V8 - Experiment Procedure “Off to Mars”

GENERAL INFORMATION

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Version number	1
Last edited on	27-Oct-2024

SHORT EXPERIMENT DESCRIPTION

A voyage to Mars is no simple thing, one has to consider many things in order to make a transition from Earth to Mars possible. In this lesson, students will - under some simplifying assumptions discuss and graphically show the advantages of the Hohmann Transfer compared to flying straight at Mars when it is closest to Earth. They will graphically model orbits, calculate launch windows, and predict the next opportunity for a Mars mission using simplifying assumptions.

For details information and graphics, please see the resource:
https://www.jpl.nasa.gov/edu/teach/activity/lets-go-to-mars-calculating-launch-windows/

HARDWARE CHECKLIST

	Graph paper, quadrille ruled (one per student)
	Cardboard (as big as paper or bigger, one per student
	Push pins (two per student)
	String (30cm, one per student)
	Calculator
	Planetary heliocentric longitudes for appropriate years

PROCEDURE

CALCULATE LAUNCH WINDOW

Step	Action	NOTES	Duration	Check
1	Explain to students the basics of the Hohmann-Transfer and remind them of Kepler’s Second Law additionally discuss the concept of heliocentric longitude		15 min.	
2	Explain to the students the simplifications: The orbits of Earth and Mars are circular and centered on the sun Earth and Mars travel at constant speeds The orbits of Earth and Mars are in the same plane		5 min.	
3	Have students find the length of the semi-major axis of the Hohmann transfer orbit in astronomical units (AU), given that the average distance from Mars to the sun is 1.52 AU		10 min.	
4	Have students use string and pushpins to draw assumed-circular orbits of Earth and Mars about the sun on graph paper		10 min	
5	Draw approximation of the Hohmann-Transfer orbit	Students will need to compute the location of the second focus (one focus is at the sun) for the Hohmann-Transfer orbit. The focal distance is 0.26 AU, so if the sun is at (0,0), the other focus will be at (-0.52, 0) To draw Hohmann-Transfer orbit, place pushpin at each focus of the ellipse and use a loop of string equal in length to twice the sum of the length of the semi-major axis of the ellipse and the focal length	6min.	
6	Have students use Kepler’s Third Law, to determine the period of the Hohmann-Transfer orbit and then the travel time to Mars along this orbit		10 min.	
7	Using the daily motions of Earth and Mars, compute ideal relative position of Earth and Mars during launch		10 min.	
8	Let students determine: approximately when the next opportunity for launch to Mars is	Use planetary heliocentric longitude	15 min.	

NOTES:

- Use visuals or animations (if available) to demonstrate the Hohmann Transfer concept for better understanding.

- Discuss the relevance of accurate launch windows in reducing fuel consumption and mission costs.
- Encourage students to reflect on how simplifying assumptions differ from real-world orbital mechanics.