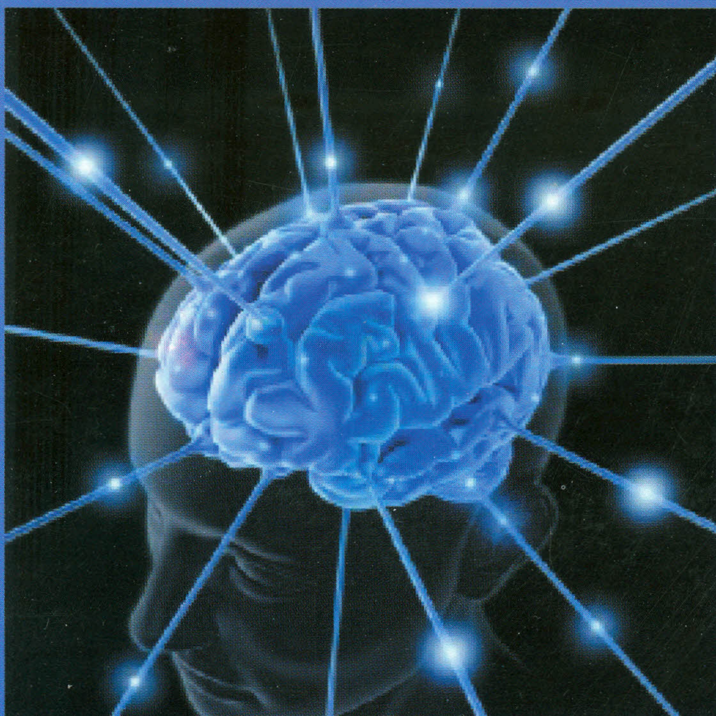
2010



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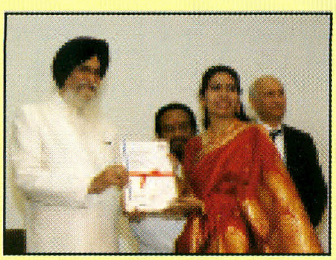

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From the Editors' Desk

Dear Readers,

Physics is a field which is beautiful and profound, while at the same time being fun; it allows us to enjoy the natural, childlike sense of curiosity that we are all born with but which most of us lose as adults. Physics allows one to explore the Universe in all its beauty, and by providing explanations, further enhances our appreciation for it. Never does it allow us to stop questioning; never can we stop marveling at all that it has revealed and all that remains to be revealed.

This is the spirit in which *Physik! 2010* has been published: it is a celebration of the incredible world of physics. It is full of articles written by students who love physics, and is intended to be an engrossing and accessible read both for the serious student of physics as well as the layperson. We have had a wonderful time putting together this magazine, and it has been an important learning experience for us all. We owe it to our classmates and our juniors that *Physik!* has been published for the fourth year in succession.

We would like to thank our Principal, Dr. Sr. Jasintha Quadras f.m.m.; the Head of our Department, Ms. Suganthi Lark Josephine A., and all of the faculty members of the Departtment of Physics at Stella Maris College for their constant support and encouragement. Above all, we owe it to generations of physicists who have inspired us and left us with so much to think, talk and write about. We hope that you find this issue of *Physik!* enjoyable and thought-provoking.

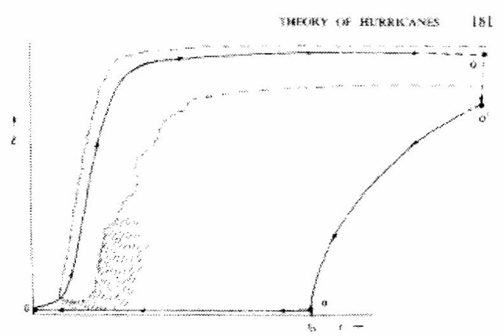
Cheers,

Manisha Caleb
Nandini Ramesh
Ashwini G.

Thermodynamics of Cyclones

Tropical cyclones, known as hurricanes in the USA and as typhoons in East Asia, are large rotating storm systems with a low-pressure centre (known as the eye) which usually develop in the tropics. They occur over the sea, and lose energy as they approach land. Every year, these storms cause extensive damage to property and are responsible for the loss of hundreds of lives. For this reason, it is important for us to understand the development and the functioning of such systems in order to be able to predict or evade them in the future.

As it turns out, cyclones are a fascinating subject of study for the physicist. They pose several challenging problems in a variety of fields such as fluid dynamics, mechanics, and thermodynamics. There are several gaps in our understanding of cyclones and cyclone modelling, and thus many scientists all over the world study cyclones today. Though the cyclone is most often viewed as a consequence of pressure differences, one of its most important, but less known features is its thermodynamic cycle.



A cyclone derives most of its energy from the thermal disequilibrium between the sea and the atmosphere above it. In order to bring the system towards equilibrium, water from the surface of the sea evaporates and enters the air. The rate of this heat transfer is dependent on factors such as wind speed and the roughness of the sea. The energy cycle of a cyclone can be idealized for study as a Carnot engine.

The Carnot engine is a simple thermodynamic system, which we have all come across in our studies both at school and at the undergraduate level. Let us quickly review this system:

The Carnot engine consists of a heat source, a heat sink, and a working fluid. The Carnot cycle has four steps:

1. Isothermal expansion - the working fluid, placed on the heat source, undergoes isothermal expansion as it absorbs heat energy from the source.
2. Adiabatic expansion - the working fluid is insulated and expands, doing work on the surroundings and thereby cooling to a lower temperature.
3. Isothermal compression - the working fluid is placed on the heat sink, where it

loses its heat energy and decreases in volume.

4. Adiabatic compression - the working fluid is insulated and compressed as the surroundings perform work on it, raising its temperature until it reaches the initial state. Step 1 takes place again after this step, and the cycle is completed.

The cyclone system may be framed in the same terms as the Carnot engine. Here, the working fluid is moist air, ie, the air containing water vapour that was picked up at the ocean surface; the heat source is the ocean and the heat sink is the cool upper atmosphere. The air at the surface undergoes step 1 as it absorbs water vapour containing heat energy while maintained at the temperature of the ocean surface. Step 2 occurs as the moist air rises and expands into the atmosphere. Step 3 takes place in the atmosphere once the moist air has attained the temperature of the surrounding atmosphere and undergoes compression. During this step, the air loses most of its moisture as the water vapour condenses at this temperature to form clouds. This is how the clouds in a cyclone are formed and it is these clouds, which give, rise to the torrential rain associated with such systems. The formation of these clouds also leads to step 4 of the cycle, during which the condensing water vapour gives up its heat energy (in the form of latent heat of vaporization) to the air by performing work on it, causing its compression and consequent increase in temperature. The air then returns to the sea surface, and the process repeats itself from step 1.

It has been shown that thermal effects balance the effects of friction out in a cyclonic system, meaning that it undergoes no frictional damping at all. This implies that this process can continue indefinitely, with the work done by the moist air in step 2 driving wind speeds faster and faster and steps 3 and 4 leading to more and more rainfall, making the cyclone more and more powerful. If this is the case, then how do cyclones ever come to a halt? Luckily for us, cyclones formed over the sea are subject to Coriolis forces and other forces in the atmosphere (usually owing to pressure differences), which bring the cyclone over a landmass. Once a cyclone reaches land, it no longer has a thermal source, ie, the air in the cyclone can no longer pick up water vapour to continue the cycle. This causes the whirling cyclone to eventually grind to a halt, and is the reason why inland areas never face the threat of cyclones. However, the only way for a cyclone to stop is by reaching the coast, and therefore, human habitations on the coast bear the brunt of the damage caused by the intense weather conditions brought by a cyclone.

Nandini Ramesh

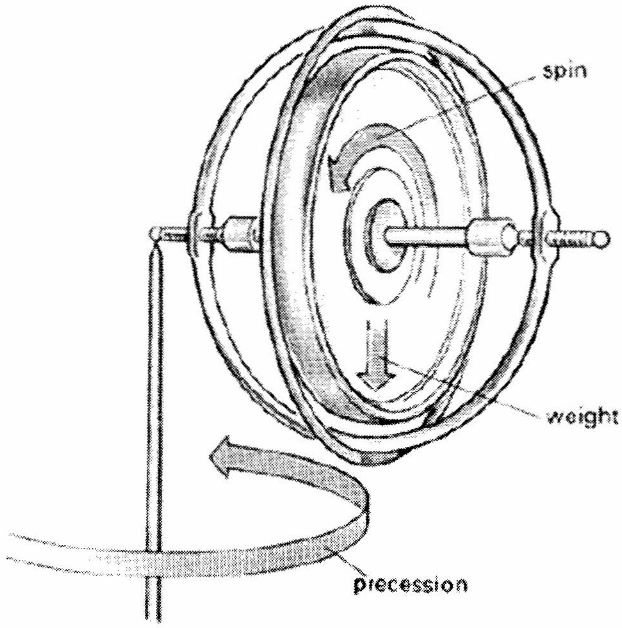
A Loyal Friend

A loyal piece of wood that comes back to you and hits your head if you do not bestow enough attention upon it, this would be my definition of a boomerang. And in support of my firm belief that a definition does not provide even the slightest peek into the magnificence of the thing or phenomenon defined, this definition gives us no clue as to how this ancient invention actually manages to lift itself into the air and then turn around in search of your head.

A couple of weeks back, when I was going through Feynman's lecture series (anyone with the slightest relation to the field of Physics should thank heavens for the life of such a person who wrote such a book) I happened to pass through a couple of paragraphs that he had devoted to something known as the 'gyroscope'.

Prior to the discussion on the gyroscope he did the amazing feat of convincing the reader that torque vector, angular momentum vector and all such vectors which involve cross products are 'false vectors' (this is what I made of what he called 'pseudo vectors'). Once this was done, being convinced of the existence of a torque, which is required for rotating any axis along which exists an angular momentum, was easy. Hence, since there is an unbalanced torque acting on the gyroscope and there is no force which can be held responsible for this torque, the gyroscope rotates in a direction which provides a counteracting torque and hence it precesses.

The torque vectors being pseudo vectors, their direction and effects become a little less obvious than the vectors in linear motion and hence we have what seems like magic. It is my firm belief that even after understanding the physics behind a gyroscope, it does not cease to seem like magic. It just starts to seem like 'explained magic'. Here is a picture of the gyroscope that I happened to come across over the net. And yes, it actually does what is depicted here.



When the gyroscope moves down under the effect of gravity, the downward motion adds to the velocity of that side of the gyroscope that happens to be moving down while the same amount of velocity is subtracted from the opposite side. So if the gyroscope remains in rotation while falling, there ought to be a force in the plane of the gyroscope that causes this acceleration and hence a resulting torque. To make up for this non-existent torque, the gyroscope starts precessing (moving around the pivoted end) and hence due to the above mentioned effect an opposite torque is created that is in the direction opposite to the first one. (Anyone interested in the mathematics should check out the lecture series. Since my intention in writing this article is only to make sure that no one misses out on something this amazing, I will skip the math).

This is precisely what happens to the boomerang in mid-air. When you throw the boomerang (if you manage to throw it right), the turning boomerang undergoes gyroscopic precession, which results in it coming back to you after having moved in a circle.

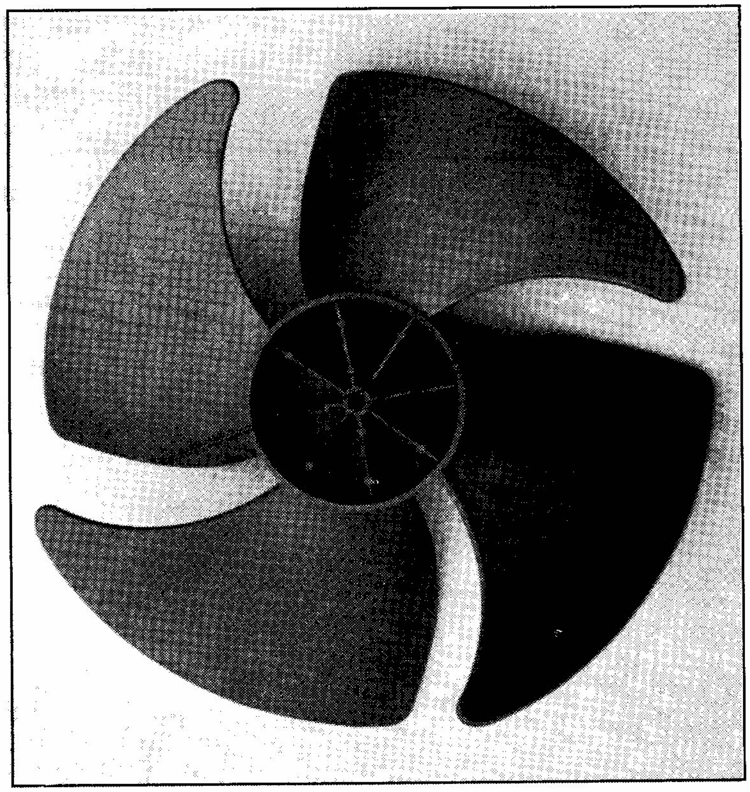
As for the lift, the bottom of the boomerang, which provides greater friction to the passing fluid, has the privilege of playing host to the incoming air for a longer time in comparison with the top layer which provides lesser friction with its smooth structure. With the air moving faster on the upper layer the pressure there drops down (well, this is one of those other times apart from standing very close to a moving train where we can truly appreciate Bernoulli's principle) thus giving it a lift.

A few fundamentals of Physics, and *voila*, you have an instrument that turns in a circle in mid-air. People who claim that those who cannot be impressed by physics do not harbor the basic human emotions must be right because I hardly think anyone can remain untouched by a boomerang if they come across it (well, physically and mentally).

This article, as you may have already realized is a reflection on what I could make of a thing that greatly fascinated me. There may be yawning gaps between my beliefs and the actual explanation, the only reason for a partiality towards this line of thought being the very appealing feature that it convinced me. And for those who are flinching on reading through the article, I extend an apology and I would be glad if you could give me your version of the boomerang. You can reach me at 'anagha_ madhu@ yahoo.co.in'.

Anagha Madhusudanan

Why are fan wings slightly curved?



Fan wings, also called blades are curved for optimum air circulation that is determined by solidity ratio, which is the ratio of the area of the blades to the area of the disc swept by them. If a flat plate is used as a blade, it will provide air circulation no doubt but the volumetric flow rate will be less compared to a blade, which is suitably curved, based on aerodynamic principles.

The cross section of the blade is in the form of a circular arc and is called camber. It will vary from the root of the blade to its tip. One can see the blade twisted from the root to the tip. The angle of attack (angle between the chord of the aerofoil and flow direction) will vary from the root to the tip. Engineers optimize these parameters, nowadays using computer modeling, so that as the fan rotates there is enough airflow. The flow also varies with rotational speed.

The number of blades in fans varies between 2 and 4. Accordingly, their shapes differ, some being slender and long while others being are broad and short.

J. Jessica

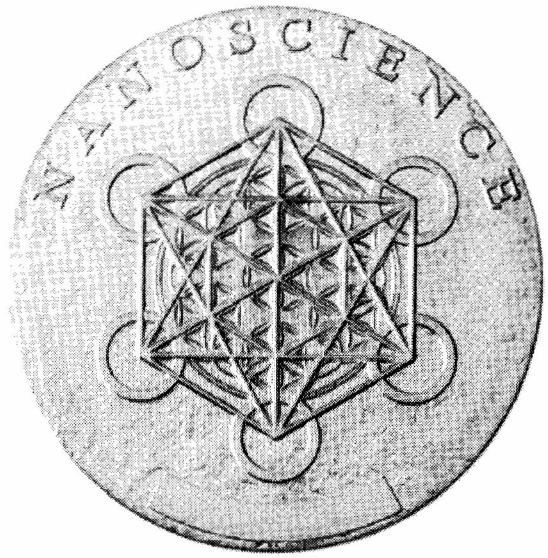
Nano - The exciting science

The most exciting technology of the present century may be nanotechnology. As we all know the nano scale is 10^{-9} m and the nano world lies between 1nm and 100nm. Two methods called the top-down and bottom-up approach are used to form nanoparticles. In top-down bulk sized materials are brought to nano-sized particles by means of processes like etching. In bottom-up, atoms are manipulated to build a nano-sized particle. The characteristics of nanoparticles can be understood by means of the Scanning Tunneling Microscope (STM), TFM, etc..

Woria Taniguchi introduced the term 'Nanotechnology'. Feynman gave the idea of nano particles during his speech in the American Physical Society. Nanotechnology has many applications. Carbon nanotubes, fullerines etc.. are examples of nanoparticles.

The excitement is all about the special properties of nanoparticles. Nano is a state in which all the particles show their properties. Also the nano state enhances these properties. As the size decreases, percentage of surface atoms increases. The surface atoms control the properties and hence the nanoparticles enhance the particle properties. The presence of dangling bonds (incomplete bonds) makes the surface more reactive.

Some of the special properties of nanomaterials are,



- As the nanosize changes, particles exhibit different colors. This is because of the difference in the size of the energy gaps.

- The most exciting application of nano science which will be available for practical use in the future are nano bots. Nano bots are used to cure the dangerous cells in our body without harming the other living cells.

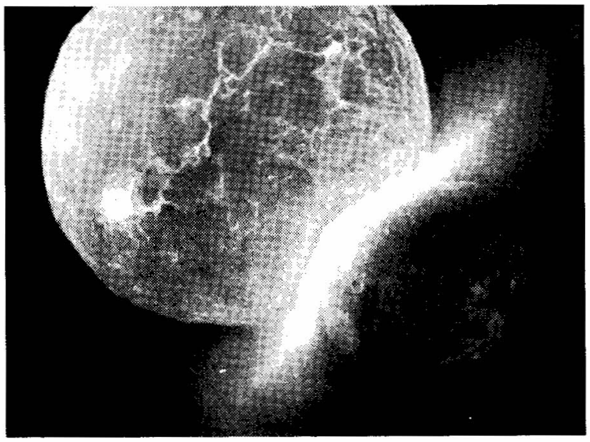
- One of the most important applications is drug delivery. We have branched polymers of size 15nm and drugs are delivered to each branch. Targeted drug delivery is used in chemotherapy to kill cancerous cells.

Nanotechnology is really a wide area of research. Let us wait for a better world with larger developments in nanotechnology.

Anju Sebastin & Sr. Anu Baby

How Was the Moon Formed?

Science has come a long, long way in explaining the various phenomena in our Universe. We understand the properties of particles down to the size of one-trillionth of

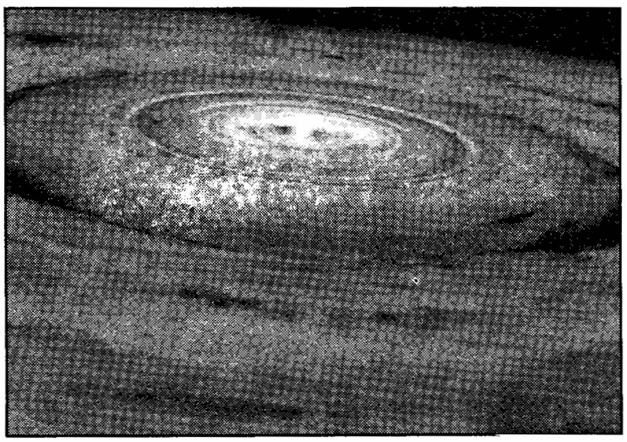


a metre, we have estimated the age of the Universe, we understand the bending of spacetime due to masses, and we are able to explain in great detail the mysterious and counterintuitive phenomenon of quantum tunneling. Most of the big questions about our everyday world, it would seem, have been answered; and the only questions left are those pertaining to the worlds of the very small and the very large, the worlds that are beyond our perception. Contrary to the image projected by the hype built around modern physics, this is far from being the case. There are plenty of fascinating unsolved mysteries to be found just around the corner if we keep our eyes open, and these questions, in my opinion, have always been much more interesting than the much-publicized answers that we are all familiar with. The sheer amount that we do not understand is humbling. One of these is the mystery of how our nearest astronomical neighbour, the familiar Moon, was formed.

Modern science still does not have a theory for the formation of the Moon which has been supported by sufficient evidence. There are many hypotheses regarding the formation of the Moon, and many of them tell incredible stories. Here are some of the more popular hypotheses:

- **Co-formation Hypothesis**

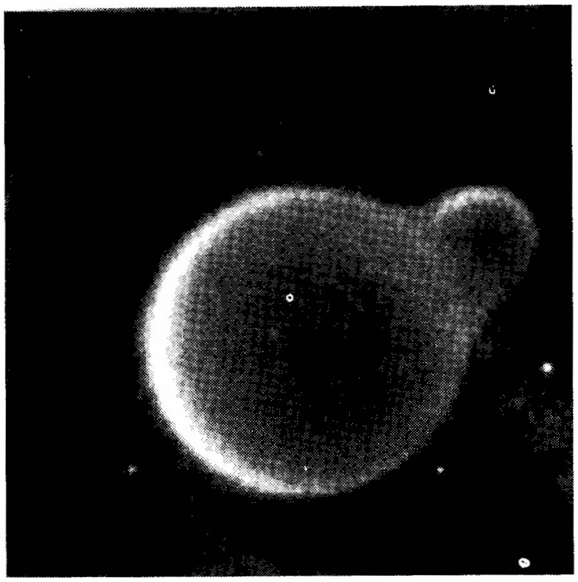
The co-formation hypothesis is perhaps the most intuitive hypothesis regarding the formation of the Moon. It puts forward the idea that the Earth and the Moon were formed together at the same time from the Solar accretion disk. The Moon would have formed from the material surrounding the young Earth, similar to the manner in which the planets formed around the Sun. However, this hypothesis is unable to account for the chemical composition of the Moon, which contains far less iron than this theory would



predict. The angular momentum of the Earth-Moon system is also not accurately predicted by this theory, the actual angular momentum being much higher than the predicted value.

- **Fission Hypothesis**

According to this hypothesis, the Earth and Moon were originally a single proto-planet formed from the accretion disk of the Sun, just like the other planets. When the Earth was very young, it was also extremely hot, and consisted entirely of molten matter. As it spun on its axis, centrifugal force combined with the action of tidal forces exerted by the Sun



and other planets led to the formation of an enormous tidal wave. The spinning of the Earth enhanced the size of this wave, and eventually the centrifugal force acting on it became so great as to send the matter contained in the tidal wave spiralling off into space. This matter was believed to have formed the moon, and the Pacific Ocean was hypothesized to be a scar left behind by the tearing away of this matter.

There are several problems with this hypothesis. Firstly, if this had been the case, the Moon's orbit would have been along the equatorial plane of the Earth, which it is not. Secondly, the initial spin required for the development of a centrifugal force of such magnitude is not in agreement with current models for the formation of the Solar System. Thirdly, the Pacific Ocean cannot be a scar left behind by the removal of matter, as this would imply that the crust of the Earth has not moved in billions of years, which contradicts the findings of plate tectonics.

- **Capture Hypothesis**

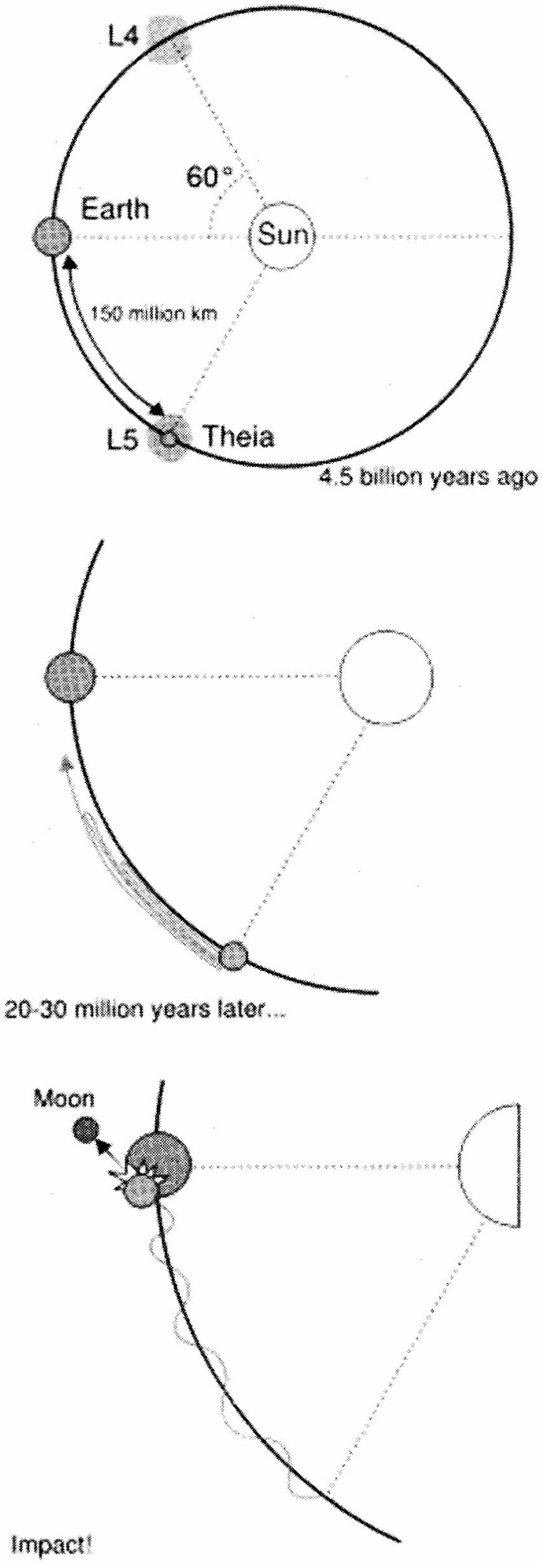
This hypothesis claims that the Moon was formed at a different time and place, and was captured by the Earth's gravitational field at some point in the Earth's history. Although this is plausible, it has been criticized for not having explained the formation of the Moon, and effectively only shifting the same problem to a different time and place. It is also widely believed that for this to have taken place, the Earth must have had a large enough atmosphere to dissipate the energy from the passing Moon, and this is highly unlikely.

- **Giant Impact Hypothesis**

This is also known as the Big Splash hypothesis, and is the most widely accepted today. According to this hypothesis, a large planet of about the same size as Mars (known as Theia) collided with the Earth about 4.5 billion years ago. During this collision, about half of the mass of Theia was ejected and formed the Moon, while the remaining matter was absorbed into the Earth. For this to have happened, the young Earth must have had a liquid surface, known as a magma ocean. Simulations of the collision seem to predict values of angular momentum of the Earth-Moon system and composition of the Moon's iron core consistent with current knowledge.

However, there are still many difficulties with this theory. There is no proof that the Earth ever had a magma ocean at all. If the Moon was formed from the matter of Theia, it should be rich in siderophilic substances, when it is actually deficient in these. Also, the recent discovery of water on the Moon is not consistent with this hypothesis - the collision would have caused the young Moon to be largely made up of molten material, and any water would have evaporated and escaped into space. Having no atmosphere, the Moon could not have retained any water.

Thus, the mystery of how the Moon was formed remains unsolved to this day. Next time you see the Moon in the sky, remember that you are staring at one of the great unanswered questions of our time.



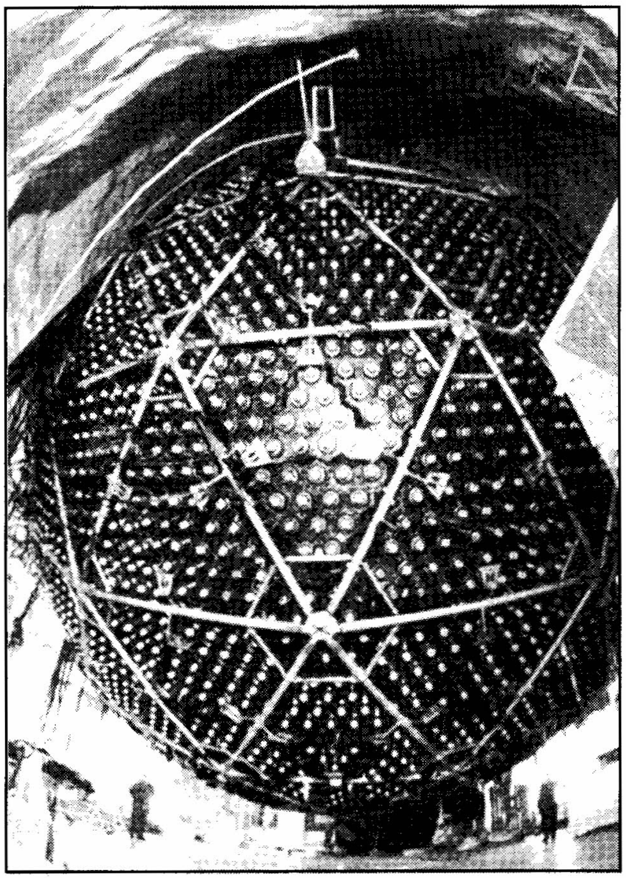
Nandini Ramesh

Theoretical Problems Regarding the Sun

We still do not have a complete understanding of our nearest star, the Sun, as there are some unsolved theoretical problems on many of its different aspects. Explained briefly below are a few of these problems, along with the current scientific consensus on the solutions:

Solar Neutrino Problem:

For many years, the number of solar electron neutrinos detected on Earth was only one third to half of the number predicted by the standard solar model. This anomalous result was termed the solar neutrino problem. Theories proposed to resolve the problem either tried to reduce the temperature of the Sun's interior to explain the lower neutrino flux or posited that electron neutrinos could oscillate, ie, they could change into undetectable tau and moon neutrinos as they travelled between the Sun and the Earth. Several neutrino observatories were built in the 1980's to measure the solar neutrino flux as accurately as possible, including the Sudbury Neutrino Observatory and Kamiokande. Results from the observations made at these stations eventually led to the discovery that neutrinos have very small rest mass and do indeed oscillate. Moreover, in 2001, the Sudbury Neutrino Observatory was able to detect all three types of neutrinos directly, and found that the Sun's total neutrino emission rate agreed with the standard solar model, although depending on the neutrino energy, as few as one third of the neutrinos seen on Earth are of the electron type. This proportion agrees with that predicted by the Mikheyev-Smirnov-Wolfenstein Effect, which describes neutrino oscillation in matter. Thus the solar neutrino problem is now considered a solved problem.

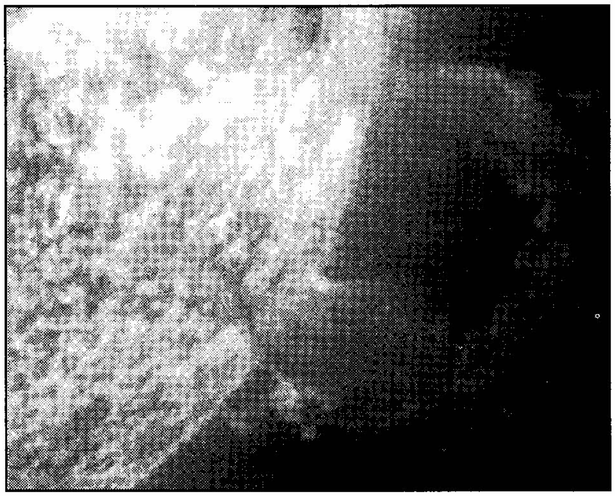


The Sudbury Solar Neutrino Observatory

Coronal Heating Problem:

The optical surface of the Sun is known to have a temperature of approximately 6,000 K. Above it lies the solar corona, with temperatures in the range 1 to 2 million K. This high temperature of the corona shows that it is heated by something other than direct heat conduction from the photosphere.

It is thought that the energy necessary to heat the corona is provided by turbulent motion in the convection zone below the

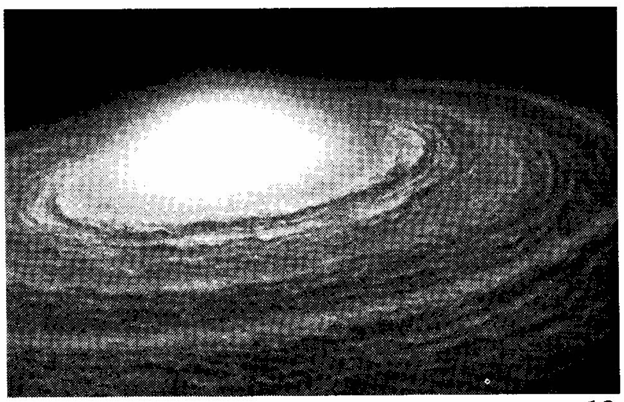


photosphere, and two main mechanisms have been proposed to explain coronal heating. The first is wave heating, in which sound, gravitational or magnetohydrodynamic waves are produced by turbulence in the convection zone. These waves travel upwards and dissipate in the corona, depositing their energy in the ambient gas in the form of heat. The second is magnetic reconnection, which is based on the behaviour of magnetic fields in plasma. In the presence of moving plasma, a magnetic field remains fixed in space. For this to happen, the magnetic poles have to "reconnect" to compensate for the motion of the plasma. This magnetic reconnection releases energy and may be able to produce minor solar flares known as microflares. In the 1980s, Eugene Parker put forward the idea that these microflares may be responsible for the heating of the corona. However, this idea is still controversial, and microflares are currently a topic of active research.

Faint Young Sun Problem:

Theoretical models of the Sun's development suggest that 3.8 to 2.5 billion years ago, during the Archean period, the Sun was only about 75% as bright as it is today. Such a weak star would not have been able to sustain liquid water on the Earth's surface, and thus life should not have been able to develop. However, the geological record demonstrates that the Earth has remained at a fairly constant temperature throughout its history and that the young Earth was actually somewhat warmer than it is today. The consensus among scientists is that the young Earth's atmosphere contained much larger quantities of greenhouse gases, which trapped enough heat to compensate for the smaller amount of solar energy reaching the planet.

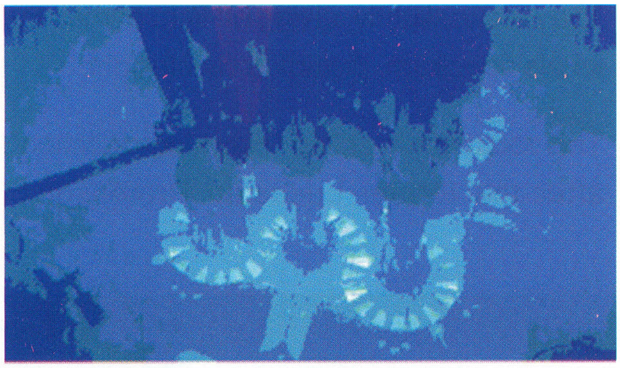
Padma Priya L.,
Sandra Jennifer T.,
Infant Sharmila P.



Weird Physics Facts

1. Things can travel faster than light; and light doesn't always travel very fast

The speed of light in a vacuum is a constant: 300,000km a second. However, light does not always travel through a vacuum. In water, for example, photons travel at around three-quarters that speed.



In nuclear reactors, some particles are forced up to very high speeds, often within a fraction of the speed of light. If they are passing through an insulating medium that slows light down, they can actually travel faster than the light around them.

When this happens, they cause a blue glow, known as "Cherenkov radiation ", which is (sort of) comparable to a sonic boom but with light. This is why nuclear reactors glow in the dark.

Incidentally, the slowest light has ever been recorded traveling was 17 meters per second – about 38 miles an hour – through rubidium cooled to almost absolute zero, when it forms a strange state of matter called a Bose-Einstein condensate.

Light has also been brought to a complete stop in the same fashion, but since that wasn't moving at all, we didn't feel we could describe that as "the slowest it has been recorded traveling".

2. Events in the future can affect what happened in the past

The weirdness of the quantum world is well documented. The double slit experiment, showing that light behaves as both a wave and a particle, is odd enough – particularly when it is shown that observing it makes it one or the other. But it gets stranger. According to an experiment proposed by the physicist John Wheeler in 1978 and carried out by researchers in 2007, observing a particle now can change what happened to another one – in the past.

According to the double slit experiment, if you observe which of two slits light passes through, you force it to behave like a particle. If you don't, and observe where it lands on a screen behind the slits, it behaves like a wave. But if you wait for it to pass through the slit, and then observe which way it came through, it will retroactively force it to have passed through one or the other. In other words, causality is working backwards: the present is affecting the past.

Of course in the lab this only has an effect over indescribably tiny fractions of a second. But Wheeler suggested that light from distant stars that has bent around a gravitational well in between could be observed in the same way: which could mean that observing something now and changing what happened thousands, or even millions, of years in the past.

3. All the matter that makes up the human race could fit in a sugar cube

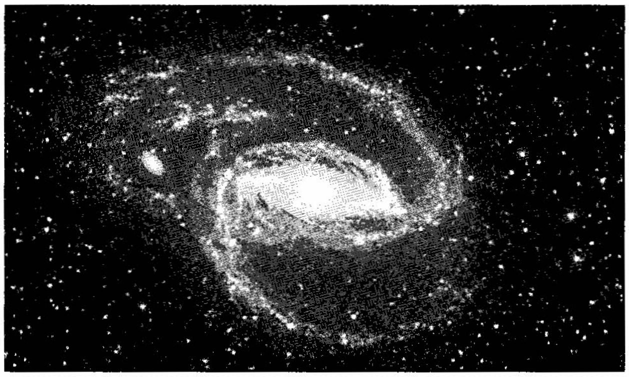
Atoms are 99.9999999999999 per cent empty space. As Tom Stoppard put it: "Make a fist, and if your fist is as big as the nucleus of an atom, then the atom is as big as St Paul's, and if it happens to be a hydrogen atom, then it has a single electron flitting about like a moth in an empty cathedral, now by the dome, now by the altar."

If you forced all the atoms together, removing the space between them, crushing them down so the all those vast empty cathedrals were compressed into the fist-sized nuclei, a single teaspoon or sugar cube of the resulting mass would weigh five billion tons; about ten times the weight of all the humans who are currently alive. Incidentally, that is exactly what has happened in a neutron star, the super-dense mass left over after a certain kind of supernova.

4. Black holes aren't black

They're very dark, sure, but they aren't black. They glow, slightly, giving off light across the whole spectrum, including visible light.

This radiation is called "Hawking radiation", after the former Lucasian Professor of

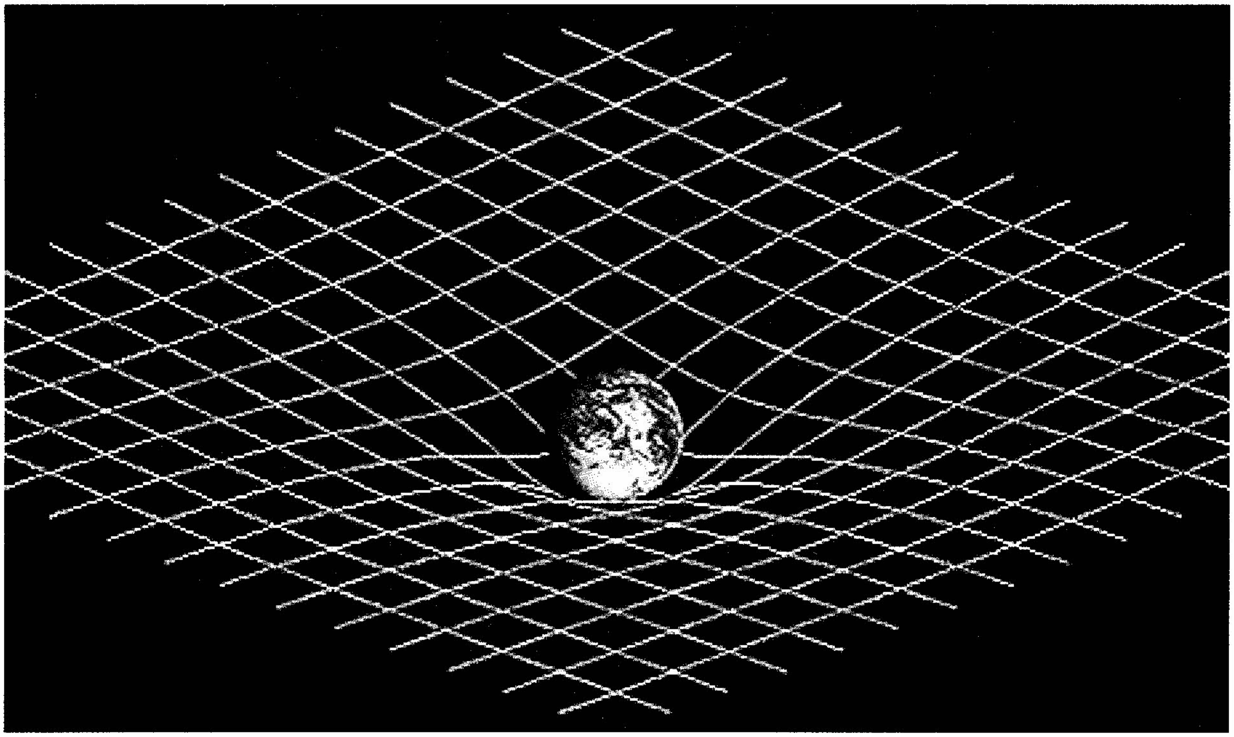


Mathematics at Cambridge University Stephen Hawking, who first proposed its existence. Because they are constantly giving this off, and therefore losing mass, black holes will eventually evaporate altogether if they don't have another source of mass to sustain them; for example interstellar gas or light.

Smaller black holes are expected to emit radiation faster compared to their mass than larger ones, so if – as some theories predict – the Large Hadron Collider creates minuscule holes through particle collisions, they will evaporate almost immediately. Scientists would then be able to observe their decay through the radiation.

speed of light, and you give it a push, it can't go very much faster. But you've given it extra energy, and that energy has to go somewhere.

Where it goes is mass. According to relativity, mass and energy are equivalent.



5. The faster you move, the heavier you get

If you run really fast, you gain weight. Not permanently, or it would make a mockery of diet and exercise plans, but momentarily, and only a tiny amount.

Light speed is the speed limit of the universe. So if something is traveling close to the

So the more energy you put in, the greater the mass becomes. This is negligible at human speeds – Usain Bolt is not noticeably heavier when running than when still – but once you reach an appreciable fraction of the speed of light, your mass starts to increase rapidly.

Renuka. N

Fluid Instabilities

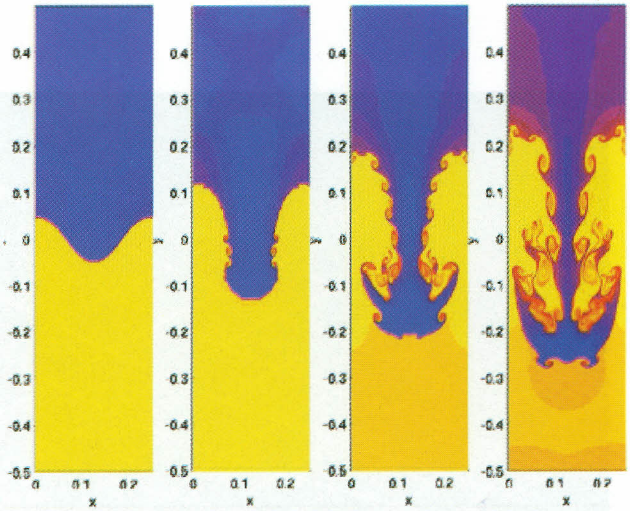
When we look at the world around us, we see a wealth of beautiful patterns: be it the waves in the ocean, the clouds in the sky, the branches of a tree, or the perfection of a water droplet. These patterns found in nature are, of course, the consequence of physical forces. The types of phenomena that lead to pattern formation have much more in common than what is revealed to the eye; in fact, they all arise from the same fundamental phenomenon: that of instabilities.

An instability is a situation in which two or more opposing forces act on a body which is in unstable equilibrium. Once the unstable equilibrium has been broken, a pattern may arise.

In this article, we shall discuss a few fluid instabilities which give rise to some truly breathtaking patterns. A fluid instability can occur when there are two fluids with differing properties in contact with each other, or when the different properties of a single fluid tend to pull it in different directions. Some of the more commonly observable fluid instabilities are:

Rayleigh -Taylor Instabilities

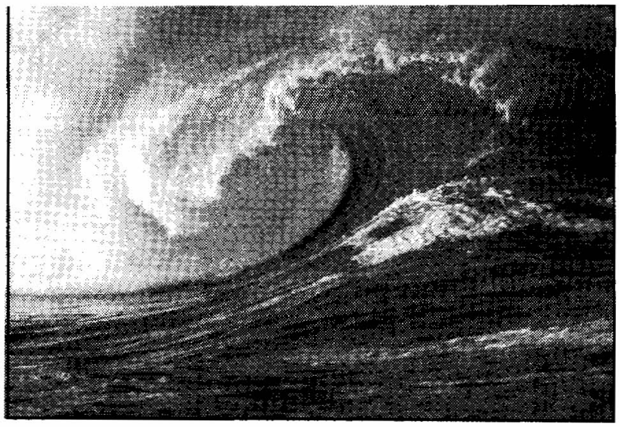
Rayleigh-Taylor instabilities arise due to differences in density between two fluids. When one fluid is forced through another fluid of a different density, fingerlike protrusions develop, provided that the two fluids are immiscible. For example, when enamel paints are stirred in water, they produce these instabilities, which are familiar to us as a "marbled" pattern. These are observed in varioussituations, such as when oil floats on



A computer simulation of a Rayleigh-Taylor instability

water. It is even observed in space, with the filaments of the famous Crab Nebula being fine examples of this type of instability, where denser material has been pushed through lighter material during the supernova explosion.

A Kelvin-Helmholtz instability formed in the clouds as one layer of air passes another



Waves in the ocean are a result of Kelvin-Helmholtz instabilities.

Kelvin-Helmholtz Instabilities

Kelvin-Helmholtz instabilities are very commonly observed in nature. They occur due to a difference between the velocities of two fluids in contact with each other. The difference in velocities leads to shear forces which distort the boundary between the two fluids, forming wavelike bends in the boundary. In fact, the waves at the surface of the ocean are Kelvin-Helmholtz instabilities, produced by the difference between the high velocity of the wind and the nearly-stationary ocean.

Plateau-Rayleigh Instabilities

Plateau-Rayleigh instbilities, unlike the instabilities described above, occur within a single fluid. As a cylindrical stream of fluid falls or flows in a certain direction, the fluid tends to minimize its surface area due to surface tension. As the stream progresses, its tendency is to form smaller, usually spherical, packets or droplets. An everyday example of this instability would be in the dripping of water from a tap.

Plateau-Rayleigh instabilities can be observed as a water droplet is formed from a dripping tap

These are just a few of the fascinating fluid instabilities that we find in our day-to-day lives. There exist many more, such as the Rayleigh-Benard instability which gives rise to convection cells in a differentially heated fluid, or the Taylor-Couette instability which arises in spherical systems. Instabilities are a fascinating field, and produce a variety of wonderful images that make our everyday lives all the more beautiful.

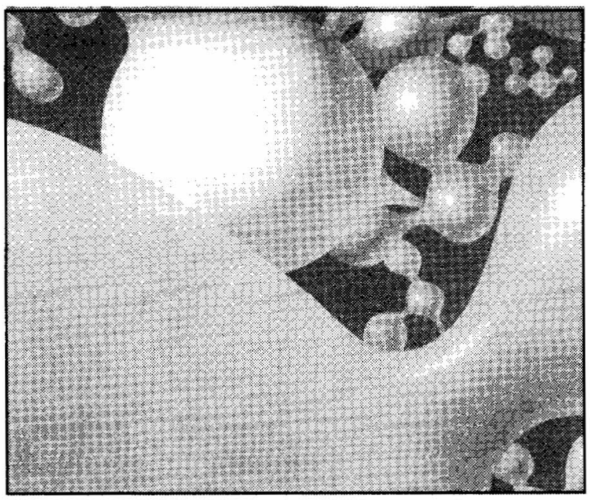
Nandini Ramesh

String Theory - A New Dimension in Understanding the Universe

Relativistic quantum field theory has worked very well to describe the observed behaviors and properties of elementary particles. But the theory itself only works well when gravity is so weak that it can be neglected. Particle theory only works when we pretend gravity doesn't exist. General relativity has yielded a wealth of insight into the Universe, the orbits of planets, the evolution of stars and galaxies, the Big Bang and recently observed black holes and gravitational lenses. However, the theory itself only works when we pretend that the Universe is purely classical and that quantum mechanics is not needed in our description of Nature. String theory is believed to close this gap.

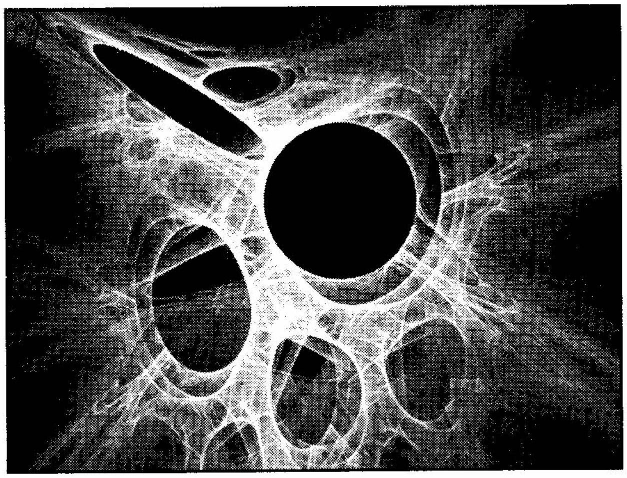
Origin of string theory:

Originally, string theory was proposed as an explanation for the observed



relationship between mass and spin for certain particles called hadrons, which include the proton and neutron. Things didn't work out, though, and Quantum Chromodynamics eventually proved a better theory for hadrons. But particles in string theory arise as excitations of the string, and included in the excitations of a string in string theory is a particle with zero mass and two units of spin. If there were a good quantum theory of gravity, then the particle that would carry the gravitational force would have zero mass and two units of spin. This has been known by theoretical physicists for a long time. This theorized particle is called the graviton.

This led early string theorists to propose that string theory can be applied not as a theory of hadronic particles, but as a theory of quantum gravity. But the presence of the graviton predicted by string theory alone was insuffient. One can add a graviton to quantum field theory by hand, but the calculations that are supposed to describe Nature become useless. This is because, for strings, particle interactions occur at a single point of spacetime, at zero distance between the interacting particles whereas for gravitons, the mathematics behaves so badly at zero distance that the answers just don't make sense. In string theory, the strings collide over a small but finite distance, and the answers do make sense. This doesn't mean that string theory is not without its deficiencies, but the zero distance behavior is such that we can combine quantum mechanics and gravity, and we can talk sensibly about a string excitation that carries the gravitational force. This is a great hurdle that has to be overcome by the particle physicist and they are basically



using complex mathematics that is necessary to study a quantum theory of interacting strings.

What exactly is String theory?

Think of a guitar string that has been tuned by stretching the string under tension across the guitar. Depending on how the string is plucked and how much tension is in the string, different musical notes will be created by the string. These musical notes could be said to be excitation modes of that guitar string under tension.

In a similar manner, in string theory, the elementary particles we observe in particle accelerators could be thought of as the "musical notes" or excitation modes of elementary strings. In string theory, as in guitar playing, the string must be stretched under tension in order to become excited.

However, the strings in string theory are floating in spacetime; and thereby experience no tension If string theory is said to be a theory of quantum gravity, then the average size of a string should be somewhere near the length scale of quantum gravity, called the Planck length, which is about 10^{-33} centimeters, Unfortunately, this means that strings are way too small to see by current or expected particle physics technology and thus require ten dimensions to understand their behavior but as of now we all are familiar with only four dimensions and so string theorists must devise more clever methods to test the theory than just looking for little strings in particle experiments.

String theories are classified into two types. The first classification is based on whether the strings of the elementary particles are closed or open loops and another classification is the situation where the particle spectrum includes fermions. In string theory, there must be a special kind of symmetry called super symmetry, which means for every boson (particle that transmits a force) there is a corresponding fermion (particle that makes up matter). So the concept of super symmetry basically relates the particles that transmit forces to the particles that make up matter.

Super symmetric partners are not observed by particle physics experiments till date but, theorists believe that this is because super symmetric particles are too massive to be detected at current accelerators. Particle accelerators could be on the verge of finding evidence for high energy super symmetry in the next decade.

Thus if the particle physicists are successful in unifying gravity with the quantum field theory (Quantum gravity) and thus exhibit the presence of gravitons the string theory will stand as good mathematical model in understanding the particles at smaller scale and will give a new dimension in understanding the universe.

Ashwini.G

One More Planet With Life-Supporting Environs

NASA detects water, methane and carbon dioxide - the basic chemistry for life - on planet HD2094586.

Organic molecules essential for life have been detected in one more hot gas planet outside the Solar System within a year by NASA scientists. Scientists at NASA's Jet Propulsion Laboratory in California detected water, methane, and carbon dioxide - the basic chemistry for life - in the planet named HD2094586, NASA said.

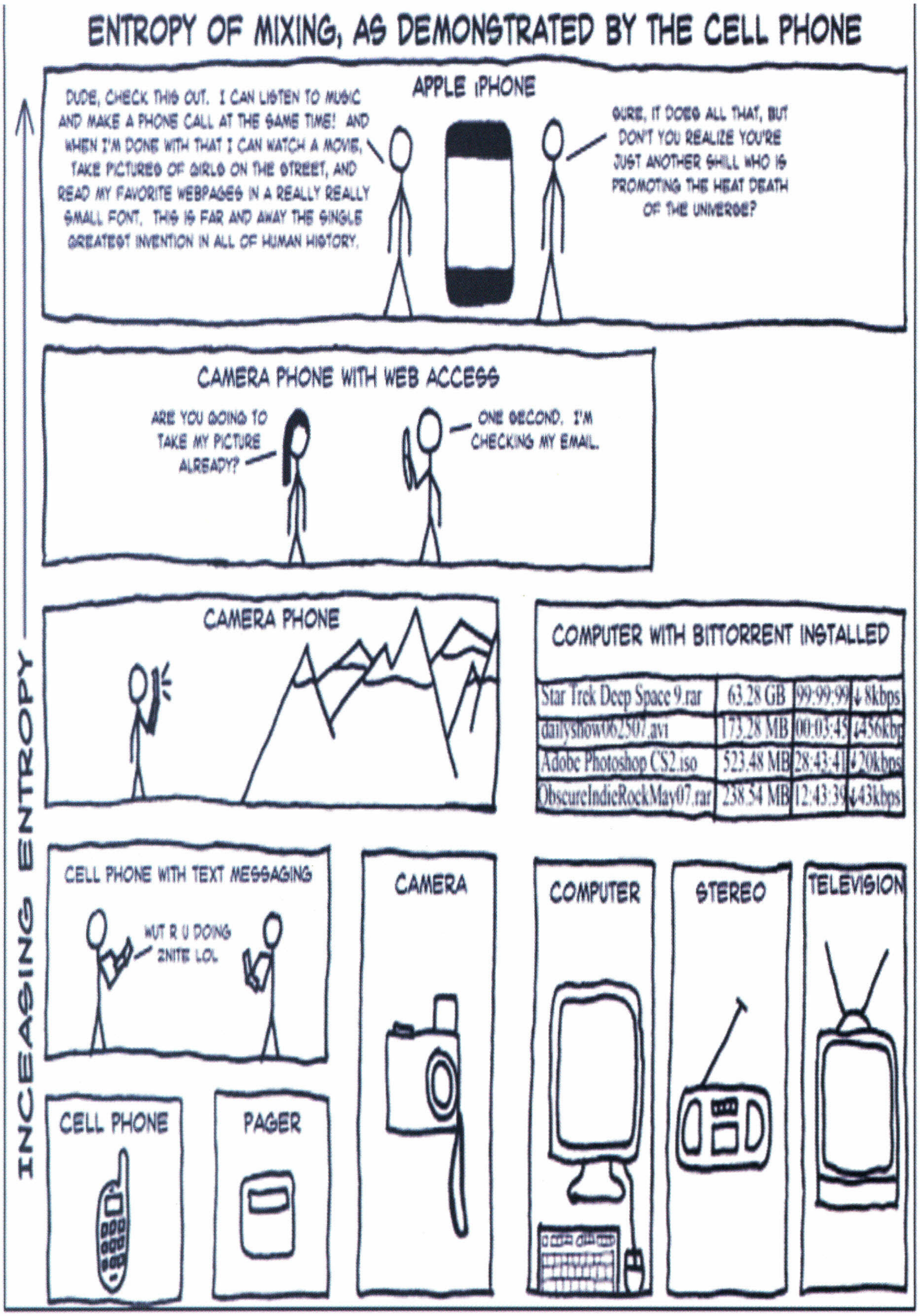
Data from the Hubble Space Telescope and Spitzer Space Telescope - NASA's two orbiting observatories - was used to detect the planet, which is bigger than Jupiter.

"It's the second planet outside our Solar System in which water, methane, and carbon dioxide have been found, which are potentially important for biological processes in habitable planets," said Mark Swain, one of the researchers at NASA.The finding follows the December 2008 discovery of carbon dioxide around another hot, Jupiter-sized planet.

"Detecting organic compounds in two exoplanets (extra solar planets) now raises the possibility that it will become commonplace to find planets with molecules that may be tied to life," Swain said. The new findings have advanced astronomers towards the goal of being able to distinguish planets where life could exist from those where life cannot exist.

HD2094586 orbits a Sun-like star about 150 light years away, in the constellation of Pegasus. The planet itself is not habitable, but has the same chemistry that, if found around a rocky planet in the future, could indicate the presence of life.

L. Leema Rose,


ENTROPY OF MIXING, AS DEMONSTRATED BY THE CELL PHONE
INCEASING ENTROPY
APPLE iPHONE
DUDE, CHECK THIS OUT. I CAN LISTEN TO MUSIC AND MAKE A PHONE CALL AT THE SAME TIME! AND WHEN I'M DONE WITH THAT I CAN WATCH A MOVIE, TAKE PICTURES OF GIRLS ON THE STREET, AND READ MY FAVORITE WEBPAGES IN A REALLY REALLY SMALL FONT. THIS IS FAR AND AWAY THE SINGLE GREATEST INVENTION IN ALL OF HUMAN HISTORY.
SURE, IT DOES ALL THAT, BUT DON'T YOU REALIZE YOU'RE JUST ANOTHER SHILL WHO IS PROMOTING THE HEAT DEATH OF THE UNIVERSE?
CAMERA PHONE WITH WEB ACCESS
ARE YOU GOING TO TAKE MY PICTURE ALREADY?
ONE SECOND. I'M CHECKING MY EMAIL.
CAMERA PHONE
COMPUTER WITH BITTORRENT INSTALLED
Star Trek Deep Space 9.rar 63.28 GB 99:99:99 ↓8kbps
dailyshow062507.avi 173.28 MB 00:03:45 ↓456kbps
Adobe Photoshop CS2.iso 523.48 MB 28:43:41 ↓20kbps
ObscureIndieRockMay07.rar 238.54 MB 12:43:39 ↓43kbps
CELL PHONE WITH TEXT MESSAGING
WUT R U DOING 2NITE LOL
CAMERA
COMPUTER
STEREO
TELEVISION
CELL PHONE
PAGER

Raman's Nobel Feat

It was Raman's first trip abroad. He represented the university at an assembly of universities in London. On the return journey, which was a two-week voyage by steamer, his scientific curiosity was aroused by the blue color of the Mediterranean Sea. The British scientist, Lord Rayleigh, had shown that the sky is blue because sunlight is scattered by molecules of air and small particles in the atmosphere. Blue, having a shorter wavelength than most of the other colors, is scattered the most.

Once the reason for the blue color of the sky had been discovered, scientists forced an easy way to explain the blue color of the seas; they said the seas were merely reflecting the color of the sky.

While Raman was crossing the blue waters of the Mediterranean Sea he wondered if the explanation was correct. Was it not possible that the blue of the sea was also caused by the phenomenon of scattering of light?

His hunch proved right. Through a simple experiment he showed that though it was true that the sea reflected the color of the sky, the main reason why it was blue was that molecules of seawater scattered the sunlight that penetrated its surface.

Raman did not stop at that. He began a systematic study of scattering of light by different substances, an investigation that led to the discovery of what came to be called the Raman Effect.

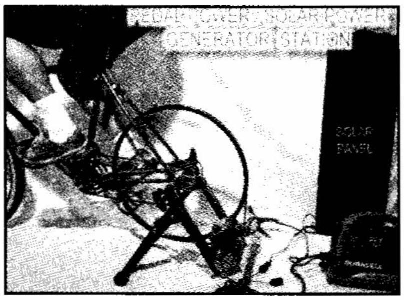
The Raman Effect is of immense importance in studying the structure of molecules, and its discovery fetched Raman the 1930 Nobel Prize for Physics. He was the first Indian to get a Nobel Prize in science. His achievement showed that India could produce world-class scientists, and gave a boost to the morale of Indian scientists and to the development of Physics in our country.

As the discovery was made on 28th February 1928, the day is now celebrated as National Science Day. In 1934, Raman became the director of the newly established Indian Institute of Science in Bangalore. In 1949, he established the Raman Research Institute.

Raman remained active till his death on November 21st 1970 at the age of 82.

G.M. Bhargavi

Powering a computer with a bicycle generator



Is it possible to power a computer with a bicycle generator?

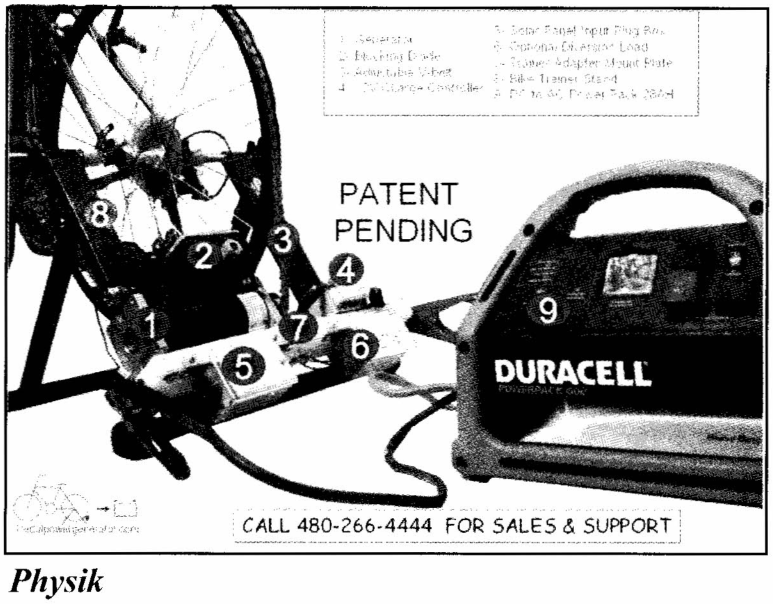
To answer this, we need to know two things.

* How much power does a computer consume?
* Can a person generate that much power with a bicycle?

If you have a normal desktop, computer and monitor, it probably consumes something around 200 watts. With a bigger monitor, it probably consumes around 250 watts. Even a large color TV consumes about the same amount of power.

We know that 1 horsepower = 746 watts. So a person would have to generate about 0.27 horsepower to power a 200 watts computer. This means that a person would have to generate about one-third of a horsepower to run a desktop PC.

Unless you are an Olympic athlete it would be a tough task to generate one-third of a horsepower on a bicycle for a substantial amount of time. A normal person might generate one-third of horsepower for half an hour before falling off the bicycle due to exhaustion.

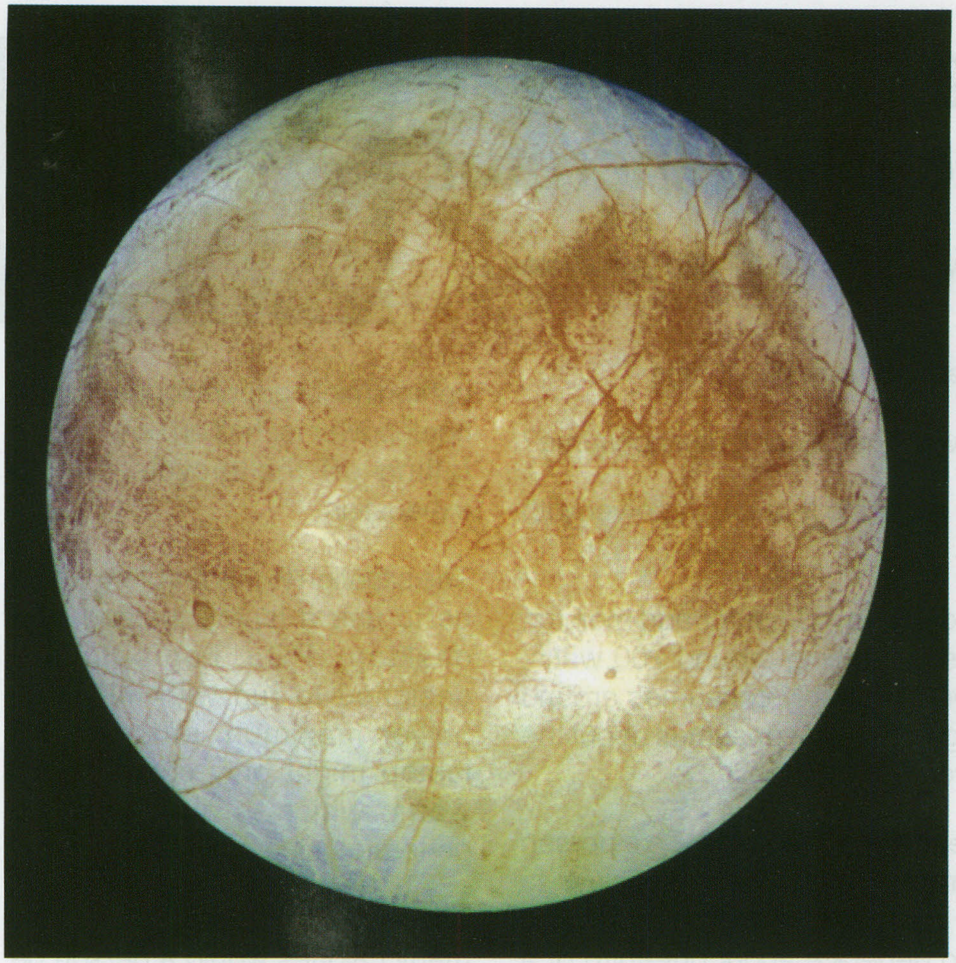


The situation to this problem would be to use a laptop instead of a desktop PC. Laptops are designed to run with minimum power maximum efficiency. A laptop might only consume 15 watts, which is quite easy to generate using a bicycle.

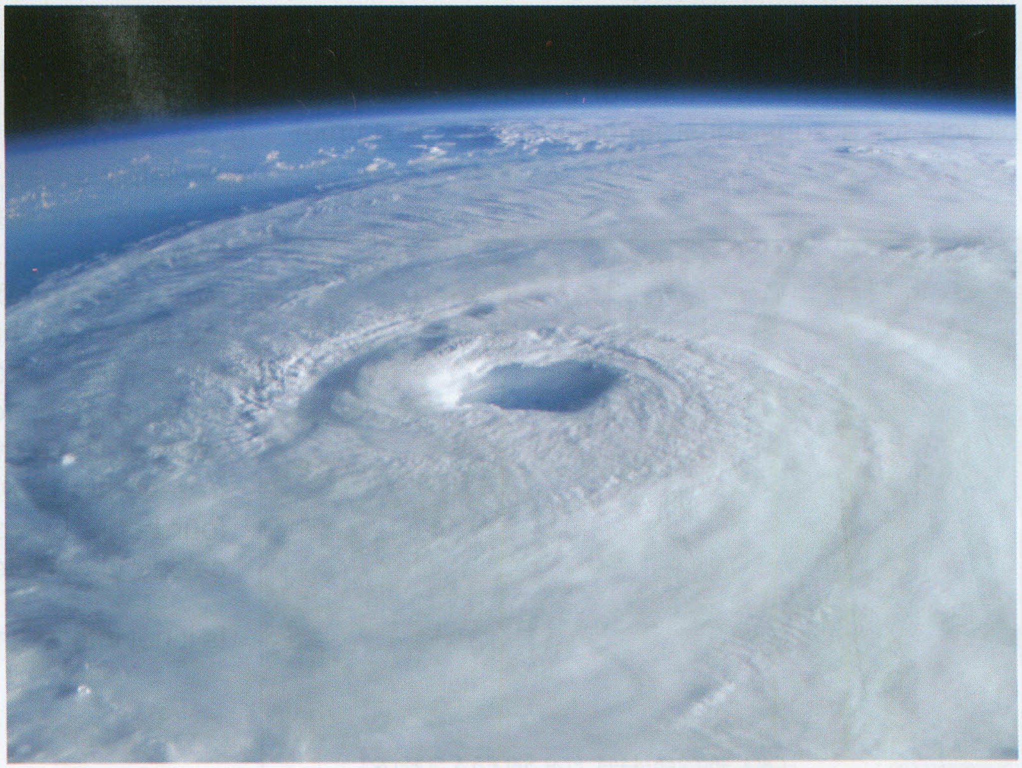
The next question would be how many calories would a person be required to burn during the generation of this power? Theoretically speaking to generate 1 watt for an hour, you burn about 0.85 calories. To make the calculation easier, let us take it as 1 calorie per watt-hour. So you should burn about 15 calories per hour using the bicycle to power the laptop. At this rate, a single 60-calorie chocolate could power a laptop for four hours. In other words you have the stamina to generate 15 watts of power for four hours by consuming a 60-calorie chocolate cookie.

Is it not interesting!

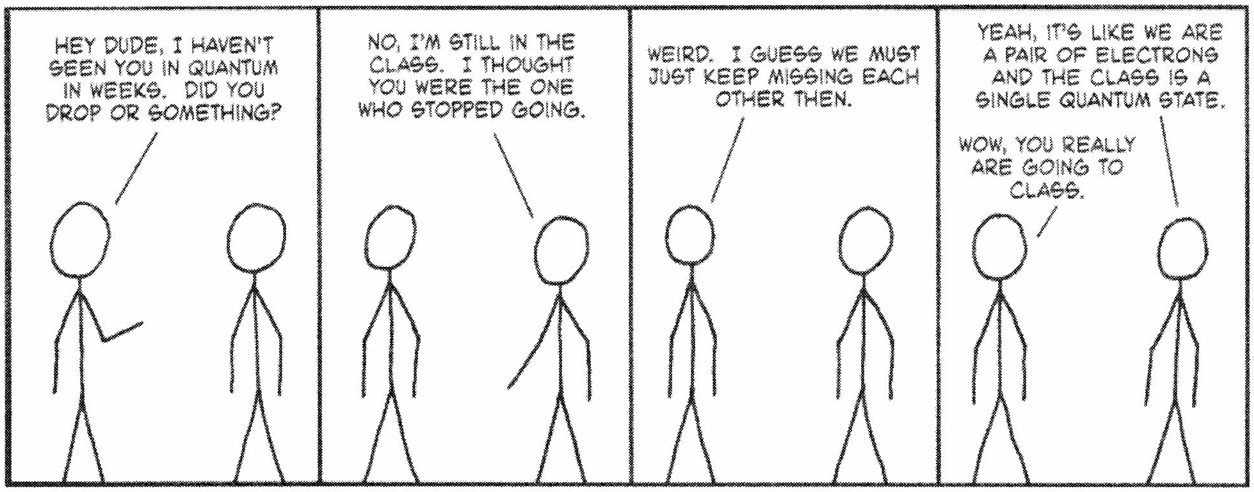
M.Gayathri

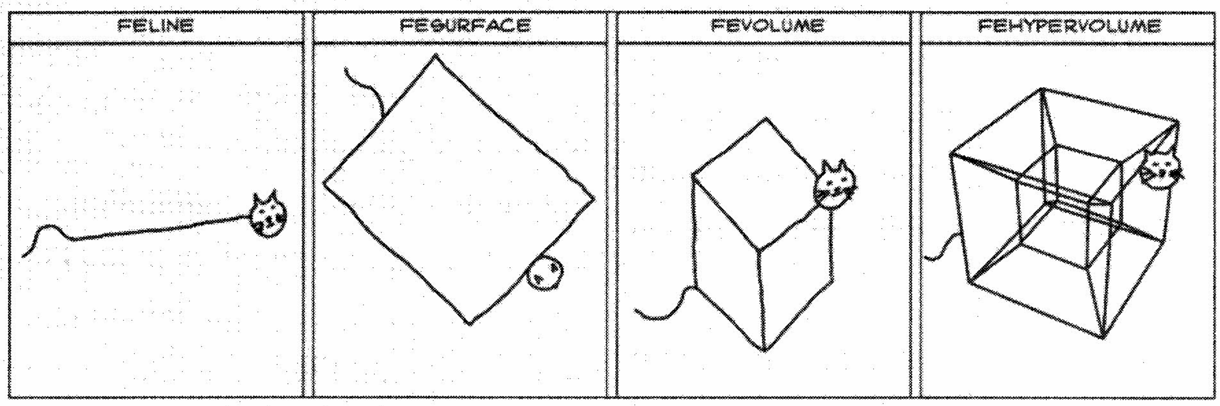


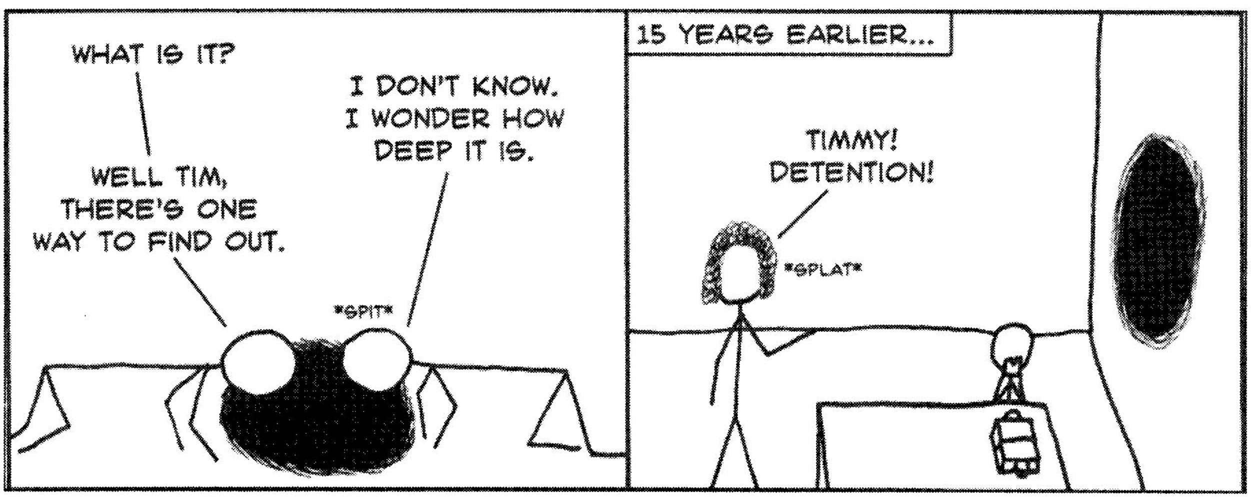
Europa, one of Jupiter's moons, has a surface covered with ice, under which is believed to be a sea. This sea is believed to be the only environment other than the Earth in the Solar System that could possibly harbour life forms.



The clouds of a hurricane as seen from space


HEY DUDE, I HAVEN'T SEEN YOU IN QUANTUM IN WEEKS. DID YOU DROP OR SOMETHING?
NO, I'M STILL IN THE CLASS. I THOUGHT YOU WERE THE ONE WHO STOPPED GOING.
WEIRD. I GUESS WE MUST JUST KEEP MISSING EACH OTHER THEN.
YEAH, IT'S LIKE WE ARE A PAIR OF ELECTRONS AND THE CLASS IS A SINGLE QUANTUM STATE.
WOW, YOU REALLY ARE GOING TO CLASS.


FELINE
FESURFACE
FEVOLUME
FEHYPERVOLUME


WHAT IS IT?
I DON'T KNOW. I WONDER HOW DEEP IT IS.
WELL TIM, THERE'S ONE WAY TO FIND OUT.
SPIT
15 YEARS EARLIER...
TIMMY! DETENTION!
SPLAT

Magneto Hydrodynamics - A Combination of Electromagnetism and Fluid Mechanics

Magneto hydrodynamics (MHD) is the physical-mathematical concept that concerns the dynamics of magnetic fields in electrically conducting fluids, e.g. in plasmas and liquid metals. One of the most famous scholars associated with MHD was the Swedish physicist Hannes Alfvén, who received the Nobel Prize in Physics for fundamental work and discoveries in magneto hydrodynamics with fruitful applications in different parts of plasma physics.

The central point of MHD theory is that conductive fluids can support magnetic fields. The presence of magnetic fields leads to forces that in turn act on the fluid typically plasma, thereby potentially altering the geometry and strength of the magnetic fields of their own. A key issue for a particular conducting fluid is the relative strength of the opposing motions in the fluid, compared to the diffusive effects caused by the electrical resistivity. Other topics belonging to the fundamental framework of magneto hydrodynamics include MHD turbulence, MHD waves (Alfvén waves), magneto-convection, MHD reconnection, and hydro magnetic dynamo theory.

When the resistivity is negligible, which is called ideal MHD, implies that the magnetic field is tightly coupled to the fluid, meaning it said to be frozen into the fluid. The relative strength of resistivity is measured by a dimensionless number, the magnetic Reynolds number. The magnetic Reynolds number can be thought of as a typical ratio of the opposing and diffusive effects. In astrophysical systems, magnetic Reynolds's number is usually very large, but mostly because the scales are large, not because the resistivity is small. Additionally, even if the resistivity is very low, MHD turbulence often produces very small-scale structures and large magnetic gradients, which lead to a finite, rate of magnetic diffusion, though the magnetic Reynolds number may be huge. Another important dimensionless number in MHD theory is the plasma beta defined as the ratio of gas pressure to the magnetic pressure .When the magnetic field dominates in the fluid; the fluid is forced to move along with the field. In the opposite case, when the field is weak, the field is swirled along by the fluid.

In ideal MHD the geometry of the magnetic field does not change. If a set of magnetic field lines is twisted into a knot, they will remain so. This means that it is very difficult to change the geometry of the magnetic field of some field configuration by MHD reconnection, if the resistivity is very low. It is thus possible to store large amounts of energy in the magnetic field by twisting it into a complex geometry by the fluid motions. This energy can subsequently be released into heat and kinetic energy, if the scales of the magnetic field become very small leading to large magnetic gradients or if the resistivity increases. In this case the ideal MHD breaks down allowing magnetic reconnection to occur.

Applications of MHD

Magnetism is found throughout the Universe. Magnetic fields are known to exist in planets, stars, the interstellar medium, galaxies and in active galactic nuclei. Often these magnetic fields are generated and maintained by magneto hydrodynamic dynamo action e.g. the solar dynamo or planetary dynamos which are described by hydro magnetic dynamo theory, and in many cases the magnetic field is dynamically dominant, determining the evolution of the object. Topics studied within MHD include typical computational astrophysics topics, such as magneto-convection, MHD turbulence and hydro magnetic dynamo action. On the Sun and other stars, these magnetic structures may take the form of cool spots (sunspots) and magnetic bright points. Magnetic structures can store enormous amounts of energy that may be released through reconnection of magnetic field lines (MHD reconnection) leading to solar flares and stellar or even galactic eruptions. It is in this way that the Sun causes storms in the heliospherical magnetic field and ultimately aurora and space weather. In engineering MHD is employed to study, the magnetic behavior of plasmas in fusion reactors, liquid-metal cooling of nuclear reactors and electromagnetic casting.

Thus the article basically introduces the fundamental concept about MHD. The importance of MHD lies in the fact that it is now been offered as a separate course in the undergraduate level. MHD has lot more exciting ideas and has some handful applications in the field of plasma physics.

Ashwini.G

Physics Trivia

Reversing Attraction Shrinks Car Batteries

Transforming the most important attractive force acting between molecules into a repulsive one could enable scientists to nearly halve the size of Lithium-ion batteries.

Efficient Solar Cells from Silicon Wires

US researchers have designed a new silicon-based solar cell which uses a hundred times less silicon than conventional photovoltaic devices.

Ferroelectrics Without the Twist

Japanese scientists have developed a new ferroelectric material based on small hydrogen-bonded molecular crystals of croconic acid.

Supercooled Water Puzzles

Researchers in Israel have discovered that supercooled water freezes at different temperatures depending on whether it is in contact with a positively or negatively charged surface.

Quantum Computer Hits Hydrogen

A basic quantum computer has successfully tackled one of the most challenging tasks facing chemists today - calculating molecular energy from basic scientific principles.

Locking Molecular Motors

Dutch scientists have designed a molecular motor that can be locked using an acid and unlocked using a base.

Infrared Optoelectronics You Can Apply With a Brush

Infrared quantum dots will lead to cheaper photovoltaic cells. When the fabrication of optoelectronic devices becomes almost as easy as splashing paint on a canvas, our assumptions about the high cost of high-performance optoelectronic devices will be turned on their head.

The Full Story of Newton's Faling Apple Revelation

For the first time, Britain's Royal Society recently opened online access to an eighteenth-century hand-written manuscript detailing the life of Sir Isaac Newton, including his inspiration for the theory of gravity, to mark the Institution's 350th anniversary.

Johnsemy

The leaves of a tree create pinholes which cast images of a solar eclipse on the ground as it occurs.

Liquid crystals display a variety of colourful patterns when exposed to polarized light. These patterns can be controlled by the application of magnetic fields, which is the principle behind the working of modern liquid crystal display screens.

Resonance Particles - The Short-Lived Ones!

In particle physics, an extremely short-lived phenomenon associated with subatomic particles called hadrons that decay via the strong nuclear force. This force is so powerful that it allows resonances to exist only for the amount of time it takes light to cross each such object. A resonance occurs when the net energy of the colliding subatomic particles is just enough to produce its rest mass, which the strong force then causes to disintegrate within 10^{-23} seconds

The most straightforward explanation of resonance particles, or resonances, is that they are extremely short lived particles. The lifetime of these particles is on the order of 10^{-23} seconds. Traveling at the speed of light, these particles could only travel about 10^{-15} meters, or about the diameter of a proton, before decaying. Distances of this magnitude cannot be measured in bubble chambers or any other device for detecting subatomic particles.

To understand how we deduce properties of resonance particles, it is first necessary to examine another, more complicated, explanation of their existence. This explanation involves the scattering cross-section of a particle. When two particles move towards each other and collide, it is possible to say that the collision was caused by the cross-section of the particles. The greater the cross-section of the particles is, the more likely it is that there will be a collision. So, if we have two beams of particles, the amount of scattering that occurs is related to the cross-section of the particles that make up the beams (this is a simplification, but it helps to understand resonances). We can measure the cross-section of a particle by knowing how much scattering occurs when two beams of particles collide.

If we draw graph for the results of observations for the cross-section of the particles versus the total energy of the particles, we can see that the graphs have peaks and valleys. This means that the cross-section of the colliding particles changes as a function of the total energy in the collision. Most collisions have several possible outcomes, and each possibility has peak cross-sections at certain energies. When graphs of the different possible results of the same collision are compared, we find that the peak cross-sections occur at the same energies for each possibility. There must be some reason why all the peaks occur at the same energy.

There are two explanations for the peaks, both involving resonances. In one view, the peaks themselves are resonant states or resonances. The resonance is the peak itself, not a particle. Resonances are simply energies at which the cross section of a particle reaches a maximum. In this view, resonances are similar to atomic energy levels, the only

Difference being that energy levels can be explained by quantum electro-magnetic theory and the need for discussing peak electron levels at certain energies is gone. Elementary Particles are not as well understood, so most of the information we have comes from the resonances.

The second explanation says that the peaks are evidence for actual particles that form as intermediate steps in the collision. In this view, the presence of resonance particles adds to the cross-section of the particles in the collision, making the collision more likely. The peaks are interpreted as evidence for the presence of resonance particles, and the different peaks are caused by a large number of distinct particles, which are just as real as other particles, the only difference being a difference in lifetime.

Both explanations, resonant states and resonance particles, have their advantages, and either can be used to find resonance properties. The energy of resonances is easy to find; it is just the energy at which the cross-section reaches a peak. In the particle theory, the energy is the mass of an intermediate particle through which the reaction takes place. The particle is formed by the collision but almost instantly decays into more stable particles. According to the resonance explanation, the energy is a resonant state of the reaction between the colliding particles, an energy at which the collision is more probable.

Finding the lifetime of a resonance is also fairly uncomplicated. According to the uncertainty principle, dE*DT is greater than or equal to h/2. The mean lifetime is given by t=h/dE. This is the same formula used to find lifetimes of excited nuclear states. dE is the width of the peak at the half maximum. If resonances are particles, then this formula gives their lifetimes. If they are resonant states, then the lifetime is the duration of the resonance, which is harder to understand. Again, the comparison to atomic energy states is useful. The time of the resonance is analogous to the time an electron stays in an excited state.

The debate over the nature of resonances will probably last until we have equipment sensitive enough to measure the extremely short distances which resonances would travel if they were particles.

Ashwini.G


NO PARKING

A Galileo Thermometer works on the principle of buoyancy and contains several bulbs of different densities which rise or fall based on the temperature (and therefore the density) of the transparent liquid in which they are suspended.

Amazing Facts

On an average our bodies constantly resist an atmospheric pressure of about 1 kg/sq inch.

The diameter of a proton is approximately 0.000000000001 mm.

The lightning bolt is 3 times hotter than the sun. And the lightning strikes about 6000 times per minute on our planet.

On a clear day a beam of sunlight can be reflected off a mirror and seen up to 25 miles away.

At the ocean's deepest point due to immense pressure an iron ball would take more than an hour to sink to the ocean floor.

If you could throw a snowball fast enough it would vapourize when it hits a brick wall.

The effect if relativity made an astronaut Sergei Abdeyer a fraction of a second younger upon his return to earth after 747 days in space.

When a glass breaks the cracks move at a speed of more than 3000 miles.

Due to gravitational effect you weigh slightly less when the moon is directly overhead.

If you yelled for 8 years 7 months and 6 days you would have produced just enough sound energy to heat one cup of coffee.

Many physicists believe that worm holes exist all around us but they are smaller than atomes.

Need-to-know Physics Terms

The Letter A:

Absolute zero: lowest possible temperature at which gas would have a zero volume.

Absorption spectrum: spectrum of electromagnetic radiation absorbed by matter when radiation of all frequencies is passed through it.

Acceleration: change in velocity divided by time interval over which it occurred.

Accuracy: closeness of a measurement to the standard value of that quantity.

Achromatic lens: lens for which all light colors have the same focal length.

Action-reaction forces: pair of forces involved in an interaction that are equal in magnitude and opposition in direction.

Activity: number of decays per second of a radioactive substance.

Adhesion: force of attraction between two unlike materials.

Air resistance: force of air on objects moving through it.

Alpha decay: process in which a nucleus emits an alpha particle.

Alpha particle: positively- charged particles consisting of two protons and two neutrons emitted by radioactive materials.

Ammeter: device to measure electrical current.

Amorphous solid: solids that have no long-range order; no crystal structure.

Ampere: unit of electric current; one ampere is the flow of one coulomb of charge per second.

Amplitude: in any periodic motion, the maximum displacement from equilibrium.

Angle of incidence: angle between direction of motion of waves and a line perpendicular to surface the waves are striking.

Angle of reflection: angle between direction of motion of waves and a line perpendicular to surface the waves are reflected from.

Angle of refraction: angle between direction of motion of waves and a line perpendicular to surface the waves have been refracted from.

Angular momentum: quantity of rotational motion. For a rotating object, product of moment of inertia and angular velocity.

Annihilation: process in which a particle and its antiparticle are converted into energy.

Antenna: device used to receive or transmit electromagnetic waves.

Antineutrino: subatomic particle with no charge or mass emitted in beta decay.

Antinode: point of maximum displacement of two superimposed waves.

Archimedes' principle: object immersed in a fluid has an upward force equal to the weight of the fluid displaced by the object.

Artificial radioactivity: radioactive isotope not found in nature.

atomic mass unit: unit of mass equal to 1/12 the atomic mass of carbon- 12 nucleus.

Atomic number: number of protons in the nucleus of the atom.

Average acceleration: acceleration measured over a finite time interval

Average velocity: velocity measured over a finite time interval.

The Letter B:

Back-EMF: potential difference a cross a conductor caused by change in magnetic flux.

Band theory: theory explaining electrical conduction in solids.

Baryon: subatomic particle composed of three quarks. Interacts with the strong nuclear force.

Battery: device that converts chemical to electrical energy consisting of two dissimilar conductors and an electrolyte.

Beat : slow oscillation in amplitude of a complex wave

Bernoulli's principle: when a fixed quantity of fluid flows, the pressure is decreased when the flow velocity increases.

Beta decay: radioactive decay process in which an electron or positron and neutrino is emitted from a nucleus.

Beta particle: high speed electron emitted by a radioactive nucleus in beta decay.

Binding energy: negative of the amount of energy needed to separate a nucleus into individual nucleons.

Boiling point: temperature at which a substance, under normal atmospheric pressure, changes from a liquid to a vapor state.

Breeder reactor: nuclear reactor that converts nonfissionable nuclei to fissionable nuclei while producing energy.

Bubble chamber: instrument containing superheated liquid in which the path of ionizing particles is made visible as trails of tiny bubbles.

Buoyant force: upward force on an object immersed in fluid.

The Letter C:

Calorimeter: device that isolates objects to measure temperature changes do to heat flow.

Candela: unit of luminous intensity.

Capacitance: ratio of charge stored per increase in potential difference.

Capacitor: electrical device used to store charge and energy in the electrical field.

Capillary action: rise of liquid in narrow tube due to surface tension.

Carnot efficiency: ideal efficiency of heat engine or refrigerator working between two constant temperatures.

Centripetal force: force that causes centripetal acceleration.

Chain reaction: nuclear reaction in which neutrons are produced that can cause further reactions.

Charged : object that has an unbalance of positive and negative electrical charges.

Charging by conduction: process of charging by touching neutral object to a charged object.

Charging by induction: process of charging by bringing neutral object near charged object, then removing part of resulting separated charge.

Chromatic aberration: variation in focal length of lens with wavelength of light.

Circular motion: motion with constant radius of curvature caused by acceleration being perpendicular to velocity.

Clock reading: time between event and a reference time, usually zero.

Closed, isolated system: collection of objects such that neither matter nor energy can enter or leave the collection.

Closed-pipe resonator: cylindrical tube with one end closed and a sound source at other end.

Coefficient of friction: ratio of frictional force and the normal force between two forces.

Coefficient of linear expansion: change in length divided by original length and by temperature change.

Coefficient of volume expansion: change in volume divided by original volume and by temperature change.

Coherent waves: waves in which all are in step; are in phase.

Cohesive force: attractive force between similar substances.

Complementary color: two colors that, when added , produce white light. Two pigments, that when combined, produce black.

Compound machine: machine consisting of two or more simple machines.

Compton effect: interaction of photons, usually X rays, with electrons in matter resulting in increased wavelength of X rays and kinetic energy of electrons.

Concave lens: lens thinner in center than edges; a diverging lens.

Concave mirror: converging mirror, one with center of curvature on reflecting side of mirror.

Conduction band: energies of charge carries in a solid such that the carries are free to move.

Conductor: materials through which charged particles move readily; or heat flow readily.

Conserved properties: property that is the same before and after an interaction.

Consonance: two or more sounds that, when heard together, sound pleasant.

Constant acceleration: acceleration that does not change in time.

Constant velocity: velocity that does not change in time.

Constructive interference: superposition of waves resulting in a combined wave with amplitude larger than the component waves.

Convection: heat transfer by means of motion of fluid.

Conventional current: motion of positive electrical current.

Converging lens: lens that causes light rays to converge; usually a convex lens.

Convex lens: lens that is thicker in the center than at edges.

Convex mirror: diverging mirror. Center of curvature is on side opposite reflecting side of mirror.

Cosine: the ratio of the adjacent side to the hypotenuse.

Coulomb: unit of electrical charge. Charge caused by flow of one ampere for one second.

Crest of wave: high point of wave motion.

Critical angle: minimum angle of incidence that produces total internal reflection.

Crystal lattice: structure of solid consisting of regular arrangment of atoms.

The Letter D:

De Broglie wavelength: length of de Broglie wave of particle; Planck's constant divided by momentum of particle.

Decibel: unit of sound level.

Dependent variable: variable that responds to change in manipulated variable.

Derived units: unit of quantity that consists of combination of fundamental units.

Destructive interference: superposition of waves resulting in a combined wave with zero amplitude.

Diffraction: bending of waves around object in their path.

Diffraction grating: material containing many parallel lines very closely spaced that produces a light spectrum by interference.

Diffuse reflection: reflection of light into many directions by rough object.

Dimensional analysis: checking a derived equation by making sure dimensions are the same on both sides.

Diode: electrical device permitting only one way current flow.

Dispersion of light: variation with wavelength of speed of light through matter resulting in separation of light into spectrum.

Displacement: change in position. A vector quantity.

Dissonance: two or more sounds that, when together, sound unpleasant.

Distance: separation between two points. A scalar quantity.

Diverging lens: lens that causes light rays to spread apart or diverge; usually a concave lens.

Dopants: small quantities of material added to semiconductor to increase electrical conduction.

Doppler shift: change in wavelength due to relative motion of source and detector.

Dynamics: study of motion of particles acted on by forces.

The Letter E:

Effective current: DC current that would produce the same heating effects.

Effective voltage: DC potential difference that would produce the same heating effects.

Efficiency: ratio of output work to input work.

Effort force: force extended on a machine.

Elastic collision: interaction between two objects in which the total energy is the same before and after the interaction.

Elasticity: ability of object to original shape after deforming forces are removed.

Electrical charge pump: device, often a battery or generator, that increase potential of electrical charge.

Electrical circuit: continuous path through which electrical charges can flow.

Electrical current: flow of charged particles.

Electrical field: property of space around a charged object that causes forces on other charged objects.

Electric field lines: lines representing the direction of electric field.

Electric field strength: ratio of force exerted by field on a tiny test charge to that change.

Electric generator: device converting mechanical energy into electrical energy.

Electric potential: ratio of electric potential energy to charge.

Electric potential difference: difference in electric potential between two points.

Electric potential energy: energy of a charged body in an electrical field.

Electromagnet: device that uses an electric current to produce a concentrated magnetic field.

Electromagnetic force: one of fundamental forces due to electric charges, both static and moving.

Electromagnetic induction: production of electric field or current due to change in magnetic flux.

Electromagnetic radiation: energy carried by electromagnetic waves throughout space.

Electromagnetic waves: wave consisting of oscillating electric and magnetic fields that move at speed of light through space.

Electromotive force: potential difference produced by electromagnetic induction.

Electron: subatomic particle of small mass and negative charge found in every atom.

Electron cloud: region of high probability of finding an electron around an atom.

Electron diffraction: effects on electrons due to wave-like interference of electrons with matter.

Electron gas model: description of current flow through conductors.

Electroscope: device to detect electric charges.

Electrostatics: study of properties and results of electric charges at rest.

Electroweak force: unification of electromagnetic and weak forces.

Elementary charge: magnitude of the charge of an electron. 1.602 *10^ -19

Emission spectrum: spectrum produced by radiation from excited atoms.

Energy: non-material property capable of causing changes in matter.

Energy levels: amounts of energy an electron in an atom may have.

Entropy: measure of disorder in a system; ratio of heat added to temperature.

Equilibrant force: force needed to bring an object into transitional equilibrium.

Equilibrium: condition in which net force is equal to zero. Condition in which net torque on object is zero.

Equivalent resistance: single resistance that could replace several resistors.

Evaporation: change from liquid to vapor state.

Excited state: energy level of atom higher than ground state.

External forces: forces exerted from outside a system.

Extrinsic semiconductor: semiconductor in which conduction is primarily the result of added impurities.

The Letter F:

Factor-label method: dimensional analysis.

Farad: unit of capacitance. One coulomb per volt.

Ferromagnetic materials: materials in which large internal magnetic fields are generated by cooperative action of electrons.

First harmonic: in music, the fundamental frequency.

First law of thermodynamics: change in internal or thermal energy is equal to heat added and work done on system. Same as law of conservation of energy.

Fluid: material that flows, i.e. liquids, gases, and plasmas.

Focal length: distance from the focal point to the center of a lens or vertex of a mirror.

Focal point: location at which rays parallel to the optical axis of an ideal mirror or lens converge to a point.

Forbidden gap: energy values that electrons in a semiconductor or insulator may not have.

Force: agent that results in accelerating or deforming an object.

Frame of reference: coordinate system used to define motion.

Fraunhofer lines: absorption lines in the sun's spectrum due to gases in the solar atmosphere.

Frequency: number of occurrences per unit time.

Friction: force opposing relative motion of two objects are in contact.

Fundamental particles: those particles(i.e. quarks and leptons) of which all materials are composed.

Fundamental tone: lowest frequency sound produced by a musical instrument.

Fundamental units: set of units on which a measurement system is based(i.e. meter, second, kilogram, ampere, candela).

Fuse: metal safety device in an electric circuit that melts to stop current flow when current is too large.

Fusion: combination of two nuclei into one with release of energy.

The Letter G:

Galvanometer: device used to measure very small currents.

Gamma decay: process by which a nucleus emits a gamma ray.

Gamma particle: high energy photon emitted by a radioactive nucleus.

Gas: state of matter that expands to fill container.

Geiger-Mueller tube: device used to detect radiation using its ability to ionize matter.

General theory of relativity: explanation of gravity and accelerated motion invented by Einstein.

Gluon: carrier of strong nuclear force.

Grand unified theories: theories being developed that unify the stronger and electroweak forces into one force.

Gravitational field: distortion of space due to the presence of mass.

Gravitational force: attraction between two objects due to their mass.

Gravitational mass: ratio of gravitational force to object's acceleration.

Gravitational potential energy: change of energy of object when moved in a gravitational field.

Graviton: particle that carries the gravitational force. Not yet observed.

Ground state: lowest energy level of an electron in an atom.

Grounding: process of connecting a charged object to Earth to remove object's unbalanced charge.

The Letter H:

Half-life: length of time for half of a sample of radioactive material to decay.

Harmonics: frequencies produced by musical instrument that are multiples of fundamental tone.

Heat: quantity of energy transferred from one object to another because of a difference in temperature.

Heat engine: device that converts thermal energy to mechanical energy.

Heat of fusion: quantity of energy needed to change a unit mass of a substance from solid to liquid state at the melting point.

Heat of vaporization: quantity of energy needed to change a unit mass of a substance from liquid to gaseous state at the boiling point.

Heavy water: deuterium oxide used mainly in CANDU nuclear reactors.

Heisenberg uncertainty principle: the more accurately one determines the position of a particle, the less accurately the momentum can be known, and vice versa.

Hertz: unit of frequency equal to one event or cycle per second.

Hole: absence of an electron in a semiconductor.

Hooke's law: deformation of an object is proportional to force causing it.

Huygens' wavelets: model of spreading of waves in which each point on wavefront is source of circular or spherical waves.

Hydraulic system: machines using fluids to transmit energy.

Hyperbola: mathematical curve that describes an inverse relationship between two variables.

Hypotenuse: side opposite the right angle in a triangle.

The Letter I:

Ideal mechanical advantage: in simple machine, the ratio of effort distance to resistance distance.

Illuminance: rate at which electromagnetic wave energy falls on a surface.

Illuminated object: object on which light falls.

Image: reproduction of object formed with lenses or mirrors.

Impulse: product of force and time interval over which it acts.

Impulse-momentum theorem: impulse given to an object is equal to its change in momentum.

Incandescent body: object that emits light because of its high temperature.

Incident wave: wave that strikes a boundary where it is either reflected or refracted.

Incoherent light: light consisting of waves that are not in step.

Independent variable: variable that is manipulated or changed in an experiment.

Index of refraction: ratio of the speed of light in vacuum to its speed in a material.

Inelastic collision: collision in which some of the kinetic energy is changed into another form.

Inertia: tendency of object not to change its motion.

Inertial mass: ratio of net force exerted on object to its acceleration.

Initial velocity: velocity of object at time t=0.

Instantaneous acceleration: acceleration at a specific time; slope of tangent to velocity-time graph.

Instantaneous position: position of an object at specific time.

Instantaneous velocity: slope of the tangent to position- time graph.

Insulator: material through which the flow of electrical charge carriers or heat is greatly reduced.

Interference fringes: pattern of dark and light bands from interference of light waves.

Interference of waves: displacements of two or more waves, producing either large or smaller waves.

Internal forces: forces between objects within a system.

Intrinsic semiconductor: semiconductor in which conduction is by charges due to host material, not impurities.

Inverse relationship: mathematical relationship between two variables, x and y, summarized by the equation xy=k, where k is a constant.

Ionizing radiation: particles or waves that can remove electrons from atoms, molecules, or atoms in a solid.

Isolated system: a collection of objects not acted upon by external forces into which energy neither enters nor leaves.

Isotope: atomic nuclei having same number of protons but different numbers of neutrons.

The Letter J:

Joule: SI unit of energy equal to one Newton-meter.

Joule heating: increase in temperature of electrical conductor due to conversion of electrical to thermal energy.

The Letter K:

Kelvin temperature scale: scale with 0 K= absolute zero and 273.16 K = triple point of water.

Kepler's laws: three laws of motion of bodies attracted together by the gravitational force.

Kilogram: SI unit of mass.

Kilowatt hour: amount of energy equal to 3.6 $*10^6$J. Usually used in electrical measurement.

Kinematics: study of motion of objects without regard to the causes of this motion.

Kinetic energy: energy of object due to its motion.

Kinetic-molecular energy: description of matter as being made up of extremely small particles in constant motion.

The Letter L:

Laser: devise that produces coherent light by stimulated emission of radiation.

Laser- induced fusion: proposed method of creating nuclear fusion by using heating caused by intense laser beams to squeeze matter together.

Law of conservation of energy: in a closed, isolated system, the total momentum is constant.

Law of reflection: angle of incidence of a wave is equal to the angle of reflection.

Law of universal gravitation: gravitational force between two objects depends directly on the product of their masses and inversely on the square of their separation.

Lens: optical device designed to converge or diverge light.

Lens equation: See mirror equation.

Lenz's law: magnetic field generated by an induced current opposes the change in field that caused the current.

Lepton: particle that interacts with other particles only by the electroweak and gravitational interactions.

Lever arm: component of the displacement of the force from the axis of rotation in the axis of rotation in the direction perpendicular to the force.

Light: electromagnetic radiation with wavelengths between 400 and 700 nm that is visible.

Linear accelerator: device to accelerate subatomic particles by applying successive electric field.

Linear relationship: relationship between two variables, x and y, summarized by the equation y= ax + b, where a and b are constant.

Linear restoring force: force in direction toward equilibrium position that depends linearly on distance from distance from that position.

Liquid: materials that have fixed volume but whose shape depends on the container.

Lodestone: naturally occurring magnetic rock.

Longitudinal waves: wave in which direction of disturbance is the same as the direction of travel of wave.

Loudness: physiological measure of amplitude of a sound wave; heard on pitch and tone color as well as amplitude.

Lumen: unit of luminous flux.

Luminance intensity: measure of light emitted by source in candelas; luminous flux divided by 4pie.

Luminous flux: flow of light from source measured in lumens.

Luminous object: object that emits light, as opposed to one that reflects light.

Lux: unit of luminous flux; one lumen per square meter.

The Letter M:

Machine: device that changes force needed to do work.

Magnetic field: space around a magnet throughout which magnetic force exists.

Magnification: ratio of size of an optical image to the size of the object.

Manipulated variable: variable that the experimenter can change.

Mass defect: mass equivalent of the binding energy; $m=E/c^2$

Mass number: number of nucleons (protons plus neutrons) in the nucleus of an atom.

Mass spectrometer: device used to measure the mass of atoms or molecules.

Matter wave: wave-like properties of particles such as electrons.

Mechanical advantage: ratio of resistance force to effort force in a machine.

Mechanical energy: sum of potential and kinetic energy.

Mechanical resonance: condition at which natural oscillation frequency equals frequency of driving force; amplitude of oscillatory motion at a maximum.

Mechanical wave: wave consisting of periodic motion of matter; e.g. sound wave or water wave as opposed to electromagnetic wave.

Melting point: temperature at which substance changes from solid to liquid state.

Meson: medium mass subatomic particle consisting of combination of a quark and antiquark.

Meter: SI unit of length.

Mirror equation: 1/do +1/di=1/f, where do is object distance, di is image distance, f is focal length.

Moderator: material used to decrease speed of neutrons in nuclear reactor.

Momentum: product of object's mass and velocity.

Monochromatic light: light of a single wavelength.

Mutual inductance: measures the amount of overlap between the magnetic flux produced in one coil and that which passes through a second coil, thus the amount of EMP induced in a secondary coil by the varying flux in the primary coil.

Myopia: defect of eye, commonly called nearsightedness, in which distant objects focus in front of the retina.

The Letter N:

n-type semiconductor: semiconductor in which current is carried by electrons.

Net force: vector sum of forces on object.

Neutral: object that has no net electric charge.

Neutrino: chargeless, massless, subatomic particle emitted with beta particles; type of lepton.

Neutron: subatomic particle with no charge and mass slightly greater than that of proton; type of nucleon.

Newton: SI unit of force.

Newton's law of motion: laws relating force and acceleration.

Node: point where disturbances caused by two or more waves result in no displacement.

Normal: perpendicular to plane of interest.

Normal force: force perpendicular to surface.

Nuclear equation: equation representing a nuclear reaction.

Nuclear fission: reaction in which large nucleus splits into two parts, often approximately equal in mass.

Nuclear fusion: reaction in which two nuclei are combined into one.

Nuclear reaction: reaction involving the strong force in which the number of protons or neutrons in a nucleus changes.

Nuclear reactor: device in which nuclear fusion is used to generate electricity.

Nuclear transmutation: change of one nucleus into another as the result of a nuclear reaction.

Nucleon: either a proton or a neutron.

Nuclide: nucleus of an isotope.

The Letter O:

Object: source of diverging light rays; either luminous or illuminated.

Octave: interval between two frequencies with a ratio of two to one.

Ohm: SI unit of resistance; one volt per ampere.

Ohm's law: resistance of object is constant, independent of voltage across it.

Opaque: material that does not transmit light.

Open- pipe resonator: cylindrical tube with both ends closed and a sound source at one end.

The Letter P:

p-type semiconductor: semiconductor in which conduction is the result of motion of holes.

Pair production: formation of particle and antiparticle from gamma rays.

Parabolic mirror: mirror the shape of a paraboloid of revolution that has no spherical aberration.

Parallel circuit: circuit in which there are two or more paths for current flow.

Parallel connection: connection of two or more electrical devices between two points to provide more than one current path.

Pascal: SI unit of pressure; one neutron per square meter.

Pascal's principle: pressure applied to a fluid is transmitted undiminished throughout it.

Period: time needed to repeat one complete cycle of motion.

Periodic motion: motion that repeats itself at regular intervals of time.

Photoelectric effect: election of electrons from surface of metal exposed to electromagnetic radiation.

Photon: quantum of electromagnetic waves; particle aspect of these waves.

Photovoltaic cell: device that converts electromagnetic radiation into electrical energy.

Physics: study of matter and energy and their relationship.

Piezoelectricity: electric potential produced by deforming material.

Pigment: colored material that absorbs certain colors and transmits or reflects others.

Pitch: perceived sound characteristics equivalent to frequency.

Planck's constant: ratio of energy of photon to its frequency.

Plane mirror: flat, smooth surface that reflects light regularly.

Plasma: state of matter in which atoms are separated into electrons and positive ions or bare nuclei.

Point object: object idealized as so small to be located at only one position.

Polarized light: light in which electric fields are all in same plane.

Position: separation between object and a reference point.

Position- time graph: graph of object's motion that shows how its position depends on clock reading, or time.

Positron: antiparticle equivalent of electron.

Potential difference: difference in electric potential between two points.

Potential energy: energy of object due to its position or state.

Potentiometer: electrical device with variable resistance; rheostat.

Power: rate of doing work; rate of energy conversion.

Precision: degree of exactness in a measurement.

Pressure: force per unit area.

Primary coil: transformer coil that, when connected to voltage source, creates varying magnetic flux.

Primary light colors: red, green, or blue light.

Primary pigment: yellow, green, or magenta light.

Principal axis: line connecting center of curvature of spherical mirror with its geometric vertex. Line perpendicular to plane of lens passing through its center.

Principle of superposition: displacement due to two or more forces is equal to vector sum of forces.

Projectiles: motion of objects given initial velocity that then move only under force of gravity.

Proton: subatomic particle with positive charge that is nucleus of hydrogen atom.

The Letter Q:

Quantized: a quantity that cannot be divided into smaller increments forever, for which there exists a minimum, quantum increment.

Quantum mechanic: study of properties of matter using its wave properties.

Quantum model of atom: atomic model in which only probability of locating electron is known.

Quantum number: integer ratio of energy to its quantum increment.

Quark: basic building block of protons, neutrons, other baryons, and mesons.

Quark model: model in which all particles that interact via the strong interaction are composed of two or three quarks.

The Letter R:

Radiation: electromagnetic waves that carry energy.

Radioactive decay: spontaneous change of unstable nuclei into other nuclei.

Radioactive materials: materials that undergo radioactive decay.

Range of projectile: horizontal distance between launch point of projectile and where it returns to launch height.

Ray model of light: light may be represented by straight line along direction of motion.

Ray optics: study of light using ray model.

Rayleigh criterion: two optical images are separable if central bright spot of one image falls on first dark band of second.

Real image: optical image at which rays from object converge.

Receiver: device that detects electromagnetic waves.

Reference level: location at which potential energy is chosen to be zero.

Reference point: zero location in a coordinate system or frame of reference.

Refraction: change in direction of light ray when passing one medium to another.

Refractive index: ratio of speed of light in vacuum to that in the medium.

Resistance: ratio of potential difference across device to current through it.

Resistance force: force exerted by a machine.

Resistor: device designed to have a specific resistance.

Responding variable: variable that changes as result of change in manipulated variable.

Rest energy: energy due to mass of object; $E= mc^2$.

Resultant: vector sum of two or more vectors.

Right -hand rules: used to find force on current or moving particle in magnetic field; used to find direction of magnetic field caused by current or of induced EMF.

Rutherford's model of atom: nuclear model of atom; essentially all mass in compact, positively- charged object at center, surrounded by electrons.

The Letter S:

Scalar: quantity, like distance, that has only a magnitude, or size.

Schematic diagram: representation of electric circuit using symbols.

Scientific notation: numbers expressed in form $M * 10^n$, where $1< M < 10$, and n is an integer.

Scintillation: flash of light emitted when substance is struck by radiation.

Second: SI unit of time.

Second law of thermodynamics: heat flow only from region of high temperature o region of lower temperature.

Secondary coil: transformer coil in which varying EMF is induced.

Secondary light colors: yellow, cyan, or magenta light.

Secondary pigment: red, green, or blue pigment.

Self- inductance: induced EMF produced in coil by changing current.

Semiconductor: material in which electrical conduction is smaller than that in a conductor, but more than in insulator.

Series circuit: circuit in which electrical current flows through each component, one after another.

Series connection: arrangement of electrical devices so that there is only one path through which current can flow.

Short circuit: low resistance connection between two points, often accidental.

SI: internationally agreed -upon method of using the metric system of measurement.

Significant digit: reliable digits reported in a measurement.

Simple harmonic motion: motion caused by linear restoring that has a period independent of amplitude of motion.

Simple machine: machine consisting of only one lever, inclined plane, wedge, screw, pulley, or wheel and axle.

Sine: the ratio of the opposite side and the hypotenuse.

Sliding friction: force between two surfaces in relative motion.

Slope: ratio of the vertical separation, or rise to the horizontal separation, or run.

Solid: state of matter with fixed volume and shape.

Sound level: quantity measuring logarithm of sound intensity in decibels.

Spark chamber: device used to detect path of charged subatomic particles by a spark that jumps along path of ionization created in a gas.

Specific heat: thermal energy needs to change temperature of unit mass of substance one Kelvin.

Spectroscope: device used to study spectrum of material.

Spectrum: collection of wavelengths in electromagnetic spectrum.

Speed: ratio of distance traveled to time interval.

Speed of light: in vacuum, 2.9979458 * 10^8 m/s.

Spherical aberration: inability of spherical mirror to focus all parallel rays to a single point.

Standing wave: wave with stationary nodes.

Static friction: force that opposes start of motion between two surfaces.

Step- down transformer: transformer with output voltage smaller than input voltage.

Step- up transformer: transformer with output voltage larger than input voltage.

Stimulated emission: emission of photon from excited atom caused by impact fo photon of same energy.

Strong nuclear force: force of very short range that holds neutrons and protons in nucleus together.

Superconductor: electrical conductor that has no resistance and low temperatures.

Surface wave: wave on surface of liquid with characteristics of both longitudinal and transverse waves.

Symmetry: property that is now charged when operation or reference frame is charged.

Synchrotron: device to accelerate particles in which particles move in circular path.

System: defined collection of objects.

The Letter T:

tangent: the ratio of the opposite side and the adjacent side.

Temperature: measure of hotness of object on a quantitative scale. In gases, proportional to average kinetic energy of molecules.

Terminal velocity: velocity of falling object reached when force of air resistance equals weight.

Test charge: charge used, in principle, to measure electric field.

Thermal energy: internal energy. Sum of kinetic and potential energy of random motion of particles making up object.

Thermal equilibrium: state between two or more bodies where temperatures do not change.

Thermal expansion: increase of length or volume of object due to change in temperature.

Thermometer: device used to measure temperature.

Thermonuclear reaction: nuclear fusion.

Thin- film interference: light interference caused by reflection from both front and rear surface of thin layer of liquid or solid.

Timbre: sound quality or tone color; spectrum of sound frequencies that produce a complete wave.

Time interval: difference in time between two clock readings.

Tokamak: type of fusion reactor.

Tone color: timbre or tone quality.

Torque: product of force and the lever arm.

Trajectory: the path followed by projectile.

Transformer: device to transform energy from one electrical circuit to another by means of mutual inductance between two coils.

Transistor: semiconductor device that controls large current by means of small voltage changes.

Translucent: material transmitting light without but distorting its path.

Transmutation: nuclear change from one element to another.

Transparent: material transmitting light without distorting directions of waves.

Transverse waves: wave in which disturbance is perpendicular to direction of travel of wave.

Traveling wave: moving, periodic disturbance in a medium or field.

Trigonometry: branch of math that deals with the relationship among angles and sides of triangles.

Trough of wave: low point of wave motion, where displacement is most negative.

The Letter U:

Uniform acceleration: constant acceleration.

Uniform circular motion: motion in a circle of constant radius with constant speed.

The Letter V:

Valence band: in a solid, the range of energies of electrons that are bound to atoms.

Vector quantity: quantity having both magnitude (size) and direction.

Vector resolution: process of finding the effective value of a component in a given direction.

Velocity: ratio of change in position to time interval over which change takes place.

Velocity- time graph: plot of velocity of object as a function of time.

Virtual image: point from which light rays appear to diverge without actually doing so.

Viscous fluid: fluid that creates force that opposes motion of objects through it. The force is proportional to object's speed.

Volatile liquid: liquid that is easily vaporized.

The Letter W:

Watt: unit of power, one joule per second.

Wavelength: distance between corresponding points on two successive waves.

Wave pulse: single disturbance moving through a medium or field.

Weak boson: particle that carries or transmits the weak interaction of force.

Weak interaction: force involved in beta decay of the neutron and atomic nuclei; one aspect of the electroweak force.

Weight: force of gravity of an object.

Weightlessness: object in freefall, on which only the gravitational force acts.

Wilson cloud chamber: chamber containing supersaturated vapour through which ionizing radiation leaves trails of visible droplets.

Work: product of force and displacement in the direction of the force.

Work function: energy needed to remove an electron from metal.

Work energy theorem: work done on object is equal to the change in its kinetic energy.

The Letter X:

X ray: high- energy photons; high- frequency, short-wavelength electromagnetic waves.

X-ray diffraction: A complicated technique using x-rays to "create an image" where no lens to focus the light rays is available.

X-ray images: Images such as photographs or computer enhanced images produced by bombarding a target with x-rays.

The Letter Y:

Young's modulus: A constant of proportionality associated with the change in length of a material according to its elastic properties.

The Letter Z:

Zero-point energy: The lowest energy state of molecular vibration.

Amazing Facts

On an average our bodies constantly resist an atmospheric pressure of about 1 kg/sq inch.

The diameter of a proton is approximately 0.000000000001 mm.

The lightning bolt is 3 times hotter than the sun. And the lightning strikes about 6000 times per minute on our planet.

On a clear day a beam of sunlight can be reflected off a mirror and seen up to 25 miles away.

At the ocean's deepest point due to immense pressure an iron ball would take more than an hour to sink to the ocean floor.

If you could throw a snowball fast enough it would vapourize when it hits a brick wall.

The effect if relativity made an astronaut Sergei Abdeyer a fraction of a second younger upon his return to earth after 747 days in space.

When a glass breaks the cracks move at a speed of more than 3000 miles.

Due to gravitational effect you weigh slightly less when the moon is directly overhead.

If you yelled for 8 years 7 months and 6 days you would have produced just enough sound energy to heat one cup of coffee

Many physicists believe that worm holes exist all around us but they are smaller than atoms.

101 Physics Facts

Mechanics

1. Weight (force of gravity) decreases as you move away from the earth by distance squared.

2. Mass and inertia are the same thing.

3. Constant velocity and zero velocity means the net force is zero and acceleration is zero.

4. Weight (in newtons) is mass x acceleration (w = mg). Mass is not weight!

5. Velocity, displacement [s], momentum, force and acceleration are vectors.

6. Speed, distance [d], time, and energy (joules) are scalar quantities.

7. The slope of the velocity-time graph is acceleration.

8. At zero (0) degrees two vectors have a resultant equal to their sum. At 180 degrees two vectors have a resultant equal to their difference. From the difference to the sum is the total range of possible resultants.

9. Centripetal force and centripetal acceleration vectors are toward the center of the circle- while the velocity vector is tangent to the circle.

10. An unbalanced force (object not in equilibrium) must produce acceleration.

11. The slope of the distance-tine graph is velocity.

12. The equilibrant force is equal in magnitude but opposite in direction to the resultant vector.

13. Momentum is conserved in all collision systems.

14. Magnitude is a term use to state how large a vector quantity is.

Energy

15. Mechanical energy is the sum of the potential and kinetic energy.

16. Units: a = [m/sec^2], F = [kg•m/sec^2] (newton), work = pe= ke = [kg•m^2/sec^2] (joule)

17. An electron volt is an energy unit equal to 1.6×10^{-19} joules

18. Gravitational potential energy increases as height increases.

19. Kinetic energy changes only if velocity hanges.

20. Mechanical energy (pe + ke) does not change for a free falling mass or a swinging pendulum. (when ignoring air friction)

21. The units for power are [joules/sec] or the rate of change of energy.

Electricity

22. A coulomb is charge, an amp is current [coulomb/sec] and a volt is potential difference [joule/coulomb].

23. Short fat cold wires make the best conductors.

24. Electrons and protons have equal amounts of charge (1.6×10^{-19} coulombs each).

25. Adding a resistor in parallel decreases the total resistance of a circuit.

26. Adding a resistor in series increases the total resistance of a circuit.

27. All resistors in series have equal current (I).

28. All resistors in parallel have equal voltage (V).

29. If two charged spheres touch each other add the charges and divide by two to find the final charge on each sphere.

30. Insulators contain no free electrons.

31. Ionized gases conduct electric current using positive ions, negative ions and electrons.

32. Electric fields all point in the direction of the force on a positive test charge.

33. Electric fields between two parallel plates are uniform in strength except at the edges.

34. Millikan determined the charge on a single electron using his famous oil-drop experiment.

35. All charge changes result from the movement of electrons not protons (an object becomes positive by losing electrons)

Magnetism

36. The direction of a magnetic field is defined by the direction a compass needle points.

37. Magnetic fields point from the north to the south outside the magnet and south to north inside the magnet.

38. Magnetic flux is measured in webers.

39. Left hands are for negative charges and right hands are for positive charges.

40. The first hand rule deals with the B-field around a current bearing wire, the third hand rule looks at the force on charges moving in a B-field, and the second hand rule is redundant.

41. Solenoids are stronger with more current or more wire turns or adding a soft iron core.

Wave Phenomena

42. Sound waves are longitudinal and mechanical.

43. Light slows down, bends toward the normal and has a shorter wavelength when it enters a higher (n) value medium.

44. All angles in wave theory problems are measured to the normal.

45. Blue light has more energy. A shorter wavelength and a higher frequency than red light (remember- ROYGBIV).

46. The electromagnetic spectrum (radio, infrared, visible. Ultraviolet x-ray and gamma) are listed lowest energy to highest.

47. A prism produces a rainbow from white light by dispersion (red bends the least because it slows the least).

48. Light wave are transverse (they can be polarized).

49. The speed of all types of electromagnetic waves is 3.0 x 108 m/sec in a vacuum.

50. The amplitude of a sound wave determines its energy.

51. Constructive interference occurs when two waves are zero (0) degrees out of phase or a whole number of wavelengths (360 degrees.) out of phase.

52. At the critical angle a wave will be refracted to 90 degrees.

53. According to the Doppler effect a wave source moving toward you will generate waves with a shorter wavelength and higher frequency.

54. Double slit diffraction works because of diffraction and interference.

55. Single slit diffraction produces a much wider central maximum than double slit.

56. Diffuse reflection occurs from dull surfaces while regular reflection occurs from mirror type surfaces.

57. As the frequency of a wave increases its energy increases and its wavelength decreases.

58. Transverse wave particles vibrate back and forth perpendicular to the wave direction.

59. Wave behavior is proven by diffraction, interference and the polarization of light.

60. Shorter waves with higher frequencies have shorter periods.

61. Radiowaves are electromagnetic and travel at the speed of light (c).

62. Monochromatic light has one frequency.

63. Coherent light waves are all in phase.

Geometric Optics

64. Real images are always inverted.

65. Virtual images are always upright.

66. Diverging lens (concave) produce only small virtual images.

67. Light rays bend away from the normal as they gain speed and a longer wavelength by entering a slower (n) medium {frequency remains constant}.

68. The focal length of a converging lens (convex) is shorter with a higher (n) value lens or if blue light replaces red.

Modern Physics

69. The particle behavior of light is proven by the photoelectric effect.

70. A photon is a particle of light {wave packet}.

71. Large objects have very short wavelengths when moving and thus can not be observed behaving as a wave. (DeBroglie Waves)

72. All electromagnetic waves originate from accelerating charged particles.

73. The frequency of a light wave determines its energy ($E = hf$).

74. The lowest energy state of a atom is called the ground state.

75. Increasing light frequency increases the kinetic energy of the emitted photo-electrons.

76. As the threshold frequency increase for a photo-cell (photo emissive material) the work function also increases.

77. Increasing light intensity increases the number of emitted photo-electrons but not their KE.

Internal Energy

78. Internal energy is the sum of temperature (ke) and phase (pe) conditions.

79. Steam and liquid water molecules at 100 degrees have equal kinetic energies.

80. Degrees Kelvin (absolute temp.) Is equal to zero (0) degrees Celsius.

81. Temperature measures the average kinetic energy of the molecules.

82. Phase changes are due to potential energy changes.

83. Internal energy always flows from an object at higher temperature to one of lower temperature.

Nuclear Physics

84. Alpha particles are the same as helium nuclei and have the symbol .

85. The atomic number is equal to the number of protons (2 for alpha)

86. Deuterium () is an isotope of hydrogen ()

87. The number of nucleons is equal to protons + neutrons (4 for alpha)

88. Only charged particles can be accelerated in a particle accelerator such as a cyclotron or Van Der Graaf generator.

89. Natural radiation is alpha (), beta () and gamma (high energy x-rays)

90. A loss of a beta particle results in an increase in atomic number.

91. All nuclei weigh less than their parts. This mass defect is converted into binding energy. ($E=mc^2$)

92. Isotopes have different neutron numbers and atomic masses but the same number of protons (atomic numbers).

93. Geiger counters, photographic plates, cloud and bubble chambers are all used to detect or observe radiation.

94. Rutherford discovered the positive nucleus using his famous gold-foil experiment.

95. Fusion requires that hydrogen be combined to make helium.

96. Fission requires that a neutron causes uranium to be split into middle size atoms and produce extra neutrons.

97. Radioactive half-lives can not be changed by heat or pressure.

98. One AMU of mass is equal to 931 meV of energy ($E = mc^2$).

99. Nuclear forces are strong and short ranged.

General

100. The most important formulas in the physics regents are:

101. Physics is fun. (Honest!)

Solar Cycles

There are two major cycles related to the Sun known as solar cycles. They are:

* Sunspot Cycle, and
* Possible Long-Term Cycle

Sunspot Cycle

When the Sun is observed using the appropriate filtration, the most immediately visible features are usually its sunspots, which are well-defined areas on the surface that appear darker than their surroundings because of lower temperatures. Sunspots are regions of intense magnetic activity where convection is inhibited by strong magnetic fields, reducing energy transport from the hot interior to the surface. The magnetic field causes strong heating in the corona, forming active regions that are the source of intense solar flares and coronal mass ejection. The largest sunspots can be thousands of kilometres across.

The number of sunspots visible on the Sun is not constant, but varies over an eleven-year cycle known as the solar cycle. At a typical solar minimum, only a few sunspots are visible and occasionally one at all can be seen. Those that do appear are at higher solar latitudes. As the sunspot cycle progresses, the number of sunspots increases and they move closer to the equator of the Sun, a phenomenon described by Sporer's Law. Sunspots usually exist as pairs with opposite magnetic polarity. The magnetic polarity of the leading sunspot alternates every solar cycle, so that it is a North magnetic pole during one cycle and a South magnetic pole during the next.

The solar cycle has a great influence on space weather, and is a significant influence on the Earth's climate since luminosity has a direct relationship with magnetic activity. Solar activity minima tend to be correlated with colder temperatures, and longer-than-average solar cycles tend to be connected with hotter temperatures. In the 17th Century, the solar cycle appears to have stopped entirely for several decades; very few sunspots were observed during this period. During this era, known as the Maunder Minimum or the Little Ice Age, Europe experienced very cold temperatures. Earlier extended minima have been discovered through the analysis of tree rings and appear to have coincided with lower-than-average global temperatures.

Possible Long-Term Cycle

A recent theory claims that there are magnetic instabilities in the core of the Sun that cause fluctuations with periods of either 41,000 or 100,000 years. These could provide a better explanationfor the Ice Ages than the Milankovitch Cycles.

Padma Priya L., Sandra Jennifer T., Infant Sharmila P.

Solar Neutrino Problem - Introduction to Neutron Oscillation

The solar neutrino problem was a major discrepancy between measurements of the numbers of neutrinos flowing through the Earth and theoretical models of the solar interior, lasting from the mid-1960s to about 2002. The discrepancy has since been resolved by new understanding of neutrino physics, requiring a modification of the Standard Model of particle physics – specifically, neutrino oscillation. Essentially, as neutrinos have mass, they can change from the type that had been expected to be produced in the Sun's interior into two types that would not be caught by the detectors in use at the time.

The Problem

The Sun is a natural nuclear fusion reactor, powered by a proton–proton chain reaction which converts four hydrogen nuclei (protons) into helium, neutrinos and energy. The excess energy is released as gamma rays and as kinetic energy of the particles, including the neutrinos — which travel from the Sun's core to Earth without any appreciable absorption by the Sun's outer layers. As neutrino detectors became sensitive enough to measure the flow of neutrinos from the Sun, it became clear that the number detected was lower than that predicted by models of the solar interior. In various experiments, the number of detected neutrinos was between one third and one half of the predicted number. This came to be known as the solar neutrino problem

Attempts to Solve the Problem

Early attempts to explain the discrepancy proposed that the models of the Sun were wrong, i.e. the temperature and pressure in the interior of the Sun were substantially different from what was believed. For example, since neutrinos measure the amount of current nuclear fusion, it was suggested that the nuclear processes in the core of the Sun might have temporarily shut down. Since it takes thousands of years for heat energy to move from the core to the surface of the Sun, this would not immediately be apparent. Detailed observations of the neutrino spectrum from the more advanced neutrino observatories also produced results which no adjustment of the solar model could accommodate. In effect, overall lower neutrino flux which the Homestake experiment results found required a reduction in the solar core temperature. However, details in the energy spectrum of the neutrinos required a higher core temperature. This happens because different energy neutrinos are produced by different nuclear reactions, whose rates have different dependence upon the temperature; in order to match parts of the neutrino spectrum a higher temperature is needed. An exhaustive analysis of alternatives found that no combination of adjustments of the solar model was capable of producing the observed neutrino energy spectrum, and all adjustments that could be made to the model worsened some aspect of the discrepancies.

Currently, the solar neutrino problem is assumed to have resulted from an inadequate understanding of the properties of neutrinos. According to the Standard Model of particle physics, there are three different kinds of neutrinos: electron neutrinos (which are the ones produced in the Sun and the ones detected by the above-mentioned experiments, in particular the chlorine-detector Homestake Mine experiment), muon neutrinos, and tau neutrinos. In the 1970s, it was widely believed that neutrinos were mass less and their types were invariant. However, in 1968 Pontecorvo proposed that if neutrinos had mass, then they could change from one type to another. Thus, the "missing" solar neutrinos could be electron neutrinos which changed into other types along the way to Earth and therefore escaped detection.

Mass of the Neutrino Becomes the Solution to the Problem

The supernova 1987A produced an indication that neutrinos might have mass, because of the difference in time of arrival of the neutrinos detected at Kamiokande and IMB However, because very few neutrino events were detected it was difficult to draw any conclusions with certainty. In addition, whether neutrinos have mass or not could have been more definitively established had Kamiokande and IMB both had high precision timers which would have recorded how long it took the neutrino burst to travel through the Earth thereby establishing if neutrinos travel at the speed of light which would be the case if they were mass less or slightly under the speed of light which would be the case if they had mass. However because the detectors were not intended for supernova neutrino detection, this was not done. The first strong evidence for neutrino oscillation came in from the Super-Kamiokande collaboration in Japan. It produced observations consistent with muon-neutrinos (produced in the upper atmosphere by cosmic rays) changing into tau-neutrinos. What was proved was that fewer neutrinos were detected coming through the Earth than could be detected coming directly above the detector. Not only that, their observations only concerned muon neutrinos coming from the interaction of cosmic rays with the Earth's atmosphere. No tau neutrinos were observed at Super-Kamiokande.The first direct evidence of solar neutrino oscillation came in 2001 from the Sudbury Neutrino Observatory (SNO) in Canada. It detected all types of neutrinos coming from the Sun and was able to distinguish between electron-neutrinos and the other two flavors. After extensive statistical analysis, it was found that about 35% of the arriving solar neutrinos are electron-neutrinos, with the others being muon- or tau-neutrinos .The total number of detected neutrinos agrees quite well with the earlier predictions from nuclear physics, based on the fusion reactions inside the Sun.

The crux of the solar neutrino problem, and its resolution, lies in the fact that both the interior of the Sun and the behavior of traveling neutrinos are unknown to begin with. One may assume knowledge of one and determine the other by experiment here on Earth. If we assume that the Standard Solar Model is valid, we can derive the propagation properties of neutrinos, such as neutrino oscillations, given the data from solar neutrino experiment.

ASHWINI.G

The Density of Death

Death enters the Physics Laboratory
Meanders past the magnets' poles
Wires coil on spools and rolls
The slide projector stops its story

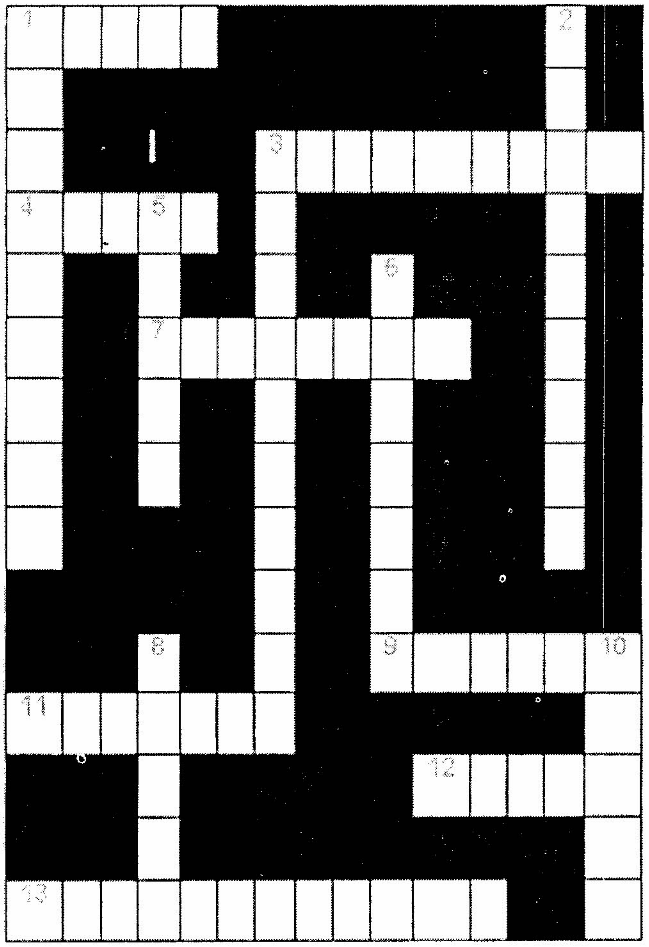
Darkness diffracts through sharp-edged prisms
Sweeps across oscilloscopes
Blackens textbooks' indexed hopes
And silences their catechisms.

An airless breeze turns super cool
As volt-ohmmeter's needle dips
The teeth of the alligator clips
Are clenched unopening and cruel.

Not vacuum tubes hold their breath
Nor manual for engineers
Erase from blackboards of our fears
The chalky fingerprints of death.

- **Vigneshwari. G,**

Crossword



Clues

Down

1. The discoverer of radioactivity (9)

2. When a quantity varies regularly with time between two extremes, passing through an equilibrium point once per cycle, it is said to _____ (9)

3. The first scientist to receive two Nobel Prizes (10)

5. Waves with wavelength greater than 1mm (5)

6. The force experienced by a charged particle moving in a magnetic field (7)

8. Light amplification by stimulated emission of radiation (5)

10. Unwanted signal obtained during measurement due to random fluctuations in the environment or in the instrument (5)

Across

1. A type of subatomic particle named after an Indian scientist (5)

3. The branch of physics concerned with the behaviour of physical bodies when subjected to forces or displacements (9)

4. The constituents of hadrons (5)

7. One of the scientists who discovered electron diffraction (8)

9. An effect involving the splitting of spectral lines in the presence of a magnetic field (6)

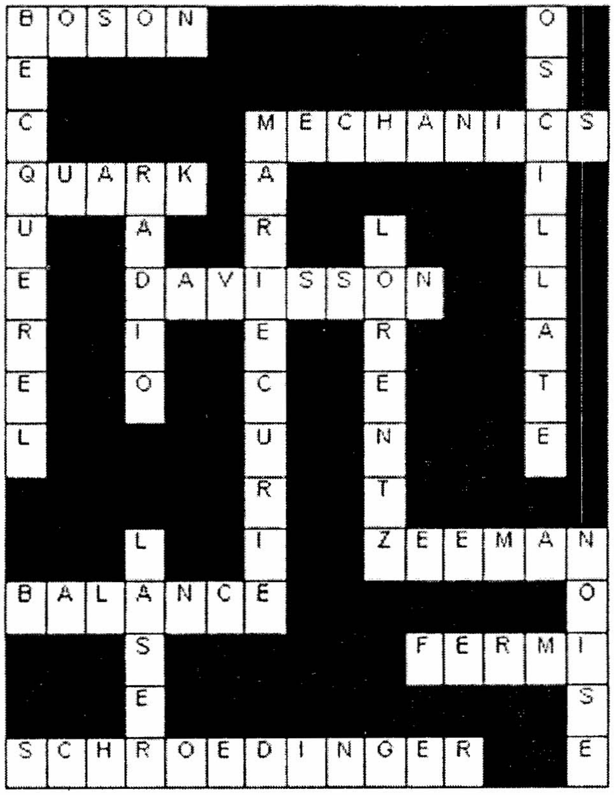
11. An instrument used to measure weight (7)

12. The scientist who developed the first nuclear reactor (5)

13. The equation used to determine the probability of finding a particle in a region of space (12)

See reverse for solution

Crossword Puzzle Solution



For 13 both "Schroedinger" and "Schrodingers" are acceptable.

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91 - 180 days	5.25	5.25
181 - 270 days	5.75	5.75
271 - 364 days	6.25	6.25
1 year - less than 2 years	**7.25**	**8.00**
2 years - less than 3 years	7.25	8.00
3 years - upto 5 years	7.75	8.50
5 years and above	7.00	7.75

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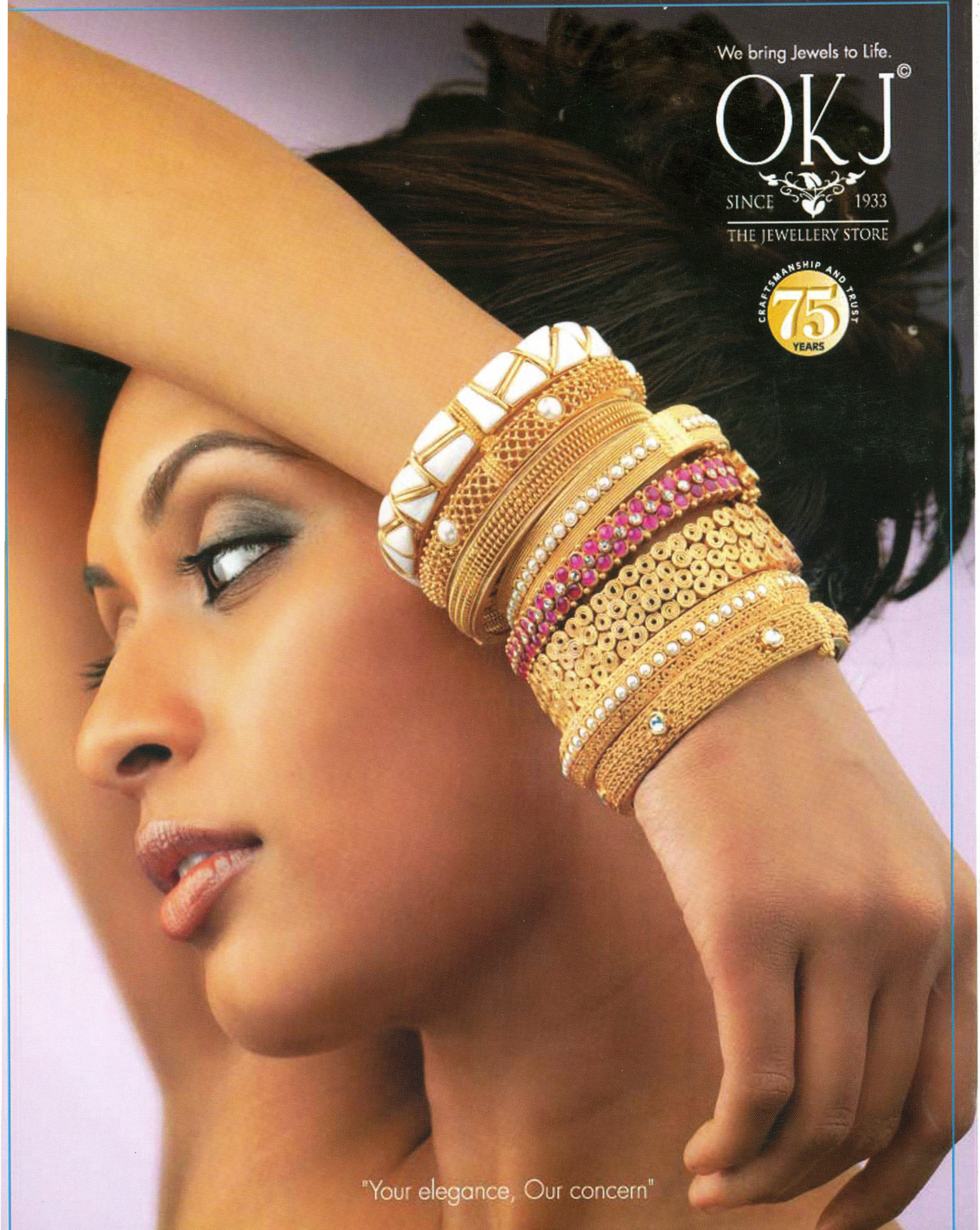
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