Introduction to Orbital Mechanics — Syllabus

Overview: The course will introduce students to basic elements of orbital mechanics. In particular students will learn to understand orbital elements, and to compute orbits from given initial data. This will be done using a variety of analytical and numerical tools.

Time: MTThF June 4 — June 22, 10AM-noon and 2pm-4pm.

Instructors/TAs/Consultants: B. Bennett, W. Horn, B. Shapiro, F. Varadi.

Pre-requsites: Some multi-variable Calculus is necessary. Some differential equations, Physics and Astronomy is desirable.

Electronic Resources: Mathematica, Tracking Software, Numerical Solvers, Web resources.

Suggested Reading:

Books: Nathaniel Grossman: The sheer joy of celestial mechanics; V. G. Szebehely and H. Mark: Adventures in celestial mechanics.

Web sites: http://spaceflight.nasa.gov/realdata/elements/index.html, http://celestrak.com/columns/v04n03, http://celestrak.com/NORAD/elements, http://liftoff.msfc.nasa.gov.RealTime/JTrack/3D/JTrack3D.html.

Contents

June 4

Morning: Introductory examples, Newton's Law's of motion, Newton's Law of Gravity. The two body problem.

Afternoon: Review of Calculus of Several Variables, Change of Variables, Polar Coordinates, Conic Sections in Polar coordinates.

Homework: Selected problems from Calculus of several variables, Derive a formula for the gradient in polar coordinates. Spherical coordinates.

June 5

Morning: The two body problem in a central field, first integrals (Conservation of Energy and Angular momentum). Kepler's laws. Uniform circular motion. Examples.

Afternoon: More on Conic Sections (eccentricity, semi axes, foci etc.) Review of differential equations.

Homework: Compute examples for geostationary and polar circular orbits. Compute the ground traces of some circular orbits.

June 7

Morning: Solving Newton's laws of motion and deriving Kepler's laws. Examples. Orbital elements. Kepler equation.

Afternoon: More on ODE, Numerical solutions (Euler & Runge-Kutta) using Mathematica to solve systems of ODE. Visit to the planetarium to study the night sky.

Homework: Simple Orbital computations in a central field.

June 8

Morning: Continuing the material of the previous day. Relationship between Orbital Elements, Cartesian and polar coordinates.

Afternoon: Access NASA Website for specific data on satellites, due computations based on the material of the first week and compare with NASA data. Explain the differences.

Homework: More examples of actual satellite orbits.

June 11

Morning: Observation of Satellites, Ground traces, tracking satellites in the night sky.

Afternoon: Guest lecture

Homework: Studying the effects on orbits using software.

June 12

Morning: Perturbations of central fields impact on spherical and elliptical orbits.

Afternoon: Introduction to professional software packages.

Homework: Simple exercises in using the software packages. Plotting curves.

June 14

Morning: More on perturbations, physical origins and mathematical treatment of perturbations. Using orbital elements to describe perturbed orbits.

Afternoon: Applying the professional packages to previous problems.

Homework:

June 15 All day Mini project: landing on the moon.

Evening: Field trip to star gaze.

June 18 — June 21 Assignment of projects, solving projects, preparing the results. Molniya orbits and critical inclinations. Guest lectures

June 22 Presentation of the results of the projects. 15 minutes lectures accompanied by a short article on the project.