Computer methods for astrodynamics

INCLUDES EXAMPLES WITH POLIASTRO SOFTWARE

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First Edition

Preface

This book tries to describe in detail all the principles for astrodynamics, orbital mechanics and orbit determination. Reader will also find non common topics such us timescales, reference frames and low-thrust maneuvers, for example. My intention writing this book is not only to have a reference manual on astrodynamics but also an open-source book on the topic, so anyone can contribute and add more information, chapters, references or algorithms.

Some errata may appear along this book, although intention is always good. If found, please send me an email to ingenierodeaviones@gmail.com or just open an issue in the official GitHub repository at https://github.com/jorgepiloto/astrobook. You can also correct by yourself the errata and open a pull request so it can be corrected in future versions.

Finally, I want to thank all open-source community. No matter if you contribute to scientific, engineering or web projects, sharing knowledge will guide humanity towards a real free world. For that reason this book has been developed using only open-source tools such us LaTeX, Inkscape and Python.

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CHAPTER 1

Astronomy introduction

We usually refer to celestial mechanics, astrodynamics, orbital dynamics, attitude dynamics or astronomy as the same thing. However it is important to make clear that these concepts differ from each other and we should properly understand what we refer to when talking about each one. Let us start this chapter by defining them in detail:

Definition

Celestial mechanics is the scientific study of celestial body dynamics.

Definition

Orbital dynamics is the scientific study of the motion of small orbiting bodies.

Definition

Attitude dynamics is the scientific study of the relative position and orientation of bodies in space.

Definition

Astronomy is the scientific study of matter and phenomena in the universe, especially in outer space, including the positions, dimensions, distribution, motion, composition, energy, and evolution of celestial objects.

Definition

Astrodynamics is the branch of astronomy that studies the motion of celestial and man-made bodies in space subjected to both natural and artificial perturbations.

1.1 The Solar System models

When first human beings started to look at the stars, they tried to explain

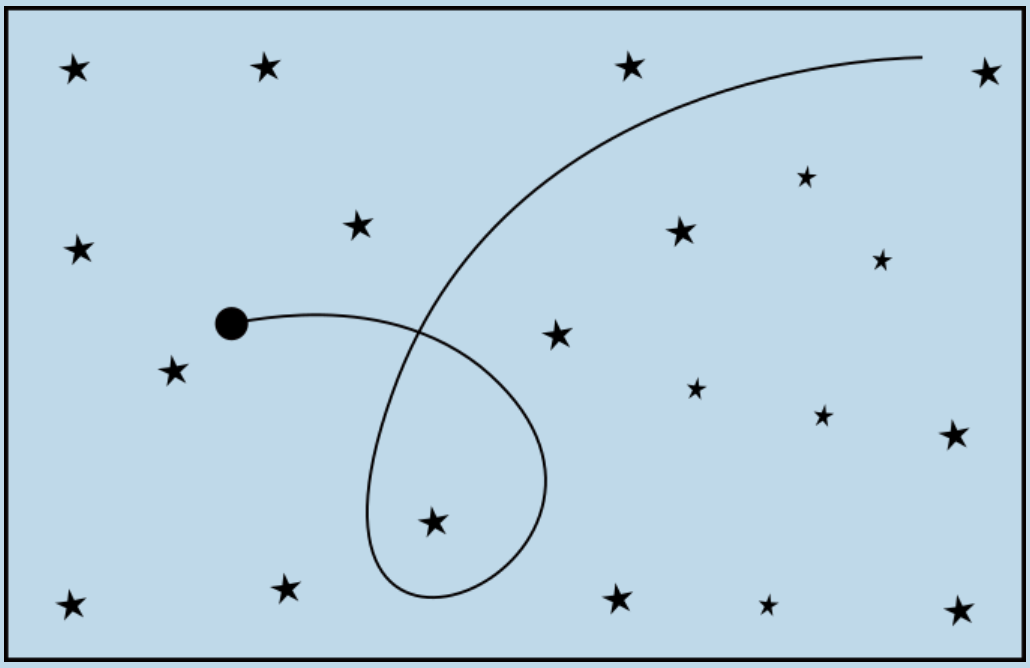

Figure 1.1.1: Apparent path of a celestial body

1.2 The Solar System and its main bodies

In this section, the Solar System

1.2.1 Mercury

Mercury is the most inner planet that orbits the Sun, which makes difficult to observe from Earth. It completes an orbit around the Sun in approximately 88 Earth days. This is the main reason behind its name: the fleet-flooted messenger of the gods. In addition, the chemical element mercury is also a quick-flowing silvery liquid.

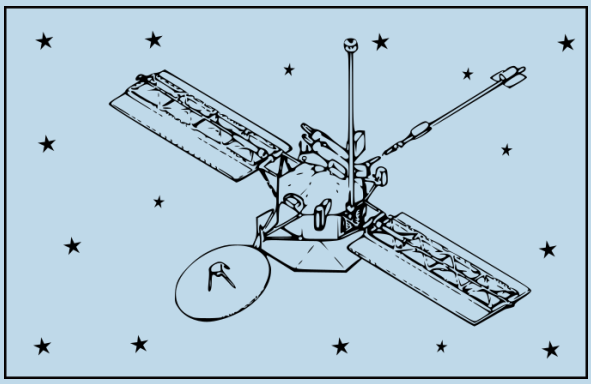

Figure 1.2.1: Mariner 10 spacecraft drawing

When the Mariner 10 spacecraft orbited the planet, it took some pictures of the surface. They revealed a heavily cratered planet similar to our Moon's surface. The spacecraft also discovered a magnetic field 10^{-4} times the Earth one. However, due to its small size, the planet has lost all its internal energy and thus it is no longer geologically active. After Mariner mission, the MESSENGER spacecraft revealed the biggest ringed area: the Caloris Basin, which has a 1300[km] diameter.

Mercury does not have an atmosphere since the solar wind is so strong in this region. The planet is quite dense and mission data indicates that its core should be composed by a large metallic core, which is supposed to occupy around 70% of planet's radius. As a brief resume, Mercury is a metal planet with a tiny rock mantle.

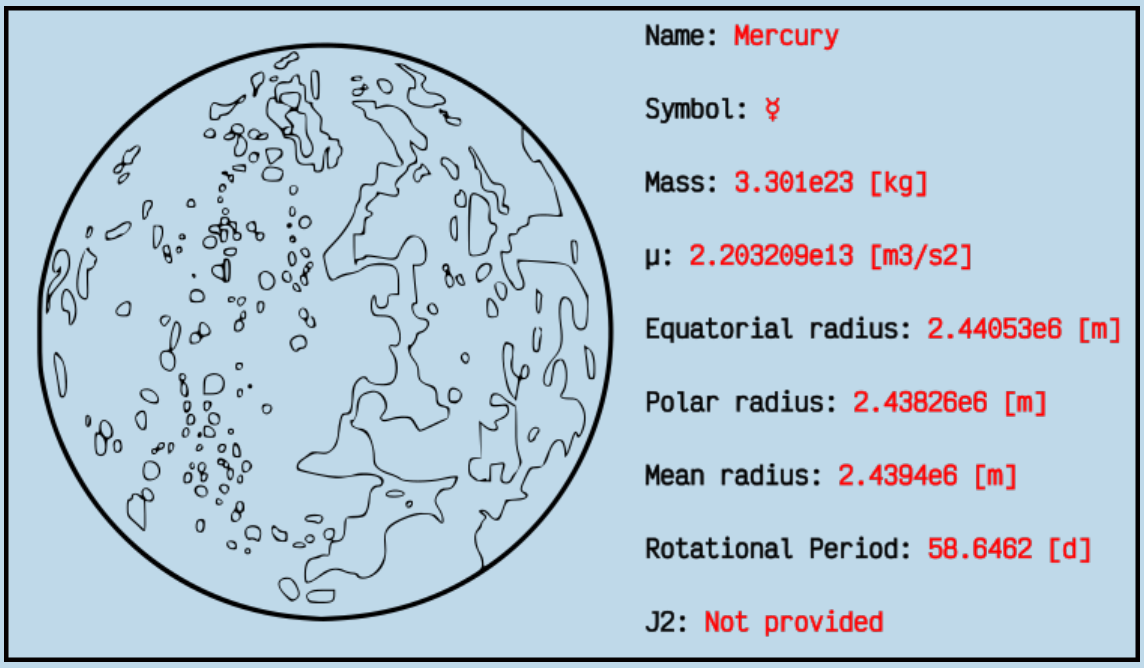

Figure 1.2.2: Mercury data

1.2.2 Venus

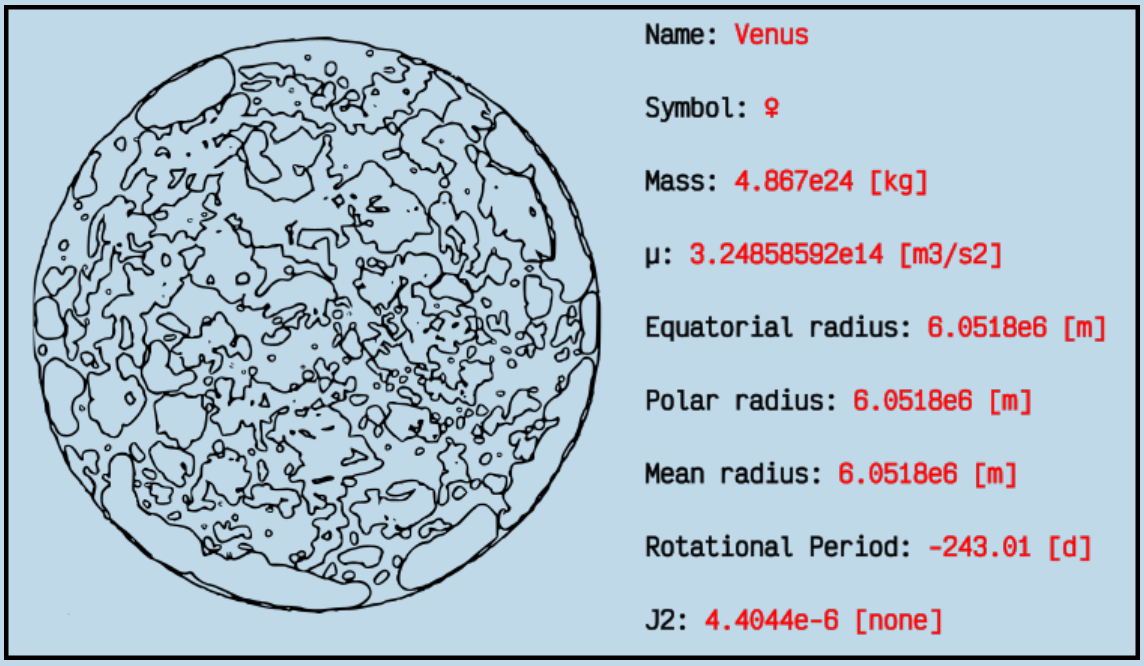

Figure 1.2.3: Venus data