P5 6 The Gnarliest Paper Ever Written

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Abstract

This paper looks to examine the mechanics behind how many stairs a skateboarder can ollie on a skateboard, this is done by looking at the theoretical maximum velocities that a skateboarder could achieve before structural failure of their wheels, as well as the maximum ollie height, and then utilising projectile mechanics to determine a maximum number of stairs that can be cleared. It was found that theoretically with perfect conditions a skateboarder could clear 79533 steps, with a more realistic estimate for the upper limit being 1132 stairs.

Introduction

The invention of the flat-ground ollie is credited to Rodney Mullen in 1981 and involves a skateboarder slamming their tail against the ground then using their front foot to level out the skateboard thus creating height for themselves and the skateboard. 34 years later in 2015, Aaron "Jaws" Homoki landed an ollie down the largest stair set ever, the Lyon 25 stair [1]. How far someone is able to ollie is dependant on two factors: how fast they are going and how high they are able to pop.

Method - Maximum Velocity

The velocity of a rolling object without slipping is given by

$$v_{cm} = R\omega \qquad (1)$$

where R is the radius of the rolling object and ω is the angular velocity. Thus, if we can figure out the maximum angular velocity that a skateboard wheel can achieve before structural failure we will have an upper limit for the maximum velocity that a skateboarder can reach on a skateboard. As the wheel spins, centrifugal forces act on the wheel attempting to rip the wheel apart, this is known as "hoop stress". We can model a standard polyurethane skateboard wheel as an annular rotating disk of constant thickness, and thus the maximum stress it experiences is given by the equation [2]

$$\sigma_{r,max} = \frac{3+v}{8}(b-a)^2 \rho \omega^2 \qquad (2)$$

where v is Poisson's ratio for the material, ρ is the density of the material and b and a are the inner and outer radii respectively. By using known values for a polyurethane skateboard wheel in equation 2, and matching the maximum stress to the tensile strength of polyurethane we can calculate the maximum possible angular velocity and thus an upper limit for the maximum possible velocity that a skateboard can travel.

Method - Maximum Height

The maximum height that a person can ollie is limited by how high a person can jump vertically. By equating kinetic energy at take off to gravitational potential energy at the jumps peak

we can find that

$$h = \frac{v^2}{2g} \quad (3)$$

therefore, the height of any jump is dependant solely on the take off velocity. We can calculate the take off velocity by assuming that all work done by the jumper's legs is transferred into kinetic energy.

$$Fd = \frac{1}{2}mv^2 \quad (4)$$

As we are trying to figure out the maximum possible height we therefore require the maximum possible take off velocity, so to achieve this we can use information from the biggest mass ever successfully squatted and the measurements from the tallest person on Earth for our theoretical work done value.

Finally, once we have calculated our maximum height and velocity values we can use constant acceleration equations to figure out what is the maximum horizontal distance a skateboarder can achieve when jumping down a stair set and thus how many stairs the skater can ollie.

Results for speed and takeoff velocity

Utilising Eq (2), we can use known values for polyurethane such as $v = 0.5$ [3] and $\rho = 1000 kgm^{-3}$ [4]. From measurements of my own skateboard wheels, we can approximate a and b to be 0.01m and 0.029m respectively. Finally, by equating the maximum stress $\sigma_{r,max}$ to the tensile strength of polyurethane which is 25 MPa [5] we find that $\omega_{max} = 12581 \text{rads}^{-1}$. We can then use our measured b value from earlier in place of R in Eq (1) to give us the velocity of our rolling wheel which we find to be $v_{cm} = 365 \text{ms}^{-1}$ Next we need to figure out the pop height.

Using the longest possible leg length as 130×10^{-2} m [6] and the greatest mass squatted as 525 kg [7], we find that the work done is equal to 682.5 J. Therefore, by assuming an average mass of a human to be 70 kg, the theoretical maximum possible takeoff velocity is 4.4 ms^{-1}.

Results for the number of stairs

By taking $x = 0, y = 0$ at the launch point of the top stair, we find that the coordinates for the front edge of the n-th stair is at $x_n = n \times w, y_n = -n \times h$ where w and h are the width and height of the stairs respectively. We can now use equations of motion $x(t) = v_x t$ and $y(t) = ut - \frac{1}{2}gt^2$ at $x = n$ to find the final equation for the number of stairs it is possible to clear.

$$n_{max} = \frac{2(uwv_x + hv_x^2)}{gw^2} \quad (5)$$

Using a standard height and width of stairs to be 18×10^{-2} m and 25×10^{-2} m along with our previously calculated values we find that the maximum possible number of stairs that can be cleared by a human ollieing on a skateboard to be 79533 steps.

Conclusion

The calculated value of 79533 steps is a mass overshoot of what is realistically possible and would require a skateboarder not experiencing any air resistance, i.e. performing this stunt in a very large vacuum chamber. Additionally, we have not taken into account friction between the wheels and the ground, so we are assuming a perfectly smooth floor which is not possible to produce in real life. This leads to a maximum speed that far exceeds what is possible in real life which is where our largest source of error is coming from.

Additionally, our use of the largest recorded squat along with the longest recorded legs, would be a complete biological anomaly and does not match to a person of average mass 70 kg. However, as we are attempting to calculate a theoretical maximum, this is an appropriate method.

For a more realistic upper limit we can use the fastest recorded speed of a human on a skateboard of 40.75 ms^{-1} [8] and the highest ollie recorded of 114.3×10^{-2} m [9] along with Eq (5) to calculate a more realistic upper limit of 1132 stairs.

References

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