

Spirals, Helixes, and Cycloids



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Animation
Physics

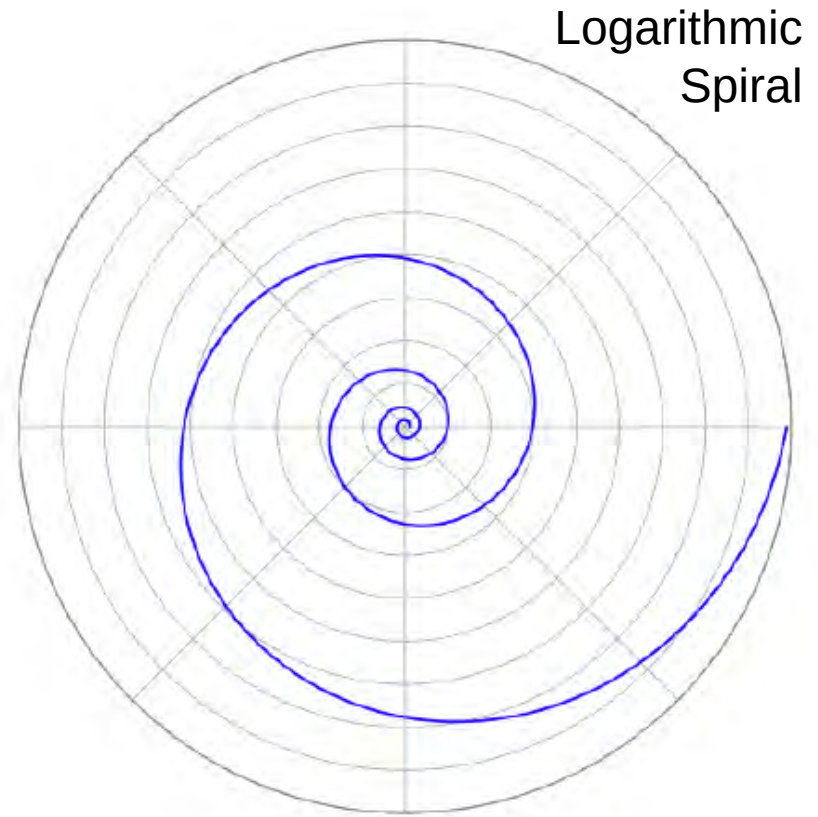


Spirals

A spiral is just a circular arc with a radius that's either increasing (spiraling out) or decreasing (spiraling in).

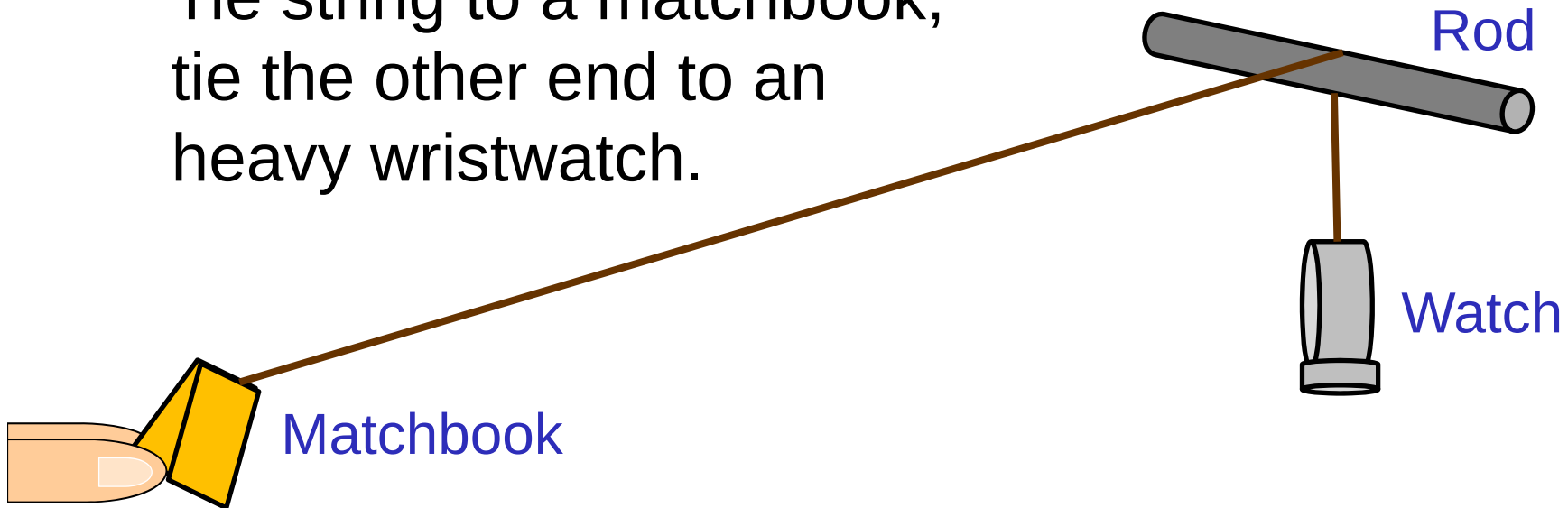


Concept art from
Pirates of the Caribbean 3



Rapid Wrap Demo

Tie string to a matchbook;
tie the other end to an
heavy wristwatch.

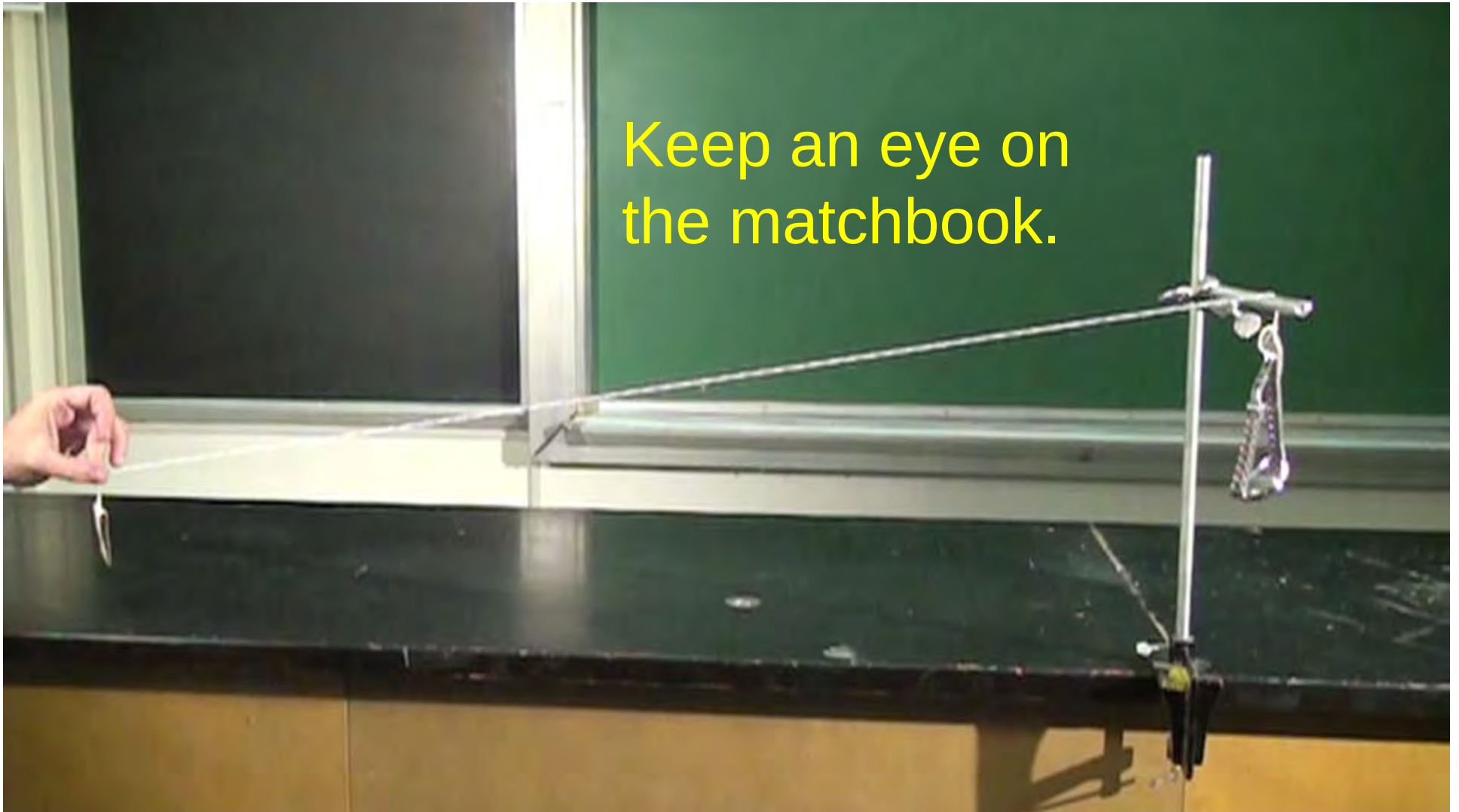


Drape the string over a rod.
Let go of the matchbook.

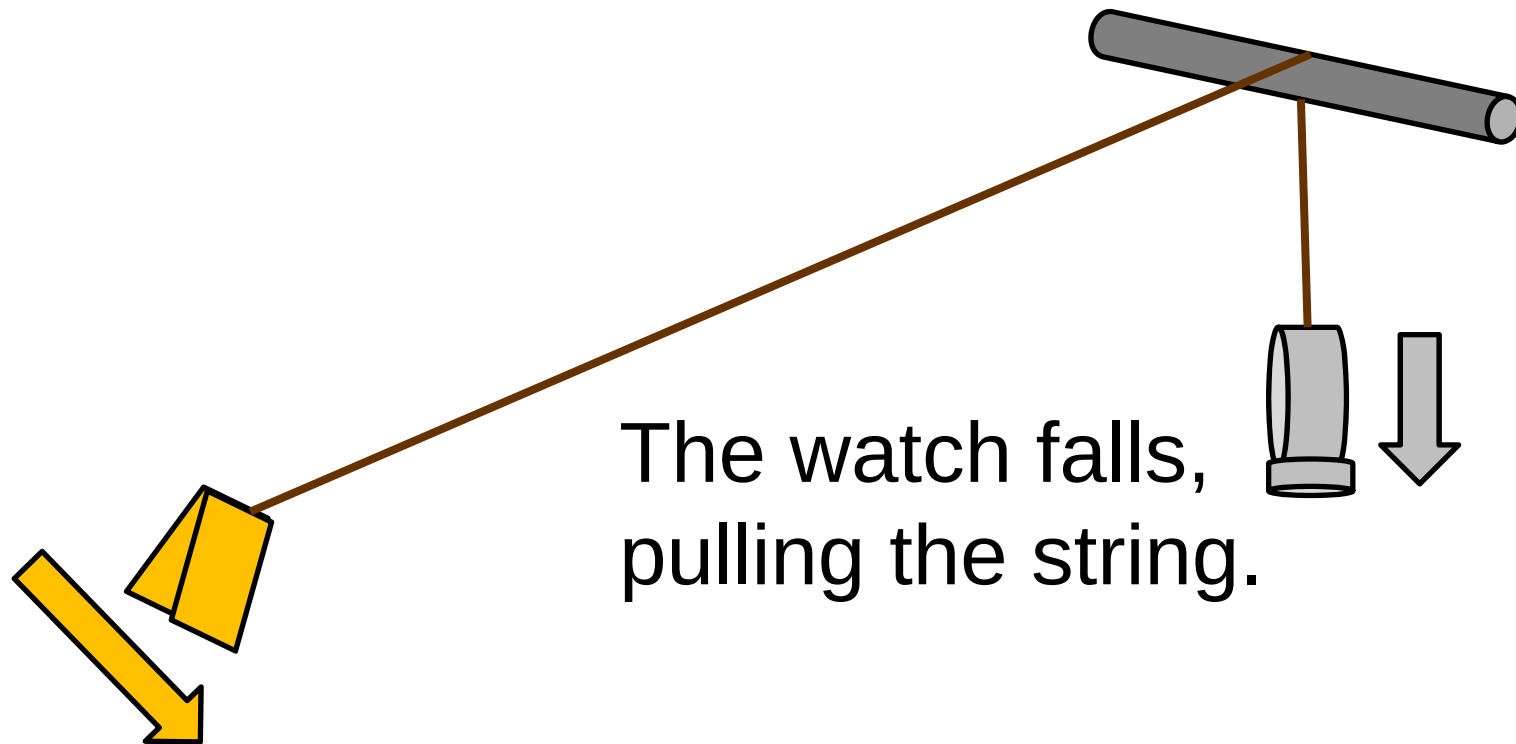
Rapid Wrap Demo

Filmed at 120 fps

Keep an eye on
the matchbook.



Rapid Wrap Demo



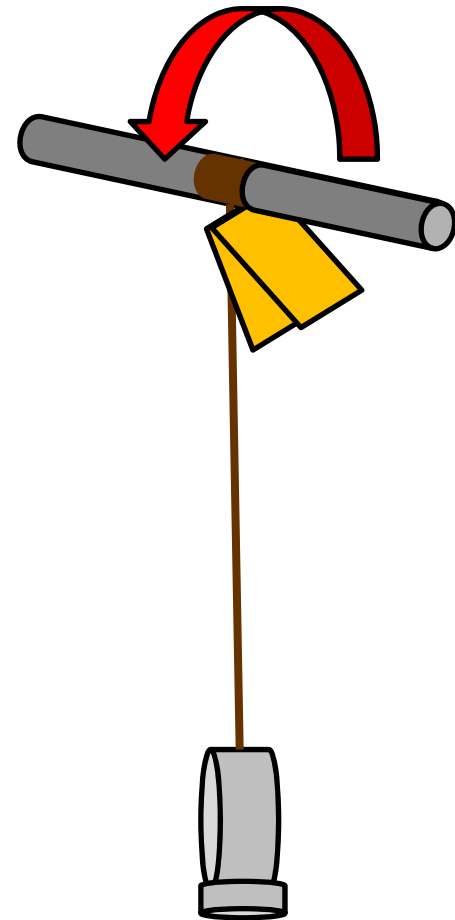
The watch falls,
pulling the string.

Matchbook falls and
rapidly accelerates as
the string shortens.

Rapid Wrap Demo

The matchbook goes so fast that it quickly wraps itself around the rod, stopping the falling watch.

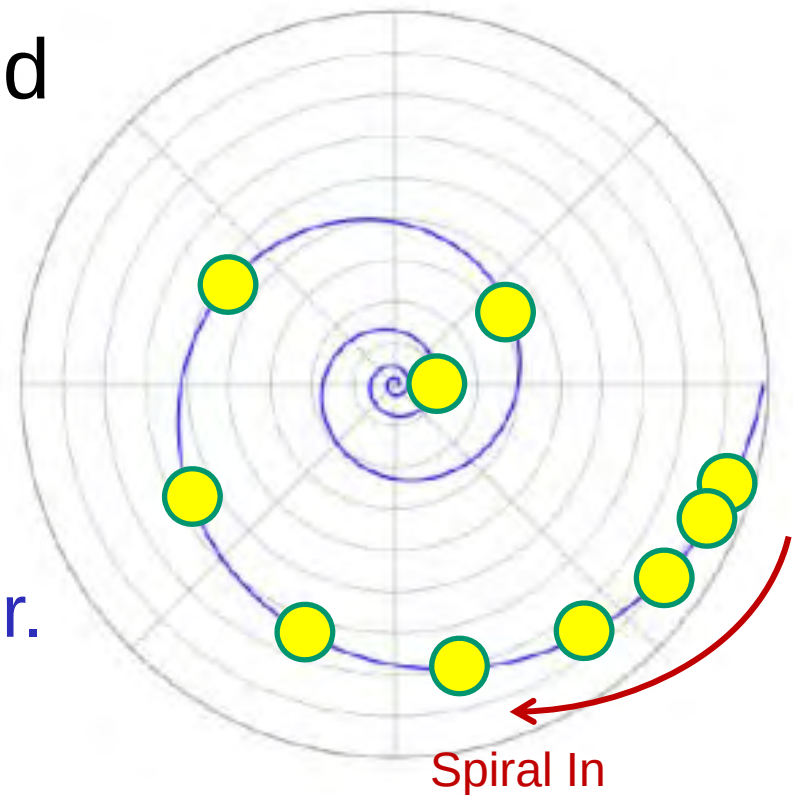
Path of action of the matchbook is a spiral.



Rotation & Spirals

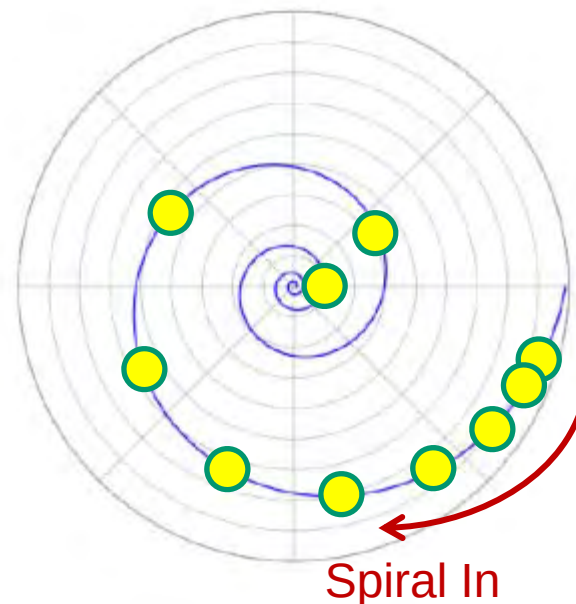
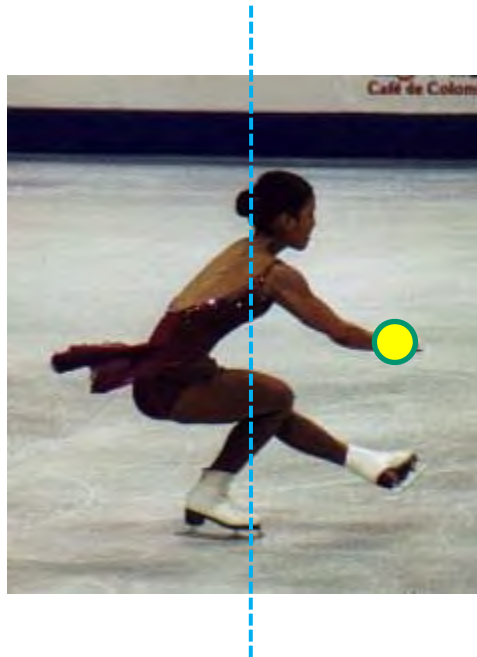
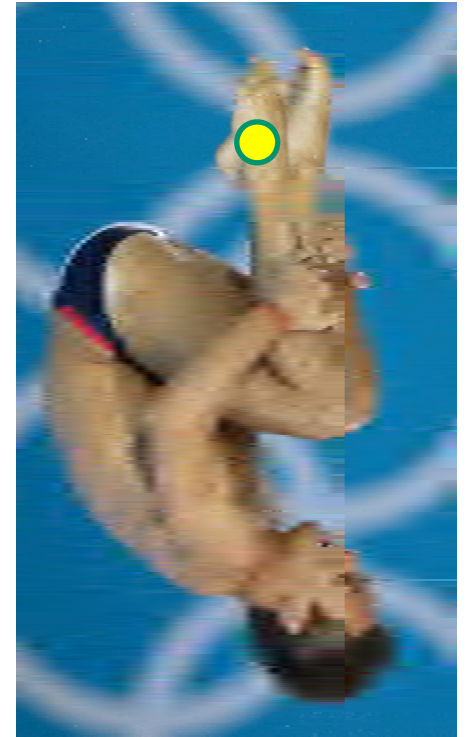
If the radius decreases by pulling an object inward then the revolutions per second increases and the speed increases.

Spacings *along* the curve get bigger and bigger.

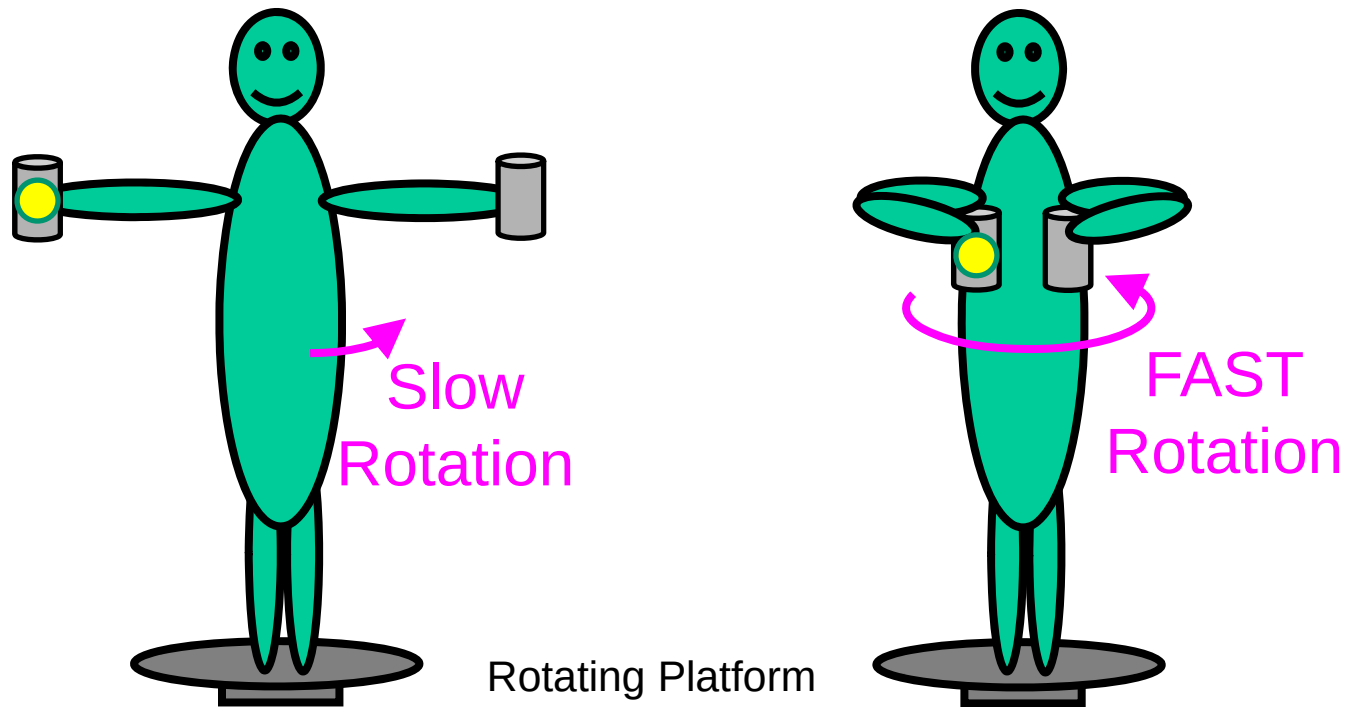


Rotation & Spirals

A similar example is the path of action for the hand of a spinning skater or the foot of a diver going into a tuck.



Skater's Spin

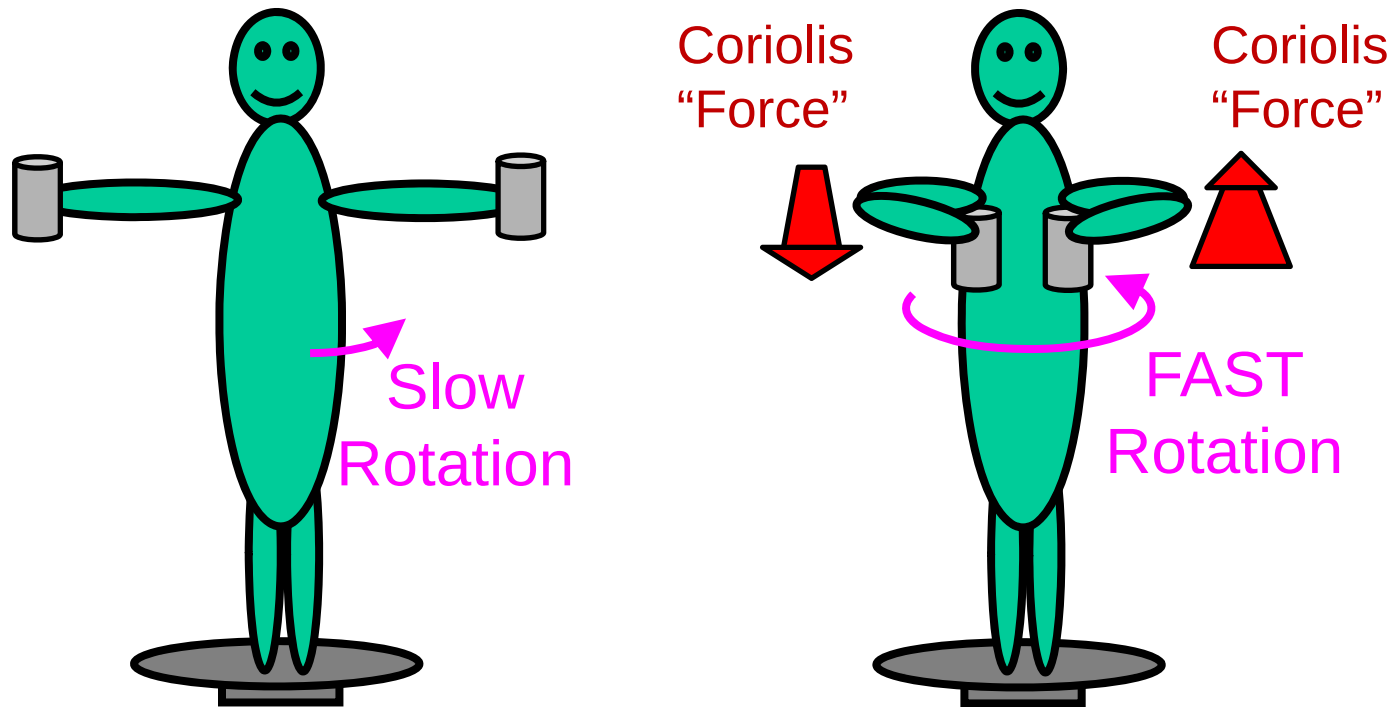


Stand on a rotating platform with hand weights.
Pulling the weights inward makes me spin faster.

Skater's Spin



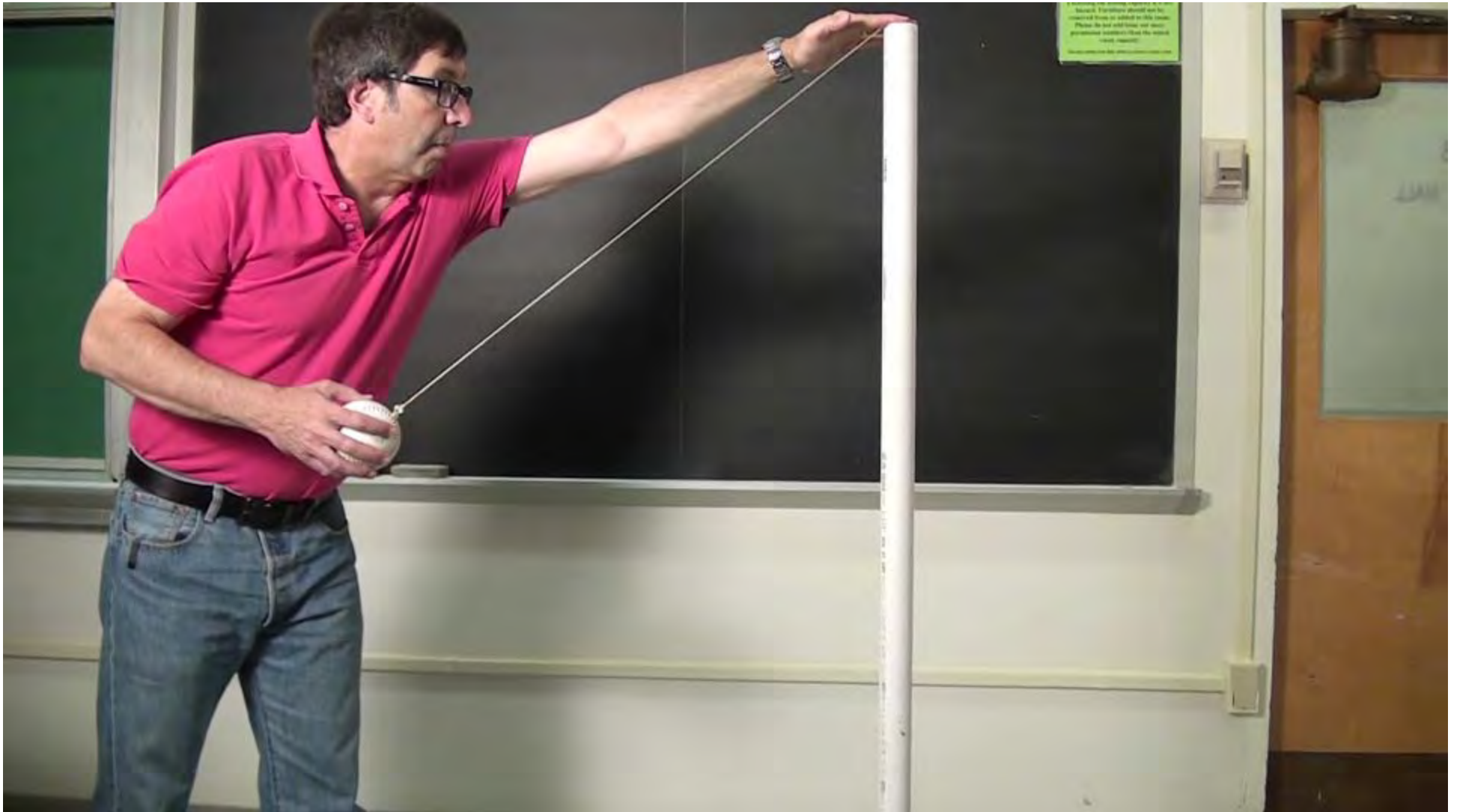
Coriolis “Force”



The increased speed feels as if it comes from an apparent force, called the Coriolis force, while spinning.

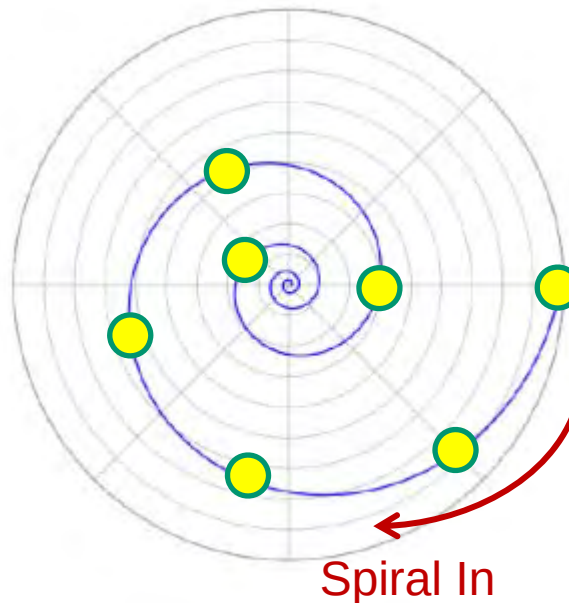
Tetherball Spiral

The ball spirals inward with a constant speed.



Rotation in Spirals

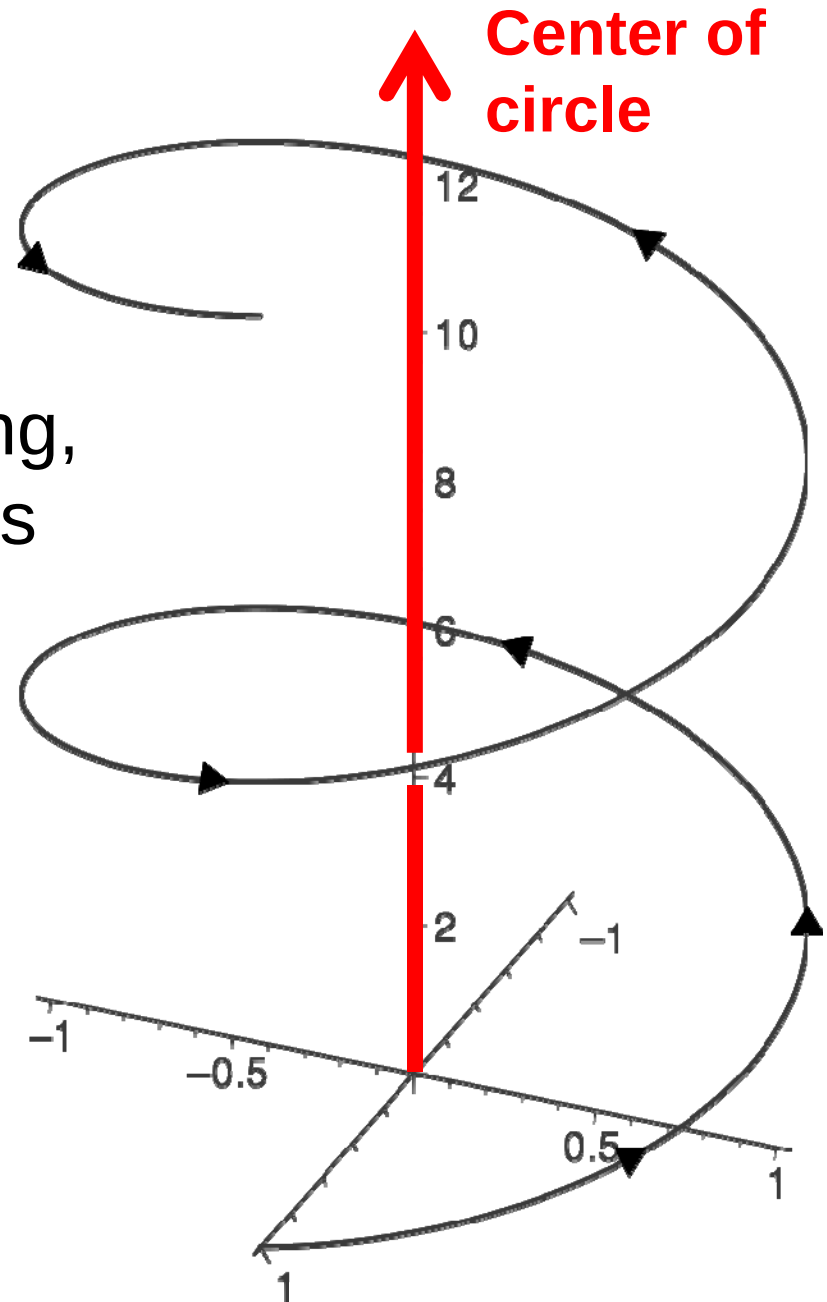
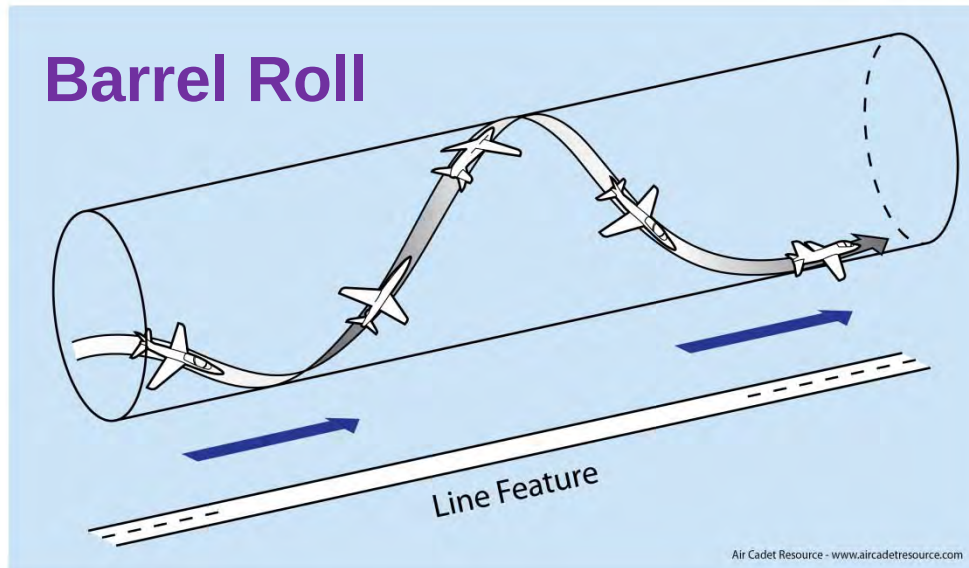
If the radius decreases *without* pulling the object inward then the revolutions per minute still increases (due to shrinking radius) yet the speed (and spacings) stays constant.



R.P.M.s go up
yet
spacings *along*
the curve stay
constant.

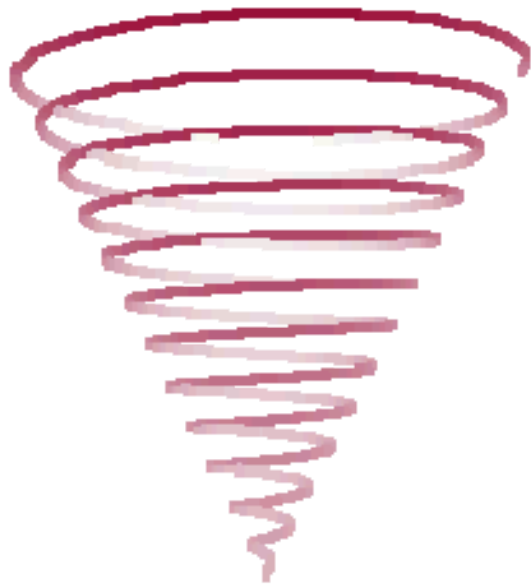
Helixies

A *helix* is like a spiral but instead of the radius changing, the center of the circle moves perpendicular to the circle.

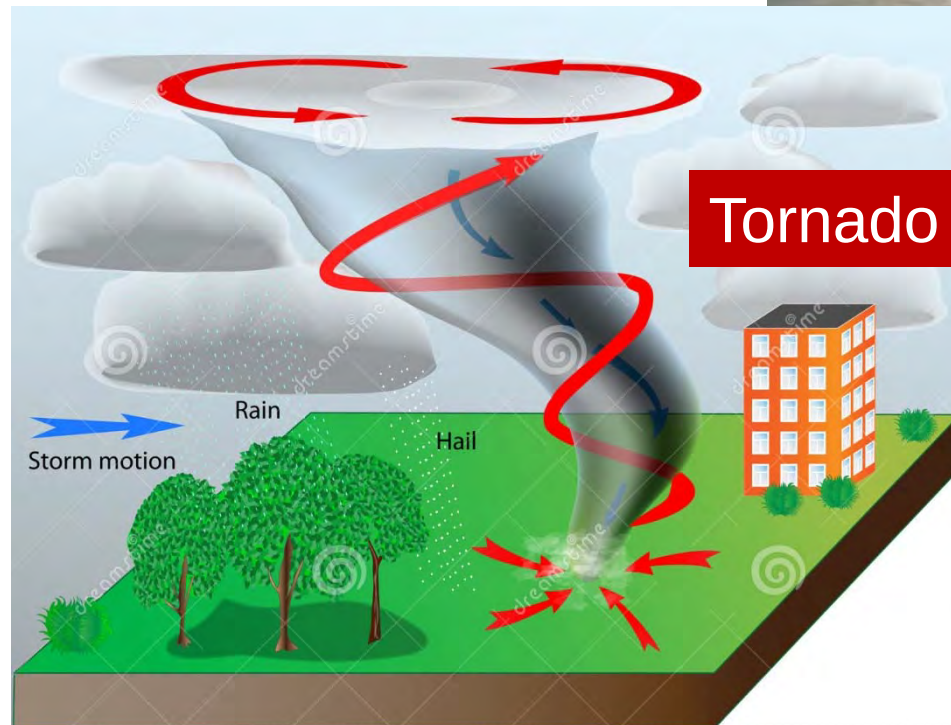


Vortex

Spinning fluids form *vortices*.
The path of action for the
fluid is often a spiral helix.



Spiral Helix



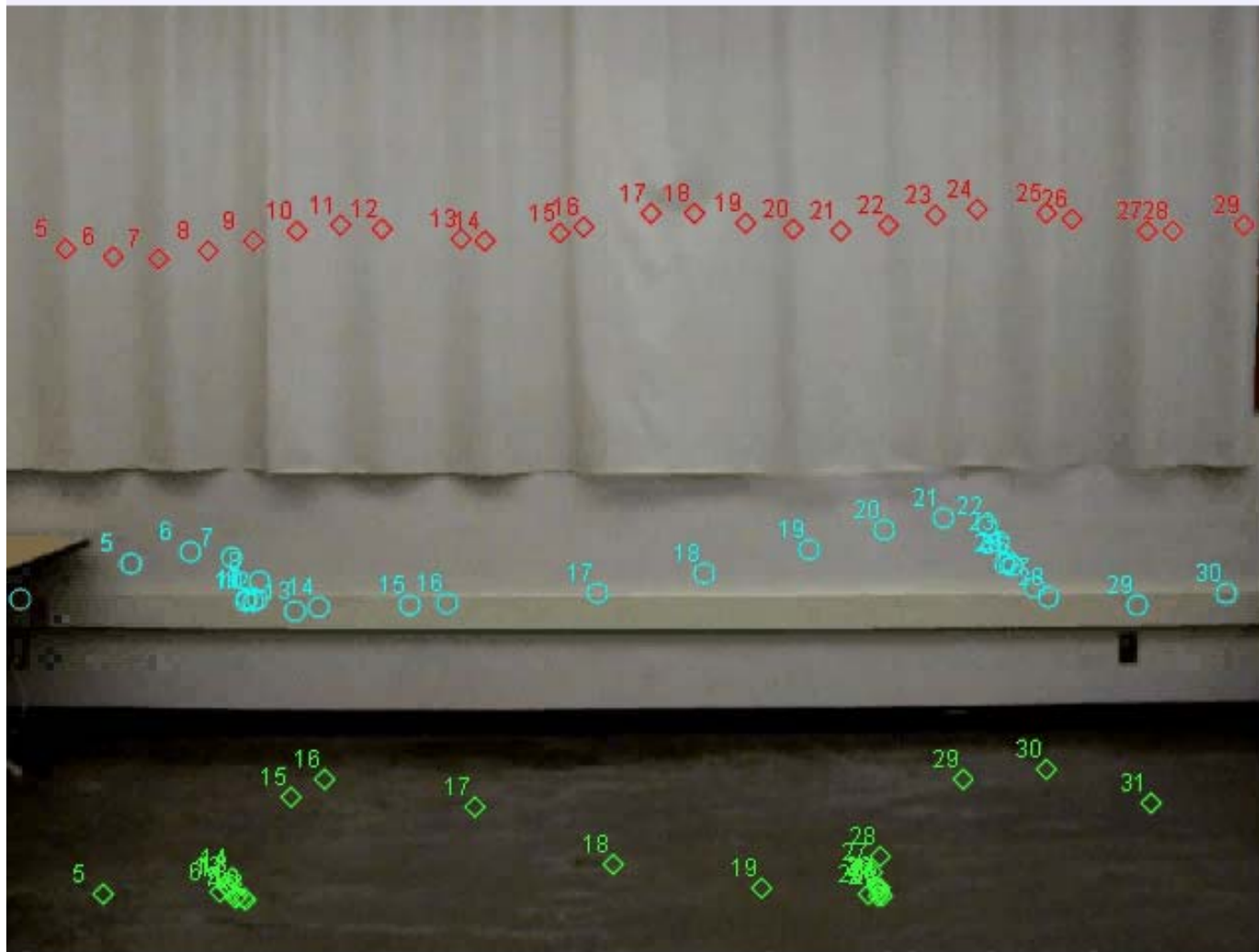
Cycloid

A *cycloid* is the path of action for a point on the rim of a rolling wheel.



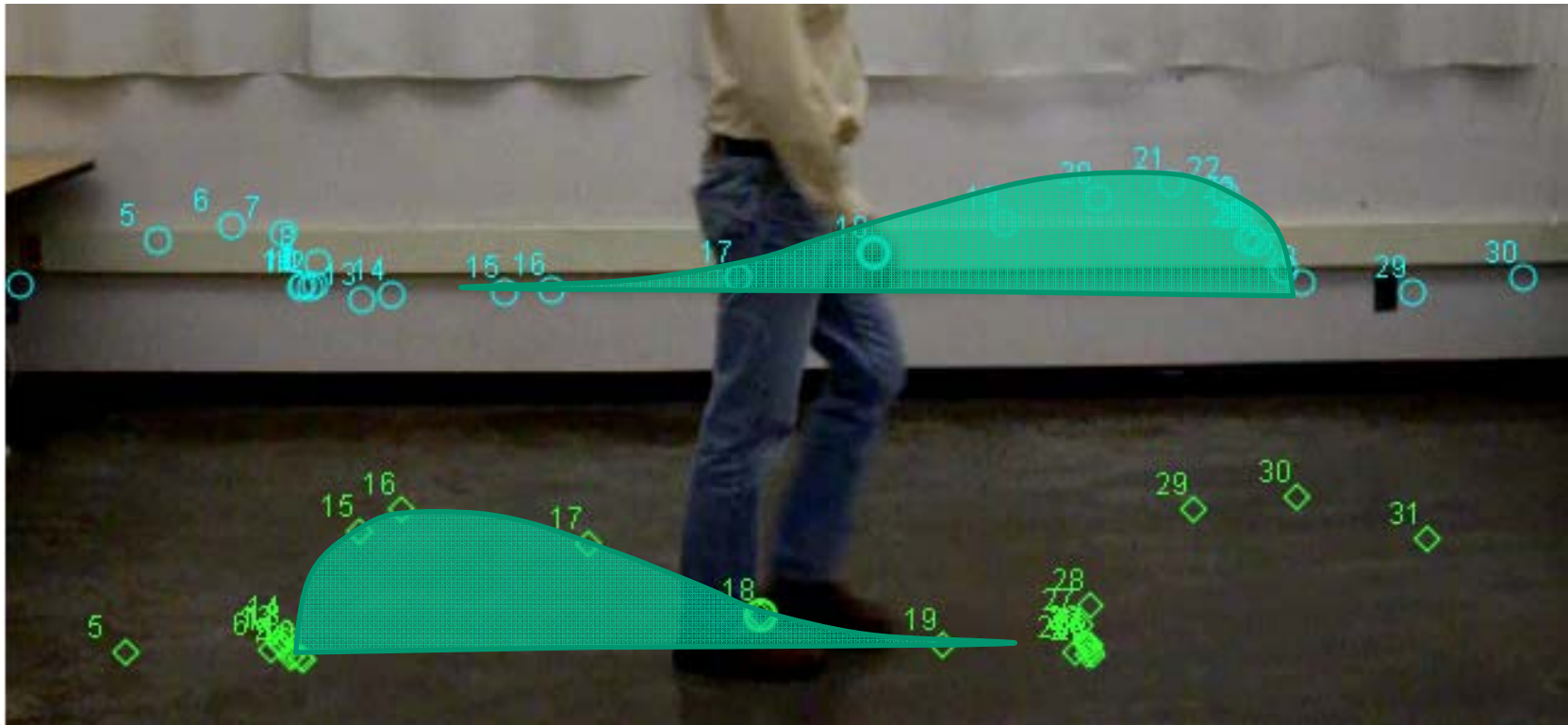
A cycloid resembles a half-circle or a half-ellipse but, mathematically, it's a different shape.

Video Analysis of Arm & Leg



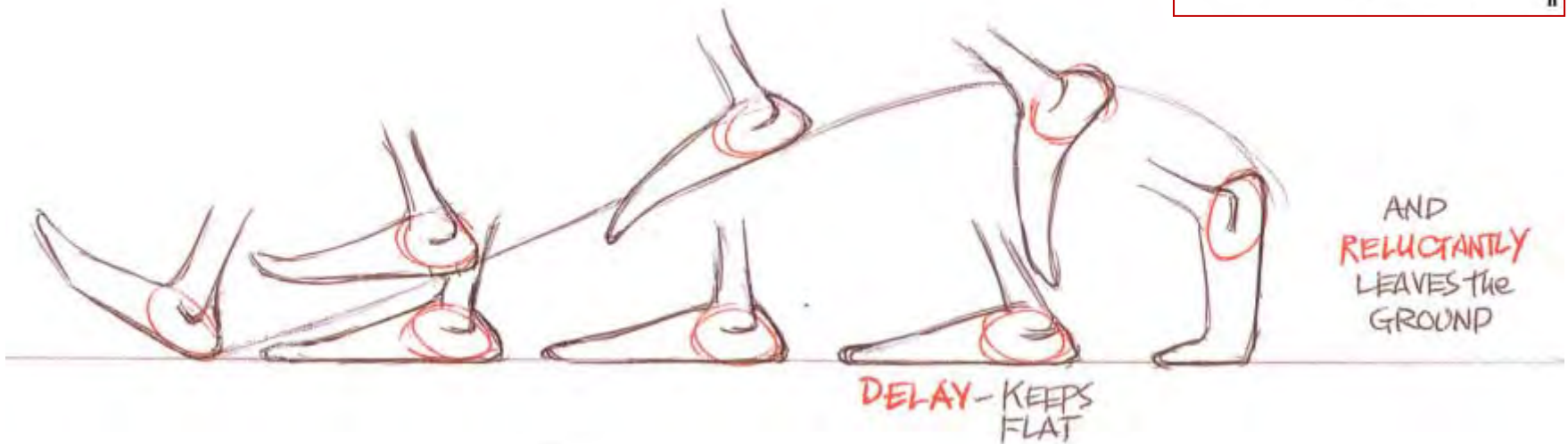
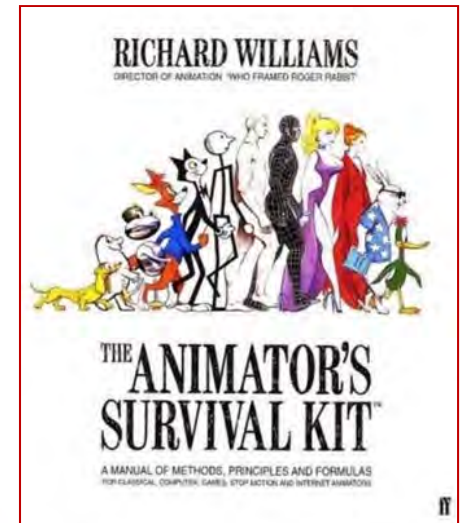
Foot (Left) selected (set mass on toolbar, shift-click to mark positions)

Hand and Ankle



Hand and ankle on opposite sides follow path of action similar to a distorted cycloid.

Animator's Survival Kit



In *The Animator's Survival Kit*, Richard Williams points out this path of action for the motion of the ankle.

Summary

- A spiral is a circular arc with a radius that's either increasing or decreasing.
- If an object is pulled inward then the spinning motion accelerates by the Coriolis force.
- A helix is circular motion with the center of the circle moving perpendicular to the circle.
- A cycloid is the path of action for a point on the rim of a rolling wheel.
- For motion with a cycle, as in a walk, some paths of action are variations of circular arcs.