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A2_9 How to be a Healthy Sith Lord

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Abstract

We find that a Sith lord must consume roughly 10^{12} kcal if he wishes to produce force lightning over a range of 10m. This is equivalent to over 1.85 million Big Macs. We thus determine it is unlikely any Sith lord who uses this power will be healthy after even one use.

Introduction

The sci-fi film series “*Star Wars*” revolves around a mysterious power known as “The Force” that can be used to move objects, and even produce lightning from one’s fingertips. We will investigate how many calories a Sith lord (a user of force lightning) will need to consume to be able to healthily produce force lightning

Theory

We model our Sith lord and his victim as the two plates of a parallel plate capacitor. We do this as the production of lightning requires a powerful discharge of electrical energy. This treatment is similar to that taken for natural lightning, where the clouds and the ground are the two plates [1]. We assume the only resistance in the model comes from the body of the Sith lord.

The total amount of energy a Sith lord will need to consume to produce lightning, W_c , is the amount of energy required to charge a capacitor which is given by

$$W_c = \frac{1}{2}CV_d^2, \quad (1)$$

where C is the capacitance of the Sith lord and V_d is the voltage across the two plates of the

capacitor i.e. the Sith lord and his victim. The capacitance is the ratio of charge on the plates and the voltage applied across the plate.

Due to air being an insulator, the discharge voltage across the plates has to be great enough to overcome the dielectric breakdown of air. This requires an electric field strength of $3 \times 10^6 \text{Vm}^{-1}$ [2] which we define as E_{ba} .

The Sith lord using his lightning is analogous to the discharge of a capacitor, we can thus model the behaviour of the current via Eq.(2)

$$I = I_0 e^{-\frac{t}{RC}} \quad (2)$$

where I_0 and I are the original and final currents through the capacitor, R is the resistance the capacitor discharges through (in this case the resistance of a human body) and t is the discharge time of the capacitor.

We can rearrange Eq.(2) for capacitance yielding

$$C = \frac{t}{R \ln\left(\frac{I_0}{I}\right)} \quad (3)$$

Substituting Eq.(3) into Eq.(1) gives us the energy required to produce lightning as a function of the current, I ,

$$W_c = \frac{tV_d^2}{2R \ln(\frac{I_0}{I})} \quad (4)$$

Using the definition of the discharge voltage of the capacitor and the resistance across the circuit, V_d and R

$$V_d = E_{ba}d \quad (5)$$

$$R = \frac{V_b^2}{P_d} \quad (6)$$

we can rewrite Eq.(4) to

$$W_c = \alpha \frac{tP_d E_{ba}^2 d^2}{2V_b^2 \ln(\frac{I_0}{I})} \quad (7)$$

where d is the separation of the capacitor plates, V_b is the voltage across the human body and P_d is the power used by a human body to remain alive. We use the resistance of the body as we assume this is the only resistance present within our circuit. α is a conversion factor from Joules to kcal. It has a value of 0.000239.

In our model we assume that there is no object that is more conductive than the target and that both the Sith lord and his victim are stationary.

Results

Fig.(1) shows how much energy is discharged from the capacitor over 0 to 10m. We use a range of 10m as force lightning is used as a short range attack and thus anything over 10m is an unrealistic use of the power. The values for I_0 and I are 0.2A and 0.1A [3]. t_d is 30s and P_d is 2700kcal \pm 300kcal per day [4]. This is equal to 0.13W \pm 0.01W. 30s is used as the discharge time, because this is the length of time prisoners given the death penalty are subjected to electrocution [5]. The voltage across a human body V_b is an average of 0.445V (\pm 0.205V) [6]. From Figure (1) we can see that the energy required by the Sith lord to generate lightning increases with the square of the distance to his target.

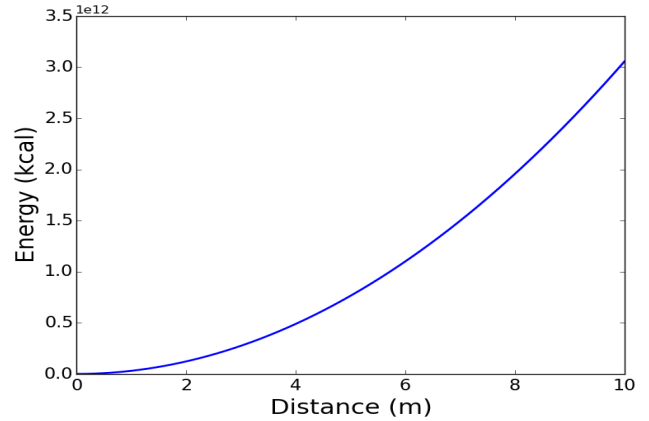


Figure 1: The graph shows how the energy (in kcal) required for the Sith lord to produce lightning increases distance.

Conclusion

We have found that for the Sith lord to produce lightning over a range of 10m he is required to consume of order 10^{12} kcal (approximately 10^{15} J). This is approximately 1.85 million Big Macs. We can thus conclude that without drawing power from some other source it is unlikely a Sith lord could healthily produce lightning.

References

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