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# Physics underlying a childhood show: Mechanics Behind 64 Zoo Lane

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**Abstract**
In every episode of the classic childhood show “64 Zoo Lane" the main character Lucy slides down Georgina the Giraffe's neck from her bedroom window to the zoo next door, the 7-year-old does this every night for story time with her neighbouring animals. This paper will investigate the physics behind this motion, calculating the friction generated along Georgina’s neck, the acceleration in which this occurs, the derived velocity that Lucy travels at and the energy required.

**Keywords:** *TV Programme; Physics; Mechanics; 64 Zoo Lane; Giraffes*

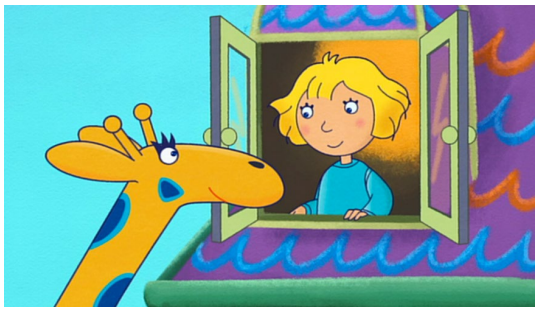

Figure 1 – Georgina the Giraffe and Lucy in 64 Zoo Lane [1].

**Assumptions made for Georgina the Giraffe**

As an adult female reticulated giraffe (*Giraffa reticulata*) [2, 3], Georgina’s height is approximately 4.57 m, with her neck being 2.44 m [4], alongside the length of the giraffe from front to tail being 4.10 m [5]. A key feature of Georgina (Figure 1) is her rough skin which will generate friction upon contact with Lucy, therefore in related friction equations the leather coefficient has been used to replicate the similarity in texture [6]. Firstly, to calculate the different forces at play, the OneNote software was used to measure the angle present in the inclined plane (Figure 2) to be 49°.

**Normal force and Friction generated**

Normal force ($F_N$) is the force exerted on Lucy by the giraffe's neck as she travels down, perpendicular to the surface of Lucy’s travels (Figure 2). Lucy’s mass has been assumed at 22.4k g, as an average weight for a 7 year old girl [7]. $F_N$ is calculated to be 144.17 N (eq$^n$ 1) derived from the mass of Lucy, gravitational potential field strength and the angle of the inclined plane.

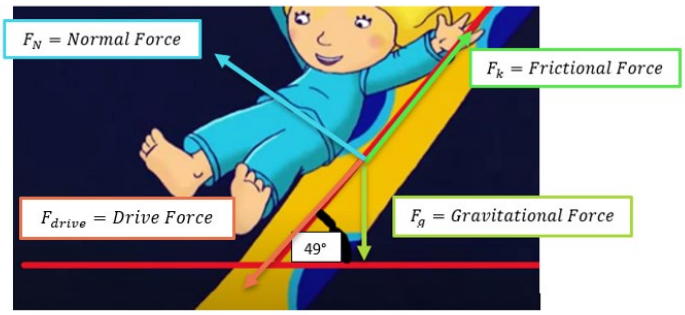


Figure 2 – Force diagram of Lucy on the giraffe neck [8].

$$F_N = mg\cos(49^o)$$

$$F = 22.4 \times 9.81 \times \cos(49°) = 144.17\ N\ (eq^n\ 1)$$

$$F_k = \mu_f F_N$$

$$F_k = 0.60 \times 144.17 = 86.502\ N \quad (eq^n\ 2)$$

Another force present is friction ($F_k$) which is generated when Lucy comes into contact with the giraffe's skin, with 86.502 N of the total normal force being frictional (eq$^n$ 2), thus opposing the motion being undertaken [9]. The frictional force is less than the normal force due to the leather material friction

coefficient ($\mu_f = 0.60$), to factor in the material on which the motion occurs. However, reticulated giraffes also have fur along their skin, which could potentially increase the level of friction generated.

**Acceleration and velocity determined for Lucy**

Using the driving force ($F_{drive}$) and subtracting the frictional force opposing (accounting for mass cancelling throughout (eqn 3)), we can determine Lucy's average acceleration to be 3.54 $ms^{-2}$ (eqn 4). Due to the resultant acceleration generated from the gravitational force and the energy change from the top to bottom of the giraffe's neck, she is unable to maintain a constant velocity.

$$F_{drive} = mg\sin(\theta)$$
$$F_{drive} = 22.4 \times 9.81 \times \sin(49°) = 165.84\ N$$
$$F_{net} = F_{drive} - F_k$$
$$F_{net} = 165.84 - 86.502 = 79.34\ N$$
$$F_{net} = ma$$
$$a = \frac{F_{net}}{m}\ (eq^n\ 3)$$
$$a = \frac{79.43}{22.4} = 3.54\ ms^{-2} (eq^n\ 4)$$

The final velocity is reached at the bottom of the giraffe's neck i.e. at the end of Lucy's journey, with the show depicting Lucy (Figure 2) travelling down Georgina's neck in 5 seconds, displacing from the top to the bottom of the neck. Assuming the acceleration to be constant, we can use eqn 5 to determine the final velocity achieved at the bottom of the neck to be 17.71 $ms^{-1}$, with a start velocity of 0 $ms^{-1}$ as Lucy is stationary before she slides down Georgina's neck.

$$v = v_0 + at$$
$$v = 0 + (3.54\ \times 5) = 17.71\ ms^{-1}\ \ (eq^n\ 5)$$

**Kinetic energy and gravitational potential energy**

Kinetic energy (KE) is the energy Lucy possesses through the motion of travelling down the giraffe's neck whereas gravitational potential energy (GPE) is from the gravitational field imposed on Lucy [9]. From the velocity calculated, we can use eqn 6 to determine the kinetic energy at the bottom of the neck. From inputting the velocity and mass values we can determine that 3512.81 J of energy is used.

$$KE = \frac{1}{2}mv^2$$
$$K = \frac{1}{2} \times 22.4 \times 17.71^2 = 3512.81\ J\ (eq^n\ 6)$$

GPE at the top of the neck is calculated below (eqn 8) to be at 757.90 J using mass, gravitational field strength and the height of Lucy above the ground (Supplementary Figure 1). Deviation of the KE at the bottom of the neck is likely due to energy being added as Lucy pushes herself off Georgina, as well as the fictional-based cartoon utilising artistic license. Both KE and GPE will change along Lucy's journey down the giraffe's neck.

$$GPE = mgh \qquad (eq^n\ 7)$$
$$GPE = 22.4 \times 9.81 \times 3.45 = 757.90\ J\ \ (eq^n\ 8)$$

**Injuries and evolutionary features of protection**

Giraffe skin itself is extremely thick as an evolved feature for protection in the harsh environment (Figure 3) against predators [10]. In this case, the thickness can help protect against injury from Lucy's travels, the neck itself weighing around 226.80 kg [10]. Stresses applied on the giraffe's neck daily can potentially lead to issues of neck pain, deformities and long-term injuries, due to factors of both weight and friction generated.

Figure 3 – A reticulated giraffe in the species' natural habitat of the savannah [10].

**Conclusion**

Lucy reaches a 17.71 $ms^{-1}$ final velocity near the end of her journey down Georgina the Giraffe and utilises 3512.81 J of kinetic energy, ~78% greater than the initial GPE at the start of the journey. The paper further highlights the 86.502 N of frictional force generated through Lucy's travels down Georgina's neck. This level of friction generated is likely to cause serious harm to her "incredibly tall" friend [1] in the long term and Lucy should leave Georgina's neck alone for recovery. A safer but less fun option is to use the stairs.

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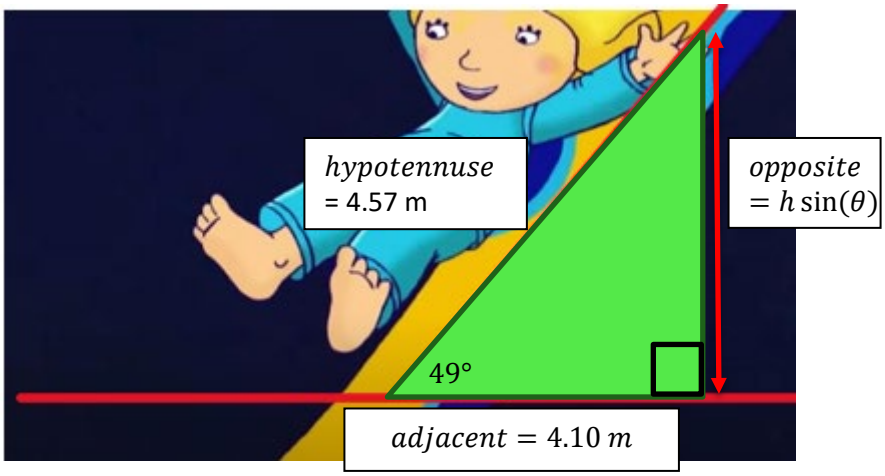
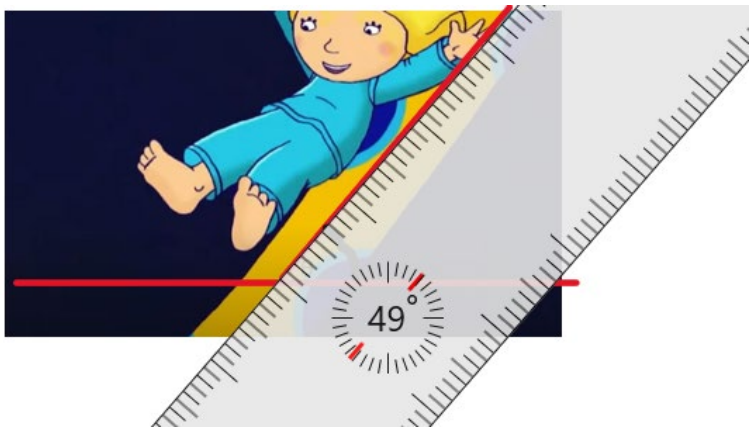
**Appendix A:**

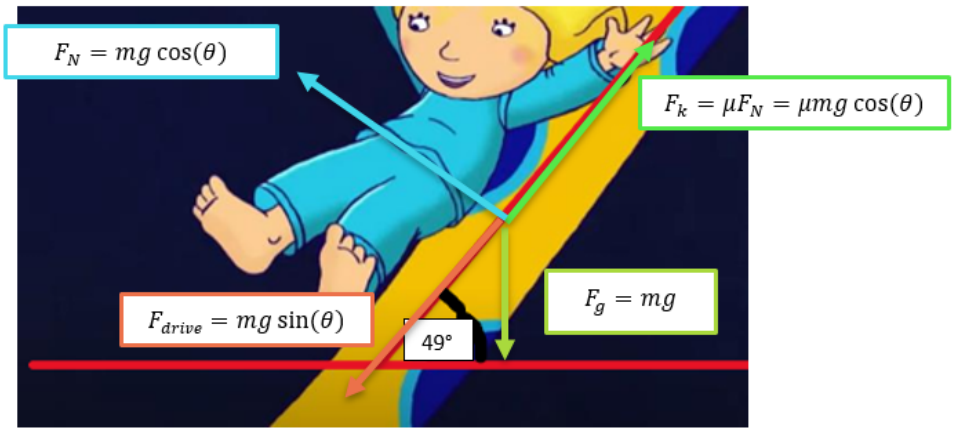



$$\sin(\theta) = \frac{o}{h} \qquad o = h\sin(\theta) \qquad height = 3.45\ m\ \ (eq^n\ 9)$$

Supplementary Figure 1 – Height calculated for the GPE equation using equation 9 above. The height and length values (hypotenuse and adjacent) of the average female reticulated giraffe have been used [5, 8].




Supplementary Figure 2 – An In-built protractor was used to measure the required angle used in the equations above, with a 49-degree angle measured for the inclined plane [8].




Supplementary Figure 3 – Force diagram of Lucy travelling down Georgina's neck with equations attached [8].