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Could Hercules Have Destroyed the Marketplace?

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Abstract
This paper explores the physics behind a scene in the Disney animation 'Hercules' in which the Demi-God destroys a whole market place by colliding with a pillar and, in an attempt to salvage the situation, causes a domino effect of destruction. By modelling the pillars on a Tuscan Order model, the physical force required to cause such devastation is calculated using simple force equations. Ultimately, what is shown in the film is fantasy as a man of the average weight 75 kg would be unable to generate the required amount of force without being at an extremely high speed.

Introduction
The popular retelling of the Ancient Greek story about the mythical character 'Hercules' by Disney [1] is filled with fantasy that only animated films can provide; such as fighting off a multi-headed dragon. However, one scene in particular is being investigated here for its validity, where simple physics can give us an answer. When trying to make some friends in the market-place, the protagonist runs to catch a discus with calamitous results, toppling a pillar that ultimately destroys the whole market. Here we model the force it would take to dislodge a standardised pillar in order to conclude if Hercules would have, or could have, knocked it over.

Assumptions
In order to carry out a calculation for the velocity that Hercules was travelling when he impacted upon the column certain parameters need to be defined.

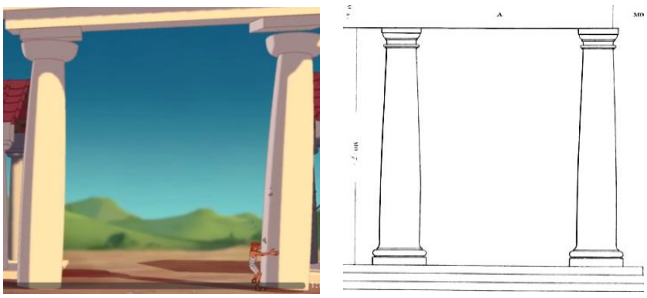

Figure 1 – (left) Screen capture of columns that are shown in Hercules [1] and (right) the Tuscan Order design of columns [2].

Using images from the film (figure 1), it has been determined that the pillars are similar to that of a 'Tuscan Order' architecture [3]. These have a width to height ratio of 1:7 [4]; we have taken the height (h) of the column to be 5m and width to be 0.71 m. The volume of the column is therefore calculated from equation 1. It is noted that the column alone (consisting of the vertical shaft) is used in the calculation.

$$V = \pi r^2 h = 1.98 m^3 \qquad (1)$$

Secondly, the mass of the column needs to be determined (equation 2 and 3). Here density (ρ) has been stated at 2.55×10^3 kgm^{-3} taken as an average of the density range listed on engineering toolbox for stone [5].

$$m = \rho V = 5049\ kg \qquad (2)$$

Model
The model itself focusses on the toppling force (equation 3) for the pillar [6]. This includes the weight of the pillar, the lever arm – the perpendicular distance from the axis of rotation to the line of axis of the force [7] – and the height of the column. The lever arm length (l) is stated at 0.355 m (half the width of the base of column).

$$F = \frac{mgl}{h} = 3517\ N \qquad (3)$$

Now that the force required for the column to topple over has been found, it can be applied to Newton's second law, *F=ma*, in order to determine the acceleration upon impact. The mass has been estimated using the average mass of a 6ft 17 year old male: 75 kg [8].

$$a \approx 47 ms^{-2} \text{ (2sf)}$$

This value for acceleration is then converted into a velocity. Velocity is found from equation 4, and the time (t) is defined from the moment he catches the discus to the point of impact with the pillar. This is determined to be 1.11 s.

$$v = at \approx 52\, ms^{-1} \qquad (4)$$

This velocity of 52 ms^{-1} is equivalent to travelling at around 116 mph. Usain Bolt, the fastest recorded man alive, runs at a speed of 28 mph at maximum velocity, over 4x slower than that of Hercules according to this model.

Conclusion

Using mechanical models for the toppling force of a stone pillar, and the corresponding acceleration required to reach this force, we have calculated that the speed Hercules would have had to have been travelling to cause the pillars to topple would be 52 ms^{-1}, or 116 mph.

This speed is not possible for humans: however, as Hercules possesses some qualities akin to a God, it may be that he has the capacity to travel at speeds not humanly possible.

Assuming his god-like powers do not encompass super speed, as this is not referenced in other scenes of the film, it can therefore be concluded that he could not have caused the pillar in the marketplace to have toppled.

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