Putting the Pokedex to the test using Maths

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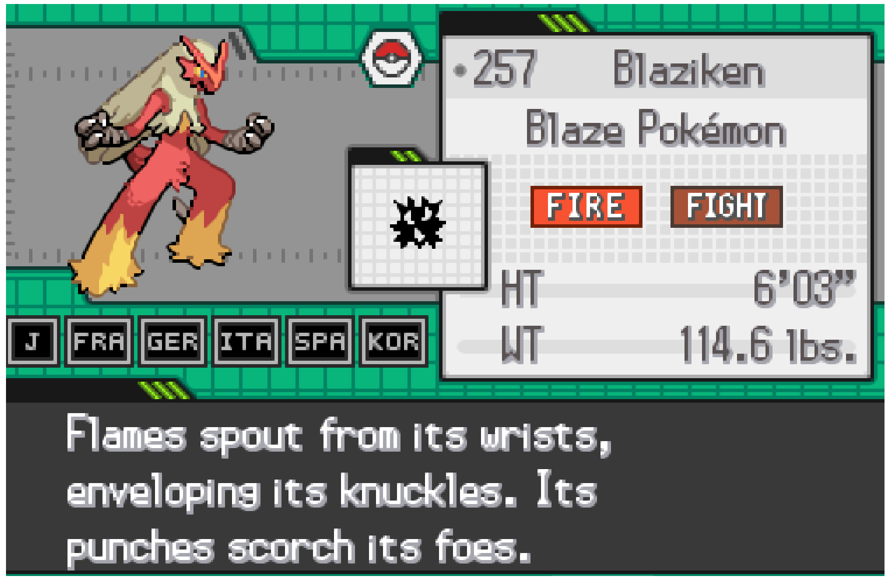
If you've been anywhere near the video game scene in the past 30 years, you should be quite familiar with the Pokémon franchise. The main series games are RPGs that allow players to battle each other with creatures called Pokémon in different regions, gyms or routes. All the information about these Pokémon is stored in a compact handheld device called a Pokedex, which is handed to our protagonist at the start of every game. Pokedex entries usually consist of the Pokémon's name, typing, category, weight, height and a short description. Those descriptions range from cute little quips to wild, questionable claims that make me doubt Nintendo's view of the players' intelligence. Nevertheless, in this essay, I will attempt to test and/or validate these claims through the most powerful tool in the universe: Mathematics.



The Poxedex entry for *Blaziken* from *Pokémon Black*

1.

The first Pokémon on trial today is none other than Magcargo, a Pokémon whose Gen V dex entry states that "its body temperature is roughly 18,000 degrees F" (Around 10,000°C). You may wonder whether that is even physically possible, especially considering Magcargo's measly weight and height of 0.8 m and 55 kg. To put this into context, the sun has a surface temperature of only 5,500 °C and weighs about 36 Octillion times Magcargo. There are multiple reasons that this would be a serious issue, such as:

1. Magcargo would be radiating extreme amounts of energy. We can calculate this using the **Stefan-Boltzmann law**, $\mathbf{P = \sigma A T^4}$, where P represents power in watts, σ

represents the Stefan-Boltzmann constant of 5.670×10^{-8} $W \cdot m^{-2} \cdot K^{-4}$, A represents the surface area of the object, and T represents the temperature in Kelvins. For this test, I approximated Magcargo's surface area to be approximately 2 m^2, assuming he is perfectly spherical (which he is not). Using this formula, Magcargo would be radiating around 1.3 billion joules of energy every second. That's the same as an average volcanic explosion. Not very safe to keep in your pocket.

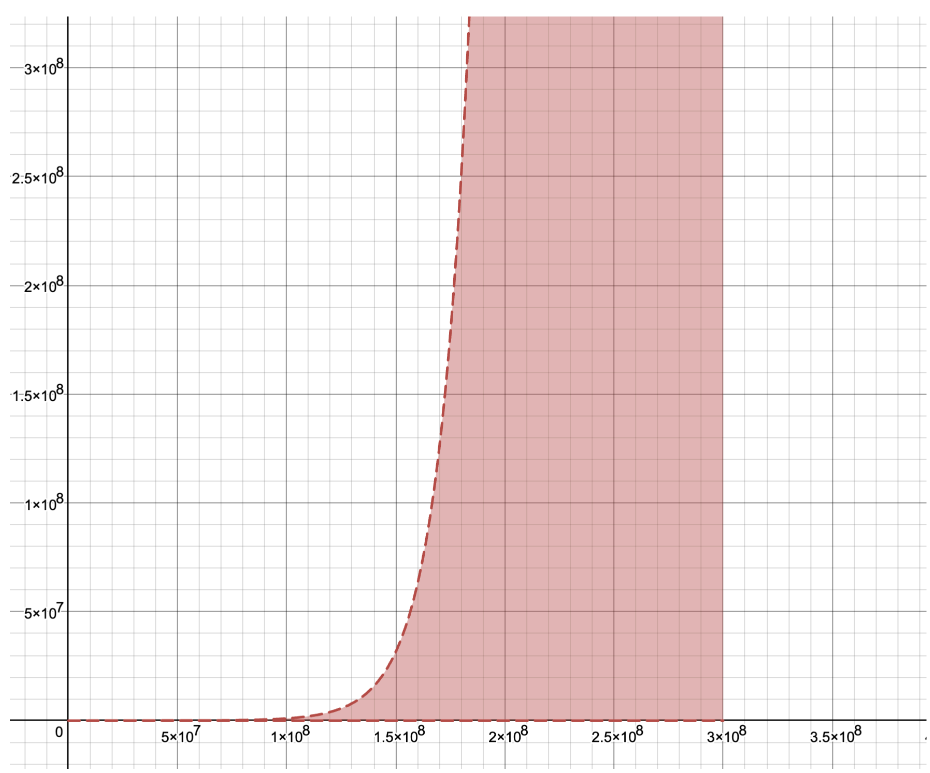
2. Magcargo is also said to have a Shell on its back that is "cooled" as per its Gen II Pokedex entry. Assuming the cooled shell is room temperature, the temperature difference from Magcargo's insides to its shell would be 9975 K. Using **Fourier's Law of Heat Conduction**, which states that the rate of heat transfer of a material is proportional to its negative temperature gradient, we can calculate the heat flux of the shell. The Pokedex informs us that the shell is composed of hardened magma or basalt. Therefore, we will use a thermal conductivity value of 2.5 $W \cdot m^{-1} \cdot K^{-1}$ and a thickness of around 5cm. This gives us a heat flux value of 498,750 $W \cdot m^{-2}$, making it essentially impossible for the shell to be even solid, let alone cool. We can also take a roundabout approach and instead attempt to derive a thermal conductivity value for this shell using a heat flux value of 100, which is far more reasonable. Using the same units from before, we get a thermal conductivity value of 0.000488 W/m·K. The most efficient insulator ever made, silica aerogel, only has a thermal conductivity of 0.013. If Magcargo really was this insulating, it would find much better use in the Johto Space Agency rather than the depths of Celadon City.
3. To sustain this high temperature while actively losing the energy of a small city every second, Magcargo would have to be on a serious high-calorie diet. For this test, I will use a standard stick of butter, which has approximately 810 calories or 3,389 kilojoules of energy. Dividing it by the radiation rate from earlier, we find that Magcargo would need to be consuming 384 sticks of butter every single second. That would be 43 kgs of food that Magcargo would have to eat, nearly its entire body weight, every second of every minute of every day– a completely ludicrous suggestion .

Magcargo is clearly biologically and physically impossible. Small snails simply cannot be hotter than the Earth's core. And even if this were possible by some wild distortion of space and time, it should still definitely have an attack stat higher than 50.

2.

The next Pokémon at the stand is none other than Alakazam. Despite being one of my favourite psychic types, Alakazam's dex entry makes a worrying claim that it has an IQ of 5000 and "a thorough memory of everything that has occurred in the world". The dex is essentially saying that Alakazam's brain stores every single event in Pokémon history. To test this, we would need to quantify these events and simplify them as bits that we can store in Alakazam's brain.

For this model, we can assume Pokémon history began 300,000,000 years ago, the earliest time stamp recorded in Pokémon lore. It is possible to go beyond this date to when Arceus, the Pokémon god, was first created; however, this is typically referred to as myth in Pokémon, and so I chose to leave it out. To calculate the events for every year, I am going to use an exponential function, as it is only logical that as time went on and the population increased, the number of events would also increase. The function should be of the form **$E(t)= 1000e^{kt}$**, where t is time in years, 1000 represents the initial amount of events per year, and k is a specific growth constant. To define k, I decided to approximate around 1000 events per year in our year 0 and 1 trillion events per year in our present year. These have all been very modest estimates so far, but I wanted to give Alakazam a fair shot. Rewriting and substituting the function with the estimated values, I got k to be 6.908×10^{-8}. I then integrated the function from t=0 to t=300,000,000. This gave me an area of 1.45×10^{19}. A visual representation of this area can be seen on this graph:



My next task was to decide how many bits, the most basic unit of information, I would assign to each event. I decided to do this 3 different ways based on the level of memory Alakazam would have for each event:

1. **The most basic of basic memory.** For this method, I assigned each event only a single kilobyte of storage, meaning Alakazam stores only a short 1024 character summary of each event. This would mean Alakazam would have to have 1.18×10^{23} bits of storage in his brain, or 14.9 Zettabytes. That's about a tenth of all the data on the entire internet; a massive amount, but still possible for a high-intelligence creature like Alakazam.
2. **Medium level memory.** Realistically, a memory of an event should be much more than a quick text summary. If each memory were a decent resolution digital image, it would have around 5MB, and Alakazam would have to have a maximum capacity of 72.5 Yottabytes. This number far surpasses the storage capacity of any living organism, including humans. Alakazam's brain would have to be extremely large to account for this.
3. **High level, more accurate memory.** Our memories are full sensations, with audio and video that can feel like reliving the moment. If we simulate each memory as a 10-second 1080p video clip, around 50MB, we would get a total storage of 725 Yottabytes. Here, we have to start considering the limits of physics as a whole. The Bekenstein Bound is a physics concept that determines the maximum information that can be contained in a system. Using the formula $\mathbf{I} \leq \frac{2\pi RE}{\hbar c}$, where **I** is information, **R** is the radius of the sphere that encloses the system, **E** is the energy of the system, $\hbar$ is the Planck constant and c is the speed of light. If we assume the brain is 3kg with a radius of 12cm (a generous estimate; a human brain is only 1.5kg and has a radius of 10cm), we can use $\mathbf{E=mc^2}$ and the aforementioned formula to get the upper limit of information storage in Alakazam's brain. We get a total of 1.2×10^{42} bytes, much larger than 725 Yottabytes.

So, despite Alakazam's insane memory being well within the constraints of physics, we know that no biological creature can hold that much information and still function normally. The simple task of shifting or accessing that memory would require astronomical amounts of energy; energy that Alakazam's 48kg body cannot provide. Even an IQ of 5000 cannot let you escape science.

3.

The last Pokémon case we'll be examining today is a very inconspicuous one: Lanturn. It's a cute little Gen II Pokémon whose dex entry states "The light it emits is so bright that it can illuminate the sea's surface from a depth of over three miles." This claim doesn't seem too outrageous at first glance. To check if it's actually possible, we can use another Physics concept: **The Beer-Lambert Law.**

The Beer-Lambert Law states that the absorbance of light passing through a substance is directly proportional to its concentration and the distance it travels. We can modify this to help us determine the amount of light Lanturn will have to emit to still be visible from the surface, using the formula $\mathbf{I= I_0e^{-\mu x}}$, where $\mathbf{I}$ and $\mathbf{I_0}$ represent final and initial intensity, $\mathbf{x}$ represents the depth in meters and μ represents the coefficient of absorption. For clear water, the absorption coefficient is roughly 0.02 m^{-1}. Inputting this into the formula with a depth of 4828 m, we find that the ratio of I to I_0 is 1.16×10^{-42}. This means that the light Lanturn emits would have to be 10^{42} times the intensity of what is being seen at the surface. We can calculate the light Lanturn would have to emit for it to be even just visible at the surface. Since the pokedex uses the term "illuminate", I will use a surface lux value of 30, comparable to a streetlamp in the dead of night. If we multiply 30 by 1.16×10^{42}, we find that Lanturn would have to emit a whopping 2.6×10^{43} lux to fulfil that requirement. That's 10^{38} times brighter than the sunniest of sunny days, and far brighter than any actual anglerfish, the animal Lanturn is based on. GameFreak has created a 3 foot, 50 pound supernova-level bulb that we can safely put in our pockets.

We've shown how Magcargo would have to be running like a nuclear reactor to even come close to its dex entry. We've explained how, unless Alakazam is secretly a gargantuan data centre disguised as a Pokémon, it could never remember every single event in Pokémon history. We've proven that Lanturn would have to be the brightest object humans have ever seen to be visible from the sea surface. The Pokedex is clearly not a very reliable source. Despite all this, I do have to admit that in a world where the embodiment of space, time, god and the devil can be stored in the pocket of a 10-year-old, there is room for a pinch of reality-warping. Mathematical modelling is very cool, but it does have a hard time translating into the world of fiction. And so, for my final act as the grand Pokémon judge, I will be letting Magcargo, Alakazam, Lanturn and any other insolent mons free of all charges.

References:

1. Bulbapedia (2026). *Alakazam (Pokémon) - Bulbapedia, the community-driven Pokémon encyclopedia*.
2. Bulbagarden.net. (2020). *Lanturn (Pokémon) - Bulbapedia, the community-driven Pokémon encyclopedia*.
3. Bulbagarden.net. (2020). *Magcargo (Pokémon) - Bulbapedia, the community-driven Pokémon encyclopedia*.
4. Bulbapedia (2009). *History of Pokémon - Bulbapedia, the community-driven Pokémon Encyclopedia*.
5. BYJU's (n.d.). *Stefan Boltzmann Law - Derivation, Formula, Equation, Examples*.
6. BYJU's (2025). *Fourier's Law - Formula, Derivation, Definition, Equation*. [online]
7. Wikipedia Contributors (2025). *Bekenstein bound*. Wikipedia.
8. BYJU'S (2018). *Derivation of Beer Lambert Law*.