

TEACHER GUIDE
For Toying With Science Workshop
By Garry Krinsky

The following information is provided as an aid for teachers who have participated in Garry Krinsky's "Toying with Science" workshop. This study guide contains information that is directly related to the show as well as additional information that may help with further curriculum development. This guide should help reinforce the scientific principles and exercises that the teachers experienced during the workshop, as well as help them apply and adapt the information to their respective classrooms. It is designed to be used in conjunction with the "performance study guide", which can be accessed at the bottom of the "Toying With Science" page at www.garrykrinsky.com.

Teacher workshops encourage participants to experience the information in three ways: 1) as learners (students), 2) as applicers (teachers), and 3) as adapters. In other words, teachers first experience and digest this new information for themselves, as their students do. After each activity, they then explore how they would apply this experience to their classrooms, adapting it to their individual needs and themes. Classroom space, student size and ages, and curriculum integration all factor into each teacher's adaptation.

GRAVITY AND AIR RESISTANCE

The principles of gravity and its opposing force, air resistance, can be seen and understood through two activities: object balancing and juggling.

OBJECT BALANCING

In the first workshop activity, teachers explore air resistance (and how to find the center of gravity) by balancing peacock feathers on their hands. Teachers experience, first-hand, how the feather resists the pull of gravity (by trapping air) and, thus, allows them ample time to move the bottom stem to keep the feather balanced (as gravity pulls down the length of the feather through their hands). Sharing the workshop space in a harmonious way is emphasized, as teachers do the feather balancing as a group. Garry will model ways to make this activity safe, and then lead them through a series of feather balancing exercises (see "Tips for Balancing Feathers" in the performance study guide), which challenge and hone their balancing abilities, providing each teacher with a unique learning experience. Following this, the teachers discuss the various scientific principles that they've explored with these exercises, and how they'll share the experience with their students. Their adaptations will be governed somewhat by how much mastery each individual teacher feels they've gained, but also how teachers can adapt the activity to their respective curriculum, classroom layout, student size and interest. The workshop is not designed to create circus artists and/or mimes, but rather to allow the teachers a unique experience that they feel capable (and excited) to share with their students.

Some key phrases to remember with feather balancing are:

-“Be soft with your bodies. If you make contact with someone, do not move them out of your way, but rather slide on through following and eventually controlling your feather.”

- “Let the feather fall, not you, or your classmates.”
- “Share the space!”
- “Be gentle with the feathers. They break easily.”
- “Keep your eye on the top of the feather. Don’t begin to balance until you’ve focused on the top.”
- “Give each other positive feedback, so that if a feather toss to a partner isn’t high enough, ask for it to be higher, as opposed to saying that it was too low. Work together!”

-Cautions- Students often want to test their balancing abilities after working with the feathers by trying to balance other objects. This can be dangerous as a group activity, and is better suited to be an individual activity or done in small groups. Still, a few safety checks are an important starting point:

- Stress how vital it is to catch the object before it falls. Aside from students possibly getting hurt, accidents can also adversely affect the student’s ability.
- Nothing should ever be balanced that can’t easily (and safely) be caught (if it falls), as well as be safely lifted and put down afterwards.
- The balancing space should always be inspected for safety before balancing. When the student’s eye is focused on the top of the balanced object, they can’t see below them, so be sure to remove anything on which they might trip.
- Students should be careful as they move on from feather balancing to other objects. Longer objects tend to be easier to balance (up to a point), such as yardsticks, broom handles, rakes, baseball bats, tennis rackets, etc. It took Garry almost a full year before he was able to balance a ladder on his chin, and he made sure that he had (adult) “spotters” surrounding him to catch it if it fell. The ladder did not fall, mainly because he worked his way up to it step by step, gradually balancing more challenging objects, but also because he could relax and do his best, knowing that he had “spotters” there for safety. Feeling safe is an important element in learning anything new.

JUGGLING

Teachers also explore the concept of juggling during the workshop, working with scarves and/or plastic bags, both of which have great air trapping abilities. It becomes immediately clear how air resistance slows down the force of gravity, making it much easier to see and understand the juggling pattern. The basic juggling pattern is in the shape of a “figure 8”, with the “8” standing on its side. The figure 8 is a single twisted, but continuous line, similar to the symbol for infinity. In this pattern, there is basically only one object in the air at all times, which is why the basic juggling pattern normally involves three objects (one in each hand, plus one in the air).

- Suggestions-** It is also helpful (and fun) to juggle two objects in one hand. Naturally, the pattern changes to become either circular or to parallel lines. Juggling is a fun way to recognize and illustrate a variety of geometric patterns.
- It can also be enlightening to hold the plastic bags with two hands by the open end and swing it so that it fills with air, then move it in different patterns (circles, figure 8s, lateral motions), eventually letting it go and watching it languidly float down to Earth. Wouldn’t it be nice if we could slow down all kinds of physical

motion to better understand how things work? What other activities can we think of where humans juggle multiple activities? What other ways can we see gravity and air resistance at work?

- **Other Challenges-** With younger children (or older children who are having trouble mastering the figure 8 pattern), it can be quite helpful to simply throw the scarves/bags (even one at a time) straight up, do a body motion (a spin, a leap, touching the ground, slapping someone “five”) and then catch the scarf/bag before it hits the ground.
- It can also help to count how long it takes from the time it leaves the hand to just before it hits the ground to see how much time air resistance truly gives us. One nice thing about working with plastic bags is that they are cheap (free) and easily available.
- If a juggler has trouble maintaining a figure 8 pattern, because he or she keeps handing off (rather than tossing up) the object to their stronger hand (reverting to a circular pattern), it helps to start juggling with the weaker hand, because one is less likely to “stick” the object into their weaker hand.
- It can also help for the teacher to stand facing the student juggler and catch each scarf/bag at its peak and slow its descent (holding it) even more than the air would. This can help allow the student to truly see the figure 8 pattern, without the pressure of gravity (even gravity slowed by air resistance) rushing them. In other words, the teacher can slow things down to match the learner’s comprehension. Remember, the hand that throws, then immediately catches, and if the objects travel in a true figure 8 pattern, the object should be right there for the catching.
- Learning to juggle, especially with balls, requires thousands of drops, so it’s best not to practice when a class is taking a test or doing concentrated work on the floor below. Juggling over a couch or a low table or even a bed, at home, not only protects your neighbors, but saves the juggler the strain of constantly picking balls up after they fall to the ground.

Partner Juggling- A helpful variation is to have two students stand, side by side, and have each student use only their outside arm, as they juggle three objects, together, in a figure 8 pattern, each using only one arm. There are a number of more advanced patterns for jugglers to explore once the preceding challenges are met.

Juggling is basically learning to do one thing well enough that you can add something else to your pattern. In other words, walking while talking on the phone is a form of juggling, as is playing the guitar and simultaneously singing, taking notes while listening to a lecture or dribbling a basketball while searching for an open teammate to pass to. Humans juggle a variety of motions all of the time, and so learning to juggle 3 inanimate objects (please, no cat juggling allowed) simply exercises our multi-tasking abilities.

MACHINES

Machines are often designed with the human body as a model or built to enhance certain human motions. Some machines such as bicycles and automobiles increase our

abilities (in this case our ability to travel), while others are designed to make our lives easier and/or more organized. The human body, though, has such incredible mechanics that scientists have rarely been able to create robots that move as smoothly and gracefully as we humans do. When we reach for a glass of water, there are a multitude of simultaneous motions that are near impossible to duplicate with a machine.

-Suggestion- A fun and educational experiment that highlights this is to conduct an everyday task as a robot might, and then compare how many moves a human needs to accomplish the same action. Try a series of tasks such as pouring liquid into and then drinking from a glass, sharpening a pencil, tying a shoe, hanging up a coat, taking a book out of desk and opening it. It can also be fun (also easier to organize and clean up afterwards) to “mime” these tasks (first as a robot and then as a human, or vice versa). There are mechanics involved in all of our actions. When we lift or move heavy objects, we use our legs and arms as levers and create our own fulcrums. Understanding how are bodies move can provide great insight into how machines work, as understanding how machines work can sharpen our awareness of our own physical motion.

SIMPLE MACHINES

Simple machines are powered by humans (as opposed to being powered by electricity, burning fuel). Scientists have organized these machines into six different categories:

- 1) **Screw** – an inclined plane (slanted surface) wrapped around a cylinder to form a spiral. {bottle cap, piano stool}
- 2) **Lever** – a rigid rod or bar to which a force may be applied to overcome resistance. {crowbar, seesaw}
- 3) **Inclined plane** – a slanted surface used to raise or lower an object. {ramp}
- 4) **Pulley** – a chain, belt, rope or string wrapped around a wheel. {window shade, curtain}
- 5) **Wedge** – an inclined plane that moves. Most wedges (but not all) are combinations of two inclined planes (often two slanted surfaces). Wedges generally split things apart. {ax, knife}
- 6) **Wheel and axle** – a lever that rotates in a circle around a center point (or fulcrum). The larger wheel (outside) rotates around the smaller wheel (axle). {wagon, skateboard}

In an effort to remember the various types of simple machines, Garry has Composed a simple phrase and accompanying rhyme:

“Don’t SLIP on the two Ws”
(A Rhyme to Remember the 6 Types of Simple Machines)
(By Garry Krinsky)

Simple machines, there’s six different kinds.
To remember them, here’s a few clues,
A silly phrase that helps to remind;
“Don’t SLIP on the two Ws!”

“S” is for screw, “L” is for lever,
and “I”s for the inclined plane.
“P” is for pulley. The first “W”s wedge.
Wheel and axle is all that remains.

Don't slip; Don't slip;
Don't slip, slip, slip;
Don't slip on the two Ws.
It's a silly phrase
That helps to remind,
Don't SLIP on the 2 Ws!

Screw, Lever, Inclined Plane, Pulley, Wedge, Wheel and axle

THREE CLASSES OF LEVERS

*Levers can be further categorized into three different classes, according to where the fulcrum is in relation to the effort used to overcome the resistance. For example, in a seesaw, the fulcrum is in the middle of the lever, between the effort on one end and the resistance on the other. This is a **first class lever**, as is a catapult or an automobile jack. In a **second class lever**, the resistance is located between the fulcrum and the effort. Picture a wheel barrel (a second class lever), where the effort to raise it becomes more difficult when it is heavier (loaded up with more mass), and the fulcrum is the wheel and axle on the end. A door is another example of a second class lever, because the effort (mass of the door) is between the knob (where we exert the effort to open and close it) and the hinges (the fulcrum.) To understand a **third class lever**, observe a set of tweezers and you will see that the fulcrum is on the attached end, while the effort is located in the middle, where we squeeze them to overcome the resistance of what we're gripping on the other end. So, a simple way to remember the different classes of levers is to identify where the (F) fulcrum is located relative to the (E) effort and the (R) resistance.*

First class: E – F – R

Second class: E – R – F

Third class: R – E – F

COMPOUND MACHINES

Many simple machines are actually “compound machines”, which are machines comprised of two or more types of simple machines. For example: A scissors is made of two levers (attached at the fulcrum), while the sharp (inside) edge of each of these levers are wedges (two slanted surfaces). Within a can opener, you'll find two levers, a circular wedge and a wheel and axle.

-Suggestions- A great exercise is to picture (or enter) a room and list all of the simple machines you can find, and then break them down into their various categories. You might start with your classroom. There, you'll find a treasure trove of human

powered machines, everything from window shades (pulleys), to books (two attached levers with the binding acting as the fulcrum) to tape dispensers (wheel and axle, wedge) to pencil sharpeners (lever, wheel and axle, wedge... Remember, a wedge usually separates, in this case, separating the old wood from the new, revealing more lead to write with). Move outside to the playground and note the varying types of simple machines.

-Try the gymnasium. Think about kitchens. How about bathrooms? (warning: the latter can lead to toilet humor.)

-Ask your students to think of rooms (garages, basements, artist studios, dance or gymnastic studios), places and activities (carnivals, the beach, sporting events, boat trips, outdoor adventures) that contain lots of simple machines, and continue identifying and categorizing them. Of course, whenever possible, locate the respective fulcrums of these machines.

Powered machines often have simple machines parts. For example, a gas-powered lawn mower, has a handle which acts as a lever, and some have a pulley chord to start them up. Refrigerators have doors on hinges (levers), and buttons (levers) that when released light up the inside when opened. Cars have wheel and axles, steering wheels, levers that recline the seats, and, of course, doors with hinges (levers with fulcrums).

-It is also a worthwhile exercise to identify the “ancestors” of our modern machines. Before there were cars, there were horse and buggies, as before there were modern plows, we plowed our fields with large simple machines pulled by horses and other animals. Predating the computer was the typewriter. Before touch tone phones, there were rotary phones, and before that, phones that had to be cranked up. Explore the mechanics that went into bringing these “ancient” machines into the modern age.

EXPLORING MECHANICS THROUGH MIME

-Suggestions- An interesting activity is to have the students play the different parts of some of these machines.

-A good starting point would be to try a “statue” game. Pair them in groups of two, and have them take turns manipulating each other into various poses (one is the sculptor, while the other is the clay), mindful of how our bodies move at the various joints (elbows, wrists, fingers, shoulders, waist, neck, hips, knees, ankles and toes.) It is important to set some boundaries before beginning about being respectful to each other, as well as stressing that the sculptor must maintain the clay-person’s balance. At various intervals, the teacher could call out, “freeze!” They could then examine each others’ statues, before the teacher again shouts, “switch!” at which points the sculptor becomes the clay, etc... They should be encouraged to bend at a wide variety of joints, as opposed to just moving each others hands and arms. How does bending at the knee affect the body’s balance and shape? ...bending at the waist? ...gently twisting the hips?

-You could also expand the groups and have one sculptor create a “work of art” out of two or three people. A variation on this game is to match the statue(s) to a photo, but it is important to keep exploring how the “clay people” are molded into the finished product, as opposed to just posing without being “sculpted”. Ideally, these exercises should warm them up and give them a better sense of body mechanics.

Before they undertake portraying different machines, make a list (with them) of some machines that might have animated parts, such as an automobile, a vending machine, computer game or carnival ride. Then, have them separate into groups and decide upon a machine (or related machines) to create. Remind the students that machines transfer, send or change energy, and how this energy gets moved should help them work together, and also help their classmates figure out the particular type of machine. Often having a human(s) manipulate the machine can illuminate the kind of machine it is. Have them work out who plays which parts, and then ask the class to try to figure out the type of machine(s) that they are miming. Sounds are perfectly acceptable and can be quite helpful. After identifying each machine(s), discuss how the energy got transferred through the machine, where fulcrums appeared, and which types of the six simple machines were employed (levers, pulleys, etc...). If a student portrayed a door as part of the machine, where was the hinge (fulcrum)? What type of simple machine was the knob? Was it wheel and axle attached to a lever (door latch)? Humor should be encouraged, so long as it does not digress into outright silliness. Sometimes a few props can spark the imagination (a yardstick, a hoop, a ball, etc...), but less can often be more with these activities. The imagination makes up for a lot.

A simple variation on miming machines is to have individuals create a mime using an object. Generally, levers, such as a yardstick, work well, but a bat or a tennis racket can also serve the purpose. The audience guesses what was just mimed, but also where the fulcrum(s) were located. In the general study guide, you'll find a number of fulcrum exercises including "Find the Fulcrum!" Fulcrums are not always fixed as they are, for example, in a rowboat's oar bracket. The fulcrum moves when we swing a golf club or a baseball bat. The same is true when we cast with a fishing rod, or swing an ax. The energy still transfers or changes at the fulcrum, except, in these examples, the fulcrum is no longer fixed. Attention should be paid to what type of simple machine (if it is a machine) that the mime creates. This can also work as a warm-up activity. Ideas often spark other ideas, and a next step could be to let audience members add to (or join in with) each mime, so that you'd have group mimes.

All of these various activities should result in students becoming more aware of the various machines that surround us, and how these machines come from and reflect who we are. As Garry says, "May the fulcrum be with you!"

WEB LINKS

The following web sites relate to the material covered in Garry's Teacher Workshops, and may be helpful to further understanding these concepts, as well as applying them and adapting them to your classrooms:

<http://www.garrykrinsky.com/Study%20Guide.pdf>

<http://www.kidskonnnect.com/content/view/99/27/>

<http://www.usoe.k12.ut.us/curr/science/sciber00/8th/machines/sciber/intro.htm>

To purchase peacock feathers (Garry thinks the 40" length is best, but the shorter lengths also work well):

<http://www.ostrich.com/shop/cat?cmd=stdsearch:feather,peacock,eye-nat&>