School Science | A Quarterly Journal of Science Education

Form IV (See Rule 8)
SCHOOL SCIENCE

1. Place of Publication	National Council of Educational Research and Training (NCERT)
2. Periodicity of Publication	Quarterly
3. Printer's Name (Whether citizen of India?) (If foreigner, state the country of origin) Address	Manoj Sharma Yes Not applicable Proprietor : Chaar Dishayen Printers Pvt. Ltd. G-40, Sector 3, Noida (U.P.) 201 301
4. Publisher's Name (Whether citizen of India?) (If foreigner, state the country of origin) Address	Ashok Srivastava Yes Not applicable Head, Publication Division, NCERT Sri Aurobindo Marg, New Delhi 110 016
5. Editor's Name (Whether citizen of India?) (If foreigner, state the country of origin) Address	V. P. Srivastava Yes Not applicable Academic Editor (JIE), DESM, NCERT New Delhi 110 016
6. Names and addresses of the individuals who own the newspaper and partner or shareholders holding more than one per cent of the total capital	National Council of Educational Research and Training, New Delhi *(An autonomous body of the Government of India in the Ministry of Human Resource Development)*

I, Ashok Srivastava, hereby declare that the particulars given above are true to the best of my knowledge and belief.

Publisher

Published at the Publication Department by the Secretary, National Council of Educational Research and Training, Sri Aurobindo Marg, New Delhi 110 016 and printed at Vrindaban Graphics (P) Ltd., E-34, Sector 7, Noida (U.P.) 201 301

Contents

EDITORIAL

Constructivism is the cornerstone of National Curriculum Framework (NCF)–2005. To achieve the goals of constructivism, there are various methods and tools that can be used in and outside the classrooms. Story-telling is one of the tools that is more used in teaching of social science than science. The article by Tanu Tandon tells us how the tools of story-telling can be used to achieve the goals of constructivism in science teaching. It goes into different aspect of the theme and also describes a practical experience. Motion of simple pendulum is not that simple. There are many misconceptions in minds of teachers about this topic as discussed in a study conducted by H.C. Jain during training programmes of physics teachers of higher secondary stage. The author advocates for appropriate strategy to be adapted while teaching this topic. We have an interesting article by Vedavati Jogi on how participatory video can be used for developing spirit of innovation in socio-economically under-privileged students. This article shows how students can be taught the use of video equipments to produce films on topics in their textbooks.

Air resistance affects the range of projectile. This is our common experience. To what extent it happens, is discussed by V.B. Bhatia in his article. Students, teachers and parents are curious about career opportunities in different disciplines of science. A.K. Modi talks in details about scope and career opportunities through physics. This issue, in addition to regular columns like Science News, Web Watch and Book Reviews carries a scholarly article by R.P. Maurya on exploring mathematics.

The comments and suggestions of the readers are welcome.

STORY-TELLING – A CONSTRUCTIVIST TOOL IN SCIENCE TEACHING

Tanu Tandon
Lecturer, Amity Institute of Education
Amity University, Lucknow Campus
Uttar Pradesh

Constructivism asserts that knowledge is actively constructed by the learner through interaction with the world and social negotiation, learner explores the world and transforms his understanding of the world. Story-telling, is also an integral part of our lives, in understanding and communicating with the world. Science, on the other hand, is a subject which rests upon inductive reasoning and analytical thinking, and also requires social negotiation and classroom is the social unit where knowledge is constructed. This paper discusses how story-telling can be used as a constructivist tool in teaching of science.

Visualise a science class going on. What will come in your mind? Use of model and pictures, question and answer session going on. Now picture this, a science class, going on the topic of structure of flower with teacher holding a hand puppet of honeybee and a large puppet of flower and narrating a story with full expressions and proper voice modulation about baby honeybee. "A baby bee goes to the garden for the first time and sees a beautiful red flower in centre of the garden. It goes round and round, buzzes with excitement, pokes inside the flower and it's so curious about the flower and wants to know everything. You all are baby bees and you all come to mummy bee (teacher) and together they go on a trip to garden to explore it and to know parts of flower". This is followed by a slide show on the structure of flower.

Science has always been associated with scientific rational thinking skills and story-telling always reminds us of a literature class but these two put together can prove to be very effective. This paper will discuss story-telling approach in teaching of science. Science has always been associated with experiments, demonstrations, inductive – deductive reasoning and analysis and for this reason scientific concepts are consistently described as challenging to learn and difficult to teach.

Enhancing students higher thinking, logical reasoning, scientific skill has always been a considerable challenge in education. The Dearing Report (Dearing, 1997) has re-emphasised their importance and the need to introduce tasks to foster reflective thinking and skills to enable students to learn how to learn. The emphasis on skills is needed to develop the lifelong learners who will effectively be able to be part of the future learning society. This supports the constructive learning approach.

A constructivist approach to education emphasises upon the learner and how they construct representation of reality through their interaction with the world and their discussions

with others (Bruner, 1986). The learners are, therefore, encouraged to explore their world, to learn by doing, to look at things in different ways, to discuss their world view with others and as a result to continually transform their understanding of the world in light of these experiences.

Many of our encounters with the world are not direct, our meaning and interpretation about an event is constructed through reflection on it with others. Bruner (1986) suggests that we need to encourage a situation whereby information is not presented from one dominant view and where reflection, discussion and opposing views are included in the process. Education shapes our thoughts and ultimately the way in which we represent and view our world.

Constructivism in Science Teaching

Constructivism both radical and social asserts that knowledge is actively constructed by the learner. Learning is perceived as a cultural apprenticeship and that cognition is argued to be situated in the specific context (Lave, 1988; Brown *et.al.* 1989). Driver *et.al.* (1994) stated that scientific knowledge is symbolic in nature and socially negotiated and classroom is the social unit where knowledge is constructed and negotiated.

Constructivism in science teaching is an approach which focuses on each student, treat her/him as a unique case with her/him own set of realities, experiences, values and culture. Constructivism emphasises that students should be taught in natural settings with multiple representations of reality and varied experiences.

The opportunities to explore, observe and discuss, should be provided to children. Students should be encouraged to ask questions, share their experiences, carry out analogies and reach to conclusions and draw inferences. Negotiation of outcomes is equally important so that students can compare their reality with others and corelate their knowledge with the outside world. Constructivist learning has emphasis on all three—past, present and future. The students are actively involved in construction of knowledge by reflecting upon old and new knowledge and thus evolve new knowledge and learns, unlearns and relearns in this process.

Story-telling – A Constructivist Tool in Science Teaching

Story-telling is one of the constructivist approaches that can be used in science teaching. Story-telling is one of the basic to our everyday lives in communicating with and understanding the people around us and the world we live in (Schank and Abelson, 1995). The stories we tell are more about how we experience and perceive events than about how things really are. They can help us deal with unexpected situations and consider the possibilities for what could have happened as well as what actually transpired (Bruner, 1990). They are an excellent constructivist tool, enabling us to explore the many representations of our worlds. Story-telling has been extensively used in child education as a valuable and creative tool. Construction of stories requires students to actively engage in making sense of their experiences to present stories from different view points. Students were able to set

their own goals, thus enabling them to become self-organised and independent learners. McDuray and Alterio (2003) have proposed a five stage model of reflective learning through Story-telling, which they have mapped on to Moons (2000) five stages of learning.

Story-telling, thus enables the students to make their own decisions, share their views and experiences, and this is the basic premise of constructivism, to construct own knowledge. Story-telling in science teaching can be used to make it more effective as analogy uses the learner's existing knowledge to generate new understanding (cognitive constructing project). Yanowitz (2001) demonstrated that their 3rd grade children can actually answer inferential question about a science concept that they had learned analogically. Elaborated analogies tend to be more effective when explaining, because they allow the learner to predict which as the basics of establishing causal relationships, one of the key scientific skills. According to Glynn (1991) at it's simplest analogy is the process of identifying similarities between different concepts.

Harrison (2002) points out that the ability of analogies to raise students interest levels is at times more important in the motivation for learning. Analogies matched to developmental levels are more likely to result in effective learning partially because they are more likely to be interesting and accessible to the learner. For nearly 50 years (Oppenheimer, 1956), science educators have been concerned with how children use analogies to create new understandings in science. The purpose of analogy in science education is to effect conceptual change specifically in terms of new or attended understanding. A complex, boring class can be transformed into simpler and more interesting class wherein students can connect with their past experiences and construct the own knowledge, ideas, relate the new knowledge with old one (analogy) and come up with new ideas.

Story-telling in Teaching of Science—A Practical Experience

This approach was used during practice teaching wherein the pupil-teacher used Story-telling as constructivist tool to explain the concept of translation of DNA. Instead of starting the class in usual inductive manner, the teacher narrated the story about the candy factory and corelated with translation process. This not only enhanced the aesthetic aspect of pupil and teachers, but the 'affective domain' which is always seen as a neglected aspect in science teaching. The use of figurative language, to explain aesthetic ideas can be combined with logical analytical reasoning of sciences. This also supports the constructive point of view cementing the thought that the multiple realities and multiple understandings can coexist.

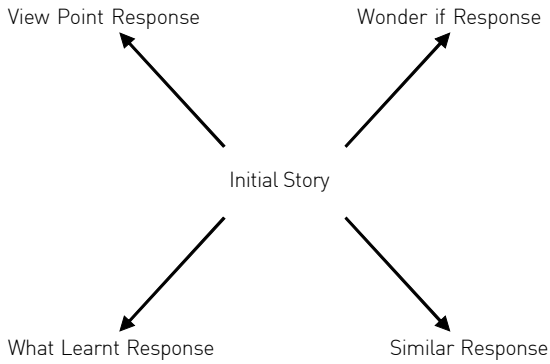
The teacher started the lesson with narration of story about David the boss, who owns a candy factory. "David is a rich man who has candy factory and he makes delicious candies of the world. And he has the library of all the recipes stored in his office. As the recipes are with the boss David, similarly the recipe to make the protein is stored in the DNA (boss of the cell) and as the candies are produced in factory, the proteins are produced in the protein producing factories called the ribosomes, as messenger or

the peon would deliver the recipe of the candy to the workers from the office to the factory, same way the mRNA is the peon or the messenger in the cell which delivers the message from the DNA– the boss from the nucleus (office of the boss) to the ribosomes (factory)". Thus analogy between candy production and protein synthesis was established through this story.

This approach also agrees with Dynamicist theory which sees cognition as a multi-dimensional space all possible thoughts and behaviours that is traversed by a path of thinking (Van Gelder and Port, 1995)

Story-telling method can be further improvised by adding various dimensions to it as given by McDrury and Alterio's in 2003 as five-stage model of Story-telling.

- a "View Point Response", which explores different views.
- a "Wonder if Response", which considers all the different possibilities.
- a "What Learnt Response", which encourages students to think about the lessons learned.
- a "Similar Response", which calls for students similar experiences.



Story-telling is one of the constructive tool which can be used in science teaching, there are various other ways in which we can make our lessons interesting and effective. We just need to challenge our thinking and push ourselves a bit more beyond the envelope to make an impact.

References

Brown, J. S.; A. Collins and P. Duguid.1989. Situated Cognition and the Culture of Learning. *Educational Researcher, 18*, 32-42.

Bruner, J. 1986. Actual Minds, Possible Worlds. Cambridge, Harvard University Press, Massachusetts.

Bruner, J. 1990. Acts of Meaning. Cambridge, MA: Harvard University Press.

Bruner, J. S. 1996. *The Culture of Education,* Cambridge, MA: Harvard University Press.

Dearing, R. 1997. Report of the National Committee of Inquiry into Higher Education: Higher Education in a Learning Society. HMSO, London.

Dewey, J. 1991. How We Think. Prometheus Books, New York.

Driver, R.; H. Asoko.; J. Leach.; E. Mortimer and P. Scott.1994. Constructing Scientific Knowledge in the Classroom. *Educational Researcher*.

Gardner, D. 1999. Intelligence Reframed: Multiple Intelligences for the Twenty-first Century. Harvard Business School Press, Massachusetts.

Gentner, D. 1989. The Mechanisms of Analogical Learning. In S. Vosniadou and A. Ortony (Eds.), Similarity and Analogical Reasoning, pp. 119-241, Cambridge University Press, New York.

Gibbs, R. 1994. The Poetics of Mind: Figurative Thought, Language and Understanding. Cambridge University Press, Cambridge.

Glynn, S. M. 1991. Explaining Science Concepts: a Teaching-with-Analogies Model. In S. Glynn, R. Yeany and B. Britton (Eds.), The Psychology of Learning Science. Erlbaum, New Jersey.

Glynn, S. M. 1997. Learning from Science Text: Role of an Elaborate Analogy; College Park, MD: National Reading Research Centre.

Glynn, S.M. and T. Takahashi. 1998. Learning from Analogy-Enhanced Science Text. *Journal of Research in Science Teaching*, 35.

Harrison, A. G. 2002. Analogical Transfer – Interest is Just as Important as Conceptual Potential. Paper Presented at AARE, Brisbane.

Harrison, A.G. and D. F. Treagust.1993. Teaching with Analogies: a Case-study in Grade-10 Optics. *Journal of Research in Science Teaching*, 30.

Lave, J. 1988.*Cognition in Practice: Mind, Mathematics and Culture in Everyday Life,* Cambridge University Press, Cambridge.

McDrury, J. and M. Alterio. 2003. Learning through Story-telling in Higher Education: Using Reflection and Experience to Improve Learning, Kogan Page, London.

Moon, J. 2000. Reflection in Learning and Professional Development, Kogan Page, London.

McKillop, C. 2004. 'Stories About... Assessment': Supporting Reflection in Art and Design Higher Education through On-line Story-telling. Paper Presented at the 3rd International Conference for Narrative and Interactive Learning Environments, Edinburgh, Scotland.

Oppenheimer, R. 1956. Analogy in Science. *American Psychologist*, 11.

Schank, R. C. and R.P. Abelson. 1995. Knowledge and Memory: The Real Story. In R. S. Wyer, Jr. (Eds.), *Advances in Social Cognition,* Vol. VIII, pp. 1-85, Hillsdale, Erlbaum, New Jersey.

Van Gelder, T. and R. Port. 1995. "It's About Time: An Overview of the Dynamical Approach to Cognition." In *Mind as Motion: Explorations in the Dynamics of Cognition*. MA: MIT Press, Cambridge.

Yanowitz, K.L. 2001. The Effects of Analogies on Elementary School Students' Learning of Scientific Concepts. *School Science and Mathematics*, *101*, 133-142.

COMPLEXITIES ABOUT SIMPLE HARMONIC MOTION

H.C. Jain

Former Principal
Regional Institute of Education, Ajmer
National Council of Educational Research and Training

Study of Simple Harmonic Motion (SHM) is not as simple as it appears to be. It has a number of complexities. The present paper deals with the concepts held by experienced teachers pertaining to sign for displacement, velocity, and acceleration, its effect on speed during different time intervals and direction of acceleration while executing SHM Responses obtained in training programmes have been analysed and indicate several misconceptions. Treating the path of an oscillating pendulum along a straight line particulalry poses a lot of difficulty. In view of these concepts having direct implications on teaching to students, strategy for teaching the related concepts pertaining to SHM, in particular, and problem-solving, in general, using basic cocepts and principles has been emphasised.

Introduction

One of the instructional objectives in teaching Physics at Intermediate level is to facilitate the learners in developing problem-solving competencies. It affects the learners in a number of ways such as promoting knowledge development, critical thinking, searching logic, ability, seeing relationships, capability to analyse an unfamiliar situation and synthesis of different ideas in a given problem, divergent thinking, interpreting a concept, drawing fig.1 inferences and so on. All these competencies lead to construction of new knowledge instead of putting thrust on memorisation of facts, rules, principles, laws and derivation of formal. It is however, observed that many problem solvers, students and teachers both, jump to solve a problem by using a formula instead of starting from basic concepts and principles. A study in this connection pertaining to teach about simple pendulum was carried out for three years in training programmes. Total number of participants in the programmes were eighty. Each participant had an experience of teaching at + 2 level for not less than two years.

Teaching about simple pendulum at +2 level includes key points such as simple harmonic motions under limited conditions, measurement and calculation of time period with varying lengths of pendulum, discussion on acceleration proportional to displacement and oppositely dissected, equation of simple harmonic motion, potential and kinetic energy and its transformation during oscillation of the pendulum and so on. Keeping these teaching points in view, following two problems were taken-up in order to determine teachers concepts during the training programmes.

Problems

(I) For simple harmonic motion represented as in Fig. 1, write the sign for displacement, velocity and acceleration for different time intervals viz. (0 –T/4), (T/4 – T/2), (T/2 – 3 T/4)

and (3 T/4 – T) and also mention if the speed is increasing or decreasing.

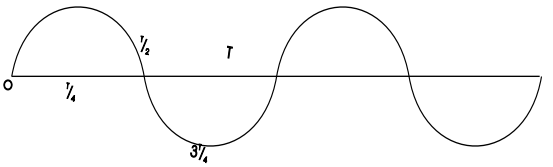


Fig. 1

(2) Draw the direction of acceleration for the care of a simple pendulum for the positions A, B, C, D and E (Fig. 2). Give reason for the same.

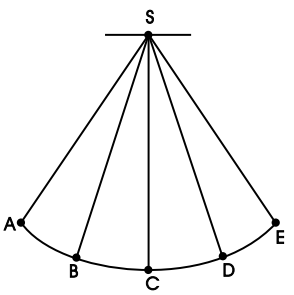


Fig. 2

Analysis of Responses (Problem 1)

Table1 gives the percentage of correct responses for question number (1), obtained from the participants along with the carried answer in the bracket:

These responses followed by discussion indicated that:

(i) Mostly the participants thought the solution to this problem taking into consideration an oscillating pendulum. For the time interval (0 – T/4), 97.5 per cent considered the displacement to be positive because of its being in the positive direction with respect to mean equilibrium position. However, only 67.5 per cent considered velocity to be positive and 68.7 per cent thought acceleration to be negative thinking that the speed of the pendulum is seen to be decreasing during this time interval.

(ii) Relatively smaller percentage of about 66.2 per cent considered displacement to be positive during the time interval (T/4 – T/2). Rest of the participants considered the displacement from the extreme position at T/4 and took it therefore, to be negative. Interestingly while 67.5 per cent correctly considered the speed to be increasing as per observations, only 38.8 per cent and 40 per cent considered the velocity and acceleration respectively to be negative. Others thought them to be positive because of increasing speed for this time interval.

Table 1: Responses of Participants

Time Interval	Displacement	Velocity	Acceleration	Speed
$0 - T/4$	97.5 (+)	63.7 (–)	68.7 (–)	67.5 (Decreasing)
$T/4 - T/2$	66.2 (+)	67.5 (+)	40 (–)	67.5 (Increasing)
$T/2 - 3T/4$	73.7 (–)	38.8 (–)	43.7 (+)	66.2 (Decreasing)
$3T/2 - T$	71.2 (–)	50 (+)	75 (+)	66.2 (Increasing)

(iii) For the time interval (T/2 – 3T/2), 73.7 per cent participants correctly considered the displacement to be negative as it was in negative direction with repeat to mean equilibrium position. Also, 63.7 per cent correctly considered the velocity to be negative but 43.7 per cent rightly considered acceleration to be positive. Other participants wrongly thought the acceleration to be negative because of decreasing speed for this time interval.

(iv) For the time interval (3T/4 –T), 71.2 per cent correctly thought the displacement to be negative because of its being in negative direction with respect to mean equilibrium position. Other wrongly thought it from the extreme position at 3T/4. While only 50 per cent correctly thought velocity to be positive, a large percentage of about 75 per cent also correctly considered acceleration to be positive because of increasing speed towards the mean position from the position at 3T/4.

Conceptual Approach

These results indicate that while solving this problem, one may treat the pendulum to be oscillating in a straight line. Besides,

(a) Emphasis on considering reference point (in the present case the mean position) to be the same for all time intervals has to be made while determining the sign for displacement.

(b) For determining the sign for velocity, the direction of the change in displacements per unit time with respect to mean position together with their magnitude is to be considered. To do so, two displacement vectors, one corresponding to any instant in a given time interval and another corresponding to an instant preceding to it in the same time interval with respect to mean position can be drawn and their difference can be obtained.

(c) For determining the sign for acceleration, the direction for change in velocity per unit time together with its magnitude should be considered. To do so, two velocity vectors, one corresponding to any instant in a given time interval and another corresponding to an instant preceding to it in the same time interval, both with respect to mean position can be drawn and their difference can be obtained.

Alternatively, if one is familiar with the curves for displacement, velocity and acceleration with respect to time, these can be drawn and the sign for each of them during any time interval can be obtained.

Another method for determining the sign for each of them can be making use of simple calculus.

Equation viz. $x = A \sin \omega t$, $u = \omega A \cos \omega t$ and $a = -\omega^2 A \sin \omega t$ can be used to obtain the desired results.

Analysis of Responses (Problem 2)

Responses obtained from the participants to question number (2), pertaining to direction of acceleration in case of a simple pendulum at different positions can be categorised as follows:

(i) Acceleration is towards the mean position and directed along the path (66.3 per cent).

(ii) Acceleration is towards the mean position and directed horizontally at the given point (15 per cent).

(iii) Acceleration is towards the mean position and tangential at the point under consideration (11.3 per cent).

(iv) Acceleration is towards the suspension point (1 per cent).

(v) No Response (6.3 per cent).

It is thus evident that a number of misconceptions exist regarding the direction of acceleration in case of a simple pendulum. Studies conducted at the international level also indicate the same. One of the basic reasons regarding these misconceptions during the discussion with the participants indicated that motion of the simple pendulum is considered to be a straight line which strictly speaking is not the case. Another important reason is considering acceleration to be proportional to the displacement and oppositely directed which is really the case if the pendulum had been oscillating along a straight line.

Conceptual Approach

To overcome the above situation, following questions are relevant so as to arrive at the correct result for determining the direction of acceleration:

(i) Is the motion of a simple pendulum stately a straight line?

(ii) If not what is the nature of the path executed by a simple pendulum?

(iii) How is acceleration defined?

(iv) Through discussion, it may be inferred that the path of the pendulum is an arc of a circle and the acceleration is the change in velocity per unit time. Then another question of significance can be posed viz, Is the speed of the pendulum constant while executing the motion during the period O to T ? Obviously, since the speed is not constant, it may be discussed that magnitude as well as direction of velocity, both, are changing with time and acceleration in that case can't always be towards the suspension point. To understand it further, one may ask to draw a vector (u1) representing velocity at a slightly later time. The direction of difference of these vectors (u1–u) will give the direction of acceleration during the time interval between the two points. It will be seen that the direction of acceleration will be as shown in the Fig. 3 given below:

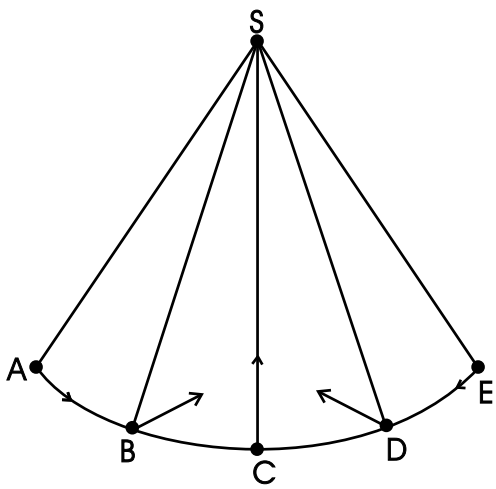


Fig. 3

Suggestions

It is obvious that teachers misconceptions have direct implications on teaching to students. As a

remedial measure, it is suggested that before taking up problem-solving, interpretation of a concept or principle should be adequately discussed. The conditions under which the same is applicable should also be thoroughly explained. The concept 'idea first and name after words' is a correct strategy for achieving it. Otherwise, the difficulty of correct interpretation along with complexities in problem-solving will always arise and one will have to deal with both of them for all the times.

References

National Curriculum Framework–2005, National Council of Educational Research and Training, New Delhi.

Physics Part II, Class XI, National Council of Educational Research and Training, New Delhi.

Jain, H.C. 1996. Development of Problem-solving Competencies in the Classroom, *Bulletin of The Indian Association of Physics Teachers*, 211-213.

Jain, H.C. 2011. Fostering Scientific Temper, Neelkamal Publication Pvt. Ltd., Hyderabad.

Raif, F. 1944. Milliken Lecture : Understanding and Teaching Important Scientific Thought Processes.

PARTICIPATORY VIDEO FOR DEVELOPING SPIRIT OF INNOVATION IN SOCIO-ECONOMICALLY UNDERPRIVILEGED HIGH SCHOOL STUDENTS

Vedavati Ravindra Jogi
Media Professional
5, 'Om-tat-sat' Apartment, 212/50
Rambaug Colony, Navi Peth, Pune

Many centuries ago Aristotle had observed, 'What we have to learn, we learn by doing'.
However, quite contrary to this observation, in typical Indian Education system, which is mainly examination-centric, learning science in school is by rote, which is the most unscientific way of learning science !
Learning by rote may fetch marks but can neither create scientific temper nor can develop scientific mindset.
Breaking away from the conventional path of producing video films for children with professional support, the author has tried to tap the spirit of innovation and creativity in children themselves to produce video clips that have a direct relevance to their studies.
The present paper discusses, the objectives, methodology, observations and inferences that could be drawn from personal observations and the products, viz., video clips created by the students which throw light on how video with participatory approach can bring about qualitative change in participating student's personality as a 'student of science'.

Introduction

While conducting her research for Ph.D., this author came across very disturbing facts regarding the science education of students coming from socio-economically underprivileged community. Some of these facts are as follows :

- As these students speak rustic form of dialect, they find it difficult to understand scientific language in their science textbooks. Hence, understanding of basic concepts was found to be poor.
- They don't find content in the science book interesting, relevant and useful in their day-to-day life which make them absolutely passive learners in the class.
- Concepts not understood in each standard, go on accumulating to such an extent that, by the time students reach high school, they are unable to understand even 10 per cent of the new concepts taught in the school.
- Questions asked in routine school examinations, judge only memory-based knowledge which encourages mugging.
- Science practicals too, are carried out in most unscientific way in which students don't explore, instead they just go to laboratory and perform as per instructions given by their teachers. This can not create spirit of enquiry in students.
- They cannot relate to science programmes shown on channels like Discovery or science

clips shown on news channels mainly due to language barrier.

What they Need are Some Tools

- The tools will give them experience of learning and will make them active partners in education processes.
- Will create suitable environment for their thinking and reasoning faculty to develop.
- They can relate easily.
- They can easily use. There should not be any language or any other barrier.
- Will provide them stimulation required to stay at school and help them to understand the subject and teach them to apply that acquired knowledge.
- Will help to shape up their personality as a science student who possesses spirit of enquiry.

Camera in the hands of a learner

Thought behind the Experiment

Developing video requires creative and communication skills. Creativity involves originality, which generates invention. Hence, actually getting learners, coming from underprivileged community to create video, would be more effective than use of educational videos produced by professional. This was the thought behind the experiment.

Experiment Done by the Author

The author carried out the experiment in Swami Vivekanand High School, village Asade in Mulashi Tehsil in Pune district of Maharashtra. She, herself a media professional, trained 64 students studying in Classes VIII and IX, all from socio-economically underprivileged community in videography. Two days Workshop was conducted for them and with low-cost video equipment, they were introduced to basic knowledge of skills like video camera operations, editing, direction and script writing using different formats like documentary, drama, etc.

Then they were divided into five sub-groups comprising of approxmately 12-13 students in one

sub-group showing interest and skills in different video production activities. Each group chose topics from their science textbooks, developed scripts under the guidance of the author and their science teachers and produced video films on a selected concept.

Shooting was done with two cameras. One was handled by an expert cameraman and another was handled by students. Thus, five films on concepts in science textbooks for Classes VIII and IX were produced by these students under the guidance of the author and teachers.

At the time of editing, though students did not operate the machine, they drafted the editing script and were sitting next to the professional editor for getting the editing of the films done. Thus, content selection, script development, preparing required material for the film, recording, editing, everything was done by students very enthusiastically.

All the 64 students viewed their own film as well as films produced by other groups and tried to evaluate their own work.

Some Observations

(1) Students were quite receptive to video technology. Glamour associated with video medium provided required stimulus for study.

(2) While developing a film, students discussed the subject, communicated with teachers and themselves removed obstructions in learning process, which made learning process very interesting for them.

(3) Students felt the need to visit school library while in search of visuals for the film.

(4) Even those students who didn't possess good reading and writing skills could participate in video production wholeheartedly and could acquire knowledge overcoming literacy handicap.

(5) While developing a script on 'Chemical Bonds' students did lots of brainstorming which made them understand their problem in studying Chemistry that , 'there are too many names of elements, compounds, etc., in Chemistry. Too much of informations lead to confusion.'

Understanding a problem was the first step towards solving it.

Students dramatised the theory, personified the elements and compounds, called each other by the names : Mr Chlorine, Mr Oxygen, Miss Hydrogen, etc., and wore the name-plates. Thus, while rehearsing and shooting this film, theory was automatically learnt by heart.

(6) While developing a script on the topic 'Force and Pressure', brainstorming made students understand that, 'Physics is not an information-based science'. Instead, concepts and logic behind them are of prime importance. If those concepts are not clear then mugging of theory is also not possible.

Hence, they chose drama-in-classroom format in which a teacher (role played by a student) performed 'Practicals' and students 'Asked' questions. Reflection of student's educational communication needs was found in the reason behind choosing

Cooperative working attitude displayed by students while working. Discussion, brainstorming never happen in routine school activities

this format. According to them this was the teaching coupled with practical and was the 'ideal way' of learning Physics—which does not happen in their routine class.

(7) In another film on 'Acid-Base-Salt' (Chemistry), neutralisation reaction in which 'acid and base chemically react with each other to form salt and water ' was picturised as , 'fighting between acid and base leading to disappearance of two and water and salt appeared on the screen' which gave naughty playful touch appropriate to their age, to the whole theory. This can be termed as the best example of *Science through child's eye* .

(8) In a seven minutes film on the concept, 'Balanced and unbalanced force', blend of two formats —documentary and drama— was used for presentation. Initially an anchor (role played by a student) shows many acts like shifting a book, opening a box, throwing a ball, etc., to create curiosity in the minds of viewers.

Then she asks the audience, 'Have you recognised me? I am force!' Same way, balanced and unbalanced forces (roles played by two IX Class girls) introduce themselves to the audience by means of a very simple yet apt examples of game *Rassikhech* played by children.

Two groups of girls try to pull the rope standing face-to-face in opposite directions to each other. When rope remains at the centre, i.e., there is no displacement of rope in either of the sides then it shows that girls from both the sides have applied the same force.

Inversely, when either of the groups applies more force, rope is pulled towards that side showing presence of unbalanced force.

Each and every participant gave equal contribution. They rewrote the script five times and thus showed great perseverance. They rehearsed the complete programme many times and hence could complete the task in lesser time than other groups. Drama rehearsals helped students to learn the theory by heart, which otherwise they do unwillingly by mugging, that too, without understanding the theory. It proved that, students do any activity voluntarily only when they 'feel the need' to do so.

(9) For a seven minutes film on Newton's laws of Class IX, Physics format used was musical drama. Film opens with a group of students singing Newton's 'Powada' (An age old famous Maharastrain folkart). One-by-one two lines of 'Powada' are sung on different concepts like inertia, motion, conservation of momentum, action-reaction, etc. After each song, students present video capsule showing relevant visuals of that concept with suitable examples in drama format. Student realised that Physics is not information-based subject, instead, concepts and logic behind them are of prime importance.

Brainstorming helped students to remove obstructions in their learning process and made them understand the relevance of the science in their day-to-day life.

Evaluation

The processes used in the evaluations are observations, interviews, test, etc. Evaluation of the project was done on the basis of following criteria :

(1) Qualitative changes in student's personality was judged from following factors:

(a) Motivation (urge for self-development, curiosity, exploration, persistence, novelty)

(b) Cognitive (attentiveness, memory retention, imagination)

(c) Acquired skills (communication, science process skills, self-evaluation, critical as well as divergent thinking, problem-solving tactics)

(d) Habits (reading books, watching educational TV programmes, showing interest in practical work)

(e) Abilities (concentration, goal-setting, decision-making)

(f) Rise in self-confidence.

In one production process, we cannot expect total change but there was definitely positive qualitative change observed in students' personalities. Considering the factors mentioned above we found that:

- After viewing the films, all the participating students* tried to evaluate their own work and expressed their feelings that 'Next time we will do better job. We will correct the mistakes which we have committed this time.'
- This type of 'urge for self-development' is never displayed by them in regular school sessions.
- While developing from scripts for the films, students realised that they need to understand certain concepts which they had studied in previous standards and 'had not understood at that time'. So they referred to previous standard books, and tried to understand those concepts, which they never do in their routine school work.
- Students started using school library.
- Their active involvement in day-to-day classroom activity increased. They started

* Most important point to be mentioned here is "Not all students who could think and solve those tricky problems are otherwise good scorers in routine school examination."

demanding more number of practical sessions in their school.

- They searched for good science programmes on television and found that 'there are no good science programmes for high school students'. They expressed their desire to see science-based programmes on TV in their own mother tongue 'Marathi'.

(2) To measure Quantitative changes, after preview session, students were given a test based on concepts taught through films. Test comprised of both objective as well as subjective questions judging understanding and application of the acquired knowledge and science process skills like observing, inferencing, analysing, etc. Instead of asking direct question like, 'Explain Archimede's Law', which judges memory and which is usually asked in any routine school examination, students were asked questions judging 'understanding' and 'application of gained knowledge'. These students had never come across such type of questions which would require them to 'think'. For example :

Q. (A) Students were asked to measure the volume of the paper-weight without using scale. Sixty-six per cent of the students who had produced film on Archemede's Law could solve this question. Thirty-one per cent students who 'watched' this film could solve this question. While, those students who had neither watched nor produced the film could not even 'think' over this problem. Their result was 0 per cent.

Q. (B) If a glass chip is immersed in water, it displaces 140 cc water, then which of the following can be the dimensions of the chip?

a) 10, 7, 2 cm, b) 15, 4, 7 cm, c) 14, 4, 5 cm

Seventy-one per cent students who had produced this film could give correct answer. Thirty-three per cent students who had watched this film could answer correctly. But again, those students who had neither watched nor produced the film could not even 'think' over this problem. Their result was 0 per cent.

Conclusion

It is as found that in the approach, adverse factors like, communication gap, use of symbols/ examples not familiar to students, volume of content which student cannot grasp at that time were considerably reduced.

Many students who can't score well in science in routine school examination are looked upon as dullards, which is wrong because all the aspects of intelligence are not judged in routine school examination, e.g. science process skills.

This study showed the importance of participatory video activity in science education.

Video production process requires synchronising physical and mental processes, which is vital for learning science. It is possible to sharpen various skills like communication, science process skills, etc., and shape up attitude, e.g. co-operative working attitude, urge for self-development in the process of acquiring proficiency in various tasks in video production.

Students can be in control of their own learning according to their own needs, own speed and

capacity to grasp the concept and apply that acquired knowledge in practice. While looking through camera lens, students can grasp exactly 'What is to be focused and while editing a film they understand' what is to be picked up and highlighted, in effect, they realise— 'what is to be studied'.

Thus, learning happens naturally.

Foundations of participatory video activity are participation rather than passive learning, Suitable visuals rather than verbal explanation and exploration rather than mugging.

Thus, with the help of participatory video, school education should be remoulded to the mode of 'learning by discovery' and 'learning by doing'.

This experiment can be replicated in other schools for underprivileged students in India. Video network can be formed among schools run by Municipal Corporations or *Zilla Parishadas.*

PROJECTILE WITH AIR RESISTANCE

V.B. Bhatia
Professor of Physics (*Retired*)
215/21A, Faridabad

It is interesting to know what effect the resistance of air has on the trajectory of a projectile. Here, we compute the trajectories for various amounts of air resistance.

We all know that, in the absence of any air resistance, the path of a projectile is a parabola. What happens to the path if air resistance is taken into account? Does it depart substantially from parabolic curve? Let us explore these questions.

For an object moving fast in air, such as a cricket ball bowled by a fast bowler (~144 km/h, or, ~ 40 m/s), the resistance due to air, also called air drag, can be taken to be proportional to the square of the velocity. If drag coefficient is denoted by *D*, and the velocity with which the projectile is launched is $\vec{v}$, then the magnitude of the drag force is

$$F = Dv^2. \qquad (1)$$

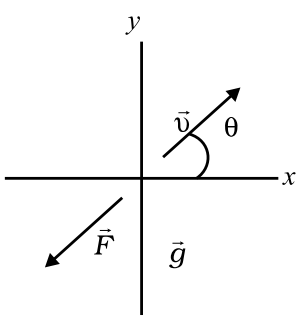


Fig. 1 : Showing all the relevant quantities

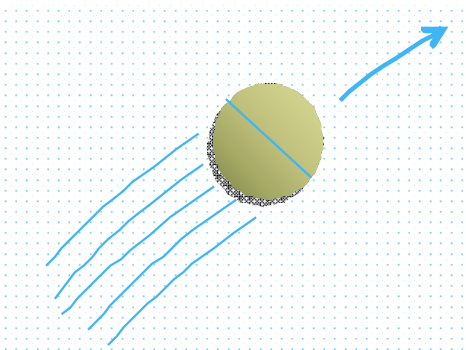


Fig. 2: A ball moving in air

The drag coefficient *D* depends on the area of the projectile facing the air in the direction of its motion and the density of air through which it moves. If *A* is the surface area of the projectile and ñ is the density of air, then drag coefficient can be written as:

$$D = C\frac{A\rho}{2}, \qquad (2)$$

where the constant C takes care of the shape and nature of the surface of the projectile and other factors are not included here. The value of C may vary between 0.1 and 1.0.

The direction of the resistance or the drag force is always opposite to that of the velocity $\vec{v}$ (Fig. 1).

While the components of the velocity vector are

$$v_x = v\cos\theta,\ \ v_y = v\sin\theta, \qquad (3)$$

the components of the drag force acting on the projectile are

$$F_x = -Dvv_x,\ \ F_y = -Dvv_y\ . \qquad (4)$$

Consequently, the acceleration experienced by the projectile along the *x*– and *y*– direction is

$$a_x = -\frac{Dvv_x}{m}, \qquad (5)$$

$$a_y = -g - \frac{Dvv_y}{m} \qquad (6)$$

where g is the magnitude of the acceleration due to gravity and *m* is the mass of the projectile. Notice that, in accordance with the usual convention, all quantities measured upwards are taken as positive and those in the downward direction are taken as negative. Notice also, that the appearance of *D* and *m* in the expression for the acceleration will make the trajectory of the projectile depend on the mass and radius of the projectile. Recall that in the absence of any resistance these two factors do not come into our calculation of the trajectory.

Having got the expressions for the velocity and acceleration components, it is easy to write an algorithm to compute the trajectory. The algorithm can be converted into a computer programme, too.

We specify the initial position (*x*, *y*), mass and radius of the projectile along with the constant *C*. Specifying the initial velocity with which the projectile is launched and the angle at which it is launched, v_x and v_y can be found. These lead to the knowledge of a_x and a_y (Equations 5 and 6). We choose a suitably short interval of time during which we can assume the acceleration to remain constant. At the end of this interval

$$v_x \to v_x + a_x\Delta t \qquad (7)$$

$$v_y \to v_y + a_y\Delta t\ . \qquad (8)$$

The *x*-and *y*-coordinates advance to

$$x \to x + v_x\Delta t + \frac{1}{2}a_x(\Delta t)^2 \qquad (9)$$

$$y \to y + v_y\Delta t + \frac{1}{2}a_y(\Delta t)^2\ . \qquad (10)$$

The new velocity found in Equations 7 and 8 is fed back into Equations 5 and 6 to get the new acceleration. Steps 7, 8, 9 and 10 are then

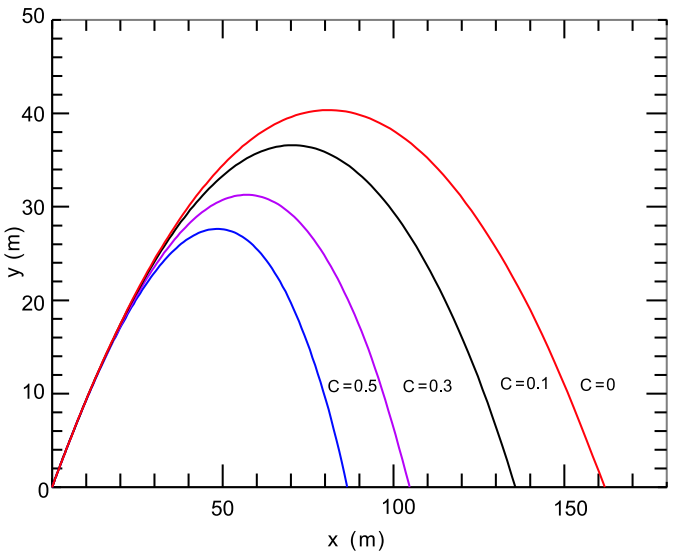


Fig. 3 : The trajectories of a projectile with varying resistance of air

repeated. The process is repeated a number of times and y is plotted against x to get the trajectory.

The trajectories in Fig. 3 have been plotted for a cricket ball travelling at a velocity of 40 m/s (144 km/h) at an angle of 45° to the horizontal. The data was generated by a computer programme. The mass of the cricket ball is taken as 0.160 kg and its radius as 0.0360 m (these are typical values). The value for the density of air has been adopted as 1.22 kg/m^3, appropriate for sea level at 15 °C. The values of the constant C are shown along each curve.

Conclusion: It is clear that the resistance due to air, at least in the case of high velocity projectiles, cannot be ignored while computing their trajectories. Not only does the projectile not reach its expected height, its range is also considerably reduced. Moreover the trajectory of the projectile becomes dependent on the mass and the shape of the projectile.

Here is a simple programme in power basic for computing x and y, which you can plot:

```
x = 0:y = 0:m = 0.160:rho = 1.22:r = 0.036:v = 40:g = 9.8: π = 3.14159:th = 45:t = 0  c = 0.5
d = rho*c* π *r*r*0.5:thd = π /180*th
vx = v*cos(thd):vy = v*sin(thd)
for i = 1 to 360                                   (start of loop)
 ax =  – d/m*v*vx:ay = – g – d/m*v*vy              (updation of acceleration components)
 t = t + 0.0001                                    (updation of time, time step should be small)
 vx = vx + ax*t:vy = vy + ay*t                     (updation of velocity components)
 x  =  x + vx*t + 0.5*ax*t*t:y  =  y + vy*t + 0.5*ay*t*t   (updation of position coordinates)
 if (int(i/20) = (i/20) then print x,y             (prints every twentieth value)
 v = sqr(vx*vx + vy*vy)                            (updation of velocity magnitude)
next I                                             (end of loop)
```

By adding a few lines to the programme you can actually plot the curves, rather than noting x,y.

EXPLORING MATHEMATICS ON YOUR OWN

R.P. Maurya
Department of Education in Science and Mathematics
National Council of Educational Research and Training, New Delhi

The present article illustrates that how mathematics can be explored by an individual. As mathematics relies on logic and reasoning, the reasoning has been dealt in two ways, namely; inductive and deductive. These two have been shown through activities. The article also discusses about various branches of mathematics through some interesting examples, patterns, conjectures and also shows use of mathematics in every walk of life. It also highlights the historical development of some important disciplines/concepts in mathematics.

This is Mathematics

Why has Mathematics become so important in recent years? Why are industrialists and politicians so concerned about the shortage of Mathematicians? Can the new electronic brains solve our mathematical problems faster and more accurately than a person and eliminate the need for Mathematicians?

To answer these questions, we need to know what Mathematics is and how it is used. Mathematics is much more than arithmetic, which is the science of numbers and calculations. It is more than algebra, which is the language of symbols, operations and relations. It is much more than geometry, which is the study of shapes, sizes and spaces. It is more than statistics, which is the science of interpreting data and graphs. It is more than calculus, which is the study of change, limits and infinity. Mathematics includes all of these and much more.

Mathematics is a way of thinking and reasoning. Mathematics can be used to determine whether or not an idea is true, or at least, whether it is probably true. Mathematics is a field of exploration and invention, where new ideas are being discovered everyday. It is the way of thinking that is used to solve all kinds of problems in the fields of science, government and industries. It is a language of symbols that is understood in all civilised nations of the world. Also, Mathematics is a language of precision and accuracy. It has even been suggested that Mathematics would be one of the language that would be understood by inhabitants of Mars (if there are any). It is an art like music, with symmetry, pattern and rhythm that can be very pleasing.

Mathematics has also been described as the study of patterns, where pattern is any kind of regularity in form or idea. This study of patterns has been very important for science because pattern, regularity and symmetry occur so often in nature. For example, light, sound, electric currents, magnetism, waves of the sea, the flight of a plane, the shape of a snowflake and the mechanics of the atom all have patterns that can be classified by Mathematics.

Mathematics in Our World

If we look back at the story of civilisation, we will find that mathematics has always played a major role.

It has been the means of:

measuring property boundaries

predicting the seasons

navigating ships

building homes and bridges

drawing maps

developing weapons and planning warfare

understanding the motion of heavenly bodies

increasing trade and commerce.

During our lifetime, mathematics has been the tool for:

discovering new scientific principles

inventing new machines

creating electronic brains

developing strategy in games

directing traffic and communications

making new vaccines and medicines

harmless atomic energy

navigating in space

discovering new ores

forecasting the weather

predicting population growth.

Not everyone can be mathematician or a scientist, but in order to understand our modern world, it is necessary to know something about mathematics. This knowledge should make you more successful in school, at home, or in your future vocation. Just to be a good citizen in a nation when all these changes are taking place will require a knowledge of some mathematics. Certainly, people in our government must be mathematically informed, if they have to make wise decisions in our complex world of new ideas. Of course, if you are interested in a career in science, statistics or engineering, which are based on mathematics, you will need to become an expert in the field. Today, there is a great demand for mathematicians to do research, teach or find new applications of mathematics. The professional mathematicians of the world has often played an important role in the building of our civilisation. The methods of reasoning used by the great mathematicians of the world and the products of their logic are more important than ever in our present culture.

About Arithmetic

We are aware that arithmetic is a logical mathematical system. But arithmetic began as a language to answer questions about man's everyday life. To answer these questions, it was necessary to invent numbers and measures and a way of combining and comparing these numbers. This finally led to the development of the science of numbers of arithmetic.

It took a man a long time to invent a workable system of symbols for numbers. These symbols for numbers are called numerals. People worked for a long time before a zero symbol was invented. We know that our base ten numeration system, which uses the place value principle, is much better than many ancient systems of numeration. But our system is not only the system, nor it is necessarily the best one. Some people feel that a numeration system using twelve basic symbols would be superior to our base ten system. Another numeration system, called the binary system, which uses only two symbols, 0 and 1, has found use in new computers and other electronic devices.

Binary Numbers

0 zero	100 four
1 one	101 five
10 two	110 six
11 three	111 seven

The study of numbers has always been a fascinating topic. Even the most common numerical problem can suggest new questions or ideas. See if you can explain the method used in solving the following division problem:

$$
\begin{array}{r|l}
23 & 552 \\
\hline
 & 230 = 10 \times 23 \\
\hline
 & 322 \\
 & 230 = 10 \times 23 \\
\hline
 & 92 \\
 & 92 = \ 4 \times 23 \\
\hline
 & 24
\end{array}
$$

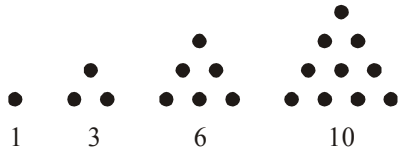
$552 \div 23 = 10 + 10 + 4 = 24$

We can often find unusual numerical patterns that give new insight into number relations. A good illustration is the pattern of multiples of 9.

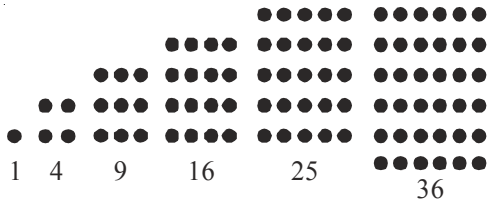
1×9	$= 9$	$0 + 9 = 9$
2×9	$= 18$	$1 + 8 = 9$
3×9	$= 27$	$2 + 7 = 9$
4×9	$= 36$	$3 + 6 = 9$
5×9	$= 45$	$4 + 5 = 9$
6×9	$= 54$	$5 + 4 = 9$
7×9	$= 63$	$6 + 3 = 9$
8×9	$= 72$	$7 + 2 = 9$
9×9	$= 81$	$8 + 1 = 9$
10×9	$= 90$	$9 + 0 = 9$

Note how the tens digit goes up from 1 to 9 while the units digit goes down from 9 to 0. After 45, the products are the previous numerals written backwards.

There are many other interesting number patterns. For instance, triangular patterns can be used to represent numbers like 1, 3, 6 and 10.



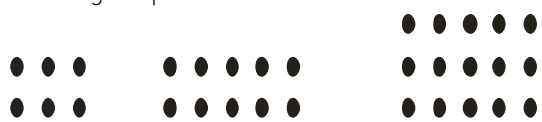
Then there are patterns of squares that represent numbers like 1, 4, 9, 16, 25, 36, 49, 64, 81, 100.



A strange relationship for square numbers is that they are equal to the sum of consecutive odd integers (whole numbers), like this:

$$4 = 1 + 3$$
$$9 = 1 + 3 + 5$$
$$16 = 1 + 3 + 5 + 7$$

Some numbers, like 6, 10, 15 can represented with a rectangular pattern.

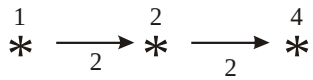


$2 \times 3 = 6$

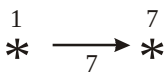
Some numbers, such as 2, 3, 5, 7, 11 and 13, cannot be used to form either squares or rectangles. These numbers have no divisors except themselves and 1 and are called prime numbers. Mathematicians have been trying for many years to find relationships between prime numbers so that they could write a formula to describe these numbers and tell how to find them. No one has yet found a formula that will give all

the prime numbers. Hence a good part of the work with prime numbers is still inductive.

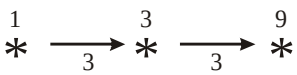
Let us examine some interesting prime number patterns. If we use an arrow (⟶) to represent a prime number as a multiplier, and asterisk (*) to represent a product, we can make drawings to show that every whole number is the product of prime numbers beginning with 1.



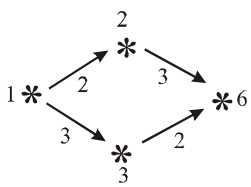
This diagram tells us that 1 × 2 = 2 and 2 × 2 = 4. The pattern for 7 is



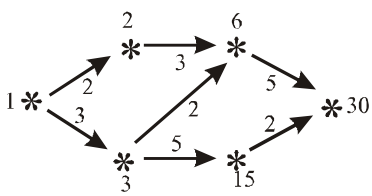
While the pattern for 9 is

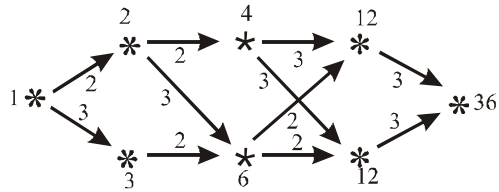


But, 6 can have two different paths, like this:



Note that the length of the arrows is not related to the size of the multiplier. Other patterns might look like this:





What kind of numbers have a straight line as a pattern? What kind of numbers have a complex figure as a pattern?

These examples illustrate how the patterns found in number relationships are of interest to mathematicians. The theory of numbers, a field of mathematics concerned with the study of number patterns, has been responsible for the discovery of many new mathematical ideas. We see that simple arithmetic can be the basis for many intriguing mathematical ideas and relationships.

Here, we would like to give some examples based on reasoning.

Example 1: There are between 50 and 60 eggs in a basket. If I count them out 3 at a time, I have 2 left over, but if I count them out 5 at a time, I have 4 left over. How many eggs are there in the basket?

Answer: 59 eggs

Example 2: Three men who share a food are charged ₹ 10 each or ₹ 30 in all. The manager, after some reflection, decides that he has overcharged them, since they are sharing the food, so he gives a servant ₹ 5 to return to them. The servant, not being able to divide ₹ 5 into three equal parts, pockets ₹ 2 for himself and returns only ₹ 1 to each man. That makes the food cost for each man ₹ 9 or 27 for all three. If we add this ₹ 27 to the ₹ 2 the servant keeps, we get a total of ₹ 29. Yet the men paid ₹ 30. Where is other ₹ 1?

The men paid ₹ 27, of which the manager got ₹ 25 and the servant ₹ 2.

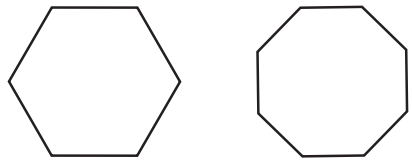
Example 3: A king who wishes to choose a prime minister decides to test the mentality of the three top candidates for the position. He tells the candidates that he will blindfold each one and then mark either a red cross or a blue cross on the forehead of each. He will then remove the blindfolds. Each candidate has to raise his hand, if he sees a red cross and drop his hand when he determines the colour of his own cross. The king, then blindfolds each candidate and proceeds to mark a red cross on each forehead. He then removes the blindfolds. After looking at each other, the prospective prime ministers raise their hands. After a short time, one candidate lowers his hand and says, 'My cross is red', and gives his reasons. Can you duplicate his reasoning?

Suppose the candidates are A, B and C. A reasons that if he had a blue cross, then B or C would immediately know that they had a red cross. Since B and C would not determine their colour, A must also be marked with a red cross. This is an example of indirect reasoning.

The World of Mathematics

Let us try an experiment with geometrical figures. Draw several geometrical figures with different numbers of sides, as shown in the following figure:

Triangle Rectangle Pentagon



Hexagon Octagon

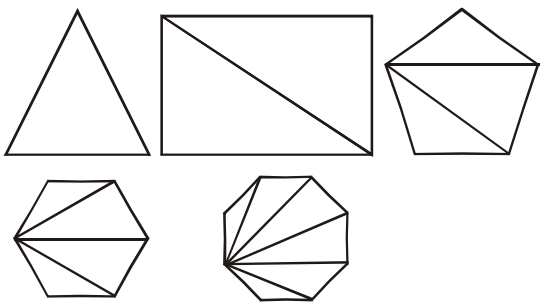
Measure the angles of these figures. We should get results like these:

Figures	No. of sides (n)	Sum of internal angles (S)	No. of st. angles (180°) in each sum
Triangle	3	180°	1
Rectangle	4	360°	2
Pentagon	5	540°	3
Hexagon	6	720°	4
Octagon	8	1080°	6

How does the number of sides of each figure compare with the number of straight angles? This table suggests the following conclusion: 'The sum of the measures of the angles of a geometrical figure equals the product of 180° multiplied by 2 less than the number of sides (n – 2)'. This could be written as a formula, $S = (n - 2)\,180°$

This experiment is the example of the inductive method. When using this method, it is necessary to repeat the measurements many times to see if the same pattern is always obtained. Of course, it is impossible to work with all possible geometrical figures, and sometimes our measurements are not exact. This means that we cannot be sure that our conclusion will apply to every geometrical figure. Thus, the inductive method gives an answer that is only probably true.

However, we can arrive at a conclusion by using a different method. Let us divide the geometrical figures into triangles as shown in the following figure:



Here, we make the assumption that a geometrical figure can be divided into $(n - 2)$ triangles, a number of triangles that is 2 less than the number of sides. From our previous experiment with triangles, we assume that the measures of the angles of a triangle add up to 180°. It is also assumed that the angles of any geometrical figure will be made up of the sum of the angles of the triangles into which it can be divided. Then, we can conclude that the measure of the angles of any geometrical figure is $(n - 2)\,180°$.

Reasoning: Let us examine the reasoning just used. We started with several ideas that either assumed to be true or had previously established. Then, we use these ideas to reach a conclusion by the force of reasoning. No measurements were made. By starting with an assumption about the number of triangles in any geometrical figure, we found a specific conclusion about the angles of any geometrical figure. Such a method of logical reasoning is called deductive reasoning. By deductive reasoning we obtain a specific conclusion from other ideas or assumptions.

Of course, the truth of our conclusion depends upon the truth of the starting assumptions and ideas. Here is another, very simple example of deductive reasoning. Suppose, we assume every pupil in the fourth standard takes mathematics. If we know that Anshu is in the fourth standard, we can deduce that Anshu is taking mathematics. This specific conclusion is dependent upon the assumption with which we started our reasoning. Of course, we can be certain that our conclusion is true only if our original assumption that all fourth formers take mathematics is true.

Reasoning, Logic and Proof in Mathematics

We have examined two types of reasoning used in mathematics. We will see that both are useful, but both also have some drawbacks. Inductive reasoning is useful in making discoveries. If the examples considered are not representative or are misinterpreted then it can lead to false conclusions. Deduction will produce correct conclusions when you start with correct assumptions. These two methods are often used together in mathematics: induction to develop acceptable assumptions, deduction to derive true conclusions from the assumptions.

Man's first experience with mathematics was of an inductive nature. The ancient Egyptians and Babylonians developed many mathematical ideas through observation and experimentation and made use of this mathematics in their daily life. Then the Greeks became interested in philosophy

and logic and placed great emphasis on reasoning. They accepted a few basic mathematical assumptions and used them to prove deductively most of the geometrical facts we know today. Hence of deductive proof became an important part of mathematics.

Since the time of ancient Greeks, deduction has been the most important type of reasoning used in mathematics.

However, mathematicians, like scientists, still discover new ideas from hunches, intuition, analogies, guesses and experiments. Then they work out rigorous proofs to check the truth of new ideas. This formal proof leaves nothing to the imagination. They use assumptions and definitions and previously proved statements to prove new statements. Usually they do not say, 'Such and such is true'. Instead they make statements like, 'If A is true, then B is true'. And they realise that the conclusion B, depends upon the starting assumption A, and might be true only in the world of mathematics with no apparent application or illustration in the physical world. For example, by using a logical proof, two Polish mathematicians, Stefan Banach and Alfred Tarski, have proved, from a mathematical stand point, that a solid sphere of the size of a pea could be divided into a finite number of pieces and then reassembled into a sphere of the size of the sun. No wonder mathematics is considered an unusual science.

Some Unsolved Mathematical Problems

Although we usually think that mathematics is an 'exact science' which solves all problems, but there are a number of mathematical problems, that are still mysteries to mathematicians.

1. **The Prime Number Mysteries:** No one has been able to write a formula or system that will test whether or not a given number is prime number. There must be some way of forming prime numbers, but no one has yet been able to find a systematic way to do it. Another mystery about prime numbers is asked by the question, 'Is there an infinite number of prime pairs?'

   A prime pair is a pair of prime numbers whose difference is 2; for example (3,5), (11,13), (41,43). These prime pairs seem to occur throughout our number system.

   No one has been able to find how many there are to discover a formula to locate them. But on the other hand, no one has been able to prove that there is a number beyond which there are no prime pairs.

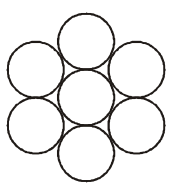
2. **Goldbach's Conjecture:** Is every even number the sum of two primes? C. Goldbach wrote a letter to Leonhard Euler, in which he made the conjecture that every even number except 2 was the sum of two primes. This was an interesting statement that was true for every even number he examined, but he could not prove that it was a true statement for all even numbers.

   For example $4 = 2 + 2$, $6 = 3 + 3$, $8 = 3 + 5$. No even number has been found that is not the sum of two primes. But these is no proof that every even number is the sum of two primes.

3. **The Odd Perfect Number Mystery:** The ancient Greeks considered some numbers to

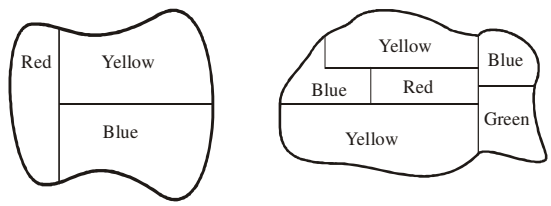
be perfect. Perfect numbers are numbers which are equal to the sum of their divisors. The number 6 is such a number because 6 = 1 + 2 + 3, 28 = 1 + 2 + 4 +7 + 14. Others have been found and all of them are even numbers. No one has ever found an odd perfect number. But no one has been able to prove that every perfect number must be even.

4. **Three Construction Problems:** Some of the first unsolved problems in mathematics were these three famous constructions proposed by the Greeks, to be solved using only a pair of compasses and a straight edge:
   (i) Can you draw a circle with the same area as a square?
   (ii) Can you drawa cube exactly twice the volume of a given cube?
   (iii) Can you divide an angle into exactly three equal angles?
5. **How to Pack Spheres:** A geometry problem that is still unsolved involves the packing of spheres such as ping-pong balls. How should spheres be packed in a box so that they use the least possible space? This is similar to a problem of drawing circles. How should circles be drawn or round objects like pennies be packed to cover the least surface? The arrangement for the circles on a surface has been found to be of the following pattern:



In packing spheres, this is also the best arrangement for the first layer. But nobody has solved the problem of how to arrange the second layer of the spheres.

6. **The Four-colour Map Problem:** There are also unsolved problems in the field of topology. One of them is the four-colour map problem. How many different colours are needed to make a map so that countries with a common border are coloured differently? The drawing below illustrates some possible maps.



This is a real mystery to map makers and to mathematicians. They have not been able to draw a map that needs more than four colours. But at the same time they have not been able to prove that four colours are enough for any possible map. However, technological proof is available for this problem.

Some Problems on Mathematical Thinking

1. Write the squares of the whole number from 1 to 10. Beginning with 2, write all numbers that can be obtained as sum of two or three or four of these squares.

   For example, 13 = 9 + 4 and 33 = 16 + 16 + 1 = 25 + 4 + 4. Can you find a number less than

100 that requires more than four squares as a sum?

Every number can be written as the sum of 4 squares or less

2. As $3^2 \times 3^2 \times 3^2$ cube painted red on all sides is cut into 27 cubes $1^2 \times 1^2 \times 1^2$. How many of these cut cubes are painted on 3 sides? 2 sides? 1 side? No sides? How did you solve the problem—by experiment or by using your imagination?

8 cubes have 3 sides painted.

12 cubes have 2 sides painted.

6 cubes have 1 side painted.

1 cube has no side painted.

3. Write all the prime numbers from 1 to 50. Find the differences between the primes. Can you find a formula that will give you any prime?

There is no formula that will give the prime numbers.

4. (a) What prime can you find less than 100?
   (b) How far apart are these prime pairs?
   (c) Are these prime pairs equally spaced?

(a) (3,5), (5,7), (11,13), (17,19), (29,31), (41,43), (59,61), (71,73)

(b) 0, 4, 4, 10, 10, 16, 10

(c) No

5. What two prime numbers have each these even numbers for their sum?

a. 8 b. 26 c. 18 d. 48

a. 5 + 3 b. 19 + 7 c. 11 + 7
d. 37 + 11

6. Do these sets of number satisfy the equation $x^2 + y^2 = z^2$?
   a. $x = 3, y = 4, z = 5$
   b. $x = 7, y = 24, z = 25$
   c. $x = 8, y = 6, z = 10$

a. Yes b. Yes c. Yes

7. Do these sets of numbers satisfy the equation $x^3 + y^3 = z^3$?
   a. $x = 1, y = 2, z = 3$ b. $x = 2, y = 3, z = 4$

a. No b. No

8. A girl once said: 'The man I marry will be tall, not dark, quite heavy, will wear glasses, will drive fast cars, and will be an Indian'.

   Amar is fair, tall Indian and wear glasses but does not drive fast cars.

   Apurva is not short, wears glasses, drive fast cars, is not fair, is not heavy and is an Indian.

   Anshuman drives fast cars, is dark and not too heavy, is not short and is certainly not fair. He wears glasses.

   Which one of the three men will the girl marry?

The girl will marry Amar because, he has more of the required qualities than any other man. She will marry none of them, if she insists that the man have all of the qualities she is looking for.

9. What is the limit of the unending decimal 1.99999...?

   Answer : 2

10. How many fractions are there in between 0 and 1 ?

    Answer : Infinite number

11. What is the limit of $1\frac{1}{2}-\frac{1}{4}-\frac{1}{8}-\frac{1}{16}-.....?$

    Answer : 0

12. Find examples of some number or measurements that are unending?

13. Which one of the following would be the best sample to use deciding what car is most popular in your town?

    a. A sample of the owners of Jaguars.

    b. A sample of the women drivers in your town.

    c. A sample of the people who do not have own a car.

    d. A sample of the people who bought a car during the last year.

    e. A sample of everyone in your town. (Answer c)

14. Collect data from your newspaper or school or friends to find the answers to questions like these:

    a. How many hours do your classmate spend watching TV each week?

    b. How the average score in rugby games changed for your school in the past 5 years?

    c. What is the average height of your friends?

    d. How many of your school go on to university each year?

15. Here are some data for an object falling to the earth:

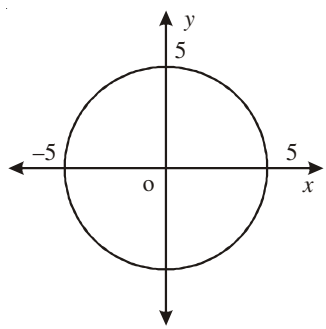
    What formula shows the relationship of S and t?

Time in seconds (t)	Distance fallen (s)	t^2
1	16	1
2	64	4
3	144	9
4	256	16

$S = 16t^2$

16. On the graph paper, draw the geometrical figure for the equation $x^2 + y^2 = 25$ from the following data:

x	y	x^2	y^2
0	5	0	25
1	4.9	1	24 (approx.)
2	4.6	4	21 (approx.)
3	4	9	16
4	3	16	9
5	0	25	0



About Different Branches of Mathematics

Each branch or field of mathematics has been developed and organised logically. For this reason, each field of mathematics is called a *logical structure or system*. To build a mathematical system, the mathematician begins with a set of undefined words and a set of unproved assumptions. He must have words to express his ideas and assumptions from which he can deduce his ideas. He then develops rules that describes the things that can be done with the mathematical system. Next, he invents symbols to simplify the use of the rules. These words, symbols or rules do not need to have any reference to objects of the world around us. Mathematics often includes things that have never been seen or experienced. Some persons think that all mathematics have to be verified by concrete objects, measurements or experimentation. This is not so, for mathematics belongs to the realm of ideas, imagination and fantasy. But, mathematics is unique in that it is also one of the most practical studies known to man.

Arithmetic: A Sample Mathematical Structure

Let us see how elementary arithmetic illustrates a deductive system. Arithmetic begins with the number 1 as an undefined term. With this unit, all other numbers can be defined. The operations of addition and multiplication are also undefined terms. We describe these operations with addition and multiplication tables, but we do not give a definition of them. However, we define the operations of subtraction and division in terms of addition and multiplication, respectively.

Next, we state some assumptions about numbers that seem to agree with our experiences.
For example, we assume the associative law to be true, that is,

$$2 + (3 + 4) = (2 + 3) + 4$$

We also assume that the sum of two numbers is always another number.

Then we define our numbers in terms of the unit 1 and addition:

$2 = 1 + 1,\ 3 = 2 + 1, 4 = 3 + 1$, and so on.

These undefined terms, undefined operations, assumptions and definitions are then used to prove new relationships called *theorems*. Let us see, how we can use this deductive system to prove that $2 + 2 = 4$.

A Sample Logical Proof

Statements	Reasons
1. $2 + 2 = 2 + (1 + 1)$	1. 2 is defined as equal to 1 + 1
2. $2 + (1 + 1) = (2 + 1) + 1$	2. Associative law
3. $(2 + 1) + 1 = 3 + 1$	3. 3 is defined as equal to 2 + 1
4. $3 + 1 = 4$	4. By the definition of 4

In a similar manner, we can prove most relationships in arithmetic that we usually take for granted. This method of deduction can be applied to other mathematical systems and concepts. In each case, the mathematical structure developed is based on undefined terms, assumptions, definitions and the proofs of theorems.

Geometry

The mathematical study of space, shape and measurement is know as geometry. Geometry

tells us how to draw different shapes or figures and tells us many facts about the relationships among these figures.

The study of geometry has been basic for artists, engineers and architects. Drawing accurate plans for a building, determining the effect of a strong wind on an aeroplane, painting a picture that has a balanced and pleasing design, all are related to the ideas about points, lines, angles and shapes that are studied in geometry.

For centuries, man was curious about geometrical mysteries such as the relationship between the diameter and circumference of a circle, whether parallel lines ever meet, whether space is curved and without a boundary. Even such a simple idea as a line has been interesting. You see, no one has ever seen a line. In geometry, a line has no width — only length. And no one knows if it is possible for a line to be 'straight'.

New Geometries

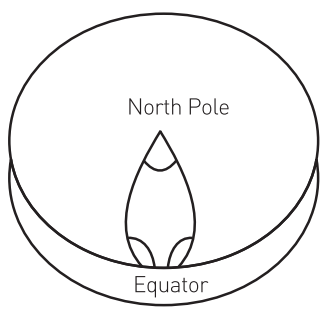
The geometry with which we are most familiar is called *Euclidean geometry*. This name is a tribute to the Greek scholar Euclid (323-285 B.C.), who collected, systematised and recorded the geometrical knowledge of his day. However, Euclidean geometry is not the only possible kind of geometry. By starting with some assumptions about lines that differ slightly from the assumptions of Euclid, mathematicians in the last century developed some strange geometries, all are called non-Euclidean geometries.

One non-Euclidean geometry says that the shortest distance between two points is not a straight line, but, rather, a curved line. Does this sound strange? It does if we are talking about flat surfaces. But this idea makes sense, if we consider a sphere or a ball instead of a flat surface. Indeed, navigator ships and aircraft know that the shortest distance between two points on the surface of the earth (approximately a sphere) is a curve which we call a great circle.

With this idea of a great circles, we can go a step further and reach another astonishing conclusion of non-Euclidean geometry, that the measures of the angles of a triangle drawn on a sphere may add up to more than 180 degrees.

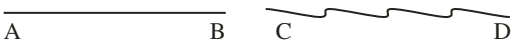
Suppose that the sphere is the earth. The base of the triangle is the equator. The two lines intersecting the equator are meridians, meeting at the North Pole and forming the triangle. The sum of the measures of the angles of this triangle is equal to the two 90° angles (spherical angles are measured by the degrees in their arcs) plus the angle formed at the North Pole.

Another kind of new geometry is one called *topology*. Unlike the geometry we usually study, topology is not interested in size or shape. Topology deals with lines, points and figures but these elements are allowed to change in size and



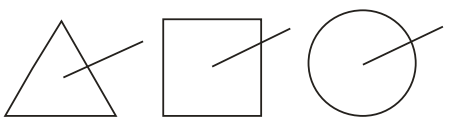
shape in topology. Sometimes topology is called the *rubber-sheet geometry* because topological

figures can be stretched and twisted, as they might be on a rubber-sheet, and still remain the same, topologically speaking.



Topology is concerned with properties of position that are not related to size or shape. In the world of topology, a straight line like AB below is the same as the curved line CD because each of them represents a path between two points.

Topology also says that a triangle, a square and a circle are the same. They all have one inside and one outside and to go from the inside to the outside you must cross one and only one line.



These new ideas of topology have been the means of solving many problems in mathematics.

Exercise

An explorer walks 1 km south, turns and walks 1 km east, turns again and walks 1 km due north. He finds himself back where he started. At what places on the earth's surface is this possible? (There is more than one place where this is possible).

[Answer: At the north pole or about 1 km for the south pole.]

Algebra, the Language of Mathematics

One of the things about mathematics that makes it such a powerful science is its use of symbols such as + or –. These symbols make mathematics a shorthand language. It is much simpler to write 5+3 =8 than to write 'the sum of five and three is eight'. Such symbols make it easy to think about mathematical ideas, and make it possible to show that ideas or relationships which are true for specific numbers may also be true for all numbers. For example, we know that $5 + 3 = 8$ and $8 - 3 = 5$. If we use a, b and c to represent any numbers, then we can say that $a + b = c$ then $c - b = a$. This use of letters as placeholders for numbers is one of the big ideas of algebra. You have probably used letters as placeholders in a similar way in formulas like $c = \pi d$, the formula for the circumference of a circle.

Formulas like the one above, $c = \pi d$, are called mathematical sentences. In algebra you learn how to find the value for placeholders like c and d which make a sentence true. In the sentence, $x + 3 = 8$, what number can replace x so that this is a true sentence?

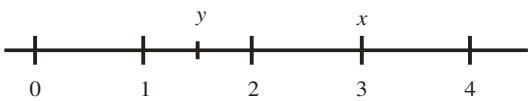
When a scientist performs an experiment to discover new facts, he often arranges his measurements in the form of a table. Then he tries to write a mathematical sentence like a formula that shows how the numbers in his table are related.

Let us look at the following set of data to see whether it can be expressed by a formula.

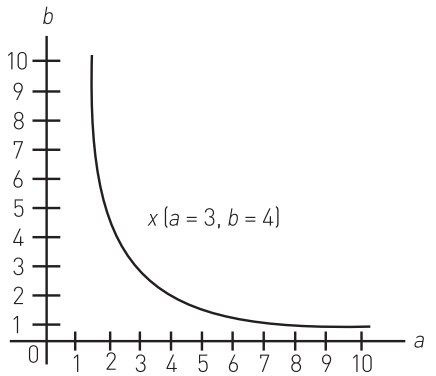
Measurement a	*Measurement* b	a + b	a × b
1	*12*	*13*	*12*
2	*6*	*8*	*12*
3	*4*	*7*	*12*
4	*3*	*7*	*12*
6	*2*	*8*	*12*
8	$1\frac{1}{2}$	$9\frac{1}{2}$	*12*
10	$1\frac{1}{5}$	$11\frac{1}{5}$	*12*
12	*1*	*13*	*12*

If we compare the measurements by addition ($a + b$), we do not find a pattern for the sums. But if we look at the products of the measurements ($a \times b$), we find that they are always 12. This tells us that formula for this pattern is $a \times b = 12$. In this way, algebraic ideas are used to discover and state relationships.

A famous French mathematician by the name of Rene' Descartes (1596 – 1650) showed how algebra and geometry are related. He drew a line to show that any number could be represented by a point on the line and that any point on the line could represent a number. For example, in the following figure, point x represents 3 and point y represents 1.43786



With two number lines drawn perpendicular to each other, we can use a point to represent a pair of numbers. For example, point x in the following figure represents the number pair $a = 3$, $b = 4$. If we locate points for the number pairs for a and b given in the table and join the points with a curved



line, we get a part of a geometrical figure called the hyperbola as shown in the following figure:

Thus, the mathematical sentence, $a \times b = 12$, can be represented by a geometrical figure.

Some Magic with Algebra

Algebra is best known for its use in solving problems. This is illustrated by this number trick:

Think of a number between 0 and 10. Multiply it by 5.

Instructions	Your friend's arithmetic	Your solution with algebra
Think of a number between 0 and 10.	Think of 6	Use x as a placeholder for 0 this unknown number.
Multiply it by 5	$5 \times 6 = 30$	$5x$
Add 7 to your answer	$30 + 7 = 37$	$5x + 7$
Multiply this answer 2	$37 \times 2 = 74$	$10x + 14$
Add any other number between 0 and 10	Pick 8; $74 + 8 = 82$	Use y as a placeholder $10x + 14 + y$
Subtract 3 from this result	$82 - 3 = 79$	$10x + (14 - 3) + y = 10x + 11 + y$
If you tell me your answer, I will tell you what numbers you choose	79	6 and 8

Add 7 to your answer.

Multiply this number by 2.

Add any other number between 0 and 10.

Subtract 3 from this result.

If you tell me your answer, I will tell you what numbers you choose.

Here, how this trick works with a friend?

How can you get the unknown numbers 6 and 8? You set your algebraic expression equal to the number by your friend:

$10x + 11 + y = 79$

Then subtract 11 from your expression and your friend's answer to get

$10x + y = 68$

Now, you know that $10x$ is 10 times the number he choose first, or the tens digit 6, and the symbol y represents the number he added to the tens digit or 8. Try this trick with your friends to demonstrate the magic you can do with algebra.

Probability: The Science of Chance

One of the most intriguing fields of mathematics is the study of probability or chance. Probability tells us how often we may expect some event to occur. It is the field of study which is giving the scientists and the social scientists the tools to deal with our uncertain world. Calculating the probability that something will happen is like looking into the future.

Probability is used in business, in government, and in science to make predictions. Using probability, an insurance company predicts how many houses are likely to burn every year, civil servants predict how much income tax will be collected next year, and a scientist predicts the performance of a space ship before it takes off. Since we all run the risk of accidents, difficulties or success every day in our life. It is important that we know something about the mathematics of probability.

A simple illustration of probability is the tossing of a coin. If you toss a coin, it is just as likely to turn up heads as tails. When we toss several coins, we expect about half of them to turn up heads and the other half tails. So we say your chance of getting a head when you toss one coin is $\frac{1}{2}$. In more technical language, we say that the probability of an event happening is equal to the ratio of favourable ways to the total number of ways it could happen.

To see how this works with several coins, we need to study all the possibilities. If we toss two coins, the coins may fall four ways, as shown below:

H	T	H	T
H	H	T	T

Since one of the four ways gives us 2 heads, we say the chance of tossing 2 heads with 2 coins is $\frac{1}{4}$.

If we toss 3 coins, the coins may fall eight ways, like this:

H	H	H	H	T	T	T	T
H	H	T	T	H	H	T	T
H	T	H	T	H	T	H	T

What are the chances of getting 3 heads? What are the chances of getting 2 heads and 1 tail?

Statistics: Making Sense out of Data

Number facts called data or numerical statistics are found in every daily newspaper. In industry, on the farm, in state and national legislatures, at home, in school, and at church, statistics plays an important role. Information about the weather, sports, jobs, wages, prices and population changes is daily news. These data are the basis for important decisions. If these decisions are to be the right decisions, the data must be read and interpreted intelligently.

An important application of statistics is the use of sampling. Sampling is used in public opinion polls, television programmes popularity ratings and quality control in industry. In sampling, we choose a small number of items which we think are typical of the whole and examine the sample. We can then say, if our sample has been properly chosen, that what is true of the sample is also true of the whole.

Here is a simple example of how sampling works. Suppose you wish to find out something about the size of the pebbles on a beach. Obviously, you cannot measure all pebbles. Instead, you might select a sample of, say, 500 pebbles from all parts of the beach. The statistician has determined that 99 times out of 100 only 1 per cent of all the pebbles on this beach will be larger than the largest pebble in the sample, so you can get good picture of the size of all the pebbles from those in your sample.

This same type of result is expected whether the sample is of people, fish, flowers or numbers drawn out of a hat. An application of this method in industry might be to test samples of tyres to determine the quality of all the tyres produced. By testing a proper sample of 65 tyres, the manufacturer can conclude that 90 per cent of all the tyres in the sample will almost certainly have a longer wearing life than the second tyre to wear out during the test. By the way, statistician calls 99 chances out of 100 "almost certain".

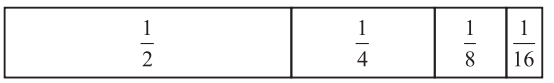
Statistical methods, such as the presentation of data in tables and graphs, help us to read and interpret data. Statistics also tells us how to calculate measures such as averages or deviations that tell us the trend of the data. Relationships are determined by finding a measure of association called the correlation coefficient. Then probability is used to state the meaning of the data or to predict a result in the future. For example, a statistician may look at your mathematics test scores, tell you how to compare with an average student, predict your success in college, and tell you the probability that his prediction is right.

Infinity, Limits, Changing Quantities and Calculus

How far is it to the end of space? How long ago did time begin? How many numbers are there in our number system? How many points are there on a line? The answer to all these questions is "an infinite number". By this, we mean that the number of items in the answer cannot be counted.

Infinity is an idea to understand and impossible to visualise. But mathematicians have invented ways

of dealing with relationships and situations that involve an infinite number of terms. Suppose we have the series of fractions, $\frac{1}{2}, \frac{1}{4}, \frac{1}{8}, \frac{1}{16}$ and so on, each new fraction being formed by taking half of the preceding fraction. What is the sum of all the fractions of this form that you could write?



$$\frac{1}{2}+\frac{1}{4}+\frac{1}{8}+\frac{1}{16}+\ldots.$$

There is no end to the number of fractions like this that you could write. We say there would be an *infinite* number of fractions. If you find the sum of large number of these fractions, you will find that the sum is very close to 1. Mathematicians say that the limit of the sum of these fractions is 1 because you can write fractions like this until the sum is as close to 1 as you desire. However, the sum will never be as much as 1. Whenever we work with infinite amounts of things such as time, points, or numbers, we use special kinds of mathematics. One field of mathematics that deals with infinity and limits is *calculus*.

Calculus is the mathematics that enables us to study the relationship between changing quantities. Here is a typical question that has been answered by calculus:

If a pebble is dropped from a cliff, at what speed would the pebble be travelling in 6 seconds?

In this problem, the distance changes as the time changes and the speed also will change as the time changes. The methods of calculus have been used to solve this problem by finding a *limiting value* for the speed as the time divided into smaller and smaller units. These methods would finally tell us that the speed at any instant would be equal to 9.8 times the number of seconds travelled. In 6 seconds, the pebble would be travelling at a speed of 58.8 meter per second.

Sets: A Useful Mathematical Idea

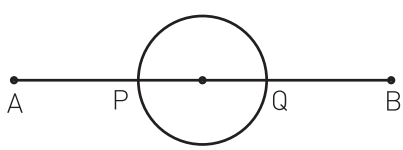
One of the newest ideas in mathematics developed in the past century is set theory, invented by the German mathematician George Cantor (1845-1918). It has been a means of finding new facts and of proving old facts.

The ideas of a set is very simple. A set is a collection of objects, numbers, persons or ideas. You are already familiar with sets such as a set of books, a set of dishes, or a set of tools. You are even a member of a set of people such as your mathematics class, your scout troop or your family.

Set ideas are used in many fields of mathematics. In arithmetic, we talk about set of numbers. For example, the set of prime numbers less than 10 is {2, 3, 5, 7}.

In algebra, we talk about the solution sets for sentences. For example, the solution set for $x - 7 = 5$ is the number 12.

In geometry, we talk about the set of points that meet certain conditions. The set of points on line AB and also on the boundary of the circle are the points P and Q.



In statistics, we talk about sets of data. For example, the set of scores on the weekly mathematics quiz was {7, 10, 5, 6, 9, 7, 8, 4, 6, 8, 5, 7}.

In probability, we talk about the set of all possible events. For example, the set of ways three letters, A,B, C can be arranged is {ABC, ACB, BAC, BCA, CAB, CBA}.

In measurement, we talk about a set of units of measure. A set of metric units of length is {kilometer, hectometer, decameter, meter, decimeter, centimeter, millimeter}.

Set theory has been the basis for new philosophy about mathematics. It has freed mathematics from working with individual numbers, permitting it to consider sets of numbers. Set ideas have also made it possible to solve many problems that involve relationships rather than numbers. Sets have also been proved useful in setting up problems for electronic computers.

Developments in New Mathematics

Although mathematics is one of the oldest sciences, it is growing like a boy at school. New ideas, new vocabulary, new methods, new problems are constantly being created. Mathematics has never been changing as rapidly as it is today.

One of the most exciting new fields of mathematics is *game theory*. The mathematician John von Neumann contributed a great deal to this theory. Game theory is a mathematical way of describing and analysing competition among groups of people such as clubs, athletes or draughts players. Game theory gives a mathematical analysis of what decisions or moves should be made to 'win' in a competitive situation. Thus, game theory can be used to make decisions in business, in foreign affairs, and in the detection of a murderer.

New electronic computers and new ways of solving problems with computers have been designed by mathematicians. These computers have been used to design automatic control of factories. These computers have also been used to extend mathematical knowledge; for example, a computer has made a list of all prime numbers below 46,000,000. However, a computer cannot create new mathematical ideas, and cannot solve the simplest problem unless a mathematician first 'tells' it how to solve the problem.

A new algebra that applies to motions, numbers, or space is called *group theory*. We have already mentioned a new geometry, topology, that is concerned with relationships of points and lines but is not concerned with shape or size. A new arithmetic has been created to compute with new numbers called *quaternions*. *Sets* are being used in a new way to solve logical problems with electric circuits.

How does a mathematician create new mathematical ideas? New mathematics often comes from plain curiosity about a problem or an idea. By intuition, estimation, guess, experimentation, recollection, visualisation, the mathematician searches for a clue to the mystery. *Experiments in mathematics often require no tools, no equipments and usually no materials*

other than paper and pencil. From the results, the mathematician states a conclusion. Then he uses deduction to prove that his conclusion is correct.

New Uses for Old Mathematics

Although we have noted many practical uses for mathematics, mathematicians are not always concerned with applications when they produce new mathematics. When Gottfried Leibnitz

(1646-1716), the great German mathematician, created the binary numeration system, in which we can write any number using only the figures

0 and 1, is the one that is used in the operation of electronic computers. When the existence of a number such as $\sqrt{-5}$ was suggested, it was called an *imaginary number* because it seemed such a ridiculous idea. After all, it was thought, there is no number which, when multiplied by itself, produces – 5. But now imaginary numbers are needed to solve the problems about electricity. When the German mathematician Bernhard Riemann (1826 –1866) suggested that the shortest distance between two points is a curved line, it was considered a foolish statement. Now, nuclear physicists are using this idea and other ideas of non-Euclidean geometry in their research.

Throughout the study of pattern, mathematicians have discovered ideas that later have been found very useful. For example, the Greeks studied the ellipse over a thousand years before the German astronomer and mathematician Johannes Kepler (1571-1630) used their ideas to predict the motion of the planets. Now, the formulas for predicting the motion of planets are applied to artificial satellites and will be useful in acquiring knowledge about space travel.

The new mathematical ideas being created today may not have application for years or even centuries. But most mathematicians are confident that if they create good mathematics it will someday be found useful. The Polish-American mathematician, Samuel Eilenberg, illustrates this when he compares his work with that of a creative tailor. He says, "Sometimes I make coats with five sleeves, other times with seven sleeves. When it pleases me, I make a coat with two sleeves. And if it fits someone, I am happy enough to have him wear it".

The Power of Mathematics

In this brief journey into mathematics, we have tried to throw a spotlight on some of the interesting scenery that lies along the road. When you travel a road more slowly in the work that you will do in mathematics classes, you will have an opportunity to look more carefully at the trees, the plains, the structures lining that road. But even in this quick trip, we hope that you have been able to see that these are some of the remarkable qualities that mathematics possesses:

Mathematics provides an ideal model for logical reasoning: The deductive logic of mathematical proofs is considered the best method known for proving that a new idea is true. When the inductive method is used to establish facts, the conclusion is usually stated in terms of the mathematical theory of probability.

Mathematics has clarity and conciseness of expression: For example, the expression $\{x \mid x + 3 = 5\}$ is a short way of saying, "find all values of x which make the sentence $x + 3 = 5$ a true statement".

Mathematics has novelty and a variety of fields: For instance, 2 + 3 = 5 is a truth that always has been true and always will be true as long as 2, 3 and 5 are counting numbers. Mathematics may be concerned with such different things as maps, motion, games, music, arts, probability, infinity, philosophy and numbers. Who would ever expect that a mathematician would be interested in paper folding? But the folding of paper flexagons has intrigued many mathematicians.

Mathematics has abstractness which adds to its power: Geometry discusses points and lines, but no one has even seen a point or a line. No one can make an object that has more than three dimensions, but mathematicians use expressions for the fourth dimension. No one can write all the prime numbers, but mathematicians can prove that there are an infinite number of prime numbers.

Mathematics has the power to predict events: In 1905, Einstein was able to write the formula that predicted the amount of energy that would be obtained by an atomic explosion. In astronomy, it is possible to predict an ellipse of the Sun using the formulas that give the motion and position of the heavenly bodies.

Mathematics can measure amounts indirectly: Mathematicians have measured the distance to the Sun and the temperature at the middle of the Sun without getting closer than about 92000000 miles (14,72,00,000 km). Even in 230 B.C., Eratosthenes measured indirectly the distance around the Earth before it was even known that the earth was round.

Mathematics has unlimited opportunity for creativeness: Just as no one has composed the most elegant poem or painted the most beautiful picture, so no one has invented the ultimate mathematical structure. Even field of mathematics, from arithmetic to topology, gives ample opportunity for the creation of new ideas.

Mathematics has more permanence than any other field of knowledge: It is the only science in which the measure theories of 20 centuries ago are still true and useful. The value of π has always been 3.14159... and always will be (even a state legislature once tried to change it to 3!).

The musical scale that the ancient Greek philosopher and mathematician Pythagoras established, in which vibrations producing tones have the ratios $\frac{1}{2}, \frac{1}{3}$ and $\frac{3}{4}$, continuous to be a basic scale in music.

Mathematical curves and surfaces have a balance and symmetry that are as pleasing as a masterpiece in art: From the simple circle to the complex hyperbolic paraboloid, from the golden section to the pendulum patterns, mathematical curves are basic in art and architecture, in advertising and in the arts.

Mathematics is found in the designs and laws of nature: From the spiral of a snail's shell to the symmetry of a snowflake, from the bee's hexagonal cell to the elliptical orbits of the planets, mathematical curves and geometrical designs occur in the world of nature. Similarly, the distance of fall of a raindrop $\left(S = \frac{1}{2}gt^2\right)$ and energy in an atom ($E = mc^2$) can be expressed by mathematical formulas.

Conclusion

Thus, in the preceeding paragraphs, we have discussed:

- Role of inductive and deductive reasoning and explaining basic concepts/formulas involving activity.
- Role of patterns in mathematics leading to conjectures and generalisations.
- Use of mathematics in handling problems in interdisciplinary areas.
- Use of examples and exercises to sharpen mathematical reasoning.
- Developmental process of some fundamental concepts/branches in historical perspective.

SCOPE AND CAREER OPPORTUNITIES THROUGH PHYSICS

A. K. Mody
Department of Physics
VES College of Arts, Science and Commerce
Sindhi Society, Chembur
Mumbai

This article discusses what Physics encompasses as a subject upto Intermediate level and application of it can lead to as one pursue the same beyond +2 level. It also touches upon career opportunities available to Physics graduates. The purpose of the article is to illustrate for students of +2 Science stream and physics undergraduate students, possible opportunities which physics offers as a discipline and also to motivate undergraduate physics students who may otherwise be pursuing graduation in absence of any (so called) better opportunity, just for sake of graduation, a most likely contemporary scenario.

Physics is broadly classified into mechanics, heat and thermodynamics, waves, optics, electromagnetism and modern physics as taught upto Intermediate level in present system. One often encounters a phenomenon that deals with more than one of these areas simultaneously. In this article, we want to see what are the different phenomena and applications physics deals with. Many of the phenomena that are discussed in this article may require one to go beyond the +2 level techniques though fundamental principles remain mostly same. Therefore, it becomes important to go through scope to appreciate importance of the subject.

Primary objective of mechanics is to deal with motion, different laws that govern motion, cause and effect. Well, cause and effect is at the foundation of any science. Mechanics tries to understand motion in terms of Newton's laws and conservation principles. For this, it defines and deals with physical quantities like position, momentum, force, energy etc.....

Laws of mechanics are used to understand what happens in sports, e.g. in cricket: spin, swing, trajectory while throwing and similarly in football, base ball etc... Well-known scientist Hemholtz used analogy of a pump to explain mechanism of heart. As students learn: motion is possible only due to action-reaction forces (for example that of rockets) and friction (in day-to-day life). Understanding centre of mass and motion of and around centre of mass are very important for machines and structures. It is important to give thought to how boomerang works, how we balance ourself or how animals use their tail while in different state of motion. The recent Hollywood movie *Avatar* shows tails of aliens fairly accurately. One must note here that stunt sequences in *Hindi* movie are often unrealistic from the viewpoint of Physics.

Study of motion of projectiles is important from the point of view on sports, launching missiles and firing rockets. This also requires rotational motion of earth to be taken into consideration (using pseudo force called Coriolis force). Coriolis force is useful in understanding cyclones, water currents, whirlpools and weather pattern. Circular and rotational motions cover wide range of

interesting areas. These include design of curved roads and racetracks, motion of divers and ice skaters, and balancing in different parts of machines that uses motors. Gyroscopes are used in navigation for ships, planes and automatic guiding systems, including missiles.

Interaction between two different objects in motion is a useful study based on indoor games like carom, billiards to guide planetary probes using gravity of a planet (as in case of pioneer and voyager) and scattering of elementary particle. One such experiment by Rutherford in late nineteenth century of scattering of alpha particles by Goldfoil lead to understand atomic structure and latest Large Hardon Colliders (LHC) to understand mysteries of fundamental force and origin of universe.

Study of simple oscillation turns out to be useful in understanding of vibration of different structures, machines to acoustics. At molecular level, using quantum nature of the world one can understand properties of material and design new materials.

Motion in presence of gravitational field applies to motion of planets and satellites, to galaxies and launching of man-made satellites. Understanding gravitation in finer detail is important for Geo-Positioning System (GPS) to mobile communication. Satellites not only have application for communication and military purpose but also for spying economic benefits in this globalised economy. Most of these are taken for granted by present generation students.

Understanding of sound/mechanical waves are not only important for musical instruments but extends to acoustic design of auditorium, to ultrasonic for medical diagnosis, to Doppler radar for prediction of calamities like Tsunami, weather forecasting and use by traffic police for measuring speed of vehicles. Different types of waves generated during earthquake allow to locate its epicenter from anywhere on the earth.

Study of elasticity is useful in structural strength and design, to design strong materials for various applications.

Understanding properties of fluids has an interesting event in the life of Archimedes. This is of course related to loss of weight or floating objects. Surface tension is important in plants, detergent and it has also been used in understanding of nuclear property in liquid drop model. Change in melting and boiling point of liquid with impurity has interesting application in freezing mixtures, anti-freeze solvents, to cook food. Other than static fluid it is extremely interesting to understand fluids in motion. This has application in sports (remember reverse swing in Cricket), generation of wind power, aerodynamic design of simple automobiles to aeroplanes and space launch vehicles, flow of blood in veins to flow of fluids through different systems in plants and those in machines like automobile engines. Magneto-hydrodynamics is an important branch in astrophysics and is also useful in controlling plasma especially for controlled fusion reaction. Computational fluid dynamics has turned out to be extremely rewarding branch with variety of applications.

Thermal properties of substances have their roots in motion of atoms and molecules. We have made sufficient progress to control and manipulate these properties to use it for our benefit. Expansion properties of metals are used in

bimetallic strip of starters, that of liquids are used in simple thermometers and that of gases have been used for example in storage of liquid petroleum gas for household cooking purpose. Refrigerators, water heaters, air conditioners are also similar examples. These properties and laws also help us to understand and predict weather patterns and understand effect of pollution on weather conditions. Changing properties of substances as melting point using salt (to melt snow) or boiling point using pressure (as in pressure cooker), anti-freeze in lubricants and fuels are such examples. Understanding the relationship between various parameters also helps in designing new materials with designed properties. Invention of heat engine has changed the history and geography of mankind.

Thermal conductivity helps us in designing engines and other materials. As an example, copper bottom vessels have been designed keeping in mind high conductivity of copper. Understanding convection is useful in understanding climatic changes, ocean currents, weather pattern, etc. As a simple application, one needs to understand need of intermitten stirring when heated using microwave as compared to traditional cooking on stoves.

Black body radiation curve matches with spectrum from (i) tungsten filament, (ii) Sun, (iii) nuclear explosion, (iv) any type of flame, and (v) microwave background radiation. Colour and brightness are related to temperature by Wien's law ($l_m T = 0.29$ cm °K). This has direct application in Colour Physics. Understanding of black body radiation curve has also allowed understanding of evolution of universe.

Thermodynamics deals with macroscopic properties of fluids that can be understood as due to collective behaviour of $\gg 10^{26}$ molecules. This is understood in terms of kinetic theory of matter and its success is direct evidence of atomicity.

Study of behaviour of specific heat has led to discovery of super-conductivity-fluidity. It helps understanding climate of Mumbai (island city) as compared to other inland cities in terms of high specific heat of water. Discontinuity in specific heat of H_2 is direct evidence of quantisation and equipartition of energy. It is also an evidence of rotation and vibration of molecules.

Low temperature physics involves thermodynamics of molecular and nuclear magnetic systems. Possibility is seen of manipulating atoms in a phenomenon called Bose-Einstein condensation at nano Kelvin temperature that can help to develop exotic materials.

Thermodynamics is used in design of internal combustion engines, conventional and nuclear power plants, propulsion system for rockets, missiles, aircraft, ships and land vehicles. It helps in designing fuel efficient, energy/cost saving systems.

Thermodynamic principles are also applied to communication and information theory, and to chemical and biological systems. In the latest development, Einstein's general relativity is viewed as thermodynamic limit of statistical theory with atoms of space-time being the microscopic constituents.

Optics deals with light in two ways. One, its propogation through different media, what is known as geometrical optics; and second, physics of its interaction with itself and to different configuration of optical devices, known as

physical optics. Lenses, camera, microscopes, telescopes, etc., are devices that work on these principles. Diffraction, interference and polarisation are the physical phenomena involved in interaction of light that helps us to understand molecular and crystal structures. LASER has its application in medicine, surgery, defence, entertainment etc... LASERs also have found their way into our homes through CD/DVD players.

Electricity has been blessing and at the same time has been a problem for production to meet its demand. Electromagnetic waves are used in microwave range for cooking as well as for telecommunication. They are also used in missile and rocket guiding systems. Magnets and electromagnets have found their way into speakers, magnetic door catchers and in medical applications. Photocopiers, smoke precipitators, electric shockguns are a few common examples where principles of electromagnetic theory are used.

Progress in communication has been possible due to understanding of production, propagation and detection of waves of different kinds. One needs to understand various parameters of wave which are involved and how they are related. Today we are able to talk across continents using mobile phones, know our position with GPS system and transfer large amount of data using internet which may use wireless or optical cable transmission.

Electromagnetic waves in different domains are used for various applications. Radio waves are used for telecommunication and navigation. Microwaves are used for cooking, mobile links and telecommunications. Infra-red are used in sensors, imaging, night vision, etc. Visible range is the one to which our eyes are sensitive. X-rays are used for study of crystal structures, security systems, medical application and even detecting cracks in the rocks. Gamma rays are used for radiation therapy to treat disease like cancer.

Laws of physics are different in the domain of atoms and molecules. The atomic world exhibits quantum nature. It is our understanding of these laws that allowed us to manipulate crystal structures to reach present stage of development of electronics, which has revolutionised quality of our life. Attempts are being made to manipulate atoms to reach power of tera-flop computers.

Photosynthesis and response of eye are based on photoelectric effect. Spin flip transition of outermost electron of Cs^{133} is used to calibrate one second. This is what we call atomic standard clock. Wave nature of electron beam is used in electron microscope to view substance at micrometer level. Scanning Tunneling Microscope (STM) and Atomic Force Microscope (AFM) are based on quantum tunneling effect and are used to observe at atomic level and study biological processes, respectively.

Study of matter at nuclear dimensions exhibit two new types of forces, namely, strong and weak nuclear force. Strong nuclear force has direct relation to nuclear energy, which has civilian as well as military use. Weak force holds keys to some of the cosmic mysteries that we are trying to understand through experiments like Large Hadron Colliders (LHC).

Description of scope of physics as discussed above is suggestive and not exhaustive and one can add many such examples.

Purpose of any physics course/curriculum would introduce in college for students to these phenomenon and laws governing them. This requires students to grasp the basic concepts well enough and acquired necessary skills involved to be able to contribute to the society.

The processes one has to deal with, at frontier level are too complex and involves large number of phenomena to be addressed simultaneously.

To identify the area of interests in physics for a student, should develop her/his extra ordinary skill in that particular area along with the capability by the time of their gradution. Today many excellent carreer options are available for students, who would like to pursue physics at frontier level as their carreer. In the preceding paragraphs, applications described also gives the indication of possible areas available for one to contribute. A professional physicist is expected to invent new physics, study new phenomenon, understand new processes and develop new applications for the benefit of mankind.

However those who donot want to be a researcher, also can have excellent career opportunities after becoming physics graduate. Physics learned in the right spirit develops analytical abilities which are very useful in those career which look for such abilities rather than background training in a specific area. Software development, data analysis in knowledge industry (financial services), banking and management etc... are good examples of this. One may need to do post graduation in these specific subjects like MBA, MCA, etc... In industry like software, physics graduates are much valued manpower due to analytical abilities they acquire while doing their graduation. In fact, game physics has emerged as an important area which is important for those developing computer games and programmes like driving and flight simulation.

Teaching is another area where physics graduates and post graduates are expected to have extraordinary career in time to come due to Information and Communication Technology-based education that is likely to take over.

Government services like public service (like IAS, IPS...) and allied services like banking, railways and public sector companies do recruit physics graduates and post graduates. All these jobs require people with good analytical and problem-solving abilities and not merely those who have passed their exams. Students who are careful in preparing themselves through physics can have a career equally challenging, rewarding, and satisfying as any engineer, doctor or any other professional. Most of those who have done their gradutation in physics (B.Sc.) are found with very successful career in one of those fields described above. All what is required from students is focus on the career that they would want to pursue as a physics graduate. Success is bound to follow.

SCIENCE NEWS

New Hope of Detecting the Gravitational Waves: Final Piece of Einstein's Jigsaw Puzzle

Direct evidence of the existence of gravitational waves is something that has long eluded researchers, however new research has suggested that adding just one of the proposed detectors in Japan, Australia and India will drastically increase the expected rate of detection.

In a study published on May 27, 2011 in IOP Publishing's journal *Classical and Quantum Gravity*, Professor Bernard Schutz of the Albert Einstein Institute, Germany, demonstrated that an additional detector would more than double the detection rate of gravitational waves and could double the amount of sky being covered.

It was estimated last year that by 2016 the existing network of four detectors would be able to detect, on an average, 40 neutron-star merger events per year by monitoring the gravitational waves they produce. Using a computer analysis, this study showed that by performing optimal coherent data analysis, the network could theoretically detect 160 events per year.

The positioning of the current network actually makes such a large increase in detection rate unlikely; however Schutz has shown that using any of the three additional locations would change this dramatically.

The addition of all three new detectors would enable the detection of around 370 events a year, which could increase to 500 events after a few years of operation.

These detectors are most likely to encounter 'short bursts' of gravitational waves that arise from two stars or two black holes orbiting each other. The sheer acceleration of these types of events cause a distortion in space time—known as a gravitational wave—that spreads outwards like ripples moving across a lake.

Professor Schutz said, "The improvements brought about by new detectors are much bigger than the proportionate extra investment required. Even moving an existing LIGO detector to Australia brings two to four times the number of good-quality detections and also dramatically improves the direction information for the events."

"The new detector in Japan, approved last year, would add extra sensitivity and reliability and greatly improve sky coverage. Not only would we be more certain than ever of making detections, we would begin to be able to study neutron stars and gamma ray bursts with information obtainable in no other way."

Einstein's theory of general relativity describes how objects with mass bend and curve space-time. One can imagine holding out a taut bed sheet and placing a football in the centre—the bed sheet will curve around the football, readily representing how space-time gets curved by objects with mass.

Just like the ripples moving across a lake, the distortion in space-time, caused by accelerating objects, gradually decreases in strength, so by the time they finally reach Earth they are very hard to detect.

Professor Schutz continued, "In my mind, detecting gravitational waves opens up a new way of investigating the universe. We expect frequent detections of gravitational waves from merging black holes, whose waves will carry an unmistakable signature. Since gravitational waves are the only radiation emitted by black holes, we will for the first time have a direct observation of a black hole."

"Beyond that, gravitational waves have great penetrating power, so they will allow us to see directly to the centre of the systems responsible for supernova explosions, gamma-ray bursts and a wealth of other systems so far hidden from view."

At the moment, there are four detectors, currently being updated, that have the necessary sensitivity to measure gravitational waves. Three of these detectors exist as part of the LIGO project—two in Hanford, Washington, and one in Livingston, Louisiana, whilst another detector exists in Cascina, Italy, as part of the VIRGO project.

Funding has begun for an additional detector located in Japan whilst there are further proposals for developing detectors in Australia and India. It has also been proposed to move one of the Hanford detectors to Australia.

A jointly owned British-German detector, located near Hanover, Germany, called GEO 600 will begin observations for gravitational waves this summer, until the LIGO and VIRGO detectors become fully operational again.

(Source: Science Daily Online)

Physicists Explain the Long, Useful Lifetime of Carbon-14

The long, slow decay of carbon-14 allows archaeologists to accurately date the relics of history back to 60,000 years.

And while the carbon dating technique is well-known and understood (the ratio of carbon-14 to other carbon isotopes is measured to determine the age of objects containing the remnants of any

living thing), the reason for carbon-14's slow decay has not been understood. Why, exactly, does carbon-14 have a half-life of nearly 6,000 years while other light atomic nuclei have half-lives of minutes or seconds? (Half-life is the time it takes for the nuclei in a sample to decay to half of the original amount.)

"This has been a very significant puzzle to nuclear physicists for several decades," said James Vary, an Iowa State University professor of physics and astronomy. "And the underlying reason turned out to be a fairly exotic one."

The reason involves the strong three-nucleon forces (a nucleon is either a neutron or a proton) within each carbon-14 nucleus. It's all about the simultaneous interactions among any three nucleons and the resulting influence on the decay of carbon-14. And it's not an easy task to simulate those interactions.

In this case, it took about 30 million processor-hours on the Jaguar supercomputer at Oak Ridge National Laboratory in Tennessee. Jaguar has a peak performance of 2.3 quadrillion calculations per second, a speed that topped the list of the world's top 500 supercomputers when the carbon-14 simulations were run.

The research project's findings were recently published online by the journal *Physical Review Letters*.

James Vary and Pieter Maris, Iowa State research staff scientists in physics and astronomy, are the lead authors of the paper. Collaborating on the paper are Petr Navratil of TRIUMF (Canada's National Laboratory for Particle and Nuclear Physics in Vancouver) and the Lawrence Livermore National Laboratory in California; Erich Ormand of Lawrence Livermore National Lab; plus Hai Ah Nam and David Dean of Oak Ridge National Lab. The research was supported by contracts and grants from the U.S. Department of Energy Office of Science.

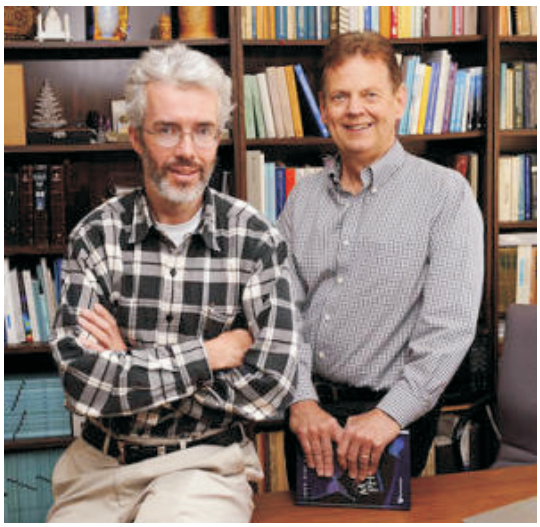
Vary, in explaining the findings, likes to remind people that two subatomic particles with different charges will attract each other. Particles with the same charges repel each other. Well, what happens when there are three particles interacting that's different from the simple addition of their interactions as pairs?

The strong three-nucleon interactions are complicated, but it turns out a lot happens to extend the decay of carbon 14 atoms.

"The whole story doesn't come together until you include the three-particle forces," said Vary. "The elusive three-nucleon forces contribute in a major way to this fact of life that carbon-14 lives so long."

Maris said the three-particle forces work together to cancel the effects of the pairwise forces governing the decay of carbon-14. As a result, the carbon-14 half-life is extended by many orders of magnitude. And that's why carbon-14 is a very useful tool for determining the age of objects.

To get that answer, Maris said researchers needed a billion-by-billion matrix and a computer capable of handling its 30 trillion non-zero elements. They also needed to develop a computer code capable of simulating the entire carbon-14 nucleus, including the roles of the three-nucleon forces. Furthermore, they needed to perform the corresponding simulations for nitrogen-14, the



Iowa State University physicists (from left to right) Pieter Maris and James Vary have used supercomputing power to solve the puzzle of the long, slow decay of carbon-14. That long half-life makes carbon-14 a useful tool to determine the ages of skeletons and other artifacts (Credit: Photo by Bob Elbert)

daughter nucleus of the carbon-14 decay. And, they needed to figure out, how the computer code could be scaled up for use on the Jaguar petascale supercomputer.

"It was six months of work pressed into three months of time," Maris said.

But it was enough for the nuclear physicists to explain the long half-life of carbon-14. And now they say there are more puzzles to solve:

"Everybody now knows about these three-nucleon forces," Vary said. "But what about four-nucleon forces? This does open the door for more study."

(Source: Science Daily Online)

Study Shows Siginificant Benefits of Yoga in People with Rheumatoid Arthritis

Individuals with rheumatoid arthritis who practice yoga showed statistically significant improvements in disease activity, according to a small study presented at the EULAR, 2011 Annual Congress.

The results of the study conducted in the United Arab Emirates (UAE) among 47 patients (26 yoga patients and 21 controls) demonstrate that patients who completed 12 sessions of Raj yoga which is one of the gentler styles of yoga, combining exercise and breathing techniques showed significant improvements in disease activity scores (DAS28) of $p = 0.021$ and health assessment questionnaire's (HAQ†) of $p = 0.0015$. However, there was no statistically significant improvement on the quality of life scale (QoL).

"Most patients with RA do not exercise regularly despite the fact that those who do, report less pain and are therefore more physically active," said Dr Humeira Badsha, MD, Rheumatologist and founder of the Emirates Arthritis Foundation, Dubai, UAE. "While our study has been conducted in a small group of patients the results show clear benefits for patients who regularly practice Raj yoga. We believe that practising yoga longer term could infact result in further significant improvements and hope our study drives further research into the benefits of yoga in RA."

Patients were recruited by email through the Emirates Arthritis Foundation RA database (mean age of yoga group 44 years, mean age of control group 46.2 years, 80% female). Demographic data,

disease activity indices, health assessment questionnaire (HAQ) and SF-36 (a standard patient survey commonly used to calculate patient quality of life) were documented at enrolment and after completion of 12 sessions of yoga.

Results of a separate study show the positive effects of yoga on the quality of life in patients with Fibromyalgia, a long-term condition which causes extreme pain all over the body.

Results of one further study investigating the effects of yoga on the QoL of patients with fibromyalgia, demonstrated that QoL scores, after an eight session classical yoga programme which combines gentle yoga postures, breathing techniques and meditation, were better than scores obtained before the programme ($p \leftarrow 0.05$) along with a significant decrease in the anxiety levels of patients ($p \leftarrow 0.05$). As anxiety is often a key symptom in patients with this condition, this study represents a positive step in improving the lives of people suffering from fibrolmyalgia.

(Source: Science Daily Online)

Omega-3 may cut Risk of Artery Disease, Heart Attacks for Patients with Stents

Omega-3 fatty acids, combined with two blood-thinning drugs, significantly changed the blood-clotting process and may reduce the risk of heart attacks in patients with stents in their heart arteries, according to research reported in Arteriosclerosis, Thrombosis and Vascular Biology: Journal of the American Heart Association.

Foods rich in omega-3, such as salmon and other oily fish, have been previously shown in other studies to reduce the risk of heart problems in people with coronary artery disease. In this study, the participants were given the pill form of omega-3 (1,000 milligrams n-3 PUFA daily) and were encouraged to increase their consumption of oily fish.

This study sought to determine what effects omega-3 might add to those of aspirin and clopidogrel.

"There are no other studies on omega-3 effects in patients who were already being treated with optimal medical therapy after stent placement," said Grzegorz Gajos, M.D., Ph.D., lead author and assistant professor of cardiology at Jagiellonian University in Krakow, Poland. "This was a proof of concept study. We were looking for any effect and what it might be."

The Omega-PCI Study—a double-blind, placebo-controlled trial—found patients who received the omega-3 pills with aspirin and clopidogrel had blood clots more susceptible to destruction than patients who received only the two blood thinners.

The research team particularly targeted the protein fibrin and the interlaced structure it forms in coagulated blood.

Gajos and colleagues examined findings from 54 patients (41 men, 13 women, average age 62.8 years) who participated in the trial conducted at John Paul II Hospital in Krakow.

This study evaluated the effects of omega-3 in patients with stable coronary artery disease who had their clogged heart arteries opened by a catheter procedure and a stent successfully

inserted to help in keeping the vessels opened. Previously, the researchers had reported that adding omega-3 to the clopidogrel antiplatelet drug after stenting significantly lowered the platelet response in clotting.

For this study, researchers randomly selected 24 patients as controls and 30 for treatment before their heart procedures. Both groups received the same daily doses of aspirin and clopidogrel for four weeks after stenting. The treatment group received 1,000 milligrams of omega-3 daily and the controls received a placebo each day.

The study showed that, in comparison with the control group, the omega-3 treated patients:

- produced less of a clotting factor called thrombin.
- formed clots with an altered and favourable structure —including larger pores —that made them easier to disrupt. Therefore, the clot-destruction time was 14.3 per cent shorter. This might prove important in protecting patients, especially those with drug-eluting stents who occasionally develop potentially fatal late clots.
- had less oxidative stress.
- showed no significant changes in fibrinogen and clotting factor (II, XIII) levels. Fibrinogen is a protein produced by the liver. This protein helps to stop bleeding by helping in the formation of blood clots.

Fibrinogen is converted by thrombin into fibrin during blood coagulation. The implication of this finding suggests that changes in the three biomolecules had no role in reducing the treatment group's thrombin generation and altering the structure of blood clots that formed, Gajos said.

"Our study suggests that combined moderate anti-thrombotic and anti-platelet actions of omega-3, when added to those of other treatments, may improve outcomes for coronary artery disease patients," Gajos said.

Study participants experienced only mild adverse side effects and the number of events did not vary significantly between the two groups. There were not enough participants to assess clinical benefit from the changes in the clotting process.

Another limitation of the study was the inability to extrapolate the findings to healthy individuals, those with a high coronary artery disease risk, and those not taking aspirin and/or clopidogrel.

"We are planning a larger follow-up study that will include outcomes and continue indefinitely," Gajos said.

Co-authors are Jaroslaw Zalewski, M.D., Ph.D.; Pawel Rostoff, M.D.; Jadwiga Nessler, M.D., Ph.D.; Wieslawa Piwowarska, M.D., Ph.D.; and Anetta Undas, M.D., Ph.D.

(Source: Science Daily Online)

Superior Sound for Telephones, Mobiles and Related Devices

Telephone calls and video conferences with a sound quality that approaches that of direct communication are now possible with a new audio coding technology—it is almost as if the discussion participants are sitting across from one another.

MP3 for phone calls—Considering the poor sound quality of many phone calls, this is a great

idea. Videoconference phone calls in particular can be unintentionally awkward because, the participants start to speak at the same time due to the time delay in the transmission. The reasons for this are long delay times and the poor quality of today's video calls. Fraunhofer's task was therefore to improve the quality and simultaneously minimise the delay time. The technology that makes this possible is called Enhanced Low Delay Advanced Audio Coding, in short, AAC-ELD. It was developed by Manfred Lutzky, Marc Gayer, Markus Schnell and their team from the Fraunhofer Institute for Integrated Circuits IIS in Erlangen.

Fraunhofer IIS is known as the main inventor of MP3, the audio codec that made it possible to greatly reduce the size of music or other audio files without impairing the sound. To implement something similar for the telephone and other devices was easier said than done. "The algorithm requires a certain amount of time to encode the data and to decode it again at the other end of the line. The process requires data that is still in the future, as it must wait for the data to arrive. This can result in a situation where interactive communication is very difficult," explained Markus Schnell.For several years, the IIS team continued to improve the algorithm even further to shorten the delay and not impair the quality at the same time. The solution, "We attempted to further minimise the area that is forward-looking and to only process current data. We did that until we found an optimum balance between quality and delay," said Schnell.

One technology—many applications

The results are audibly good as the delay with Enhanced Low Delay AAC is only about 15 milliseconds. During this extremely short timespan, the algorithm manages to reduce the audio data to less than one-thirtieth of its original volume without major losses of sound quality. Due to its enormous performance capacity, the coding process has already prevailed in many areas.

Email With audio coding technologies, Marc Gayer, Manfred Lutzky and Markus Schnell (from left to right), were able to considerably improve the quality of communication systems. (Credit: Image courtesy of Fraunhofer-Gesellschaft)

Marc Gayer explains, "Currently, AAC Low Delay, the forerunner of AAC-ELD, is the actual standard for many video-conferencing systems. But the process is also increasingly applied in radio broadcasts, for example for live sports reports."

The advantage of improved speech transmission is also heard in mobile devices, such as the iPhone4 and in the iPad2, for example. Video telephone transmissions in particular are supported in these devices. The developers created a very special application to promote the communication between groups that are socially close to each other. A system was created that makes it possible to play games across the borders of cities or countries. "Thanks to the optimised image and sound quality, there is the impression that game partners who are far apart from each other are not in front of screens, but actually sitting across from one another," said Manfred Lutzky.

(Source: Science Daily Online)

'Sweet wheat' for Tastier and more Healthful Baking

"Sweet wheat" has the potential for joining that summertime delight among vegetables—sweet corn—as a tasty and healthful part of the diet, the scientific team that developed this mutant form of wheat concludes in a new study. The report appears in the ACS Journal of Agricultural and Food Chemistry.

Just as sweet corn arose as a mutation in field corn—being discovered and grown by Native American tribes with the Iroquois introducing European settlers to it in 1779 —Sweet wheat (SW) originated from mutations in field wheat. Toshiki Nakamura, Tomoya Shimbata and colleagues developed SW from two mutant types of wheat that each lack a different enzyme needed to make starch. Because the new wheat has much more sugar than regular wheat, they called it "sweet wheat." To see whether the flour from this new wheat could be used as an ingredient in foods, such as breads and cakes, the researchers analysed its components.

They found that SW flour tasted sweeter, and SW seeds and flour contained higher levels of sugars, lipids and dietary fiber than seeds and flours of other wheat varieties. "The specific compositional changes that occurred in SW seed suggest that SW flour may provide health benefits when used as a food ingredient," say the researchers, noting its high levels of healthful carbohydrates termed fructans.

The authors acknowledge funding from the Ministry of Agriculture, Forestry and Fisheries of Japan.

(Source: Science Daily Online)

Electron is Surprisingly Spherical, Say Scientists following 10-Year Study

Scientists at Imperial College, London have made the most accurate measurement yet of the shape of the humble electron, finding that it is almost a perfect sphere, in a study published in the journal Nature on May 25.

The experiment, which spanned more than a decade, suggests that the electron differs from being perfectly round by less than 0.0000000000000000000000000001 cm. This means that if the electron were magnified to the size of the solar system, it would still appear spherical to within the width of a human hair.

The physicists from Imperial's Centre for Cold Matter studied the electrons inside molecules called ytterbium fluoride. Using a very precise

laser, they made careful measurements of the motion of these electrons. If the electrons were not perfectly round, then like an unbalanced spinning-top, their motion would exhibit a distinctive wobble, distorting the overall shape of the molecule. The researchers saw no sign of such a wobble.

The researchers are now planning to measure the electron's shape even more closely. The results of this work are important in the study of antimatter, an elusive substance that behaves in the same way as ordinary matter, except that it has an opposite electrical charge. For example, the antimatter version of the negatively charged electron is the positively charged anti-electron (also known as a positron). Understanding the shape of the electron could help the researchers to understand how positrons behave and how antimatter and matter might differ.

Research co-author, Dr Jony Hudson, from the Department of Physics at Imperial College, London, said, "We're really pleased that we've been able to improve our knowledge of one of the basic building blocks of matter. It's been a very difficult measurement to make, but this knowledge will let us improve our theories of fundamental physics. People are often surprised to hear that our theories of physics aren't 'finished', but in truth they get constantly refined and improved by making even more accurate measurements like this one."

The currently accepted laws of physics say that the Big Bang created as much antimatter as ordinary matter. However, since antimatter was first envisaged by Nobel Prize-winning scientist Paul Dirac in 1928, it has only been found in minute amounts from sources such as cosmic rays and some radioactive substances.

Imperial's Centre for Cold Matter aims to explain this lack of antimatter by searching for tiny differences between the behaviour of matter and antimatter that no one has yet observed. Had the researchers found that electrons are not round, it would have provided proof that the behaviour of antimatter and matter differ more than physicists previously thought. This, they say, could explain how all the antimatter disappeared from the universe, leaving only ordinary matter.

New research suggests the electron is surprisingly spherical—much more spherical than, say, a common billiard ball (Credit: © Hedgehog/Fotolia)

Professor Edward Hinds, research co-author and head of the Centre for Cold Matter at Imperial College, London, said: "The whole world is made almost entirely of normal matter, with only tiny traces of antimatter. Astronomers have looked right to the edge of the visible universe and even then they see just matter, no great stashes of antimatter. Physicists just do not know what happened to all the antimatters, but this research can help us to confirm or rule out some of the possible explanations."

Antimatter is also studied in tiny quantities in the Large Hadron Collider at CERN in Switzerland, where physicists hope to understand what happened in the moments following the Big Bang and to confirm some currently unproven fundamental theories of physics, such as supersymmetry. Knowing whether the electrons are round or egg-shaped tests these same fundamental theories, as well as other theories of particle physics that even the Large Hadron Collider cannot test.

To help in improving their measurements of the electron's shape, the researchers at the Centre for Cold Matter are now developing new methods to cool their molecules to extremely low temperatures, and to control the exact motion of the molecules. This will allow them to study the behaviour of the embedded electrons in far greater detail than ever before. They say the same technology could also be used to control chemical reactions and to understand the behaviour of systems that are too complex to simulate with a computer.

(Source: Science Daily Online)

Supercapacitors: Cheaper, Greener, Alternative Energy Storage

Every year, the world consumes approximately 15 tera watts of power, according to some estimates. Since the amount of annual harvestable solar energy has been estimated at 50 tera watts, students at Stevens Institute of Technology are working on a supercapacitor that will allow us to harness more of this renewable energy through biochar electrodes for supercapacitors, resulting in a cleaner and greener planet.

Supercapacitors are common today in solar panels and hydrogen fuel cell car batteries, but the material they use to store energy, activated carbon, is unsustainable and expensive. Biochar, on the other hand, represents a cheap, green alternative. The Chemical Engineering Senior Design team of Rachel Kenion, Liana Vaccari and Katie Van Strander has designed biochar electrodes for supercapacitors, and is looking to eventually bring their solution to market. The group is advised by Dr Woo Lee, the George Meade Bond Professor of Chemical Engineering and Materials Science.

For their project, the team designed, fabricated and tested a prototype supercapacitor electrode. The group demonstrated biochar's feasibility as an alternative to activated carbon for electrodes, which can be used in hybrid electric automobile batteries or home energy storage in solar panels.

"While the team's findings are preliminary, the approach taken by us represents a small, but potentially very important step in realising sustainable energy future over the next few decades," says Dr Lee.

Biochar is viewed as a green solution to the activated carbon currently used in supercapacitor electrodes. Unlike activated carbon, biochar is the byproduct of the pyrolysis process used to produce biofuels, i.e., biochar comes from the burning of organic matter. As the use of biofuels increases, biochar production increases as well. "With our process, we are able to take that biochar and put it to good use in supercapacitors. Our supply comes from goldenrod crop, and

through an IP-protected process, most organics, metals and other impurities are removed. It is a more sustainable method of production than activated carbon," Liana says. Another significant advantage: biochar is non-toxic and will not pollute the soil when it is tossed-out. The team estimates that biochar costs almost half as much as activated carbon, and is more sustainable because it reuses the waste from biofuel product, a process with sustainable intentions to begin with.

One of the largest concerns for solar panel production today is the sheer cost of manufacturing supercapacitors. Current photovoltaic arrays rely on supercapacitors to store the energy that is harnessed from the sun. And while the growth rate of supercapacitors is advancing at 20 per cent a year, their cost is still very high, in part because, they require activated carbon. Biochar, on the other hand, is cheaper and readily available as a byproduct of a process already used in energy production.

"My favourite part of this project was seeing the creation of the prototype," Katie says. "It was cool to be able to hold it in my hand and test it and say that I made this."

"Using this technology, we can reduce the cost of manufacturing supercapacitors by lowering the cost of the electrodes," Katie says. "Our goal is eventually to manufacture these electrodes and sell them to a company that already makes supercapacitors. Once supercapacitors become cheaper, they will become more common and be integrated into more and more devices."

(Source: Science Daily Online)

Portable Hydrogen Reactor for Fuel Cells

Chemical engineering students at Stevens Institute of Technology are transforming the way that American soldiers power their battery-operated devices by making a small change: a really small change. Capitalising on the unique properties of microscale systems, the students have invented a microreactor that converts everyday fossil fuels like propane and butane into pure hydrogen for fuel cell batteries. These batteries are not only highly efficient, but also can be replenished with hydrogen again and again for years of resilient performance in the field.

With soldiers carrying up to 80 per cent of gear weight in batteries, the Army has a high interest in replacing the current paradigm of single-use batteries with a reliable, reusable power source. The Stevens-made microreactors thus have the potential to not only reduce waste from disposable batteries, but also provide American soldiers with a dependable way to recharge the batteries for the critical devices that keep them safe.

Current methods for generating fuel cell hydrogen are both sophisticated and risky, requiring high temperatures and a vacuum to produce the necessary chemical-reaction-causing plasmas. Once in a container, hydrogen is a highly volatile substance that is dangerous and expensive to transport.

The Stevens microreactor overcomes both of these barriers by using low temperatures and

atmospheric pressure, and by producing hydrogen only as needed to avoid creating explosive targets in combat areas. These advanced reactors are created using cutting-edge microfabrication techniques, similar to those used to create plasma television screens, which use microscale physics to produce plasma under normal atmospheres.

The team has already achieved success producing hydrogen from methanol. After gasifying the methanol by suspending it in hot nitrogen gas, the mixture is drawn into a 25μm channel in the microreactor. There, it reacts with plasma to cause thermal decomposition, breaking down the methanol into its elemental components. Now the team is conducting tests to see what kinds of yields are realisable from various starter fuels. Eventually, soldiers will be able to convert everyday liquid fuels like propane or butane, commonly found on military bases, into high-potency juice for portable fuel cell batteries.

The team, made up of seniors Ali Acosta, Kyle Lazzaro, Randy Parrilla, and Andrew Robertson, are supporting Ph.D. candidate Peter Lindner in a research project sponsored by the U.S. Army. The project is overseen by Dr Ronald Besser. The team will be presenting their device prototype at Senior Projects Expo on April 27.

(Source: *Science Daily online*)

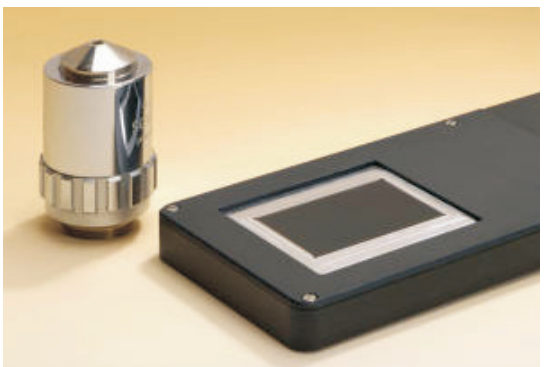
Microscope: Handy, Quick and Flat

In the future, doctors can pull out a new type of microscope to get to the bottom of suspicious changes in the skin that may indicate melanoma. The new device provides a high-resolution image of skin areas of any size—and so quickly that you can hold it in your hand without blurring the resulting picture.

Are the dark spots on a patient's skin malignant? In the future, doctors will be able to take a closer look at suspicious blemishes using a new microscope—with results in just a few fractions of a second. It examines to a resolution of five micrometers, it's also flat and lightweight, and it records images so quickly that the results are not blurred even if the doctor is holding the microscope in his or her hand. For results with comparable resolution values, a conventional microscope would either be restricted to a tiny field forced to scan the surface-conventional equipment slowly sweeps the surface, point-by-point, recording countless images before combining them to create a complete picture. The drawback of this, it takes quite a while before the image is complete. The new microscope designed by researchers at the Fraunhofer Institute for Applied Optics and Precision Engineering IOF in Jena, combines the best of both types of microscope–because it foregoes the grid, it needs to make just a single measurement, and that's what makes it very fast. Still, it records across a broad imaging area. "Essentially, we can examine a field as large as we want," remarks IOF group manager Dr Frank Wippermann. "At five micrometers, the resolution is similar to that of a scanner." There is also another benefit to the new system–with an optical length of just 5.3 millimeters, the microscope is extremely flat.

But how did researchers accomplish this feat? "Our ultrathin microscope consists of not just one but a multitude of tiny imaging channels, with lots of tiny lenses arrayed alongside one another. Each

channel records a tiny segment of the object at the same size for a 1:1 image," Wippermann explains. Each slice is roughly 300 × 300 μm^2 in size and fits seamlessly alongside the neighbouring slice; a computer programme then assembles these to generate the overall picture. The difference between this technology and a scanner microscope–all of the image slices are recorded simultaneously.



In a single pass, the ultrathin microscope can deliver high-resolution images of objects the size of a matchbox. (Credit: © Fraunhofer IOF)

The imaging system consists of three glass plates with the tiny lenses applied to them, both on top and beneath. These three glass plates are then stacked on top of one another. Each channel also contains two achromatic lenses, so the light passes through a total of eight lenses. Several steps are involved in applying the lenses to glass substrates: first, the scientists coat a glass plate with photoresistant emulsion and expose this to Ultra violet (UV) light through a mask. The portions exposed to the light become hardened. If the plate is then placed in a special solution, all that remains on the surface are lots of tiny cylinders of photoresist; the rest of the coating dissolves away. Now, the researchers heat the glass plate, the cylinders melt down, leaving spherical lenses. Working from this master tool, the researchers then generate an inverse tool that they use as a die. A die like this can then be used to launch mass production of the lenses–simply take a glass substrate, apply liquid polymer, press the die down into it and expose the polymer layer to UV light. In a process similar to the dentist's method of using UV light to harden fillings, here, too, the polymer hardens in the shape the die has printed into it. What remains are tiny lenses on the glass substrate. "Because we can mass-produce the lenses, they are really pretty low-cost," Wippermann adds.

Researchers have already produced a first prototype and will be showcasing it at the LASER World of PHOTONICS trade fair in Munich, from May 23 to 26. Boasting an image size of 36 × 24 mm^2, this microscope can capture matchbox-sized objects in a single pass. It will be at least another one to two years before the device can go into series production, according to the researcher. The spectrum of applications is diverse–with this technology, even documents can be examined for authenticity.

(Source: Science Daily Online)

Earth's Core is Melting ... and Freezing

The inner core of Earth is simultaneously melting and freezing due to circulation of heat in the overlying rocky mantle, according to new research from the University of Leeds, UC San Diego and the Indian Institute of Technology.

The findings, published on May 19, *Nature*, could help us understand how the inner core formed

and how the outer core acts as a 'geodynamo', which generates the planet's magnetic field.

"The origins of Earth's magnetic field remain a mystery to scientists," said study co-author Dr Jon Mound from the University of Leeds. "We cannot go and collect samples from the centre of Earth, so we have to rely on surface measurements and computer models to tell us what's happening in the core."

"Our new model provides a fairly simple explanation to some of the measurements that have puzzled scientists for years. It suggests that the whole dynamics of Earth's core are in some way linked to plate tectonics, which isn't at all obvious from surface observations".

"If our model is verified it's a big step towards understanding how the inner core formed, which in turn helps us to understand how the core generates the Earth's magnetic field."

Earth's inner core is a ball of solid iron about the size of our Moon. This ball is surrounded by a highly dynamic outer core of a liquid iron-nickel alloy (and some other, lighter elements), a highly viscous mantle and a solid crust that forms the surface, where we live.

Over billions of years, Earth has cooled from the inside out causing the molten iron core to partly freeze and solidify. The inner core has subsequently been growing at the rate of around 1mm a year as iron crystals freeze and form a solid mass.

The heat given off as the core cools flows from the core to the mantle to Earth's crust through a process known as convection. Like a pan of water boiling on a stove, convection currents move warm mantle to the surface and send cool mantle back to the core. This escaping heat powers the geodynamo and coupled with the spinning of Earth generates the magnetic field.

Scientists have recently begun to realise that the inner core may be melting as well as freezing, but there has been much debate about how this is possible when overall the deep Earth is cooling. Now the research team believes that they have solved the mystery.

Using a computer model of convection in the outer core, together with seismology data, they show that heat flow at the core-mantle boundary varies depending on the structure of the overlying mantle. In some regions, this variation is large enough to force heat from the mantle back into the core, causing localised melting.

The model shows that beneath the seismically active regions around the Pacific 'Ring of Fire', where tectonic plates are undergoing subduction, the cold remnants of oceanic plates at the bottom of the mantle draw a lot of heat from the core. This extra mantle cooling generates down-streams of cold material that cross the outer core and freeze onto the inner core.

Conversely, in two large regions under Africa and the Pacific where the lowermost mantle is hotter than average, less heat flows out from the core. The outer core below these regions can become warm enough that it will start melting back the solid inner core.

Co-author Dr Binod Sreenivasan from the Indian Institute of Technology said: "If Earth's inner core is melting in places, it can make the dynamics near the inner core-outer core boundcomplex than previously thought".

"On the one hand, we have blobs of light material being constantly released from the boundary where pure iron crystallises. On the other hand, melting would produce a layer of dense liquid above the boundary. Therefore, the blobs of light elements will rise through this layer before they stir the overlying outer core ".

"Interestingly, not all dynamo models produce heat going into the inner core. So the possibility of inner core melting can also place a powerful constraint on the regime in which the Earth's dynamo operates."

The inner core of Earth is simultaneously melting and freezing due to circulation of heat in the overlying rocky mantle, according to new research. The findings could help us to understand how the inner core formed and how the outer core acts as a 'geodynamo', which generates the planet's magnetic field. (Credit: © KristijanZontar / Fotolia)

Co-author Dr Sebastian Rost from the University of Leeds added – "The standard view has been that the inner core is freezing all over and growing out progressively, but it appears that there are regions where the core is actually melting. The net flow of heat from core to mantle ensures that there's still overall freezing of outer core material and it's still growing over time, but by no means is this a uniform process".

"Our model allows us to explain some seismic measurements which have shown that there is a dense layer of liquid surrounding the inner core. The localised melting theory could also explain other seismic observations, for example why seismic waves from earthquakes travel faster through some parts of the core than others."

(Source: Science Daily Online)

New Solar Product Captures up to 95 per cent of Light Energy

Efficiency is a problem with today's solar panels; they only collect about 20 per cent of available light. Now, a University of Missouri , engineer has developed a flexible solar sheet that captures more than 90 per cent of the availability of ` light, and he plans to make prototypes available to consumers within the next five years.

Patrick Pinhero, an associate professor in the MU Chemical Engineering Department, says "energy generated using traditional photovoltaic (PV) methods of solar collection is inefficient and

neglects much of the available solar electromagnetic (sunlight) spectrum". The device his team has developed — essentially a thin, mouldable sheet of small antennas called nantenna — can harvest the heat from industrial processes and convert it into usable electricity. Their ambition is to extend this concept to a direct solar facing nantenna device capable of collecting solar irradiation in the near infrared and optical regions of the solar spectrum.

Working with his former team at the Idaho National Laboratory and Garrett Moddel, an electrical engineering professor at the University of Colorado, Pinhero and his team have now developed a way to extract electricity from the collected heat and sunlight using special high-speed electrical circuitry. This team also partners with Dennis Slafer of Microcontinuum, Inc., of Cambridge, Mass., to immediately port laboratory bench-scale technologies into manufacturable devices that can be inexpensively mass-produced.

"Our overall goal is to collect and utilise as much solar energy as is theoretically possible and bring it to the commercial market in an inexpensive package that is accessible to everyone," Pinhero said. "If successful, this product will put us orders of magnitudes ahead of the current solar energy technologies available to us today."

As part of a rollout plan, the team is securing funding from the U.S. Department of Energy and private investors. The second phase features an energy-harvesting device for existing industrial infrastructure, including heat-process factories and solar farms.

Within five years, the research team believes they will have a product that complements conventional PV solar panels. Because it's a flexible film, Pinhero believes it could be incorporated into roof shingle products, or be custom-made to power vehicles.

Once the funding is secure, Pinhero envisions several commercial product spin-offs, including infrared (IR) detection. These include improved contraband-identifying products for airports and the military, optical computing and infrared line-of-sight telecommunications.

A study on the design and manufacturing process was published in the *Journal of Solar Energy Engineering.*

(Source: Science Daily Online)

New way to Control Conductivity: Reversible Control of Electrical and Thermal Properties could find uses in Storage systems

A team of researchers at MIT has found a way to manipulate both the thermal conductivity and the electrical conductivity of materials simply by changing the external conditions, such as the surrounding temperature. And the technique they found can change electrical conductivity by factors of well over 100, and heat conductivity by more than three-fold.

"It's a new way of changing and controlling the properties" of materials—in this case a class called percolated composite materials—by controlling their temperature", says Gang Chen, MIT's Carl Richard Soderberg, Professor of Power Engineering and Director of the

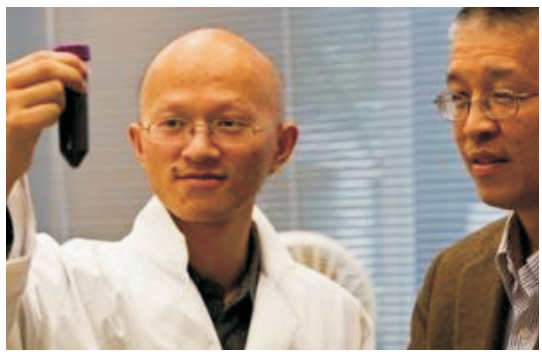
Pappalardo Micro and Nano Engineering Laboratories. Chen is the Senior author of a paper describing the process that was published online on April 19 and will appear in a forthcoming issue of *Nature Communications*. The paper's lead authors are former MIT visiting scholars Ruiting Zheng of Beijing Normal University and Jinwei Gao of South China Normal University, along with current MIT graduate student Jianjian Wang. The research was partly supported by grants from the National Science Foundation.

The system Chen and his colleagues developed could be applied to many different materials for either thermal or electrical applications. The finding is so novel, Chen says, that the researchers hope some of their peers will respond with an immediate, "I have a use for that!"

One potential use of the new system, Chen explains, is for a fuse to protect electronic circuitry. In that application, the material would conduct electricity with little resistance under normal, room-temperature conditions. But if the circuit begins to heat up, that heat would increase the material's resistance, until at some threshold temperature it essentially blocks the flow, acting like a blown fuse. But then, instead of needing to be reset, as the circuit cools down the resistance decreases and the circuit automatically resumes its function.

Another possible application is for storing heat, such as from a solar thermal collector system, later using it to heat water or homes or to generate electricity. The system's much-improved thermal conductivity in the solid state helps it to transfer heat.

Essentially, what the researchers did was suspend tiny flakes of one material in a liquid that, like water, forms crystals as it solidifies. For their initial experiments, they used flakes of graphite suspended in liquid hexadecane, but they showed the generality of their process by demonstrating the control of conductivity in other combinations of materials as well. The liquid used in this research has a melting point close to room temperature—advantageous for operations near ambient conditions—but the principle should be applicable for high-temperature use as well.



Graduate student Jianjian Wang holds a flask containing the suspension of graphite flakes in hexadecane, as Gang Chen looks on. (Credit: Photo by Melanie Gonick)

The process works because when the liquid freezes, the pressure of its forming crystal structure pushes the floating particles into closer contact, increasing their electrical and thermal conductance. When it melts, that pressure is relieved and the conductivity goes down. In their experiments, the researchers used a suspension that contained just 0.2 per cent graphite flakes by volume. Such suspensions are remarkably stable— Particles remain suspended indefinitely in the liquid, as was shown by examining a container of the mixture three months after mixing.

By selecting different fluids and different materials suspended within that liquid, the critical temperature at which the change takes place can be adjusted at will, Chen says.

"Using phase change to control the conductivity of nano composites is a very clever idea," says Li Shi, a professor of mechanical engineering at the University of Texas at Austin. Shi adds that as far as he knows "this is the first report of this novel approach" to produce such a reversible system.

"I think this is a very crucial result," says Joseph Heremans, professor of physics and of mechanical and aerospace engineering at Ohio State University. "Heat switches exist," but involve separate parts made of different materials, whereas "here we have a system with no macroscopic moving parts," he says. "This is excellent work."

(Source: Science Daily Online)

Who Knows You Best? Not You, say Psychologists

Know thyself. That was Socrates' advice, and it squares with conventional wisdom. "It's a natural tendency to think we know ourselves better than others do," says Washington University in St. Louis assistant professor Simine Vazire.

But a new article by Vazire and her colleague Erika N. Carlson reviews the research and suggests an addendum to the philosopher's edict: *Ask a friend.* "There are aspects of personality that others know about us that we don't know ourselves, and vice-versa," says Vazire. "To get a complete picture of a personality, you need both perspectives." The paper is published in *Current Directions in Psychological Science*, a journal of the Association for Psychological Science.

It's not that we know nothing about ourselves. But our understanding is obstructed by blind spots, created by our wishes, fears and unconscious motives—the greatest of which is the need to maintain a high (or if we're neurotic, low) self-image, research shows. Even watching ourselves on videotape does not substantially alter our perceptions—whereas others observing the same tape easily point out traits we're unaware of.

Not surprisingly, our intimates and those who spend the most time with us know us best. But even strangers have myriad cues to who we are—clothes, musical preferences or Facebook postings. At the same time, our nearest and dearest have reasons to distort their views. After all, a boorish spouse or bullying child says something to the other spouse or parent. "We used to collect ratings from parents—and we've mostly stopped, because they're useless," notes Vazire. What such data would show— Everyone's own child is brilliant, beautiful and charming.

Interestingly, people don't see the same things about themselves as others see. Anxiety-related traits, such as stage fright, are obvious to us, but not always to others. On the other hand, creativity, intelligence or rudeness is often best perceived by others. That's not just because they manifest themselves publicly, but also because they carry a value judgement—something that tends to affect self-judgement. But the world is not always the harsher critic. Others tend to give us higher marks for our strengths than we credit ourselves with.

Why doesn't all this information add up to better personal and mutual understanding? People are complex, social cues are many, perceptions of others are clouded by our own needs and biases, studies show. Plus, the information isn't easy to access. "It's amazing how hard it is to get direct feedback," Vazire notes, adding that she isn't advocating brutal frankness at any cost. There are good reasons for reticence.

The challenge, then, is to use such knowledge for the good. "How can we give people feedback and how can that be used to improve self-knowledge?" Vazire asks. "And how do we use self-knowledge to help people be happier and have better relationships?"

The first answer to these questions may be the most obvious, but not the easiest to practice—Listen to others. They may know more than you do—even about yourself.

(Source: *Science Daily online*)

World's Smallest Atomic Clock: Tiny Laser Reduces Power Consumption 1,000-Fold

A matchbook-sized atomic clock 100 times smaller than its commercial predecessors has been created by a team of researchers at Symmetricom Inc. Draper Laboratory and Sandia National Laboratories. The portable Chip Scale Atomic Clock (CSAC)—only about 1.5 inches on a side and less than a half-inch in depth—also requires 100 times less power than its predecessors. Instead of 10 watts, it uses only 100 milliwatts. "It's the difference between lugging around a device powered by a car battery and one powered by two AA batteries," said Sandia lead investigator Darwin Serkland.

Despite common implications of the word "atomic," the clock does not use radioactive elements as an energy source. Instead, where an old-fashioned alarm clock uses a spring-powered series of gears to tick-off seconds, a CSAC counts the frequency of electromagnetic waves emitted by cesium atoms struck by a tiny laser beam to determine the passage of time.

Still, given that the CSAC does not actually display the time of day—measured in millionths of a second, its passage would defy the ability of human eyes to read it—why would anyone want it?

The clock's uses are, indeed, specialised. Miners far underground or divers engaged in deep-sea explorations, blocked by natural barriers from GPS signals, could plan precise operations with remote colleagues who also had atomic clocks, because their timing would deviate from each other by less than one millionth of a second in a day.

A CSAC timekeeper would be invaluable to experts using electromagnetic interference to prevent telephone signals from detonating Improvised Explosive Devices, or IEDs. Though GPS signals also would be blocked, a CSAC timekeeper would still function.

On a nationwide scale, relay stations for cross-country phone and data lines, which routinely break up messages into packets of information and send them by a variety of routes before reconstituting them correctly at the end of their voyages, would continue functioning during GPS outages.

The clock's many uses, both military and commercial, are why the Defense Advanced

Research Projects Agency (DARPA) funded the work from 2001 until the CSA Clock hit the commercial market in January.

"Because few DARPA technologies make it to full industrial commercialisation for dual-use applications, this is a very big deal," said Gil Herrera, director of Sandia's Microsystems and Engineering Sciences Application (MESA) center. "CSAC now is a product with a data sheet and a price."

Cesium atoms are housed in a container the size of a grain of rice developed by Cambridge, Mass.-based Draper Lab. The cesium atoms are interrogated by a light beam from a vertical-cavity surface-emitting laser, or VCSEL, contributed by Sandia. Symmetricom, an atomic clock manufacturer, designed the electronic circuits and assembled the components into a complete functioning clock at its Beverly, Mass., location.

The reduced power consumption that was key to create the smaller unit required, in addition to a completely new architecture, a VCSEL rather than the previous tool of choice, a rubidium-based atomic vapour lamp.

"It took a few watts to excite the rubidium lamp into a plasmalike state," Serkland said. "Use of the VCSEL reduced that power consumption by more than a thousand times to just two milliwatts" (Serkland's success in attaining this huge power reduction caused some in the clock business to refer to him as "the VCSEL wizard").

The way the clock keeps time may be best imagined by considering two tuning forks. If the forks vary only slightly in size, a series of regular beats are produced when both forks vibrate. The same principle works in the new clock.

The VCSEL—in addition to being efficient, inexpensive, stable and low-power—is able to produce a very fine, single-frequency beam. The laser frequency, at 335 terahertz (894.6 nanometers), is midway between two hyperfine emission levels of the cesium atom, separated in terms of energy like the two differently sized tuning forks. One level is 4.6 gigahertz above and the other 4.6 gigahertz below the laser frequency (Hyperfine lines are the energy signatures of atoms). A tiny microwave generator sends an oscillating frequency that alternates adding and subtracting energy from the incoming laser carrier frequency. Thus, the laser's single beam

Darwin Serkland measures the wavelength of a tiny laser called a VCSEL, or vertical-cavity surface-emitting laser. The image on the monitor (left) shows a bright circle of light emitted from a VCSEL operating at the wavelength of 894 nanometers needed to drive the atomic clock. The objects that look like black baseball bats are tiny wire needles carrying milliampere currents. The round white plastic containers on Serkland's workbench each contain about 5,000 VCSELs fabricated from one-quarter of a 3-inch diameter gallium arsenide wafer. Each wafer is designed differently to yield a unique type of laser. (Credit: Image courtesy of DOE/Sandia National Laboratories)

produces two waves at both hyperfine emission energies. When they interact, the emitted waves produce (like two tuning forks of different sizes) a series of 'beats' through a process known as interference.

A photodiode monitors the slight increase in light transmission through the cesium vapour cell when the microwave oscillator is tuned to resonance. According to the international definition of the second (since 1967), the clock indicates that one second has elapsed after counting exactly 4,596,315,885 cycles (nearly 4.6 gigacycles) of the microwave oscillator signal.

Because magnetism has an influence on cesium atoms, they are shielded from Earth's magnetic field by two layers of steel sheathing.

While this sounds cumbersome, atomic clocks are simpler to maintain than timepieces of a century ago, when a pendulum clock in Paris was the source of the world's exact time. Kept in a room that was temperature- and humidity-controlled, not only would a change of one degree affect the pendulum's swing, but the difficulty of bringing accurate time to the U.S. was extreme: one synchronised a portable clock in Paris and then had to transport it across the ocean by ship, during which time the mechanical clock would inevitably drift from the time of the Paris clock.

A description of the technical details of the clock, available for approximately $1,500, can be found at Symmetricom's website at: http://www.symmetricom.com/products/frequency-references/chip-scale-atomic-clock-csac/SA.45s-CSAC/

Sandia is developing a follow-on technology for DARPA–a trapped-ion-based clock. It will improve timing accuracy at similar size, weight and power to the CSAC. Researches are working on the first compact prototype.

(Source: *Science Daily online*)

Curtains that Block Noise

Researchers at Empa, in cooperation with textile designer Annette Douglas and silk weavers Weisbrod-Zürrer AG, have developed lightweight, translucent curtain materials, which are excellent at absorbing sound. This is a combination that has been lacking until now in modern interior design. And the new "noise-quenching" curtains have just gone onto the market.

Noise is annoying. It interrupts communication, reduces productivity and tires people out—in extreme cases it can even make them ill. Sound absorbing surfaces are, therefore, needed in rooms where people work, talk to each other or are trying to relax. These decrease reverberation and so make rooms quieter. However, so called acoustically "hard" materials such as glass and concrete, which are commonly used in interior design, scarcely absorb sound at all. Heavy curtains made of material such as velvet are often used to absorb sound. On the other hand, lightweight and transparent curtains are acoustically almost useless, at least they were until now.

Together with industrial partner Weisbrod-Zürrer AG, a silk weaving company, and the textile designer Annette Douglas, Empa researchers have developed a new curtain fabric that is lightweight but still absorbs sound.

"Acousticians are pretty astonished when they see the readings we are achieving with the new

Researchers at Empa, in cooperation with textile designer Annette Douglas and silk weavers Weisbrod-Zürrer AG, have developed lightweight, translucent curtain materials, which are excellent at absorbing sound. (Credit: Image courtesy of Swiss Federal Laboratories for Materials Science and Technology (EMPA))

curtains in the reverberation room. The weighted sound absorption coefficient is between 0.5 and 0.6," commented Kurt Eggenschwiler, Head of Empa's Acoustics/Noise Control Division. In other words, the new textiles "quench" five times more sound than conventional translucent curtains. Eggenschwiler continued, "The new curtain genuinely absorbs sound, noticeably improving the room acoustics—and its design is also of very high quality."

A real gap in the market

Another advantage is that because the new curtains are translucent, they can be used in a variety of places such as offices, living rooms, restaurants, hotel lobbies, seminar rooms and even multi-purpose auditoriums. They are often the deciding factor in satisfying the acoustic requirements and regulations that apply to these rooms. Just shortly after their launch, it became apparent that the new textiles are really filling a gap in the market, as interest in them is "massive" according to Eggenschwiler.

The idea of a curtain that absorbs noise while, at the same time, being lightweight and translucent, came from the textile designer Annette Douglas, who has worked with the interaction between sound and textiles for many years and received the Swiss Textile Design Award in 2005 for the project "Acoustic walls for open plan offices." In cooperation with researchers from Empa's Acoustics/Noise Control Division and silk weavers Weisbrod-Zürrer AG, and with support from researchers from Empa's Advanced Fibres Division, she submitted an associated project to the Commission for Technology and Innovation (CTI) in 2010. Not a simple task, because thin and, therefore, translucent fabrics are normally poor sound absorbers.

Successful combination of computer modelling, acoustic measurement and specialised textile knowledge

The first acoustically optimised lightweight textile came into being on a computer. The Empa acousticians wanted to use the characteristics of this virtual textile in order to prepare a kind of "recipe" for material experts, which would enable them to specifically manufacture a fabric that could absorb sound. In addition, they first developed a mathematical model to illustrate both the microscopic structure of the fabric as well as its macroscopic composition. On the basis of numerous acoustic measurements made on

various samples, specifically woven by Weisbrod-Zürrer, they were able to gradually optimise the acoustic properties of the fabric. Annette Douglas then succeeded in translating the new findings into weaving techniques. She chose yarns that gave the materials the necessary characteristics in terms of flammability and translucence and determined the weave structure, i.e., how the threads should be woven in and out of each other. Weisbrod-Zürrer then adjusted the sophisticated manufacturing process so that the industrially-made curtains actually displayed the required acoustic characteristics.

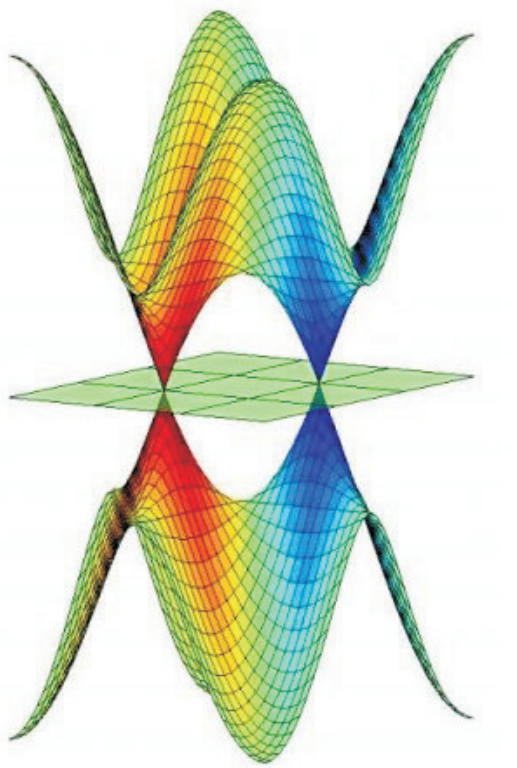
(Source: Science Daily Online)

Electronics: A Step Toward Valleytronics

Valley-based electronics, also known as valleytronics, is one step closer to reality. Two researchers at the Naval Research Laboratory (NRL) have shown that the valley degree of freedom in graphene can be polarised through scattering off a line defect. Unlike previously proposed valley filters in graphene, which rely on confined structures that have proven hard to achieve experimentally, the present work is based on a naturally occurring line defect that has already been observed.

The discovery was published in *Physical Review Letters* on March 28, 2011 and was also the subject of a separate viewpoint article in *Physics*.

Information in solid-state, either classical or quantum, is generally carried by electrons and holes. The information can be encoded in various degrees of freedom such as charge or spin. Charge representations, for example the absence or presence of an electron in a quantum dot, are attractive as they are easily manipulated and interrogated through electric fields. The advantage of spin representations, used in the field of spintronics, is their superior shielding from undesired electric fluctuations in the environment, making the information in these latter representations more robust. In the future, there might be a third middle-ground alternative



The band structure of graphene with its two valleys is shown in blue and red. (Credit: Naval Research Laboratory)

in the valley degree of freedom that exists in certain crystals, including graphene.

The valley degree of freedom in graphene gained attention in 2007, when it was proposed that electrons and holes could be filtered according to which valley they occupy. Unfortunately, the structures required for this and subsequent valley filters are difficult to fabricate, and as a result a valley filter has yet to be demonstrated experimentally. The present study from NRL shows that an extended line defect in graphene acts as a natural valley filter. "As the structure is already available, we are hopeful that valley-polarised currents could be generated in the near future" said Dr Daniel Gunlycke who made the discovery together with Dr Carter White. Both work in NRL's Chemistry Division.

Valley refers to energy depressions in the band structure, which describes the energies of electron waves allowed by the symmetry of the crystal. For graphene, these regions form two pairs of cones that determine its low-bias response. As a large crystal momentum separates the two valleys, the valley degree of freedom is robust against slowly varying potentials, including scattering caused by low-energy acoustic phonons that often require low-bias electronic devices to operate at low temperatures typically only accessible in laboratories.

Valley polarisation is achieved when electrons and holes in one valley are separated spatially from those in the other valley, but this is difficult to do as the two valleys have the same energies. It was found, however, that this spatial separation can be obtained in connected graphene structures that possess reflection symmetry along a particular crystallographic direction with no bonds crossing the reflection plane. This property turns out to be present in a recently observed line defect in graphene. The reflection symmetry only permits electron waves that are symmetric to pass through the line defect. Anti-symmetric waves are reflected. By projecting an arbitrary low-energy wave in graphene onto its symmetric component, one gets the transmission amplitude through this defect, which is strongly dependent on the valley. Electron and hole waves approaching the line defect at a high angle of incidence results in a polarisation near 100 per cent.

"There is a long way to go before valleytronics can become a viable technology", explains Gunlycke. The recent advance, however, provides a realistic way to reach a crucial milestone in its development. This research was supported by the Office of Naval Research, both directly and through the Naval Research Laboratory.

(Source: Science Daily Online)

Research Shows that Music Changes Perception

Music is not only able to affect your mood—listening to particularly happy or sad music can even change the way we perceive the world, according to researchers from the University of Groningen.

Music and mood are closely inter-related—listening to a sad or happy song on the radio can make you feel more sad or happy. However, such mood changes not only affect how you feel, they

also change your perception. For example, people will recognise happy faces, if they are feeling happy themselves.

A new study by researcher Jacob Jolij and student Maaike Meurs of the Psychology Department of the University of Groningen shows that music has an even more dramatic effect on perception—even if there is nothing to see, people sometimes still see happy faces when they are listening to happy music and sad faces when they are listening to sad music.

Smileys

Jolij and Meurs had their test subjects perform a task in which they had to identify happy and sad smileys while listening to happy or sad music. Music turned out to have a great influence on what the subjects saw—smileys that matched the music were identified much more accurately. And even when no smiley at all was shown, the subjects often thought they recognised a happy smiley when listening to happy music and a sad one when listening to sad music.

Expectation

The latter finding is particularly interesting according to the researchers. Jolij: 'Seeing things that are not there is the result of top-down processes in the brain. Conscious perception is largely based on these top-down processes—your brain continuously compares the information that comes in through your eyes with what it expects on the basis of what you know about the world. The final result of this comparison process is what we eventually experience as reality. Our research results suggest that the brain builds up expectations not just on the basis of experience but on your mood as well.'

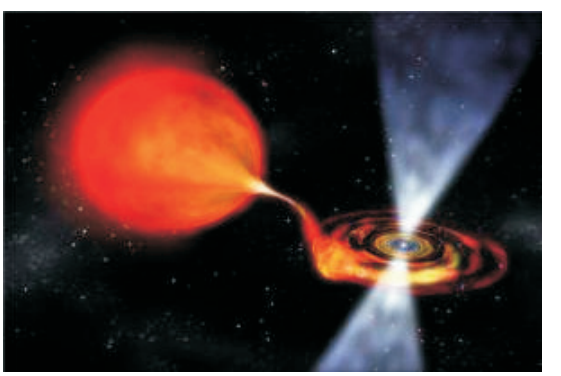
The research was published in the open access journal *PLoS ONE* on 21 April.

(Source: Science Daily Online)

School Students Help Astronomers to Study Mysterious X-Ray Source

Astronomers from Wales and the Netherlands, in collaboration with five schools, have used eight telescopes simultaneously to study the strange behaviour of an X-ray binary star system. Results were presented by postgraduate student Fraser Lewis at the RAS National Astronomy Meeting in Llandudno, Wales, on April 18.

IGR J00291 + 5934 ('00291') is a rare X-ray binary system containing a pulsar—a neutron star spinning several hundred times per second—and a normal star. Only 12 such systems are known. In September 2008, 00291 increased in brightness at X-ray wavelengths by



Artist's impression of IGR J00291+5934. The strong gravity from the dense pulsar attracts material from the companion. The flow of gas from the companion to the pulsar is energetic and glows in X-ray light. (Credit: NASA/Dana Berry)

a factor of at least a thousand times and in visible wavelengths by a factor of around a hundred times. While such type of outburst is not uncommon for this type of system, the timescale is usually months to years. However, 00291, having been in outburst for 20 days, faded away to its normal faint state but then re-brightened within 30 days.

"We had never seen this rapid a turnaround in a system of this type before" said Lewis, of the Faulkes Telescope Project at the University of Glamorgan. "To try to understand what was driving this unique behaviour, we gathered data from several telescopes, at different wavelengths, to create a dataset of unprecedented detail."

The group, led by Lewis and Dr David Russell, of the University of Amsterdam, used data from Faulkes Telescope North, the Isaac Newton Telescope and the Keck Telescope (optical wavelengths), PAIRITEL (infrared), the Westerbork Synthesis Radio Telescope (radio), the Swift GRB mission (UV and X-ray), and the XMM-Newton and RXTE satellites (X-ray). Five schools, including St. Brigid's School, Denbigh and St. Davids College, Cardiff, were involved in collecting the data using Faulkes Telescope North.

In X-ray binary systems, material from the star spirals in towards the pulsar, forming an accretion disc. Friction and gravity heat this material up until it reaches temperature of millions of degrees and emits X-rays.

"The behaviour of 00291 is baffling. Outbursts are thought to be driven by the 'emptying' of the accretion disc, which means that the time between outbursts indicates the time that it takes to fill the disc, and the size of the disc itself. However, for a system as compact as 00291, it's unlikely that it could replenish its supply within 30 days," said Lewis.

To find a solution to this mystery, Lewis and Russell have turned to a group at the Naval Research Laboratory in Washington led by Dr Jacob Hartman. Hartman's group suggests that the outburst is all one event that was interrupted halfway through by a propeller effect.

"The idea is that when the 'propeller' switches on, the material that was spiralling inwards becomes ejected from the system, stopping the outburst. Then the propeller switches off again, the outburst restores itself. However, there are still many things that we don't understand," said Lewis.

These results are presented within the wider context of an extensive optical monitoring programme of 32 low-mass X-ray binaries using the 2-metre Faulkes Telescopes in Hawaii and Australia.

(Source: Science Daily Online)

Optical Microscope without Lenses Produces High-Resolution 3-D Images on a Chip

UCLA researchers have redefined the concept of a microscope by removing the lens to create a system that is small enough to fit in the palm of a hand but powerful enough to create three-dimensional tomographic images of miniscule samples.

The advance, featured in the early online edition of the journal *Proceedings of the National Academy of*

Sciences, represents the first demonstration of lens-free optical tomographic imaging on a chip, a technique capable of producing high-resolution 3-D images of large volumes of microscopic objects.

"This research clearly shows the potential of lens-free computational microscopy," said Aydogan Ozcan, senior author of the research and an associate professor of electrical engineering at UCLA's Henry Samueli School of Engineering and Applied Science. "Wonderful progress has been made in recent years to miniaturise life-sciences tools with microfluidic and lab-on-a-chip technologies, but until now optical microscopy has not kept pace with the miniaturisation trend."

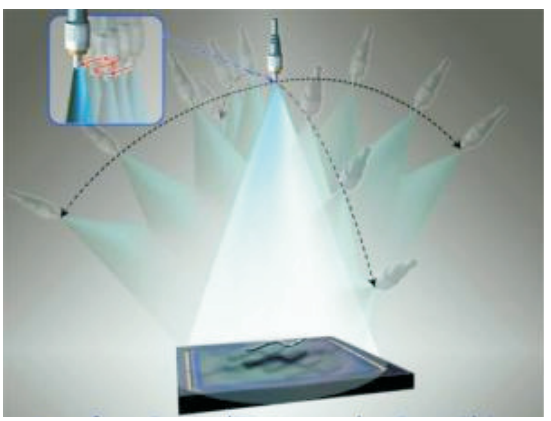
An optical imaging system small enough to fit onto an opto-electronic chip provides a variety of benefits. Because of the automation involved in on-chip systems, scientific work could be sped up significantly, which might have a great impact in the fields of cell and developmental biology. In addition, the small size not only has great potential for miniaturising systems but also leads to cost savings on equipment.

The optical microscope, invented more than 400 years ago, has tended to grow larger and more complex as it has been modified to image ever-smaller objects with better resolution. To address this lack of progress in miniaturisation, Ozcan's research group—with graduate student Serhan Isikman and postdoctoral scholar Waheb Bishara as lead researchers—developed the new tomographic microscopy platform through the next evolution of a lens-free imaging technology the group created and has been improving for years.

Ozcan, a researcher at the California Nano Systems Institute at UCLA, makes the analogy that a traditional optical microscope is like a huge set of pipes delivering content, in the form of images, to the user. Over years of development, bottlenecks occur that impede further improvement. Even if one part of the system—that is, one bottleneck—is improved, other bottlenecks keep that improvement from being fully realised. Not so with the lens-free system, according to Ozcan.

"Lens-free imaging removes the pipes altogether by utilising an entirely new design," he said.

The system takes advantage of the fact that organic structures, such as cells, are partially



Lens-free tomographic imaging: Schematic diagram of the lens-free tomography set-up showing the angles of rotation for the light source to illuminate a sample. (Credit: Image courtesy of UCLA)

transparent. So by shining a light on a sample of cells, the shadows created reveal not only the cells' outlines but details about their sub-cellular structures as well.

"These details can be captured and analysed if the shadow is directed onto a digital sensor array," Isikman said. "The end result of this process is an image taken without using a lens."

Ozcan envisions this lens-free imaging system as one component in a lab-on-a-chip platform. It could potentially fit beneath a microfluidic chip, a tool for the precise control and manipulation of sub-millimeter biological samples and fluids, and the two tools would operate in tandem, with the microfluidic chip depositing and subsequently removing a sample from the lens-free imager in an automated, or high-throughput, process.

The platform's 3-D images are created by rotating the light source to illuminate the samples from multiple angles. These multiple angles also allow the system to utilise tomography, a powerful imaging technique. Through the use of tomography, the system is able to produce 3-D images without sacrificing resolution.

"The field of view of lens-based microscopes is limited because the lens focuses on a narrow area of a sample," Bishara said. "A lens-free microscope has both a much larger field of view and depth of field because the imaging is done by the digital sensor array and is not constrained by a lens."

The research was funded by grants from the National Science Foundation, the U.S. Office of Naval Research and the National Institutes of Health and was also supported by the Gates Foundation and the Vodafone Americas Foundation.

(Source: Science Daily Online)

WEB WATCH

In this section, we present websites and a brief introduction about them. Inclusion of a site does not imply that School Science endorses the content of the site. Sites have been suggested on the basis of their possible utility to school systems.

- **A look into the atom**
  httt://www.aip.org/history/electron/jhome.htm

  This is an initiative of the American Institute of Physics (AIP). It exhibits six themes : J.J. Thomson, Mysterious Rays, !897 Experiments, Corpuscles to Electron and Legacy for Today. Very well-illustrated and informative for students and teachers. One can also hear J.J.Thomson talk about the size of electron.

- **Cell World**

  bio.edu.ee/models/en/

  This site is run by University of Tartu, Estonia presents a good collection on interactive animations for high school biology. Themes included are photosynthesis, Transcription, Gene expression, Translation, Genetic code, Membrane transport, Replication, Respiration, Synapse and muscle cell and contraction. It provides link for students, teachers and composers. Users may register free.

- **Exploring Earth Visualisation**
  www.classzone.com/books/earth_science/terc/navigation/visualisation.cfm

  This website presents many animations on themes related to Earth. For example, one can observe: animation of Earth turning around its axis, Earth's daily rotation, video taken during an earthquake, an animation of Himalayas forming,etc. One can also examine the Sun at different wavelengths.

- **Global Chemistry Experiment**
  http://my.rsc.org/globalexperiment

  This site presents a major IUPAC project to engage students across the world in practical activities around the theme,: Water: A Chemical Solution".part of the world's biggest chemistry experiment. It is one of the ways for students to be part of the International Year of Chemistry (IYC), 2011.
  It involves four simple experiments to collect important quality measurements of your local water. Once the data collected, you can submit it through the IYC website, and your students' work will join thousands of others in the biggest ever chemistry experiment.

- **Obsetion** Observatory in Education
  www.iucaa.ernet.in/~scipop/obsetion/

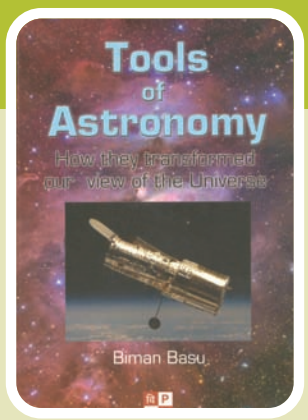
  This website is maintained by the Inter-University Centre for Astronomy and Astrophysics (IUCAA), Pune, India and is intended to promote experimental skills in students. It presents projects related to weather and astronomy. The website is updated by adding new experiments and projects. One can also visit IUCAA website for virtual observatory.

Compiled and Edited by

V.P. Srivastava
DESM, NCERT, New Delhi

Book Review

Title	**Tools of Astronomy**
Author	**Biman Basu**
Publisher	**Vigyan Prasar** **A-50, Institutional Area,** **Sector 62, Noida-201 307**
No. of Pages	**216**
Price	**₹180**



As we all know, astronomy is the study of the Sun, Moon, stars, galaxies and the Solar system, ultimately, of the whole universe. It is perhaps the oldest of all sciences, dating back to the time the humans came to live in the open and wondered about the spectacle in the sky. Periodic occurrence of eclipses and occasional appearance of comets in the sky were fascinating and awe-inspiring. In addition to the curiosity about goings on in the sky, there were practical reasons for studying astronomy. The two of these reasons were the calendar making for measuring time and the use of constellations for navigating on land and on high seas.

Ancient cultures like India, China and others had rich traditions of astronomy. In India, Varahamihira, Aryabhatta and many others made significant contributions to astronomy. Astronomy is an integrated part of the Indian culture. Almost all our festivals—be it *Diwali*, *Holi*, *Eid*, or a *Gurupurubh* (birthday of the *Guru*)—are based on the phases of the Moon and the motion of the Sun. It is a pity, therefore, that our children get so little exposure to astronomy during their schooldays. Earlier astronomy was included in the senior secondary syllabus. However, at the time of revision a few years back, syllabus makers thought it wise to remove astronomy from senior secondary syllabus and replace by a 'modern' topic like communication. At the moment, only the upper primary syllabus has some very elementary ideas of astronomy.

It is in this context that one must laud the programme launched by *Vigyan Prasar* to

popularise astronomy. The present volume, the *Tools of Astronomy* by Biman Basu, is a part of the same programme. Mr Basu is a former Editor of Science Reporter, a popular science magazine brought out by the Council of Scientific and Industrial Research, and is eminently placed to write a book on popular astronomy. The *Tools of Astronomy* tells us the story of how observational tools have refined and developed over time and how they have led to improvement in our understanding of the universe.

Mr Basu starts with the most ancient instruments. These are quite primitive by modern standards. But they show the amazing curiosity of the mankind towards the celestial phenomena and their ingenuity in inventing instruments to satisfy this curiosity. An example is just a number of stones arranged in a certain pattern at Stonehenge in England. This simple device facilitated the observation of phenomena associated with the annual motion of the Sun, and eclipses. Another example is the astrolabe, a multifunctional instrument, which was used to track the movement of the Sun and other heavenly bodies. Mr Basu also describes the various *Jantar Mantars* in India which were used for astronomical observations.

Observations of the phases of the Venus and the four nearest satellites of Jupiter by Galileo with the telescope that he himself fabricated are described in some detail. These observations, as we know, ushered a revolution in science by showing that the earth could not be the only centre about which other bodies could revolve. This was against the entrenched belief at that time that the earth does not move and all heavenly bodies revolve round the earth. As is well-known, and pointed out by Mr Basu, the observations of Galileo supported the heliocentric model of Copernicus, wherein the Sun is at the centre of the solar system. It was left to the work of Kepler and Newton to establish the heliocentric model beyond any doubt.

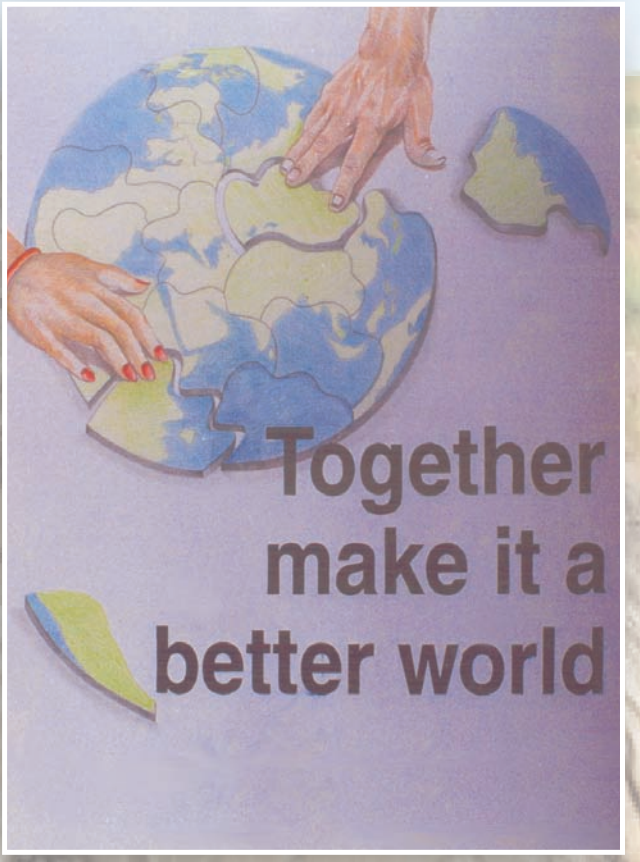
Mr Basu devotes a considerable part of the book to the developments of telescopes of all types, radio, infrared, optical, x-ray, gamma-ray and rightly so because our only link with the celestial bodies is the electromagnetic radiation that we receive from them. The description of observations by these telescopes takes Mr Basu to the most recent developments in astronomy, including those relating to the planetary studies in our own solar system, discovery of planets outside the solar system, the cosmic black body radiation, gamma-ray sources and the elusive dark energy.

The book has been well brought out. Printing, illustrations and photographs are good. They make the book quite attractive.

It is easy to see that through *Tools of Astronomy* Mr Basu has been able to cover a lot of ground in astronomy which would interest a lot of readers

who are eager to read about astronomy. In the opinion of this reviewer, the utility of the book for readers would have been enhanced considerably, if there had been a section on elements of spherical astronomy explaining the various terms, for example, altitude, azimuth, used in relation to the stellar observations. A glossary of astronomical terms would also have helped readers who are not initiated into astronomy. These are minor reservations. I have no hesitation in recommending this book to those who enjoy learning astronomy.

V.B. Bhatia
Professor of Physics (*Retired*)
215/21A, Faridabad



Nirmalya Chakraborty, College of Art, New Delhi

To Our Contributors

School Science is a journal published quarterly by the National Council of Educational Research and Training, New Delhi. It aims at bringing within easy reach of teachers and students the recent developments in science and mathametics and their teaching, and serves as a useful forum for the exchange of readers' views and experiences in science and mathametics education and science projects.

Articles suitable to the objectives mentioned above are invited for publication. An article sent for publication should normally not exceed ten typed pages and it should be exclusive to this journal. A hard copy of the article including illustrations, if any, along with a soft copy should be submitted in CD. Photographs (if not digital) should be at least of postcard size on glossy paper and should be properly packed to avoid damage in transit. The publisher will not take any responsibility or liability for copy right infringement. The contributors, therefore, should provide copy right permission, wherever applicable, and submit the same along with the article.

Manuscripts with illustrations, charts, graphs, etc., along with legends, neatly typed in double space on uniform sized paper, should be sent to Executive Editor, School Science, Department of Education in Science and Mathematics, NCERT, Sri Aurobindo Marg, New Delhi 110 016 or email at **school.science@yahoo.co.in**