The Viability of coming in like a Wrecking Ball

David McDonagh
The Centre for Interdisciplinary Science, University of Leicester
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Abstract
A pop song that made the charts in late 2013 alludes to the idea of entering a given location analogous to a wrecking ball, raising questions over if such a feat is possible. Perhaps more significantly, the singer claims to have impacted both love and ostensibly the walls of someone's house with similar momentum at some point, providing a somewhat unique case in studying the effects of shock on human beings. Both claims are investigated with a view to their viability, concluding that any human behaving like a wrecking ball would likely result in serious injury.

Introduction

Popular music has a rich history of musicians stating extraordinary feats, from The Beatles claiming an eight-day week, to Westlife achieving human-powered flight without wings. Such claims must follow the basic known principles of science if they are to be believed, and can often be investigated through making simple approximations. The Miley Cyrus song *Wrecking Ball* is no exception to this, and can be scrutinised using basic classical mechanics. Of particular focus here are the chorus lyrics *"I came in like a wrecking ball. I never hit so hard in love. All I wanted was to break your walls".*

I came in like a wrecking ball

Wrecking balls are typically on the order of 1000-7000 Kg[1][2][3], and are a common tool in industrial demolition, where a mass is attached to a rope and risen to a certain height by a crane, before being left to free fall under gravity. Such motion can be modelled as a simple pendulum, where the potential energy of the ball is converted into kinetic energy, assuming air resistance is negligible:

$$\frac{1}{2}mv^2 = mgh,$$

where m is the mass of the wrecking ball, v is the velocity, h is the height of the ball and g is the acceleration due to gravity. As the wrecking ball is moving in an arc rather than in free fall, h can be calculated using simple trigonometry, as shown in *figure 1.*

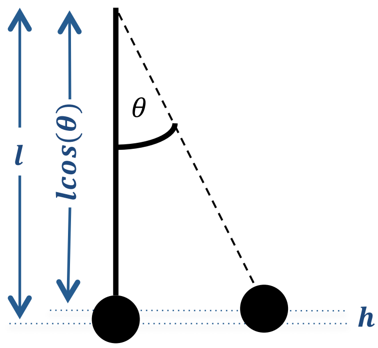

Figure 1: identifying h in terms of the wrecking ball rope length and the angle the ball is raised. Drawn using Ms Word.

From this, h can be rewritten as

$$h = l - lcos(\theta).$$

In rearranging for velocity, the impact velocity can be obtained where the potential energy of the ball is fully converted into kinetic energy, given as

$$v = \sqrt{2gl(1 - cos\theta)},$$

where l is the length of the rope of the crane, and θ is the angle raised before release. The momentum of the wrecking ball is then the product of the impact velocity and its mass. Taking modest values of a wrecking ball with a mass of 1000kg raised by a 10m rope to 60° gives a momentum of

$$P = mv$$

$$P = 1000 \times \sqrt{2 \times 9.81 \times 10(1 - \cos(60°))}$$

$$P = 9904.54\ kg\ ms^{-1}.$$

Assuming now a mass of 70kg, the required velocity for the equivalent momentum for a human being is then

$$v = \frac{9904.54\ kg\ ms^{-1}}{70\ kg} = 141.49\ ms^{-1},$$

or around 316 mph. As current theoretical limits to human speed are placed at around 40mph[4], these results make it unlikely that a human being could enter somewhere like a wrecking ball, without being propelled.

I never hit so hard in love/All I wanted was to break your walls

Upon making contact with a wall, a force is exerted on the object as it suddenly decelerates to zero velocity. This will be dependent on the time over which the force is applied, which, for concrete, steel and other common building materials for which wrecking balls are used, will be short due to their rigid structure. Estimating a value on the order of tens of milliseconds results in a deceleration of

$$a = \frac{0\ ms^{-1} - 141.49\ ms^{-1}}{0.05\ s}$$

$$a = -2829.80\ ms^{-2},$$

equivalent to around 288g, which, from Newton's second law of motion gives a force of magnitude 198086N. An assumption is made here in the object not breaking through or damaging the wall, as the song implies breaking through the walls was unsuccessful.

Discussion and Conclusion

Decelerations in the area of the value calculated are well beyond known limits to what a human being can stand without severe injury[5], hence it is unlikely that such a feat could be achieved under these conditions. As the damage inflicted by an impact is dependent on the time over which the force is applied, it could be possible to identify a material in which the deceleration is gradual enough to remain within the current safe limits of deceleration for human beings. However, it is the view of the author that wrecking balls would not be used on these types of materials and hence the analogy would no longer be consistent. Based on these findings, it is clear that a human being cannot possess the characteristics of a wrecking ball without sustaining significant injury, and other objects should be sought as an analogy.

References

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