Technical Question

Q. Exactly what is gravity?

We do not know exactly. We can define what it is as a field of influence, and with general relativity we can define a language which states that it is a property of our real world that is mathematically equivalent to not just the geometry of space-time, but equivalent to space-time itself. Some think that it is made up of particles called gravitons, which flit about at the speed of light just as photons do. In any true fundamental sense, we do not know what gravity is, we only know how it operates in various corners of our universe. Without gravity, there would be no space and time.

Q. How do we know that the Milky Way is a spiral galaxy and not some other kind of flat system of stars?

We know it is a kind of flat system of stars because when we look at the night sky, the Milky Way's stars are arrayed along a rather thin band across the sky to form the familiar Milky Way. Telescopically, we can study other galaxies and we see that they come in three basic types: Spirals, Ellipticals and Irregulars. The Milky Way cannot be of the last two categories because no amount of juggling of position of the Sun in these types of galaxies would give us the kind of night sky that we see. So by the process of elimination, the Milky Way must be some kind of spiral galaxy.

Q. If the Milky Way was the size of a coffee cup, how big would the rest of the universe be?

The Milky Way has a radius of about 50,000 light years. The visible universe has a radius of about 15 billion light years or 300,000 times the size of the Milky Way. So for an 8-centimeter-wide coffee cup as the Milky Way, the VISIBLE universe would be a sphere about 48 kilometers (almost 30 miles) in radius...give or take.

Q. Is it some kind of conspiracy that astronomers only talk about other galaxies and not the Milky Way?

No. Galactic research is one of the most active areas in astronomy. It is just that out of the hundreds of research papers written about this subject every year, few attract much media attention. So the average person on the street doesn't hear much about it. In large terms, astronomers study the interstellar medium and stellar evolution in our galaxy, but discussions of the large-scale shape of the Milky Way are hampered by the fact that we can never get outside of the Milky Way to really see what it looks like.

As for conspiracies, you will not find them in science, except that lack of interest and resources can sometimes be interpreted as a conspiracy when in fact there simply are not enough astronomers and resources to advance a subject very fast at a given time. But over a few decades, most subjects in astronomy get their proper due and make progress. You just have to be patient; after all, we have to leave something for our children to do!

Q. Why send people into space when robotic spacecraft usually cost less?

Humans and robots each have their own special roles in space.

Robots are best qualified for missions that require precise, repetitive measurements or maneuvers, and for missions that last for a long time, such as trips to the outer planets.

Humans remain better equipped than robots for tasks that involve analytical decision-making or constant adjustments.

By launching humans into space, we also gain unique insights into the workings of the human body, many of which are masked or changed by gravity when a person is on the Earth.

To find out more about sending humans into space, please visit the Web site below.

Q. When was the last solar eclipse seen from North America, and when will the next one happen?

The last solar eclipse was on May 10, 1994. It was annular and could be seen in the United States. The next U.S. eclipse will be on May 20, 2012, and will also be annular. Similar eclipses occur 18 years apart in the Saros Cycle.

Q. Why don't solar eclipses occur exactly at noon?

Because the geometry required for a total solar eclipse has nothing to do with local noon. It has to do with when the lunar shadow sweeps across your location during the time when the Sun is above the horizon. Even so, it is possible for the Sun to be in full eclipse before it rises at your particular location!

Q. How much does a spacecraft weigh when it is in space?

An object in space is said to be in a state of weightlessness, although its original mass remains the same. (Mass can be understood as a measurement of inertia, the resistance of an object to be set in motion or stopped from motion.) Objects in space near the Earth, the Moon or other large bodies retain a small amount of weight due to the tiny amount of planetary gravity that continues to pull on them. However, orbital motion reduces this condition to an extremely low level of gravity known as microgravity (about one-millionth of the normal gravity we feel at the Earth's surface). When an object is in orbit about a large body like a planet, it is traveling just fast enough to fall in a continuous curved path around the planet, without flying off or falling down to the planet's surface. This free fall results in microgravity.

Thus, when a Space Shuttle crew wants to land, the astronauts fire the orbiter's engines directly into its forward path, slowing the Space Shuttle enough that it drops out of orbit.

Q. When are we going to Mars? And when are we going back to the Moon?

We must accomplish at least four objectives before we are prepared for a Mars mission. We must successfully build and operate the planned International Space Station, gain working-level experience with other nations in space cooperation, develop an affordable mission scenario that can be accomplished in about one decade, and allow time for the world economy to improve substantially. With these goals in mind, NASA currently plans to operate the Space Station for at least the first decade of the next century; sending astronauts back to the Moon or on to Mars during the second decade of the new century. This timeframe could change with technological breakthroughs.

Q. Is NASA using ion power in its spacecraft?

NASA has been working on ion propulsion and nuclear propulsion technologies for decades, and ion thrusters are commonly used on satellites to provide gentle "station-keeping" nudges to keep them in the right orbit.In October 1998, NASA launched the Deep Space 1 spacecraft to perform an asteroid flyby later in 1999. It was a virtual test bed of new, exotic technology, including the first ion drive which supplied the main thrust for the voyage. Ion motors sound exotic, and they are, but they aren't in the league of "warp drive" or other stock propulsion systems used in science fiction stories. Still, the name does have a certain, mysterious, ring to it!

Q. How are stars born?

We haven't been able to observe in detail all of the stages in this process, but from many specific young objects we have studied, it all seems to start with a dense, interstellar cloud many light years across. For reasons that we do not fully understand, small regions within such a cloud perhaps a fraction of a light year across begin to collapse under their own gravity.

As the collapse continues, the center of this core region becomes denser and denser, climbing from only 100 atoms per cubic centimeter to millions of atoms per cubic centimeter and higher. As it collapses, whatever very slight rotation it originally had gets amplified so that, like a figure skater on ice, it spins faster and faster. Although the gas falling along the axis of the collapsing cloud feels nothing more than the gravitational force of the central core, along the equator of the object, centrifugal forces due to its spinning become so strong that they impede the collapse along this direction. The cloud collapses into a flattened disk with a central bulge containing most of the mass, and it is in this central object that the star will be born.

We see many rotating cloud cores like this, and many with a disk-like shape, so we are pretty certain we understand this phase of the evolution of stars, but what we don't fully understand is why the core collapses in the first place. There seem to be many things that can cause this physically; perhaps all of them occur in one cloud or another.

Q. What is the temperature in space?

Temperatures in space depend on whether the thermometer is in sunlight or darkness. Near the Earth and the Moon, objects in direct sunlight can heat up to temperatures of about 250 degrees F (121 degrees C). In the shade, objects can cool down to around -250 degrees F (-156 degrees C). This extreme range is the reason why the thermal designs of spacecraft and spacesuits are so important.

Q. Is there really sound in space?

Actually...yes!!

What is sound? It is a pressure wave. So long as you have some kind of gaseous medium, you will have the possibility of forming pressure waves in it by "shocking" it in some way. In space, the interplanetary medium is a very dilute gas at a density of about 10 atoms per cubic centimeter, and the speed of sound in this medium is about 300 kilometers per second. Typical disturbances due to solar storms and "magneto-sonic turbulence" at the Earth's magnetopause have scales of hundreds of kilometers, so the acoustic wavelengths are enormous. Human ears would never hear them, but we can technologically detect these pressure changes and play them back for our ears to hear by electronically compressing them.

Q. If you towed enough stars into a region the size of the Earth's orbit, could you make a black hole?

You would have to do it so carefully that the stars would not gravitationally eject each other before the event horizon has expanded to 1 AU (Astronomical Unit -- 1 AU = 93 million miles). In its simplest definition, an Astronomical Unit is approximately the mean distance between the Earth and the Sun. It is a derived constant and used to indicate distances within the Solar System. In nature, supermassive black holes are formed from small black holes that eat about one star each year...gradually. Click on the link below to understand how to build a supermassive black hole.

Q. What is on the other side of a black hole?

We don't know, other than theoretically, what might be inside of a black hole (if that is what you mean by "the other side"). Inside, we encounter the surface of the object that collapsed to make the black hole in the first place, and because we cannot tunnel inside this body, all we see is a solid surface. Mathematicians and physicists have theorized a hollow black hole that doesn't require the collapse of a star to form it. This type of black hole is imagined to have an exotic geometry and be a place where time travel is possible.

Q. Can a star clog a black hole that is swallowing it?

No. A black hole is not really like a drain pipe! In fact, if it consumes matter at too ferocious a rate, the radiation pressure generated by the in-falling matter provides tremendous resistance to the flow of matter. The rate at which matter can fall into a black hole is regulated to what is called the Eddington Accretion Rate, which depends on the mass of the black hole. Also, it all depends on whether the star has been captured into orbit or is just passing by. Orbital capture means that the black hole, over the course of millions of years, can leisurely nibble away at the star "without choking."

Q. How is it possible for time to change inside a black hole?

In general relativity, time and space are a set of variables that can be used to parameterize the geometry of spacetime and the kinds of geodesics that are possible. But they are not the only kinds of variables that form a set of four coordinates that "span" the dimensionality of space-time. In probing the mathematics of black holes, physicists have discovered other sets of coordinates that are even better. For example, the event horizon appears in the mathematics as a "coordinate singularity" if you use the coordinate set (x, y, z, t) or (t, r, theta, phi), but if you use the "Kruskal-Szekeres" coordinates, it vanishes completely. There is only one true singularity in a non-rotating Schwartzschild black hole solution, and that is the one at r=0, at the event horizon, the curvature of space is non-infinite. That means that coordinate singularities are not real singularities and can be mathematically transformed away. Now, if you study what happens to the Kruskal-Szekeres coordinate system as you pass inside the black hole event horizon, nothing unusual happens. But in the conventional Newtonian (x, y, z, t) system, if you look at the formula for the so-called "metric," you see that the space and time parts reverse themselves. This means that just inside the horizon, space becomes time-like and time becomes space-like. What we call time does change to something with the mathematical properties we have normally associated with space. This sounds pretty bizarre, but consider that we are using a non-proper coordinate system in the first place. It is possible that time changes somehow inside a black hole, but that is an experiment we will never be able to test because we can never receive information from inside a black hole.

Q. What happens when black holes touch?

Their event horizons distort into a dumbbell shape so that the midpoint between them initially lies on the surface of both event horizons. Then in the next instant, from the standpoint of a local observer who is falling onto them, it is inside the merged horizon.

Q. For a black hole the size of our Solar System, could you avoid its singularity?

Not for a non-rotating black hole. The internal geometry prevents avoiding the central singularity for a time much longer than the light travel time from the event horizon to its center...a few hours. For rotating black holes, in principle you could avoid the singularity by simply choosing not to enter the equatorial plane where the ring singularity lives.

Q. What happens to time as you pass through an event horizon and approach the singularity?

We are guided in our understanding of the interior of black holes by the theory of general relativity developed by Albert Einstein, and in particular, the mathematics of the complete, relativistic equation for gravity and space-time. This theory describes, in considerable mathematical detail, both those regions of space-time that are accessible to humans and those that are accessible only by individual observers but not distant observers. For black holes, distant observers will see only the outside of the event horizon, while individual observers falling into the black hole will experience quite another "reality." General relativity predicts that for distant observers outside the horizon, they will experience the three space-like coordinates and one time-like coordinate, as they always have.

For someone falling into a black hole and crossing the horizon, this crossing is mathematically predicted to involve the transformation of your single time-like coordinate into a space-like coordinate, and your three space-like coordinates into three time-like coordinates. Along any of these three former space-like coordinates, they now all terminate on the singularity; you're experiencing them as time-like now. All choices always terminate on the singularity -- at least in the case of a non-rotating black hole. The coordinate which used to measure external time now has a space-like character which affords you some wiggle room, but dynamically, in terms of these new reversed space and time coordinates, you find that no stable orbits about the singularity are possible no matter what you try to do. Without any stable orbits, and the inexorable freefall into the singularity, relativists often refer to this as the collapse of space-time geometry.

Q. Is information about what fell into a black hole stored on its event horizon?

It seems that is indeed the case. Recent calculations by the folks who study quantum gravity theory and superstrings have confirmed what Stephen Hawking and his collaborators proposed a decade or more ago. Evidently, the information contained in matter that falls into a black hole is by some curious means encoded in the pattern of frozen quantum fields at the horizon. This raises some interesting possibilities that we could resurrect clocks, humans, spacecraft, and whole planets into something like their pristine form if we could magically reverse the in-fall and collapse process. Many believe that this mathematical result means that we have reached a watershed moment in history in understanding the connection between quantum mechanics and gravitation theory. Quantum mechanics deals with statements about the information that we can extract about a quantum mechanical process involving observation. Now this same information language can be applied to configurations of the gravitational field and space-time itself.

Q. What is the importance of black holes to cosmology?

Indirectly, they tell us that our relativistic theory of gravity and space-time provided by Einstein's general relativity is fundamentally correct, so that when we use these same equations to study cosmology we have some confidence that they may be correct. Directly, black holes tell us that the universe can hide much of its matter in a way that still contributes to the total mass of the universe, but may not contribute to the abundances of certain primordial elements such as hydrogen and helium. If enough black holes were produced soon after the Big Bang but before the first few minutes, this could have an impact on the relationship between how rapidly the universe is expanding and the origin ofthe primordial element abundances. But it is expected that most black holes formed long after the Big Bang by stellar evolution, and these black holes may contribute to the missing mass in the universe up to the maximum limit set by the primordial element abundances themselves. It is a bit complex, but black holes are cosmologically important from many different standpoints.

Q. Do black holes die if they are not fed?

No, they just stay at the same mass until they slowly evaporate over trillions of years.

Q. Will our universe expand and bump into other universes?

We don't really know what the universe looks like beyond the visible horizon we see around us, but all modern theories say there is plenty more space "out there." The most interesting prospect is described by inflationary Big Bang cosmology. If the universe emerged from a quantum patch of energy in a primordial space-time, it inflated until now the limits of our particular "patch" could be 10^100 light years or more. Beyond this patch is possibly an infinitude of other "patches," each with slightly different physical properties. In the remote future, our visible universe will inexorably expand at the speed of light until these distant patches come into view. The smooth and uniform conditions we see around us today will be replaced by very nonuniform conditions as more of these distant patches come into our horizon. In a truly infinite universe, there will be an infinite number of these patchwork universes.

Q. Where does space come from?

This is a very complicated question to answer -- and frankly, we do not yet fully understand how to answer it. According to Einstein's General Relativity, which is our premier way of explaining how gravity works, it makes no formal distinction between the description of what a gravitational field is, and what space-time is.

Essentially, space is what we refer to as three of the four dimensions to a more comprehensive entity called the spacetime continuum, and this continuum is itself just another name for the gravitational field of the universe. If you take away this gravitational field -- space-time itself vanishes! To ask where space comes from is the same as asking, according to general relativity, where this gravitational field came from originally, and that gets us to asking what were the circumstances that caused the Big Bang itself. We don't really know.

Q. How could there not have been something before the Big Bang?

Nature has over the years presented us with many physical situations where our intuition about how things "ought" to behave has been shown to be absolutely false. The speed of light is an absolute speed limit; people age differently if they are moving, or in strong gravitational fields; space can dilate; particles have wave-like properties; objects can be in many places at the same time; matter can be created out of pure energy; matter can be created spontaneously out of the vacuum. The list is actually quite long. So, as to how it is that the universe "may"' not have required something or some event "before" the Big Bang to start the process, this may be just another example of our intuitions demanding a phenomenon that nature simply did not need to provide to get the job done.

In the quantum world -- the world that the universe inhabited when it was less than a second old --many things work very differently. One of these is that time itself does not mean quite the same thing as it does to us in the world at large. Although we have no complete theory of the relevant physics, there are many indications from the mathematics that yield sound experimental results that time itself may have ceased to have much meaning near the Big Bang event. This means that there was no "time" as we know this concept "before" the Big Bang. That being the case, the question of what happened before the Big Bang is now a question without any possible physical answer.The evolution of the universe has always been a process of transformation from one state to the next as the universe has expanded. At some point in this process, looking back at the Big Bang, we enter a state so removed from any that we now know, that even the laws that govern it become totally obscure to science itself. In the quantum world, we see things "appearing" out of nothing all the time. The universe may have done the same thing. What this means to us may never be fully understood.

Q. What facts disprove the Big Bang Theory?

Right now, the only serious problem facing Big Bang cosmology is that the NASA COBE satellite has shown that the cosmic background radiation is slightly lumpy in a way predicted by a version of Big Bang cosmology called "inflationary Big Bang cosmology." This version, however, requires that the universe have an average density that is exactly its "critical density" given how fast it is currently expanding. But when astronomers use a variety of independent observational techniques to measure what the density of our universe is, the numbers seem to come up short by a factor between two and five. The recent study of supernovae located some 5 billion light years away have, again, indicated that the universe seems to have about five times less density than inflationary cosmology demands that it must have to be consistent with the COBE measurements. Something is not adding up, but too many other things DO add up to favor Big Bang cosmology. No astronomer is even remotely suggesting that Big Bang cosmology is incorrect; only that we still do not know exactly the values of the specific parameters that define Big Bang cosmology.

There seemed to be problem with the age of the universe turning out to be shorter than the ages of the oldest stars, but the Hipparcos Satellite recalibrated the distance estimates, and now the ages of stars and cosmos are within about 10 percent of each other. The COBE/supernova problem may be resolved once we get more, distant supernovas to study.

Q. Is it true that no telescope will ever see the Big Bang because of the transparency of the universe when it was young?

Well, not quite. The statement is true for telescopes that use electromagnetic radiation as the information carrier, because during the time before about 300,000 years after the Big Bang, the universe contained hot plasma which prevented light from traveling very far before getting scattered. But for telescopes that detect neutrinos, you can (inprinciple) see a cosmic background from neutrinos which can penetrate right through the plasma like it wasn't there at all. Neutrino telescopes would let you see how rough the universe looked all the way to a millisecond after the Big Bang. Then there is gravitational radiation which would yield a "picture" of how lumpy the universe was all the way back to possibly the Planck Era itself just after the Big Bang. So, the transparency of the universe depends on the kind of telescope you use. Check out Beyond Einstein -- From the Big Bang to Black Holes Web site that provides an overview of the complex nature of our universe.

Q. What is the Space Infrared Telescope Facility (SIRTF)?

The Space Infrared Telescope Facility (SIRTF) was renamed Spitzer Space Telescope in honor of Dr. Lyman Spitzer Jr., a widely known authority in the field of theoretical astrophysics. The Spitzer Telescope marks the finale of NASA's Great Observatories program, which includes the Hubble Space Telescope, the Chandra X-ray Observatory and the Compton Gamma Ray Observatory. Its unprecedented infrared sensitivity will allow astronomers to capture what they affectionately call "the old, the cold, and the dirty," referring to the coldest, oldest, and most dust-obscured objects and processes in the universe. The observatory's amazing ability to sleuth around for low-temperature objects will also aid in the search for planetary systems in the making, some of which may breed Earth-like planets harboring life. The mission is a cornerstone of NASA's Origins Program, which seeks to answer the questions, "Where did we come from? Are we alone?"

Q. How much younger are astronauts after they return from orbit?

When an astronaut returns home they will be 0.000023 seconds younger for each day they spend in orbit. For aoneyear stay on the International Space Station, the returning astronauts will be about 0.0085 seconds younger. Not much to get excited about, but it is measurable on a good stopwatch if the experiment is set up correctly.

Q. How much does the Space Shuttle cost?

The Space Shuttle Endeavour, the orbiter built to replace the Space Shuttle Challenger, cost approximately $1.7 billion.

Q. What are the names of the Space Shuttle orbiters?

Their names, in the order they were built, are Enterprise, Columbia, Challenger, Discovery, Atlantis, and Endeavour. The Enterprise was flown only within Earth's atmosphere, during Shuttle approach and landing tests conducted in 1977. Columbia flew the first five Shuttle missions, beginning in April 1981, and was modified to fly extended-duration missions as long as 16 days. Columbia and its seven-member crew were lost during reentry on Feb. 1, 2003. Challenger was built as a vibration-test vehicle and then upgraded to become the second operational Shuttle. The Challenger and its seven-member crew were lost in a launch accident on Jan. 28, 1986. Discovery made its first flight in August 1984, and Atlantis followed in October 1985. Endeavour, built to replace Challenger, made its debut in May 1992 with a dramatic mission that featured the rescue of a stranded Intelsat 6 commercial communications satellite. The link below will take you to the NASA Orbiter Fleet site providing descriptions of the Space Shuttles.

Q. How much does it cost to launch a Space Shuttle?

The average cost to launch a Space Shuttle is about $450 million per mission.

Q. Can I apply to take a ride on the Space Shuttle? Can I be the first kid in Space?

NASA has no immediate plans to send children, teenagers or any other general citizens into space. For the near future at least, space flight remains too risky and too expensive for anyone but highly trained astronauts and payload specialists. However, one of our goals is to help industry develop new rocket systems that would make space flight much more simple and routine, so that many more people could go into orbit in the future.

Q. How do astronauts in space go to the bathroom and take care of their personal hygiene?

Astronauts brush their teeth just like they do on Earth. There is no shower on the orbiter, so astronauts must make do with sponge baths until they return home. Each Space Shuttle has a toilet that can be used by both men and women. Designed to be as much as possible like those on Earth, the units use flowing air instead of water to move waste through the system. Solid wastes are compressed and stored onboard, and then removed after landing. Wastewater is vented to space, although future systems may recycle it, such as they do on the International Space Station. The air is filtered to remove odor and bacteria and then returned to the cabin.

Q. What is the International Space Station used for?

The International Space Station (ISS), the largest international scientific and technological endeavor ever undertaken, draws on the resources and scientific expertise of 16 nations around the world. Canada, Japan, 11 members of the European Space Agency, Russia and Brazil are our partners. It is a permanent laboratory where gravity, temperature and pressure can be manipulated in a variety of scientific and engineering pursuits in ways that are impossible in groundbased laboratories.

Q. How has NASA benefited the United States?

NASA has the smallest budget of the major agencies in the federal government -- less than 1 percent since 1977. But even with that relatively small budget, NASA has expanded human knowledge through a program of exploration and discovery. Virtually every aircraft utilizes technology pioneered by NASA. Aeronautics is one of the nation's strongest industries, employing almost one million Americans. The U.S. aerospace industry generates over $40 billion in annual exports and $30 billion in positive balance of trade each year. New industries have been built on space technology, including personal computers, advanced medical equipment, communications satellites, weather forecasting and natural resource mapping. NASA's high-technology research and development generates jobs, the demands for goods and services, and new technologies in the private sector. Many NASA technologies contribute to research in education, transportation, pollution control, rain forest protection and health care.

Q. How do I become an astronaut?

Any adult man or woman in excellent physical condition who meets the basic qualifications can be selected to enter astronaut training. For mission specialists and pilot astronauts, the minimum requirements include a bachelor's degree in engineering, science or mathematics from an accredited institution. Three years of related experience must follow the degree, and an advanced degree is desirable. Pilot astronauts must have at least 1,000 hours of experience in jet aircraft, and they need better vision than mission specialists. Becoming an astronaut is extremely competitive, with an average of more than 4,000 applicants for about 20 openings every two years. Astronaut recruiting occurs periodically. You can find the qualifications for becoming an astronaut at the website link listed below or you can write to :

Astronaut Selection Office
NASA Johnson Space Center
Houston, TX 77058
Astronaut Qualifications/Training

Q. What is an astronaut's salary?

Salaries for civilian Astronaut Candidates are based on the Federal Government's General Schedule pay scale for grades GS-12 through GS-13. Each person's grade is determined according to his/her academic achievements and experience. Currently, a GS-12 starts at $65,140 per year and a GS-13 can earn up to $100,701 per year. Military Astronaut Candidates are assigned to the Johnson Space Center and remain in an active duty status for pay, benefits, leave, and other similar military matters.

• There will be a special Life Support category. Entries with strength in life support and/or describe biology laboratories and experiments that take advantage of variable psuedo-gravity levels and the radiation environment inside space colonies will be considered for this category.

• Contestants give NASA the right to publish their submissions without restriction as a condition for entering the contest.

Q. Can lightning be harnessed as a source of power?

A. People have considered harnessing lightning for electrical power, but no serious attempts are currently under way, nor are any planned. It is impractical for numerous reasons, as listed below.

1. Most of the power in lightning is dissipated as thunder and light, which cannot be easily harnessed to generate electric power.

2. However, even just the electrical current of lightning is considerable -- 20,000 amps on average, the same as 100 steel welders. But the power is on for only a brief fraction of a second, so the total power is actually small, only enough to power a 100-watt light bulb for six months.

3. The huge surge of electrical current over very brief times makes storing the energy impractical.

4. Lightning strikes to specific locations are infrequent and inconsistent. This makes scheduling power availability impractical.

5. Lightning can be very damaging. The collection systems have to be incredibly robust, which would drive up costs. Lightning is also very dangerous, making it tough on the collection system workers.

6. Lightning would have to be collected over a huge area, making the system impractically expensive.

So as you can see for several scientific, engineering, economic and legal problems, harnessing lightning for electric power is not practical.

Q. What is the strongest magnetic field ever known?

A. The strongest naturally occurring fields are found on a new kind of neutron star called a magnetar. More information is available by clicking on the link below.

Q. Exactly what is gravity?

A. We do not know exactly. We can define what it is as a field of influence, and with general relativity we can define a language which states that it is a property of our real world that is mathematically equivalent to not just the geometry of space-time, but equivalent to space-time itself. Some think that it is made up of particles called gravitons, which flit about at the speed of light just as photons do. In any true fundamental sense, we do not know what gravity is, we only know how it operates in various corners of our universe. Without gravity, there would be no space and time.

Q. Why can the Hubble Space Telescope see distant galaxies, but not objects beyond Pluto?

A. The Hubble Space Telescope cannot see objects beyond Pluto because the distant things are so luminous that even at their great distances they outshine the feeble sunlight that would be reflected from small bodies beyond the orbit of Pluto.

Q. What is the farthest object we know about in the universe?

A. NASA's Galaxy Evolution Explorer (GALEX) is an orbiting space telescope that will observe galaxies in ultraviolet light across 10 billion years of cosmic history.

Q. Can the oldest galaxies in the universe be found by looking in any direction?

A. Actually, the oldest galaxies we can see are right next door to us in the present universe. When we look out into space using the Hubble Space Telescope for example, we see images of galaxies that become younger and younger the further out we look. We actually see images of the youngest galaxies in the universe the farther out we look.

Because there are probably over 100 billion galaxies in our visible universe, and because there are only about 42,000 square degrees in the surface of the sky, that means that in every square degree we will see nearly 3 million galaxies. Most of these will be the most distant and hence 'youngest' ones. So it doesn't seem to matter what direction you look.

Q. What happens when two galaxies collide?

A. On the largest scales, the changing gravitational fields cause the galaxies to distort their shapes tremendously to produce great streams of stars and gas that are often ripped from each of the galaxies and hurled into intergalactic space. Most of the matter, however, settles back into a new system which often looks nothing like either of the galaxies before the event. When the interstellar clouds in each of the galaxies collide, they can trigger bursts of star formation resulting in very massive, short lived, stars being formed. These stars form in large numbers and over small enough regions their light can combine to turn the galactic collision into a so-called star-burst system. If the cores have massive black holes, the systems can flare-up into quasar, or near-quasar brilliance for millions of years.

For individual stars, they are so small compared to their average distances that you might get only a handful of close encounters or impacts out of literally hundreds of billions of stars. Planetary orbits could be upset, however, either by the changing galactic gravitational fields or by close encounters with passing stars.

Q. Where can I find more technical information on NASA's research?

A. Additional information about NASA technical publications and papers can be accessed by clicking on the link below to NASA's Scientific and Technical Information (STI) Web site.

Q. How is osteoporosis/bone density measured in space?

A. For three decades, NASA scientists have been researching and have developed an instrument for testing bone density. For additional information, please click on the link below.

Q. What causes the twin sonic booms?

A. Sonic booms are the result of an aircraft or other type of aerospace vehicle flying overhead faster than the speed of sound. Information on sonic booms is available by clicking on the link below.

Q. How much does a spacecraft weigh when it is in space?

A. An object in space is said to be in a state of weightlessness, although its original mass remains the same. (Mass can be understood as a measurement of inertia, the resistance of an object to be set in motion or stopped from motion.) Objects in space near the Earth, the Moon or other large bodies retain a small amount of weight due to the tiny amount of planetary gravity that continues to pull on them. However, orbital motion reduces this condition to an extremely low level of gravity known as microgravity (about one-millionth of the normal gravity we feel at the Earth's surface).

When an object is in orbit about a large body like a planet, it is traveling just fast enough to fall in a continuous curved path around the planet, without flying off or falling down to the planet's surface. This free fall results in microgravity. Thus, when a Space Shuttle crew wants to land, the astronauts fire the orbiter's engines directly into its forward path, slowing the Space Shuttle enough that it drops out of orbit.

Q. Did NASA claim the Moon as property of the United States when it planted a flag on the Moon, like Columbus did when he landed in America?

A. When a NASA astronaut placed the flag on the Moon, the action signified that "America went in peace for all Mankind." Acquisition in outer space is prohibited under the United Nations Treaty on Outer Space signed in 1967.

The law states: ARTICLE I: ..."Outer space, including the moon and other celestial bodies, shall be free for exploration and use by all States without discrimination of any kind, on a basis of equality and in accordance with international law, and there shall be free access to all areas of celestial bodies. There shall be freedom of scientific investigation in outer space, including the moon and other celestial bodies, and States shall facilitate and encourage international cooperation in such investigation."

ARTICLE II: "Outer space, including the moon and other celestial bodies, is not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means."

Q. Is the flag still on the Moon?

A. Yes. Although not visible to the naked eye from Earth, the American flag is still on the Moon.

Q. Which planets would it be possible to live on?

A. Jupiter, Saturn, Uranus and Neptune have no solid surfaces, so that eliminates them rather thoroughly!

Venus has such a thick atmosphere, it would crush you like an eggshell. The rest of the bodies such as Mercury, Mars, Pluto and the satellites of the giant planets are possibilities, but you would have to provide your own atmosphere to breathe and probably live below the surface to protect yourself from the extreme temperature changes and harmful radiation and cosmic rays from the Sun.

Q. When are we going to Mars? And when are we going back to the Moon?

A. We must accomplish at least four objectives before we are prepared for a Mars mission. We must successfully build and operate the planned International Space Station, gain working-level experience with other nations in space cooperation, develop an affordable mission scenario that can be accomplished in about one decade, and allow time for the world economy to improve substantially. With these goals in mind, NASA currently plans to operate the Space Station for at least the first decade of the next century; sending astronauts back to the Moon or on to Mars during the second decade of the new century. This timeframe could change with technological breakthroughs.

Q. Can Mars hold an atmosphere as thick as the Earth's?

A. Learn more about Mars' atmosphere by clicking on the link below.

Q. Exactly how tall is Olympus Mons on Mars?

A. Olympus Mons is a shield volcano 374 miles (624 km) in diameter (approximately the same size as the state of Arizona), 16 miles (25 km) high. To compare, the largest volcano on Earth is Mauna Loa. Mauna Loa is a shield volcano 6.3 miles (10 km) high and 75 miles (120 km) across. The volume of Olympus Mons is about 100 times larger than that of Mauna Loa. In fact, the entire chain of Hawaiian Islands (from Kauai to Hawaii) would fit inside Olympus Mons!

Q. How are stars born?

A. We haven't been able to observe in detail all of the stages in this process, but from many specific young objects we have studied, it all seems to start with a dense, interstellar cloud many light years across. For reasons that we do not fully understand, small regions within such a cloud perhaps a fraction of a light year across begin to collapse under their own gravity.

As the collapse continues, the center of this core region becomes denser and denser, climbing from only 100 atoms per cubic centimeter to millions of atoms per cubic centimeter and higher. As it collapses, whatever very slight rotation it originally had gets amplified so that, like a figure skater on ice, it spins faster and faster. Although the gas falling along the axis of the collapsing cloud feels nothing more than the gravitational force of the central core, along the equator of the object, centrifugal forces due to its spinning become so strong that they impede the collapse along this direction. The cloud collapses into a flattened disk with a central bulge containing most of the mass, and it is in this central object that the star will be born.

We see many rotating cloud cores like this, and many with a disk-like shape, so we are pretty certain we understand this phase of the evolution of stars, but what we don't fully understand is why the core collapses in the first place. There seem to be many things that can cause this physically; perhaps all of them occur in one cloud or another.

Q. If space ends, what's on the other side?

A. If space is infinite, there is nothing on the other side. If space is finite because it has been bent around upon itself because of gravity, then again there is nothing on the other side of it because there is no seam. It looks like the surface of a smooth ball which represents a piece of flat paper bent upon itself.

Q. How is it possible for time to change inside a black hole?

A. In general relativity, time and space are a set of variables that can be used to parameterize the geometry of space-time and the kinds of geodesics that are possible. But they are not the only kinds of variables that form a set of four coordinates that "span" the dimensionality of space-time. In probing the mathematics of black holes, physicists have discovered other sets of coordinates that are even better. For example, the event horizon appears in the mathematics as a "coordinate singularity" if you use the coordinate set (x, y, z, t) or (t, r, theta, phi), but if you use the "Kruskal-Szekeres" coordinates, it vanishes completely.

There is only one true singularity in a non-rotating Schwartzschild black hole solution, and that is the one at r=0, at the event horizon, the curvature of space is non-infinite. That means that coordinate singularities are not real singularities and can be mathematically transformed away. Now, if you study what happens to the Kruskal-Szekeres coordinate system as you pass inside the black hole event horizon, nothing unusual happens. But in the conventional Newtonian (x, y, z, t) system, if you look at the formula for the so-called "metric," you see that the space and time parts reverse themselves. This means that just inside the horizon, space becomes time-like and time becomes space-like. What we call time does change to something with the mathematical properties we have normally associated with space.

This sounds pretty bizarre, but consider that we are using a non-proper coordinate system in the first place. It is possible that time changes somehow inside a black hole, but that is an experiment we will never be able to test because we can never receive information from inside a black hole.

Q. What happens when black holes touch?

A. Their event horizons distort into a dumbbell shape so that the midpoint between them initially lies on the surface of both event horizons. Then in the next instant, from the standpoint of a local observer who is falling onto them, it is inside the merged horizon.

Q. For a black hole the size of our Solar System, could you avoid its singularity?

A. Not for a non-rotating black hole. The internal geometry prevents avoiding the central singularity for a time much longer than the light travel time from the event horizon to its center...a few hours. For rotating black holes, in principle you could avoid the singularity by simply choosing not to enter the equatorial plane where the ring singularity lives.

Q. What happens to time as you pass through an event horizon and approach the singularity?

A. We are guided in our understanding of the interior of black holes by the theory of general relativity developed by Albert Einstein, and in particular, the mathematics of the complete, relativistic equation for gravity and space-time. This theory describes, in considerable mathematical detail, both those regions of space-time that are accessible to humans and those that are accessible only by individual observers but not distant observers. For black holes, distant observers will see only the outside of the event horizon, while individual observers falling into the black hole will experience quite another "reality." General relativity predicts that for distant observers outside the horizon, they will experience the three space-like coordinates and one time-like coordinate, as they always have.

For someone falling into a black hole and crossing the horizon, this crossing is mathematically predicted to involve the transformation of your single time-like coordinate into a space-like coordinate, and your three space-like coordinates into three time-like coordinates. Along any of these three former space-like coordinates, they now all terminate on the singularity; you're experiencing them as time-like now. All choices always terminate on the singularity -- at least in the case of a non-rotating black hole. The coordinate which used to measure external time now has a space-like character which affords you some wiggle room, but dynamically, in terms of these new reversed space and time coordinates, you find that no stable orbits about the singularity are possible no matter what you try to do. Without any stable orbits, and the inexorable freefall into the singularity, relativists often refer to this as the collapse of space-time geometry.

Q. Is information about what fell into a black hole stored on its event horizon?

A. It seems that is indeed the case. Recent calculations by the folks who study quantum gravity theory and superstrings have confirmed what Stephen Hawking and his collaborators proposed a decade or more ago. Evidently, the information contained in matter that falls into a black hole is by some curious means encoded in the pattern of frozen quantum fields at the horizon. This raises some interesting possibilities that we could resurrect clocks, humans, spacecraft, and whole planets into something like their pristine form if we could magically reverse the in-fall and collapse process. Many believe that this mathematical result means that we have reached a watershed moment in history in understanding the connection between quantum mechanics and gravitation theory. Quantum mechanics deals with statements about the information that we can extract about a quantum mechanical process involving observation. Now this same information language can be applied to configurations of the gravitational field and space-time itself.

Q. Where does space come from?

A. This is a very complicated question to answer -- and frankly, we do not yet fully understand how to answer it. According to Einstein's General Relativity, which is our premier way of explaining how gravity works, it makes no formal distinction between the description of what a gravitational field is, and what space-time is.

Essentially, space is what we refer to as three of the four dimensions to a more comprehensive entity called the space-time continuum, and this continuum is itself just another name for the gravitational field of the universe. If you take away this gravitational field -- space-time itself vanishes! To ask where space comes from is the same as asking, according to general relativity, where this gravitational field came from originally, and that gets us to asking what were the circumstances that caused the Big Bang itself. We don't really know.

Q. How can I view a Shuttle launch?

A. Due to recent world events, NASA has suspended the issuance of car passes for Space Shuttle launch viewing from inside the Kennedy Space Center. Bus tickets to view Space Shuttle launches are available through Delaware North Park Services at the Visitor Complex. Visitors to the Kennedy Space Center may inquire about these tickets by contacting Kennedy's Visitor Complex at (321) 449-4444 or by visiting their Web site listed below.

Launches are always subject to unanticipated delays and changes. For updated information, please call1-877-893-NASA (6272) for the KSC launch status report. For up-to-date information on the next launch, check out the NASA Launch Schedule link below.

Q. What is a launch window?

A. A launch window is the precise period of time, ranging from minutes to hours, within which a launch must occur for a rocket or Space Shuttle to be positioned in the proper orbit.

Sometimes, this window is determined by the passing of an orbiting spacecraft with which the orbiter must rendezvous, such as the International Space Station or an ailing satellite. At other times, the Space Shuttle or an unmanned rocket must be launched within a certain window so that it can release its satellite payload at the right time to place it in an orbit over a certain region of Earth.

Q. Is it true that launching the Space Shuttle creates a local ozone hole, and that the Space Shuttle releases more chlorine than all industrial uses worldwide?

A. No, that is not true. NASA has studied the effects of exhaust from the Space Shuttle's solid rocket motors on the ozone. In a 1990 report to Congress, NASA found that the chlorine released annually in the stratosphere (assuming launches of nine Shuttle missions and six Titan IVs - which also have solid rocket motors - per year) would be about 0.25 percent of the total amount of halocarbons released annually worldwide (0.725 kilotons by the Shuttle 300 kilotons from all sources).

The report concludes that Space Shuttle launches at the current rate pose no significant threat to the ozone layer and will have no lasting effect on the atmosphere. The exhaust plume from the Shuttle represents a trivial fraction of the atmosphere, and even if ozone destruction occurred within the initial plume, its global impact would be inconsequential.

Further, the corridor of exhaust gases spreads over a lateral extent of greater than 600 miles in a day, so no local "ozone hole" could occur above the launch site. Images taken by NASA's Total Ozone Mapping Spectrometer at various points following Shuttle launches show no measurable ozone decrease.

Q. How are NASA program names such as Mercury, Gemini and Apollo chosen?

A. NASA officials consider a variety of factors when choosing a name for a program. Sometimes the names are descriptive, like Skylab or the Space Shuttle. Some names honor famous scientists and explorers, like Galileo, Hubble and Magellan.

Others are chosen from classical mythology that relates to some feature of the mission. Mercury was the messenger of the gods. Gemini, Latin for twins, was appropriate because each Gemini mission carried two astronauts. Apollo was the god of the Sun, who spread knowledge. For the origins of NASA names, please refer to the Web site link below.

Q. Why hasn't the United States developed a way to rescue astronauts who are in trouble on space missions?

A. NASA has a range of systems that could come to the aid of endangered astronauts. Following the Shuttle Challenger accident, NASA developed an emergency escape hatch for the Shuttle fleet that enables crewmembers to exit from the side of a Shuttle on a parachute during certain types of emergencies in the later parts of a landing.

Aboard the Space Station, resident crews have access to a modified Russian Soyuz spacecraft as an emergency rescue vehicle should they need to leave the outpost when a Space Shuttle is not docked to it. A more advanced rescue vehicle may be developed in the future.

Q. Did any Space Shuttle launches take place at Vandenberg Air Force Base in California?

A. A joint decision by the U.S. Air Force and NASA to consolidate Space Shuttle operations at Kennedy Space Center in Florida, following the Challenger accident in 1986, resulted in the official termination of the Space

Shuttle program at Vandenberg on December 26, 1989, before any launches took place there. For more information about Vandenberg AFB, see the Web site link listed below.

Q. What types of propellants are used in the Shuttle? How much do they weigh?

A. At liftoff, an orbiter and External Tank carry 835,958 gallons of the principle liquid propellants: hydrogen, oxygen, hydrazine, monomethylhydrazine, and nitrogen tetroxide. The total weight is 1,607,185 pounds.

Q. How fast does a Shuttle travel? What is its altitude? How much fuel does it use?

A. Like any other object in low-Earth orbit, a Space Shuttle must reach speeds of about 17,500 miles per hour (28,000 kilometers per hour) to remain in orbit. The exact speed depends on the Space Shuttle's orbital altitude, which normally ranges from 190 miles to 330 miles (304 kilometers to 528 kilometers) above sea level, depending on its mission.

Each of the two Solid Rocket Boosters on the Space Shuttle carries more than one million pounds of solid propellant. The Space Shuttle's large External Tank is loaded with more than 500,000 gallons of super-cold liquid oxygen and liquid hydrogen, which are mixed and burned together to form the fuel for the orbiter's three main rocket engines.

Q. Can the Space Shuttle fly to the Moon?

A. No, the Space Shuttle is designed to travel in low-Earth orbit (within a few hundred miles of the Earth's surface). It does not carry enough propellant to leave Earth's orbit and travel to the Moon. The Space Shuttle also is not designed to land on the Moon since it lands like an airplane and the Moon has no atmosphere. The Shuttle could be used to carry pieces of Moon or Mars vehicles to low-Earth orbit, where they could be assembled prior to beginning their mission.

Q. Why is so much water released at the pad during launch?

A. A sound-suppression water system was installed on the pads at Launch Complex 39 following the Apollo Program to protect the Space Shuttle orbiter and its payloads from damage by acoustical energy reflected from the Mobile Launcher Platform (MLP) during launch. The Space Shuttle is much closer to the surface of the MLP than was the Saturn V rocket, carrying the Apollo spacecraft. Acoustical levels reach their peak when the Space Shuttle is about 300 feet above the platform and cease to be a problem at an altitude of about 1,000 feet. For additional information, please refer to the Web site link below.

Q. How are modern spacesuits different than the first ones?

A. Early portable life-support systems were cumbersome and often very tiring to use. In the Mercury, Gemini and Apollo Programs, each spacesuit was tailored to fit a specific astronaut.

Today's Space Shuttle spacesuits come in two major pieces, each of which comes in several different sizes. They have more flexible joints than early spacesuits and better environmental controls. They also can be repaired and reused many times. Spacesuits on the International Space Station are improved versions of these suits.

Q. What does STS stand for?

A. "STS" stands for "Space Transportation System," the original name for the Space Shuttle Program.

Q. How are Space Shuttle missions numbered? Why don't the missions launch in number order?

A. Every launch is assigned an "STS" number. The mission numbers are assigned in order when they are on the "drawing board." However, some circumstances with payload development or orbiter processing, for example, may cause one mission to be postponed, allowing another mission to move ahead of it in line. Imagine that you are standing in line with other people to buy tickets to an event, and each one of you is given a number based on your place in the line. If you cannot find your money, you may say to the person behind you, "Go ahead of me because I'm not ready." Your number is the same and his number is the same; but he stepped ahead of you because you needed more time. Now, imagine that this process is happening to others in line. Everyone keeps his original number. Although the numbers may get mixed up, everyone eventually gets his or her turn.

Q. How do they track time in space?

A. Astronauts go by Mission Elapsed Time, or MET. In this time frame, the clock starts ticking when the astronauts blast off. Minutes accumulate into days, hours, minutes and seconds that have passed since liftoff. The clock stops when the Space Shuttle's wheels again touch Earth, and the total MET is tabulated.

Q. What happens to used spacecraft? Where is the Enterprise, the first Space Shuttle?

A. All retired NASA space vehicles belong to the Smithsonian Institution's Air and Space Museum. In early human space flight programs such as Mercury, Gemini and Apollo, the spacecraft underwent detailed post-mission analysis that often yielded important new information on the rigors of traveling in space. Most of these vehicles are displayed for the public at NASA Centers and science museums across the country.

The Space Shuttle Enterprise, which was not designed to fly in space, made a series of appearances at air shows in the United States, Europe and Canada before being turned over to the Air and Space Museum. It is now on display in the McDonnell Space Hangar at the National Air and Space Museum's Steven F. Udvar-Hazy Center in Chantilly, Va.

Q. What should I do if I find a piece of debris that may have come from the Space Shuttle Columbia?
A. If you find a piece of debris that may have come from the Space Shuttle Columbia, you should not touch it but call the Columbia Recovery Office at (866) 446-6603 (toll-free). All debris is United States Government property and should be reported to government authorities. Unauthorized persons found in possession of accident debris will be prosecuted to the full extent of the law.

Q. Where in the sky can I see the International Space Station or the Space Shuttle?
A. The naked-eye visibility charts for the International Space Station and the Space Shuttle during a mission can be found through the Human Space Flight home page at the Web site link listed below.

Note :- For more FAQ and for further query you shall search the Website or you can Email us to easternguilds@gmail.com / guild@egts.org / shaktichariot@gmail.com/ camp@shaktichariot.in