ANGULAR MOMENTUM CONSERVATION Unit 16

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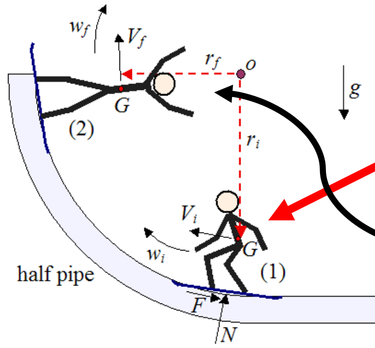
Snowboarding, Once a High-Flying Sport, Crashes to Earth

Snowboarders practicing on the halfpipe at the 2016 U.S. Open on Wednesday after events at Colorado's Vail Ski Resort were canceled because of the weather.



INTRODUCTION: What is the physics taking place that enables the snowboarder to increase his speed on the half-pipe? <u>To increase his speed, the snowboarder crouches down in the straight part of the half-pipe.</u> Then *<u>when he enters the curved portion of the half-pipe he lifts his body and arms up, which results in him exiting the pipe at greater speed than he would otherwise.</u>* The basic snowboarding physics behind this phenomenon can be understood by <u>applying the principle of angular impulse and momentum.</u>

~~$T \Delta t$~~ $+ I_i \omega_i = I_f \omega_f$ **eq.1**

The snowboarder is able to increase his speed on the half-pipe with his feet remaining firmly on the board. This begs the question, what is the physics taking place that enables the snowboarder to increase his speed on the half-pipe? To increase his speed, the snowboarder crouches down in the straight part of the half-pipe. **<u>Then when he enters the curved portion of the half-pipe he lifts his body and arms up, which results in him exiting the pipe at greater speed than he would otherwise.</u>** The basic snowboarding physics behind this phenomenon can be understood by **<u>applying the (((principle of angular impulse and momentum))).</u>** The schematic in (above) this analysis is given below.

w_i is the initial angular velocity of the body (consisting of snowboarder plus board), at position (1)
w_f is the final angular velocity of the body, at position (2), which is the point at which the snowboarder exits the half-pipe
V_i is the initial velocity of the center of mass *G* of the body, at position (1)
V_f is the final velocity of the center of mass *G* of the body, at position (2)
r_i is the initial distance from the center of rotation *o* to the body's center of mass *G*, at position (1)
r_f is the final distance from the center of rotation *o* to the body's center of mass *G*, at position (2)
***N* is the normal force acting on the snowboard, as shown . *F* is the friction force acting on the snowboard, as shown**
It is assumed that the half-pipe is a perfect circle with center at *o*.
IMPORTANT ADDITIONAL INTRODUCTION: Note the Normal force N direction goes right through the center of the circle arc the Snowboarder is going around. *<u>(((Thus, there is NO external torque about center point o. With NO external torque (eq. 1) the initial angular momentum = final angular momentum.)))</u>* Decreasing r_f , decreases I_f causing w_f to increase.

As the Swiss snowboarder Iouri Podladtchikov twisted, flipped and spun above the halfpipe at X Games Oslo last week on his way to a silver medal, the bottom of his board — one of the more valuable pieces of advertising real estate in the sport — displayed no corporate logo. Instead, it was adorned with an artistic design he had created for a college class assignment. The reason for the triumph of art over commerce: Podladtchikov, 27, the 2014 Olympic halfpipe champion, no longer has a board sponsor.
Snowboarding — <u>which scarcely existed 30 years ago and took over ski resorts around the world seemingly overnight, adding 5 million participants in two decades — has tumbled to earth recently.</u> A weakened global economy, shifting weather patterns and changing tastes and technology have added up to create a challenging atmosphere for snowboarding. According to the trade group SnowSports Industries America, snowboarding peaked in popularity with nearly 8.2 million <u>participants in the 2010-11 season, declining in each of the next three years.</u>

Considering snowboarder's mass at center of mass we can express initial and final moment of inertia as: **$I_i = m\, r_i^2$**
$I_f = m\, r_f^2$. Thus, eq. 1 can be expressed as : $m\, r_i^2\, \omega_i = m\, r_f^2\, \omega_f$

QUESTIONS: (a) If $r_i = 1.5$ m. , $r_f = 1$ m , find ratio of ω_f / ω_i = ? , (b) $V_i = 1.5\, \omega_i$, $V_f = 1.0\, \omega_f$, find ratio of V_f / V_i = ?
ANSWERS: (a) $\omega_f / \omega_i = 2.25$, thus $\omega_f = 2.25\, \omega_i$, (b) $V_f / V_i = 1.5$, thus $V_f = 1.5\, V_i$, thus final linear & angular velocity are increased. Snowboarder's kinetic energy increased due to work pumping (pushing out).