Space Mechanics
(Meccanica Spaziale)

2024/2025, second semester

Teacher: Giulio Baù

The physical exploration of space could be possible only partially without space missions, where a space probe equipped with science instruments is sent to one or more specific targets in the Solar System. One example of space mission is Europa Clipper, which will orbit around Europa, the smallest of the four Galilean moons of Jupiter, to discover whether it can host life. Another challenging project is the Artemis program intended to reestablish a human presence on the Moon for the first time since the Apollo 17 mission in 1972.

Space Mechanics deals with the application of Celestial Mechanics to problems concerning the motion of a space probe. In particular, the trajectory design of a space probe is based on our knowledge of the properties of different dynamical models which allow us to approximate the real dynamics.

In the course, first the classical patched-conic method, commonly employed in the preliminary design of interplanetary trajectories, will be presented. Then, after recalling in detail the planar circular restricted 3-body problem (PCR3BP), the geometry of the solutions will be studied thanks to some fundamental results due to Conley, Moser, and McGehee. Part of the course deals with the description of the most typical maneuvers made to change the orbit of a space probe. Other related topics to the previous ones are included: the gravitational sphere of influence, Lambert's theorem, the local integrability of the PCR3BP in a neighborhood of a binary collision, and Kepler's problem with variable mass. Finally, if time allows, it will be introduced Pontryagin's maximum principle, which is relevant for problems of optimal control often arising in the context of space missions.

Practical information

The course lasts 42 hours and it takes place in the second semester. The exam consists of an oral presentation on one topic presented in the course. Prerequisites for this course consist in part of the notions given in the courses of "Istituzioni di Fisica Matematica" and "Elementi di Meccanica Celeste".

If you are interested to have more information about this course, you can contact me by e-mail: giulio.bau@unipi.it.