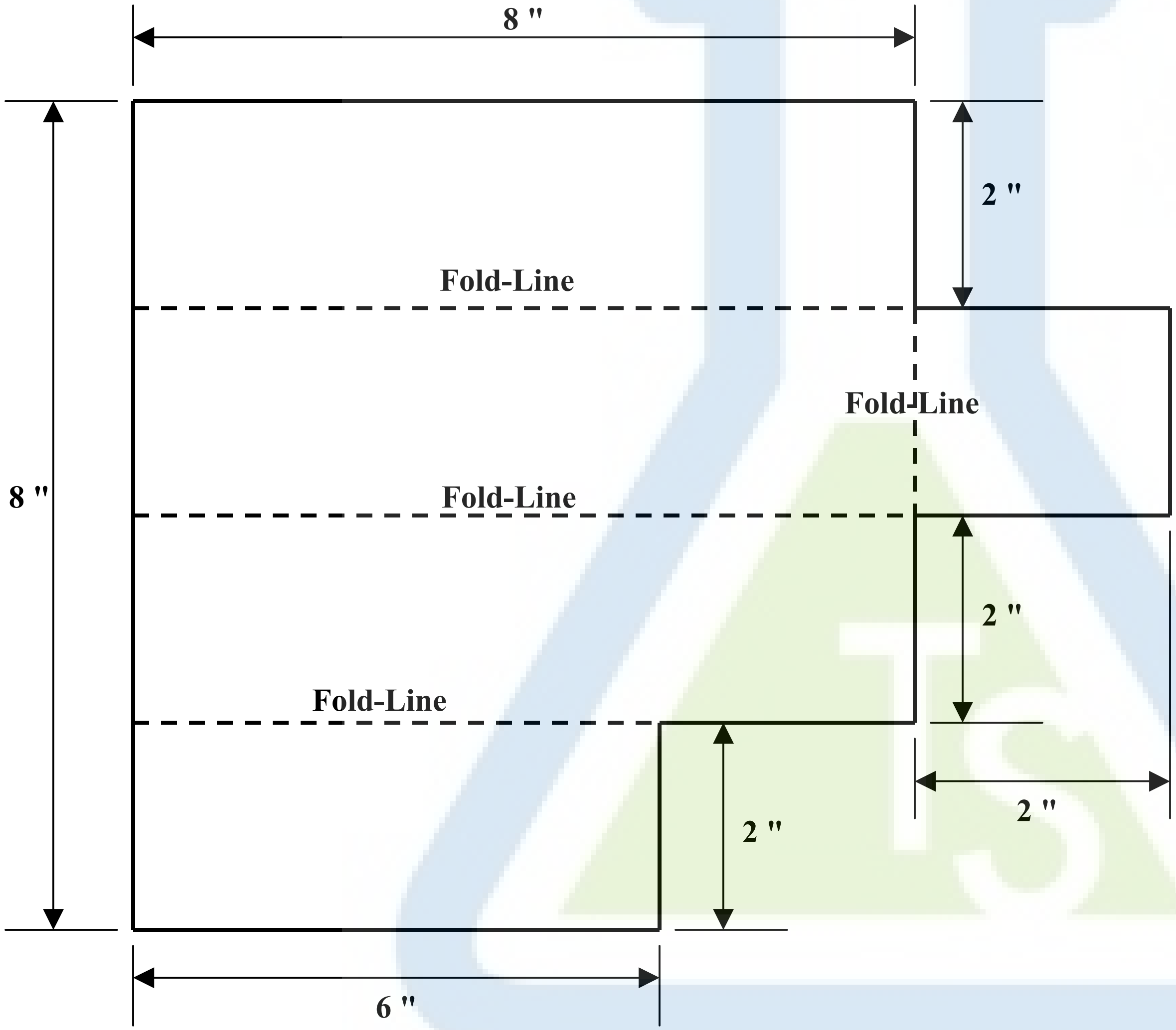
Figures are not to scale

Small Marble Sorter



Figures are not to scale

Large Marble Sorter



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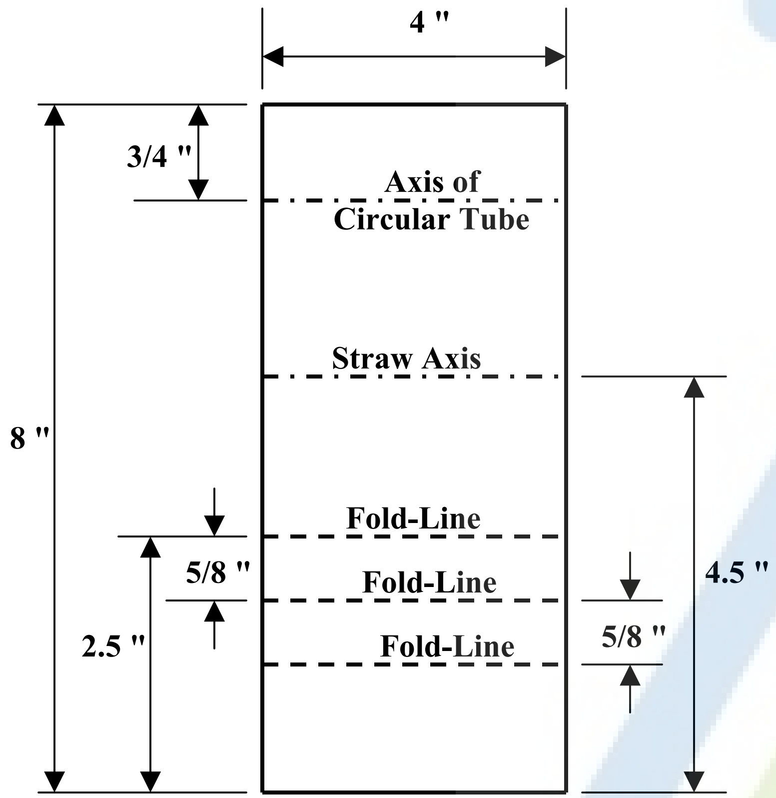
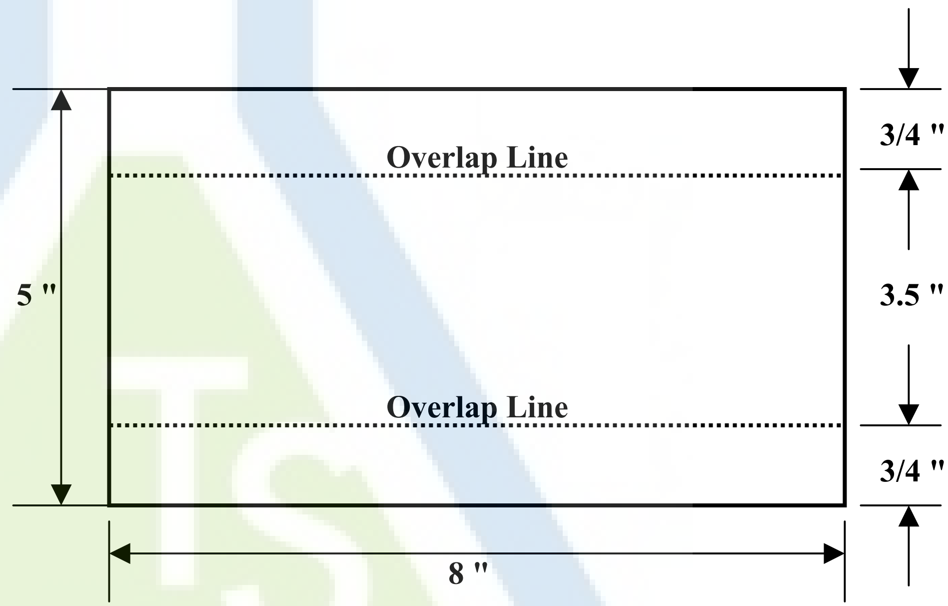
Sorter



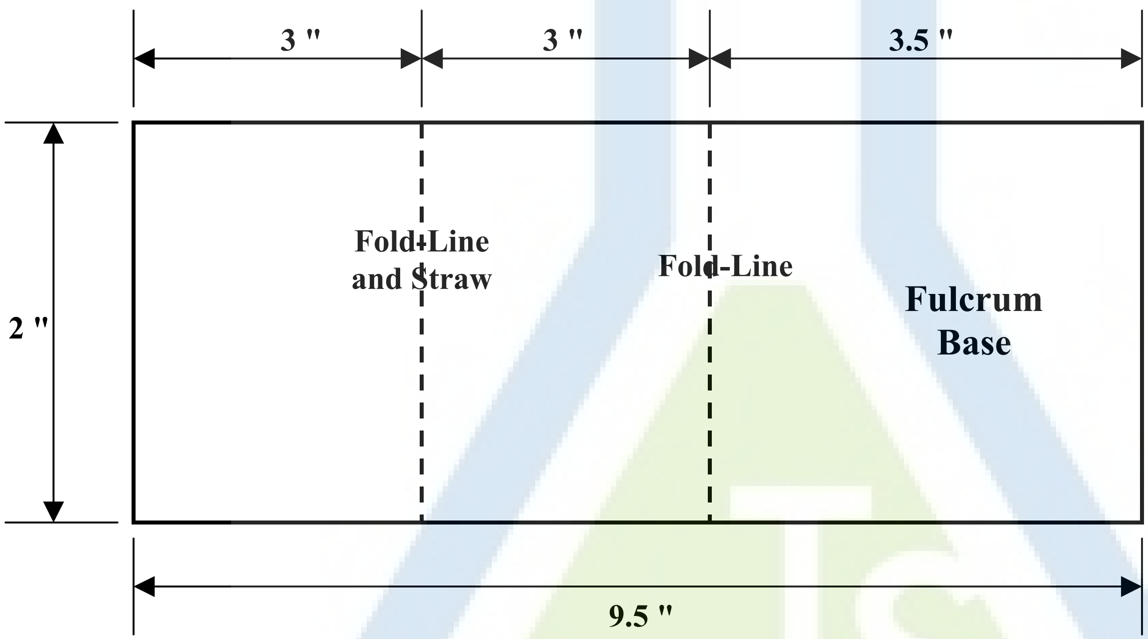
Sorter



Circular Tube

Figures are not to scale

Fulcrums



(Two Pieces)

Figures are not to scale

LAB: Energy Transfer

Required Materials:	Grapefruit	Orange
	String	Scissors

Description: Conservation of energy: Energy can neither be created nor destroyed. When something loses energy, it is either transferred to something else or changed into another kind of energy. This experiment will demonstrate energy transfer from a grapefruit to an orange and vice versa.

Lecture: The Law of Conservation of Energy: Energy cannot be created or destroyed.

Consider a ball rolling over hills. When the ball is at the top of the hill it is at rest thus possessing a form of energy called "potential energy". When the ball is at the bottom of the hill, it is travelling at some velocity or speed - the potential energy was transferred to the motion of the ball - "kinetic energy". The ball will not keep rolling forever - some of the energy of the ball gets transferred into other kinds of energy (sound, heat). The energy is not destroyed, though - just transferred somewhere else.

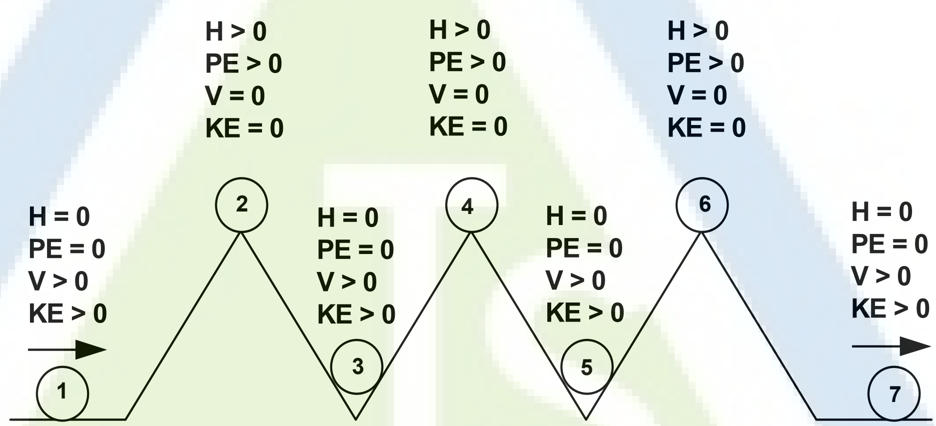


Figure 1: Conservation of Energy Principle

Kinetic Energy can be computed by the following equation:

$$K.E. = 1/2 * m * v^2$$

Where K.E.= Kinetic Energy
m = Mass of object
v = Velocity of object

Potential Energy can be computed by the following equation.

$$P.E. = m * g * h$$

Where P.E. =Potential Energy
m = Mass of object
g = Acceleration due to gravity
h = Height of object from reference point

In this experiment, kinetic energy is transferred from one object to another and back again.

Experiment:

Cut a piece of string and tie it to the grapefruit, leaving a long, loose end. Do the same with the orange.

˜Tie a long piece of string between two fixed points. Suspend both fruits from it. (Keep the string taut. Hang the two fruits at the same level.)

˜Gently pull the grapefruit back and let go. The grapefruit swings back and forth.

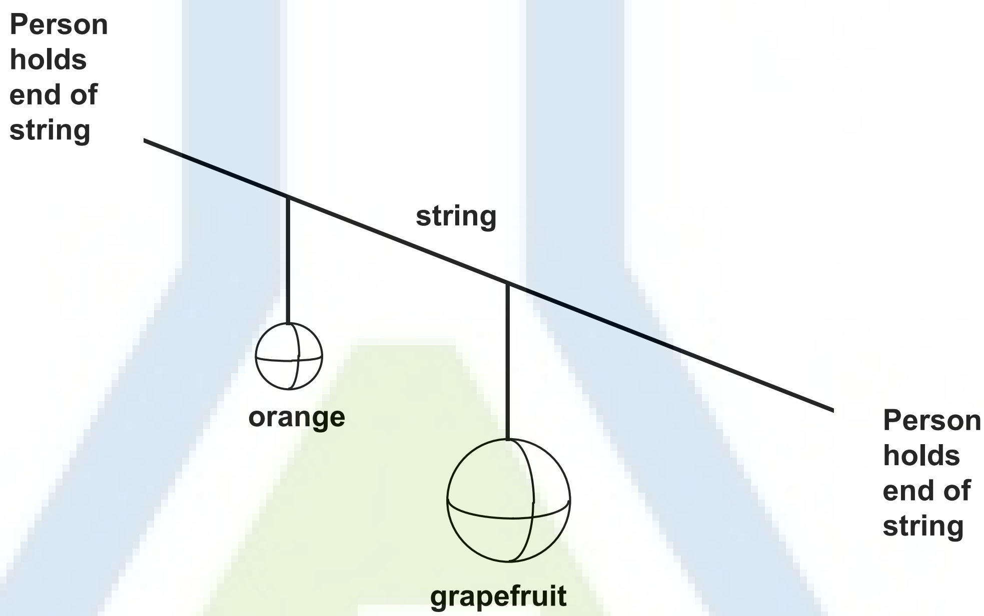


Figure 2: Energy transfer setup - Grapefruit and Orange

When the grapefruit begins to slow down, the orange starts swinging. (The grapefruit transfers kinetic energy along the string to the orange. When all the energy has transferred to the orange, the grapefruit stops swinging.)

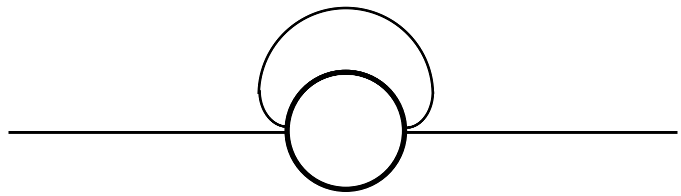
When the orange begins to slow down, the grapefruit starts moving again (the kinetic energy of the orange is transferred back along the string to the grapefruit). Each fruit stops and starts a few more times, and eventually both fruits stop swinging. Their kinetic energy has changed into another kind of energy.

Questions:

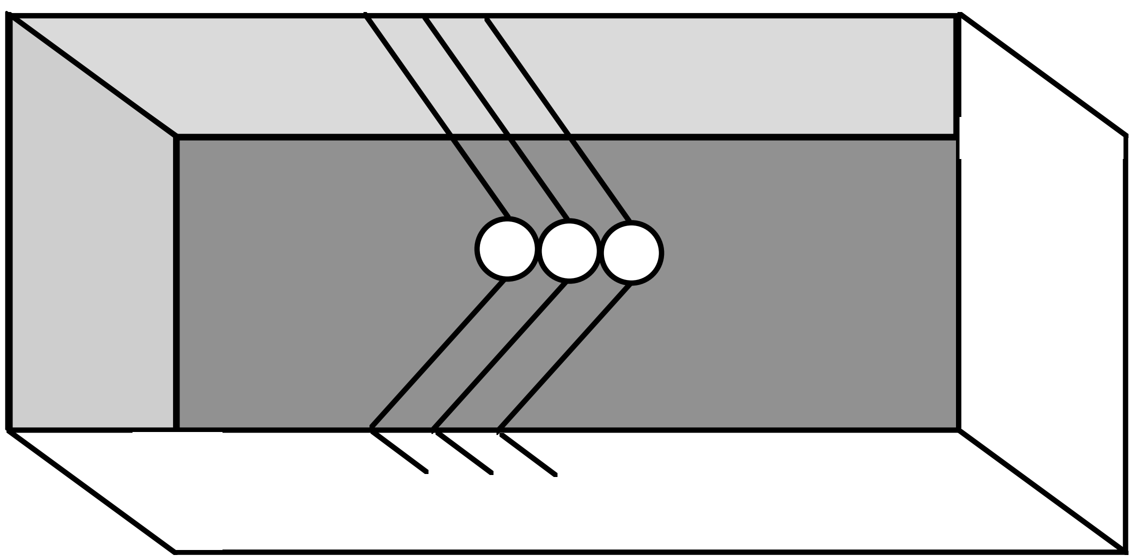
1. What happens when the grapefruit begins to slow down?
2. What causes the orange to start swinging?
3. Why does the grapefruit stop swinging?
4. What happens when the orange begins to slow down?

Experiment: Each group will build a momentum transfer device (Newton's cradle).

1) Thread pieces of string of equal length through the beads (you should have three) and loop it through the hole once. Pull the string tight.



2) Lower the bead into the box and pull the thread over opposite edges of the box. Line it up so that the bead is centered in the box, and not touching the bottom. Tape the ends of the thread in place. Lower the other two beads into either side of the box and attach them so they just barely touch the middle bead. Make sure the beads are all aligned.



3) Pull the first bead back and let it go. It hits the middle bead and stops. The last bead springs away. This process continues for several more collisions.

Questions:
1)Why don't the beads keep moving forever if the momentum is always being "transferred"?

LAB: Water Balloon Physics

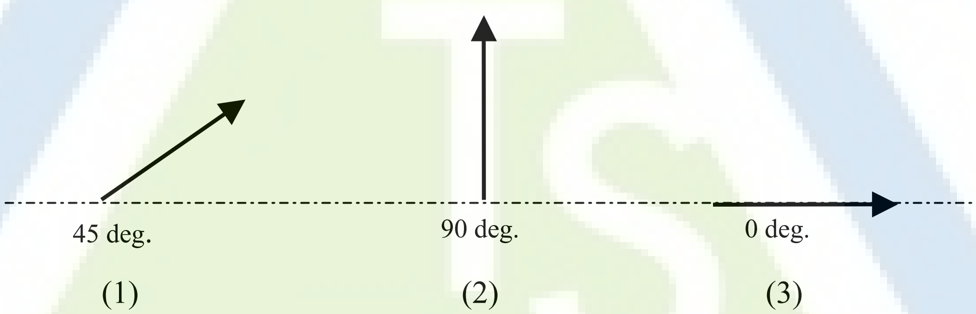
Materials: Water Balloon Launcher
Small Water Balloons
Meter Stick
Graphing Calculator or Microsoft Excel
Large area with a length of approximately 60 meters or more

Description: This lab launches water balloons with a range of 10 meters to 60 meters, or even more depending on the spring constant of the rubber band. The purpose of this lab is to predict where a water balloon will land, using vertical and horizontal motion equations. This lab builds on the drop test lab where gravity is measured.

Lecture: *(motion)* All objects feel a force due to gravity on Earth. This force is seen easiest when any object moves. The acceleration due to this force is called the "acceleration dude to gravity". This was measured previously in the Drop Test Lab. Objects accelerate toward the Earth at this rate. Knowing this and the initial velocity of an object, the distance an object will travel can be found.

(energy) Energy has two major forms, potential and kinetic. This was seen in the Reversing Roller Lab. Knowing the potential energy of the "rubber band" portion of the launcher will allow us to know the object's kinetic energy based on conservation of energy. Kinetic energy of an object will tell us its velocity from the equation K.E. = $\frac{1}{2} * m * v^2$.

(launch angle) The angle of launch is also very important in order to predict water balloon ranges.



(2) and (3) will not yield any real range because they only allow for velocities in either the horizontal or vertical direction only. Both directions are needed to launch a balloon. 45 degrees gives us the angle that maximizes our range.

Activity: Find the distance or range you want your water balloon to! Measure off your specified range. Extend the rubber band launcher to the extension you found which coincides with the range. **Let it fly!!**

Finding the "Range":
Some equations of motion must be introduced in order to find the range, "R", of the projectile or how far the balloon will go.
(All symbols and letters at bottom of page)

A projectile has the equation:

$R = [(\mathbf{V_o})^2 \text{Sin}(2\boldsymbol{\theta})]/\mathbf{g}$

Conservation of Energy Provides this:

Potential Energy = $(1/2)\mathbf{K}(\Delta d)^2 = (1/2)m(\mathbf{V_o})^2$ (Kinetic Energy once balloon is launched)

Combining the two energy equations gives: $(\mathbf{V_o})^2 = \mathbf{K}(\Delta d)^2/m$

Therefore after substituting the combined energy equation into the first equation:

$$R = [(\mathbf{V_o})^2 \text{Sin}(2\boldsymbol{\theta})]/\mathbf{g} = [\mathbf{K}(\Delta d)^2 \text{Sin}(2\boldsymbol{\theta})]/(m\mathbf{g})$$

Therefore:

Range of Balloon = $(\Delta d)^2 [\mathbf{K}\text{Sin}(2\boldsymbol{\theta})]/(m\mathbf{g})$ ← **Final Equation!**

Δd = Extension of "spring" on the launcher (must be in meters)
K = Spring Constant (must be in N/m)
θ = Angle of Launch (must be in degrees)
m = Mass of "spring," launch pouch and water balloon combined (must be in Kg)
g = Acceleration due to Gravity (must be in m/s^2)
$\mathbf{V_o}$ = Initial Velocity (cancels out)

Questions:

1. Why did the launcher have an angle of 45 degrees?
2. What types of energy did the water balloon have?
3. What causes the balloon to fall?

ACME Quiz Material

Drop Test

1. What is gravity?

2. What is the value of earth’s acceleration of gravity?

3. What is the equation for the force (F) of gravity acting on a mass (m)?

4. Which of Newton’s law does this activity demonstrate?

Parachute

1. What is drag?

2. How are lift and drag affected by surface area?

3. What kind of parachute would you use to deliver cargo boxes to a specific target?

4. What kind of parachute would you use for yourself?

Energy Transfer

1. What principle of physics does this demonstrate?

2. What is kinetic energy?

3. How is the energy transferred?

Newton’s Cradle

1. Which two principles of physics does this activity demonstrate?

2. What is momentum?

3. What is kinetic energy?

Reversing Roller

1. Where is the energy stored in the reversing roller?

2. Describe how this stored energy is used.

Spool Racer

1. Where is the energy stored?

2. Is the stored energy converted to some other kind of energy? What kind?

3. How is this kinetic energy exhibited

Jump for Joy

1. What do cams do? How do they work?

2. What did we use as our CAM on this activity?

3 What was our follower?

Pulley Power

1. What advantage did this machine give us?

2. How do pulleys work?

Keeping Cool

1 . What simple machine did we use to make our fan?

2. How was power transmitted from one gear to the other?

3. What is the velocity ratio? How do we calculate it?

4. Why use belts on gears?

Sorter

1.What kind of machine is the sorter? (controller)

2. What were the various parts of the machine? (Brain, etc.)

Air Rocket

1. Which of Newton's Laws did this lab demonstrate?

2. What is a vector—what two characteristics describe a vector?

Bibliography & Author's Note

I. Ardley, Neil, The Science Book of Energy, Harcourt Brace Jovanovich, 1992.

II. Ardley, Neil; The Science Book of Machines; Harcourt Brace Jovanovich, 1992.

III. Cash, Terry; 101 Physics tricks: Fun Experiments With Everyday Materials, Sterling Publishing Co., Inc.; 1992.

These books can be purchased at the following locations:

Little Professor Bookstores

Natural Wonders

Nature Company

Target

Walden Books

Your local Teachers Supply Stores.

Most of the supplies used in this workshop were found digging through my own garbage. Some of the supplies, like the corks, were purchased at Cost Plus Imports (they sell them in packages of 10).

Your local library can direct you to books concerning the basic concepts presented in this booklet. If you have any comments or questions concerning the material provided in this package, please feel free to contact me at my work address. Good luck and have fun!