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A4_3 Chicken Run... Away?

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Abstract

In this paper the height a chicken could fly over a farm fence after being launched on a wagon from an elastic belt slingshot is determined. This was 0.02 ± 0.009 m. The fence was is 1.65 m [7] so it was an impossible challenge.

Introduction

Chicken run is a take on the classic "great escape", where Ginger and her friends try to flee from Mr & Mrs Tweedy's farm, after they start to kill chickens that do not lay enough eggs, and bake them into meat pies. These daring prison escapes are attempted again and again, one of which involved dragging a "chicken-made" wagon back using elastic belts and launching it towards the fence. As the wagon approaches the fence, Bunty (the brave hen attempting escape) flies off the wagon and collides with the fence. This paper investigates whether the average chicken could have made the jump.

Equations

To begin, the elastic energy contained within the belts needs to be determined. This is so the kinetic energy and velocity of the wagon can be calculated. From there the projectile motion of the chicken can be found and the possible height that it could fly can be determined.

$$E_{elastic} = 4\left(\frac{1}{2}k\Delta x^2\right) = 2k\Delta x^2 \qquad (1)$$

Eq.(1) is the elastic energy of the belts. Where k is the spring constant and Δx is the distance that the belts moves when let go. There is an additional factor of 4 as there were 2 belts tied together each side of the slingshot.

$$k = \frac{f}{\Delta l} \qquad (2)$$

Eq.(2) shows how the spring constant was calculated. f is the force that the chicken uses to stretch the belts. The maximum pecking force of a chicken is 1.39 N [1], this can be used to approximate the force assuming they used their beaks. Δl is the change in length of the belts as they are stretched.The average stretched and unstretched lengths are 0.87 m and 0.48 m respectively [2]. This makes Δl to be 0.39 m. The extremes of the unstretched length given in [2] were used to determine errors later on.

$$\Delta x = \sqrt{l^2 - \left(\frac{l}{2}\right)^2} = \frac{\sqrt{3}}{2}l \qquad (3)$$

Eq.(3) as well as Figure (1) shows the distance that the belts move when launching the wagon. The slingshot was approximated as an equilateral triangle, where each side is the length of two belts tied together (1.74 m) as seen in the movie. Pythagoras's theorem was used to calculate the distance, making Δx to be 1.51 m.

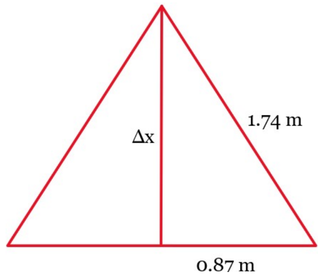

Figure 1: Diagram showing the distance the slingshot will cover.

This can then be substituted into Eq.(1) to get an elastic energy of 16.19 J.

$$E_{Kinetic} = \frac{1}{2}mv^2 \tag{4}$$

Eq.(4), shows the kinetic energy of the wagon system, where m is mass of the chicken (2.5 kg [3]) and wagon (14 kg [4]) and v is the velocity.

$$2k\Delta x^2 = \frac{1}{2}mv^2 \tag{5}$$

Assuming no loss of energy, the elastic and kinetic energy can be set equal (Eq.(5)) and the velocity determined using Eq.(6)

$$v = \sqrt{\frac{4k\Delta x^2}{m}} = \sqrt{\frac{2E_{elastic}}{m}} \tag{6}$$

This came to a value of 1.40 m s^{-1}. Next the friction of the gravel path should be considered as this would dampen the velocity. This was attempted using Eq.(7) where v_d is the dampen velocity, μ is the coefficient of friction 0.60 [6], and g is gravity at 9.81 m s^{-2}. d is the distance that the wagon moves. Using 10 m as an example, the new velocity would be -9.45 m s^{-1}. This means that the wagon would get to 9 meters before coming to a stop. Over larger distances this would get worse, so for simplicity friction has been ignored for these calculations and the original velocity has been used.

$$v_d = v - \sqrt{2\mu g d} \tag{7}$$

Finally using the height of a projectile, Eq.(8) and assuming that the chicken exits the wagon at an angle 30^0 (θ), as this is the most comfortable angle that a chicken can get up a ramp [5]. The height was calculated to be 0.02 ± 0.009 m .

$$H = \frac{v^2 sin^2(\theta)}{2g} \tag{8}$$

The error was determined by repeating this process for the extremes of the unstretched belt range [2] and finding the difference with the used value and averaging them.

Conclusion

The final height of the fence that Bunty could have gotten over turned out to be 0.02 ± 0.009 m. In the movie, the height of the fence was comparable to the height of Mrs Tweedy, so if the fence was the height of an average women, at 1.65 m [7], Bunty could not have flown away to freedom. The error on the height was ± 0.009 m, so the upper and lower end of the range are not high enough for escape either. The calculations ignored friction so realistically it was never going to happen, leaving Ginger and her crew to think of another escape plan.

References

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