Journal of Physics Special Topics
An undergraduate physics journal

P1_9 Sail the Cosmos, Enterprise!

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December 7, 2021

Abstract

The USS *Enterprise* (CV-6), the legendary carrier that fought alone against the entirety of the Imperial Japanese Navy - and won - is one of the most decorated ships ever constructed. The planet Neptune, the last of the gas giant planets in our solar system, named after the God of the Seas. In this paper, we shall attempt to sail one 'god of the seas' upon another - the USS *Enterprise* upon the planet Neptune - and determine how long it would take for her to sail around the around the entirety of Neptune. It is found that when suspended at the height in the atmosphere where the atmospheric pressure is 1 bar (as it is found that *Enterprise* would sink at that height), the USS *Enterprise* would take 70.81 (Earth) days to sail around the Neptunian equatorial plane.

Introduction

The force of gravity acting upon *Enterprise* is equal to her mass, m, multiplied by the force of gravity on Neptune, $g = 11.15$ m/s^2 [1].

$$F_g = mg \tag{1}$$

The buoyant force resulting from the Neptunian atmosphere being displaced is given from the Archimedes Principle, which states that the mass of fluid displaced provides an upward force on the displacing object [2], given by Eq. (2):

$$F_b = m_a g \tag{2}$$

Substituting in the volume displaced V and the atmospheric density, $\rho_a = 0.45$ kg/m^3 [1], will rearrange Eq. (2) to Eq. (3), below:

$$F_b = gV\rho_a \tag{3}$$

The engines on the USS *Enterprise* (CV-6) were four Parsons single reduction geared steam turbines, capable of producing a maximum speed of 32.5 knots (37.6 mph) in the oceans of Earth, which translates to a velocity of 16.81 m/s (4 S.F.) [3]. As the Neptunian atmosphere does not have the same density as seawater on Earth, the drag force acting upon the USS *Enterprise* will be affected by the change in density. Using the Rayleigh Drag Equation [4], given below, will allow us to determine the speed at which the USS *Enterprise* will travel through the Neptunian atmosphere. This can be done by first finding the drag force acting upon the USS *Enterprise* in seawater on Earth, which has a density of *1.03 kg/m*^{3} [5]. Then, assuming this drag force will remain a constant, the Rayleigh Drag Equation will be applied once more to determine the change in the USS *Enterprise's* velocity.

$$F_d = \frac{1}{2}\rho v^2 C_d A \tag{4}$$

The distance the USS *Enterprise* must travel to sail around Neptune is found from Neptune's radius, r.

$$d = 2\pi r \tag{5}$$

Thus, the time for the USS *Enterprise* to sail around Neptune is found from the equation given below:

$$t = \frac{d}{v} \tag{6}$$

Analysis

Taking the mass of the USS *Enterprise* to be 19,800 tons [3], the force of gravity acting upon her within the Neptunian atmosphere is found to be 2.208 x 10^8 N (4 S.F.).

The resultant buoyant force acting upon the USS *Enterprise* is given by her dimensions, as she will be suspended at the point where the atmospheric pressure is 1 bar, resulting in a buoyant force of 324,700 N (4 S.F.).

As the buoyant force is much smaller than the force of gravity - almost negligible in comparison - it is unlikely that the USS *Enterprise* could float upon the surface of Neptune. An additional upthrust of 2.204 x 10^8 N (4 S.F.) must be provided in order to float - a force almost equal to that of the force of gravity acting upon her - which is unfeasable to provide, even with modern technology.

The drag force resulting from seawater on Earth is found to be 11,260 N (4 S.F.), which in turn gives the velocity of the USS *Enterprise* in the Neptunian atmosphere to be 25.43 m/s (4 S.F.), or 56.9 mph.

The circumference of Neptune at the equator is found to be 1.556 x 10^8 m (4 S.F.), using the known equatorial radius of 24,764 km [1]. As a result, the USS *Enterprise* would take 6.118 x 10^6 (4 S.F.) seconds - 70.81 (Earth) days - to sail around Neptune, assuming that the USS *Enterprise* is managing to float at the point where the atmospheric pressure is 1 bar.

Assumptions

It is assumed that the USS *Enterprise* (CV-6) is a rectangular cuboid of dimensions 246.7 m x 33.2 m x 7.9 m [3] [6], as shown in *Figure 1.*

It is assumed that the drag force acting upon the USS *Enterprise* will remain constant between the oceans of Earth and the atmosphere of Neptune.

It is assumed that the drag coefficient for the USS *Enterprise* is 0.295; as given by *NASA* for a bullet-shaped airfoil [7].

References

[1] `https://nssdc.gsfc.nasa.gov/planetary/factsheet/neptunefact.html` [Accessed 30 November 2021]

[2] P. A. Tipler and G. Mosca, *Physics for Scientists and Engineers* (2008), 6th Edition, p. 432

[3] `http://www.cv6.org/ship/big_e.htm` [Accessed 30 November 2021]

[4] `https://www.chemeurope.com/en/encyclopedia/Drag_equation.html` (Accessed 29/10/2021)

[5] `https://hypertextbook.com/facts/2002/EdwardLaValley.shtml` [Accessed 30 November 2021]

[6] `http://www.cv6.org/ship/1938view.htm` [Accessed 30 November 2021].

[7] `https://www.grc.nasa.gov/WWW/k-12/airplane/shaped.html` [Accessed 30 November 2021]

Figures

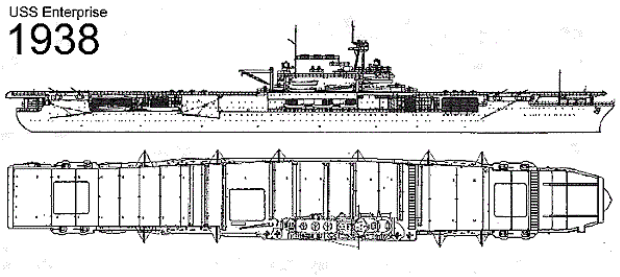

Figure 1: A diagram of the USS Enterprise (CV-6) depicting her as commissioned in 1938. [6]