Dynamics and Statics

Euler's Disc

(Ireland)

Background

Euler's disc was invented by Joe Bendik in the late 1980's. He named it in honour of the 18th century Swiss mathematician Leonhard Euler. Euler was very interested in the math and physics of "spolling" (spin & roll) of rigid bodies.

Many of us have spun a coin on a smooth surface but a heavy Euler's disc takes this activity to another dimension.

Many papers have been published by mathematicians and physicists on the complex motion.

Teachers and students can make their own version.

You will need….

- ✓ The platter disks from old computer hard drives (as many as possible)
- ✓ Clamp and glue
- ✓ A flat surface- ideally a glass concave mirror such as a magnifying cosmetic mirror
- ✓ A stop watch such as on a smart-phone
- ✓ A green laser **CAUTION** Use laser safety glasses Do not stare into the beam.

Follow these steps:

1. Glue the hard drive together using the glue and clamp
2. Spin your disk on the mirror
3. Time how long it takes to stop
4. Repeat observing your mark on the disk this indicates the disks rotation
5. Repeat shining the green on the upper surface spolling

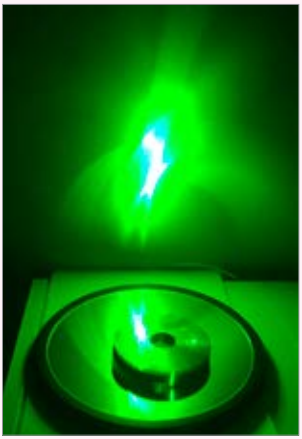
disk. The image produced can viewed on a nearby wall or ceiling

So what happened?

It is very obvious that the disk spins for a very long time before it comes to a stop. A very distinctive sound is also heard.

At the beginning the disk has both potential and kinetic energy. The potential energy results from the initial tilt and the kinetic energy from the rotation and precession or wobble. The energy is dissipated by the vibration, sound, and friction with the surface and the air. This highlights the importance of using both a smooth disk and surface.

While the rotation speed remains approximately constant,



the velocity of the precession increases continually. This can be observed by the increasing frequency heard and the decreasing radius of the circular laser projection.

The motion can also be described in terms of angular momentum. Just like a spinning top, the Euler's disk uses its angular momentum to remain upright. As the disk spolls there is a balance between the gravitational force (weight) and the reaction of the surface.

What next?

- Students could record the distinctive sound of the disk and analyse it's frequency with FFT (Fast Fourier Transform) software such as http://audacity.sourceforge.net and others.
- A graph of the change of frequency with time could be plotted.
- Observe the spolling of the disk on different surfaces: glass, wood, wet, dry etc. investigating the resulting times.
- Pose the question "what would happen if the experiment was performed in a vacuum?"
- If the disk is viewed edged on, it forms "a figure-of-eight pattern "this can be described by a function of differential geometry called "Viviani's curve". Students could video and analyse this with software such as https://physlets.org/tracker/ or others.