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P2_6 Surfin' Fury

T. Holesinsky, Z. Harrison, S. Mandhai, B. G. S. Harris

Department of Physics and Astronomy, University of Leicester, Leicester, LE1 7RH

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Abstract

In a short film called Kung Fury, the main hero uses a person as a surfing board. We investigate the force he would need to push himself forward based on the kinetic friction and drag force. We additionally estimate the maximum friction he would be able to overcome. The force ranges between 335.24 ± 6.87 N and 980.74 ± 6.87 N. The value for coefficient of friction is estimated as 0.72.

Introduction

In a spoof film of 80s culture, Kung Fury, the main protagonist of the same name fights an army of Nazis [1]. In the fighting scene he uses one of the Nazi soldiers as a surf board. We investigate the force he would have to exert to propel himself at average skateboard speed as the situation resembles both skateboard and surfboard. We also approximate the maximum coefficient of kinetic friction he would be able to overcome.

Theory

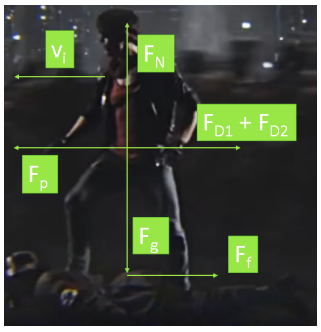

Figure 1: The free body diagram of forces acting on Kung Fury while surfing.

We start by identifying all forces acting on Kung Fury and his "surfboard" as seen in Figure 1. The two drag forces come from Kung Fury as a standing person and the soldier in supine position. The drag force can be calculated using following equation

$$F_D = \frac{1}{2} C_D A \rho {v_i}^2 \tag{1}$$

where C_D is drag coefficient, A is the cross sectional area, ρ is the density of air, and v_i is the speed of the object [2]. The drag coefficient for a standing person is 1.2 and for supine person 0.2 [3]. The cross sectional area for Kung Fury was taken as a rectangle of dimensions 1.74 m and 0.65 m [6]. As the soldier is lying his cross sectional area was also assumed as a rectangle of width 0.65 m and we assumed height of 0.1 m. The average speed achieved on a skateboard is about 6.7 ms^{-1} [4]. The density of air at 1 atm is 1.225 kgm^{-3}.

We assumed that the motion starts with initial velocity. Thus we only consider the kinetic friction coefficient. The value of kinetic friction coefficient, μ_k, between leather and steel was found to be 0.25 [5]. This value was the most compa-

rable one found.

To determine the force Kung Fury has to overcome to be able to maintain his speed, we used the following equation

$$F_f + F_{D1} + F_{D2} = F_p \tag{2}$$

where $F_f = \mu_k mg$ is the frictional force, F_{D1} and F_{D2} are the standing and prone drag forces, and F_p is the force necessary for propelling. We assumed the mass of each person to be 70 kg. So total mass is 140 kg.

Discussion

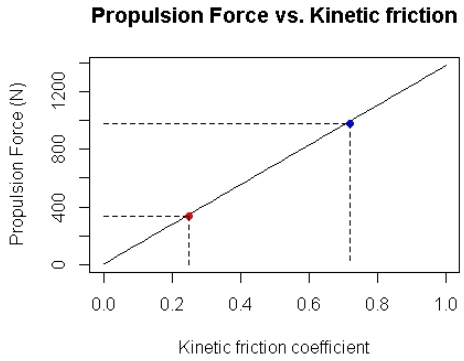

Figure 2: The relationship between the kinetic friction coefficient and the propulsion force. The point indicated in red is for the leather on metal coefficient of kinetic friction. The blue point signifies the maximum coefficient of kinetic friction Kung Fury would surpass. All the data points have error value of ± 6.87 N.

The force necessary to thrust Kung Fury at a constant speed was found to be

$$F_p = 335.24 \ \pm 6.87 \ N$$

We have also decided to investigate what maxim value of coefficient of kinetic friction would allow the motion to be unhindered and produced Figure 2. In Figure 2 we assumed that Kung Fury should be able to push with force of $F_p = 980.74 \pm 6.87$ N.

This is our assumption of maximum force he could apply with one leg based on his body mass [7]. The blue point provides the maximum value of kinetic friction coefficient at which he would be able to remain at constant speed of

$$\mu_k = 0.72$$

The values of the drag forces are as $F_{D1} = 5.57$ N and $F_{D2} = 0.05 \pm 0.005$ N. These values are very low and affect the motion minimally due to the low speed.

The errors arise from the assumptions in the cross sectional area and have the same value on all data points (± 6.87 N).

Conclusion

Based on our model it appears to be possible for Kung Fury to use a human being as a surf board. The force of 335.24 ± 6.87 N provides an idea of how much force he is applying in the film. Furthermore, the force value of 980.74 ± 6.87 N based on our assumption of his physical capabilities sets a maximum value for kinetic friction coefficient of 0.72 that would allow surfing to occur.

References

[1] `http://www.kungfury.com/` (Accessed 27/11/2016)

[2] Tipler, P. A. Tipler and G. Mosca, *Physics For Scientists and Engineers With Modern Physics*, (W. H. Freeman and Company, New York, 2008)

[3] `https://goo.gl/VtxBqS` (Accessed 16/11/2016)

[4] `https://goo.gl/m0rsS5` (Accessed 16/11/2016)

[5] `https://goo.gl/yfE6XL` (Accessed 16/11/2016)

[6] `https://goo.gl/Gktydi` (Accessed 14/10/2016)

[7] `https://goo.gl/ddRh72` (Accessed 16/11/2016)