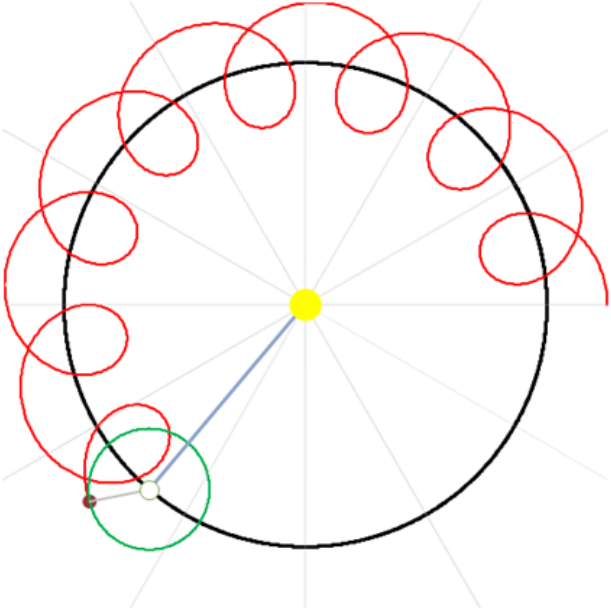
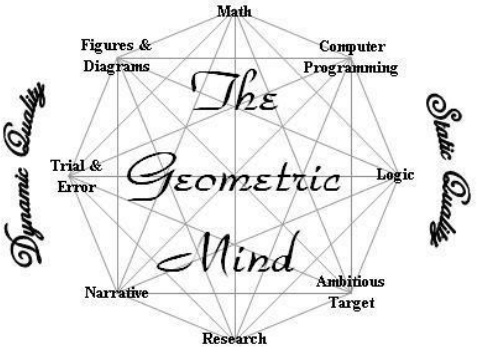
THE GEOMETRIC MIND SERIES
an *auto*SOCRATIC QUICK-START publication

From an Apple to the Planets

Newton, Gravity, and Planetary Motion





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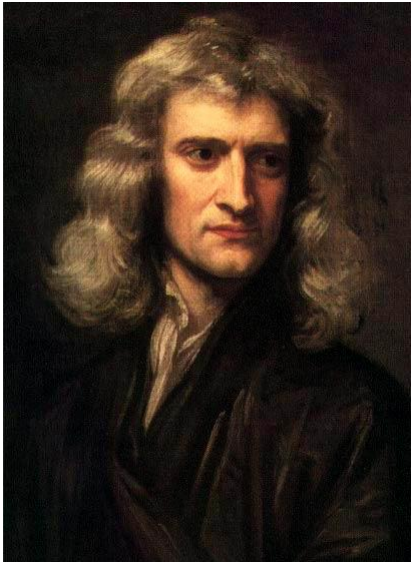
A Simple Observation

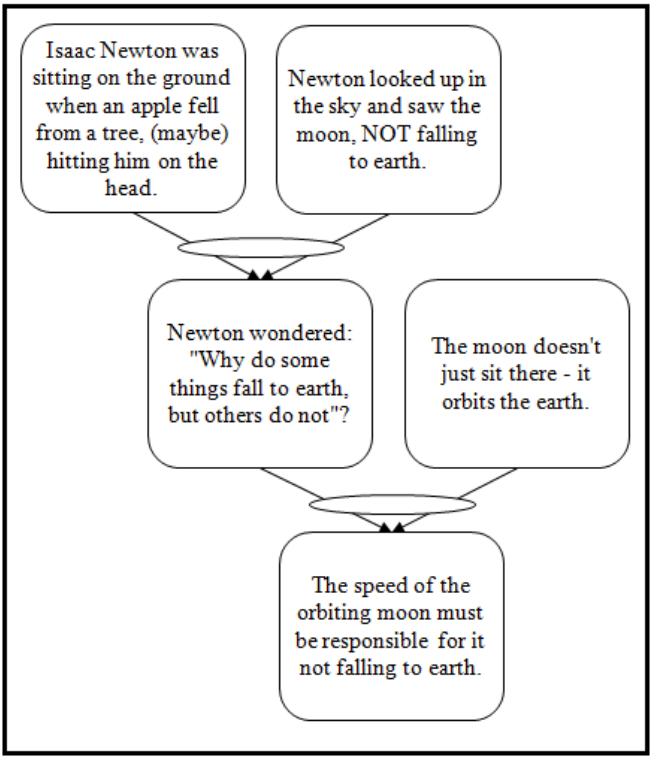
An apple fell from the tree. The moon is not falling. *Why not?*

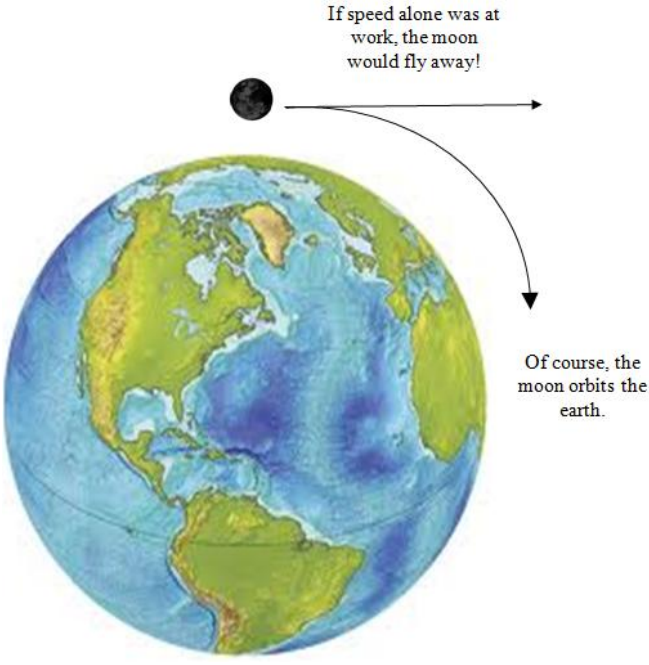


ISAAC NEWTON
1642 – 1727

NEWTON'S APPLE

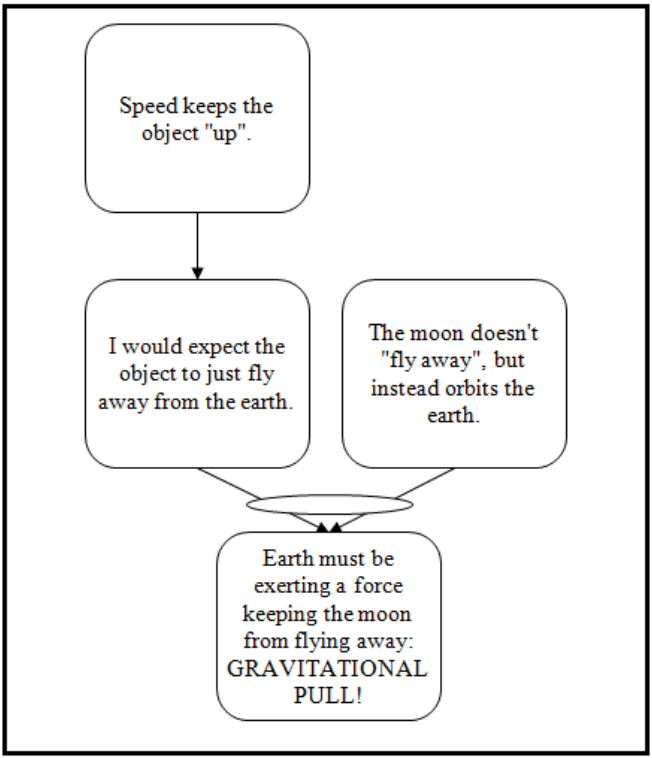
An Interesting Astronomical Story




If speed alone was at work, the moon would fly away!
Of course, the moon orbits the earth.

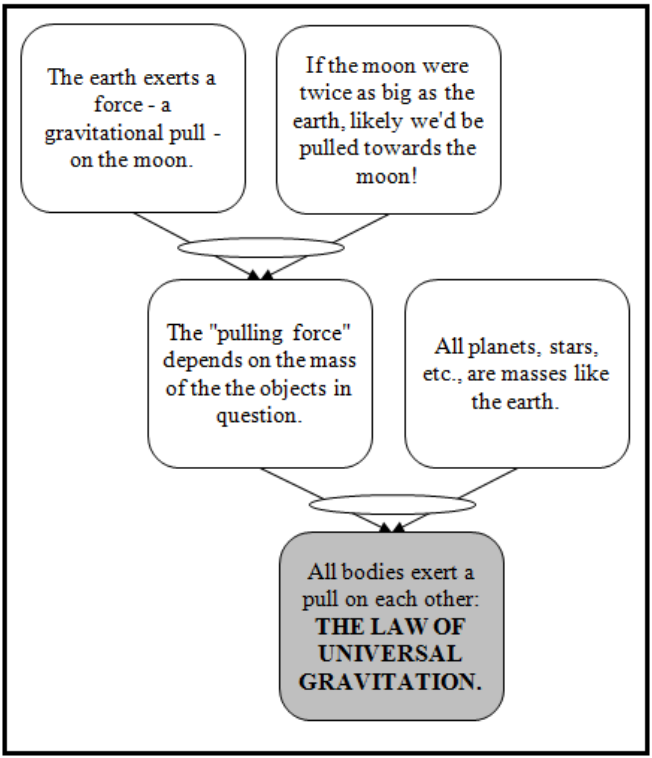
SPEED IS THE KEY

But where does "attraction" come from?



UNIVERSAL GRAVITATION

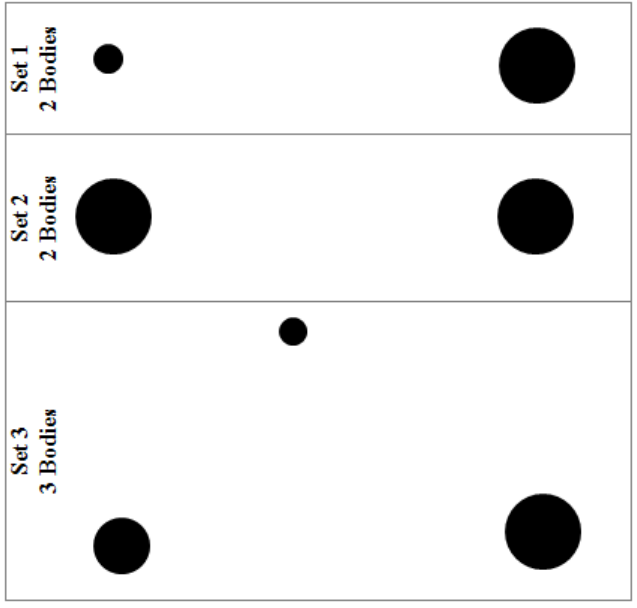
Newton's Famous Law

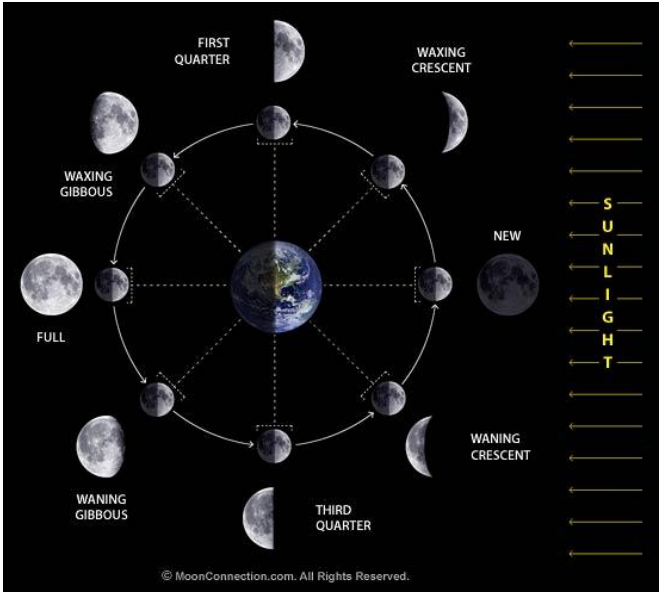


A FEW EXAMPLES

Planetary Systems

If there are no other forces acting, and these bodies are completely stationary, and if Newton is right about the Law of Universal Gravitation is correct, then where will these planets meet?





Exploring the Lunar Orbit

Since we're talking about the moon and orbits, *what is the lunar orbit?* The *earth's* orbit, of course, is about 365.25 days. How long does it

take for the *moon* to go around the *earth*? A little research tells me: about 27.3 days.

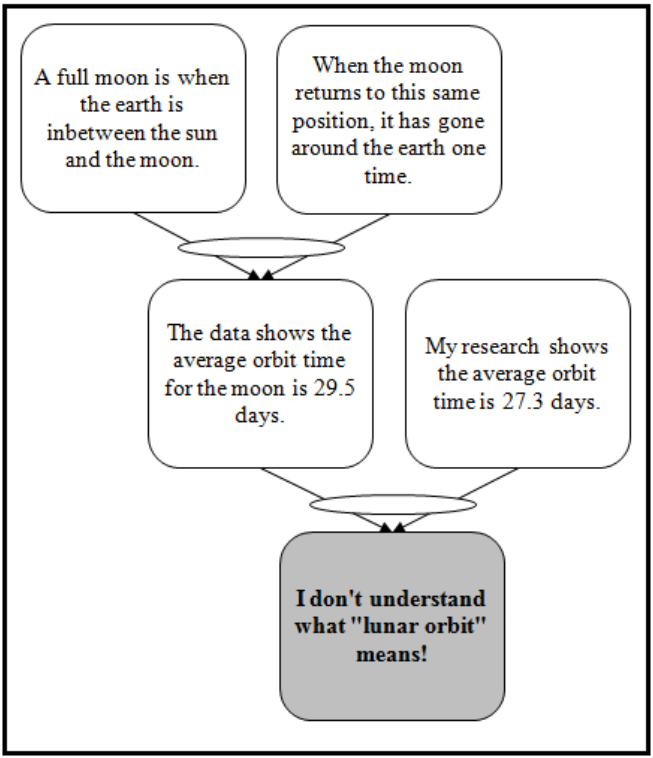
Another way to think about this is: what's the number of days between full moons? Let's see:

Day	Time	Approximate Difference
January 26th	11:38 PM	
February 25th	3:26 PM	30.0
March 27th	5:27 AM	30.0
April 25th	3:57 PM	28.0
May 25th	12:25 AM	31.0
June 23rd	7:32 AM	29.0
July 22nd	2:16 PM	29.0
August 20th	9:45 PM	29.0
September 19th	7:13 AM	30.0
October 18th	7:38 PM	29.0
November 17th	10:16 AM	30.0
December 17th	4:28 AM	30.0
Average Days Between Full Moons		**29.5**

What's this? 29.5? Why is there a difference?

THE LUNAR ORBIT

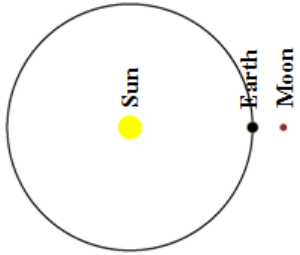
What is going on?



THE LUNAR ORBIT

What is Going on?

Let's just model it. Here's a "solar system", with just the sun, the earth, and the moon:



Since I'm going to just look at one moon orbit, let's strip away some of the detail above:

MONITORING THE MOON
AS IT ORBITS THE EARTH

Orbit Time: ¼ of 27.3 days.
This puts the moon ¼ of the way around the earth:

Orbit Time: ½ of 27.3 days.
This puts the moon ½ of the way around the earth:

Orbit Time: ¾ of 27.3 days.
This puts the moon ¾ of the way around the earth:

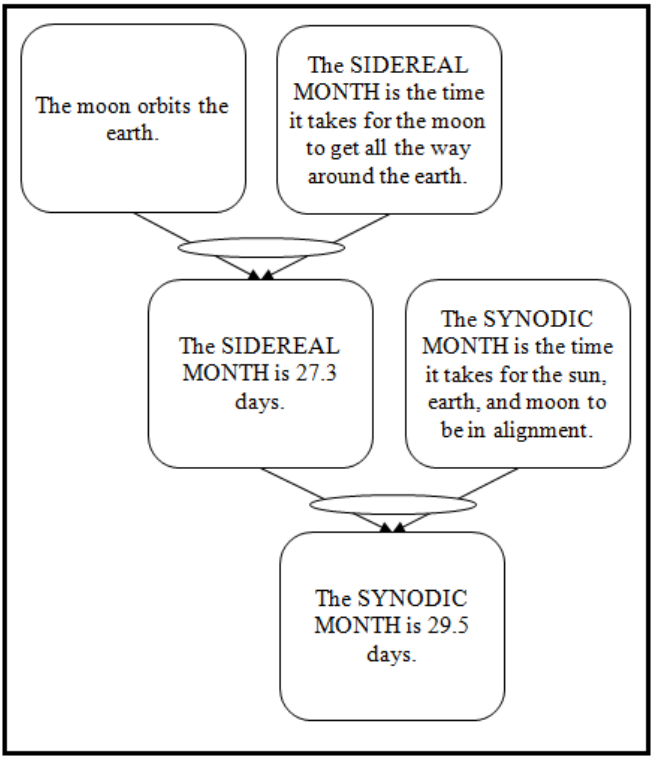
Orbit Time: 27.3 days.
This puts the moon all the way around the earth:

THE PROBLEM

And now I see the problem. Yes, the moon has made one "complete trip" around the earth. However, the earth has now moved itself as it rotates around the sun! Therefore, the sun, earth, and moon are not in alignment. When are they in alignment? We know that: 29.5 days!

LUNAR MONTHS

There ARE Two of Them After All!



Solar System Designs

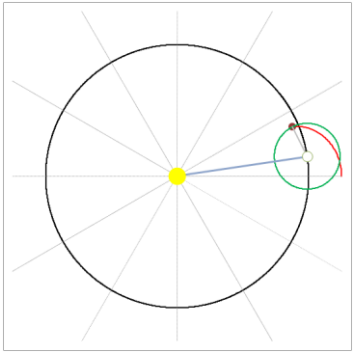
Let's Continue the Analysis

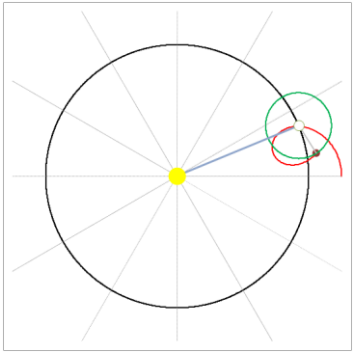
Above, we've looked at the moon going around the earth just once. What happens if we trace the moon's path over several years?

Another thing to keep in mind: in this model, we've got a certain radius for the earth's orbit, and one for the moon. The earth's is approximately 200 units, and the moon 50 units. This was for the sake of demonstration. The real relationship is much different than this. We'll talk about this shortly.

Tracing the Path of the Moon About the Earth

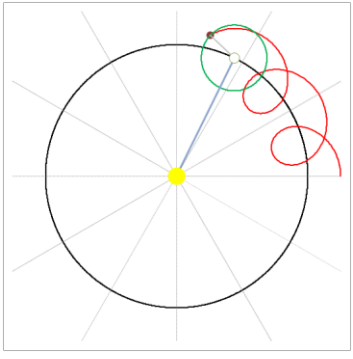
Through one orbit

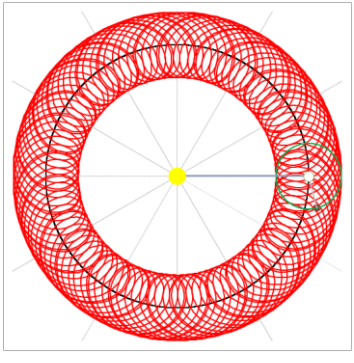




Tracing the Path of the Moon About the Earth

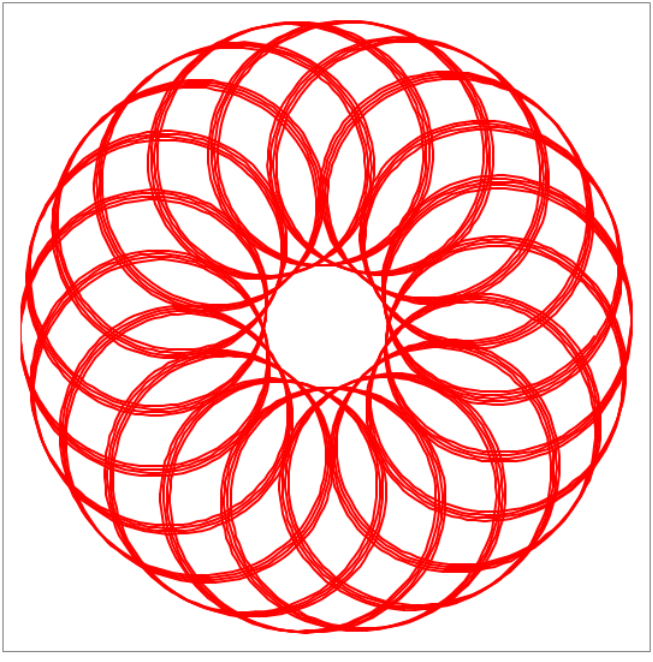
Through Several – and then Hundreds – of orbits



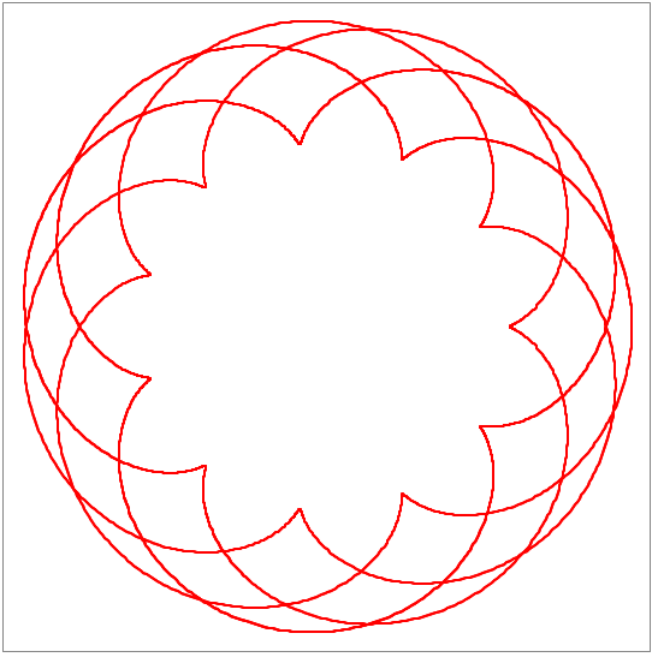


DIFFERENT PARAMETERS

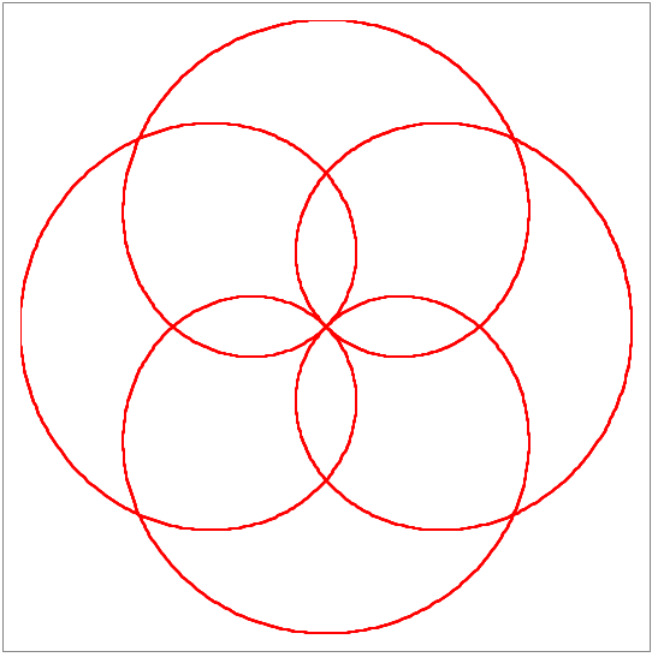
	Earth	Moon
Orbit (Radius)	150	100
Orbit (Days)	360	19



	Earth	Moon
Orbit (Radius)	200	50
Orbit (Days)	150	40



	Earth	Moon
Orbit (Radius)	125	125
Orbit (Days)	275	55



PROBLEMS

The following three problems each have a CHECK (to make sure you've done the problem right).

Once you've confirmed you've done the problem right, there's a KEY. The key is necessary to unlock the next installment.

Key1

Key2

Key3

PROBLEM 1

	Average Distance of Earth from Sun (miles)	Average Distance of Moon from Earth (miles)	
Actual	93,000,000	240,000	
Model	200	50	incorrect scale
Model	200		correct scale

0	.	5		

Check Key 1

PROBLEM 2

	Sidereal Month	Synodic Month
Actual	27.3	29.5
Theoretical	45.0	

		.	3
	Key 2		Check

PROBLEM 3

The model assumed the earth goes around the sun every 365.25 days. That's not exactly right. Actually, it's 365 days, 5 hours, 49 minutes, and 12 seconds. What's the difference? (Hint – convert the fractional part to seconds).

About	3	6	5	.	2	5	0	0
Exact	3	6	5	.				
				.			7	
							Check	Key3

CONCEPT CARD

Look for the Exception

Things fall. Wait a minute. The moon isn't falling. Why not? To every rule, there's an exception, and in explaining that exception is a wealth of information!

LUNAR MONTHS

There ARE Two of Them After All!