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Monthly Newsletter of Vigyan Prasar

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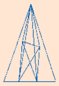
VP News

Inside



VIPNET Orientation Programme-cum-Workshops on "Innovative Physics Experiments" in Punjab and Madhya Pradesh

Vigyan Prasar and Punjab State Council for Science and Technology (PSCST), Chandigarh jointly organized a two-day orientation-cum-training programme for the teachers and science communicators of Punjab State on 26-27 October 2006. The objective of the workshop was to initiate the process of formation of science clubs in the state and familiarize the schools, voluntary organizations about the programmes and activities of VP in general and VIPNET in particular. Along with the orientation programme, a workshop on Innovate Physics Experiments was also conducted. About 76 teachers from Ludhiana, Muktsar, Kapurthala, Gurdapur, Mohali, Amritsar, Patiala, Bathinda, Moga, Ropar, and Ambala districts of Punjab attended the workshop, which was inaugurated by Dr. N.S. Tiwana, Executive Director, PSCST.

Workshop cum orientation programme in Chandigarh is in progress

Dr Mukesh Roy, Associate Professor, IIITM, Jabalpur (M.P.) was the main resource person for conducting the workshop on Innovative Physics Experiments. About 100 experiments relating to magnetisms,

Contd. on page 19

Training and Capacity building programmes using EduSAT Network

Vigyan Prasar has established a satellite communication network using the EduSAT for science communication and disaster preparedness. In the first phase, 20 centres have been set up all over the country under Vigyan Prasar EduSat Network. Since January 2006 Vigyan Prasar has been using the network for science communication activities. In the initial phase most of the activities were limited to lectures or talks by experts. However, with a view to utilise the full potential of the satellite network innovatively, capacity building programmes are being experimented since October 2006.

With Mr Sanjay Kapoor (Diksha), Mr Taiyab Hussain (BGVS) and Ms Irfana Begum, a science toys workshop was held on 26 and 27 October 2006. While the trainers demonstrated making of the toys from the teaching end located at New

Contd. on page 19

... think scientifically, act scientifically... think scientifically, act scientifically... think scientifically, act...

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Editor : Dr. V.B. Kamble

Already Hot and Getting Hotter

The Earth has been either very hot or very cold during most of its history. Of course, this is true as far as the human beings are concerned. Some fifty million years ago, there was no ice on the poles. Eighteen thousand years ago, there was ice nearly three kilometres thick in parts of Europe. As a result of the huge size of the ice sheets, the sea level was 130 metres lower. Studies show that in some parts of the world, swift dramatic changes took place around that time and temperatures rose by nearly 20^0 C in a short period of ten years causing wild fluctuations. About ten thousand years ago, the climate settled down to the fragrant, mild and soothing state that we have enjoyed since then. Well, it was around this time that human beings began to progress.

What is it that warms our planet, anyway? Radiation from the Sun passes through the atmosphere and is absorbed by the Earth's surface. A part of the heat absorbed by the Earth is then emitted back to the atmosphere. Gases like water vapour (H_2O), carbon dioxide (CO_2), methane (CH_4), Nitrous oxide (N_2O), and a few other gases trap that heat which would otherwise be released into space, thereby raising the temperature of the atmosphere; and subsequently that of the Earth's surface. This naturally occurring process in the Earth's atmosphere is called the greenhouse effect that warms our planet and maintains a pleasant average temperature of about 33^0 C at the Earth's surface.

The stability of the naturally occurring greenhouse effect is now threatened by the human-made greenhouse gases. Increase in the concentration of gases like CO_2 increases the amount of heat trapped by the atmosphere causing global warming and the change in the climatic pattern. During the past 20 years, about three-quarters of human-made CO_2 emissions were from burning fossil fuels. While the natural processes can absorb only *some* of the net 6.1 billion metric tons of human-made carbon dioxide emissions produced by burning of fossil fuel each year, an estimated 3.2 billion metric tons is *added* to the atmosphere each year. Further, of all the greenhouse gases, the single most important gas is CO_2 which accounts for about 62 % of the increase in the Earth's greenhouse effect. Methane is a natural byproduct of decomposition; however, significant quantities are also produced via agriculture, animal husbandry, and by fossil fuel production.

True, the world's climate has not much changed since the industrial revolution. Over the past 100 years, the average global temperature has gone up by about 0.6^0 C. What then is this great fuss about global warming and the climate change? Well, this increase is *primarily* due to the human-made greenhouse gases. Levels of CO_2 have increased from around 280 parts per million (ppm) to around 380 ppm now. Studies of ice core show that concentrations of CO_2 have not been so high for nearly half a million years. At the current rate of increase, they will have reached 800 ppm by the end of the 21st century! Beyond 550 ppm it would not be liveable! CO_2 being emitted stays in the atmosphere for up to 200 years, and hence getting those concentrations down will take a long time.

Incidentally, 2005 was the warmest year on record since the end of the last major ice age nearly 12,000 years ago. Indeed, this is a sobering thought for an energy-hungry planet and hence deserves serious attention from both policymakers and citizens. A further rise in temperatures by 1^0C will equal the maximum level experienced in a million years. In its 2001 Report, the Intergovernmental Panel on Climate Change (IPCC) predicted that global temperatures would rise by 1.4^0 C - 5.8^0 C over the next 100 years, including a 2.7^0 C - 4.3^0 C increase over India by the 2080s. Anything much higher than that could lead to catastrophic results.

What could be the possible effects of climate change on us? A warmer world would be extremely harsh on biodiversity. Species in natural ecosystems may attempt to migrate with the changing climate, but may differ in their degree of success. Increases in temperature and changes in rainfall may have significant impacts on water resources, either reducing or increasing water availability. Coastal areas may experience additional sea-level rise that may interact with coastal storms to erode beaches, inundate land, and damage structures. Rise in sea levels could threaten coastal mangroves and wetland systems. Droughts, heavy rains, flash floods, tornadoes, cyclones and forest fires, could become more common. Changing rainfall patterns could also severely affect food security. Climate change could threaten human health - water and vector borne diseases. Cholera, typhoid, malaria and dengue could become more wide spread and virulent.

Already we have started experiencing the heat. The profound impact rising temperatures have had on the melting of Arctic ice provides a window into a future we may all experience. Glaciers in the Himalayas are retreating at an average rate of 15 metres per year since1970s. It is estimated that already some 1,700 species of plants, animals, and insects have moved towards the poles at a measurable rate each year in the second half of the 20th

Contd. on page... 19

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Jean Baptiste Joseph Fourier

The French Mathematician and Physicist

❑ **Subodh Mahanti**
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"The profound study of nature is the most fertile source of mathematical discoveries."
Jean Baptiste Joseph Fourier (Quoted in M Kline, *Mathematical Thought from Ancient to Modern Times* (New York, 1972)

"His (Fourier's) work continues to be extremely important in many areas of mathematical physics, but it has also been developed and generalized to yield a whole new branch of mathematical analysis, namely, the theory of harmonic analysis."
A Dictionary of Scientists, Oxford University Press (1999)

"Fourier introduced the expansion of function of trigonometric series, now known as Fourier series, which proposed that almost any function of a real variable can be expressed as the sum of the sines and cosines of integral multiples of the variable. This method has become an essential tool in mathematical physics and a major theme of analysis."
Chambers Biographical Dictionary (1997)

"Fourier series, Fourier integrals, Fourier transforms—you see them wherever you turn, whether in physics or chemistry or electrical or communication engineering. It is amazing that Fourier's mathematical idea—born in the course of solving the problem of heat conduction—has been so successful and applies to so many practical situations."
N. Mukanda in *Resonance* (October 1998)

Victor Hugo wrote in *Les Miserables*: "There was a celebrated Fourier at the Academy of Sciences, whom posterity has forgotten; and in some garret an obscure Fourier, whom the future will recall." Hugo's Fourier in a garret was Charles Fourier (1772-1837), the French social philosopher. As we know today the 'celebrated Fourier's posterity cannot afford to forget him. Fourier's ideas were to influence to a great degree the mathematics of the nineteenth and twentieth centuries.

Fourier's fame rests on his much celebrated work, *Theorie analytique de la Chaleur.* The monograph, which was published in 1822, contained a mathematical treatment of the theory of heat. In this monograph, he developed the partial differential equation governing heat diffusion. He solved the equation by using infinite series of trigonometric functions. Such series of trigonometric series were used earlier also. However, Fourier investigated them more thoroughly.


Jean Baptiste Joseph Fourier

He made important contributions to probability theory, statistics, and mechanics. Perhaps it is not a well-known fact that some of the ideas of the modern theories of optimization and linear programming (a fundamental topic in the development of the computational sciences) date back to Fourier. Fourier also worked on musical sounds. He demonstrated that all musical sounds having three components – pitch, loudness, and quality – can be described by mathematical expression. Fourier's work on musical sounds paved the way for others to represent musical scores graphically. Undoubtedly Fourier was one of the greatest mathematical analysts of his time. He said the following about mathematical analysis: "…mathematical analysis is an extensive as nature itself…This difficult science grows slowly but once ground has been gained it is never relinquished. It grows, without ceasing, in size and strength, amid the constant error and confusion of the human spirit…it follows the same path when applied to all phenomena and interprets them all in the same language as if to attest to the unity and simplicity of the design of the universe and to make still more evident that unchanging order which presides over all natural laws." [Quoted by Alladi Sitaram in *Resonance* (October 1998) from *Fourier Analysis* by T. W. Korner, Cambridge University Press, 1988]

Jean Baptiste Joseph Fourier was born on 21 March 1768 in Auxerre, France. His father was a tailor. Joseph's mother died when he was nine years old and his father died the following year. He had eleven brothers and sisters. He started his school education in the local Benedectine School in his hometown. In 1780 he went to study at the École Royale Militaire of Auxerre. Since his school days he displayed his talents and interest in mathematics. He completed the study of the six volumes of the French mathematician Etienne Bezout's (1730-1783) *Cours de mathematiques* at the age of 14. In 1783, he won the first prize for his study of the French mathematician Charles Bossut's (1730-1814) *Mechanique en general*. Bossut was famed for his textbooks, which were widely used throughout France.


Etienne Bezout

In his childhood Fourier perhaps never dreamed of becoming a mathematician. He wanted to join the army. He could not do so because of his lowly family background (as judged by the customs of those days). When he failed to join the army, he decided to enter the church. He thus went to the abbey at St. Benoit-sur-Loire for making himself ready to take the vows necessary for becoming a member of the church. He entered the abbey in 1787. While making himself ready for taking the vows, he taught mathematics to his fellow novices. By the time Fourier became ready for taking the vows, an order from the Constituent Assembly stopped taking holy orders throughout France. We do not know whether Fourier was really disappointed for not being able to take the vows. He came back to work at the École Royale Militaire as an assistant to his old mathematics teacher Bonard. Later he moved to the College Nationale in Auxerre. This was the time when the French revolution started, which very much influenced the life and career of Fourier. Thus David A Keston writes: "The life of Baron Jean Baptiste Joseph Fourier, the mathematical physicist, has to be seen in the context of the French Revolution and its reverberations. One might say his career followed the peaks and troughs of the political wave." For the first four years of the Revolution, Fourier stayed in Auxerre. Like many other young men of high ideals Fourier could not keep himself away from the Revolution. However, when the revolution brought in the reign of terror, Fourier tried to resist it by whatever way he could.


Lazare Carnot

When the Revolution was in progress in France, a war between France and England was declared on 1 February 1793. This was seen as the inevitable end of the trade war that was raging between the two countries. The declaration of the war changed the call to revolution to a call to arms. Lazare Carnot (1753-1823), the French statesman and mathematician, proposed enlisting people en masse for the war. Fourier supported the idea advanced by Carnot but he thought people enlisted for the war should be true volunteers. He expressed his ideas on the subject while addressing the members of the Popular Society in Auxerre. The members of the Popular Society were very much impressed by the eloquence of Fourier and so he was invited to join the Society. He was entrusted the responsibility of organizing the levee in the region. He was also elected to the committee of surveillance, which was later used as a secret police force. Besides he carried out a number of missions of importance. While carrying out one of these missions, he found himself in deep trouble. There were many factions and crosscurrents in the revolution. Fourier was imprisoned and he was released only after the leading French revolutionary Maximilien Robespierre was beheaded.

After his release from the prison, Fourier was nominated for getting trained as a teacher at the newly established college, the École Normale. The college was specially founded to train teachers in France. This is mostly because the Reign of Terror beheaded many would-be teachers and so there was an acute shortage of trained teachers. Incidentally, it might be interesting to know about the guidelines set at that time to be observed by lecturers or trainers of the newly established college because they would be as relevant today. The lecturers or trainers of the college were to observe the following guidelines: i) lectures to be delivered while standing; ii) while giving lectures no notes previously prepared could be used; iii) whenever there was a question from any of the students during a lecture, it was to be addressed immediately by interrupting the lecture; and iv) only an active researcher in the field could be selected for teaching in the college.


Charles Bossut

Fourier joined the École Normale in January 1795. He was certainly one of the best students at the college. Among his teachers were some of the most accomplished French mathematicians namely, Joseph Louis Lagrange (1736-1813), Pierre Simon Laplace (1749-1827) and Gaspard Monge (1746-1818). However, his trouble for his association with revolutionary activities was not over. He was rearrested in September 1795. In France of those days, getting arrested for a second time meant a serious affair. There was hardly any chance of escaping the guillotine. In fact, Fourier himself later wrote that he seriously thought that

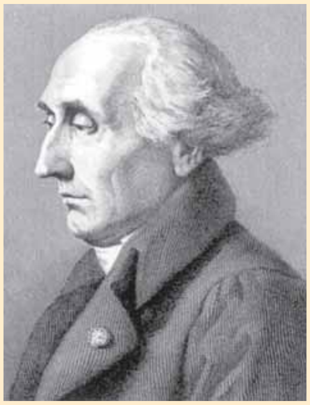

Pierre Simon Laplace

he would be killed. But luck again favoured him and he was released. After coming out of the prison for the second time he joined the École Centrale des Travaux Publiques (which was later renamed as École Polytechnique) as a mathematics teacher. In getting this job he was helped by his contacts made at the École Normales. St the time of Fourier's joining to the École Centrale, the college was run under the direction of Lazare Carnot and Monge. Fourier started teaching at the École Normale on 1 September 1795. In 1797, he succeeded his teacher Lagrange as Professor of Analysis and Mechanics.

In 1798, Napoleon invaded Egypt. Fourier accompanied Napoleon in the campaign, as one of the member of the entourage of 165 scientific and literary intelligentsia or the so-called the Legion of Culture. Fourier contributed to and oversaw the publication of the *Description de l'Egypte* (1808-25), a massive compilation of the cultural and scientific materials brought back from the expedition. The French occupation of Egypt was not long lasting. Napoleon returned to Paris in 1799. Fourier came back to France in 1801 and resumed his duties at the École Polytechnique. He was happy at the college teachings and doing research in mathematics. But very soon he had to leave his academic assignment for taking up administrative duties. Napoleon was in total control of France by the time Fourier returned from Egypt. Napoleon wrote to him: "...the Prefect of the Department of Isere having recently died, I would like to express my confidence in citizen Fourier by appointing him to this place." Fourier was not very much interested in taking up administrative responsibilities, but he had hardly any choice. Certainly he could not refuse Napoleon. The administrative headquarters were at Grenoble. As a Prefect, Fourier was both a public figure and a governor. Two of his most important achievements as Administrator of Isere were overseeing the operation of draining of a large area of marshland at Burgoin and supervising the construction of a new highway from Grenoble to Turin. He also organized the visits of the King of Spain and Pope Pius VII and Napoleon to the region.


Gaspard Monge

Fourier's work continues to be extremely important in many areas of mathematical physics. N. Mukanda, a well-known Indian physicist, in his Editorial in *Resonance* (October 1998) has beautifully summed up the importance of his work to mathematical physics: "Turning to physics, we all know how much Fourier's methods are used in wave propagation problems, classical electromagnetic theory, diffraction theory and problems of signal processing and communication. But the deepest of all is in quantum mechanics: how could Fourier have guessed that a century after his time, physics would find that the position and the momentum of a particle are mutually complementary, cannot be simultaneously measured, and obey an uncertainty principle because they are Fourier conjugate to one another? And the same for energy and time? Behind the formulae of Planck, Einstein and de Broglie linking the particle and wave aspects of matter and radiation lies the magic of Fourier! One cannot avoid the eerie feeling that Nature knew Fourier theory all along!"


Joseph Louis Lagrange

Fourier was made a chevalier in Napoleon's Légion d'Honneur in 1804 and in 1809 he was made a baron. Fourier was elected permanent mathematical secretary of the French Academy of Sciences in 1822.

Fourier died in Paris on 16 May 1830.

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(This article is a popular compilation of the important points on the life and work of Jean Baptiste Joseph Fourier available in the existing literature. The idea is to inspire the younger generation to know more about Fourier. The author has given the sources consulted for writing the article, However, the sources on the internet are numerous and so they have not been individually listed. The author is grateful to all those authors whose works have contributed to writing this article.)

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Measure of the Universe

❑ **Prof. K.D. Abhyankar**

Introduction

There is story in the Puranas, according to which, Brahma and Vishnu went in opposite directions to find out the extent of Shiva, but they found him to be limitless in either direction. In the present scientific era, physicists are engaged in probing the mysteries of the tiniest sub nuclear particles ($<10^{-14}$ m) at one extreme, and astronomers are busy in measuring the extent of the whole universe ($>10^{23}$ m) on the other. Although they have not reached the ultimate limits on either side as yet, there has been a considerable addition to our knowledge of nature due to their efforts. These branches of science are generally incomprehensible to laymen due to their mathematical complexity. Common people might even suspect that the scientists are trying to fool them by some wizardry. But it is a fact that the scientists use the daily tested principles only in a logical manner for unraveling the mysteries of nature. It is the aim of this article to show how astronomers are able to measure vast distances with a step-by-step approach. We are surprised when we hear statements like, 'Einstein could measure the size and mass of the whole universe'. It is hoped that the reader will able to satisfy his/her curiosity in this respect to some extent, and he/she would appreciate the power of the scientific method.

We can easily determine the sizes of the objects in daily use with an ordinary measuring scale. Bigger entities, like the plots of land or farms, can be measured with the surveyor's chain. So also the sizes of the minute objects like the microbes can be gauged by observing them through a microscope. The tiniest particles like atoms cannot be seen even with an electron microscope, but their diameters can be measured indirectly by means of experiments performed in the laboratory. Similarly, the distances and sizes of the celestial objects like the planets, stars and galaxies, have to be determined without reaching them, indirectly by the method of remote sensing. Let us see how this is achieved.

Size of Earth

We are able to estimate the relative distances of the various objects that we see, because we possess two eyes placed some distance apart. A simple experiment can be performed to understand the principle of binocular vision. Keep one finger of your hand vertically straight in front of you, and look at it first by closing one eye, and then the other. The finger will appear to move against the background. The closer you bring the finger, the larger is its movement with respect to the background. This is known as *parallax,* which is used by our brain to know which object is closer and which is farther away.

A surveyor uses the same principle in the method of triangulation. Suppose he has to measure the width of a river, shown in Figure 1. What he does is to select two points A and B to form a baseline AB on the nearer bank. Then he looks at an object C, say a tree, on the opposite bank by using a theodolite (a surveying instrument for measuring horizontal and vertical angles, consisting of a small telescope mounted on a tripod). He measures angles CAB and CBA, as also the distance AB. Then, by using the trigonometric formulae, he can calculate the length of the perpendicular CD, which is the width of the river.

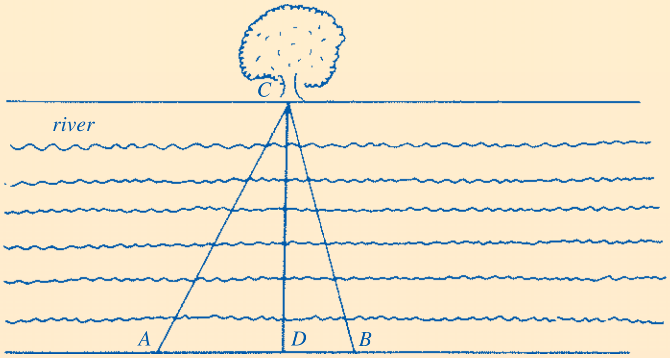

Fig 1 : Surveyor's method of measuring the width of a river

For a distant point like E in Figure 2, we have to take a longer baseline A′ B′ for better accuracy. In case it is not possible to increase the length of the baseline, we have to go in steps, first to points C and D from AB and then to E from CD. So, for very large distances, the method of triangulation will have to be repeated several times over by using intermediate points and stepping stones or bench-

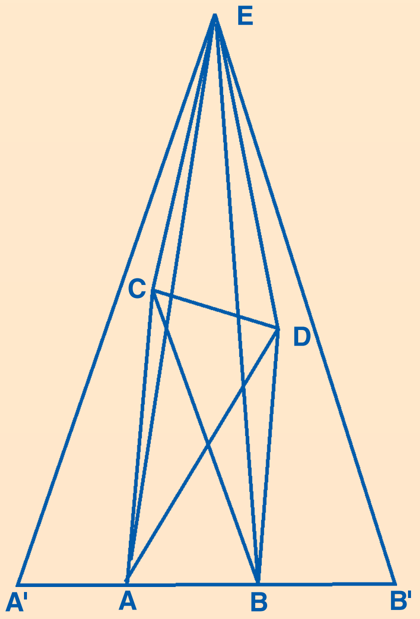

Fig 2 : Extension of the surveyor's method to a distant point marks. It is by this process that geologists have measured the circumference of the Earth. It is found that our Earth is almost spherical with a radius of 6,371 km. Actually, the Earth is slightly bulged at the equator due to its rotation, with a consequent flattening at the poles. The difference between the equatorial and polar radii of the Earth is just 26 km, which is quite small compared to its mean radius. With this knowledge, it is possible to calculate the distance between any two places on the surface of the globe.

Size of the Solar System

We can now extend the method of triangulation to extraterrestrial objects like the Moon and planets. For this, we choose two points E and F on the surface of the Earth, which lie on the same meridian as shown in Figure 3. Then the Moon will transit the common meridian at the same time. If we measure the position of the Moon M from E and F at the time of transit, it will be found that its position against the background of stars is different as seen from the two points. For example, if we look at the Moon from the two ends of the diameter of the Earth, it will appear to have been displaced by about two degrees. In other words the Moon shows a parallax. Measurement of the zenith angles Z_1EM and Z_2EM fixes the point M and the angle EMF, as well as the geocentric distance MG. As is well known, the Moon revolves round the Earth in an elliptical orbit; so the distance MG varies with time. The mean distance, however, comes out to be 384,404 km. This is now confirmed by the *radar echo technique.* Radar signals are sent to the Moon, and after reflection from its surface, they are detected by sensitive receivers. If the time taken for the to-and-fro journey is 2Δt, we get cΔt as the distance to the surface of the Moon, where c is the velocity of light. After allowing for the distance of the observer from the centre of the Earth and that of the reflecting surface from the centre of the Moon, we get the Earth-Moon distance MG. The radar echo method has been used for measuring the distances of the nearby planets Venus and Mercury.

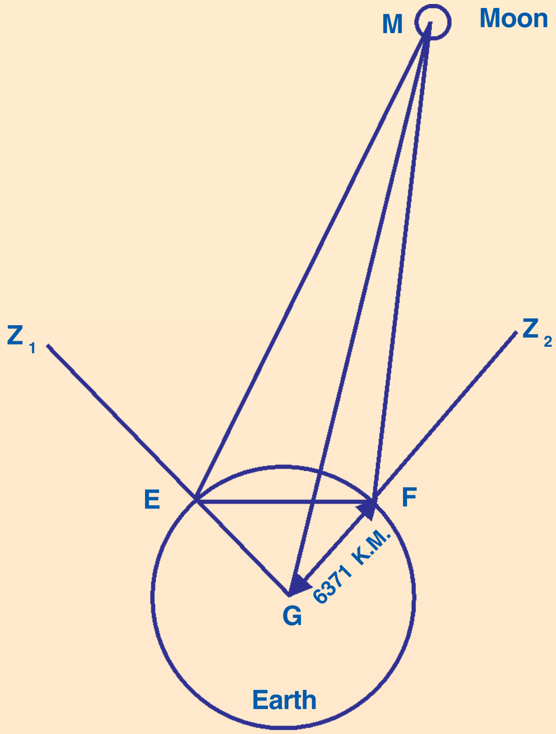

Fig 3 : Triangulation of the Moon

As far as the planets are concerned, their relative mean distances form the Sun are already known from Kepler's third law, $a^2 \infty P^2$, where a is the mean distance of the planet from the Sun and P its period of revolution as show in Figure 4. Hence, the relative distances between the various planets are known in terms of a standard distance such as the mean distance of the Earth from the Sun, which is called the 'astronomical unit'. So, we measure the parallax of any one planet at a given epoch for fixing the scale of the solar system. The planets show discs of appreciable size, which makes it difficult to measure their position among the stars accurately. Minor planets, i.e., the asteroids, are ideal for this purpose because they look almost like stars due to their small size, and hence it is easy to measure their position among the stars. That is why, long before the advent of radar, astronomers could organise a campaign for measuring the parallax of the minor planet Eros, when it came very close to the Earth in 1930. Its distance at the time was only 2.55×10^7 km, which was much less than the minimum distance of Venus amounting to 4.50×10^7 km. The Eros campaign gave for the mean distance of the Earth from the Sun, i.e., the astronomical unit (A.U.), a value of 1.496×10^8 km. This was later confirmed by the measurement of the distance of Venus by the radar echo technique.

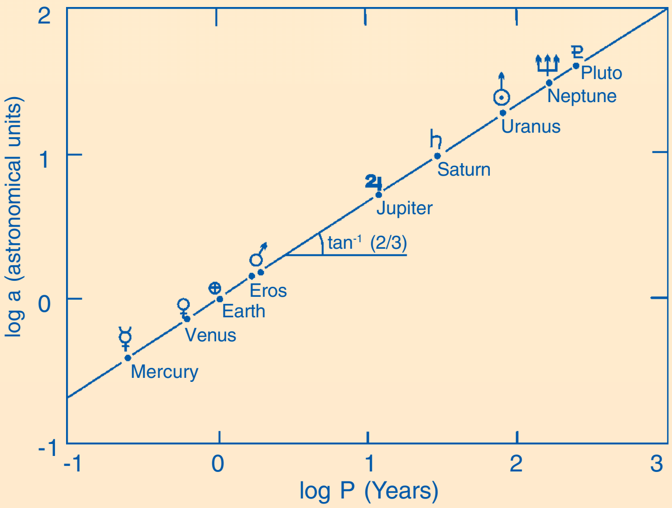

Fig 4 : Kepler's third law; semimajor axis a as a function of the period of revolution P

The Nearest Stars

The next step is to go beyond the solar system and measure the distances of stars. As the stars are much farther away one needs a longer baseline, which is provided by the diameter of the Earth's orbit. Within a period of six months, the Earth moves from one end P of its diameter to the other end Q as shown in Figure 5. If we observe a nearby star S with a telescope from P and Q, it will appear to have moved with respect to the more distant stars, as illustrated there. Its displacement will give us the angle PSQ = 2 p. Half of this angle, p, is known as the 'trigonometric parallax' of the star S. It is the angle subtended by the radius of the Earth's orbit (1 A.U.) at S.

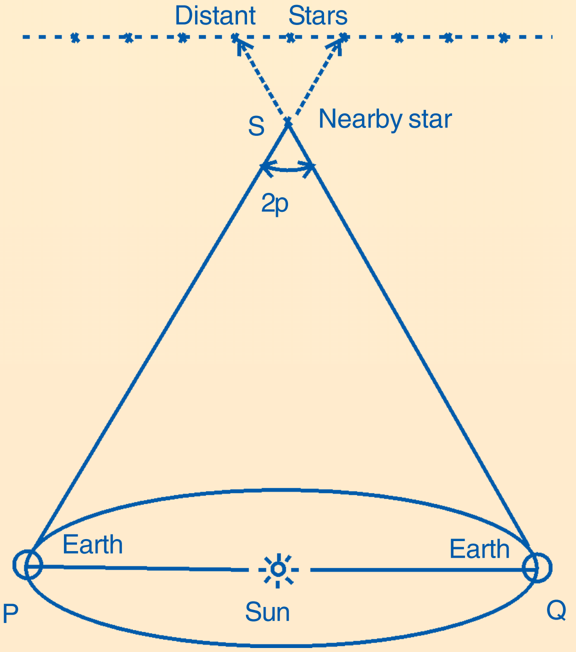

Fig 5 : Trigonometric parallax of a star

Even for the nearest star Alpha Centauri its value is found to be only 0″.75, or 3.64×10^{-6} radians. The smallness of this angle can be gauged by imagining how a 25-paise coin of one centimetre diameter would look when seen from a distance of seven kilometres. With the value of one A.U. given above, the distances of Alpha Centauri comes out to be 4.1×10^{13} km or 2.74×10^{5} A.U. As all the other stars are father than Alpha Centauri, their parallax is still smaller. That is why the parallax of not a single star was measured until 1838; and because of this, the famous Danish astronomer Tycho Brache did not believe that the Earth revolved round the Sun. However, now the motion of the Earth is an accepted fact, and parallaxes and distances are catalogued for more than 5,000 stars.

As the stars are quite far away one needs a new unit of distance much greater than the astronomical unit. Since the parallax p is inversely proportional to the distance r, its reciprocal (1/p) can be used to denote the distance. If we express p in seconds of arc its reciprocal gives the distance in parsecs (pc). Thus if p = 1 we say the distance is one parsec, if p = 0.5 the distance is two parsecs, and so on. It can be easily seen that one parsec is equal to 2.06×10^{5} A.U., i.e., 3.08×10^{13} km.

Another useful unit of distance is the light year (ly), which is the distance travelled by light in one year. It is equal to 9.46×10^{12} km, or about a third of a parsec. Thus the distance of Alpha Centauri is 1.33 pc or 4.33 ly. Similarly, the distance of Sirius (*Vyaadh*) is 2.7 pc or 8.8 ly, and that of Spica (*Chitra*) is 65 pc or 212 ly. Most of the naked-eye stars are situated at hundreds and thousands of light years distance. That is why they appear faint although some of them, like Betelgeuse, are intrinsically very much brighter than the Sun.

Use of Statistics

The trigonometric parallax cannot be measured more accurately than 0″.05, hence this method can take us up to a distance of 20 parsecs, or about 65 light years. Beyond this distance, even the diameter of the Earth's orbit is not adequately large as a baseline for measuring the parallax. At this distance, we have not yet covered even 0.01 per cent of the Milky Way which has a diameter of 100,000 light years, let alone the universe. Hence we have to use other methods, some of which are based on statistics. Here also, we make use of our daily experience.

Consider the boy at O in Figure 6, who is looking at the two motorcars each on one of the two parallel roads. If we assume that both the cars are moving with a speed of 60 km/h, it will appear to the boy that the car on the nearer road is moving faster than the one on the farther road. The reason is that, while the nearer car covers a larger angle ROS, the more distant car covers a smaller angle TOV. This angular motion is called the 'proper motion' of the car.

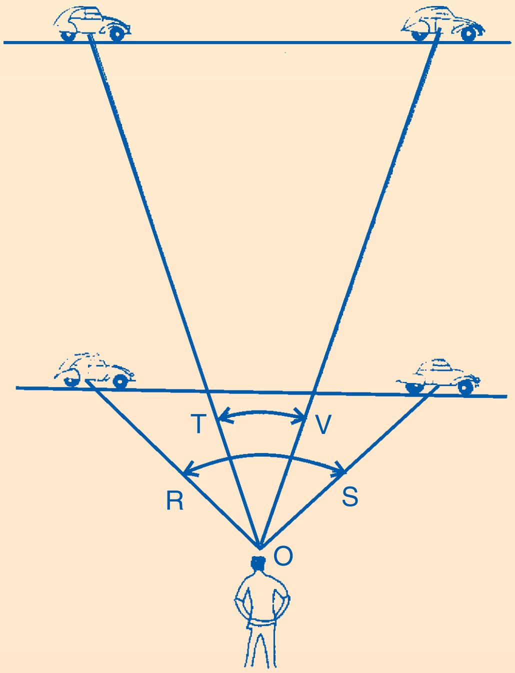

Fig 6 : The proper motion of an object

The larger the distance of the object, the smaller is its proper motion for the same transverse velocity. We have this experience while travelling in a train. The nearby trees and buildings move past us very fast, while those farther away appear to move backwards much more slowly.

We have seen earlier that we are also moving along with the Sun, which is moving towards the star Alpha Lyrae with a speed of 20 km/s. Consequently, all the stars appear to move in the opposite direction. As a result, the nearest stars have larger proper motions than those of the more distant stars. Hence, a measurement of proper motion can give us the distance of the star. The Sun covers a distance of 3 x 10^8 km in six months, which is equal to 2 A.U., and it covers a distance of 40 A.U. in ten years. So one has a fairly long baseline, which makes it easier to measure the proper motions as compared to the trigonometric parallax. In this way we can reach distances up to 2,000 parsecs or 6,500 light years. This method is particularly useful for a cluster of stars which move together, or for stars which have the same apparent brightness and colour and are thus at the same distance from us. It has given for the Hyades (*Rohinîshakata*) cluster a distance of 41 pc or 135 ly, and for the Pleiades (*Krittikâ*) cluster a distance of 126 pc or 410 ly.

There is another method of measuring distances of star clusters and galaxies. Its principle can be understood by looking at the trees along the road shown in Figure 7. It is clear that the nearby trees look larger than the distant ones, because the angular size is inversely proportional to the distance. It is in this way that villagers estimate the distance by means of the apparent sizes of familiar objects like the houses and trees. Similarly we can estimate the distances of star clusters, hydrogen clouds in interstellar space, or radio sources, by measuring their angular size.

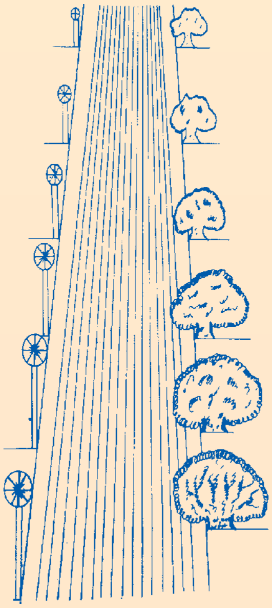

Fig 7 : Change in the angular size and brightness with distance

Now, stars have a proper motion (called 'peculiar motion') caused by their own movement. Similarly the linear size can vary from one star cluster to another. Hence proper motion, or angular size, cannot give the distances of individual objects accurately. It can give only the average distance for a group of objects, because these methods are based on statistics. For example, a bullock cart, a motorcar, and an aeroplane will have different proper motions even if they are at the same distance, because they have different velocities. Similarly, the apparent sizes of men, women and children will be different, because their actual sizes are different. Hence one has to know the type of the object before using the methods of proper motion and angular size. Further, quite often the members of the same group can have exceptional or deviant properties. For example, a tall man can be easily distinguished from others even from a distance. Hence one has to beware of the various pitfalls of statistical variations, while using the methods of proper motion and angular sizes in determining the distance of celestial object.

Spectroscopic Parallax

We shall now consider an important and highly powerful method of measuring distance. If we look at the street lamps on a road (see Figure 7), we find that the nearby lamps look brighter compared to the distant ones. Actually their brightness varies inversely as square of the distance, i.e., the lamp at twice the distance appears one-fourth as bright, the lamp at thrice the distance appears one-ninth as bright, and so on. Here by measuring the apparent brightness of a particular lamp we can determine its distance. Here also, we will get the correct answer only if all the lamps are identical. There is no point in comparing a powerful searchlight with an ordinary light bulb. But if we know the nature of the lamp by some identifying quality we can obtain its distance from its apparent brightness. For example, the airports have rotating beacon lights of a particular power and their rotation can tell us that they are airport lights. Hence looking at such a beaming light we can obtain the distance to the airport.

Now, in the case of stars it is found that intrinsic brightness of a star is correlated with the nature of its spectrum, which in turn, is related to the surface temperature of the star. A cool red star with a surface temperature of 3,000 K showing molecular bands in its spectrum is 10^4 times fainter than the Sun, which has a surface temperature of 5,800 K and whose spectrum is dominated by lines of ionized and neutral metals like iron. On the other hand, a hot blue star with a surface temperature of 40,000 K, showing lines of ionized helium in its spectrum is 6 x 10^4 times brighter than the Sun. So if we measure the apparent brightness of a star having a particular type of spectrum it is possible to calculate its distance. It is called the 'spectroscopic parallax'. But here, we have to take into account one important fact that the light of a distant star has to pass through the interstellar dust and gas. This interstellar fog attenuates the starlight by absorption and scattering, which makes the star appear fainter and redder. Both the attenuation and reddening are related to the distance of the object. Thus it is possible to estimate attenuation by measuring the reddening of the star.

As an example of the above method let us consider Alpha Centauri which is actually a double star. The brighter component of the pair, designated as Alpha Centauri A, resembles the Sun its spectrum and surface temperature. So we know that Alpha Centauri A and the Sun have the same intrinsic brightness. But Alpha Centauri A is 7.5 × 10^{10} times fainter than the Sun, hence it must be $(7.5 \times 10^{10})^{½}$= 2.74 x 10^5 times farther away. Thus its distance is 2.74 x 10^5 A.U., or 1.33 pc, which agrees with the distance obtained by the method of trigonometric parallax.

Actually, stars like the Sun are not intrinsically very bright. If we take the Sun ten times farther away than Alpha Centauri, it will be barely visible to the naked eye. Hence, in order to reach large distances we have to use blue stars like Rigel (Beta Orionis), which can be seen by the naked eye from as far as 3,000 parsecs or 10,000 light years away. In fact, such hot blue stars can be observed with large telescopes even if they are taken as far as Andromeda galaxy, which is about 2 × 10^6 light years away.

The Milky Way and Nearby Galaxies

As compared to the hot blue stars with constant brightness it is easier to detect the pulsating variable stars that show periodic changes in their brightness. These stars alternately expand and contract during each cycle of pulsation. When they expand they become hotter and brighter. The pulsating variables are found to be very useful for estimating the size of the Milky Way and for measuring the distances of external galaxies.

There are two useful varieties of pulsating stars; they are the 'RR-Lyrae variables' and the 'Cepheid variables' of Type I. The RR-Lyrae stars have periods of about half to one day and their surface temperature is about 10,000 K. From a study of their proper motions we can get their distance and from it their intrinsic brightness. They are found to be 60 times brighter than the Sun. Such stars are found in large numbers in globular clusters. From a study of the RR-Lyrae stars in 100 globular clusters the American astronomer Harlow Shapely determined in 1917 the distances of many globular clusters, which came out to be tens of thousands of light years. He found that the system of globular clusters forms a spheroid with its centre at a distance of 30,000 light years in the direction of the Sagittarius constellation. Since the Milky Way is also brighter and wider in the same direction, it was concluded that the centre of the globular cluster system is also the centre of our Milky Way galaxy. This was later confirmed by the radio astronomers from the study of the 21-cm line of hydrogen.

The Milky Way is a flat disc-like system with a central bulge. Its diameter is 10^5 light-years and it has a central thickness of 6,000 light-years. It rotates around its centre. The speed of rotation fist increases and then decreases with the distance from the centre; it is 250 km/s at the distance of the Sun. The Milky Way has several spiral arms; our Sun is situated at the inner edge of an arm, which also contains the stars of the Orion constellation. The mass of

Recent Advances in Distance Measurements

The methods of measuring distances, both intergalactic and intergalactic, are going through a continuous evolution, and in the following paragraphs we discuss the principles of some of the recent advances in the subject.

Trigonometric parallax measurements from the surface of Earth are constrained in their accuracy due to the irregularities of refraction in the atmosphere. In order to get over this difficulty a small satellite (named *Hipparcos*, after the ancient Greek astronomer) has been launched to measure parallaxes. The instrumentation is built around a small 20-cm telescope, and it is expected to lead to measures of parallaxes for about 10^5 stars with an accuracy of 0.002 seconds of arc.

Tully-Fisher relation is a very powerful method of estimating distances of spiral galaxies. The method is based on a well-defined relation between the mass of a galaxy and its luminosity, and on the relation between the mass of a galaxy and rotational velocity of gas in it. (Its rotational equilibrium is maintained through a balance of gravitational pull towards the centre of galaxy, and the centrifugal force, i.e., the acceleration for rotation is provided by the gravitational pull, which depends on the mass of galaxy.) The rotational velocity of the gas is measured through the width of 21-cm line emitted by atomic hydrogen; as different parts of a rotating disc, seen at an angle other than along its axis, would have a different velocity with reference to the observer, the radiation from each part has its own Doppler shift and hence the observed line shows a width in proportion to the rotational velocity (typically 100-300 km/s). Thus the measured line width leads to an estimate of luminosity (via mass) of the galaxy, which can be used to derive the distance from the observed brightness.

Gravitational lensing also provides an almost direct method of estimating distances to galaxies. It has been observed that some of the very luminous and very far (billion of light years) quasi-stellar-objects show multiple images – these images are very similar in their spectroscopic details and time variations. This similarity has convinced astronomers that such multiple images are caused by the gravitational field of intervening matter, say a galaxy between the (single) object and us (the effect is called gravitational lensing). Through painstaking and prolonged observations the following important parameters can be found: (a) the red-shift (due to the universal expansion as given by Hubble's law) of the quasi-stellar-object, (b) the redshift of the galaxy, which causes lensing, and (c) the relative time delay between the arrival of light in different images. Given these three observed parameters and the angular separations of the images, within the framework of Hubble's law (i.e., distance is proportional to red shift) one can derive Hubble's constant, H_0, of proportionality between distance and the velocity of recession of galaxies. The crucial input for an estimate of H_0 is the observed delay in arrival of the different images – the gravitational lensing leads to different path lengths for the light of different images, and the observed delay allows us to make an absolute estimate of the path length difference, and not just a relative estimate as given by the unknown proportionality constant H_0 – which is equated to the estimated delay in units of H_0 and the value of H_0 is deduced.

S.N. Tandon, Inter-University Centre for Astronomy and Astrophysics Pune 411 007 the Milky Way is estimated to be 5 × 10^{11} times the mass of the Sun.

The classical Cepheid variables of Type I are cooler than RR-Lyrae stars, they have a surface temperature of 6,000 to 8,000 K. But they are very much larger in size. They have periods ranging from 2 to 40 days and their intrinsic brightness increases with period. While a Cepheid with 2-day period is 1,000 times brighter than the Sun, a Cepheid with 40-day period is 10,000 times brighter than the Sun. Hence the brightest Cepheids can be easily seen at large distances like those of the external galaxies. Using the period of Cepheid variables the distance of Andromeda spiral galaxy has been found to be 2.2 × 10^6 light-years. After getting the distance of a galaxy, it is possible to determine its size, rotational velocity, mass, spiral structure, etc. It is thus found that the Andromeda galaxy is a somewhat enlarged version of our Milky Way galaxy. The Milky Way, the Andromeda galaxy, the Magellanic clouds, and about two dozen other smaller galaxies together form a local group.

The Universe

In order to go beyond the local group, we have to use still brighter objects like novae and supernovae. In the last stages of its evolution a star produces energy at a very fast rate, because of which it becomes very hot and explodes. At that time its brightness increases by several orders of magnitude. After the explosion the star becomes faint again. As such a star is seen conspicuously for a short duration only; it is called a 'nova', i.e. a new star, although it is not new at all. A nova can be 10^7 times brighter than the Sun at its maximum. About 30 to 40 novae explode in a galaxy every year. On the other hand, the brilliant firework of a supernova in a galaxy occurs once every thirty years. A supernova becomes 10^8 times brighter than the Sun at its maximum. At that time it outshines the whole galaxy in which it is found. One such supernova exploded in our galaxy in 1054 AD, which gave rise to the Crab nebula and the pulsar at its centre. Astronomers have reason to believe that the peak light output from such a supernova (called Type I) is always approximately equivalent to an absolute magnitude of –19.6. Thus, if we observe such a supernova in a distant galaxy and measure the peak light output, we can use the inverse square law to infer its distance and therefore the distance of its parent galaxy. Supernovae can give us distances up to 10^9 light years. Within this distance one can find one to two million individual galaxies, as also about 20 clusters of galaxies, each containing 100 to 1,000 members.

Photographs taken with large telescopes show one to two hundreds million galaxies in the whole sky. Only one per cent of them lie within a range of one billion light years, which can be measured with the help of supernovae. In order to obtain the distances of the remaining 99 per cent of galaxies, one has to use other methods. In one statistical method one makes use of the apparent magnitudes of the brightest galaxies in a cluster of galaxies; this method is not at all applicable to individual galaxies. For them the spectroscopic method using the Doppler effect is more powerful and reliable.

Due to the Doppler effect, the lines in the spectrum of a galaxy are shifted to longer wavelengths if galaxy is receding from us; and they are shifted towards shorter wavelengths if it is approaching towards us. It is found that the spectral lines of all distant galaxies are shifted towards the longer wavelengths, i.e., towards the red part of the visible spectrum. This observation shows that all distant galaxies are receding from us. In 1927, American astronomer Edwin Hubble found that the speed of recession of a galaxy increases directly in proportion with its distance; this is known as Hubble's law. It is illustrated in Figure 8. The distances of the galaxies on the three circles are away from the observer O, in the ratio of 1 : 2 : 3. Their speeds shown by the lengths of the arrows are also in the same ratio. The speed of recession increases by 75 km/s for every million parsecs.

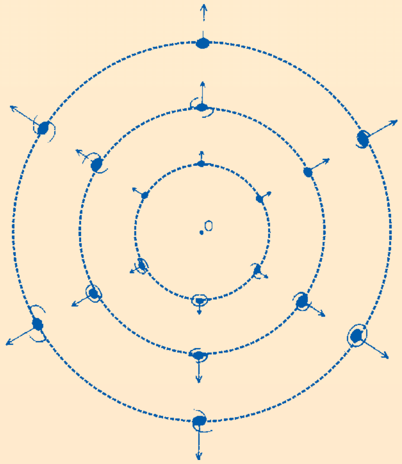

Fig 8 : Hubble's law and expansion of the universe

Hubble's law can be used for obtaining the distances of very distant individual objects like quasars. For example quasar 3C9 has a speed of recession equal to 2.4 × 10^5 km/s, which is equal to 80 per cent of the speed of light. From this its distance comes out to be 3.2 × 10^9 parsecs or 10 × 10^9 light years. Going farther out, we shall reach the speed of light at a distance of 12 × 10^9 light years, which is not allowed according to the special theory of relativity. So 12 × 10^9 light years can be considered as the theoretical limit of the observable universe. However, this does not mean that the universe in finite. The actual geometry of the universe will depend upon whether the galaxies are accelerating or decelerating and at what rate. It is also related to the total amount of matter in the universe and its density. These questions belong to the subject of cosmology, which is very active field of research at the present time.

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Heart Attack

Recognizing the Symptoms and the Steps to Take

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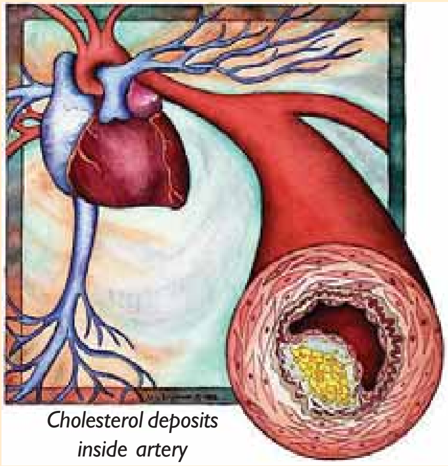
Heart Attack! The words quiver with emotion. Sending a cold shiver down the spine, they fill you with sudden trepidation. You well realize what it means. Gripping a person within seconds, it can end it all in no time.



Cholesterol deposits inside artery

A heart attack is a serious event. It requires urgent medical attention. Prompt and sensible first-aid can make a big difference in the final outcome. If the first 60 minutes can be survived, then the outlook improves dramatically. However, a close vigil has to be kept for the next 24 hours.

The sooner a heart attack victim is transported to a coronary care unit the greater are the chances of recovery. A timely shot of clot-dissolving medication can even stop a heart attack in its tracks. Timely therapy with anti-arrhythmic and other medications, emergency pacemaker implantation, mechanical assist devices and cardiac surgery can save life.

What is a heart attack?

A heart attack usually is caused by sudden blockage of a coronary artery by a blood clot. The clot usually forms in an artery that has been narrowed by fatty cholesterol deposits. If the blood flow is blocked long enough in a coronary artery – about 30 minutes to two hours – the portion of the heart muscle that is supplied by that artery will die. The heart muscle death is known as a 'myocardial infarction' or heart attack. Treating physicians often call it by the acronym, acute MI.

The blockage in a coronary artery can happen in one of the two ways: in most cases, a blood clot (thrombus) or a ruptured fatty plaque enters a narrowed coronary artery and block if off completely; else, the catastrophe occurs due to a sudden spasm and occlusion of a coronary artery.

Symptoms

Usually the attack occurs all of a sudden. One minute the victim is carrying out his usual activities; the next he is incapacitated by an acute pain, which originates in the chest, or rarely in the pit of the stomach, from where it may travel to the left shoulder and left arm. The patient feels that his chest is being squeezed, constricted, or crushed.

The attack may begin under almost any circumstance: while the person is working in his office, attending a luncheon party, driving a car, resting in a chair, or even while sleeping. It may also be triggered by an unaccustomed vigorous exercise, or a la Mumbai's tinsel world, by an emotional crisis.

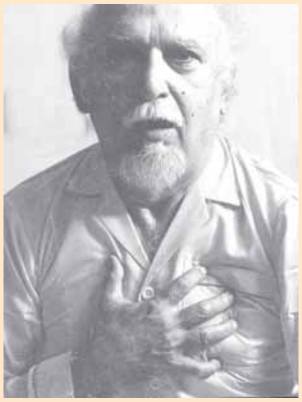
Often the pain is so killing that the patient may feel difficulty in breathing. He or she may feel weak and dizzy, and may pass out. Frequently, the person may complain of nausea. He or she may perspire heavily and the skin may break out in a moist cold sweat. A feeling of impending death may overpower the victim.

The Danger Signs

- Uncomfortable pressure, fullness or squeezing pain in the centre of your chest, lasting more than 15 minutes.
- Pain spreading to your shoulders, neck or arms.
- Light-headedness, fainting, sweating, nausea or shortness of breath.You may have all or none of these symptoms, but if you are in doubt it is best to immediately call your doctor.

The severity of pain differs from that in angina. It increases in intensity until a maximum has been reached. There is no let off in the pain with rest. Once having reached its crescendo, an infarct pain usually persists for 30 minutes or more.

The symptoms may however sometimes be confused with those of indigestion, particularly when the pain begins in the upper part of the stomach and is accompanied by nausea. Many instances are recorded where a person has attempted to dismiss his symptoms with a bottle of soda water, a helping of *churan* or a digestive preparation, only to know later that he actually had suffered a heart attack.



Beware of the painless attack

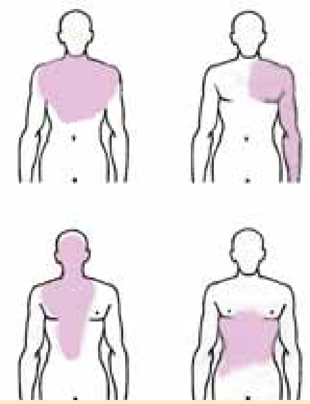
A few patients may never realize that they have had a heart attack. That's because some 15 to 20 per cent of myocardial infarcts are completely painless. The frequency of such "silent attacks" may actually even be higher than this estimate, because without pain patients are not likely to report to a doctor.

Such painless infarcts are more common in patients with diabetes, and their occurrence increases with age. In the elderly, a heart attack may present itself just as a sudden loss of consciousness, confused state, sensation of profound weakness, sudden waywardness of heart rhythm, or an unexplained drop in arterial blood pressure.

What to do

If you suspect yourself to be having a heart attack, act immediately. Prompt first aid may save your life:

- Pull all stops. Call for help immediately. If you are alone, call your physician or dial 102 to ask for the ambulance, and state the emergency.
- Sit quietly or lie down if you are feeling faint.
- Breathe slowly and deeply.
- Chew an aspirin tablet. It thins the blood and improves the outcome significantly.



Regions of pain during a heart attack

If you happen to be on the spot where someone is struck with chest pain suspicious of a heart attack, take the following steps:

- Call for medical assistance immediately. If available, a coronary care ambulance may be best. Make the message urgent and clear, stating that the person is having a heart attack.
- In towns and cities where facilities for coronary care ambulance do not exist, rush the patient to the nearest hospital where a cardiologist is available.
- While you wait for a physician, make sure that the patient remains absolutely at rest. Prop him up in a half-reclining position. Loosen his clothing. Open all the windows of the room to allow fresh air inside.
- If the patient is conscious and a chewable aspirin tablet is available, ask him to crunch it.

If the person faints or loses consciousness there is no time to lose. A person at hand or a bystander, who knows how to do a cardio-pulmonary resuscitation (CPR), can still save the situation.

Do's

- Make the patient lie down flat on a hard bed or floor.
- Raise his legs. This would divert vital blood to his brain.
- Take the pillow out from underneath his head.
- Start CPR

Don'ts

- Do not try to make the patient sit or stand.
- Do not pour water into his mouth.
- Do not crowd around the victim.

How to do CPR

If you have been a boy- or girl-cub or a scout, you would probably know how to do CPR. The aim is to keep the airway, breathing and circulation intact, until medical help arrives.

- Begin by ensuring that the patient's airway is open. Lift up his chin with one hand, and with the other tilt his head backwards. This would open up the airway, relieving it of any obstruction caused by the tongue or epiglottis.
- Next move on to breathing. The best way is a mouth-to-mouth respiration. Keep the patient's airway in open position. Pinch his nose, place a fresh handkerchief in between, and give two full breaths while maintaining an airtight seal with your mouth on his mouth. Look at his chest for simultaneous chest expansion.
- Now, feel for his carotid pulse. It lies in the groove by the side of the Adam's apple. If no pulsation can be felt, begin cardiac massage. For this, locate the notch where the bottom rims of the two halves of the rib cage meet in the middle of the chest. Place the heel of one hand here. Now place your other hand on the top of the first one. Bring your shoulders directly over the patient's breastbone and keeping your arms straight, depress it down a good 4 to 5 cm. Then relax the pressure. But do not remove your hands. Compress again. Keep doing this at a rate of 80 to 100 compressions a minute. After every 15 compressions, give two mouth-to-mouth breaths.
- Keep at it, until expert medical assistance arrives. If there is another person at hand, take help.

The next step is to transport the patient safely to the hospital. If the patient is conscious, the doctor may give him a shot of morphine to relieve him of pain and anxiety. He may be administered oxygen, medications to prevent irregularities of heartbeat, and other incidental therapy on the spot.

The first 24 hours of infarction are critical. The biggest danger is from electrical instability of the heart, which can upset its rhythm. If recognized and treated on time, the changes are potentially reversible. But more about it, next month!

• • •

Earthquake Tip 6

How Architectural Features Affect Buildings During Earthquakes?

Importance of Architectural Features

The behaviour of a building during earthquakes depends critically on its overall shape, size and geometry, in addition to how the earthquake forces are carried to the ground. Hence, at the planning stage itself, architects and structural engineers must work together to ensure that the unfavourable features are avoided and a good building configuration is chosen.

The importance of the configuration of a building was aptly summarised by Late Henry Degenkolb, a noted earthquake engineer of USA, as:

> *"If we have a poor configuration to start with, all the engineer can do is to provide a band-aid - improve a basically poor solution as best as he can. Conversely, if we start-off with a good configuration and reasonable framing system, even a poor engineer cannot harm its ultimate performance too much."*

Architectural Features

A desire to create an aesthetic and functionally efficient structure drives architects to conceive wonderful and imaginative structures. Sometimes the *shape* of the building catches the eye of the visitor, sometimes the *structural system* appeals, and in other occasions *both shape and structural system* work together to make the structure a marvel. However, each of these choices of shapes and structure has significant bearing on the performance of the building during strong earthquakes. The wide range of structural damages observed during past earthquakes across the world is very educative in identifying structural configurations that are desirable versus those that must be avoided.

Size of Buildings: In tall buildings with large height-to-base size ratio (Figure 1a), the horizontal movement of the floors during ground shaking is large. In short but very long buildings (Figure 1b), the damaging effects during earthquake shaking are many. And, in buildings with large plan area like warehouses (Figure 1c), the horizontal seismic forces can be excessive to be carried by columns and walls.

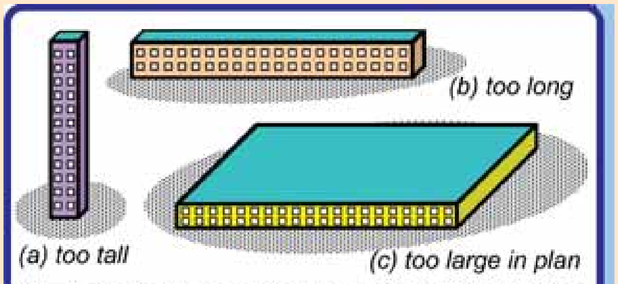


Figure 1: Buildings with one of their overall sizes much larger or much smaller than the other two, do not perform well during earthquakes.

Horizontal Layout of Buildings: In general, buildings with simple geometry in plan (Figure 2a) have performed well during strong earthquakes. Buildings with re-entrant corners, like those U, V, H and '+' shaped in plan (Figure 2b), have sustained significant damage. The damaging effects of these interior corners in the plan of buildings can be avoided by making the buildings in two parts. For example, an L-shaped plan can be broken up into two rectangular plan shapes using a separation joint at the junction (Figure 2c). Often, the plan is simple, but the columns/walls are not equally distributed in plan. Buildings with such features tend to twist during earthquake shaking. A discussion in this aspect will be presented in the upcoming *IITK-BMTPC Earthquake Tip 7* on *How Buildings Twist During Earthquakes?*

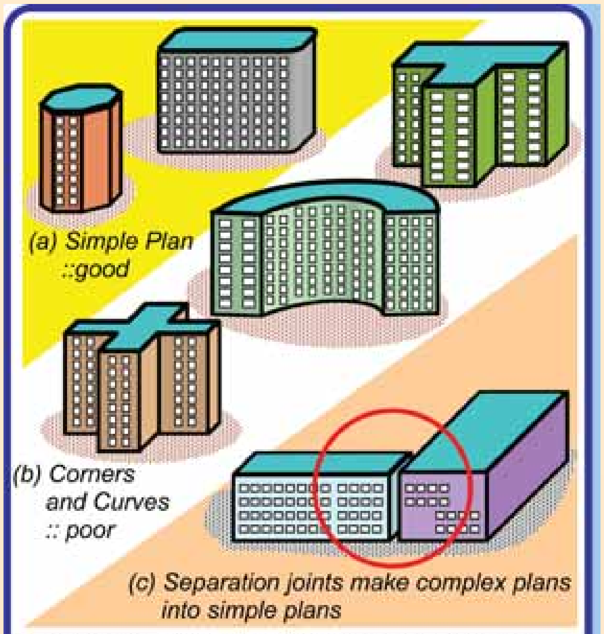


Figure 2: Simple plan shape buildings do well during earthquakes.

Vertical Layout of Buildings: The earthquake forces developed at different floor levels in a building need to be brought down along the height to the ground by the shortest path; any deviation or discontinuity in this load transfer path results in poor performance of the building. Buildings with vertical setbacks (like the hotel buildings with a few storeys wider than the rest) cause a sudden jump in earthquake forces at the level of discontinuity (Figure 3a). Buildings that have fewer columns or walls in a particular storey or with unusually tall storey (Figure 3b) tend to damage or collapse, which is initiated in that storey. Many buildings with an open ground storey intended for parking collapsed or were severely damaged in Gujarat during the 2001 Bhuj earthquake.

Buildings on sloping ground have unequal height columns along the slope, which causes ill effects like twisting and damage in shorter columns (Figure 3c). Buildings with columns that hang or float on beams at an intermediate storey and do not go all the way to the foundation have discontinuities in the load transfer path (Figure 3d). Some buildings have reinforced concrete walls to carry the earthquake loads to the foundation. Buildings, in which these walls do not go all the way to the ground but stop at an upper level, are liable to get severely damaged during earthquakes.

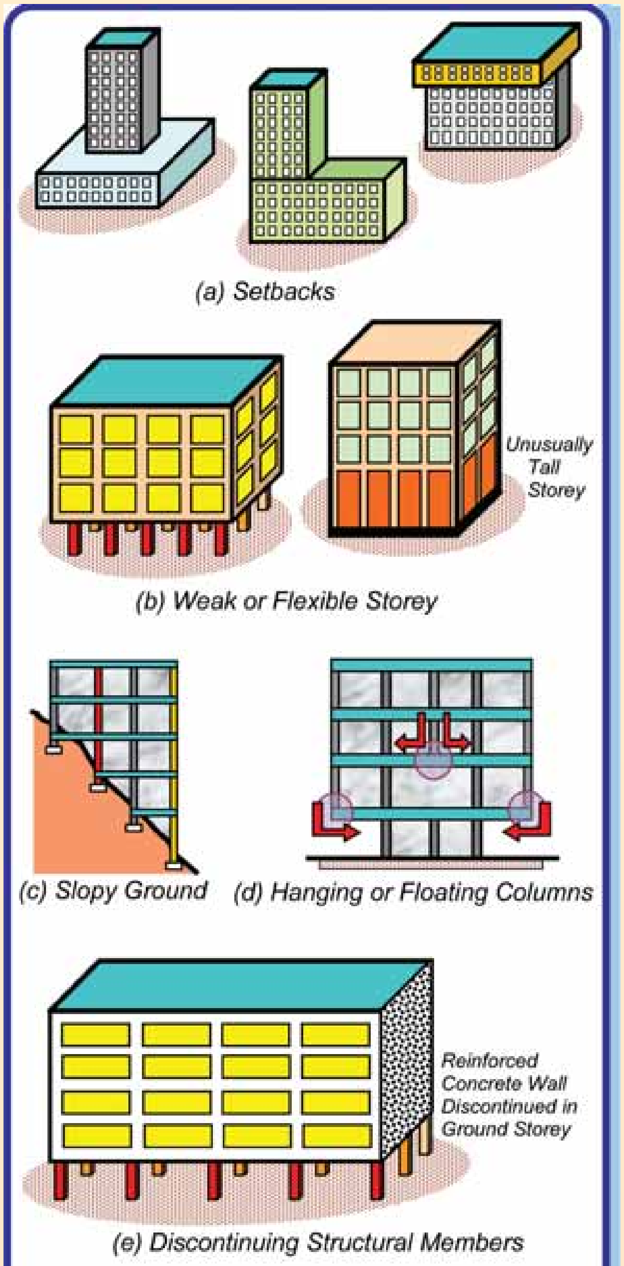


Figure 3: Sudden deviations in load transfer path along the height lead to poor performance of buildings.

Adjacency of Buildings: When two buildings are too close to each other, they may pound on each other during strong shaking. With increase in building height, this collision can be a greater problem. When building heights do not match (Figure 4), the roof of the shorter building may pound at the mid-height of the column of the taller one; this can be very dangerous.

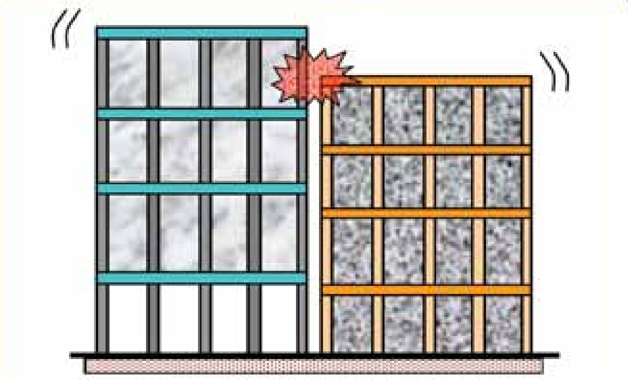


Figure 4: Pounding can occur between adjoining buildings due to horizontal vibrations of the two buildings.

Building Design and Codes

Looking ahead, of course, architects will continue to make buildings interesting rather than monotonous. However, this need not be done at the cost of poor behaviour and earthquake safety of buildings. Architectural features that are detrimental to earthquake response of buildings should be avoided. If not, they must be minimised. When irregular features are included in buildings, a considerably higher level of engineering effort is required in the structural design and yet the building may not be as good as one with simple architectural features.

Decisions made at the planning stage on building configuration are more important, or are known to have made greater difference, than accurate determination of code specified design forces.

Resource Material

1. Arnold,C., and Reitherman,R., (1982), *Building Configuration and Seismic Design*, John Wiley, USA.
2. Lagorio,H,J, (1990), *EARTHQUAKES An Architect's Guide to Non-Structural Seismic Hazard*, John Wiley & Sons, Inc., USA.

Acknowledgement :

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Recent Developments in Science and Technology

Ice and Lightning

Lightning is an abrupt, high-current electric discharge that occurs between clouds or between cloud and the Earth's surface and is often associated with thunder. A typical lightning bolt has a path length ranging from hundreds of metres to tens of kilometres. It was long believed that lightning occurs in thunderstorms because vertical air motions and interactions between water droplets in the cloud cause a separation of positive and negative charges. Now scientists have found experimental proof of exactly how clouds get charged – and the cause is tiny ice crystals. It may seem hard to believe that a powerful bolt of lightning, which heats the air in its path three times hotter than the surface of the Sun, could spring from little pieces of ice. But that's how it is, as has been confirmed by laboratory experiments.

For more than three years, Walt Petersen, a lightning researcher at the National Space Science and Technology Center in Huntsville, Alabama, USA, and his colleagues have been looking inside clouds using the 'Tropical Rainfall Measurement Mission' (TRMM) satellite. By comparing the ice content of more than one million clouds to their lightning flashes, they found a strong correlation between ice content and lightning in all environments – over land, over sea and in coastal areas. On global scales, they found that the correlation coefficient between lightning flashes per square-kilometre per month and the amount of ice per square-metre of cloud exceeded 90%. Even stronger correlations were found on the smaller scale of individual storm clouds where, for example, about 10 million kilograms of ice would produce one lightning flash per minute.

In a thundercloud, millions of pieces of ice are constantly bumping together, pushed by updrafts ranging in speed from 20 to 200 kph. As they collide with larger ice pellets, tiny ice crystals become positively charged. The two kinds of ice rubbing together act like a plastic comb rubbing against dry hair. The tiny positively charged ice crystals are carried by the updraft to the top of the cloud, while bulkier, negatively charged ice pellets plummet to the bottom. This separation creates mega-volts of electrical tension – and causes lightning.

Source: science@NASA

Pulsars Prove Einstein right

An international team of astronomers has used an unusual double pulsar to provide the strongest confirmation yet of Einstein's general theory of relativity – the theory that physicists believe best explains gravity. The double pulsar PSR J0737-3039A/B, which was discovered by a team of radio astronomers at the Jodrell Bank Observatory in the UK in 2003, lies some 2,000 light-years away from Earth. It consists of two compact neutron stars, each a mere 20 km across yet weighing more than the Sun and separated by only a million kilometres. Given the tiny size, high mass density and very short orbital period of just 2.4 hours, the double-pulsar system has a gravitational field 100,000 times stronger that of our Sun – higher than anything else in the universe, apart from black holes. Relativistic effects in this system are therefore much more pronounced and space-time is far more curved than under normal conditions that exist in our solar system. This makes the double pulsar an excellent "laboratory" for testing general relativity, particularly because both stars send out regular beams of radio waves, which can be captured by large telescopes and used to probe the curved space-time around such a system.

Using the Lovell Telescope at Jodrell Bank – as well as the Parkes Radio Telescope in Australia and the Robert C Byrd Green Bank Telescope in West Virginia, USA – the team led by Michael Kramer carried out four separate tests on the pair of rotating neutron stars, and measured five mathematical parameters that describe relativistic effects as corrections to the simple Keplerian motion of stars. The conclusion from the four independent tests of the general theory of relativity was that the pulsars are indeed behaving as predicted by the general theory of relativity, to an unerring accuracy of 99.5%.

Source: *Science*, 6 October 2006

More Efficient Solar Cells

Researchers at Lawrence Berkeley National Laboratory in USA have created a new type of semiconductor material designed to improve the efficiency of solar cells by capturing low-energy photons. Conventional single semiconductor solar cells respond only to a narrow spectrum of sunlight, making them highly inefficient; the maximum efficiency achieved is only about 25 per cent. These solar cells convert light of only certain wavelengths corresponding to the energy it takes for electrons to jump from the valence band to the conduction band. Photons with lower energy pass right through the material and are not used in the production of electricity. The new semiconductor material can capture these low-energy photons to produce electricity, which could make solar cells with efficiencies of around 45 per cent.

The new semiconductors, developed by Wladek Walukiewicz and Kin Man Yu of the Laboratory's Materials Sciences Division, have three energy bands instead of the usual two (valence and conduction). The third band lies below the conduction band, effectively splitting the gap between the valence and conduction bands into two smaller parts. This helps low-energy photons to participate in the process because they can excite electrons to the intermediate band and then up, acting like a stepping-stone. The researchers found that introducing a few atoms of oxygen into a zinc-manganese-tellurium (ZnMnTe) alloy splits the compound semiconductor's conduction band into two parts. Similarly, adding nitrogen to a semiconductor such as gallium arsenide phosphide also gives a multi-band semiconductor.

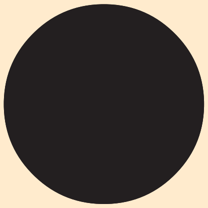
Source: www.technologyreview.com

Sky Map for December 2006

Full Moon

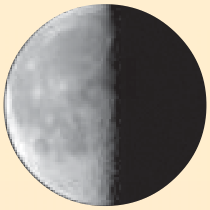
5 December

New Moon



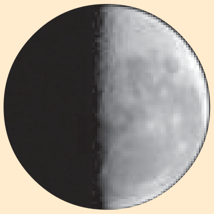
19 December

Moon - Last Quarter



13 December

Moon - First Quarter



27 December

The sky map is prepared for viewer in Nagpur (21.09° N, 79.09° E). It includes bright constellations and planets. For viewers south of Nagpur constellations of the southern sky will appear higher up in the sky, and those of the northern sky will appear nearer the northern horizon. Similarly, for viewers north of Nagpur, Constellations of northern sky will appear higher up in the sky, and those of the southern sky will appear nearer the southern horizon. The map can be used at 10 PM on 1 December, at 9 PM on 15 December and at 8 PM on 31 December.

Tips for watching the night sky :

(1) Choose a place away from city lights/street lights. (2) Hold the sky-map overhead with 'North' in the direction of Polaris. (3) Use a pencil torch for reading the sky map. (4) Try to identify constellations as shown in the Map one by one.

Planet Round up: Uranus, Neptune & Pluto: Not a naked eye object. Hence not visible.

NO PLANET IS GOING TO BE VISIBLE IN DECEMBER 2006

Prominent Constellations: Given below are prominent constellations with brightest star therein (in the parenthesis). Also given are their Indian names.

Eastern Sky: Canis Major (Sirius) / *Bruhlubdhak (Vyadha),* Canis Minor (Procyon) / *Laghullubdhak (Prashav),* Gemini (Castor, Pollux) / *Meethun Rashi (Prakruti, Purush),* Lepus / *Shashak,* Monocerus, Orion (Betelgeuse, Rigel) / *Mrig (Aardhra, Rajanya).*

Wertern Sky: Aquarius/*Kumbh Rashi,* Cygnus (Deneb) / *Hansa,* Delphinus / *Dhanishta,* Pegasus / *Maha-Ashva,* Piscis Austrinus (Fomahault) / *(Meensya).*

Southern Sky: *Columba,*Eridanus/*Yamuna,* Fornax, Grus / *Bak*, Phonix, Sculptor.

Northern Sky: Cassiopeia / *Sharmishta,* Cephus / *Vrishparva,* Ursa Minor (Polaris) / *Dhurvamatsya (Dhrubtarak).*

Zenith Sky: Andromeda / *Devyani,* Aries (Hamal) / *Mesha Rashi*, Auriga (Capella) / *Sarthi (Brahmaridhay),* Cetus (Deneb Kaitos) / *Timigal,* Perseus (Mirfak, Algol), Pisces / *Meen Rashi,* Taurus (Aldebran) / *Vrishabh Rashi (Rohini),* Trangulum.

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(Contd. from page...35)

Already Hot and Getting Hotter

century. We are already experiencing a change in the monsoon pattern with floods in Maharashtra, Gujarat and Rajasthan; and draught in the North-East.

There is no gainsaying the fact that the development and economic growth of a country is intimately linked to the extent of industrialization and hence the use of fossil fuels. Imposing restrictions on development will affect the GDP. According to an estimate, a 30 per cent reduction in carbon dioxide emissions will raise the number of poor by 17.5 per cent. It is; however, clear that profligate use of carbon-based energy sources such as fossil fuels to power homes, offices, cars, aircraft, and industries can go on only at the risk of serious harm to humanity's long-term future. Hence the scientists and economists need to devise ways and means to cut emissions incrementally over several years.

How could we reduce our CO_2 emissions? We have the technology and ingenuity to reduce the threat of global warming today – and it does not involve high costs. By investing in renewable energy we can take essential steps toward reducing our dependence on fossil fuels and oil that cause global warming. Using energy more efficiently and moving to renewable energy would significantly reduce our emissions of heat-trapping gases. CO_2 emissions from cars and other vehicles need to be reduced. Many technologies already exist that can do this. It would also help us reduce our dependence on import of oil. Indeed, one example that could be cited is the introduction of a public transport system based on compressed natural gas (methane) to reduce polluting gases, first introduced in 2001 in Delhi. We also may need to consider alternate fuels like ethanol. But, how can we cap the industrial emissions? Indeed, the cost differential between fossil-fuel-generated energy and some alternatives is already small, and is likely to come down. The technological and economic aspects of the problem are not quite as challenging as many imagine. To reduce the CO_2 emissions, a carbon tax or a cap-and-trade system, such as Europe's Emissions-Trading Scheme could be introduced, which limits how much the total amount of CO_2 producers can emit.

The Kyoto Accord that came into force in 2005 - seven years after it was agreed in December 1997 - aims at curbing the air pollution blamed for global warming. The accord requires countries to cut emissions of carbon dioxide and other greenhouse gases. Some 141 countries, accounting for 55% of greenhouse gas emissions, have ratified the treaty, which pledges to cut these emissions by 5.2 % by 2012. But the world's top polluter - the US - that produces 25 % of the world's total CO_2 emissions has not signed up the treaty. The US says the changes would be too costly to introduce and that the agreement is flawed! Large developing countries including India, China and Brazil are not required to meet specific targets at least for now.

World carbon dioxide emissions are expected to increase by 1.9 % annually between 2001 and 2025. It is estimated that much of the increase would occur in the developing world, where emerging economies like China and India fuel economic development with fossil fuels. Developing countries' emissions are expected to surpass emissions of industrialized countries near 2018. Surely, a fast-growing India must avoid wasteful use of energy. A real difference could be made by heavily subsidizing solar and wind power, expanding forests (since they absorb carbon emissions), building efficient power generation facilities, developing alternate and less polluting fuels, and improving public transport. We cannot avoid all the consequences of global warming, but committing ourselves to action today can help ensure our children and grandchildren inherit a healthy world full of opportunity tomorrow. Climate change is no more an esoteric issue. The slow, insidious changes it will bring over the next century must appear on the radar screens of people and the policymakers of our country. And earlier it happens, the better. It is already hot and getting hotter.

❐ **V. B. Kamble**

(Contd. from page 36)

VIPNET Orientation Programme...

light, mechanics, electricity, etc., were demonstrated and explained to participants. Shri B.K.Tyagi (Scientist "D") and Shri Kapil Tripathi (Scientist "C") also conducted sessions on the programme and activities of VP at the workshop. All the participants took keen interest in the activities conducted during the workshop. A CD developed by VP on "Innovative Physics Experiments" was also given to each participant besides other resource material. VP also put up a small exhibition of the software for the benefit of participants.

A similar workshop was organised in Jabalpur, Madhya Pradesh on 14-15 October 2006 at Mata Jugri Degree College in the city. For this programme about 80 teachers, science communicators and representative of agencies associated with science popularization were invited from Jabalpur, Umaria, Betul, Hoshangabad, and Khargone districts of Madhya Pradesh. This programme was organised jointly by VP and Yuva Vigyan Parishad, an S&T based voluntary organisation of Gwalior.

(Contd. from page 36)

Training and Capacity building...

Delhi, participants at distant locations got trained in making the toys. About 15 teachers and science activists participated at each location. On 26 October field centres at Medinipur (WB), Lucknow (UP), Thiruvanathapuram (Kerala), Patna (Bihar), Bhubaneswar (Orissa), and Puducherry took part, while field centres at Belgaum (Karnataka), Nagpur (Maharashtra), Itanagar (Arunachal Pradesh), Guwahati (Asom), and Raipur (Chattisgarh) took part on 27 October 2006. Making simple toys using low cost and no cost material were demonstrated.

On 31 October 2006 a training programme was organised to provide hands-on training in using the 'Earthquake kit' developed by Vigyan Prasar. Mr Kapil Tripathy, (Scientist "C"), Vigyan Prasar demonstrated the use of the kit. Field centres at Puducherry, Medinipur, and Itanagar mobilised teachers and science activists who were trained in use of the kit.