

SCIENCE OF THE OLYMPIC WINTER GAMES
A NATIONAL SCIENCE FOUNDATION AND NBC LEARN SERIES
STUDENT ACTIVITY

AERIAL PHYSICS: AERIAL SKIING

Objective: *Understand angular momentum in the classroom.*

Introduction notes for teacher:

This activity is intended for use after the viewing the NBC Learn [AERIAL PHYSICS: AERIAL SKIING](#) video clip. One of the goals of aerial skiing is to maximize the number of “tricks” (flips, twists, etc) in single leap. Performing the tricks is a matter of angular momentum, and, of course, acrobatic skill. Parts of this activity are similar to some in [FIGURING OUT FIGURE SKATING](#).

Pt. One: Starting motion by using a swivel office chair

- (1) Sit on a swivel office chair with the chair back against your chest. You can hold onto the chair back for support. (There are also specially built physics stools for this demonstration.). Find a way to hold your legs so they cannot touch the floor or the base of the chair. Try to spin yourself.
- (2) Reach sideways with one arm and push sideways on a large piece of furniture (like a desk) so that you start turning to the left. Note which direction you have to push in order to start to turn left. Repeat this so that you turn to the right.

Applying “physics” vocabulary:

- (a) In step one, when you started from a rest position and you had nothing to push against. Nothing, therefore, could push back on you to give you the angular momentum needed to turn or spin.
- (b) In step two, when you pushed to the right on the desk, the desk pushed back against you that made you start turning to the left. The desk exerted a left torque on you and this torque is what gave you angular momentum. As long as the torque is acting, you will keep gaining more angular momentum. When you stop pushing, you don’t gain more momentum.

Pt. Two: Torques on a spinning office chair:

- (3) In this part, have a fellow student give you a gentle spin while your arms are held close to you.

Applying “physics” vocabulary:

- (c) In step three, when your fellow student was giving you a spin, he was applying a torque on you. Torques are necessary to give, or take away, spin. When he stopped, you coasted to a stop because of friction. The friction caused a torque in the opposite direction. This opposite torque took away your spin. It took away angular momentum.

Pt. Three: Giving yourself angular momentum:

(4) Stand up in a space where you are several feet away from any object. (A grass lawn is ideal). Wearing athletic shoes is also a good idea. Jump straight up. Make note of how your feet pushed against the ground.

(5) Repeat step “4” only this time try to spin to your left so that when you land you face in a different (left) direction. Do this without turning your body or your head. The action will all be with you legs and feet. Make note of how differently your feet pushed compared to part “4”.

(6) Repeat step “5”, only try to spin to your right. Make note of the push made by your feet.

Applying “physics” vocabulary:

(d) In step four, your feet pushed down only, not sideways. They could not apply a torque and could not give you angular momentum.

(e) In step five, your right foot had to push to the right as you started to go up. The right foot was therefore able to apply a torque and give you a little bit of angular momentum. You ended up with a small spin.

(f) In step six the same result occurs, but the left/right directions are reversed. The push with either foot is how the aerial skier gives himself/herself some angular momentum when he/she skis off the ski ramp. If there were no push with either foot, the skier would have no spin (no angular momentum).

Pt. Four: Changing angular momentum you already have:

(7) Sit on a swivel chair like you did in part two, only this time hold barbells in each hand and hold them close in to your body. Have another student give you a gentle spin. Once you are turning freely with the angular momentum the other student gave you, slowly extend you arms straight out.

(8) Repeat step “7” only this time start with the arms held straight out. After you have been given a gentle spin, gradually bring your arms up close to you.

Applying “physics” vocabulary:

(d) In step seven, it seemed like you were losing angular momentum, but you really were not. You were losing spin speed, but not angular momentum. **Angular momentum has two components:**

(a) how fast you spin; and (b) how far out from the center the spinning takes place. When your arms extended outwards, the “distance” from the center of spin got bigger. In order to keep the same angular momentum, the spin speed had to get smaller.

(f) In step eight, the reverse happened. When you brought your arms in toward your body, the “distance out” got smaller. The spin speed got larger to keep the angular momentum the same.

Pt. Five Changing angular momentum you already have while in the air:

(9) Repeat part three where you jumped up and turned to the left at the same time. Note that when you land back on the ground, you are still turning and you were a little “off balance”.

(10) Once again, jump up and give yourself a torque with your right foot, but this time have your arms extended straight out to the sides when you take off. As soon as you are in the air, quickly pull your arms back to you body. **Warning, you may fall down the first couple of times while trying to perform this maneuver.**

(11) Repeat step ten, only start with the arms close into your body and move them out once you are up in the air.

Applying “physics” vocabulary:

(g) In step nine you were a little off balance when you landed because your body still had a little angular momentum and wanted to keep on spinning. Your feet had already been stopped by contact with the ground.

(h) In step ten, when you pulled your arms in, your body’s “distance” from the center got smaller. This means that the spin speed had to get larger. When you landed, your body was spinning even more than in part nine, and you were even more off balance when you landed.

(i) In step eleven, by moving your arms out you increased your “distance” and your spin speed had to decrease. The spin decrease would take away most of the spin given by your foot when you took off, and you should have landed with almost no balance problem.

NBC Learn, the educational arm of NBC News, teamed up with the National Science Foundation to produce Science of the Olympic Winter Games, a 16-part video series that explores the science behind individual Olympic events, from downhill skiing to curling. View the entire collection at <http://www.nbclearn.com/olympics>

Author Biography:

This activity was created by John Meyers and Joe Byrne in conjunction with Academic Business Consultants of Phoenix, Arizona.

John Meyers is a retired Physics teacher with over 40 years of classroom teaching experience. He has taught mathematics, all levels of physics, as well as chemistry, and astronomy. His longest tenure was 33 years at Alhambra High School in Phoenix, AZ.

During his career as a high school teacher, John completed numerous summer classes and workshops through grants from the National Science Foundation, winning the award for Outstanding Teacher in 1972.

Joe Byrne taught physics and math for the Phoenix Union High School District from 1967 to 1999. He was a classroom teacher for all of his tenure with this district, but also held positions as department chair for various departments: Mathematics, Science, and Title I.

At present he is mostly retired, but is also an adjunct faculty member of Paradise Valley Community College (Phoenix), where he teaches physics.

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