

# Developing discovery-based training modules for science education using structural reporting and natural language processing in Wolfram Alpha

Presented at TCC Online Conference 2010



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# Question

- ✦ What best practices have emerged in online learning?
- ✦ Many instructional designers pay attention to new paradigms (e.g. Web 2.0) while overlooking existing technologies.
- ✦ Most instructors don't accept citations and references from online sources due to their questionable credibility, and thus search engine as a medium of instruction is under-explored.

# What is Wolfram Alpha?

- ✦ An answer engine or computational knowledge engine developed by Wolfram Research.
- ✦ announced in March 2009 by Stephen Wolfram, and was released to the public on May 15, 2009.
- ✦ was voted the greatest computer innovation of the year by Popular Science

# Features

- ◆ retrieves information from reliable sources, such as peer-review journals.
- ◆ computing structured data and then provide the answer, rather than providing a list in other search engines.
- ◆ the report is structured and hierarchical. The information presented at the top level is most relevant to the query and more information can be unveiled upon user's request.
- ◆ Alpha can process natural languages, such as "what is the distance between Earth and Mars in 2010?"

# Wolfram Alpha

www.wolframalpha.com



New to Wolfram|Alpha?

## Making the World's Knowledge Computable

Today's Wolfram|Alpha is the first step in an ambitious, long-term project to make all systematic knowledge immediately computable by anyone. Enter your question or calculation and Wolfram|Alpha uses its built-in algorithms and a growing collection of data to compute the answer. Based on a new kind of knowledge-based computing... [More about Wolfram|Alpha »](#)

[Stephen Wolfram's Intro](#)

[One-page summary](#)



Sample inputs:  $7/8$     $\text{gdp spain/italy}$     $\$10.25/\text{hr}$

2 million yen   4 ounces of silver    $n\_t\_$

19-gon   steam 400F 60psi   phase of venus

ASCII 32 to 39   geogravity in Seattle   [more »](#)

[Examples »](#)   [Visual Gallery »](#)   [? FAQs »](#)

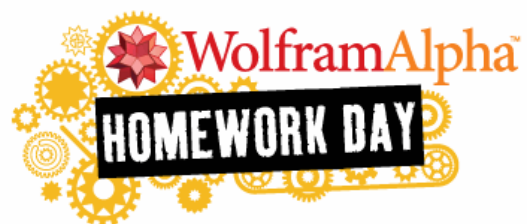
## NEWS & ANNOUNCEMENTS

### Wolfram|Alpha App for the iPad Released

Breathe expert knowledge into any facet of your life, from the coffee shop to your couch. »

### Wolfram|Alpha App for the iPhone & iPod touch Updated

Get answers. Access expert knowledge. Wherever you are. Whenever you need it. »



#### Featured Questions from Homework Day

##### College

##### Examples Utilizing Wolfram|Alpha

- Astronomy
- Biology
- Chemistry
- Geography
- Geology
- History
- Mathematics
- Physics

##### Questions Answered on Homework Day

- Astronomy
- Biology
- Chemistry
- Economics
- Engineering
- English
- Finance
- Geography
- History
- Mathematics
  - Calculus
- Miscellaneous
- Music
- Physics
- Socioeconomics

##### K-12

- Lesson Plans Utilizing Wolfram|Alpha
- Astronomy

#### Featured Questions from Homework Day

##### How do you make 1L of a 0.4% NaOH solution?

October 21, 2009

How do you make 1L of a 0.4% NaOH solution? What will be the molarity of this solution?

##### What is the derivative of...?

October 21, 2009

What is the derivative of  $\sin(3x+1)\cos(2x^3)$  using the chain rule?

-Submitted by Josh M

##### Find the electric field a distance $z$ above the center of a square loop

October 21, 2009

But seriously though please, Find the electric field a distance  $z$  above the center of a square loop (side  $a$ ) carrying uniform line charge  $\lambda$ .

-Submitted by James

##### GDP Question

October 21, 2009

What is the GDP of China compared to the United States?  
-Submitted by Mariah O'Toole from Greenville Technical College



# Some people question the idea

June 12, 2009

## **A Calculating Web Site Could Ignite a New Campus 'Math War'**

*By Jeffrey R. Young*

The long-running debate over whether students should be allowed to wield calculators during mathematics examinations may soon seem quaint.

The latest dilemma facing professors is whether to let students turn to a Web site called WolframAlpha, which not only solves complex math problems, but also can spell out the steps leading to those solutions. In other words, it can instantly do most of the homework and test questions found in many calculus textbooks.

The new tool will be a bane to teaching, some professors say—but others see a blessing.

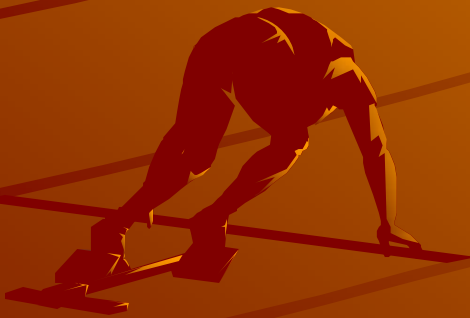
WolframAlpha was created by Stephen Wolfram, an entrepreneur who invented Mathematica, one of the first computer math engines. His new site debuted last month to much media fanfare and, like Google, provides answers to questions typed into a simple search box. It is free and already boasts millions of searches.

But unlike Google, WolframAlpha features a supercharged math engine based on the Mathematica software used by many researchers. It makes a graphing calculator look like a slide rule.

Such math engines—they're called "computer algebra systems," or CAS's—are not new. But they usually cost hundreds of dollars and involve a steep learning curve. The goal of WolframAlpha is to bring high-level mathematics to the masses, by letting users type in problems in plain English and delivering instant results.

# Not a new argument at all

Calculators Will Make Us Dumb





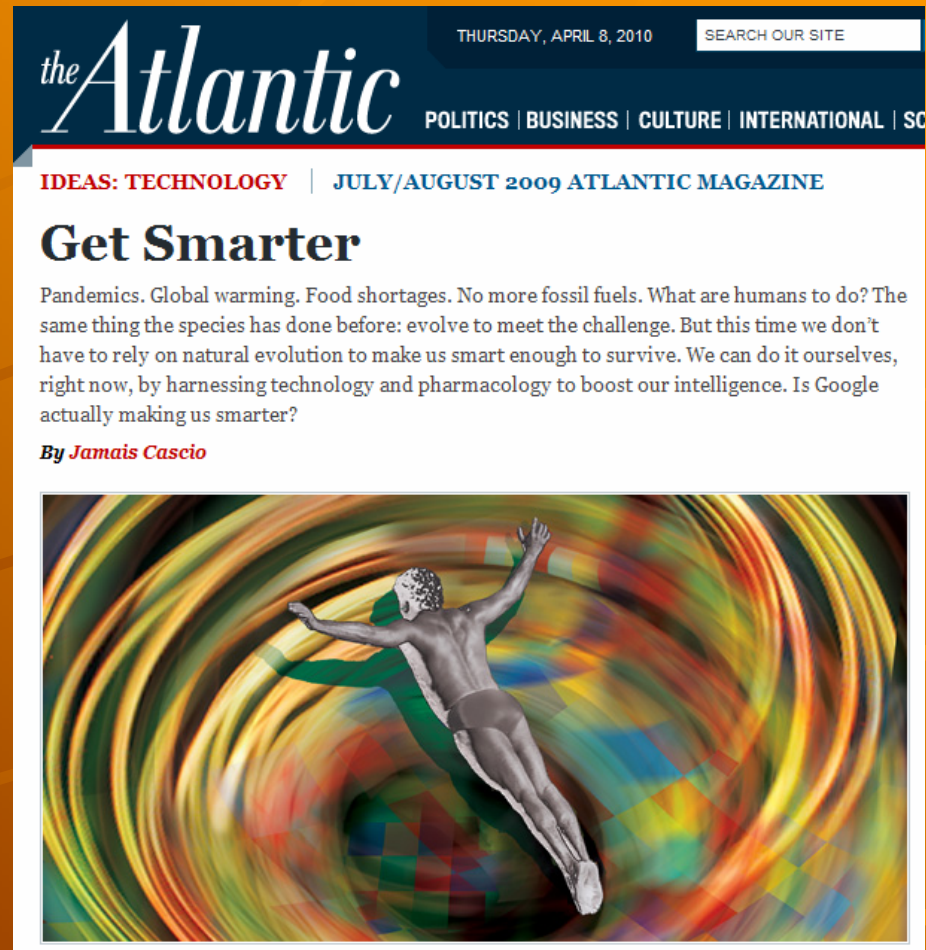
# The medium is the message

- ✦ “The medium is the message”: It changes our thinking patterns.
- ✦ We want instant results and cannot pay attention to read long articles beyond 3 pages.



# Opposite view

- ✦ Technology can make is smarter.
- ✦ Evolution: Adaptation
- ✦ Using Google changing our brains to make us better at multitasking on several short bits of information



Do you agree that search engines  
or answer engines will make us  
lazy?

- ◆ A. Agree
- ◆ B. Disagree
- ◆ C. It depends
- ◆ D. Neutral

Do you agree that search engines  
or answer engines will make us  
impatience?

- ◆ A. Agree
- ◆ B. Disagree
- ◆ C. It depends
- ◆ D. Neutral

# Will search engines or answer engines make us smarter or dumber?

- ◆ A. Smarter
- ◆ B. Dumber
- ◆ C. No impact, the same
- ◆ D. It depends on how we use it
- ◆ E. No opinion

# Discovery learning

- ✦ This new form of search engines has open up opportunities for science teachers.
- ✦ In the past, it is difficult to implement discovery-based learning because of lack of reliable resources. Many times students are asked to gather information from the Internet, but they may not able to distinguish trustworthy information from faulty information.
- ✦ In addition, very often students have difficulties in extracting relevant information from a list of Websites.



# Current Mars Rovers

- ✦ Spirit and Opportunities
- ✦ Rely on solar energy
- ✦ Cannot get around big rocks

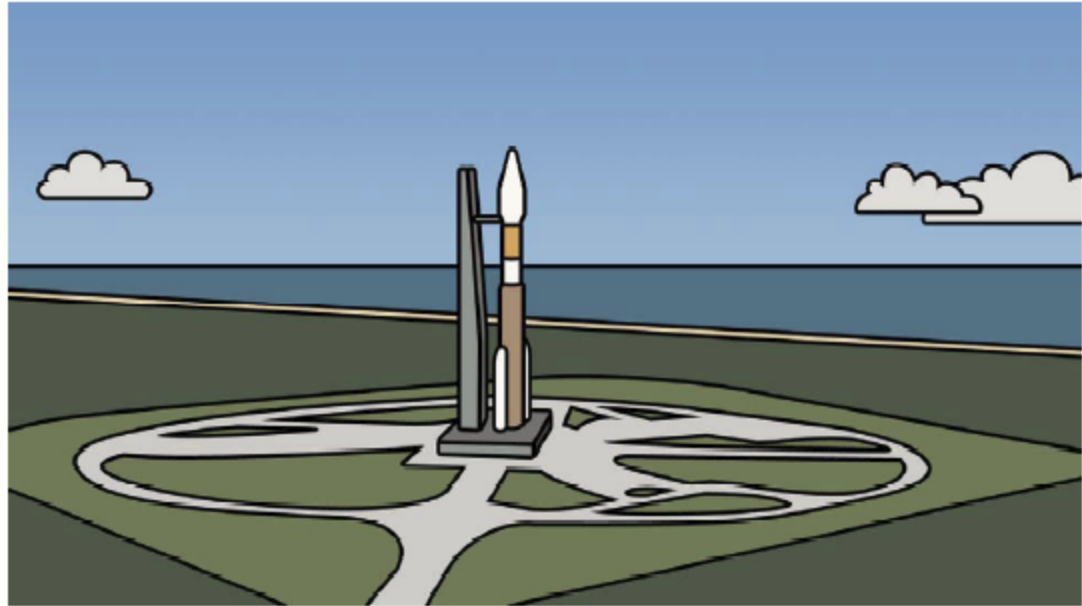


# Next Rover

- ✦ Built by JPL
- ✦ Use nuclear energy, work 24 hours
- ✦ Run like a SUV can go through big rocks

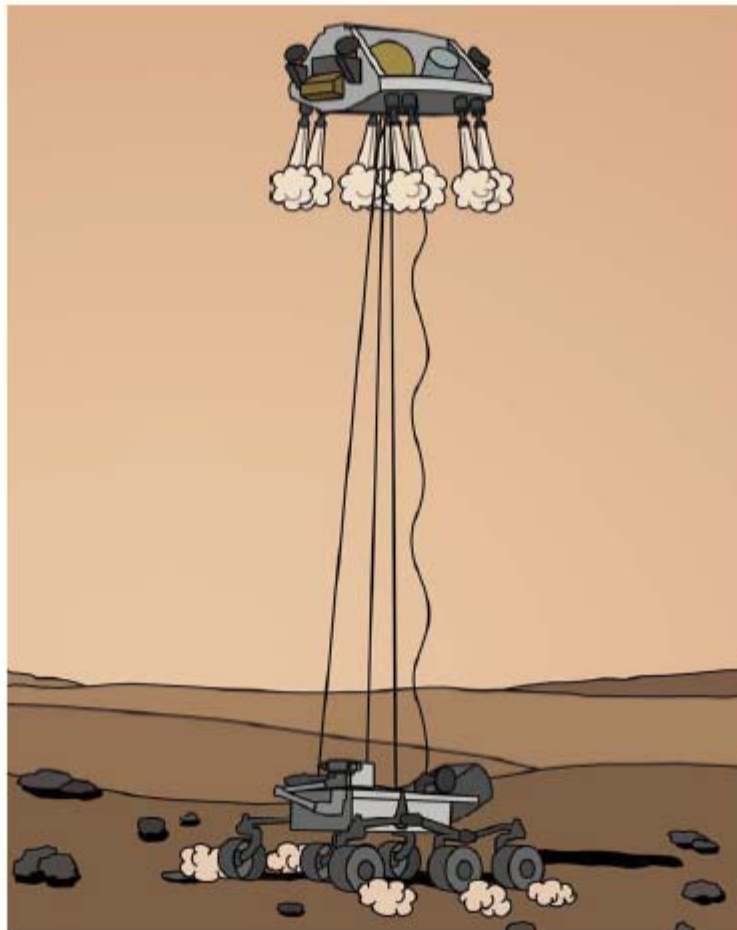


# Why 2011?



## Launch: Fall 2011

- The rover will lift-off from Cape Canaveral, Florida.
- The rover is protected inside a “nose cone” on top of a rocket called an Atlas V.
- The Atlas V is used because the rover is heavy, and this rocket is powerful enough to launch it on its trip to Mars.
  - The rover weighs almost 1900 pounds.
  - The rover, the spacecraft it rides in, and its landing system all together weigh 7500 pounds.

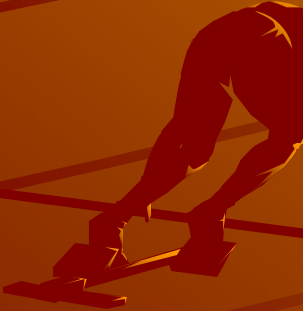



### Landing: Summer, 2012


- The landing craft will steer itself as it quickly descends through the thin martian atmosphere.
- In the final seconds before touchdown, the landing craft, often called a sky crane, will lower the rover on tethers.

# Example:

## But something is missing.



 **WolframAlpha**<sup>™</sup> computational...  
knowledge engine

What is the distance from Earth to Mars? 

Input interpretation:

Earth (planet)	distance
Mars (planet)	

Current result:

1.058 AU (astronomical units)

Value:

$1.583 \times 10^8$  km (kilometers)

$1.583 \times 10^{11}$  meters

98.38 million miles

Comparison as distance:

$\approx 1.1 \times$  mean Earth–Sun distance ( $\approx 1$  AU)

# Does it take longer?

🏁 98.38  
million  
miles in  
2010.

🏁 185.5  
million  
miles in  
2011.

 **WolframAlpha**™ computational... knowledge engine

What is the distance from Earth to Mars in September 2011? 

Input interpretation:

Earth (planet)	distance	September 2011
Mars (planet)		

Result on September 2011:

1.996 AU (astronomical units)

Value:

$2.986 \times 10^8$  km (kilometers)

$2.986 \times 10^{11}$  meters

185.5 million miles

Comparison as distance:


$\approx 2 \times$  mean Earth–Sun distance ( $\approx 1$  AU)



# Why will NSAS launch the new Mars Rover in 2011?

- ◆ A. They cannot finish building the rover in 2010.
- ◆ B. NASA would like to take a longer route to collect data between Earth and Mars.
- ◆ C. That is the shortest route for some reason.

- ✦ The distance keeps changing!
- ✦ The student can alter the month and year in Alpha to find out how NASA schedules the optimal launch date.

 **WolframAlpha**™ computational... knowledge engine

What is the distance from Earth to Mars in May 2012?

Input interpretation:

Earth (planet)	distance	May 2012
Mars (planet)		

Result on May 2012:

0.9371 AU (astronomical units)

Value:

$1.402 \times 10^8$  km (kilometers)

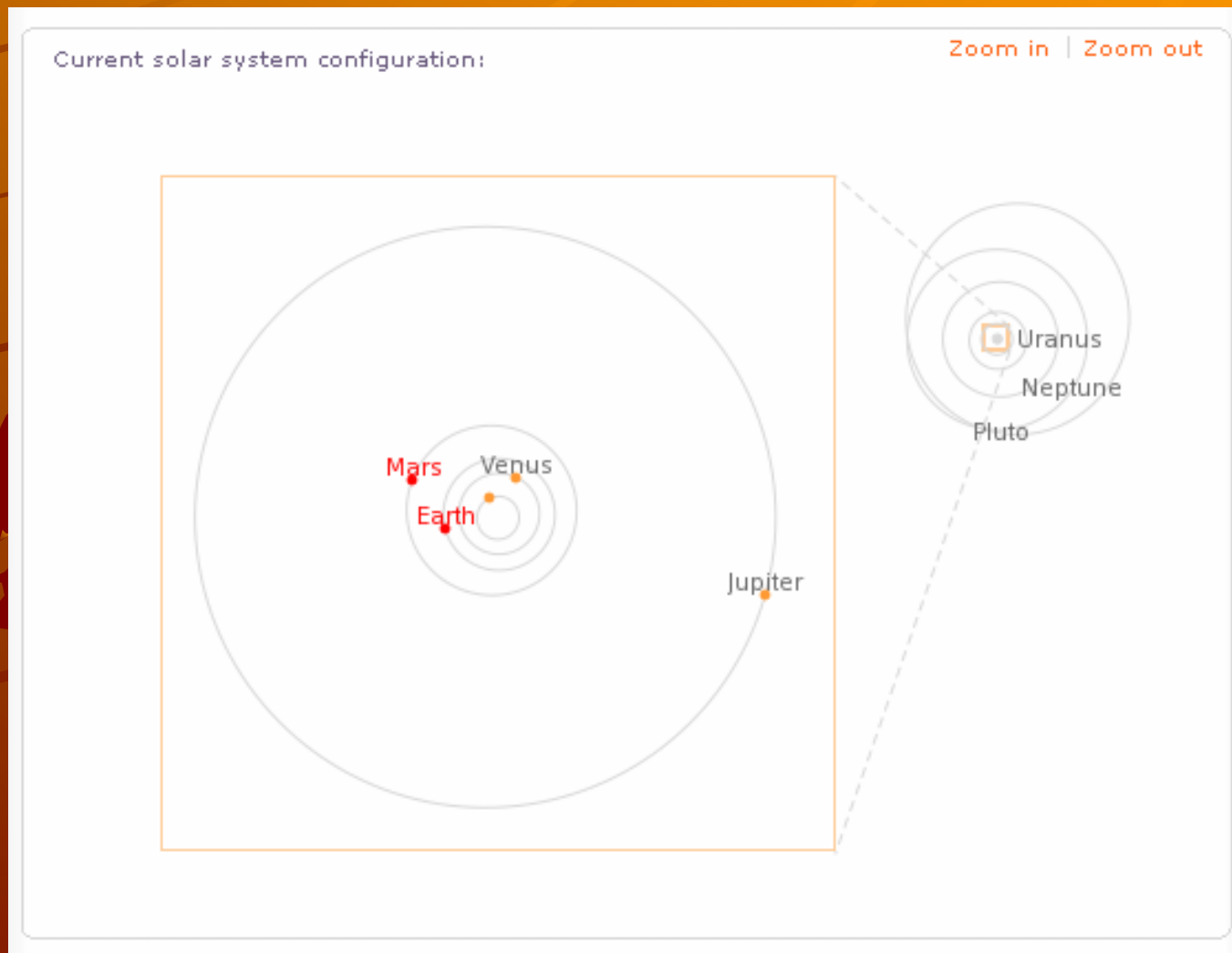
$1.402 \times 10^{11}$  meters

87.11 million miles

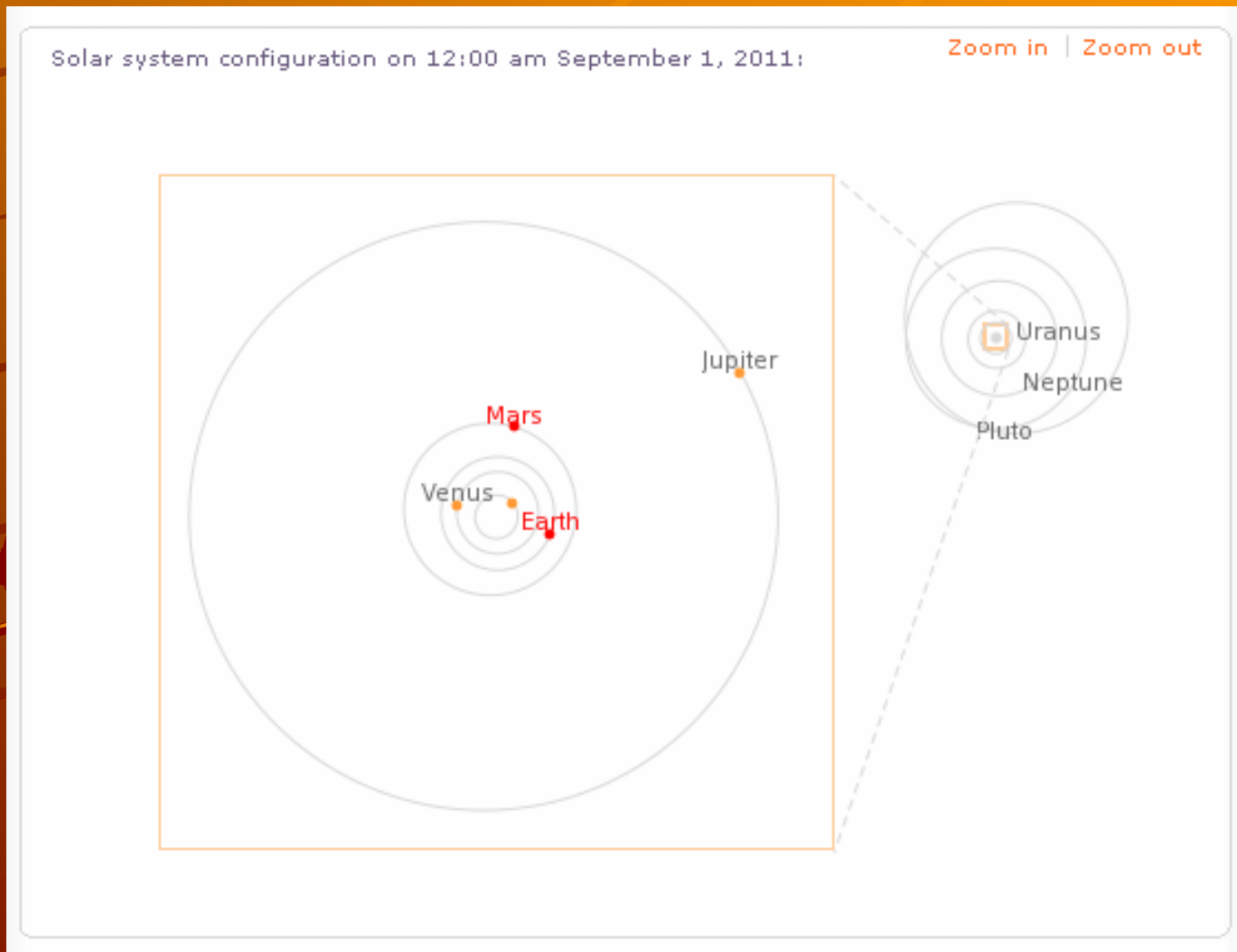
Comparison as distance:

$\approx 0.94 \times$  mean Earth–Sun distance ( $\approx 1$  AU)

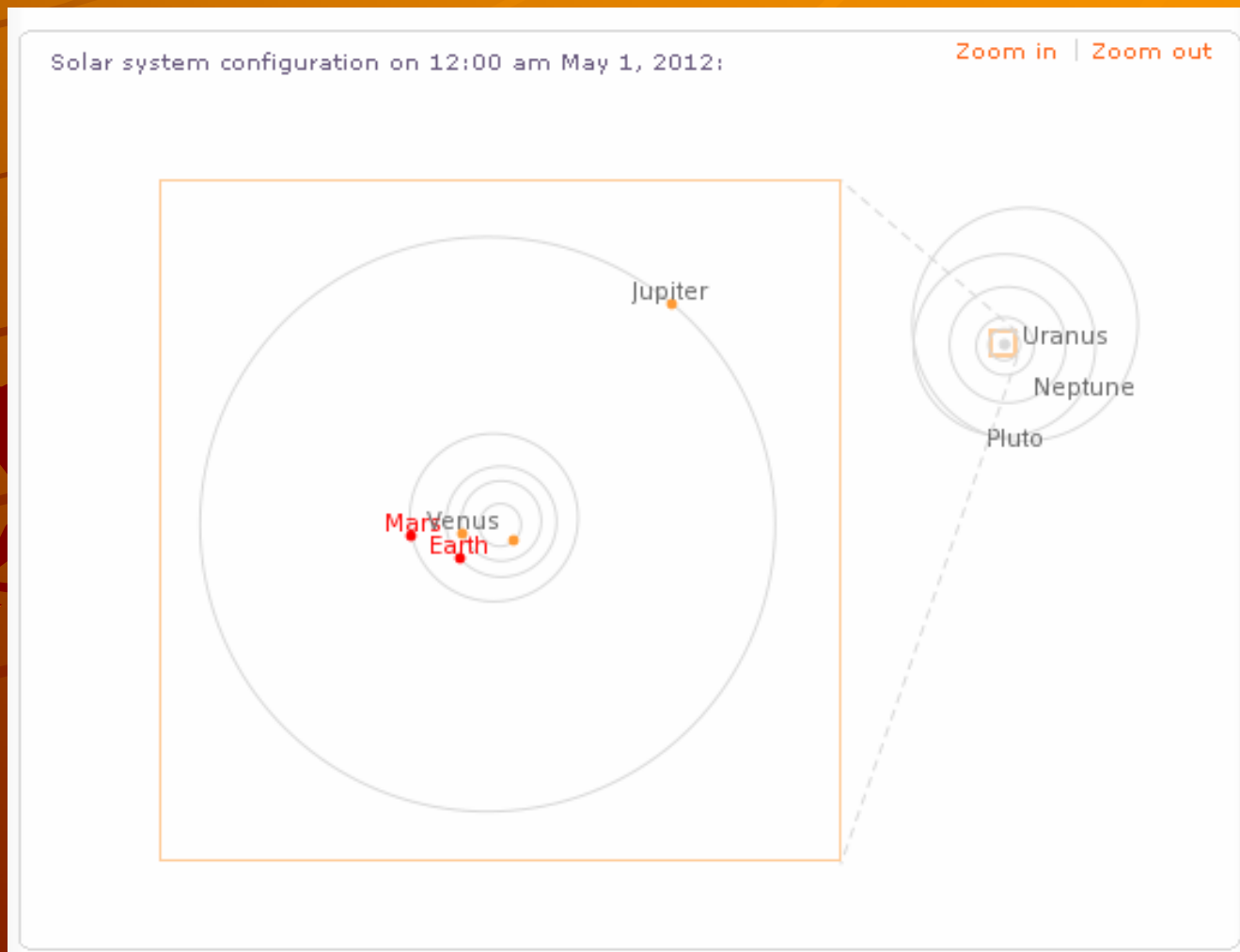
# Current relative positions



# Relative positions in Sept., 2011

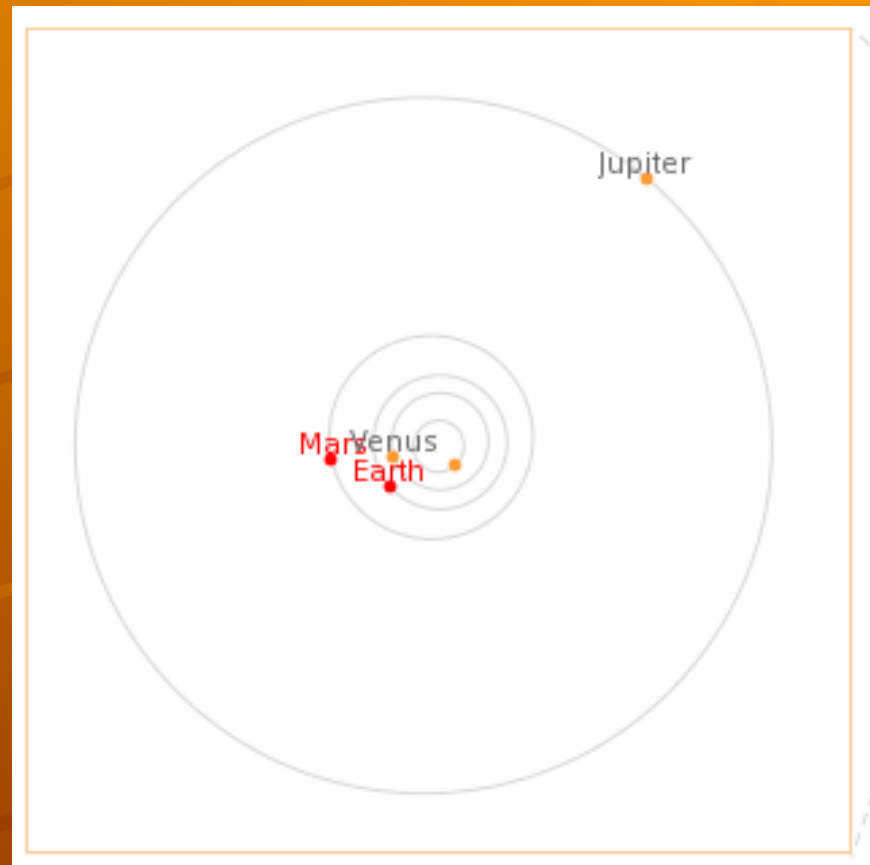
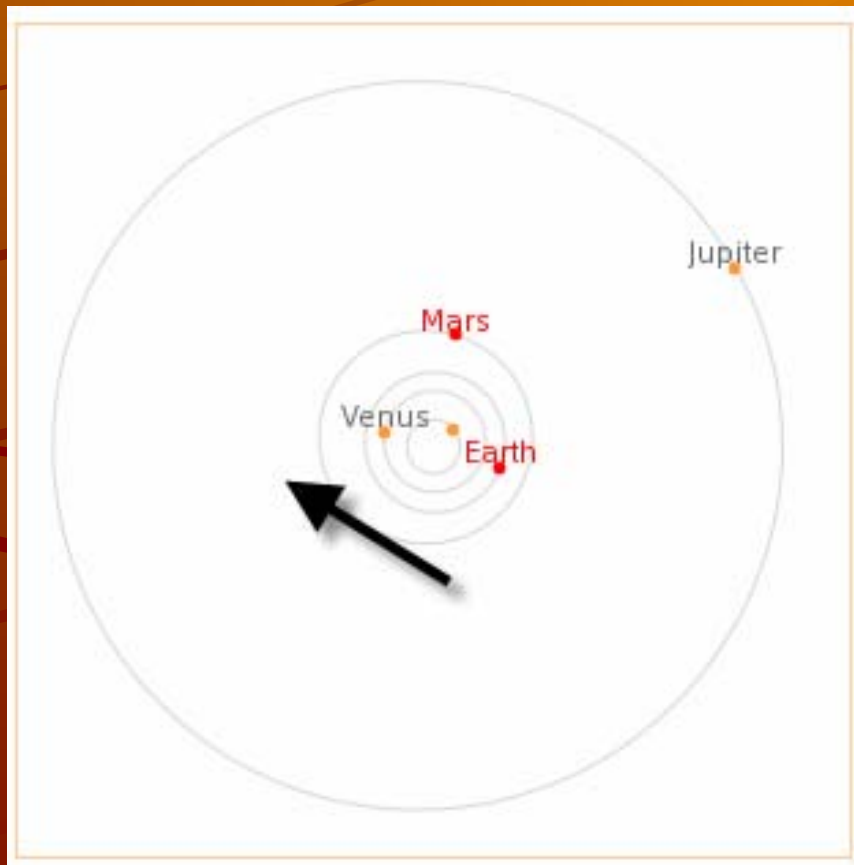


# Relative positions in May 2012



# From Fall 2011 to Summer 2012

- ✦ Go to the other direction.





# The word “Universal” may lead to misconception

✦ From NASA's website

## *(20) Newton's theory of "Universal Gravitation"*

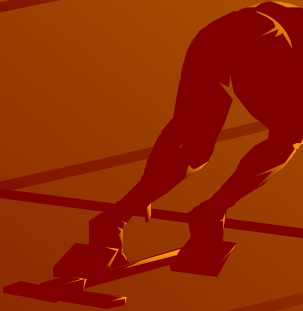
- [Index](#)
- [18. Newton's 2nd Law](#)
- [18a. The Third Law](#)
- [18b. Momentum](#)
- [18c. Work](#)
- [18d. Work against Electric Forces](#)
- [19. Motion in a Circle](#)


The Moon orbits around the Earth. Since its size does not appear to change, its distance stays about the same, and hence its orbit must be close to a circle. To keep the Moon moving in that circle--rather than wandering off--the Earth must exert a **pull** on the Moon, and Newton named that pulling force **gravity**.


Was that the **same** force which pulled all falling objects downward?

Supposedly, the above question occurred to Newton when he saw an apple falling from a tree. John Conduitt, Newton's assistant at the royal mint and husband of Newton's niece, had this to say about the event when he wrote about Newton's life:

# Another example: Something is missing again.



 **WolframAlpha**<sup>TM</sup> computational... knowledge engine

earth Gravity 

Assuming "earth" is a planet | Use the input as referring to gravity instead

Input interpretation: *Mathematica form*

Earth gravity

Result: *Show metric*

$32.2 \text{ ft/s}^2$  (feet per second squared)

Unit conversions:

$386 \text{ in/s}^2$  (inches per second squared)

$980 \text{ cm/s}^2$  (centimeters per second squared)

$35.3 \text{ km/hr/s}$  (kilometers per hour per second)

$9.8 \text{ m/s}^2$  (meters per second squared)

$21.9 \text{ mi/hr/s}$  (miles per hour per second)



Input interpretation:

Gravitational field strength for Phoenix, Arizona:

[Show non-metric units](#)

total field	$9.78834983899 \text{ m/s}^2$ (meters per second squared)
angular deviation from local vertical	$1.76565098927 \times 10^{-5}^\circ$ (degrees)
down component	$9.78834983746 \text{ m/s}^2$ (meters per second squared)
west component	$1.6988196411 \times 10^{-5} \text{ m/s}^2$ (meters per second squared)
north component	$1.71991138916 \times 10^{-4} \text{ m/s}^2$ (meters per second squared)

(based on EGM 96 12th order model; 331 meters above sea level)



**WolframAlpha**<sup>™</sup> computational...  
knowledge engine

Gravity Hawaii



Assuming "Hawaii" is a US state | Use as **an island** instead

Input interpretation:

gravitational acceleration   Hawaii (US state)

Gravitational field strength for the State of Hawaii:

[Show non-metric units](#)

total field	$9.78171441377 \text{ m/s}^2$ (meters per second squared)
angular deviation from local vertical	$2.43818029655 \times 10^{-5}^\circ$ (degrees)
down component	$9.78171441086 \text{ m/s}^2$ (meters per second squared)
east component	$4.37820624649 \times 10^{-6} \text{ m/s}^2$ (meters per second squared)
north component	$2.38455643456 \times 10^{-4} \text{ m/s}^2$ (meters per second squared)

(based on EGM 96 12th order model; for geographical center 2496 meters above sea level)