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A2 2 Lakitu's Load: The Feasibility of Cloud-Borne Kart Recovery

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Abstract

In this paper, we look to find if Lakitu could actually perform his recovery feats in the video game *Mario Kart Wii*. Specifically, whether the fishing line used would be able to support both Bowser and his kart. We determined that this feat would not be possible with the peak tensile force applied being $165 \pm 20\,kN$, which is greater than the peak stress force for a nylon line.

Introduction

The specific scenario we examined is in *Mario Kart Wii*, where a vehicle exits the track into water and they are then seen sinking before the screen turns black. When colour returns, Lakitu is seen hovering over the track with the players kart being held up by his fishing rod. From this we assumed that the peak tensile force occurs when the kart is pulled from the water, where a large amount of water resistance would be applied. Thus the total force is found by considering the combined weight of Bowser and his kart, along with the drag force applied due to water resistance and the buoyancy force. Assuming that *Mario Kart* has an earth like gravity, weight can be found by:

$$F_w = mg \tag{1}$$

where m is the combined mass of Bowser and the kart and g is the gravitational field strength (9.81 N/kg). The drag force is found via:

$$F_d = \frac{1}{2}\rho_{water} v^2 C_d A \tag{2}$$

where ρ_{water} is the density of water (997 kg/m^3), v is the velocity at which Bowser and his kart are pulled from the water, C_d is the coefficient of drag (assuming a rectangular shape with a value of 1.05) and A being the surface area. The Buoyancy force can be calculated using the equation below:

$$F_b = -\rho_{water} g V \tag{3}$$

where ρ_{water} and g are the same as before, while V is the volume of water displaced.

Water Resistance

Modelling the surface area as a rectangle enabled us to determine the force applied via water resistance. The dimensions were found by comparing the two images found in Figure 1, where Mario's known height of 155 cm can be used as a reference [1]. The width of the kart can be assumed to be Bowsers shoulder width due to his hunched nature in the kart. As such the area is found to be 5.82 ± 0.40 m^2, where the associated error came from imperfect measurements.

To find the velocity at which Bowser is pulled from the water, we first find the depth he reached and the time taken to pull him out. Assuming Bowser travels at terminal velocity while sinking:

$$v_t = \sqrt{\frac{2mg}{\rho_{water} A C_d}} \tag{4}$$

Figure 1: The left image shows a scale image of Bowser next to the known height of Mario [2]. The right image shows a scale image of Bowser in his kart.[3] These images were used in tandem to measure the dimensions of Bowser and his kart.

where all values have their previous meanings, we can use the measured time he was submerged for (1.20 ± 0.06 s from a stopwatch), to find the distance travelled to be 6.73 ± 0.41 m. The black screen lasts for approximately 1.99 ± 0.06 s, assuming that Lakitu spends half his time removing Bowser from the water and he pulls at a constant velocity. We can use equation 2 to find that the drag force is 138 ± 19 kN.

Buoyancy Force and Weight

Modelling Bowser and the kart as a rectangular top hat, with no brim on the width, we find that they displace 6.95 ± 0.46 m^3 of water (using the same method discussed previously for the dimensions). Using this value in equation 3, -67.9 ± 4.5 kN of force was found to be exerted on Bowser's kart.

Bowser's mass is 9611 kg [4], while the mass of a standard large kart can be found via the standard medium kart. The standard medium kart is based off a normal Go Kart, which has a mass of 79.0 kg [5]. Using the in game weight stats of 45 and 59 for a medium and large kart respectively, we found that the large kart has a mass of 104 kg and as such the combined weight is 95.3 kN.

Discussion

The overall tensile force applied to the fishing line is found by the sum of all the respective forces, thus 165 ± 20 kN. Assuming Lakitu uses a nylon fishing line, which has a tensile strength of 90×10^6 N/m^2 [6], the maximum tensile stress this fishing line could withstand is 70 N. This assumes one continuous inelastic piece of nylon, with a diameter of 1mm. For the fishing line to withstand the force calculated a diameter of 4.8 cm would be required, which is not in agreement with the width seen in the game.

Conclusion

From our comparison to nylon fishing line, we believe that Lakitu would not be able to pull Bowser and his kart from the water. Further investigation into other characters in the *Mario Kart* world would solidify if any of his feats are possible or if it is just this limit that is unobtainable.

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