

Johanna Klasson

Hungary

Mentors: Dr. Mihály Hömöstrej, Blanka Bartók



The phenomenon:

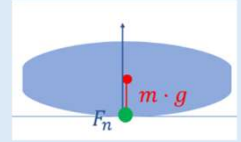
The Flipo Flip is a toy that can roll for multiple turns even though its shape is not circular.

Research questions:

1. Why can the Flipo Flip **roll** for **multiple turns**?
2. How can the motion of the Flipo Flip be **modelled**?
3. What **role** does **friction** and **geometry** play in its motion?
4. What are the **necessary initial release conditions** for it to be able to **roll over**?

1. Why can it roll for multiple turns?

- When impact with ground:
 - Forces act through axis of rotation — no torque
 - Angular momentum is conserved
- Can flip around



2. Motion – Model

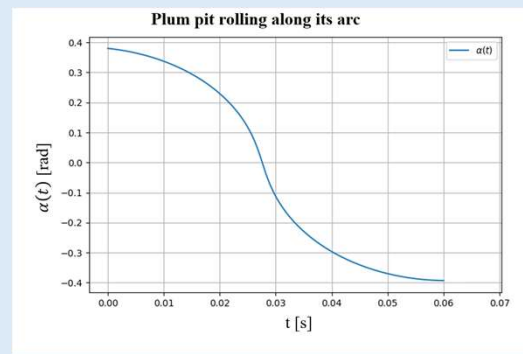
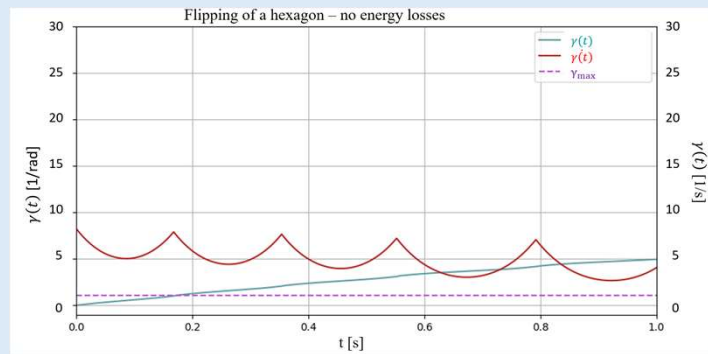
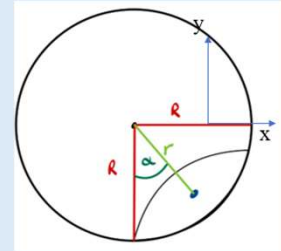
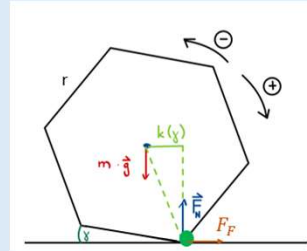
1. Phase – Tipping from one edge to the other – hexagon

$$\text{Equation for this phase: } \frac{-m \cdot g \cdot \sin\left(\frac{\pi}{6} - \gamma\right) \cdot r}{\theta} = \ddot{\gamma}$$

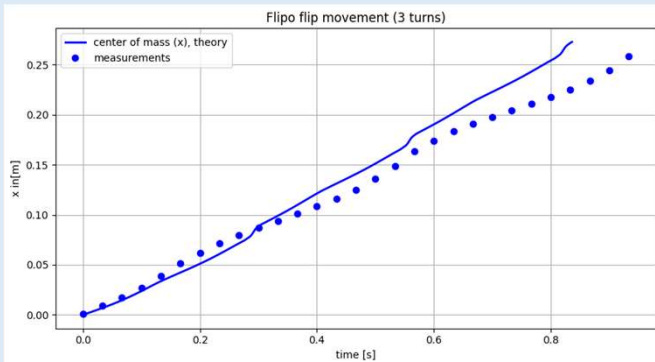
2. Phase – Rolling along its arc – plum pit

Equation for this phase:

$$\frac{-R \cdot \sin(\alpha) \cdot \dot{\alpha}^2 - g \cdot r \cdot \sin(\alpha) + \beta(R^2 - 2Rr \cdot \cos(\alpha) + r^2) \cdot \ddot{\alpha} + \lambda \sqrt{R^2 - 2Rr \cdot \cos(\alpha) + r^2}}{R^2 + r^2 - 2 \cdot R \cdot r \cdot \cos(\alpha)} = \ddot{\alpha}$$



Comparison of theory and experiments – losses included

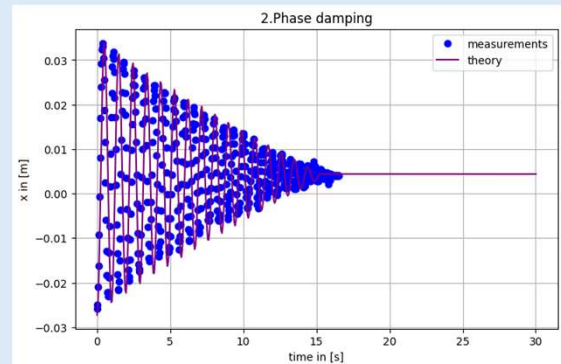


3. Role of Friction and Geometry

- Geometrical parameters:
 - Flipo Flips with different **radius of curvature**
 - Flipo Flips with different **height**
 - Flipo Flips with different **straight-side length**
- Equation for losses when it rolls along its arc – friction and air drag

$$Q_i = -\frac{\partial D}{\partial \dot{\alpha}} = \beta(R^2 - 2Rr \cdot \cos(\alpha) + r^2) \cdot \dot{\alpha} + \lambda \sqrt{R^2 - 2Rr \cdot \cos(\alpha) + r^2}$$

Comparison of **theoretical data** and **measured data**:



4. Necessary initial release conditions

Minimum static friction $\mu=0,28$

Flipo Flips rolled down on tilted surfaces of different materials:

Surface	Wood	Wooden board	Rubber
Angle	15.35°	24.55°	41.5°
μ	0.2745	0.465	0.88

Experiments - Setup

1. Tilted rubber surface – when losses neglected
2. Horizontal rubber surface & launching mechanism – losses included
3. Wooden or rubber surface

Conclusion

1. The rolling for multiple turns is possible because the **angular momentum** is conserved when it lies on its arc.
2. The modelling of the Flipo Flips motion is possible if we **split its motion up** and simulate each motion phase with simple figures
 - Flipping from one edge to the other – **hexagon**
 - Rolling along its arc – **plum pit**
3. Without **friction** the motion is not **possible**, **geometry** plays an **important** part in the motion.
4. For it to flip over it needs to have a **minimal static friction** and a **tilted surface or a force**.