Journal of Physics Special Topics
An undergraduate physics journal

A3_5 1.21 Jigawatts!?!

L. Flood, K. Holland, T. Leversha, M. Manley

Department of Physics and Astronomy, University of Leicester, Leicester, LE1 7RH

December 15, 2022

Abstract

In this paper we are investigating how much power it would take for the DeLorean from Back to the Future to reach the 88 mph speed required to travel through time. We calculated that when the DeLorean is flying it requires less power than when it is driving on a road to reach the target velocity, and in both cases it requires far less power than the 1.21 GW that the flux capacitor can provide.

Introduction

In the hit movie series Back to the Future, Marty and Dr. Brown (Doc) use a DMC DeLorean to travel in time. Doc explains to Marty that the flux capacitor is capable of providing 1.21 jigawatts (gigawatts) for the DeLorean to be able to time travel and that the car must be travelling at 88mph to initiate time travel. In this paper we calculate how much power is wasted getting the DeLorean to 88 mph, both when the DeLorean is reaching the velocity by driving such as in the first Back to the Future movie and when the car is flying like in the second movie. By doing this we are able to find what the minimum power required for the DeLorean to travel through time is according to Dr. Brown's calculations.

Theory

Whether the DeLorean is driving on a road or flying through the air, there will be many sources of power loss for the vehicle, from friction to gravitational potential energy. We first worked out what would contribute to power loss in both cases. For the car driving on the road, the power loss will be from the kinetic energy to reach 88 mph (ΔKE), drag (F_D) and friction (F_{fr}). For the car when flying, power is lost from kinetic energy, gravitational potential energy (ΔGPE) and drag. Therefore the equations for power loss are:

$$P_{dr} = \frac{\Delta KE}{\Delta t_{KE}} + (F_{fr,max})v + (F_D)v \qquad (1)$$

$$P_{fl} = \frac{\Delta KE}{\Delta t_{KE}} + \frac{\Delta GPE}{\Delta t_{GPE}} + (F_D)v \qquad (2)$$

Where P_{dr} is the power loss from driving, P_{fl} is the power loss from flying, Δt is the change in time and v is the maximum velocity of the DeLorean. Once we find the power lost in both cases we are able to find the minimum amount of energy needed for time travel. To calculate the frictional force we use the equation:

$$F_{fr,max} = \frac{mg}{2}\mu_s \qquad (3)$$

Where m is the mass of the car, g is the acceleration due to gravity and μ_s is the coefficient of static friction for rubber against asphalt. There is a factor of 1/2 due to the DeLorean being a rear wheel drive car[1]. To calculate the drag force [2] we use:

$$F_D = \frac{1}{2}\rho v^2 C_D A \tag{4}$$

Where ρ is the density of the fluid, C_D is the drag coefficient and A is the cross-sectional area of the car.

Results

To calculate the change in time for the kinetic energy, we assume acceleration is constant and that the DeLorean's initial velocity is 0 ms^{-1}. Using the equation for constant acceleration, $a = \Delta v/\Delta t$, where a is acceleration, and due to the DeLorean being able to go from 0-60 mph in 9.60 seconds [1], we can calculate an acceleration of 2.79 ms^{-2} and therefore taking a time of 14.10 seconds to reach 88 mph.

First we calculate the power loss from driving: The mass of the DeLorean is 1244 kg [1], the dimensions are 1.85 m x 1.17 m [1] and the acceleration due to gravity is 9.81 ms^{-2}. The coefficient of static friction for rubber against asphalt(dry) is 0.90 [3], the density of air is 1.20 kgm^{-3} [4] and finally the drag coefficient has a value between 0.28-0.40 [5] so we will use 0.34. Using these values we calculate that the power lost due to driving is $P_{dr} = 3.11\text{x}10^5$ W.

Now to calculate the power lost when the DeLorean is flying: We assume that the change in height for the car when flying is 5 m and that it is able to do this in 10 seconds. All other variables are the same as the previous case. Therefore the power lost due to flying is $P_{fl} = 1.01\text{x}10^5$ W.

Conclusion

In conclusion, we find that there is a smaller loss in power when the DeLorean uses flight to reach 88 mph than when driving on a road. However, due to both power losses not even being in the megawatts and the power being provided by the flux capacitor being in the gigawatt range, there is still plenty of power left for time travel; even when considering the scenario with the highest power lost, driving, there is almost the full 1.21 GW left.

Both powers calculated in this paper give a general idea of where there is a loss of power from motion for this vehicle, obviously there could also be power lost from other sources specifically the power needed to keep the DeLorean in the air when flying. We are unable to calculate this value, but it would most likely be a significant value and therefore lead to the final answer for the power lost when the DeLorean is flying to be larger than the power lost from driving. In future papers, we could calculate the power lost from using a train to push the DeLorean up to the required velocity or how using a train instead of the DeLorean would affect power lost much like the third movie in the Back to the Future franchise.

References

[1] `https://www.ultimatespecs.com/car-specs/Delorean/17644/Delorean-DMC-12-.html` [Accessed 19 October 2022]

[2] `https://www.nuclear-power.com/nuclear-engineering/fluid-dynamics/what-is-drag-air-and-fluid-resistance/drag-force-drag-equation/` [Accessed 19 October 2022]

[3] `https://www.engineeringtoolbox.com/friction-coefficients-d_778.html` [Accessed 19 October 2022]

[4] `https://www.engineersedge.com/calculators/air-density.htm` [Accessed 19 October 2022]

[5] H. Heisler, *Advanced Vehicle Technology (Second Edition)* (Butterworth-Heinemann, Oxford, 2002), Vol. 1, p.593.