Description

Figure skaters must be aware of their center of mass, which affects the balance and stability of every step, jump, spin, and lift that the skaters perform. “Science and Engineering of the 2014 Olympic Winter Games” is produced in partnership with the National Science Foundation.

Keywords

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Citation

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Physics of Figure Skating

LIAM McHUGH, reporting:

From Olympic champion Evan Lysacek…

EVAN LYSACEK (Figure Skating Gold Medalist): Imagine what it's like to hurl your body in the air and rotate four times.

McHUGH: …to Olympic hopeful Ashley Wagner...

ASHLEY WAGNER (US Figure Skating Team): This is what I've been working for my entire career.

McHUGH: …figure skaters push themselves through incredible jumps, spins, lifts, and throws - on ice - and make it look elegant and effortless.

GRACIE GOLD (US Figure Skating Team): From your starting position to your very last movement, and even the way you get off the ice, every detail counts.

McHUGH: Making the difficult elements look effortless takes exceptional artistry, athleticism and a solid understanding of some basic principles of physics.

BRAD ORR (University of Michigan): There is no better example of physics than on an ice skating rink. It's a wonderful place to see science.

McHUGH: Brad Orr is head of the Physics Department at the University of Michigan and has been funded by the National Science Foundation. Orr explains that good balance, or stability, is basic to everything a skater does - and that begins with an understanding of the center of mass: the balance point in which an object's mass is concentrated.

ORR: This is easiest to see in a completely symmetric object like a basketball. The center of mass is at the center of the sphere. As you get to objects which have less symmetry, it's a little harder to figure it out, but it's still the center of where the object is.

McHUGH: The center of mass for a figure skater is usually in the hip area, well above the feet, or point of support.

ORR: Here we come to a situation which is unstable, and this is what the figure skater actually has. Her center of mass is up around her hips and her skates are touching the ice down here.

McHUGH: A figure skater's center of mass must be kept directly above the point of support to maintain
balance, adjusting as positions change. This becomes even more challenging in pairs skating and ice
dancing, which require that both skaters keep their centers of mass over the point of support – through
lifts, throws, and complicated positions.

MERYL DAVIS (Figure Skating Silver Medalist): We like to focus on what's going to give us the most
potential to move quickly, spin quickly, achieve the most aesthetically pleasing position. That is kind of
based on where our skating blade is, where our weight is sitting.

McHUGH: Isolating a skater's center of mass helps demonstrate another physics principle found in figure
skating: projectile motion. When a skater performs a jump, he becomes a projectile - an object moving
vertically as well as horizontally - and his center of mass will follow a curved path. This trajectory is a
mathematical shape called a parabola.

ORR: And it doesn't matter whether it's a baseball, basketball, hockey puck or figure skater launched into
the air. The projectile motion will be this parabola universally. It's gravity in all of these situations that
make them behave in the same way.

McHUGH: A skater is moving horizontally when she launches herself into a jump and begins to move
vertically. All the while, gravity is pulling downward, decreasing the skater's vertical velocity without
affecting her horizontal velocity. At the top of the arch her vertical velocity is zero.

ORR: The vertical velocity will be affected by gravity, whereas horizontal velocity will be constant. And
so those two velocities - that which move me horizontally and that which move me vertically - are
independent of one another.

McHUGH: The independence of vertical and horizontal motion is another principle of physics that
explains how pairs skaters can perform amazing throws.

ORR: We have the pair of skaters coming along. He throws her in the air. The motion along the ice is the
same, and because their motion horizontally is independent from the motion vertically, they arrive at the
same point at the same time. So if we were to look at where she is at every instant in time, she will be
exactly over him, even though she's going up and down and he's just moving across the ice.

McHUGH: In motion horizontally or vertically, figure skaters give their all to accomplish the difficult and
demanding choreography.

LYSACEK: What does figure skating require? It requires everything: massive strength combined with
stamina, and then you make sure you hit it every time under pressure while the entire world is watching.
It's a pretty difficult sport, for sure.

McHUGH: Along with all the hard work, an understanding of physics helps to keep these athletes skating
toward their Olympic dreams.