Code 004.94

MODELING THE SPACECRAFT ORBITAL MANEUVERS WITH USING GEOGEBRA PACKAGE FOR VISUALIZATION

Kuznyetsov Yuriy[1], *Stolyarevska Alla*[2]

[1]The Research Production Enterprise Hartron-Arkos Ltd, Kharkiv, Ukraine
[2]The International Solomon University, Kharkiv, Ukraine

Abstract

The paper considers the using of GeoGebra package for visualization in the modeling of orbital maneuvers of spacecraft in the near-Earth space. The technique has been tested in the study of the course "The Mechanics of Space Flight" in National Technical University "Kharkiv Politechnic Institute".

Аннотация

В работе рассматриваются возможности применения пакета GeoGebra для визуализации при моделировании орбитальных маневров космических аппаратов в околоземном пространстве. Методика была апробирована при изучении курса «Механика космического полета» в Национальном техническом университете «Харьковский политехнический институт».

Introduction

An important part of the course "The Mechanics of Space Flight" is the visualization in the modeling of orbital maneuvers of the spacecraft: the transition from one orbit to another. The paper proposes the use of GeoGebra package [1] to visualize the modeling of the maneuvers. The GeoGebra package has been used in [2, 3] to describe the motion of the planets in the study of Kepler's laws, and to illustrate orbital geometry when flying satellites in near-Earth elliptical orbits.

Examples of problems and their solution

The goal of the courses "The Mechanics of Space Flight" is to acquaint students with theoretical material of celestial mechanics and space flight mechanics, to give them an opportunity to solve a number of practical problems for coplanar and spatial maneuvering of spacecraft. Various problems of impulse orbital maneuvers including the planar two-pulse interorbital transitions are examined. Among different solutions to the problems the best one is the Hohmann solution, in which the transfer orbit is tangent to the initial and final orbits [4]. In orbital mechanics, the Hohmann transfer orbit is an elliptical orbit used to transfer between two circular orbits of different radii in the same plane. The orbital maneuver to perform the Hohmann transfer uses two engine impulses, one to move a spacecraft onto the transfer orbit and a second to move off it.

Problem # 1. The transition from an elliptical orbit to a circular

The carrier rocket inserts spacecraft into initial elliptical orbit with the following parameters: H_a=250 km, H_π=175 km, Ω=0°, i=52.0°, ω_π=0°, where H_a, H_π, Ω, i, ω_π – orbital elements. Calculate the magnitude and direction of corrective impulse to give propulsion spacecraft control system consisting of two correction motors, for which the spacecraft will move to the height of the working circular orbit $H_o=H_a$, lying in the same plane as the initial orbit. Graphically build spacecraft motion trajectory for the initial and working orbits using GeoGebra.

The instructions for the solution. To determine: the type of orbit maneuver point and direction of the velocity vector of momentum (the problem should be sought in the class of single-pulse coplanar interorbital transitions); the start and end speed of the spacecraft; the value of semi-major axis of spacecraft initial orbit; the required value of pulse rate; and the orbital parameters for visualization.

Problem #2. The transition from the inner circular orbit to an elliptical

The scientific spacecraft with the mass m = 6.5 t is moving on the initial circular orbit height H_0 = 150 km. Calculate the orbital maneuver that implements the optimal transition from the initial circular orbit to elliptical orbit with parameters H_a = 1500 km, H_π = 500 km. Starting and operating the orbit are coplanar. Settings Ω, ω_π are equals to 0°. Consider the variants of apogee and perigee transitions. Compare the fuel costs required to perform transitions. The characteristics of propulsion system are the follows: P = 800.0 N is the thrust propulsion system; Q = 0.3 kg/s – the flow rate of fuel propulsion.

Paint schemes apogee and perigee transitions. Build spacecraft motion trajectory for the initial and working orbits using GeoGebra.

The instructions are the follows: to calculate the necessary impetus for the apogee and perigee transfer speed; to determine the fuel consumption to perform apocentric transition; to calculate the duration of the operation control and of the fuel consumption; to determine the fuel consumption to perform pericentric transition; to calculate the duration of the operation control and of the fuel consumption.

Fig. 1, 2 shows the results of solving the problems 1, 2.

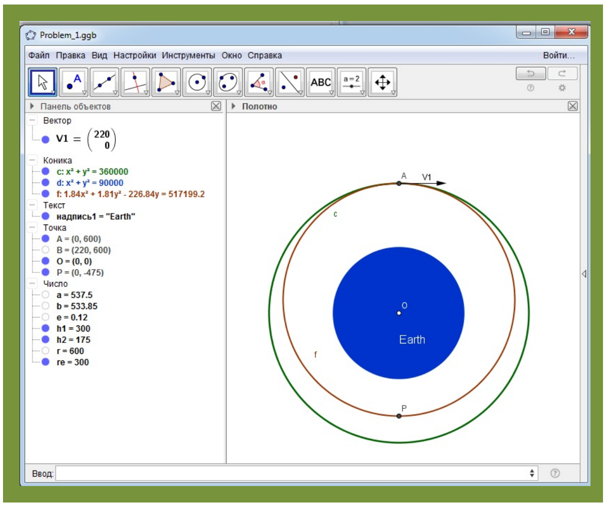

Figure 1 – The orbits of spacecraft motion in the problem 1

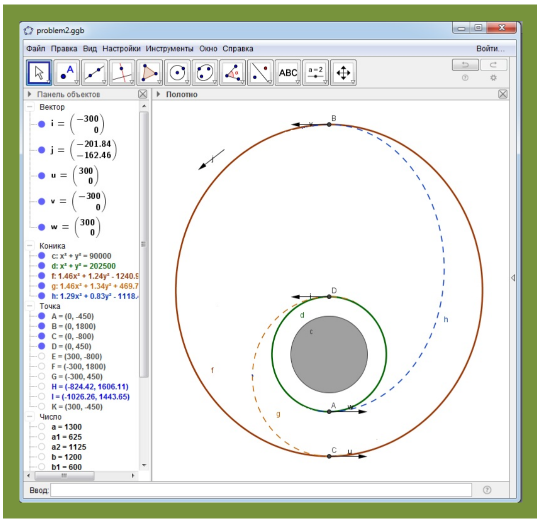

Figure 2 – The orbits of spacecraft motion in the problem 2

References:

1. https://www.geogebra.org
2. Tortosa L. Some geometric models of ancient astronomy with Geogebra. – Date: July 25, 2016 [Electronic resource] // The access mode: https://ggijro.files.wordpress.com/2011/07/article-7.pdf
3. Kerbal Space Program. – Date: August 13, 2016 [Electronic resource] // The access mode: https://www.reddit.com/r/KerbalSpaceProgram/comments/4ptxii/simple_maneuver_planner_in_geogebra/
4. Кузнецов Ю.А. Орбитальные маневры космических аппаратов в околоземном пространстве. Лабораторный практикум: Учеб.-метод. пособие / Ю.А. Кузнецов, Ю.А. Плаксий, А.В. Чумаченко. – Харьков: НТУ «ХПИ», 2013. – 84 с. – ISBN 978-617-05-0047-2.