A ~~Bold~~ Bald Leap of Faith

When someone asks me who my favorite superhero is, I don't adhere to the humdrum dilemma of Marvel versus DC. Rather, I cling to the pleasure of observing their confused frowns as I mention my homeboy, the Caped Baldy. Something about the absurd abundance of power embodied within the bounds of one "salaryman wannabe" sparks inexplicable excitement within me.

Public stigma against the subject of Japanese animation (anime) has led my appreciation of the medium to be rather covert, but the opportunity to write about a bald man in his twenties that can destroy anything with one punch has inhibited my ability to make sensible decisions. Fortunately, sensibility is the last thing that I need in order to portray my vehement passion to UChicago. Shall we begin?

An Introduction to the Hero

One Punch Man chronicles the mundane happenings of a man who has lost interest in everything due to being simply too powerful. As "someone who's just a hero for fun", he lives his unfulfilling life as a lowly ranked hero, destroying unfathomably powerful foes and never receiving credit for the work that he has done. Unbothered by this, he lives his life paycheck to paycheck, birthing the premise for a hilarious gag anime that mocks the superhero genre.

With the ability to effortlessly demolish canyons, obliterate 200 meter tall giants, and vaporize meteors at terminal velocity, this incognito hero has saved the planet tens, if not hundreds of times. But who is he? Enter Saitama, the strongest being on Earth, and quite possibly the entire universe.

Throwing Pebbles at Escape Velocity

There aren't many events in my life that I could characterize myself by, and even fewer from childhood. If there's anything of note that I could cite about this time, it would be my persistent admiration for the great beyond. More than a decade ago, my cronies and I once haphazardly threw pebbles into a pitch-black parking lot, imagining them flying deep into the night, breaking free of the menial shackles of this planet. The result? 4 mildly dented vehicles.

Regarded in infamy by at least 8 aunties and uncles, I reflected on my actions. While I did certainly feel remorse, the curiosity for how hard my throw should have been for it never to land (on those poor people's cars) plagued me endlessly. A few years later, through a developed affinity and fervor for math and science, I obtained the technical jargon to rephrase my question in a somewhat scholarly manner: *How much energy does it take to completely escape a celestial body's gravitational field?* This marked the beginning of my venture into the deep abyss that was physics.

One Small Step for Man

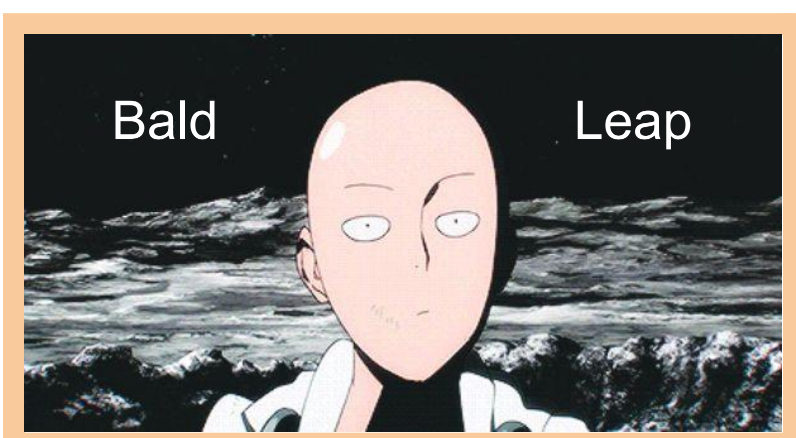
But Kathir, escape velocity is boring! It's too easy! You're going to calculate escape velocity as your one and only chance to get into the school of your dreams? Are you—

Hey, hey, slow down! Why do you think I spent an entire page introducing the Caped Baldy?

One Giant Leap for Baldkind

In episode 12 of *One Punch Man*, Saitama comes face to face with an extraterrestrial being named Boros. For the first time, one punch isn't sufficient to trounce his adversary. During the fight, Boros, in a magnificent show of stunning sakuga, flings Saitama *to the moon*. In his monotone expression, Saitama boredly looks around. He then proceeds to effortlessly leap *back to Earth*.

My deeply rooted interest in escaping gravity and relatively newfound admiration of Saitama have coalesced to originate a unit of measurement that transcends the bounds of standard logic. In honor of the hero's colossal leap (and terrible naming sense), the **Bald Leap**, or **BL** for short, shall denote the energy used (work done) by Saitama in this scene to leap back to Earth.



Bald

How much energy is 1 Bald Leap? (click here to skip to answer)

Let us define a Normal Moon Jump (NMJ) as the work required to jump off of the moon entirely, eventually arriving at Earth. This begins with a good old escape velocity calculation, followed by a consecutive kinetic energy calculation. For the rest of our calculations, let M and m denote the mass of an object, x denote the jumper's distance from the Moon, r denote the radius of a celestial body, and d denote the distance from Earth to the Moon.

$$EV_{Moon} = \sqrt{\frac{2GM_{Moon}}{r_{Moon}}} = 2376\, m/s$$

$$1\ NMJ = KE_{Normal\ Moon\ Jump} = \frac{m_{jumper} EV_{Moon}^{\ 2}}{2} = G\frac{m_{jumper} M_{Moon}}{r_{Moon}}$$

Interestingly enough, this is the negative gravitational potential for an object on the surface of the Moon! Plugging in values, with the jumper's mass being Saitama's canonical measurement (70kg), we get that 1 NMJ is about 198 megajoules.

The actual calculation of a Bald Leap is quite rigorous. Because a jump means force is only applied for a relatively negligible period, a calculation of travel time to Earth is luckily just a complex motion problem. First, the acceleration of the jumper must be calculated.

$$F_{g_{Earth}} = G\frac{M_{Earth} m_{jumper}}{(d-x)^2}\ ,\ F_{g_{Moon}} = G\frac{M_{Moon} m_{jumper}}{x^2}\ ,$$

$$\therefore \sum F = m_{jumper} G\left[\frac{M_{Earth}}{(d-x)^2} - \frac{M_{Moon}}{x^2}\right],\ a = \frac{\Sigma F}{m_{jumper}} = G\left[\frac{M_{Earth}}{(d-x)^2} - \frac{M_{Moon}}{x^2}\right]$$

With this expression of acceleration in terms of position, we can make multiple substitutions to do with position and velocity. We can then integrate to an expression for the journey's total time, dependent on many constants and a single variable condition, which is the initial velocity (we can assume a singular initial velocity due to how instantly the initial acceleration occurs, and because no force except gravitational fields is exerted over the journey).

$$t = \int_0^t dt = \int_{x_0}^{x} \frac{dx}{\frac{dx}{dt}} = \int_{x_0}^{x} \frac{dx}{v(t)} = \int_{x_0}^{x} \frac{dx}{\sqrt{v_0^{\ 2} + 2\int_{x_0}^{x} a(x)dx}}\ ,\ \int_{x_0}^{x} a(x)dx = G\int_{r_{Moon}}^{d-r_{Earth}} \left[\frac{M_{Earth}}{(d-x)^2} - \frac{M_{Moon}}{x^2}\right]dx$$

$$\therefore t = \int_{r_{Moon}}^{d-r_{Earth}} \frac{dx}{\sqrt{v_0^{\ 2} + 2G\int_{r_{Moon}}^{d-r_{Earth}}\left[\frac{M_{Earth}}{(d-x)^2} - \frac{M_{Moon}}{x^2}\right]dx}} = \int_{r_{Moon}}^{d-r_{Earth}} \frac{dx}{\sqrt{v_0^{\ 2} + 2G(-M_{Earth}(-\frac{1}{r_{Earth}} + \frac{1}{d-r_{Moon}}) + M_{Moon}(-\frac{1}{d-r_{Earth}} + \frac{1}{r_{Moon}}))}}\ ,$$

$$\therefore t = \frac{d - r_{Earth} - r_{moon}}{\sqrt{v_0^{\ 2} + 2G(-M_{Earth}(-\frac{1}{r_{Earth}} + \frac{1}{d-r_{Moon}}) + M_{Moon}(-\frac{1}{d-r_{Earth}} + \frac{1}{r_{Moon}}))}}$$

Analyzing the moon jump clip, it can be seen that Saitama jumped back to Earth in just 19.4 seconds. Plugging this value in for t, we can solve for v_0, Saitama's initial speed. This can then help us calculate his generated kinetic energy upon jumping. In other words, 1 Bald Leap!

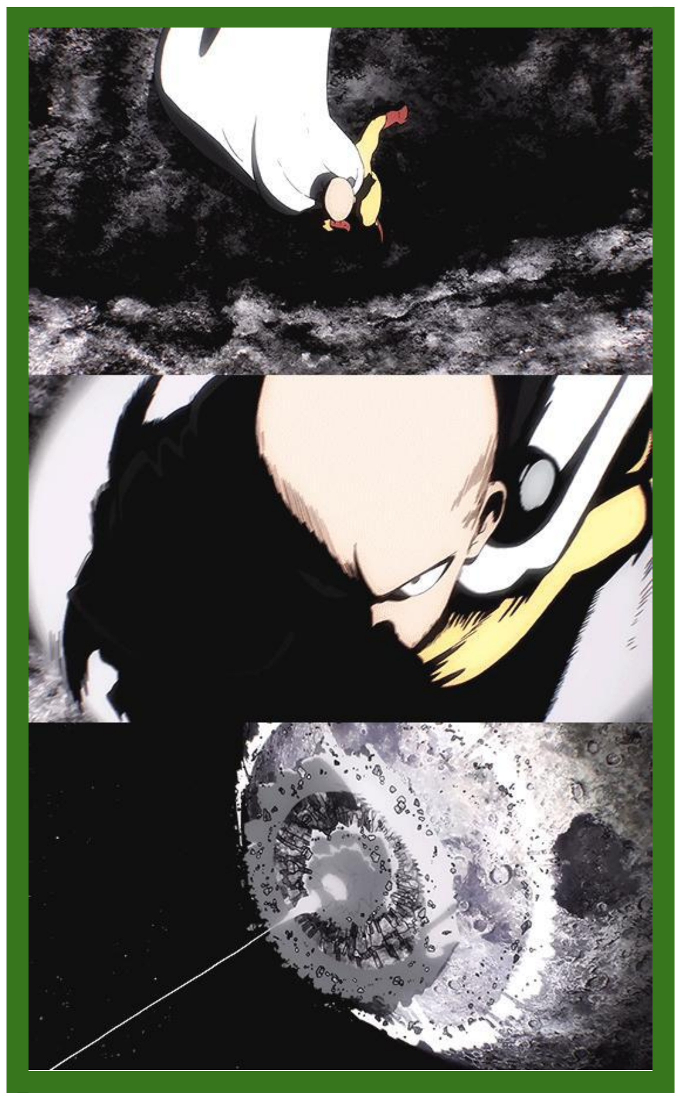
$$v_0 = \sqrt{\frac{(d-r_{Earth}-r_{moon})^2}{t^2} - 2G(-M_{Earth}(-\frac{1}{r_{Earth}} + \frac{1}{d-r_{Moon}}) + M_{Moon}(-\frac{1}{d-r_{Earth}} + \frac{1}{r_{Moon}}))},$$

$$\therefore KE = \frac{1}{2}mv_0^{\ 2} = \frac{m_{Saitama}\sqrt{\frac{(d-r_{Earth}-r_{moon})^2}{t^2} - 2G(-M_{Earth}(-\frac{1}{r_{Earth}} + \frac{1}{d-r_{Moon}}) + M_{Moon}(-\frac{1}{d-r_{Earth}} + \frac{1}{r_{Moon}}))}^{\,2}}{2}$$

$$= \frac{m_{Saitama}\left[\frac{(d-r_{Earth}-r_{moon})^2}{t^2} - 2G(-M_{Earth}(-\frac{1}{r_{Earth}} + \frac{1}{d-r_{Moon}}) + M_{Moon}(-\frac{1}{d-r_{Earth}} + \frac{1}{r_{Moon}}))\right]}{2} = 1\,BL = 1.49 * 10^{18}\,J$$

1.5 Quintillion Joules!?

So, 1 Bald Leap is about $1.49 \cdot 10^{18}$ joules (this doesn't even account for energy lost to the Earth + Saitama + Moon system as heat, rotation, and vibration, the effects of which can be seen in the image to the bottom right)! That's about 7.5 billion NMJ.



To put this monstrosity in perspective, that is ~10 times more energy than Tsar Bomba (the largest nuclear weapon ever detonated) released. $1.5 \cdot 10^{18}$ (1.5 billion billion) joules is indeed tremendous.

Other equivalents of a Bald Leap include 1.5 billion Sagan units [joules] (in honor of the alum's famous *"Billions and billions"*), 4.4 trillion John Cena's falling from the Eiffel Tower, and 2.88 years of Windy City energy.

The Bald Factor

My synthesis of this absurdity of a unit may have arisen the question as to why one would do this in the first place. I like to attribute such anomalies to a very special scapegoat.

I call it the Bald Factor. A Normal Moon Jump was all that was really needed, but the Bald Leap was what I *wanted*. The Bald Factor is the need to present something profound; the desire to produce something unorthodox; the urge to do something weird. Whether it be through my playful write ups about the utility of machine learning in demand forecasting, swanky improv sessions at Tuesday night jazz band rehearsals, or hilarious custom made learning materials for the math team, I find this depilated denominator permeating my life every waking moment.

This tribute to the Caped Baldy has amplified two facets of my persona: The physicist and the baldist. Interestingly, more questions have been derived from this endeavor than answers. For example, since Saitama was on the moon without oxygen, he generated all of the torque in his knees from anaerobic respiration. How much lactic acid did he produce, then? How much cheese is that? *Where's Baldo?*

Indeed, the Bald Factor has carried me through my high school years, and will surely propel me into a career of new discovery and wonderful revelations as I pursue a BAld in the natural sciences (well, the plan is actually a BS but I need more bald jokes). Though, even with the Bald Factor's influence, I suppose that the Bald Leap unit's calculation is a bold leap of faith of sorts. *A Bald Leap of Faith*, if you will. My hardened will to pursue physics, overflowing passion for anime, and the Bald Factor have gotten me this far in life. Who's to say they can't take me even further?