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The Shocking Truth of E.T.'s Fly High

Hannah Mahoney

Honours Integrated Science, McMaster University

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Abstract

This paper aims to calculate the forces required by E.T. to complete the 'fly high' scene in the movie '*E.T. the Extra-terrestrial*'. It provides an assumption for the weight of Elliot, the bike, and E.T. The force required for E.T. to stop the initial fall of the bike was determined to be 573.6 N using kinematic equations. Assuming E.T. is able to create a dielectric separation between himself and the ground, it was determined using Coulomb's Law that E.T. would need to elicit a positive charge of 0.004 C to create an electrostatic repulsion force strong enough to offset gravity. These results were then discussed.

Introduction

In the 1982 science fiction film '*E.T. the Extra-Terrestrial*,' a 10 year old boy named Elliot befriends an alien (E.T.) who is trying to find his way home [1]. At one point in the movie, E.T. uses his powers to lift Elliot, the bike, and himself over the cliff and land safely on the other side. This paper aims to calculate the force required by E.T.'s powers to pull off such a stunt. This paper assumes E.T. is able to manipulate electrostatic forces to keep them afloat. It is possible to calculate the amount of force required for the trip using equations for kinematic and electrostatic forces.

Electrostatic forces are associated with electromagnetic forces, one of the four fundamental forces in physics [2]. They are the attractive or repulsive forces between two charged objects at rest [2]. This paper specifically discusses E.T.'s ability to create an electromagnetic repulsive force between himself and the ground by assuming the space between himself and the ground is equivalent to a dielectric material.

Theory

Before any calculations can be made, the mass of E.T., Elliot, and the bike must be obtained. Since E.T. has been described as a "cross between a gnome and a famished refugee child" by Satyajit Ray [3], it suggests E.T. has the same mass as a small, malnourished child, or approximately 13 kg according the Centre for Disease Control and Prevention [4]. Fan sites about

the movie suggest E.T. weighs about 15 kg [5], so for the purpose of this paper, it will be assumed E.T. weighs the average of the two sources, or 14 kg. If Elliot weighs the same as an average 10 year old boy he has a mass of 32 kg [4]. The bike he rides has a mass of 12 kg assuming it weighs the same as an average recreational bike for a child [6]. Therefore the total mass, m , of the group is 58 kg.

The scene begins with Elliot and E.T. riding towards a cliff within a forest [1]. As the terrain is rough, they are moving relatively slowly, approximately 2.5 ms^{-1} . This speed is the recommended speed for safely riding bikes over rough terrain [7]. Taken from the movie, the duo initially drop off the cliff and fall 1 m before E.T.'s powers kick in and the bike steadies [1]. Once in the air, E.T. keeps the bike moving at a leisurely yet faster pace assumed to be 3 ms^{-1} , which is around the average speed for leisurely bike rides [7]. Rearranging kinematic equation 1 and assuming that Elliot's initial velocity, v_i , was 2.5 ms^{-1} his final velocity, v_f , was 3 ms^{-1} , and they travelled a horizontal distance, d , of 1 m as well the horizontal acceleration, a , of the bike can be calculated [2].

$$v_f^2 = v_i^2 + 2ad. \quad (1)$$

$$a = \frac{v_f^2 - v_i^2}{2d} = 1.375 \text{ ms}^{-2}. \quad (2)$$

The applicable acceleration of E.T. and Elliot is actually the resultant vector between the horizontal and vertical components. Assuming the vertical acceleration is equivalent to the gravitational acceleration (-9.8 ms^{-2}) the applicable acceleration can be found using the Pythagoras Theorem:

$$a^2 + b^2 = c^2, \quad (3)$$

where a and b represent the vertical and horizontal vectors, and c represents the hypotenuse, or resultant acceleration vector. Thus, the applicable acceleration is 9.89 ms^{-2} . With the acceleration, the force E.T. must elicit to stop the bike can be calculated using Newtons First Law [6]:

$$F = ma = 59 \times 9.89 = 573.6 \text{ N}. \quad (4)$$

The bike then flies at the same height for the remaining duration of the trip, at a height within the top third of a fully grown pine tree. As an adult pine can grow to be 25 m [8], it can be assumed that the group remain at a height of 17 m from the ground [1]. For E.T. to keep them steady, he needs to counteract the force of gravity, F_g . Counteracting this force would counteract the vertical component of E.T.'s and Elliot's system, leaving the horizontal component able to keep the duo moving at a constant velocity. The force of gravity is given in equation (5):

$$F_g = -mg. \quad (5)$$

As gravitational acceleration, g , has a constant value of -9.8 ms^{-2} [5], the force E.T. must exert is:

$$F_g = -58 \times -9.8 = 568.4 \text{ N}.$$

As previously mentioned, this paper assumes that E.T.'s power comes from an ability to manipulate electrostatic forces. To counteract the force of gravity, he needs to elicit charges on himself, q_1 , and the ground, q_2 , that result in repulsive force [2]. Assuming the charges on himself and the ground are equal and same, q_1 and q_2 can be stated as Q^2 and the force can be calculated using Coulombs Law [2]:

$$F = \frac{k_e q_1 q_2}{d^2} = \frac{k_e Q^2}{d^2}, \quad (6)$$

where k_e represents Coulomb's constant and is equal to $8.98755 \times 10^9 \text{ Nm}^2\text{C}^{-2}$ and d represents the distance between the charged ground and E.T. Thus, the charge that E.T. must elicit to result in enough force to remain afloat is:

$$Q = \sqrt{\frac{Fd^2}{k_e}} = \sqrt{\frac{559 \times (17^2)}{8.98755 \times 10^9}} = 0.004 \text{ C}.$$

Typically, dielectric materials are polarized when exposed to a magnetic field. The polarization results in positive charges on one side, and negative charges on another. For E.T. to create a repulsive force, the area between himself and the ground would be equivalent to the dielectric material, and both sides would have positive charges. In theory, E.T. could achieve this if he was able to nullify or 'knock out' electrons to make both sides positive.

Discussion

The quantities and characteristics of the jump made by E.T. and Elliot are very simplified and do not take into account the non-linear characteristics and unknown variables that would affect such a jump in real life. For this reason the calculated forces in this paper should be taken as approximations, although the calculations do give an outline and rough estimate of the power E.T. would need to elicit.

One aspect of the calculations that stands out is the seemingly very small charge (0.004 C) E.T. would be required to create to stay afloat. This amount of charge in reality makes sense as the relationships between coulombs and other units such as farads make one coulomb a very large amount of charge [2]. Therefore, it is typical to work with coulombs on the micro- or nanoscale [2].

Conclusion

To stop the bike E.T. would need to elicit a force of 573.6 N. To allow the bike to steadily fly, E.T. would need to continuously elicit a vertical force of 558.6 N to counteract the force of gravity and keep the bike afloat. Assuming E.T. is able to do this by manipulating electromagnetic forces, he would need to positively charge himself and the ground 0.004 C to create a large enough repulsive force. Theoretical, this would be possible if E.T. was able to nullify or remove electrons from the dielectric area.

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