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A5 2 Dropping a Watermelon

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Abstract

This paper considers the motion of a watermelon as it is dropped from the roof of a building, bouncing off a trampoline below onto the roof of a car, and calculates the watermelon to impact the car's roof with a velocity of 12.4 metres per second at an angle of 18.9 degrees to the vertical.

Introduction

In a memorable scene from season 3, episode 20, "Safety Training", of the hit US television series "The Office", the character Dwight Schrute drops a watermelon from the roof of the Dunder Mifflin office building, which then bounces off a trampoline placed in the car park below onto the roof of his co-worker Stanley Hudson's car. In this paper, we consider the motion of the watermelon during its flight and we calculate the velocities and angle at which the watermelon impacts the car.

Calculations

The building which served as the exterior of the office building during filming of "The Office" is the Chandler Valley Center Studios in Los Angeles, which is listed as having a height of 35 feet or 10.7 metres [1]. Using Google Maps, we measured the horizontal distance d_h from the edge of the building to the approximate location of Stanley's car in the adjacent car park as approximately 16 metres. The time interval Δt between the watermelon being released and the watermelon impacting the car was estimated from a video clip of the scene as being approximately 4 seconds [2]. From these two pieces of information, we can determine the horizontal velocity of the watermelon using Equation 1:

$$v_h = \frac{d_h}{\Delta t} \tag{1}$$

$v_h = 4$ m s^{-1}, assuming no accelerating force is applied to the watermelon in the horizontal direction as it travels ($a_h = 0$). Assuming a spherical watermelon with a mass $m = 10$ kg is dropped initially with no vertical velocity ($v_{0v} = 0$) from the roof of the building at a vertical height $h_0 = 10$ m above the surface of the trampoline, we can use conservation of mechanical energy to calculate the vertical velocity v_{1v} of the watermelon as it impacts the trampoline [3]; as the watermelon falls, gravitational potential energy is converted to kinetic energy as described in Equation 2:

$$0.5mv_{1v}^2 = mgh_0 \tag{2}$$

Rearranging Equation 2 and taking the acceleration due to gravity as a constant $g = 9.8$ m s^{-2}, we calculate $v_{1v} = (2gh_0)^{0.5} = 14$ m s^{-1}. As the watermelon impacts the trampoline, its kinetic energy is converted to elastic potential energy; however, some of this energy is lost as heat and sound. Approximately 25% of a ball's

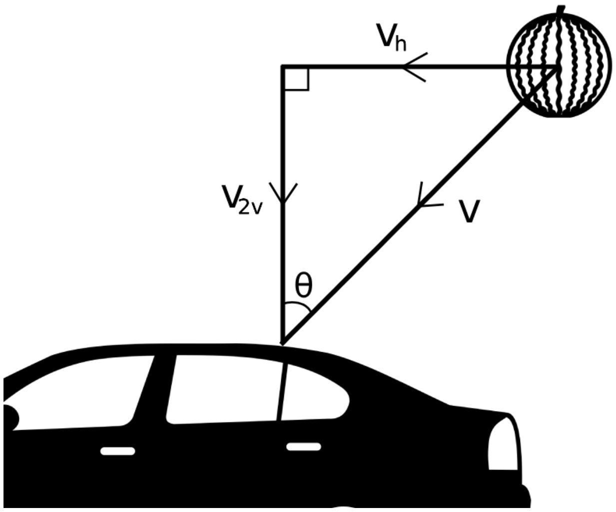

Figure 1: A diagram showing the components of the velocity of the watermelon as it impacts the car. Diagram not to scale.

energy is lost after the first bounce on a typical trampoline [4], meaning that the watermelon will reach a maximum height of $h_1 = 0.75h_0 = 7.5$ m above the surface of the trampoline after its first bounce. As the watermelon falls back down again, it impacts Stanley's car, a Chrysler 300C with a height of 1483 mm or 1.483 m [5]. If we assume the surface of the trampoline is positioned at a height of 1 metre above the ground, then the roof of Stanley's car is at a height of $h_2 = 0.483$ m above the surface of the trampoline. This means that the watermelon impacts the roof of the car with a vertical velocity $v_{2v} = (2g(h_1 - h_2))^{0.5} = 11.7$ m s^{-1}. If we assume that the only acceleration acting on the watermelon is in the vertical direction (due to gravity), then there is no change in the horizontal velocity v_h of the watermelon as it travels through the air. We can calculate the angle to the vertical at which the watermelon impacts Stanley's car using trigonometry:

$$\tan\theta = \frac{v_h}{v_{2v}} \tag{3}$$

Rearranging Equation 3 and taking the horizontal and vertical velocities at the point the watermelon impacts the car as $v_h = 4$ m s^{-1} and $v_{2v} = (2g(h_1 - h_2))^{0.5} = 11.7$ m s^{-1}, respectively, we calculate $\theta = \tan^{-1}(\frac{4}{11.7}) = 18.9°$. We can also calculate the total velocity by squaring and summing the velocity components using the Pythagorean theorem $v_{tot} = (v_h^2 + v_{2v}^2)^{0.5} = 12.4$ m s^{-1}. A diagram of the velocity components of the watermelon as it impacts the car is shown in Figure 1.

Conclusion

We have calculated that the watermelon impacts the roof of the car with a velocity of 12.4 metres per second at an angle of 18.9 degrees to the vertical. A watermelon impacting the car's roof at this speed would result in damage to the car and the watermelon, which would explode due to the force of the collision.

References

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