Journal of Physics Special Topics
An undergraduate physics journal

P1 1 Tongue-tied

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November 7, 2023

Abstract

This paper examines the tension force of a frog's tongue when modelled as a pendulum. We have demonstrated that it would not be possible for a frog's tongue to support the weight of two rats and itself as shown in the film *Flushed Away*. We calculated the tension on the frog's tongue from its own weight and a single rat to be 16.2 N, with a second rat, this increased to 19.1 N. However, given the strength-related properties of a frog's tongue, the maximum tension it can withstand is 18.5 N. Therefore, with the combined mass of two rats, 0.300 kg each, and the frog, 1.35 kg, this tension exceeds the maximum limit suggesting that such a feat would not be possible if it occurred in real life.

Introduction

In the 2006 animated film *Flushed Away*, a tsunami threatens Rodney, the protagonist, and the underground world of sewer rats[1]. In an attempt to save fellow rat, Rita, he swings through the air by latching onto the tongue of the antagonist, Le Frog. While this rescue makes for an exciting watch, it begs the question: is such a feat realistic?

This paper explores the tensioning force experienced by a frog's tongue to establish whether it could support the weight of itself and both rats when modelled as a pendulum.

Method and Results

We assumed Le Frog could be modelled as an African Bullfrog, with an average mass of 1.35 kg[2]. This species most accurately represents the relative size of Le Frog compared to the two rats, each with a mass of 0.300 kg[3].

In the film, Rodney and Le Frog swing half an oscillation, before collecting Rita at the bottom.

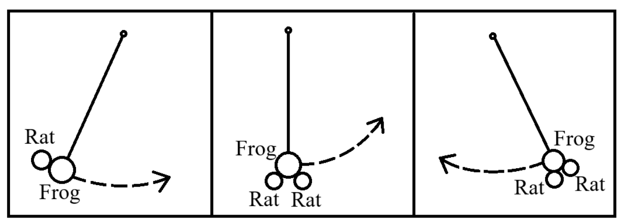

Figure 1: This figure follows the motion of the pendulum; visualising the first swing, the catch and the return swing.

They complete the remainder of the first oscillation, before returning to the origin as shown in Figure 1.

Figure 2 shows the simulation we developed from first principles for a pendulum model forming the basis of our analysis. The curves indicate the two key stages of the character's motion.

The first curve indicates Rodney and Le Frog's descent to collect Rita. With the combined mass of Rodney and Le Frog, 1.35 kg and 0.300 kg respectively, Le Frog experiences a tension of 16.2

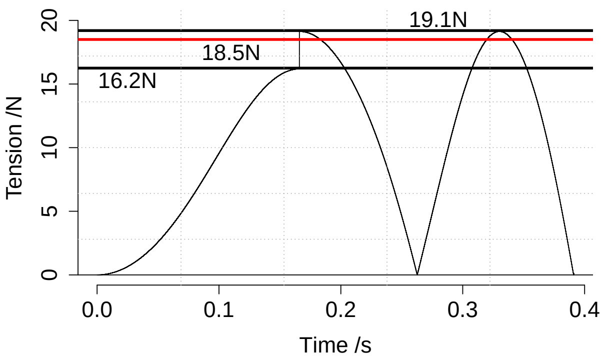

Figure 2: Tension model of Le Frog's tongue throughout the swing.

N during this stage. As Rita is caught, an additional 0.300 kg is added to the system. The tensioning force spikes and the value jumps to 19.1 N.

A frog's tongue is able to support 1.4 times its own weight [4,5]. As such, we determined the maximum tension Le Frog's tongue could withstand before snapping. By multiplying the mass of an African Bullfrog by 1.4, we determined a tensioning force of 18.5 N. The red line on our model indicates the maximum tension Le Frog's tongue can support. Figure 2 demonstrates that with the additional mass of Rita, Le Frog's tongue cannot support the three-body system.

The second peak demonstrates the hypothetical return the characters would follow to the origin. We see that this stage of the rescue gives a tensioning force of 19.1 N. This is the force imposed by Rita, Rodney, and Le Frog, on Le Frog's tongue. This value surpasses the limit the tongue can withstand, hence deeming the rescue implausible.

To corroborate our simulated results in Figure 2, we used Newton's Second Law.

$$F = ma, \tag{1}$$

where F is the net force in N, m is the mass of the system in kg, and a is the acceleration due to gravity, 9.81 m/s^2.

Whilst supporting one rat, the tension on Le Frog's tongue, F_1, is 16.2 N. With two rats, this tension is 19.1 N, F_2. These are results from our simulation, confirmed through Equation 1.

Conclusion

Our analysis demonstrates that the tensile strength of Le Frog's tongue would support the mass of both itself and Rodney, but not the additional mass of Rita. Since the tension of 19.1 N experienced by the tongue is close to the limit of 18.5 N, it should be noted that this conclusion may change by assuming a larger species of frog or a smaller species of rat. This cinematic moment is captivating for viewers, although given our assumptions it would not be possible in the real world.

References

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