CASE FILES

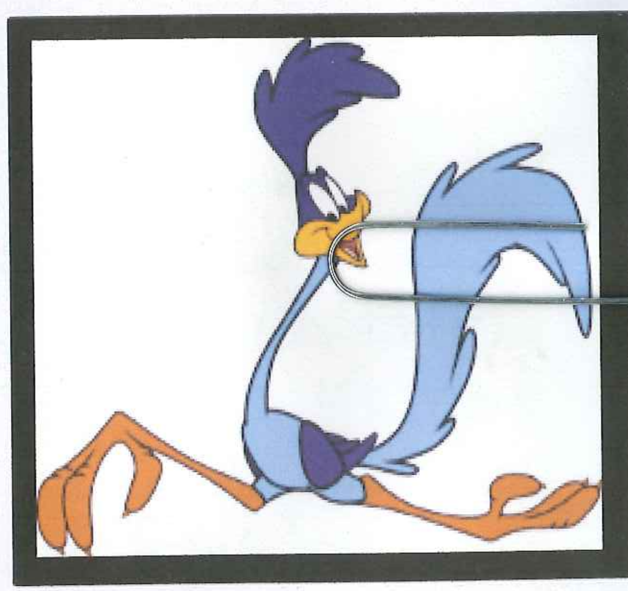
Serial Number # (1039-4531-67-03)

Name: R O A D R U N N E R _ _

Country: U N I T E D S T A T E S

Age: 65(+) Gender: ♀ ⚥ ♂ (circled: ♂)

Occupation: Runs on Roads



Biography: The Road Runn[...] traveling the deserts of [...] avoiding capture for dec[...] deceit has caused Wile [...] of stress. The Road Runner [...] associated with the "Lo[...] he might be an accomplice [...] corporations. The Road Ru[...] family or friends, and his motives are unknown as well.

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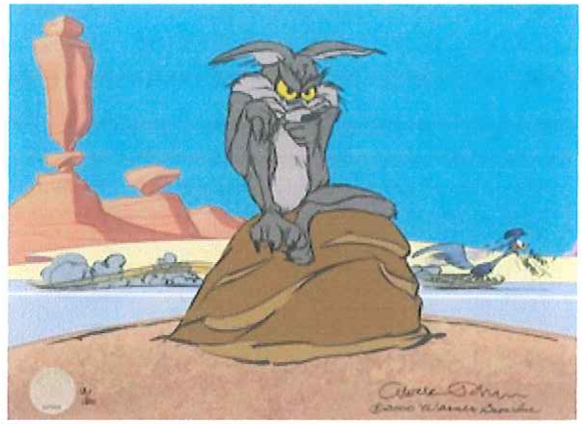
Age: 65(+)   Gender: ♀ ⚥ ♂ (circled: ♂)

Occupation: Runs on Roads.

Biography: The Road Runner has been traveling the deserts of Arizona and avoiding capture for decades. His constant deceit has caused Wile E. Coyote a life time of stress. The Road Runner is said to be associated with the "Looney Toons", and he might be an accomplice for ACME corporations. The Road Runner has no known family or friends, and his motives are unknown as well.

Chandler-Gilbert Community College
MAT 220 Students
2626 E Pecos Rd
Chandler, AZ 85225



Dear Wile E. Coyote,

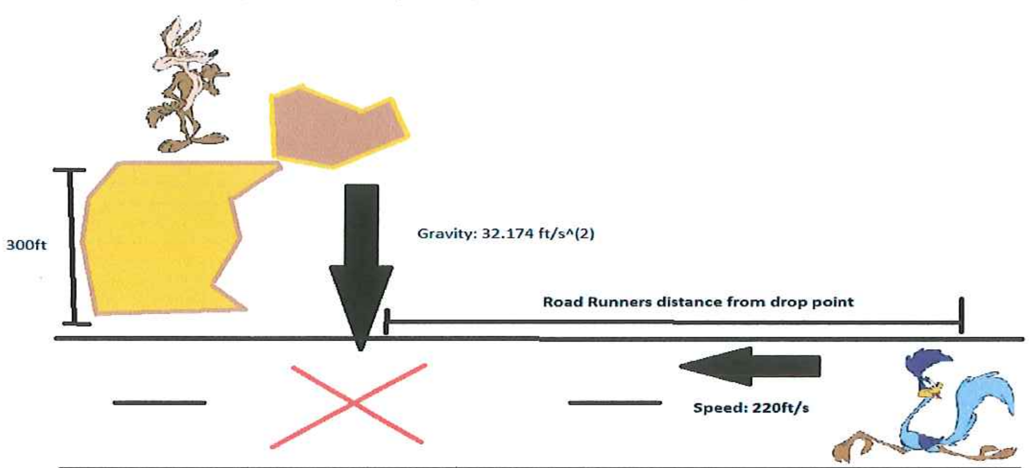
Thank you for trusting us with this TOP SECRET request. We have taken the time to review the information given to us and we decided that it is possible for you to finally catch this road runner. Enclosed in this file is classified material that will reveal exactly what needs to be done, and what to consider when carrying out this plan.

As you stated before, the Road Runner is commonly seen running right under a 300 foot spire with a giant rock sitting on top. We also were given the Road Runners top speed of 150 mph which is a very important factor in the success of this situation. Even though his top speed is 150 mph, it doesn't necessarily mean he will be running at top speed nor the same speed for the entire time that he is running and this is very important to realize. We are basing all of our assumptions off of the roadrunner already running at his top speed so if the Road Runner is not running at his top speed the results will vary. It would be beneficial to ensure that the Road Runner is at top speed or else your efforts may be in vain. Some possible solutions to this problem could be simulating a chase to make him run as fast as possible, for example an accomplice in a car chasing him.

The two ways proposed to attempt this plan are either; dropping the rock off the spire or to catapult the rock 20ft /s in the air before it drops. Let's first focus on dropping the rock. In order to figure out when to drop the rock, we must first figure out how long it takes for the rock to reach the ground. Fortunately, there is a mathematical equation that can help us figure out the time:

$$h(t) = g\,t^2 + v\,t + h$$

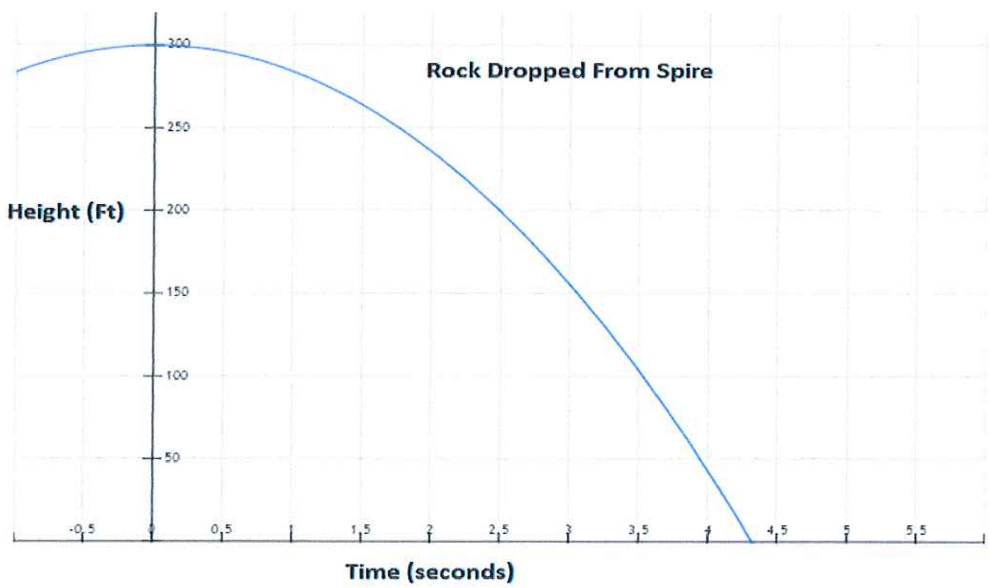
(t stands for time, g stands for gravity, v stands for velocity, and h stands for height)



Gravity is the force that is bringing the rock to the ground; therefore it is an important factor in the falling rock. The velocity is taken into account if the rock is traveling at a certain speed before is it dropped (which it is not in this case since it is simply being dropped) and the height is how far from the ground the rock will be pushed from, which is of course 300 feet. The weight of the rock is not important, because gravity carries objects the same. Gravity gives a falling objects acceleration power. According to Newton's second law of universal gravitation, falling objects will fall and hit the ground or earth at the same time despite their weight or mass and any difference observed is due to the resistance given by air. This is also an important aspect of the problem that needs to be addressed.

Our calculations have been done without calculating the wind resistance or drag on your rock. It is essential that you understand results will vary when different shaped rocks are used, for example if the rock you have is very flat and wide it will receive more drag or wind resistance, thus a slower drop speed or longer fall time duration. If the rock is more streamline or aerodynamic (think about fancy sports cars and the shape they have that allows them to have minimal wind resistance and drag rather than a Hummer or large SUV) than it will receive less resistance and travel similar to the equation we are using. Gravity accelerates objects by 32.174ft/s^(2). So, for the gravity part of the equation, we will substitute g for -16.087 because in the equation its (1/2)g. Since there is no initial velocity, v will be substituted for 0. Finally, h is substituted for 300, as that is the height of the spire. The modified equation reads:

$$h(t) = -16.087\,t^2 + 300$$



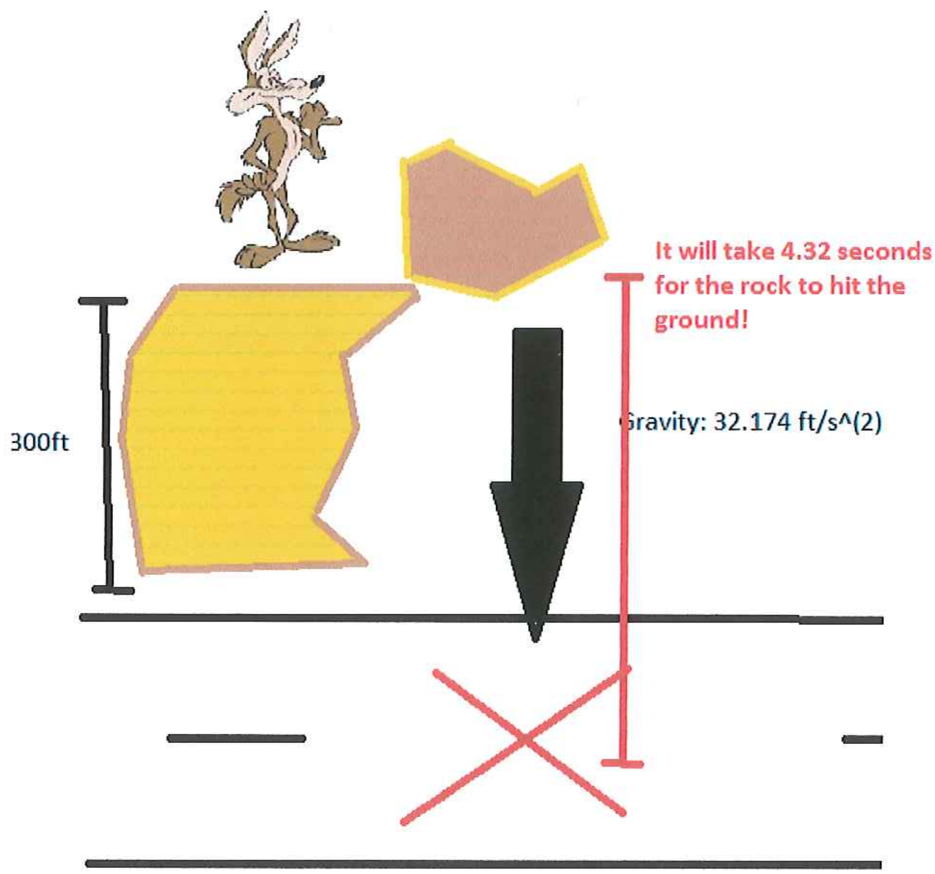
So as you can see from the graph, it takes roughly 4.3 seconds for the rock to hit the ground and in order to be more precise about this we can use another equation. This equation is a quadratic equation. We can use this formula to find where the Y value is zero and this is very helpful because in our scenario this is when the rock hits the ground:

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

Think of our equation in the from of (ax^2+bx+c) so we substitue a for -16.087, b for 0, and c for 300, the equation reads:

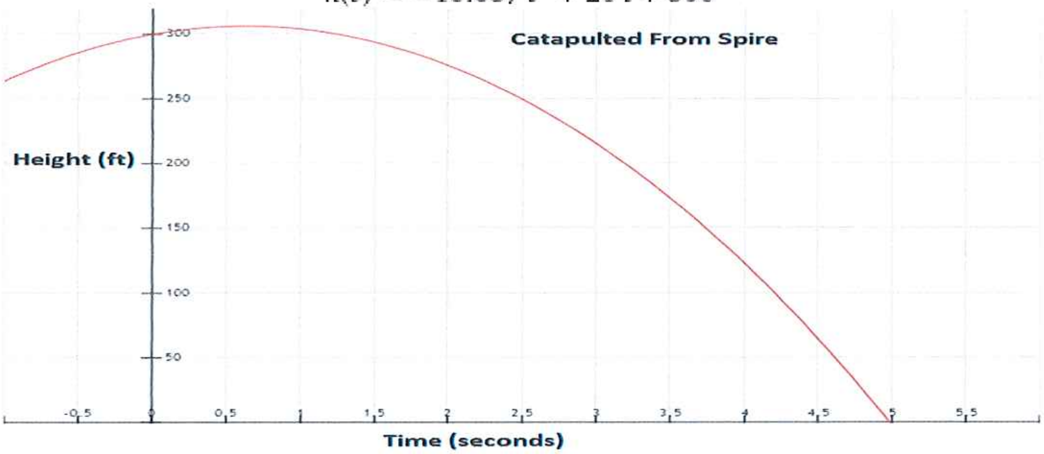
$$t = \frac{0+/-[0^2-4(-16.087)(300)]}{2(-16.087)}$$

The equation will tell us that it takes 4.32 seconds for the rock that is accelerating to hit the ground, assuming that there is not any significant wind resistance.



The second method involves the catapult. The only difference between this equation and the first is the initial velocity. You stated that the catapult will send the rock 20 feet/s into the air. If we substitute v for 20 in out equation we get:

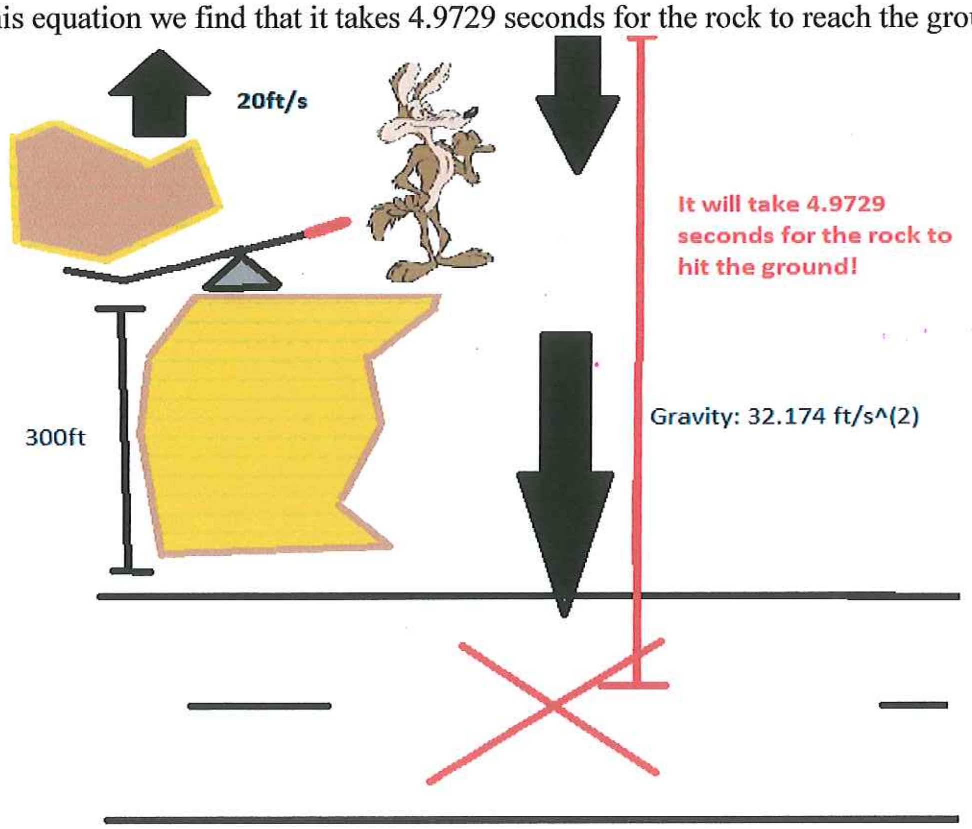
$$h(t) = -16.087\,t^2 + 20\,t + 300$$



Once again if we look at the graph it looks like it hits the ground at about 5 seconds. If we plug this quadratic equation into the quadratic formula to solve t, it reads:

$$t= \frac{20+/-[20^2-4(-16.087)(300)]}{2(-16.087)}$$

Using this equation we find that it takes 4.9729 seconds for the rock to reach the ground.

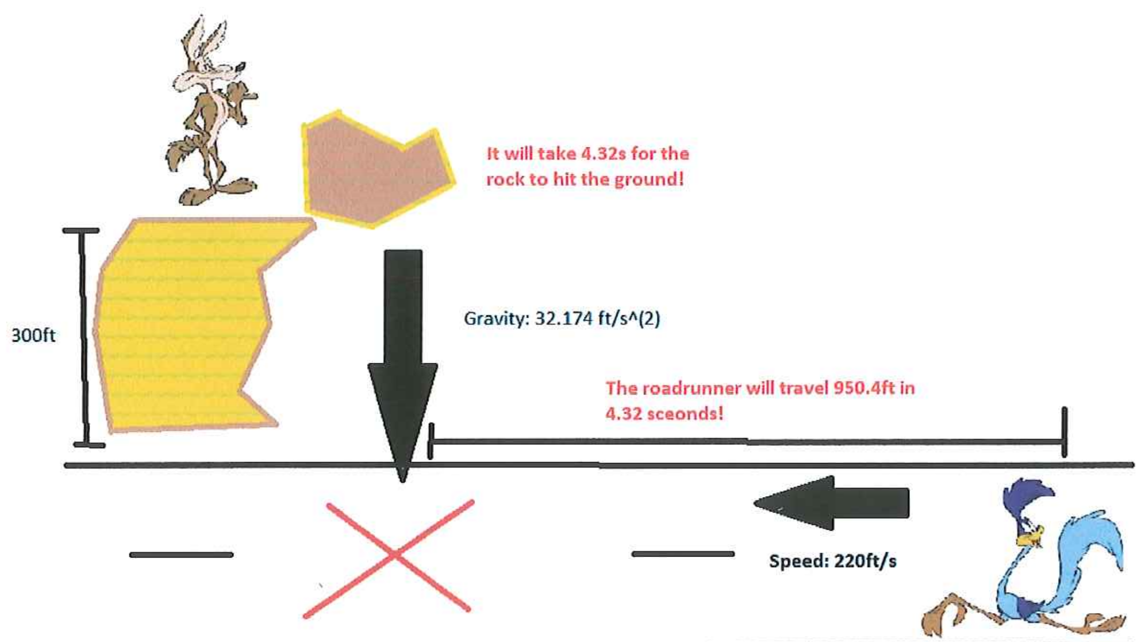


Now that we know how long it takes for the rock to hit the ground, we can figure out how far away R.R. has to be to be hit by the rock. R.R. is said to travel at 150 mph. However, we want to know how many feet he travels in a second. Converting 150 miles to feet, and 1 hour to seconds will do the trick.

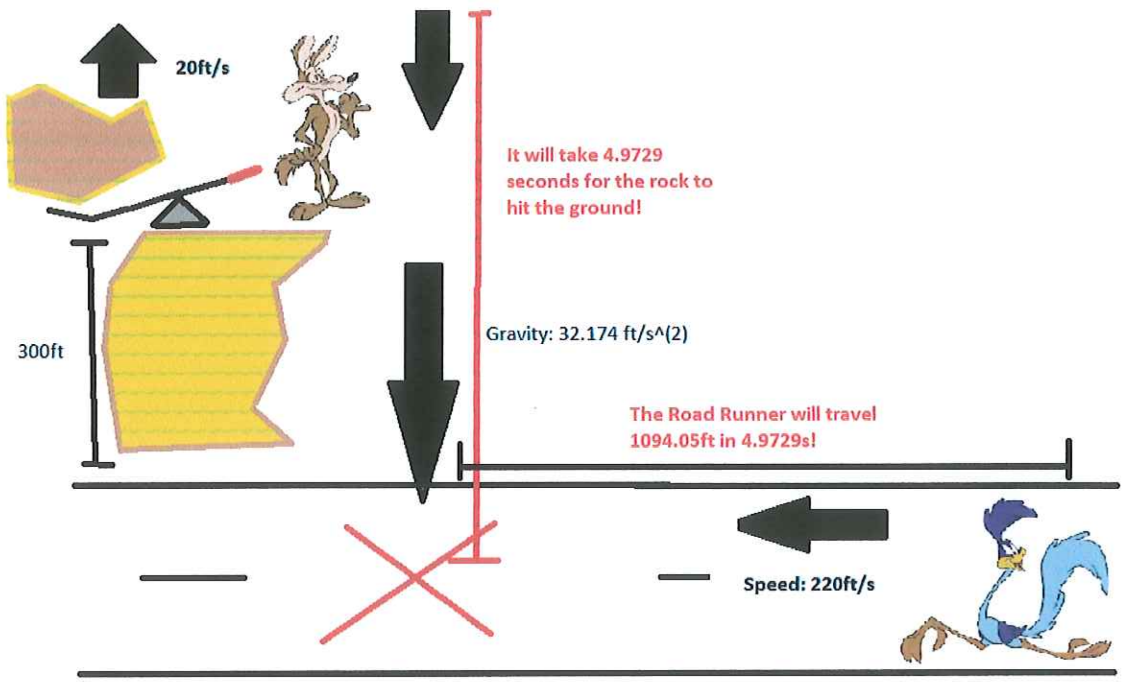
$$\frac{150\ \text{miles}}{1\ \text{hours}} * \frac{1\ \text{hours}}{60\ \text{miles}} * \frac{1\ \text{miles}}{60\ \text{seconds}} = \frac{.041667}{1}\ \frac{\text{miles}}{\text{second}} * \frac{5280\ \text{feet}}{1\ \text{mile}} = 220\ \text{feet}$$

The first part shows that 150 miles per hour equals .041667 miles in one second. In order to convert miles to feet, we multiply .041667 by 5280, because that's how many feet are in a mile. We came to the conclusion that the Road Runner travels at 220 feet per second.

So since we assume that the Road Runner has already hit his top speed and is maintaining it he is traveling 220 feet per second. In order to hit him with the boulder we must know when to drop it. So since he covers 220 feet in 1 second we can multiply 1 by 4.32 to get 4.32 seconds and since we multiplied the denominator by 4.32 to the top to ensure our new fraction is equivalent, and we get 950.4ft!

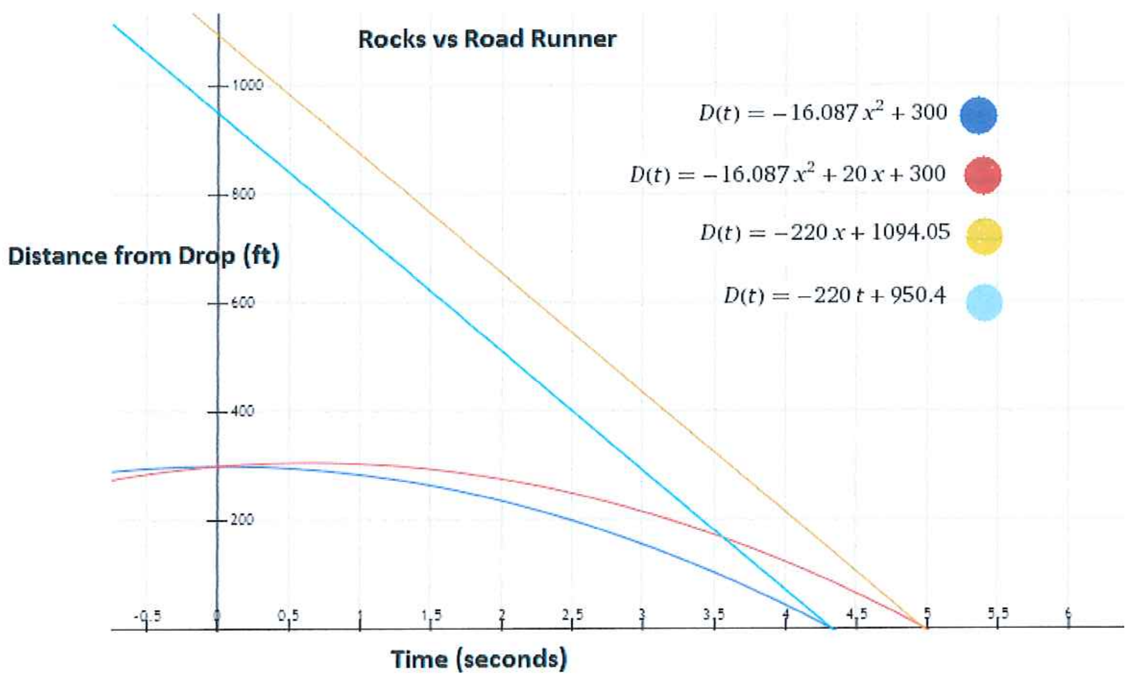


The same can be done with the catapult. It takes 4.9729 seconds to hit the ground so we can multiply by 4.9729 and see that it takes 4.9729 seconds for the Road Runner to travel 1094.05ft.



Therefore you must drop the rock when Road Runner is 950.4 feet away, or if you catapulted the rock the Road Runner must be 1094.05 feet away. You must also remember the assumptions that were made to arrive at this solution and ensure that these are met in order to achieve the desired results of a dead bird (EX: top speed and drag on rock)!

This can also be shown in the form of the graph!

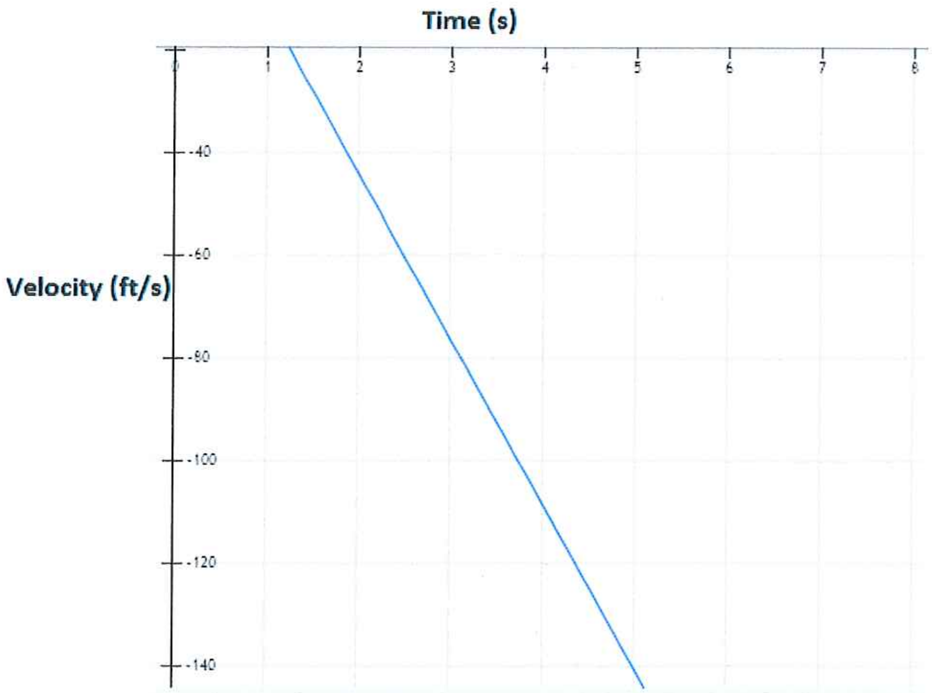


Note that the Y axis is now changed to distance from the drop point and as you can see the Road Runner (teal and orange) hits the drop zone at the same time the rock does (Blue and Red) respectively. The equations for the Road Runner represent his initial distance from the drop zone (1094.05ft and 950.4ft) and his speed toward the drop zone.

Lastly, in order to find the speed at the impact, we must find the instantaneous rate of change. We can do this by finding the derivative of the original equation:

$$h(t) = -16.087\,t^2 + 20\,t + 300$$

$$h(t) = -32.174\,t + 20$$



The Change in Velocity of the Catapulted Rock

We found this derrivative with using the power derrivative rule. This rule states:

$$\frac{\partial x^n}{\partial x} = n\,x^{n-1}$$

So we took the exponent of 2 and multiplied it by the coefficient of -16.087 and subtracted the exponent by 1 and we did the same for the 20t and since the exponent is 1 and 1-1 is 0 the x disappears. This equation can be used to find the rate of change of the object so we can see how fast its moving when it hits the ground. So we can plug our x value at the point it hit the ground, which we haved determined to be 4.9729 for the catapulted rock.

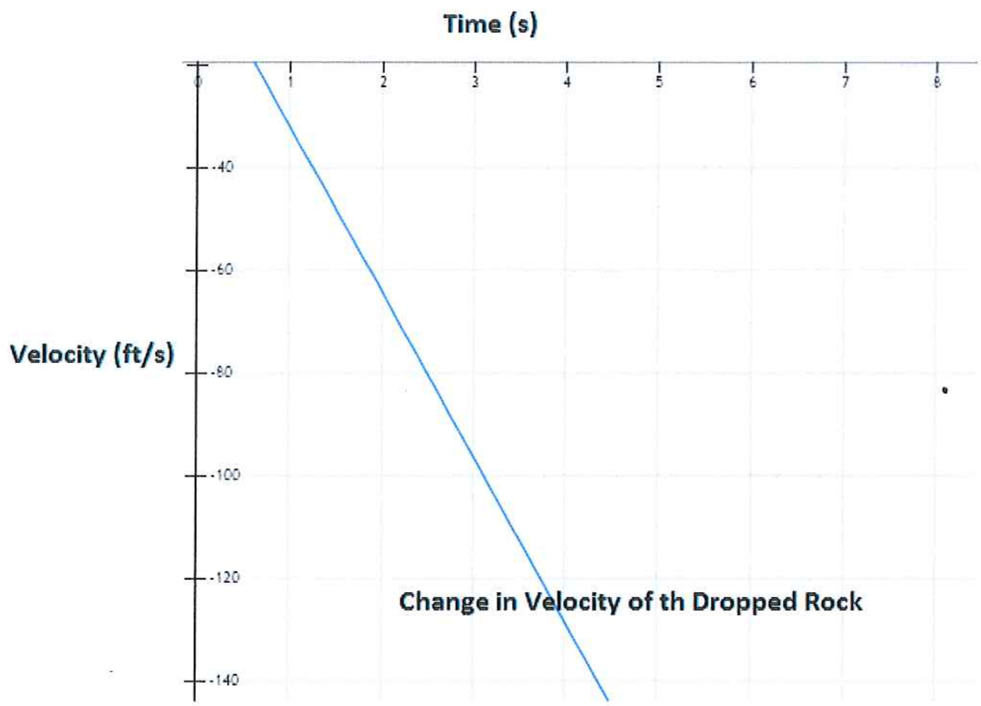
$$h(4.9729) = -32.174 \times 4.9729 + 20$$

$$h(4.9729) = -140$$

Due to the acceleration of gravity which speeds up the rock 32.174ft/s every second the rock is travelling at a whopping 140 miles an hour when it is launched from a catapult from a 300 foot spire.

We can do the same for the dropped rock as well:

$$h(t) = -16.087\,t^2 + 300$$
$$h(t) = -32.174\,t$$



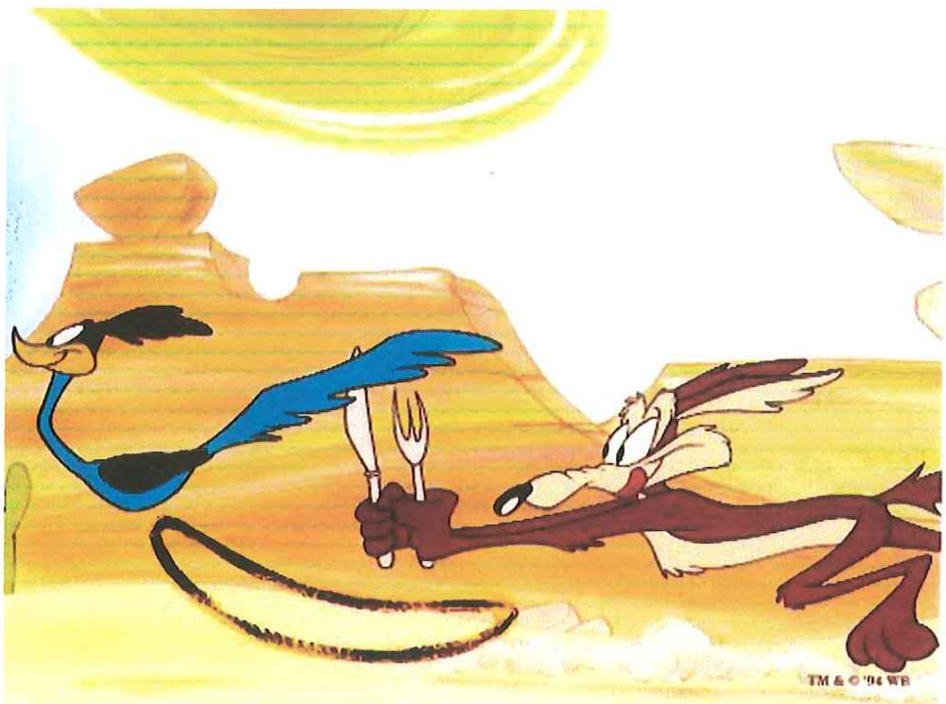
By plugging in the time it takes to for the rock to hit the ground we can estimate its speed as it hits the ground:

$$h(4.32) = -32.174 \times 4.32$$
$$h(4.32) = -138.992$$

Due to the acceleration of gravity which speeds up the rock 32.174ft/s every second the rock is travelling at a whopping 138.992 miles an hour when it is dropped from a 300 foot spire.

Therefore, we are pleased to inform you that your plan to capture the Road Runner is more than possible! With the data we have shown you, the Road Runner will be on your dinner plat in no time. Should you choose to simply push the rock off the 300 foot spire, you must push it off when the road runner is 950.4 feet out, and it would be traveling at a speed of 138.992 mph. However, if you choose to catapult the rock first, you must catapult it when the 1094.05 feet away and the rock will be traveling at 140 mph. Do not forget to take into account that these numbers come with the assumption that the Road Runner is traveling at top speed the whole time. Also, some data may vary due to wind resistance. With all that taken into account, you should cooking up something delicious in no time. I hope that our methods have helped!

Good luck!



Sincerely,

Algebraic Analysts

P.s. We like white meat!