Flipo Flip: The Physics of a Toy

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1. INTRODUCTION

The Flipo Flip is a toy that can roll for multiple turns, even though its shape is not circular. In my project I investigated why the phenomenon is possible, and how the physics behind it looks like.

2. AIMS

The aims of my research were to uncover why the motion is possible, how the motion can be modelled and what role friction plays throughout the motion.

3. THEORY AND METHODS

To model the phenomenon, the motion was split up into individual motion phases: the first phase is when it flips from one edge to the other, the second phase is when it rolls along its arc. The first phase was approached with a hexagon, and the second one was approached with a plum pit.

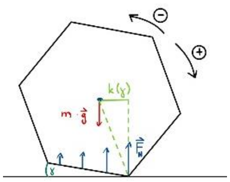

Figure 1: Hexagon

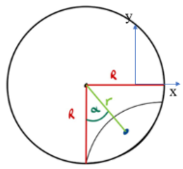

Figure 2: Plum pit rotating around imaginary circle

The equation for the first motion phase was approached with this equation (no energy losses):

$$\frac{-m\cdot g\cdot sin\left(\frac{\pi}{6}-\gamma\right)\cdot r}{\theta}=\ddot{\gamma}$$

The second motion phase was described with this equation (no energy losses):

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

The following term describes the losses when it rolls on its arc:

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

For the experimental part 3D-printed hexagons and plum pits were rolled down a tilted rubber surface. The surface was tilted, since in the theory I to begin with neglected the energy losses. When the 3D-printed objects roll down the surface the losses get compensated because of the height difference. Therefore, we can compare the theory with the experiments. To test the role of friction different „Flipo Flips" were 3D-printed with different radius of curvature, height and side length.

4. RESULTS

Then the equations were simulated in Python.

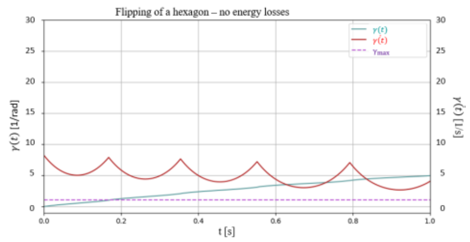

Figure 3: Flipping of a hexagon – no energy losses

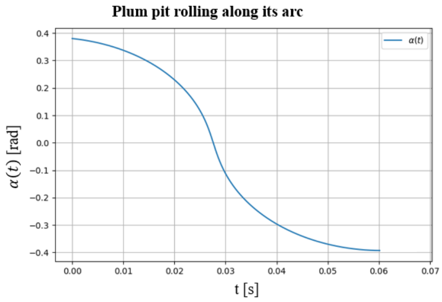

Figure 4: Plum pit rolling along its arc

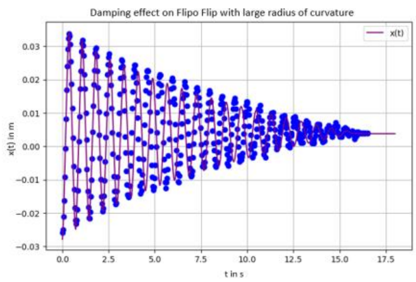

Figure 5: Damping effect on Flipo Flip with large radius of curvature

	T_simulated [s]	T_measured (n=10 average) [s]
Hexagon	0.162	0.161
Plum pit		
Flipping over	0.060	0.050
Side	0.028	0.033

5. DISCUSSION AND CONCLUSION

When we compare the experimental and theoretical approach, we can see that there is no huge difference. Therefore, we can conclude that the hexagon and plum pit is a good approach for each individual motion phase.

6. ACKNOWLEDGEMENT

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