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# Mathematics in the Search for Earth-like Planets NASA/Jet Propulsion Laboratory (JPL)


Navigator Public Engagement Team

and the JPL Education Office

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GCTM

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# The Importance of Mathematics

- Philosophy is written in this grand book, the universe, which stands continually open to our gaze. But the book cannot be understood unless one first learns to comprehend the language and read the characters in which it is written. It is written in the language of mathematics .... without these one is wandering in a dark labyrinth.

*-- Galileo*

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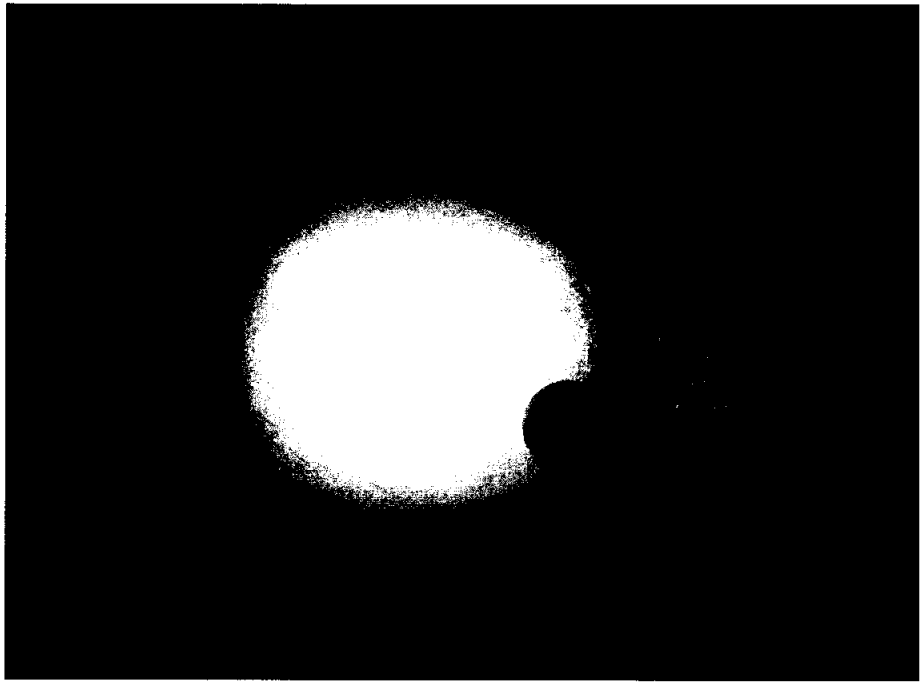
# Search for Earth-Like Planets

- Are we alone in the Universe?
- Where did we come from?
- Are there other Earth-like planets in the Universe?
- How can we find out?



*The resolving power of a telescope changes our view of the universe and our place in it.*
-Bill Whitney

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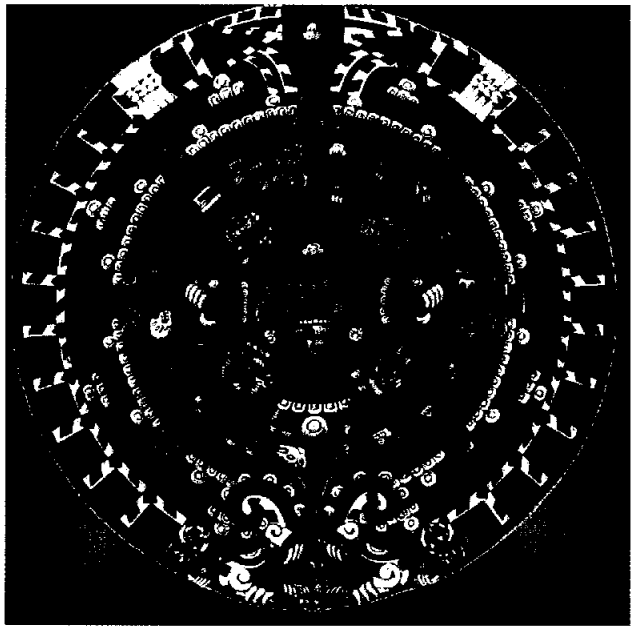
# Are we alone?

# We've been seeking understanding for a long time



**"It is the duty of every true Muslim, man and woman, to strive after knowledge"--- on the entry gate to Samarkand -- *Ulugh Beg, 1393-1449, grandson of Tamerlane, ruler of Samarkand, astronomer***

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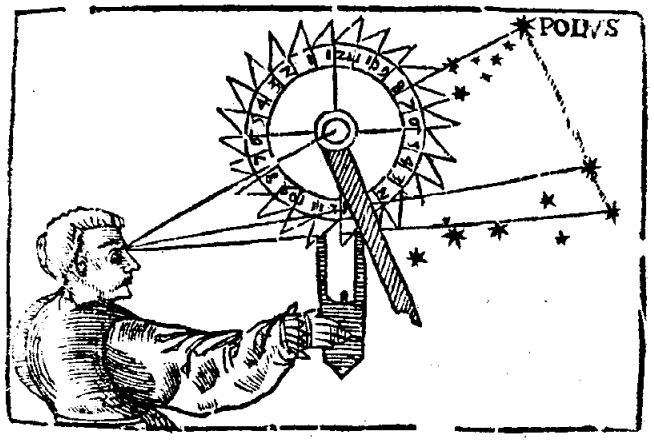
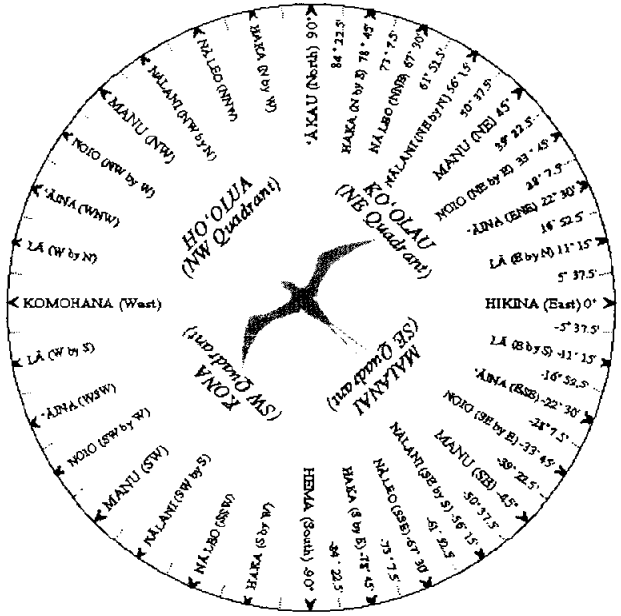
# All around the world.....



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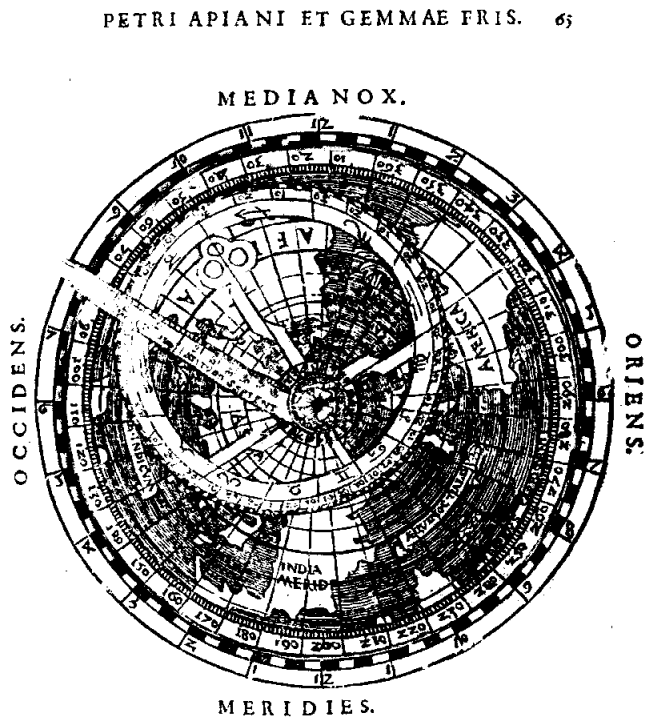
# Throughout human history.....




"There are infinite worlds both like and unlike this world of ours...We must believe that in all worlds there are living creatures and planets and other things we see in this world."--- Epicurius (c. 300 B.C)

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*"There are countless suns and countless earths all rotating around their suns in exactly the same way as the seven planets of our system. We see only the suns because they are the largest bodies and are luminous, but their planets remain invisible to us because they are smaller and non-luminous. The countless worlds in the universe are no worse and no less inhabited than our Earth"*

Giordano Bruno (1584)
in De L'infinito Universo E Mondi

# Ways to detect planets

- Radial velocity (Doppler effect)
- Transit method (eclipse)
- Astrometry (measuring distances between background stars and stars being studied)
- Direct detection (starlight nulling or blocking -- the parent star is approximately 1,000,000,000 times brighter than the orbiting planets)

***Above all, the physical nature of the universe can be observed and represented mathematically***

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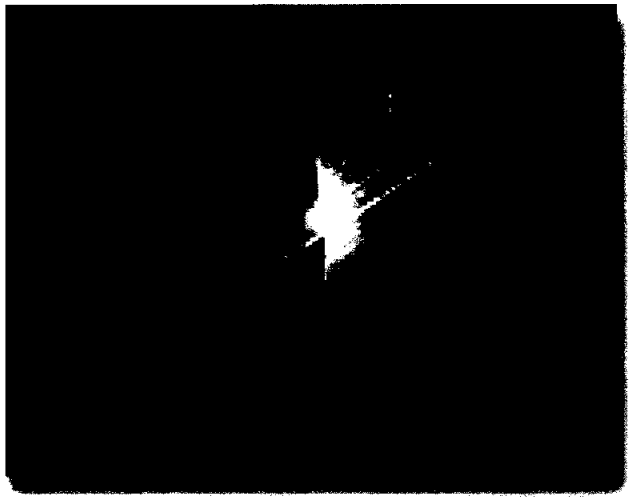
# The Challenges

- The ***closest*** star -- other than our Sun -- known to have planets is 10.4 light-years away: 98,392,320,000,000 km or $9.8 \times 10^{13}$ km. (good exercises for scientific notation)

- The light from the star is approximately *1 billion times* brighter than the light reflected from a planet, so the planets are difficult to detect directly



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# What can be done in a math classroom?

**NCTM Thematic Standards:**
**Strategies for eliciting student understanding of mathematical concepts that encourage the use of multiple modalities, learning methods and assessment tools. Objects that can be moved and rearranged and that require the processing and analysis of three-dimensional quantitative information are advised**

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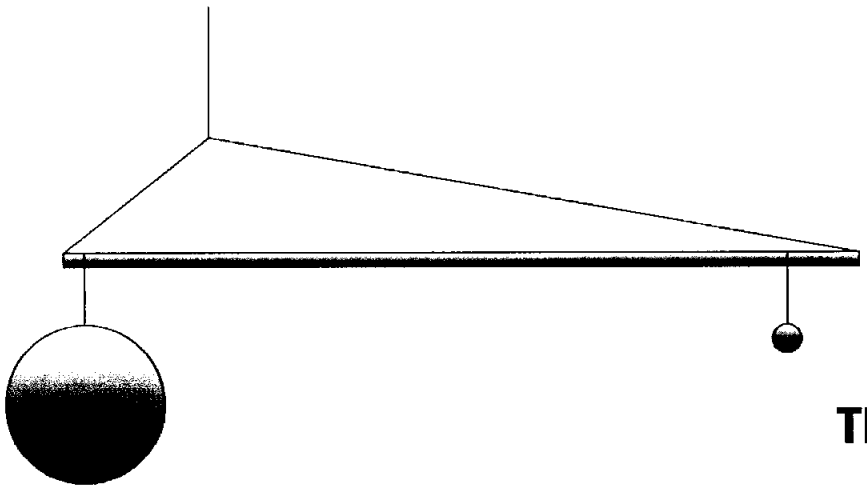
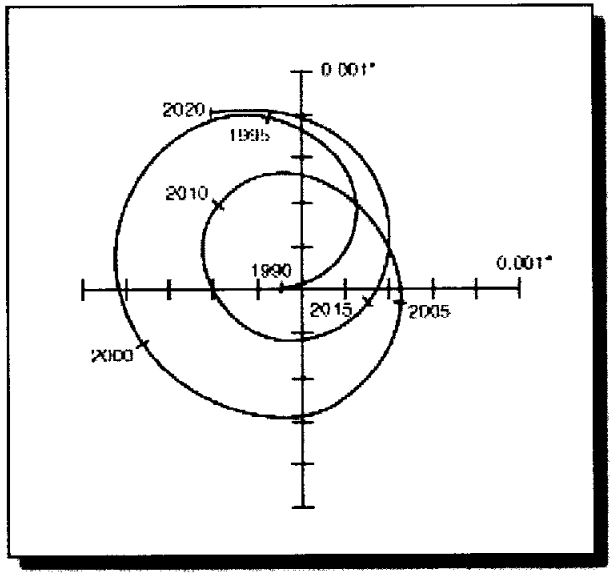
# Radial Velocity & Astrometry: Looking for the "wobble"



The wobble of our own star, sol




**Make a prediction! What would the "wobble" look like on a graph?**

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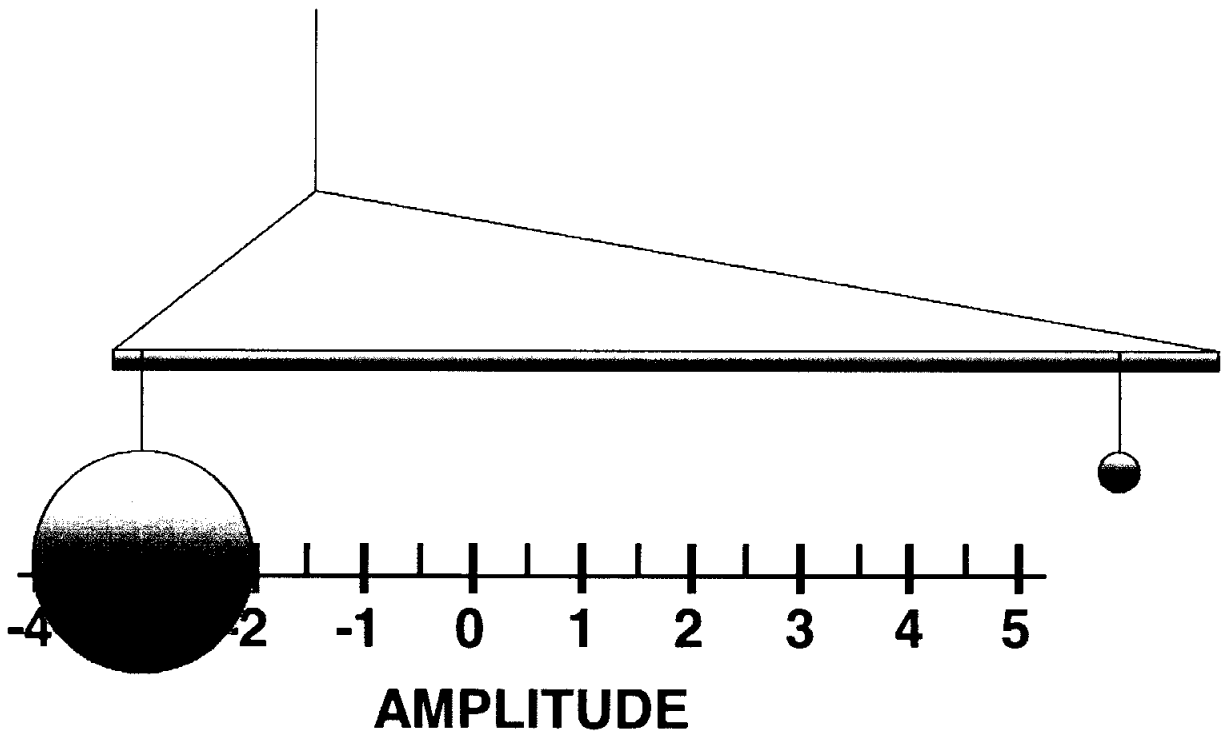
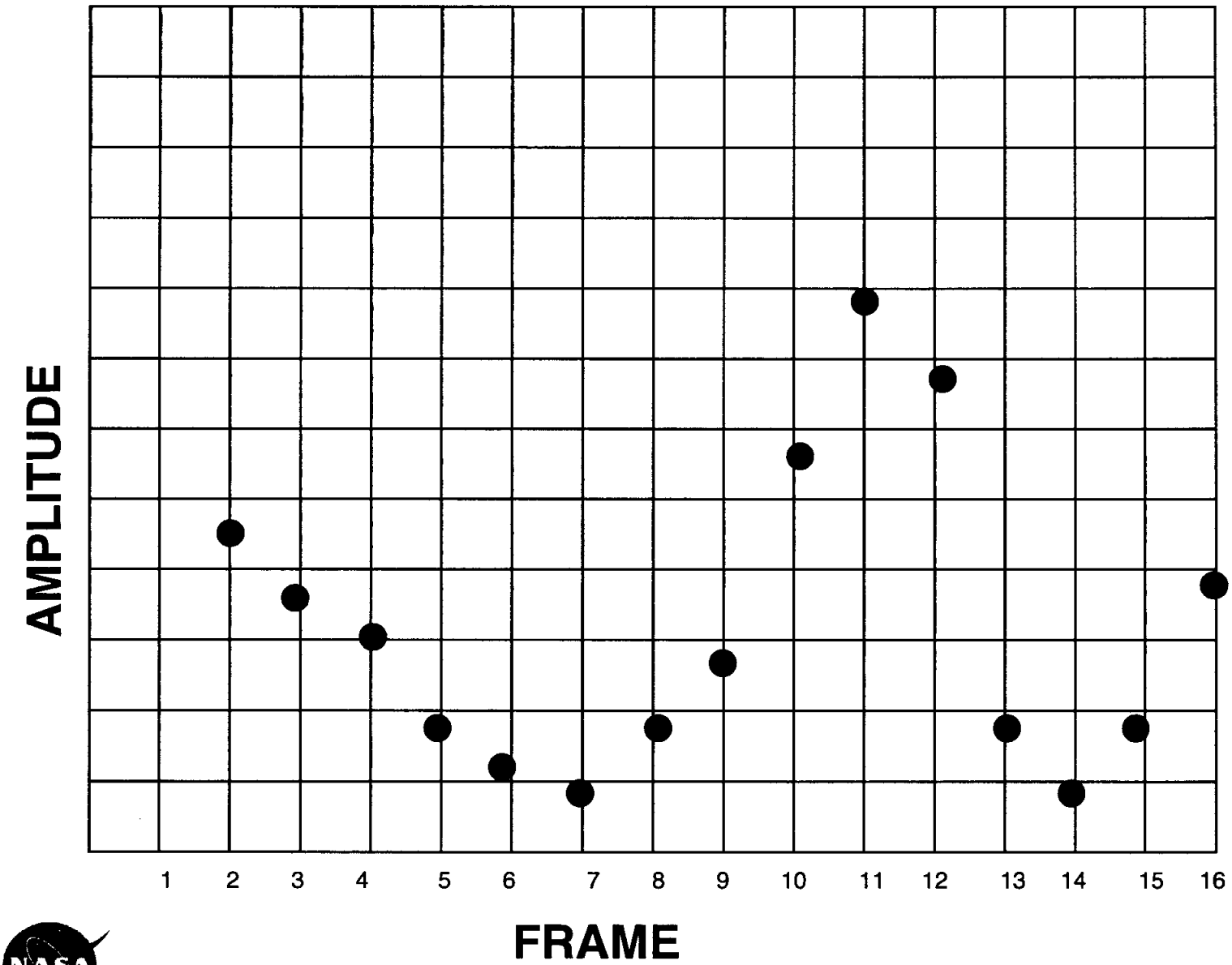
# A classroom model



# Graphical representation of orbital motion

# Data taken from a *VCR*



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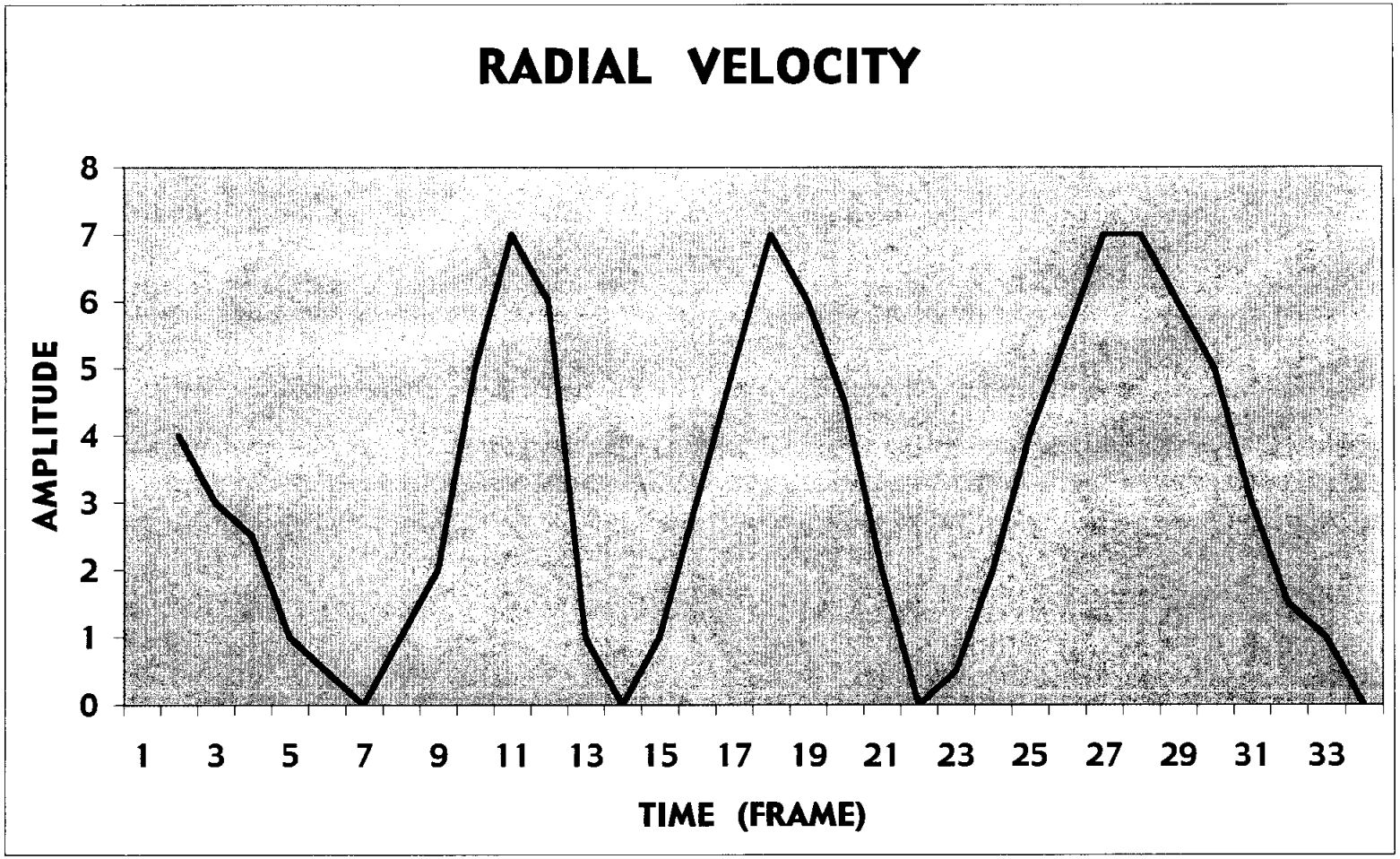
# Data Plotted on an Excel Spreadsheet (VCR counter -- slow motion)



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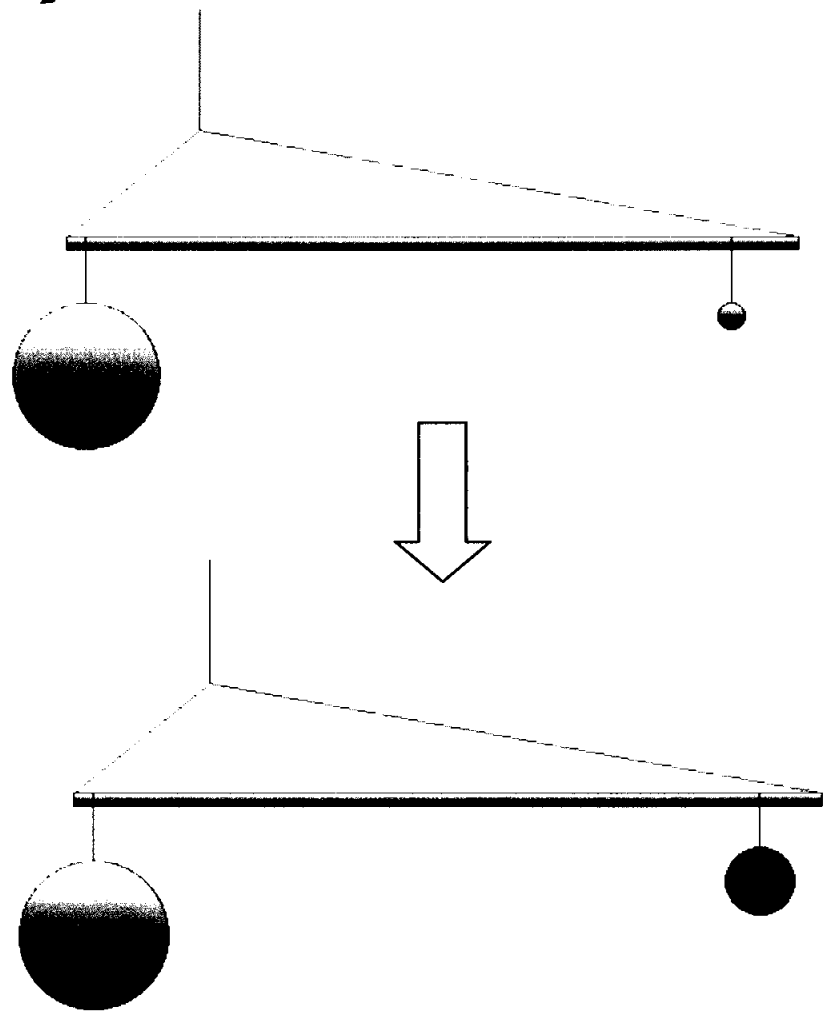
# Now change the mass of the smaller object .....

- Ask student to predict what will happen!
- How does the larger mass affect the amplitude of the "wobble"?



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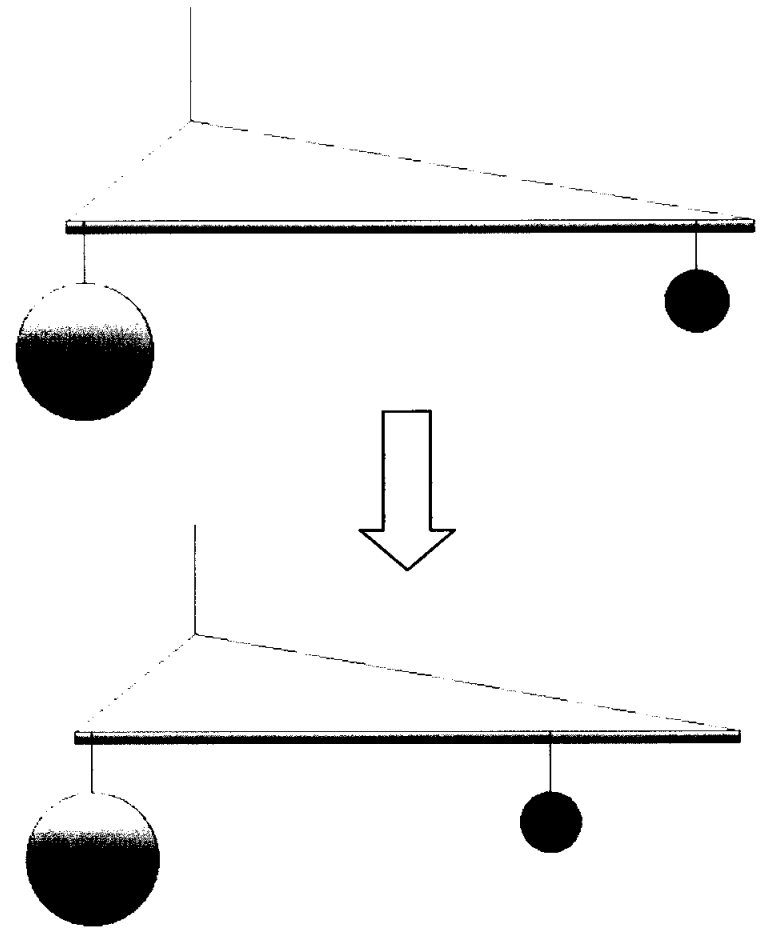
# Now change the *distance* between the objects .....

- Ask student to predict what will happen!
- How does the change in distance affect the *period* of the wave?



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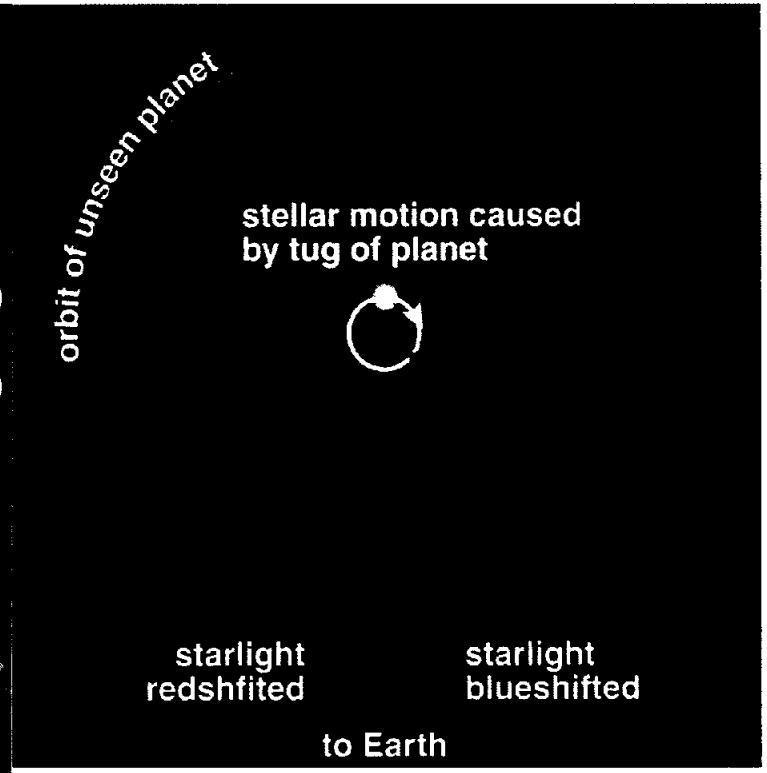


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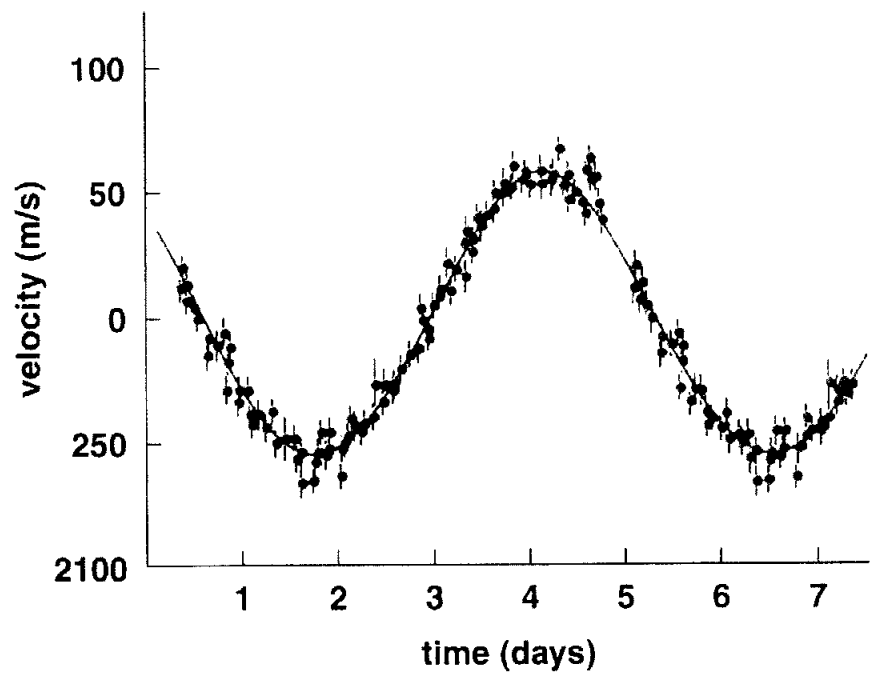
# An example of real data from an orbiting object:

⇒ periodicity

⇒mass of object

⇒distance from star ("Goldilocks" zone, liquid water)



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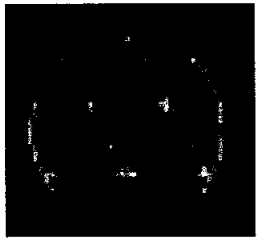
# Alignment with NCTM Standards

- Collecting, Representing, and Interpreting Data Using Spreadsheets and Graphing Software (Grades 3 – 5)



- Using Graphs, Equations, and Tables (Grades 9 – 12)

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# *A bold series of missions . . .*

**To answer the question of whether we are alone, NASA is designing the most sensitive instruments ever built.**

## Additional Information:

The missions depicted in this presentation are a part of NASA's Navigator Program, an integral part of NASA's Astronomical Search for Origins Theme, within NASA's Office of Space Science.

For more information go to:
http://planetquest.jpl.nasa.gov