Orbital Mechanics Calculator User Guide v1

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1 Introduction

The calculator is designed to provide a quick way to do simple calculations on elliptic orbits, including coplanar single burn manoeuvres. Support for hyperbolic orbits and non-coplanar manoeuvres will be added in the upcoming versions.

2 Structure

The workbook is divided into two sheets: the first one, "Main" is the calculator interface with orbit definition, inputs and outputs. The second sheet, "Workspace" contains intermediate steps for relatively more complicated calculations like Time-of-Flight and manoeuvres. The user is required to only interact with the Main sheet. Cells are color coded based on their I/O type. Pale orange fill indicates inputs, while grey-filled bold cells are outputs. In order to prevent corruption of the formulae, the sheet is protected allowing only the input cells to be editable. It is important to follow the units specified for each parameter for obtaining correct outputs.

2.1 Orbit Definition

The orbit definition section shall be used to provide orbital elements (Keplerian Element System) to fix the orbit in 3-D space. Although it is not required to define each and every element, at least the Semi-Major Axis (SMA) and Eccentricity are required for co-planar calculations. But defining the other angular elements often allows reliable interpretation of results from the I/O section.

2.2 Intermediates & Constants

This section is only for reference and does not need editing. All values here are calculated from the the definition section and will be further used for the specific calculations.

Orbit Definition	
Orbital Elements	**Value**
Semi Major Axis (km)	25000
Eccentricity	0.33
Inclination (deg)	11
RAAN (deg)	5
AoP (deg)	0
Mass of the central body (kg)	5.97E+24
Radius of the central body (km)	6371

Intermediates & Constants	
Conserved Quantities	**Value**
Sp. Angular Momentum (SI)	**9.42E+10**
Sp. Mechanical Energy (SI)	**-7.96E+06**
Orbital Period (s)	**3.94E+04**
Mean Motion (rad/s)	**1.60E-04**
Semi Parameter (m)	**22277500**
Periapsis Radius (km)	**16750**
Apoapsis Radius (km)	**33250**
Gravitation Constant (SI)	**6.67E-11**
mu (SI)	**3.98E+14**
Vesc at surface (km/s)	**11.18**
Vesc at Periapsis (km/s)	**6.90**
Orbital Period (hours)	**10.93**

CALCULATOR - I/O							
True Anomaly at Radius			**Radius at True Anomaly**			**Period to SMA**	
R (km)	25000		Nu (deg)	20		P (hours)	24
Nu (deg)	**109.27**		**R (km)**	**17004.45**		**SMA (km)**	**42226.91**
Velocity at Radius			**Flight Path Angle at True Anomaly**				
R (km)	15025		Nu (deg)	60			
V (km/s)	**6.09**		**FPA (deg)**	**13.783159**			
Time of Flight through True Anomalies				**Impulsive Burn Manoeuvre**		**(Co-planar LVLH)***	
Nu1 (deg)	0			Delta V azimuthal (km/s)		0.5	
Nu2 (deg)	60			Delta V radial (km/s)		0.5	
ToF (hours)	**0.950**					0	
ToF (%Period)	**8.69**			Nu at delta V (deg)		30	
				New SMA (km)		**42843.44**	
True Anomaly for Time Interval				**New Eccentricity**		**0.62**	
T1 (hours since last periapsis)		0					
T2 (hours since last periapsis)		2		**New Periapsis Radius (km)**		**16433.87**	
Delta-Nu (deg)		**104.17045**		**New Apoapsis Radius (km)**		**69253.00**	
* LVLH - Local Vertical Local Horizontal frame of reference							
Co-planar - burn does not change inclination							

Figure 1: A screenshot of the Main sheet

2.3 Calculator I/O section

This section deals with the specific calculations the user might be interested in performing. Most of the conversions / calculations are self explanatory if the user has a little background in orbital mechanics. If not, please see the references section for reading.

3 Glossary

Most of the parameters are named and/or abbreviated as per convention used in either the literature or the space industry. Nevertheless, some of them are listed below for the sake of convenience.

1. SMA — Semi Major Axis
2. RAAN — Right Ascension of Ascending Node
3. AoP — Argument of Perigee
4. mu — μ - Product of gravitational constant and mass of the body
5. Vesc — Escape Velocity
6. Sp. — Specific
7. Nu — ν - True Anomaly
8. FPA — Flight Path Angle
9. ToF — Time of Flight
10. deg — degrees - planar angle
11. (SI) — meaning *'in SI units'*

4 Author & Feedback

This work is available on my github. Feedback is most welcome.

- Github
- This work
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References

[1] NASA "Basics of Space Flight", Section-1, Chapters 3-5, https://solarsystem.nasa.gov/basics/chapter3-1

[2] Vallado, David A., 1997, "Fundamentals of Astrodynamics and Applications".

[3] NASA "General Mission Analysis Tool (GMAT)", https://software.nasa.gov/software/GSC-17177-1