The Physics of Super Mario

All images courtesy of Nintendo

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Introduction

A nine year old girl can calculate, on the fly, and set herself on a collision course with a baseball-shaped projectile flying through the air at a given velocity and angle with the horizontal. She can do this without even hearing the phrase "Force equals mass times acceleration". Physicists spend lifetimes trying to understand the basic principles and laws that the baseball has to follow, and as a reward, some will reach immortality in textbooks, classrooms, and `comical` posters involving an oversized apple falling on someone's head. But there is more than one reality which contains laws of physics that can be analyzed, understood, and published. The neural nets of many men and women throughout the world have adapted to the laws of physics that govern the mushroom kingdom. Many people can jump on a goomba, rendering it unable to goombate while flying through the air in multiple jumps without knowing the force of gravity, Mario's mass, or the density of the atmosphere. Now a new age is upon us, an age undreamed of where we can actually comprehend the numbers and rules that mushroom kingdom matter must abide by. Through these simple numbers, we will reach immortality and be featured in

Method

Our methods to complete our task were as simple as they were sound. We already had possession of tools we required. Our first step was to record Mario in the mushroom kingdom doing his jumping thing. This was done with relative ease and in a short time. The next thing we did was exporting the video files to a format that we could use with logger pro software to analyze. A few minor snags slowed us down slightly, but they were simply a matter of understanding the software better. Once we had everything set up, we simply had to look at the data, convert it to kinematics, and do the calculations, solving for the unknown variable.

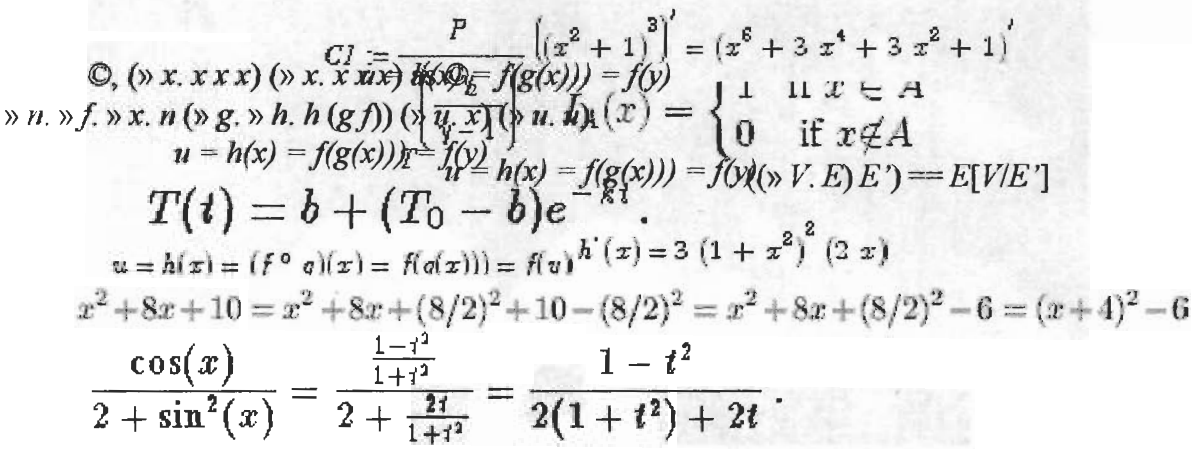


Figure 1 - The complicated mathematics of the Mushroom Kingdom

Results

All results are based on the assumption that Mario is 1.67 meters tall

5/3

Mario I

15/2 / 5/3 = 15/2 · 3/5 = 9/2 = 4½ times his height

Max Jump- 7.49m

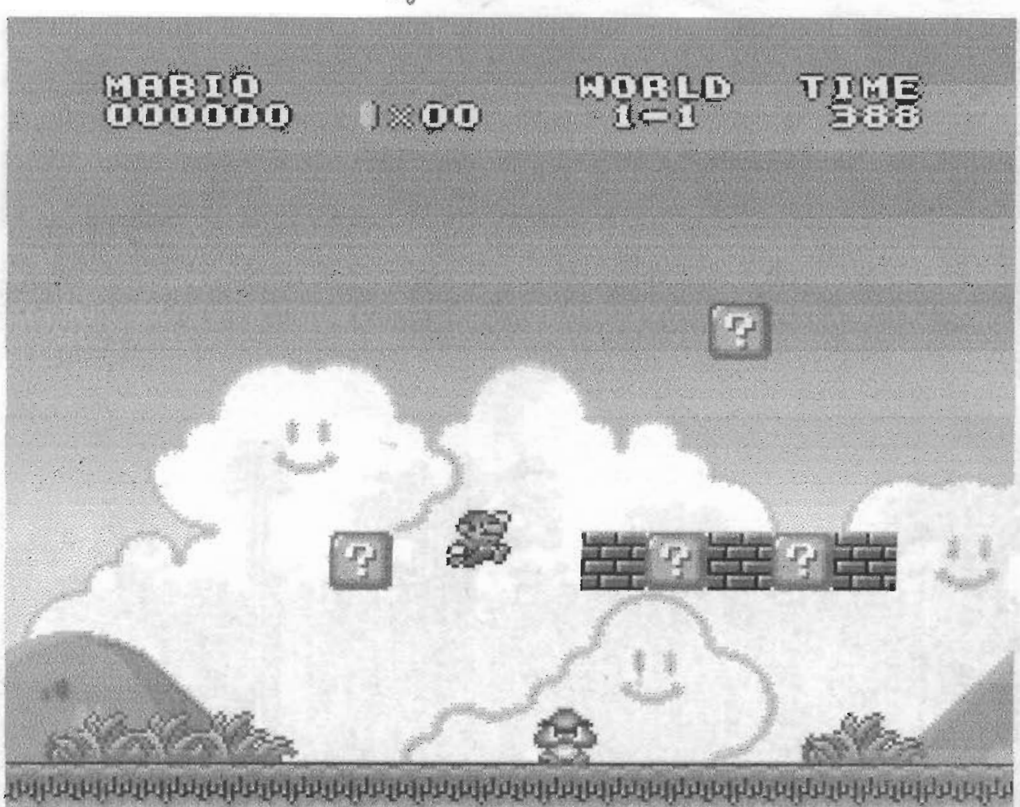
Time in air- 1.03s

G = 57.03 m/s/s

Velocity when Mario hits the ground = 29.23 m/s — same as v_i? (i.e., is gravity the same in both direction?)

$v_f^2 = v_0^2 + 2gh$

$h = \frac{v_0^2}{2g} \approx \frac{(30)^2}{} \quad \frac{30 \cdot 30}{120} \approx 7\frac{1}{2}$ .. I agree.. assuming gravity is symmetric & there are no other forces



how does "G" scale with Mario's height?

Mario II

Max Jump- 3.75m

Time in air .55s

G = 49.59 m/s/s

Velocity when Mario hits the ground = 32.98 m/s

Are the differences in G between Mario I & Mario II within measurement uncertainty?

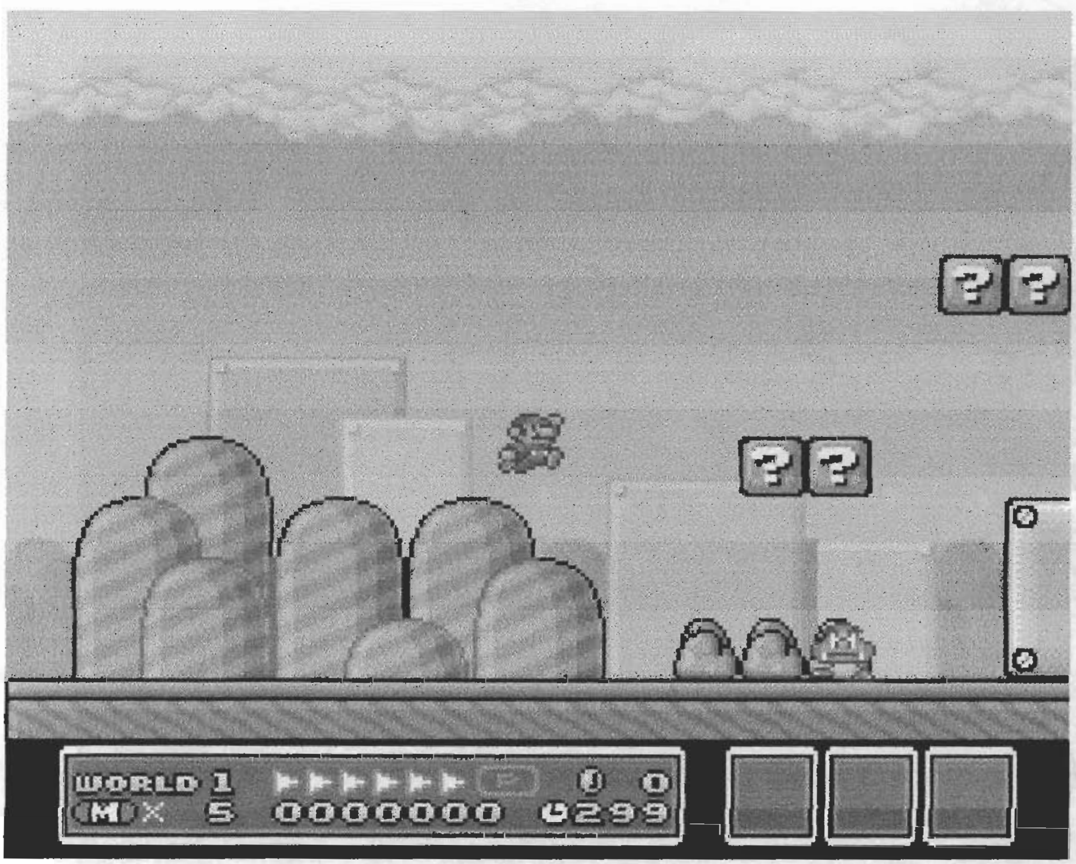
Mario III

Max Jump- 8.24m

Time in air 1.00s

G = 66.00 **m/s/s** ← again, remarkably similar. Are I, II, & III the same worlds??

Velocity when Mario hits the ground = 19.29 m/s



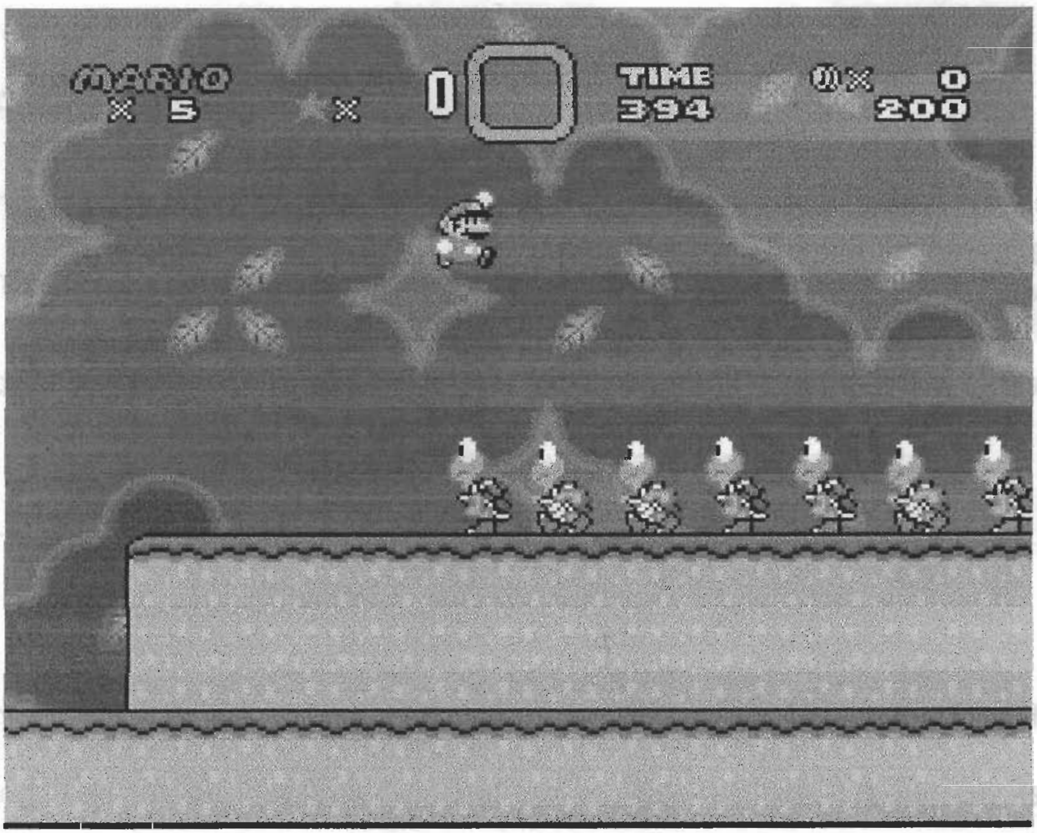
Super Mario

Max Jump 5.87

Time in air .90s

G = 57.98 m/s/s

Velocity when Mario hits the ground = 26.09 m/s



Discussion

One would think, from playing the Mario games, that the acceleration due to gravity in any of the Mario games is considerably less than in our own world. It seems like, from the hang time, that he is in the air *forever*. From the results, we know this is not the case. In fact, in Mario I, the acceleration due to gravity is six times faster [greater] in the mushroom kingdom. This seems like an error, but I checked the data and math over and over, it is correct. Allow me to explain the logic. Let us assume that Mario is 5 feet 6 inches tall, that is, 1.67 meters tall. It is immediately obvious that he jumps this a couple of times this height. In fact, in Mario I he jumps 7.49 meters high. The entire jump takes about a second. That means in half a second, the gravity pulls him down 7.49 meters. In half a second, earths gravity would only move an object 1.225 seconds.

The strange thing is that the gravity seems to change as his adventures progress. This doesn't happen at a constant rate, it seems to be the strongest in Mario III.

would like to see the uncertainty in your data/calculations. I assume you got the cartesian coordinates of Mario from Logger Pro, then calculate a 2nd order polynomial fit, etc.?? How good was the fit?? Would be nice to see some of the raw calculations

This power of gravity would account for the fact that simply jumping on top of his foes destroys them, and in each adventure, it is his jumping that puts an end to goombation. He comes down on these heinous beasts with a velocity nearing 70 miles per hour.

In the noble quest to search for knowledge, physics is arguably at the forefront. Now, at the beginning of an era, physics finally reaches into multiple realities. It is our duty as a species to make sure that no facet is left untouched by the wonder that is physics. I believe this study has toched its fare share of facets.

Note: All graphs were accidently erased, they were not included only because of that reason and that at this point all information relevamt to the calculations were already extracted from them.

I am currently working on a website for the project, I will email the link to you once I have progress. I am also amalyzing more of the Mario world. My additional ideas I am going to look at are the frictional coefficient of the ground to Mario syetem. Also the spring coefficients in the various bad guys that Mario stomps on. The bad guys act just like a spring and provide very nice graphs for analyzing. Since I have the logger pro software this shouldnt be too much trouble to figure out, I will keep you posted!

-Michael Bartley