Earth Gravity

The Earth has a mass of $5.972 \times 10^{24}\ kg$ and a radius of $3{,}963\ miles$.

Use the formula for gravity below to show that Earth's gravitational force is approximately $9.8ms^{-2}$.

$$g = \frac{Gm}{r^2}$$

Where:

$G = 6.6742 \times 10^{-11}$ *(the universal gravitational constant)*
m = mass of Earth in kg
r = radius of Earth in metres

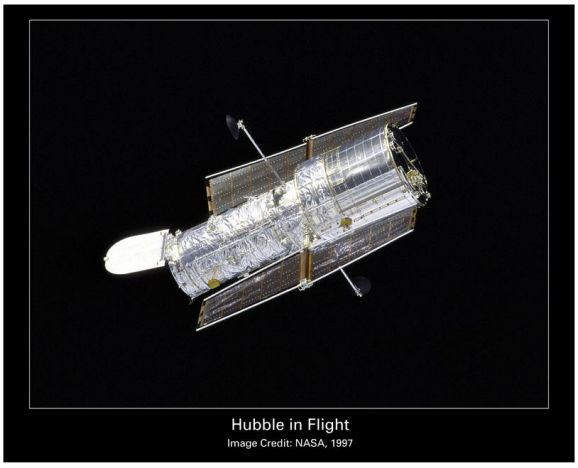
Remember to convert your units where necessary.

Skills used:

- Metric / imperial conversion
- Standard Form
- Substitution into formula's

- http://en.wikipedia.org/wiki/Gravitational_constant
- http://nssdc.gsfc.nasa.gov/photo_gallery/
- http://amazing-space.stsci.edu/resources/fastfacts/earth.php.p=Teaching+tools%40%2Ceds%2Ctools%2C%3EPictures+%2Aamp%2Aamp%3B+facts%40%2Ceds%2Ctools%2Ctype%2Cpictures.php%3EOverview%3A+Earth+facts%40%2Ceds%2Coverviews%2Cfastfacts%2Cearth.php&a=%2Ceds

Telescopes



The Hubble Space Telescope is based on a design first used by Sir Issac Newton.

Issac Newton's telescope had a primary mirror of diameter $5cm$.

The Hubble's is $2.1m$ in diameter.

How many times more sensitive to light is the Hubble compared to Issac Newton's telescope?

Remember to convert your units where necessary.

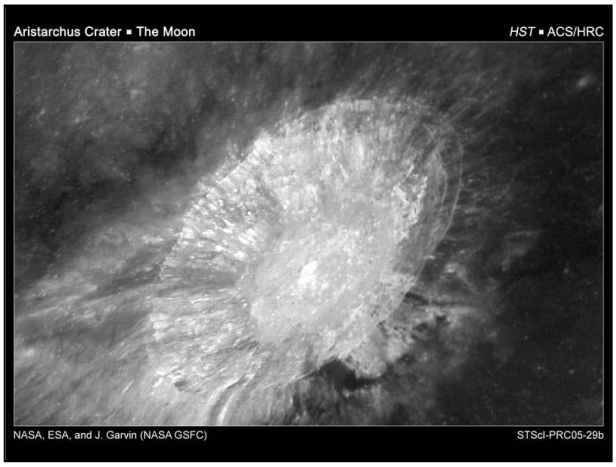
Hint: think about what affects the amount of light hitting the mirror

Skills used:

- Area & volume factor
- Metric conversion

- http://hubblesite.org/hubble_discoveries/hstexhibit/telescope/
- http://amazing-space.stsci.edu/eds/overviews/print/lithos/hst.php.p=Teaching+tools%40%2Ceds%2Ctools%2C%3EPictures+%2Aamp%2Aamp%3B+facts%40%2Ceds%2Ctools%2Ctype%2Cpictures.php

The Moon



The Moon has a mass of $7.35 \times 10^{22}\ kg$ and a radius of $1{,}080\ miles$.

Use these figures and the figure of $9.8ms^{-2}$ for Earth's gravitational force to explain why Neil Armstrong 'bounced' on the Moon.

$$g = \frac{Gm}{r^2}$$

Where:

$G = 6.6742 \times 10^{-11}$ *(the universal gravitational constant)*
m = mass of Moon in kg
r = radius of Moon in metres

Remember to convert your units where necessary.

Skills used:

- Metric / imperial conversion
- Standard form
- Substitution
- Division

- http://en.wikipedia.org/wiki/Gravitational_constant
- http://hubblesite.org/newscenter/archive/releases/solar%20system/planetary%20moon/2005/29/
- http://amazing-space.stsci.edu/resources/fastfacts/moon.php.p=Teaching+tools%40%2Ceds%2Ctools%2C%3EPictures+%2Aamp%2Aamp%3B+facts%40%2Ceds%2Ctools%2Ctype%2Cpictures.php%3EOverview%3A+Moon+facts%40%2Ceds%2Coverviews%2Cfastfacts%2Cmoon.php&a=%2Ceds

Halley's Comet

Halley's Comet has a mass of between $2.2 \times 10^{14}\ kg$ and $1.7 \times 10^{15}\ kg$ and is between $15km \times 7km \times 7km$ and $15km \times 11km \times 8km$ in size.

Find upper and lower bounds for the volume, in m^3, and density, in kg/m^3, of Halley's Comet.

Use these density figures together with known densities in the table below to predict what material Halley's Comet may be made up of:

Interstellar medium	1×10^{-20}	Iron	7,870
Cork	240	Copper	8,940
Ice	916.7	Silver	10,500
Water	1,000	Lead	11,340
Magnesium	1,740	Inner Core of the Earth	13,000
Silicon	2,330	Mercury	13,546
Aluminium	2,700	Gold	19,320
Diamond	3,500	Plutonium	19,840
Titanium	4,540	The core of the Sun	150,000
The Earth	5,515	Black hole	4×10^{17}
Zinc	7,000		

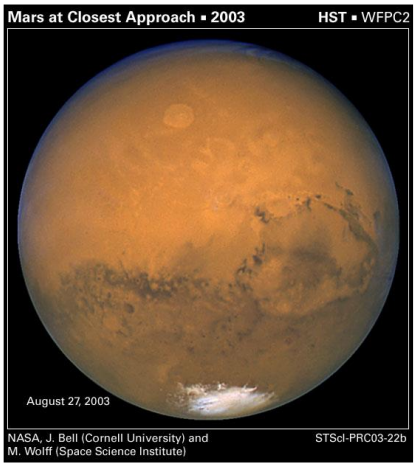
Suggest reasons why scientists and geologists may cast doubt on these figures.

Skills used:

- Upper & lower bounds
- Standard form
- Density formula

- http://neo.jpl.nasa.gov/images/halley.html
- http://en.wikipedia.org/wiki/Halleys_Comet
- http://amazing-space.stsci.edu/resources/fastfacts/comet-halley.php.p=Teaching+tools%40%2Ceds%2Ctools%2C%3EPictures+%2Aamp%2Aamp%3B+facts%40%2Ceds%2Ctools%2Ctype%2Cpictures.php%3EOverview%3A+Comet+Halley+facts%40%2Ceds%2Coverviews%2Cfastfacts%2Ccomet-hal

Mars



Mars orbits at 1.416×10^8 *miles* from the Sun.

Earth orbits at 9.296×10^7 *miles* from the Sun.

They orbit at different speeds so are sometimes close together and sometimes far apart.

What are the closest and farthest distances that they could be apart?

Mars has a radius of 0.53 relative to Earth but a volume of only 0.107 relative to Earth.

What can you deduce from this amount the composition of Mars? You may require the formula for the volume of a sphere which is:

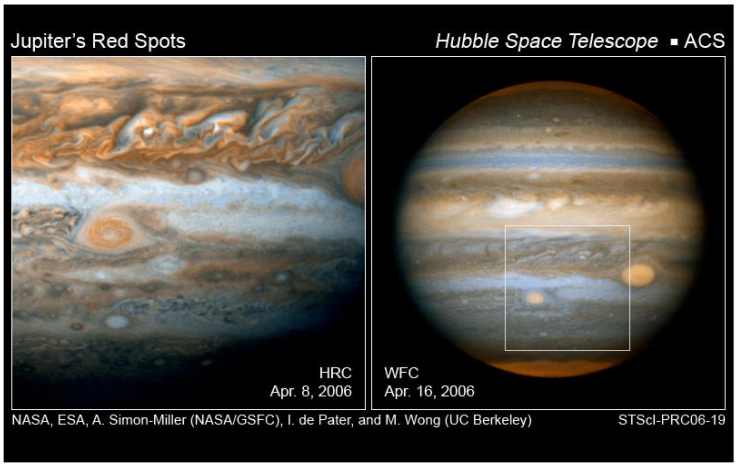
$$V = \frac{4}{3}\pi r^3$$

Skills used:

- Standard form
- Ratio
- Substitution

- http://hubblesite.org/newscenter/archive/releases/solar%20system/mars/2003/22/
- http://amazing-space.stsci.edu/resources/fastfacts/mars.php.p=Teaching+tools%40%2Ceds%2Ctools%2C%3EPictures+%2Aamp%2Aamp%3B+facts%40%2Ceds%2Ctools%2Ctype%2Cpictures.php%3EOverview%3A+Mars+facts%40%2Ceds%2Coverviews%2Cfastfacts%2Cmars.php&a=%2Ceds

Jupiter



The mass of Jupiter is approximately $1.8986 \times 10^{27}\ kg$.
The mass of Earth is approximately $5.9736 \times 10^{24}\ kg$.
The masses of the other planets in the solar system relative to Earth are as follows:

Mercury	*0.55*
Venus	*0.815*
Mars	*0.107*
Saturn	*95.152*
Uranus	*14.536*
Neptune	*17.147*

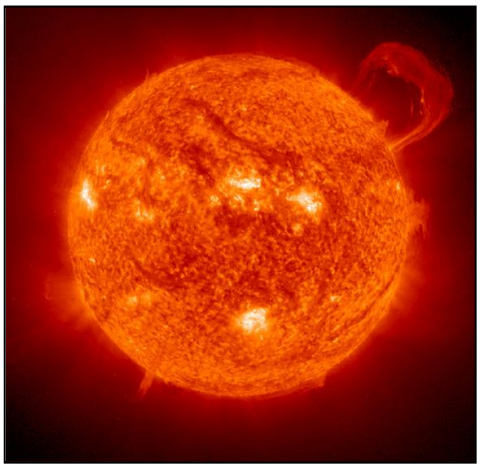
Use these figures to work out the mass of Jupiter as a percentage of the total mass of the all planets in the solar system.

Skills used:

- Percentages
- Standard form
- Constructing formula

- http://hubblesite.org/newscenter/archive/releases/2006/19
- http://amazing-space.stsci.edu/resources/fastfacts/jupiter.php.p=Teaching+tools%40%2Ceds%2Ctools%2C%3EPictures+%2Aamp%2Aamp%3B+facts%40%2Ceds%2Ctools%2Ctype%2Cpictures.php%3EOverview%3A+Jupiter+facts%40%2Ceds%2Coverviews%2Cfastfacts%2Cjupiter.php&a=%2Ced

Sol (Our Sun)



The Sun has a diameter of 8.637×10^6 *miles*.
The Earth has a diameter of 7.926×10^4 *miles*.

How many times would Earth fit across the Sun?

The volume of a sphere is given by the formula:

$$V = \frac{4}{3}\pi r^3$$

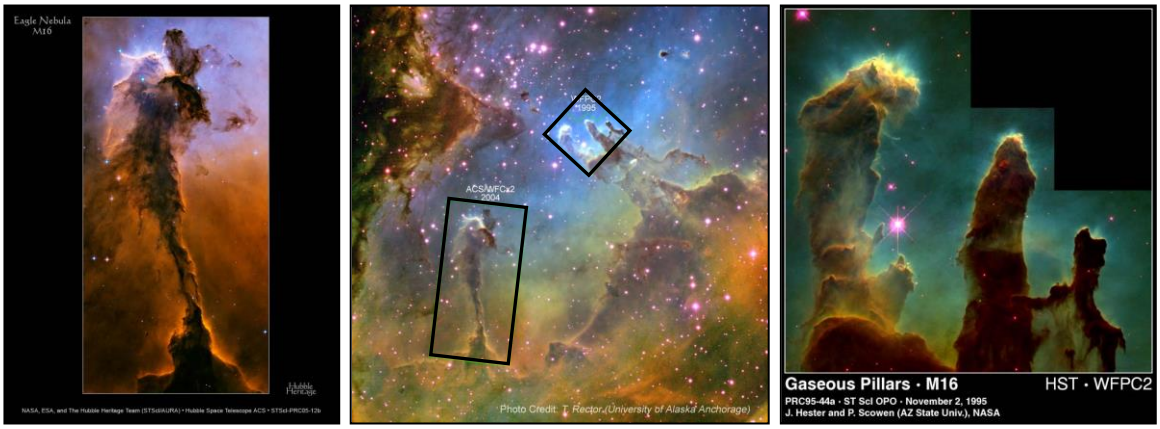
How many times would Earth's volume fit inside the Sun?

Skills used:

- Standard form
- Division
- Substitution

- http://sohowww.nascom.nasa.gov/
- http://amazing-space.stsci.edu/resources/fastfacts/sun.php.p=Teaching+tools%40%2Ceds%2Ctools%2C%3EPictures+%2Aamp%2Aamp%3B+facts%40%2Ceds%2Ctools%2Ctype%2Cpictures.php%3EOverview%3A+Sun+facts%40%2Ceds%2Coverviews%2Cfastfacts%2Csun.php&a=%2Ceds

The Eagle Nebula



The 'three pillars' of the Eagle Nebula are $2\text{-}3\ light\ years$ tall.

The pillar of the 'stellar spire' is $9.5\ light\ years$ tall.

The speed of light is $300\ million\ ms^{-1}$.

Pluto orbits at $3.69 \times 10^{9}\ miles$ from the Sun.

How many times would the diameter of Pluto's orbit fit into the Stellar Spire?

Remember to convert your units where necessary.

Skills used:

- Metric / imperial conversion
- Standard form
- Division

- http://hubblesite.org/newscenter/archive/releases/nebula/1995/44/
- http://hubblesite.org/newscenter/archive/releases/2005/12
- http://amazing-space.stsci.edu/resources/fastfacts/eagle_nebula.php.p=Teaching+tools%40%2Ceds%2Ctools%2C%3EPictures+%2Aamp%2Aamp%3B+facts%40%2Ceds%2Ctools%2Ctype%2Cpictures.php%3EOverview%3A+Eagle+Nebula+facts%40%2Ceds%2Coverviews%2Cfastfacts%2Ceagle_neb

Helix Nebula

The speed of light is $300\ million\ ms^{-1}$.

The Helix Nebula is *3 light-years* wide.

How many miles is that?

The Helix Nebula is *650 light-years* away.

How many miles is that?

Remember to convert your units where necessary.

Skills used:

- Metric / imperial conversion
- Standard form

- http://hubblesite.org/newscenter/archive/releases/2003/11
- http://amazing-space.stsci.edu/resources/fastfacts/helix_nebula.php.p=Teaching+tools%40%2Ceds%2Ctools%2C%3EPictures+%2Aamp%2Aamp%3B+facts%40%2Ceds%2Ctools%2Ctype%2Cpictures.php%3EOverview%3A+Helix+Nebula+facts%40%2Ceds%2Coverviews%2Cfastfacts%2Chelix_neb

The Whirlpool Galaxy

The speed of light is $300\ million\ ms^{-1}$.

This image is about $98{,}000\ light\text{-}years$ wide.

How many miles is that?

The Whirlpool galaxy is $31\ million\ light\text{-}years$ away.

How many miles is that?

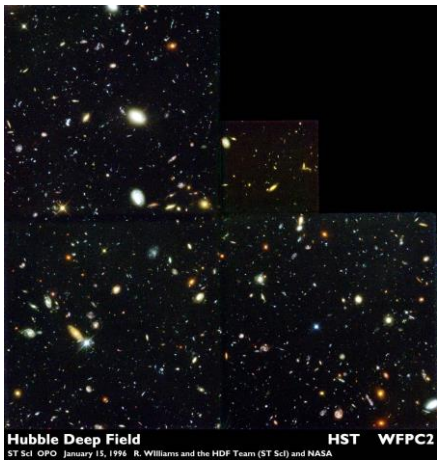
Remember to convert your units where necessary.

Skills used:

- Metric / imperial conversion
- Standard form

- http://hubblesite.org/newscenter/archive/releases/2001/10
- http://amazing-space.stsci.edu/resources/fastfacts/whirlpool_galaxy.php.p=Teaching+tools%40%2Ceds%2Ctools%2C%3EPictures+%2Aamp%2Aamp%3B+facts%40%2Ceds%2Ctools%2Ctype%2Cpictures.php%3EOverview%3A+Whirlpool+Galaxy+facts%40%2Ceds%2Coverviews%2Cfastfacts%2Cw

The Hubble Deep Field



Every 'dot' that you can see in the image of the Hubble Deep Field is a galaxy.

The area of the Hubble Deep Field image covers $\frac{1}{32{,}000{,}000}$ of the sky, or the entire universe.

There are 3000 dots, or galaxies, in the Hubble Deep Field.

Use this figure to estimate the number of galaxies in the universe.

Skills used:

- Fractions
- Interpreting standard form

- http://hubblesite.org/newscenter/newsdesk/archive/releases/1996/01/
- http://amazing-space.stsci.edu/resources/explorations/hdf/
- http://amazing-space.stsci.edu/resources/explorations/hdf/stellar_statistician/one
- http://www.faqs.org/faqs/astronomy/faq/part8/section-4.html

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Hubble Standard Form Answers

Earth Gravity

$$g = \frac{6.6742 \times 10^{-11} \times 5.972 \times 10^{24}}{6377830^2} = 9.82$$

Telescopes

$$\frac{210^2}{5^2} = 1764$$

The Moon

$$g = \frac{6.6742 \times 10^{-11} \times 7.35 \times 10^{22}}{1738000^2} = 1.62 \approx \frac{9.8}{6}$$

Halley's Comet

$$LB = \frac{2.2 \times 10^{14}}{7.35 \times 10^{11}} = 299 \qquad UB = \frac{1.7 \times 10^{15}}{1.32 \times 10^{12}} = 1288 \qquad \Rightarrow \text{ice or water}$$

Mars

$$1.416 \times 10^8 + 9.296 \times 10^7 = 2.3456 \times 10^8 \qquad 1.416 \times 10^8 - 9.296 \times 10^7 = 4.864 \times 10^7$$

Jupiter

$$\frac{1.8986 \times 10^{27}}{1.8986 \times 10^{27} + 5.9736 \times 10^{24}(1 + 0.55 + 0.815 + 0.107 + 95.132 + 14.536 + 17.147)} = 71.08\%$$

The Sun

$$8.637 \times 10^6 \div 7.926 \times 10^4 = 109$$

The Eagle Nebula

$$\frac{5.913 \times 10^{12} \times 9.5}{2 \times 3.69 \times 10^9} = 7611$$

Helix Nebula

$$5.913 \times 10^{12} \times 3 = 1.7739 \times 10^{13} \qquad 5.913 \times 10^{12} \times 650 = 3.84345 \times 10^{15}$$

Whirlpool Galaxy

$$5.913 \times 10^{12} \times 98000 = 5.79474 \times 10^{17} \qquad 5.913 \times 10^{12} \times 3.1 \times 10^7 = 1.83303 \times 10^{20}$$

Hubble Deep Field

$$3000 \times 32000000 = 9.6 \times 10^{10}$$ (see also internet answer)