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Can We Power a Spaceship?

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Abstract

This paper discusses the possibility of humans being able to produce enough energy, via effective exercising, in order to power a single space ship. The dimensions of the spaceship were taken using a paper model of the Axiom spaceship from the film WALL-E, and were scaled up to store the population value obtained from the movie. It was concluded that the acceleration of the Axiom in space would be 1.14 ms^{-1} per day, if powered by a population of exercising adults.

Introduction

In the Pixar animation film WALL-E, the Axiom (a spaceship) contains a population of 600,000 people [1]. This paper talks about the possibility of powering the spaceship, using the energy provided by the humans doing exercise rather than its usual source of power.

Modelling the Axiom spaceship

The Oasis of the Seas is the modern day equivalent of the Axiom as it's the world's largest cruise ship so we assume that they have a similar density. This was then used to calculate mass of the Axiom.

The Axiom was scaled up as a cylinder and the following values were as used, as demonstrated in table 1:

	Oasis of the sea	Axiom
Length (m)	362	4540 ^[2]
Beam* width (m)	625	1188 ^[3]
Beam radius (m)	312.5	594
Volume (m ³)	1.44×10^5	8.78×10^6
Mass (kg)	1×10^8	6.10×10^9
Density (Kg m ⁻³)	694	694

Beam*: The width at the widest point.

Table 1: Shows a comparison between the cruise ship and the Axiom [4, 5].



Image 1: Shows a comparison between the Oasis of the Sea (left), and the Axiom (right) [3].

The Energy Produced By Humans

A number of assumptions were made when calculating the dimensions of the spaceship, and the energy produced by each adult on the Axiom. Looking at Image 2, we can assume that the overweight population on the Axiom weigh 160kg on average; in comparison to the average North American (highest body mass of any continent) weighing 80.7kg [6], moderate exercise on an exercise bike burns around 768 calories an hour [7] which is equivalent to 3379.2 joules.



Image 2: Image showing the appearance of the humans in the movie, from this we can assume their weight to be much higher than the average human weight [8].

We know that there is a population of 600,000 and if each person does 2 hours of exercise a day:

$$3379.2 \text{ J hr}^{-1} \times 2 \text{ hr} \times 600,000 = 4.06 \times 10^9 \text{ Joules}$$

The exercise would not necessarily have to be done in one go, as this could possibly cause major health issues. Instead, it should be sufficient to assume that the 2 hours of exercise is completed over the course of one day. In addition, the humans would need to sustain their bodies, and hence they would be required to consume enough calories, using the resources available on the Axiom, to maintain their body mass.

We can then convert this energy to velocity using the equation for kinetic energy. The mass used will need to also include that of the population of the Axiom:

$$m = 6.10 \times 10^9 + (160 \times 600000) \\ = 6.20 \times 10^9 \text{ kg}$$

$$E = \frac{1}{2}mv^2$$

$$v = \sqrt{\frac{2E}{m}} = \sqrt{\frac{2 \times 4.06 \times 10^9}{6.20 \times 10^9}} = 1.14 \text{ ms}^{-1}$$

For this calculation, the deceleration is negligible due to the lack of a medium in space. This value

would be the acceleration per day, assuming that every person carries out 2 hours of exercise in each 24 hour period.

$$\text{Time} = \frac{\text{Velocity}}{\text{Acceleration}} = \frac{c}{a} = \frac{3 \times 10^8 \text{ ms}^{-1}}{1.14 \text{ ms}^{-1} \text{ day}^{-1}} \\ = 2.63 \times 10^8 \text{ days} = 720,000 \text{ years}$$

Assuming relativistic effects do not take place, it will take 720,000 years for the Axiom to reach the speed of light.

In the movie, the Axiom only travelled for 700 years [1], which means that it would only reach a speed of $2.91 \times 10^5 \text{ m s}^{-1}$.

Conclusion

Assuming that the humans are the ship's only power source, operating with 100% efficiency, as well as the other assumptions stated this paper, we can see that humans create 4.06×10^9 Joules of energy via medium exercise. This equates to an acceleration of 1.14 ms^{-1} per day on-board the Axiom. With this acceleration, the axiom would take over 700,000 years to accelerate to the speed of light but, in the 700 years it was away from the Earth in the movie, it would only reach a speed of $2.91 \times 10^5 \text{ m s}^{-1}$. From this, we can conclude that it is indeed possible for humans to power a spaceship through exercise. However, its velocity may not be ideal so it may be wise to seek out alternative power sources.

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