Chapter 5

Gigaworld

1 000 000 000 (1.0 x 10^9) G

5.1 Gigaworld Length

1 – 1000 Gigameters (Gm) 1 x 10^9 m

Comparison Table of Solar System Distances

Example	Distance
Mercury	58 Gm
Venus	108 Gm
Earth	150 Gm
Mars	228 Gm
Asteroid Belt	300-600 Gm
Jupiter	778 Gm
Saturn	1 429 Gm
Uranus	2 875 Gm
Neptune	4 504 Gm
Kuiper Belt	4 500-7 500 Gm
Pluto	5 915 Gm
Eris	10 166 Gm
Voyager 1	22 224 Gm
Voyager 2	18 435 Gm

Table 5.1: Solar System Object Distances from the Sun

The distances from the Sun to the planets in our Solar System are conveniently expressed in Gigameters (the Sun has a diameter of 1.39 Gm). Table 5.1 has a list of solar system distances from the Sun to various astronomical objects. When using Gigameters, one can readily compare distances using integer values. Venus is about twice as far from the Sun as Mercury, with a distance between them of 50 Gigameters. The distance between Earth and Venus, 42 Gm, is of a similar magnitude. Earth to Mars is farther at 78 Gm.

The Asteroid Belt is wider than the 170 Gigameter linear distance occupied by the inner planets, (i.e. the distance from Mercury to Mars), and is itself overshadowed by the 550 Gm distance from Mars to Jupiter.

The outer Gas Giants are each around double their previous distance from the Sun. The last planet from the Sun, Neptune, is followed by the Kuiper Belt, which is like the asteroid belt. The Kuiper Belt is thought to exist in a region about 4500-7500 Gm from the Sun. It contains many small celestial objects but is much larger than the asteroid belt. Pluto and Eris are considered dwarf planets which reside within the Kuiper Belt. Voyager 1 is over 22 000 Gigameters from the Sun as of this writing, and getting further all the time. Voyager 1 is the furthest human created spacecraft ever to leave Earth.

The total length of the Earth's roads is 64 Gigameters, which is approximately the distance from the Sun to Mercury. The total length of the roads in the United States is 6.6 Gigameters.

In late October of 1671, Giovanni Cassini (1625–1712) discovered a moon on the western side of Saturn. Months later he tried to view it on the eastern side of Saturn, but could not locate it. The next year Cassini again could observe the moon on the western side of Saturn, but failed once more to find it on the eastern side. Cassini, with the aid of a much better telescope, was finally able to locate the moon on the eastern side of Saturn in 1705. This moon, now called Iapetus, looks much like a black & white cookie. Iapetus is tidally locked, which means that one side always

faces Saturn. Because of this, the dark half of Iapetus is visible from Earth when it is on the eastern side of Saturn, and the more reflective side is seen from Earth when Iapetus is on the western side.

The shape of Iapetus is also unusual. Iapetus has an equatorial ridge on its dark side, which makes it look similar to a walnut. The ridge is about 20 Kilometers wide, 13 Km high, and 1300 Kilometers long. The bright side does not have a ridge, but instead sports a number of isolated peaks, which are about 10 Km tall.

The black and white sides of Iapetus make it unique among all satellites of the Solar System. The obvious question is: "why is one side black and the other white?" It was hypothesized that perhaps Iapetus was moving through a ring of inky particulates which collected on the dark side and left the luminous side relatively unaffected.

Tiny black dust particles would be very difficult to see against a black sky, and neither ring nor dust were detected until 2009, when a team of researchers from the University of Virginia, Charlottesville, and the University of Maryland, College Park, looked outside the visible range of light using an infrared telescope. The dust they detected is so sparse, that even if one were traveling through it, the dust would still remain invisible.

This ring of particulates became known as the Phoebe ring, because Saturn's moon Phoebe shares its orbit with this colossal ring of dust. Phoebe orbits Saturn in the opposite direction of the planet's rotation, which is called a retrograde orbit. Phoebe is thought to be a captured Kuiper belt object, and is hypothesized to be the source of the dust found in the Phoebe Ring.

The extent of this dust cloud is astonishing. New measurements of the Phoebe Ring taken in 2015, indicate that at its innermost extent, the ring is 6 Gigameters from Saturn, whereas the outermost edge of the ring is 16 Gigameters distant. Phoebe orbits at a distance of about 13 Gigameters from Saturn. The thickness of the ring is a massive 2.4 Gigameters. The Phoebe Ring is the largest ring in the Solar System, and dwarfs Saturn's visible inner

rings, which have a mean radius of only 58.2 Megameters (0.058 2 Gigameters). The inside edge of Saturn's Phoebe Ring is not encountered for another 5942 Megameters (5.942 Gigameters) after the end of the visible rings. This is about 100 times the radius of Saturn. If the Phoebe Ring were visible from Earth, it would be about the size of two full moons.

5.2 Gigaworld Area

1 – 1 000 000 Square Gigameters (Gm^2) 1 x 10^{18} m^2

Square Gigameters are convenient for describing the surface area of astronomical objects. The surface area of the Sun is 6.1 square Gigameters, and the star Vega, the second brightest star in the northern hemisphere, has 30 square Gigameters of surface.

The blue supergiant star HDE 226868 is a companion of Cygnus X-1 which is a galactic source of X-rays and a possible black hole. It is thought that matter from the stellar wind of HDE 226868, which orbits in tandem with Cygnus X-1, is falling into that candidate black hole, and producing the observed radiation. HDE 226868 has a diameter about 16 times that of the Sun and a surface area of 1556 square Gigameters.

Astronomical Gigameter Areas

Example	Area
Sun (surface area)	6 Gm^2
Vega (surface area)	30 Gm^2
HDE 226868 (surface area)	1 556 Gm^2
Mercury's Orbital Ellipse Area	11 000 Gm^2
Earth's Orbital Ellipse Area	71 000 Gm^2
Mars' Orbital Ellipse Area	160 000 Gm^2
Jupiter's Orbital Ellipse Area	1 900 000 Gm^2

Table 5.2: List of Square Gigameter Items

The Earth's orbit sweeps out an ellipse which encloses an area of 71 000 square Gigameters, and Jupiter's traces out an ellipse of

1 900 000 square Gigameters. The use of orbital ellipse area may seem like a contrived example area for illustration, but the area of an orbital ellipse is of considerable importance to astronomers.

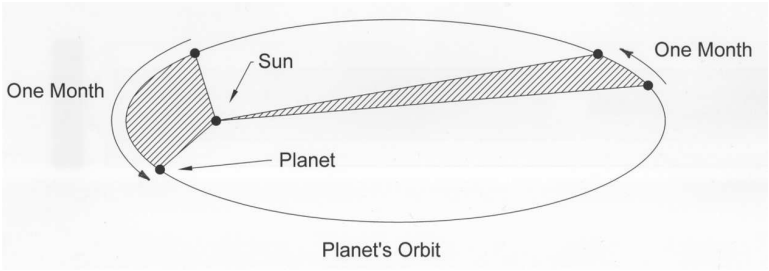

Figure 5.1: Kepler's second law of planetary motion states a planet, as it orbits the Sun, sweeps out equal areas over equal amounts of time. The two shaded areas, each traced out over a one-month interval, are equivalent.

Johannes Kepler (1571–1630) was the first scientist to effectively describe how planets orbit the Sun. He distilled how they orbit into three scientific generalizations known as Kepler's laws of planetary motion. Kepler's first law states the orbit of a planet is an ellipse. An ellipse is like a stretched-out circle with two "center points" known as foci. Kepler placed the Sun at one of these foci and the orbiting planet on the ellipse. Kepler's second law states that if you draw a line from the Sun to the orbiting planet, it will sweep out equal areas in equal time periods. This is illustrated in Figure 5.1. Although the planet will move at a changing rate of speed as it orbits along the ellipse, it will trace out equal areas.

5.3 Gigaworld Volume

1 – 1 000 000 000 Cubic Gigameters (Gm^3) 1 x 10^{27} m^3

1 – 1000 Gigaliters (GL) 1 x 10^9 L

The Empire State Building has a volume of almost exactly 1 Gigaliter.

List of Gigaliter Volume Items

Example	Area
Empire State Building	1.0 GL
The Great Pyramid of Giza	2.5 GL
Volume Displaced by Meteorite at Meteor Crater	63 GL
Capacity of US Petroleum Reserve	115 GL

Table 5.3: List of Example Gigaliter Items

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The Great Pyramid of Giza has a volume of 2 500 000 cubic meters which is 2.5 Gigaliters.

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The volume of Meteor Crater in Arizona is 62 700 000 cubic meters or 62.7 Gigaliters.

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In the wake of the 1973-1974 oil embargo, the United States created the Strategic Petroleum Reserve (SPR). The maximum capacity of the SPR is about 115 Gigaliters. The crude oil in the SPR is currently stored in four separate locations in human-created caverns inside salt domes.

Gm^3 • • • Gm^3

The realm of cubic Gigameters is so large a volume, only one body in our solar system, the Sun, is within this magnitude range. A sphere which encloses a volume of one cubic Gigameter has a diameter which is 1.24 Gigameters. The Sun has a diameter of 1.39 Gigameters and a volume of about 1.41 Gm^3. The liter is not

tenable as a volume to describe celestial objects larger than the planets found in our solar system.

List of Cubic Gigameter Volumes Items

Example	Volume
The Sun	1.41 Gm^3
Arcturus	24 000 Gm^3

Table 5.4: List of Cubic Gigameter Examples

The red giant Arcturus is the brightest star in the northern sky. It was the first star to be observed during daytime.* In 1635, the French mathematician Jean-Baptiste Morin (1583-1656) used a telescope to view the star during the day. Arcturus has a diameter of about 36 Gigameters, which encloses a volume of about 24 000 Gm^3. Arcturus is only 347 Petameters from the Earth, which is rather close in astronomical terms.

5.4 Gigaworld Mass

1 – 1000 Gigagrams (Gg) 1 x 10^9 g

The Gigagram world spans the mass of the largest living organisms to the largest of human-engineered objects. The largest giant Sequoia trees have masses of about 2 Gigagrams, and extend themselves approximately 84 meters above the ground. The Saturn V rocket, which took American astronauts to the Moon, had a total mass of about 3 Gigagrams, and a height of 110.6 meters.† The maximum payload it could launch to the Moon was 48.6 Megagrams.

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The Eiffel Tower, at 324 meters in height, protrudes well above the tallest Sequoia trees, which have a maximum height of about 115 meters, and has four times their mass at 8 Gg.

*Other than the Sun, of course.

†The Space Shuttle was 56.1 meters tall and had a mass of 2 Gigagrams

List of Gigagram Items

Example	Volume
Sequoia Tree	2 Gg
Saturn V Rocket	3 Gg
Eiffel tower	8 Gg
SS *Great Eastern*	33 Gg
RMS *Titanic*	53 Gg
Washington Monument	82 Gg
Gold Mined in Human History	174 Gg
Seawise Giant	657 Gg

Table 5.5: List of Gigagram Magnitude Items

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The SS *Great Eastern*, designed by 19th Century British engineer Isambard Kingdom Brunel (1806-1859), and launched in 1858, massed in at 32.7 Gigagrams. The RMS *Titanic*, infamously launched on May 31st 1911, had a mass of 53.2 Gigagrams. Both the *Great Eastern* and the *Titanic* have less mass than the Washington Monument. The largest ship ever constructed, until it was dismantled in 2010, is the Japanese ship *Seawise Giant*, launched in 1979. When fully loaded, it had a mass of about 657 Gigagrams.

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The total amount of gold mined by humans, from antiquity to today, is estimated at about 174 Gigagrams.[‡] A cube of gold this size would have sides 21 meters in length. The volume of the world's gold is about 9261 cubic meters (9261 Kiloliters). This is similar to the volume of a two story house.

The 56 Km long Witwatersrand area of South Africa is unequaled for the amount of gold it has produced. Around 40 Gigagrams of gold has been extracted since it was first discovered in 1886. This is estimated to be about 22% of all the existing gold

[‡]2002

on Earth. In 1961, the currency of South Africa was named the rand after the Witwatersrand area.

