Orbital Mechanics Calculator User Guide

version - 1

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1 Introduction

The calculator is designed to provide a quick way of doing simple calculations on elliptic orbits, including coplanar single burn manoeuvres. Support for hyperbolic trajectories 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. 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 definition section and will be further used for the specific calculations.

A	В	C	Ł	F G	Н		J	K	L	M	N
Orbit Definition		Intermediates & Constants					CALC	CULATOR - I/O			
Orbital Elements Value		Conserved Quantities Value		True Anomaly at Radius			Radius at True Anomaly			Period to SMA	
Semi Major Axis (km)	25000	Sp. Angular Momentum (SI)	9.42E+10	R (km)	25000		Nu (deg)	20		P (hours)	24
Eccentricity	0.33	Sp. Mechanical Energy (SI)	-7.96E+06	Nu (deg)	109.27		R (km)	17004.45		SMA (km)	42226.91
Inclination (deg)	11	Orbital Period (s)	3.94E+04								
RAAN (deg)	5	Mean Motion (rad/s)	1.60E-04	Velocity at Radius			Flight Path Angle at True Anomaly				
AoP (deg)	0	Semi Parameter (m)	22277500	R (km)	15025		Nu (deg)	60			
		Periapsis Radius (km)	16750	V (km/s)	6.09		FPA (deg)	13.783159			
Mass of the central body (kg)	5.97E+24	Apoapsis Radius (km)	33250								
Radius of the central body (km)	6371	Gravitation Constant (SI)	6.67E-11								
		mu (SI)	3.98E+14	Time of Flight th	Time of Flight through True Anomalies			Impulsive Burn Manoeuvre		(Co-planar LVLH)*	
		Vesc at surface (km/s)	11.18	Nu1 (deg)	0			Delta V azim	uthal (km/s)	0.5	
		Vesc at Periapsis (km/s)	6.90	Nu2 (deg)	60			Delta V radial (km/s)		0.5	
		Orbital Period (hours)	10.93	ToF (hours)	0.950					0	
				ToF (%Period)	8.69			Nu at delta V (deg)		30	
								New SMA (km)	42843.44	
				True Anomaly fo	True Anomaly for Time Interval			New Eccentricity		0.62	
				T1 (hours since la	ast periapsis)	0					
				T2 (hours since la	T2 (hours since last periapsis)			New Periapsis Radius (km)		16433.87	
				Delta-Nu (deg)		104.17045		New Apoap	sis Radius (km)	69253.00	
								* LVLH - Loc	al Vertical Local	Horizontal fra	me of refere
								Co-planar - l	burn does not ch	ange 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 Future Work

Some of the planned additions that can be expected in the future versions:

- 1. Rendezvous phasing circular coplanar
- 2. Hyperbolic trajectories (for fly-by's & assists)
- 3. Non-coplanar non-tangent burn manoeuvres
- 4. ΔV & ToF calculator for transfers (two tangent burns)

4 Glossary

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

1. SMASemi Major Axis 2. RAAN Right Ascension of Ascending Node 3. AoP Argument of Perigee 4. μ - Product of gravitational constant and mass of the body mu 5. Vesc Escape Velocity 6. Sp. Specific ν - True Anomaly 7. Nu Flight Path Angle 8. FPA 9. ToF Time of Flight 10. deg degrees - planar angle

5 Author & Feedback

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

meaning 'in SI units'

• Github

(SI)

11.

- 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