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# A4_15 That's ouch folks

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**Abstract**

In this paper, we explore whether Wile E. Coyote and the Road Runner of the *Looney Tunes* and *Merrie Melodies* could survive crossing a ravine. We have found that the Road Runner would require a minimum speed of 39.06 m $s^{-1}$ to cross the ravine, which we deem to be unrealistic, and that the Coyote would fail to cross the ravine and would be killed by the 1185 N force of impact on the cliff face.

## Introduction

Wile E. Coyote and the Road Runner are famous cartoon characters from the *Looney Tunes* and *Merrie Melodies* [1]. In this cartoon, Wile E. Coyote, also known as the Coyote, tries desperately to catch the Road Runner, which is a fast running bird, for his dinner. In each episode, the Coyote comes up with new ideas of traps to catch the bird without ever succeeding. In this paper we shall model the Coyote chasing the Road Runner while on roller skates. We will calculate the minimum speed the bird must have in order to cross a ravine (a deep and narrow gorge between two cliffs). In addition we will determine whether the Coyote will be killed by the force of impact with the cliff on the other side of the ravine, which he collides with due to not being fast enough to catch up with the Road Runner.

## Theory

Figure 1 represents the ravine the Coyote and the Road Runner are attempting to cross. The ravine is considered to be about 100 m wide, which is narrower than Vikos Gorge [2], and the cliffs are considered to be about 2 km deep, which is slightly deeper than Grand Canyon [3].

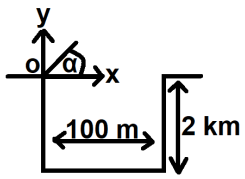


Figure 1: Diagram of the ravine the Coyote and the Road Runner are trying to cross.

The roadrunner jumps at an angle $\alpha$ to the horizontal from the cliff. We will assume this angle to be 20°. We first want to calculate the minimum speed the Road Runner need to have in order to cross the ravine. By using Newton's second law of motion ($\sum \vec{F} = m\vec{a}$) we can derive equation (1), which is the parabolic flight equation and describes the trajectory of the Road Runner above the ravine.

$$y = x\tan(\alpha) - \frac{1}{2}g\frac{x^2}{{v_0}^2\cos^2(\alpha)} \qquad (1)$$

Where: $y$ is the vertical distance from the origin of the frame of reference, $g$ is the acceleration due to gravity, $x$ is the horizontal distance from the origin of the frame of reference, $v_0$ is the initial velocity of the Road Runner, and $\alpha$ is the angle at which the bird jumps to the horizontal.

We then calculated the force of impact of the

Coyote on the cliff, on the opposite side of the ravine. We assumed that the Coyote would not be able to cross the ravine, due to its speed being smaller than the Road Runner's, which was the minimum needed to cross. This is a fair assumption due to the Coyote's misfortune in never being able to catch the Road Runner in any episode. By using equation (1), we can show that the Coyote will hit the side of the cliff and not the bottom of the ravine. The force of impact of Wile E. Coyote can be found using the impulse force, shown in equation (2).

$$\begin{aligned} F &= m\frac{\Delta v}{\Delta t} \quad [4] \\ &= m\frac{v(\Delta v)}{2\Delta d};\ \textit{as } v \textit{ is equal to } |\Delta v| \\ &= \frac{m|\Delta v|\Delta v}{2\Delta d} \end{aligned} \tag{2}$$

Where $F$ is the impulse force, $m$ is the mass of the Coyote, $v$ is the initial speed before the deceleration due to the cliff, $\Delta v$ is the difference between the initial and final speed of the Coyote, $\Delta t$ is the collision time and $\Delta d$ is the difference between the distance of the Coyote just before and just after the impact on the cliff. We assumed that the distance just before the impact is the thickness of the Coyote, and that after the impact Wile E. is flat (like a sheet of paper) against the cliff. Thus, $\Delta d$ is the thickness of the Coyote.

**Discussion & Results**

By rearranging equation (1) for $v_0$ and substituting in the numbers we get a minimum velocity of 39.06 m $s^{-1}$ for the Road Runner to cross the ravine. While this is not possible as a road runners top speed is 8.9 m $s^{-1}$ [5], it is reasonable for the cartoon, as a coyote's max speed is 19 m $s^{-1}$ [5]. This would make it possible for the bird to outrun the Coyote every time. To determine the force of impact of the Coyote on the cliff, we use the average mass of an adult coyote to be 13.9 kg [6]. The speed of someone roller skating varies from 8 mph to 16 mph [7], which is, foolishly, slower than the Coyote's max speed. We can assume that the Coyote will go at the maximum speed limit using the roller skates, as it wants to catch the Road Runner and therefore will go as fast as possible. We also assume that air resistance is negligible. By using equation (1) we calculated that the Coyote will hit the cliff at a height of about $y$ = -959 m from the top of the cliff on the other side of the ravine (using $x$ =100 m). The average height of a coyote is 60 cm [8], but in the cartoon, the legs of the animal are spread prior to landing so will we estimate $\Delta d$ to be half the height. As the Coyote will continue to fall, we shall neglect the change in the vertical component of the speed in the force calculation. We get an force of impact of approximately 1185 N, by substituting in the mass, the speed and the distance of impact into equation (2). Source [9] states that a firm blow with a hammer would kill a calf. We shall consider a calf be a similar size and shape to a Coyote. From equating the momentum of the hammer and the impact of the Coyote, we calculated that the velocity of the hammer would need to be 103 m $s^{-1}$, which we know to be vastly more than a firm blow, therefore the Coyote would not survive the impact.

**Conclusion**

While Wile E. Coyote and the Road Runner is an entertaining cartoon, we have showed that it is unrealistic. We calculated that the Road Runner in the cartoon can cross the ravine safely with a minimum speed of 39.06 m $s^{-1}$, which is improbable for a bird running in reality. We also demonstrated that the Coyote would be killed by its force of impact of 1185 N on the cliff in the cartoon, which would also be the case in real life.

**References**


[1] https://bit.ly/2OQHSYO[Accessed 26/11/19]
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