CONTENTS OF THE CONCEPTS DATABASE

OVERVIEW

The following is the textual content of the concepts database. Often, the writing is designed to explain a picture or animation.

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ATMOSPHERES

The air that you breathe and the clouds you see in the sky are part of the earth's atmosphere. An atmosphere is like a blanket completely covering a world. This blanket is made up of gases.

How Atmospheres Are Made
Some atmospheres were made when worlds were forming. Deep thick layers of gases were left swirling around Gas Giants and became their atmospheres. Some atmospheres were made after worlds formed. Earth's atmosphere was made from gases that erupted from its core. Some of the Earth's atmosphere was also delivered by comets and asteroids. Oxygen was added later when plants began to grow. It is still changing.

Holding on to an Atmosphere
Not all worlds have atmospheres. Most of the smaller worlds, such as our Moon, have almost no atmosphere. Why do some worlds have atmospheres while others don't?

The answer is gravity. A world like Jupiter has a great deal of gravity, so it is able to hold on to its gases. It can even hold onto light gases like hydrogen and helium. Earth and Venus have less gravity, but it is enough to hold onto the heavier gases, like nitrogen and carbon. Small worlds like our moon or Phobos and Deimos (the moons of Mars) are too small to have much gravity. Their atmospheres escaped into space a long time ago.

What Atmospheres Do for a World
Atmospheres affect the worlds they surround in many ways. You can see how important an atmosphere is by comparing Mercury and Earth.

Atmospheres Hold in Heat
When heat from the sun enters an atmosphere, some of it is trapped there. This means that even the side of a world turned away from the sun keeps some of its heat.

Atmospheres Block the Sun's Ultraviolet Rays
Ultraviolet rays can be very harmful to living things. An atmosphere can block most of the sun's ultraviolet rays, reflecting them back out into space. Atmospheres Reflect Light. Light from the sun bounces off of particles in the atmosphere. This gives Earth its blue daytime sky. Worlds without atmospheres always have nighttime skies.

Atmospheres Burn up Most Meteors
Meteors are bits of rock and dust that slam into a world. An atmosphere can help to protect a world from meteor collisions.

Atmospheric Pressure
The atmosphere presses in all around us on Earth. Our bodies developed in a way that allows us to push back, so we don't notice the pressure.

We measure atmospheric pressure with an instrument called a barometer. The average atmospheric pressure at the surface of Earth is assigned a value of 1.0. If an atmosphere has a barometric pressure of 2, you know that it is twice as thick as Earth's atmosphere. Some worlds have much greater atmospheric pressure than Earth.

Venus has an atmospheric pressure 90 times Earth's. You could almost swim in Venus' air.

Gas Giants have extremely deep atmospheres. At the top the atmospheres are quite thin, then get denser and denser as you travel down toward the core of the planet. In fact the pressure gets so high that it would crush most objects long before they reached the core. This pressure is strong enough to squeeze molecules so closely together that gases turn into liquids.

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CLASSIFYING PROBES

Did you know that there are many different types of spacecraft? Depending on the mission they are intended to fly, a probe may be a flyby, an orbiter, a lander, or a rover.

Flyby Probes
Flyby probes are just like the name sounds -- they fly by the planet. They do not enter the orbit of any planet. Flyby spacecraft use their instruments to gather data and take pictures as they pass by a planet. Flyby spacecraft use their instruments to gather data and take pictures as they pass by a planet. Examples of flyby probes include Voyagers 1 and 2.

Orbiter Probes
Unlike flyby spacecraft, orbiters do enter a planet's orbit. A planetary orbit is a path around the planet which keeps the spacecraft going around the planet. Examples of orbiter spacecraft include Magellan and Galileo.

Lander Probes
Can you guess what a lander spacecraft does? That's right -- a lander is designed to actually land on a planet's surface. The landers can then use their instruments to analyze rocks and soil on the planet and send the data back to Earth. Examples of lander probes include Viking and Mars Pathfinder.

Rover Probes
Scientists have now come up with a way to release a rover onto a planet from a lander spacecraft. These rovers are just like remote-control cars which can be steered from Earth. The rovers can give scientists a great view of the planet by driving over rocks and valleys to take pictures and conduct soil experiments. The probes can then send

the data back to Earth. A rover called Sojourner was released onto Mars from the Pathfinder lander.

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CONVERTING FRACTIONS TO DECIMALS

Fractions and decimals look different, but they do the same work. They are two different ways we can describe parts of a whole. Switching between them is easy, if you understand what each one means.

Menu

Parts of One Whole

Let’s say you have a candy bar. Or, a pie. Or maybe even a block of cheese. Whatever you have, you want to share it with your friends. You have one thing, whatever it is, and you want to divide it into several equal pieces. That’s what fractions and decimals are for. They’re just two different ways of expressing parts of one whole thing.

Let’s look at fractions. Fractions have two parts, a numerator and a denominator. To illustrate three-fifths, we’ll start with one whole thing, in this case, a rectangle. The denominator tells you how many pieces the whole is divided into. Since the denominator here is five, we’ll divide this rectangle into five pieces. The numerator tells you how many pieces you’re talking about. Since the numerator here is three, we’ll color in three pieces. We’ve colored in three fifths of this rectangle.

Decimals work a different way. With decimals it’s understood that our total number of pieces is some power of ten – tenths, hundredths, thousandths, etc. For example, let’s illustrate .3 (read it as “point three”). The smallest digit (the one farthest to the right) is in the tenths place. So, we’ll divide the rectangle into ten pieces and color in three.

Let’s try another example, .42 (read it as point four two). The smallest digit is in the hundredths place, so we’ll divide the rectangle into a hundred pieces and color in forty-two of them. So you can see that decimals and fractions are really the same – they both name parts of one whole thing.

Using a Calculator
Changing a fraction to a decimal with a calculator is easy. You just have to remember what a fraction means, then punch that equation into the calculator.

Take this fraction, five-eighths. The bar between the numerator and denominator means “divided by.” So this fraction just means “Five divided by eight.”

Just punch the number 5. Then the division sign. Then the number 8. Hit equal, and you get the result. Five-eighths is equal to .625 (read that as “point six two five”).

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CRATERS

Craters are formed when a meteor slams into the surface of a world. Scientists can tell a lot about the history of a world by studying its craters.

Meteor Impacts
Meteoroids are small chunks of stone or iron that orbit the sun. They range in size from small particles of dust to objects larger than trucks. Some meteoroids have been traveling in our solar system since it was formed 4.6 billion years ago. Other meteoroids are pieces of comets and asteroids that have broken off.

When a meteoroid hits the atmosphere of the Earth, it is traveling at a very high speed. As it rubs against our atmosphere, it is heated by friction. This makes it look like a glowing streak of light as it falls toward the Earth. This streak is a meteor, though people often use the phrase “shooting star.”

Most meteors burn up in our atmosphere, but a few are large enough that they reach the ground. Meteors that reach the ground are called meteorites. When a meteor that is large enough slams into the surface of a world, it can form a crater.

Protection from Cratering
Compare these aerial photographs of the Earth and its moon. One of the first differences you probably notice is in the number of craters. Why does Earth have so few craters when the moon has so many? There are two reasons.

First, the Earth has an atmosphere, which helps to protect it from the impact of meteors. When a meteoroid hits the atmosphere of the Earth, it is traveling at a very high speed. As it rubs against our atmosphere, it is heated by friction. This friction burns up the smaller meteors. Larger meteors do not burn up all the way, but by the time they hit the surface, they are much smaller than they were when they first entered our atmosphere. This means they make smaller craters when they hit the surface.

The second reason the Earth has fewer craters than the moon is that there are forces on Earth that help to erase signs of cratering. The next section describes some of those forces.

What Craters Tell Us

Look at this picture of the moon. The craters shown here were not created all at once. They are the result of millions of years of impacts by meteors. When we see a world with this many craters, we know that it has not changed much for millions of years.

The opposite is true too. When we see a world with few craters, we know that there are forces at work that change the surface. Wind, water, earthquakes, and volcanoes can cover or destroy craters. Simply by looking at the surface of a world, we can tell a lot about what that world is like.

Weathering is the breaking down of rocks. On Earth, the wind and rain beat down on the surface. Over time, this breaks the surface up into smaller pieces of rock and dust. Weathering is the reason that most places are covered in soil.

Erosion is the carrying away of pieces of the surface by the movement of water, wind, or ice. If a world has a lot of craters, it means that there has been very little erosion.

Internal Forces deep within a world can also make changes in the surface. A world which is geologically active has earthquakes and volcanoes which affect the surface and erase the signs of cratering.

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GRAVITY

Gravity is a powerful force of nature. It’s what keeps you from floating off the Earth and out into space. It is also what keeps the planets orbiting the sun, holding them in the solar system instead of spinning off into space.

The Force of Gravity

If you throw a ball up in the air, you know what will happen. It will be pulled back down by the force of gravity. Gravity is called a force because it can change the motion and speed of something. So if you throw a ball straight up, the force of gravity will gradually slow the ball as it travels upward, then eventually change the direction the ball is traveling so that the ball now travels back down toward the ground.

You know all about the Earth's gravity. It's what holds you to the ground and makes apples fall down rather than floating up when they fall off trees. But the Earth is not the only thing that has gravity. In fact, every object exerts a gravitational pull no matter how big it is. Even you have a gravitational pull. In fact, we could say that not only does the Earth pull on you, you pull on the Earth. But if that's true, when you jump up, why doesn't your gravitational pull make the Earth move toward you? It's because different objects have different levels of gravitational pull. The earth's gravity is much stronger than yours, so it pulls you more than you pull it. But gravity isn't just the pull of a big thing on a little thing. Gravity is the attraction between any two objects that have mass.

Mass and Distance

The strength of a gravitational pull is affected by two things - mass and distance. For example, both Jupiter and Europa pull on Io. However, Jupiter has more mass, so its pull is stronger. Also, Jupiter pulls on both Io and Europa. However, because Io is closer to Jupiter, Jupiter's gravitational pull is stronger on Io than on Europa.

Mass is similar to weight on Earth. It's how much stuff is in an object. Now you may think that this means that big objects have more mass than smaller objects. Well, that's often true, but it doesn't have to be. For example, a beach ball is much bigger than a bowling ball, but a bowling ball has more mass. Objects with more mass have a stronger gravitational pull than objects with less mass. So the Earth has stronger gravity than you do.

Jupiter is more massive than Earth, so it has a stronger gravitational pull. And the sun is more massive than Jupiter, so it has a stronger gravitational pull.

Gravity on Other Worlds

Since each of the worlds in our solar system has a different mass, each of these worlds also has a different gravitational level. To describe the gravity on other worlds, we compare it with Earth's. We say that Earth's gravity is equal to 1.0. There's no reason that Earth's gravity has to be 1.0; scientists just picked that figure to be the standard that we use to compare the gravity of worlds.

Then we compare other worlds to Earth. A world with higher gravity would have a number higher than 1.0. For example, Jupiter's gravity level is 2.54, so its gravity is higher than Earth's – a little more than two and one-half times Earth’s.

A world with lower gravity would have a number lower than 1.0. For example, when you read that Mars has a gravity level of .4, you know that it has less than half of the gravitational pull that Earth has.

The Force of Gravity and Weight

How much you weigh depends on where you are. If you were floating out in space, you would be weightless. This means that if you stepped on a scale, the scale would say that your weight is zero.

Does this sound like it can get confusing? It certainly does. That’s why scientists talk about the mass of an object rather than its weight. On Earth, the mass of an object is equal to its weight. However, when you leave the Earth, an object’s weight changes depending on the gravitational pull being exerted on it. But, its mass doesn’t change. An object’s mass is the same, no matter where it is in the universe. Using mass makes it much easier for scientists to compare objects that may be located in different places in the universe.

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MAGNETIC FIELDS

Life is possible on Earth because our planet is surrounded by a magnetic field. Why does the Earth have a magnetic field, when so many worlds do not? And why is a magnetic field so important to us, the residents of Earth?

The Earth is a Magnet

You’ve probably played with magnets many times in your life. You know that a magnet does not have to actually touch something to exert a pull on it. That is because a magnet is surrounded by a magnetic field. A simple bar magnet has two poles – a north pole and a south pole.

With magnets, opposites attract. The north pole in a magnet is always seeking the south pole, and the south pole is seeking the north pole. These poles pull on each other, creating a magnetic field. The Earth is like a giant bar magnet. It has a north pole and a south pole that are attracted to each other.

What makes the Earth a magnet? The core of the Earth is made of molten (liquid) iron. It spins around because the Earth rotates. When liquid metal spins this way, it creates a magnetic field. Magnetic fields can also be created by a salty ocean.

Protection from Solar Wind

The Earth is surrounded by a huge magnetic field. This is very important because this field helps to protect our world from the solar wind.

As you know, the sun sends out light. However, it also sends out small particles of matter called ions. These ions flow outward from the sun through the solar system. This is the solar wind. There are other worlds in our solar system that have magnetic fields. However, not every world has one. To have a magnetic field, a world must have a molten metal core, and it must spin (rotate) fast enough to make the core magnetic.

Northern and Southern Lights

The magnetic field of the Earth pushes most of the ions around the Earth. However, it pushes some ions toward the north and south pole where they are able to enter the upper parts of our atmosphere. The result is one of the most spectacular and beautiful phenomena on Earth – the northern and southern lights. An aurora is like a dancing light show. What colors do you see here in the Aurora Australis?

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RADIO WAVES

In the world around us, there is much going on that we cannot see. For example, we cannot see the sound that we can hear!

How We Hear Sound

There are two ways to hear sound. We can hear it directly through sound waves, or we can hear the translation of radio waves (as in a broadcast) into sound waves..

The sounds that we hear directly are carried by sound waves. Sound waves are physical vibrations so they need to be carried by something, like air, water, or even metal. (Long ago, people would listen for trains by putting their ears to a railroad track.)

The sounds we hear through the radio were carried there as radio waves. Radio waves are "electromagnetic waves." Electromagnetic waves are magnetic waves made by electricity.

The Electromagnetic Spectrum

There are many kinds of these electromagnetic waves, all arranged on a "spectrum."

The different types of waves on the spectrum have different lengths. The waves of some are short, and others are long. From longest wavelength to shortest, these electromagnetic waves include: radio waves, microwaves, infrared, optical, ultraviolet, X-rays, and gamma-rays. Also, among the different kinds of electromagnetic waves, some we can see, and others we cannot see. For example, we can only see visible light waves. This part of the electromagnetic spectrum gives us the colors we see in the rainbow.

But we cannot see microwaves or gamma rays or radio waves. Electromagnetic waves, including radio waves, can travel in a vacuum where there is no air. As you know, space is a vacuum. This means that radio waves can travel in space! This also means that radio waves travel at the same speed as light. That's a lot faster than sound travels!
Lightning and thunder illustrate this difference in speed. First, you see the lightning, and then you hear the thunder. Although both start at the same time, the light gets to us before the sound.

Using Radio Waves

One of the ways we use radio waves is to send sound farther than regular sound waves can travel. We can send "sound" through radio waves by transforming the sound waves. At the beginning, a "transmitter" translates sound into radio waves. At the other end, the "receiver" translates the radio waves back into sound. We've been using radio waves since 1900, and there are many, many uses for them. It could be difficult keeping all the different signals straight. To help, different uses are assigned to different frequencies (like radio stations have different numbers). That way your garage door opener doesn't turn on your radio!

Are you wondering how we can "tune in" to a radio station? How can someone "tune in" to messages or broadcasts in space? A broadcast can be sent on a particular frequency within that section. For example, you hear that a radio station is broadcasting at "740." That means the radio station's transmitter is using that frequency for its signal. To receive that broadcast, your receiver is focused--or "tuned"--to the same frequency, 740.

Records of Our Past

Remember that radio waves can travel far out into space. They can travel long distances! Also, even though radio waves travel at the same speed as light, which is 186,000 miles per second, there are still large distances in space--many, many miles to travel!

To make the numbers easier to work with, we use "light-years" for space distances. A "light-year" is the distance light travels in a year. It's certainly easier to use 1 light year instead of 10 trillion kilometers! Since radio waves travel the same speed as light, we can use the same measurement. Because space is so large, it can take a long time for radio waves to get anywhere. For example, if a planet is 20 light-years away, it will take radio waves 20 years to reach it!

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SPECTRA

Everything in the universe is made of a substance, like gold, silver, tin, carbon, nitrogen, or even oxygen. These are all Elements, and we can tell which they are through Spectra.

What are Elements?

Elements are the fundamental materials of which all matter - everything - is composed. Elements can be mixed with something else, but they can’t be divided. For example, Hydrogen and Oxygen can be mixed to form Water. (H2O). Here's another example: Brass is a mixture of copper, zinc, and lead!
But elements aren't a mixture of anything! Silver is silver and can't be divided into anything else. Over the years, scientists have developed a chart of all the known

elements. As far as we know, everything in the universe is made of up these elements or combinations of them. This chart is the Periodic Table.

What are Spectra?
To identify the elements, scientists test them and record the results. These results resemble a picture or graph of lines. Every element has its own special picture called a Spectrum. Because each test of the elements always provides the same picture, these spectra are part of a universal language. Since every element's spectrum is unique and never changes, it's like a "signature." Scientists can test an unknown substance from anywhere and compare that picture to the chart of all known elements. If scientists find a strange rock and test it, the resulting picture should match one of the pictures for the known elements. It might be carbon, for example!

What is a spectrograph?
A spectrograph is an astronomical instrument to get and record spectra. The spectrograph separates the light from objects into component colors of spectra. The spectra reveal information such as an object's composition, distance, or temperature.

How does it work?
A spectrograph splits the light into a spectrum by using a diffraction grating. Diffraction grating is used in CD (Compact Disk) technology. A CCD (Charge-Coupled Device) camera records the spectrum and transmits the spectrum to a computer.

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SUPERNOVAE

Stars may last billions of years, but they don't last forever. How they end their lives can be either quite a show or a very quiet event.

The Life of a Star
A star is a ball of burning gas. Its gravity pulls it inward and the energy from the burning gas pushes outward. The two forces keep the star stable. Although they may

last for billions of years, stars do not last forever. Eventually, the fuel that keeps them burning runs out.

So what happens when a star dies? That depends on the mass of the star. Some stars end quietly, while other stars explode, sending matter blazing across space. In the case of stars that aren't too large—perhaps a little bigger than our Sun or smaller — as the fuel burns up, the force balancing the gravity lessens. The star's own gravity then causes the center of the star to contract. At the same time, the outer layers expand. The star appears brighter and becomes a red giant. The red giant eventually finishes burning out. Then the star collapses into a white dwarf. Given enough time, which may be greater even than the age of our universe so far, this white dwarf may collapse even further and become a cool black dwarf. That's the case of the smaller stars. What about those really big stars, five times bigger than our sun? When those stars lose their energy, they're so massive that instead of becoming red giants, they become even larger! Instead of collapsing into a white dwarf, they go supernova!

What is a Supernova?

If a star is large enough, by the time its fuel runs out, its core is so massive that its gravity causes that core to collapse in upon itself. The collapse of the core results in a blast wave so huge that entire nearby solar systems can be vaporized! The light of a supernova can be greater than all the other 100,000,000,000 stars in its galaxy! This blast wave sends the star's remaining atmosphere and elements out into space. These bits and pieces and dust and gases are called supernova remnants. All that remains of the star may be its dense core, made up of neutrons. This is the origin of a neutron star.

However, if the original star is truly big—not 5, but 15 times larger than our Sun—the core isn't even strong enough to survive the blast, and a black hole forms. Because the density of what was the star's core has become so dense, its gravity has grown along with that density. That gravity gets so strong that nothing, not even light can escape from it. That's why we call it a black hole. It's difficult to actually see a black hole since anything that gets too close to one will be pulled inside it. We can only tell where one is by the effect it has on objects around it. As those objects are pulled inside the black hole, they heat up. Then we can use instruments that show the heat. The rest of the elements from the blast of a supernova become the material that make up other stars and planets and Earth and everything on it! Including ourselves!

The Crab Nebula

Over the age of the universe, there have been many supernovae (that's the plural of "supernova"), but there haven't been very many in our own Milky Way Galaxy. However, almost a thousand years ago, our ancestors saw the light from a supernova explosion that occurred right here in our own galaxy. Today, we see what's left of that star, and we call it the Crab Nebula.

A "nebula" is a scattered cluster of interstellar dust and gas. So the Crab Nebula is not just a star, but bits and pieces of a star scattered over a large area of space. The core of the star that exploded to create the Crab Nebula remains. It became a pulsar star. A pulsar star is a spinning neutron star. The high energy radiation is what we see as pulsing light. The light pulses rather than remains steady because the neutron star does not spin on a straight axis.

Chinese astronomers were the first to see the supernova that created the Crab Nebula in July of 1054 AD. It was so bright that it could be seen both day and night for a month. Much later, in the 1750s, the nebula was seen again, and finally in the 1840s it was named the "Crab Nebula" because its shape resembled that of a crab. However, just because people on Earth saw the supernova explosion a thousand years ago doesn't mean that that's when the star exploded. In fact, it exploded long before then. Remember that it takes a long time for light to travel the tremendous distances of space. Since the Crab Nebula is 6000 light-years away from us, can you calculate how long ago this star exploded?

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TEMPERATURE

Temperature Scales
All matter is made of atoms, and atoms are constantly moving. This movement is a type of energy that we call heat. Temperature is a measure of heat. When we measure the temperature of a substance, we are actually measuring how fast its atoms are moving.

Comparing Temperature Scales
Over the centuries, three different temperature scales have been developed. They all measure the same thing – heat. However, a certain amount of heat will have different numbers on each of the scales.

Let’s say it’s a warm spring day, and you measure the temperature with all three scales. The scales give you different numbers, but it’s still the same warm spring day. The amount of heat hasn’t changed. You’ve just measured it using different scales.

Let’s say you’re ill and are running a high fever. Usually you use a Fahrenheit thermometer, but with a few simple calculations you convert it to the other scales.

The scales give you different numbers, but you still have the same high fever. Refrigerators keep food cold but not freezing. If you measure the temperature inside your refrigerator with the three different temperature scales, you’d get different numbers, but they would all be a few degrees above the freezing point for water in that scale.

The Fahrenheit Scale

Americans use the Fahrenheit scale to talk about temperature. This scale was invented by a German physicist named Gabriel Daniel Fahrenheit. Notice how you read temperature using the Fahrenheit Scale. You would say that water freezes at thirty-two degrees Fahrenheit.

The Celsius Scale

Outside of the United States, most people use the Celsius Scale to talk about temperature. This scale is based on the freezing and boiling points of water. The zero point (0^{o}C) on the Celsius Scale is set to the temperature where water freezes. The boiling point of water is at 100^{o}C.

Of course, there are temperatures that are much colder than the freezing point of water. These temperatures are written as negative numbers, that is, numbers below zero. For example, you would say that the average temperature at the North Pole in winter is negative 35 degrees Celsius. Or you could call it 35 degrees below zero Celsius.

The Kelvin Scale

The Kelvin Scale is used mainly by scientists. It is based on the Celsius Scale, with one important difference. It sets its zero point (0 K) at absolute zero. Absolute zero is the point where atoms stop moving. Remember, heat is the energy of atoms in motion. When atoms stop moving altogether, there is no heat. Nothing can be colder than that.

While scientists have managed to bring substances to very low temperatures, there is no matter that we know of that has reached absolute zero. You read temperatures in the Kelvin Scale in a slightly different way than in the Fahrenheit and Celsius scales. You don’t use the degree sign or the word degrees. Instead, you would say that water boils at 373 Kelvin. Or you could just call it 373 K.

Converting Temperatures
To switch between Celsius and Kelvin, you use a simple formula. Click on one of the tabs to learn how to convert from one scale to the other.

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