

Bulletin of



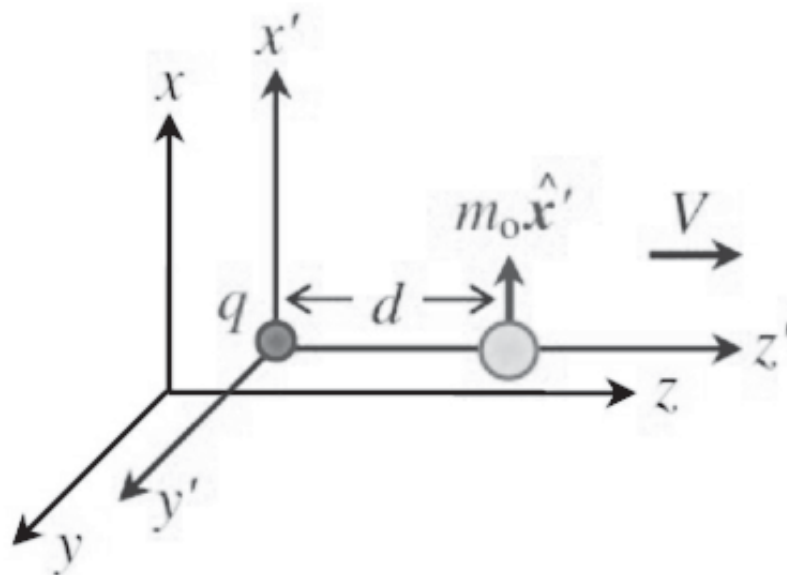
ISSN 2277-8950

THE INDIAN ASSOCIATION OF PHYSICS TEACHERS
A MONTHLY JOURNAL OF EDUCATION IN
PHYSICS & RELATED AREAS

VOLUME 4

NUMBER 6

JUNE 2012



Charge-magnet paradox: The point electric charge q and the point magnetic dipole to its right are separated by distance d in the $x'y'z'$ frame. An observer in the $x'y'z'$ frame sees no torque, but a stationary observer in the xyz frame watching the $x'y'z'$ system move with constant velocity along the z axis sees the moving electric charge exert a torque on the moving magnet. Image credit: Mansuripur.

(<http://phys.org/news/2012-05-classical-electrodynamics-law-incompatible-special.html>)

13th Asian Physics Olympiad (Delhi, 1-7 May 2012): Some photographs



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Speakers at the inaugural ceremony: (1) Shri Kapil Sibal, Honourable Minister for Human Resource Development, (2) Dr. R. Chidambaram, Principal Scientific Adviser to GOI, (3) Prof. Ming-J. Lin, President of APHO, (4) Prof. Satya Prakash, President of IAPT, (5) Prof. Dinesh Singh, Vice-Chancellor, Delhi University, (6) Prof. Jaishree Ramdas, Director of HBCSE. (7) Shri Kapil Sibal unrolling the APHO flag to declare the event open, (8) billboard to welcome the APHO delegates. (More photographs on inside back cover.)

BULLETIN OF INDIAN ASSOCIATION OF PHYSICS TEACHERS (ISSN 2277-8950)**CHIEF EDITOR:** U.S. Kushwaha, Chandigarh**EDITOR:** M.M. Gupta, Chandigarh**ASST. EDITOR:** Kuldeep Kumar, Chandigarh**EDITORIAL BOARD:**

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The Bulletin is the official organ of the IAPT. It is a monthly journal devoted to upgrading physics education at all levels through dissemination of didactical information on physics and related areas. Further, the Bulletin also highlights information about the activities of IAPT.

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<http://www.iapt.org.in><http://www.indapt.org>**National Competition on Innovation in Computer for Physics (NCICP)**

Computer is becoming an inevitable part in physics education nowadays. It finds use in simulations, interfacing, data analysis, numerical computations etc. of concepts, experiments and numerical problems in physics. Rising at par with these modern trends, IAPT is sponsoring the NCICP programme for teachers and students interested in computer for physics.

Original papers on themes, like the ones given above, are invited for presentation at the IAPT National Convention during Nov. 2-4 at International School of Photonics, Cochin University of Science & Technology, Cochin, Kerala).

Best three papers will be given cash awards of Rs.5000, 3000 and 2000. IAPT will pay traveling expenses for coming to Cochin to present papers (ten top selected).

Participants should submit detailed write-up of their papers (along with the program), in duplicate, supported with a soft copy (CD or email) to the convener, along with an extra sheet with title of entry, brief abstract, author's name, full address, telephone/mobile number, email id and a declaration that the work is original and unpublished.

Last date for entries to reach is **15 September 2012**.

T.R. Ananthkrishnan

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13th Asian Physics Olympiad (Delhi, 1-7 May 2012)**Participation of various countries**

S.No.	Country	Leaders	Observers	Students
1.	Australia	2	0	8
2.	Brunei Darussalam	2	1	5
3.	China	2	3	8
4.	Hong Kong	2	2	8
5.	India	2	1	8
6.	Indonesia	2	1	8
7.	Israel	2	1	7
8.	Kazakhstan	2	0	8
9.	Kyrgyzstan	2	0	8
10.	Malaysia	2	2	8
11.	Mongolia	2	0	8
12.	Nepal	2	0	4
13.	Russia	2	1	8
14.	Saudi Arabia	2	1	5
15.	Singapore	2	2	8
16.	Sri Lanka	1	0	7
17.	Chinese Taipei	2	1	8
18.	Tajikistan	1	0	7
19.	Thailand	2	2	8
20.	Turkmenistan	2	0	8
21.	Vietnam	2	5	8
	Total	40	23	155

PHYSICS NEWS

Is a classical electrodynamics law incompatible with special relativity?

Masud Mansuripur, a professor of Optical Sciences at The University of Arizona in Tucson, is arguing that the Lorentz law of force is incompatible with special relativity and momentum conservation. In a recent issue of *Physical Review Letters*, he has suggested replacing the Lorentz law with a more general expression of electromagnetic force density, such as one developed by Albert Einstein and Jakob Laub in 1908. The basis of Mansuripur's argument is that the Lorentz law violates special relativity by producing different results in different reference frames. He describes a scenario in which a magnetic dipole and a nearby electric charge are located a certain distance apart. When the magnet and the electric charge are at rest, no net force is exchanged between the two. This is because static electric charges only produce electric fields (to which the magnet is oblivious), and static magnets only produce magnetic fields (to which the static electric charge is oblivious). Both the Lorentz law and the Einstein-Laub version give the same result: the magnet experiences neither a force nor a torque from the electric charge. However, the Lorentz law gives a different result when a stationary observer watches the magnet and electric charge in a moving reference frame. Here, the observer sees the moving electric charge exert a torque on the moving magnet, causing the magnet to rotate as it tries to align itself with the electric field. The presence of this torque differs from the observation in the stationary reference frame where there is no torque. On the other hand, the Einstein-Laub formula, when combined with a corresponding torque formula, gives zero torque value for observers in both reference frames, complying with special relativity. Another issue is the long-standing problem of "hidden momentum," in which Mansuripur shows that the Lorentz law fails to conserve momentum in certain situations involving magnetic media. In contrast, the Einstein-Laub equations show complete consistency with the conservation laws.

However, Mansuripur's bold claim of a paradox with the Lorentz law has generated some intense criticism. Daniel Vanzella, a physics professor at the University of Sao Paulo in Sao Carlos, Brazil, has submitted a comment to *Physical Review Letters* arguing that the Lorentz law is perfectly compatible with special relativity. Vanzella points out that the Lorentz force can be put in a covariant form and a covariant law cannot lead to incompatible descriptions of the same phenomenon in different inertial reference frames. He explains that Mansuripur has incorrectly used relativistic mechanics and ignored a hidden momentum that makes the Lorentz formula predict a torque in one reference frame but not another. Vanzella thinks that the paper is so flawed that it should not have been published at all. The only paradox, he says, is why the high-ranking journal accepted the paper in the first place!

More at <http://phys.org/news/2012-05-classical-electrodynamics-law-incompatible-special.html>

Original paper: *Physical Review Letters* 108 (2012) 193901

Engineers use plasmonics to create an invisible photodetector

A team of engineers at Stanford and the University of Pennsylvania has for the first time used "plasmonic cloaking" to create a device that can see without being seen—an invisible machine that detects light. At the heart of the device are silicon nanowires covered by a thin cap of gold. By adjusting the ratio of metal to silicon—a technique the engineers refer to as tuning the geometries—the engineers have created a plasmonic cloak in which the scattered light from the metal and semiconductor cancel each other perfectly through a phenomenon known as destructive interference. The rippling light waves in the metal and semiconductor create a separation of positive and negative charges in the materials—a dipole moment. The key is to create a dipole in the gold that is equal in strength but opposite in sign to the dipole in the silicon. When equally strong positive and negative dipoles meet, they cancel each other and the system becomes invisible.

More at <http://phys.org/news/2012-05-cloak-invisibility-plasmonics-invisible-photodetector.html>

Original paper: *Nature Photonics* 6 (2012) 380

Cricket swing theory does not hold water

The widely-held belief that moisture in the air during humid conditions helps make a cricket ball swing has been clean bowled in a scientific study. Swing bowling—when a delivery curves sideways in mid-air—has long been regarded as one of the game's dark arts, not only deceiving hapless batsmen but also puzzling cricket-loving scientists. Researchers from Britain's Sheffield Hallam University and the University of Auckland in New Zealand reviewed scientific literature on the subject and conducted their own tests to try to get to the bottom of the mystery. The researchers tested the theory using 3D laser scanners in an atmospheric chamber to measure the effect different humidity levels had on deliveries using balls which had been "aged" to simulate match conditions. While altitude and the age of the ball both increased swing, the scientists did not discover any link between moisture levels in the air and sideways movement of the ball.

See <http://phys.org/news/2012-05-cricket-theory.html>

Original paper: *Procedia Engineering* 34 (2012) 188

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Panjab University, Chandigarh

Floating Ring Magnets

Sameen Ahmed Khan

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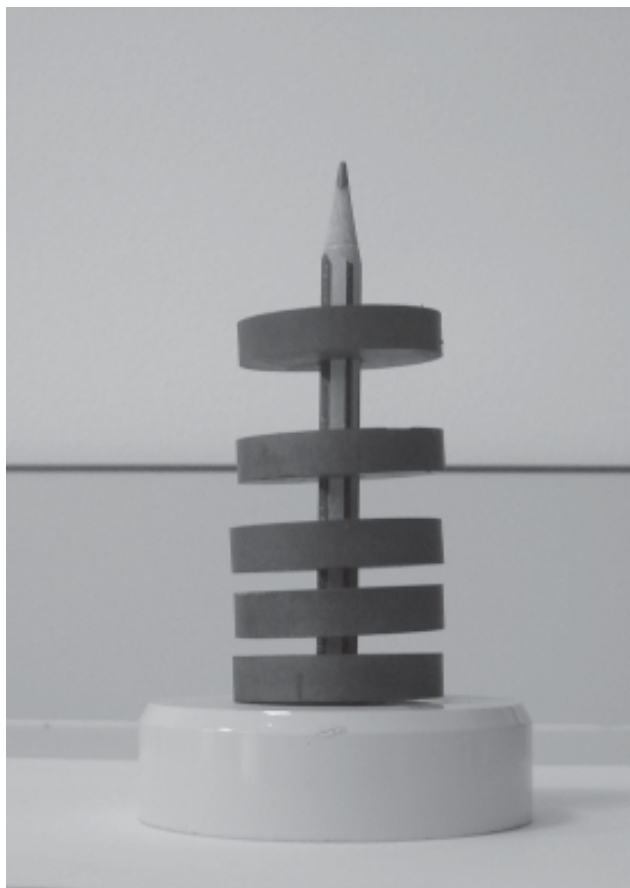
Levitation of ring magnets is used to demonstrate the force between magnets.

Introduction

Like poles of two magnets repel. This fact is the basis for the design of many laboratory and industrial equipments. This basic property of the magnets can be demonstrated by trying to bring the like poles of two bar magnets together. In this configuration the force of the repulsion is noticeable. Here, we shall use the ring magnets to demonstrate the force of repulsion. Ring magnets are cylindrical magnets with a hole in the centre. The diameter is much larger than the height of the magnets. Ring magnets can be used for many different things. Powerful rare-earth neodymium magnets are found in computer hard disks, CD players, speakers and microwave ovens. The ring magnets in the photographs are from a dismantled magnetron — the heating element in microwave ovens. Ring magnets in the above examples are very powerful.

Experimental Procedure

A wooden dowel (rod or pole) or a pencil is vertically attached to a wooden block by a screw, such that it can bear a force of few newtons. The first ring magnet is placed over the wooden dowel. The second magnet is brought close to the first magnet to feel the magnetic forces and decide which of the two poles repel. After identifying the repelling pole the second magnet is placed over the dowel in such a way that the like poles face each other. This makes the second magnet float. In a similar manner the third ring magnet is also placed over the dowel. These steps are continued to place several magnets over the dowel. We make the following observations. The force of repulsion is sufficient to overcome the force of gravity and make the magnets float. The distance between the first and the second magnet is the least, followed by the second and the third, followed by the third and the fourth, and so on. The first magnet has to bear the weight of the all the magnets, hence the distance is the least. The assembly of magnets on the dowel behaves like a spring. If the magnets are pushed down they resist, just like a spring.



Care needs to be taken while bringing the unlike poles of the magnets together. The force is strong enough to injure and damage the lab equipment.

Concluding Remarks

It has been possible to demonstrate the strong force of repulsion between magnets by levitating them. It would be an interesting exercise to study the relationship between the gaps of the magnets.

Further Reading

1. <http://en.wikipedia.org/wiki/Magnets>
2. *Physics for Class XII*, NCERT, Delhi (India) 2006, <http://www.ncert.nic.in>

13th Asian Physics Olympiad

(May 1-7, 2012)

REPORT

(Photographs are on inside front cover and inside back cover.)

The 12th Asian Physics Olympiad was held in April-May 2011 at Tel Aviv, Israel. There the President of Indian Association of Physics Teachers (IAPT) Prof. Satya Prakash received the APhO flag from Prof. Ming-J. Lin, President of APhO, with the commitment that the 13th APhO would be hosted by India. As per the statutes of APhO, a first-time participating country must host the Olympiad within five years of their participating. With that obligation in view, several meetings were held in 2010-11 by IAPT office bearers along with National Coordinator of Olympiads in India Dr. Vijay Singh and the then Director of Homi Bhabha centre for science education Dr. H.C. Pradhan in connection with India hosting the 13th in the year 2012. Dr. Ravi Bhattacharjee, the Convenor of IAPT-APhO cell facilitated the meetings and ultimately took the responsibility on behalf of IAPT to make this event happen in India. This is the first time that a voluntary organisation like IAPT with the fullest support of HBCSE, the nodal centre for Olympiads in India, took the lead in organising this event. It was a tedious path till the final countdown but ultimately everything was taken care of. On May 1, 2012, the opening ceremony of the 13th Asian Physics Olympiad was held at Manekshaw Centre in Delhi Cantt. The ceremony began at 9.30 AM, with the students from 21 participating countries, dressed colourfully in their ethnic attire being paraded on the stage. It was a feast for the eyes of onlookers. Then began the formal function with Prof. Kapadia of SGTB Khalsa College, Delhi taking over as the master of ceremonies.

Prof. Kapadia invited Prof. Satya Prakash, President of IAPT to welcome the distinguished guests, leaders, observers, students and invitees. In his welcome address, Prof. Prakash described India as a land of Bhagvat Gita, land of Buddha and of Mahatma Gandhi. He urged all those present to work for a just and equitable social order which is envisaged in the ideal of *Sarvey Bhavantu Sukhina*, meaning the well-being of all in the universe.

Next speaker was the President of APhO, Prof. Ming-J. Lin of NTNU, Taiwan. He pointed out that Asian students had performed much better than their counterparts in the west in international olympiads and APhO had been playing an important role in encouraging young talents to pursue excellence in science. APhO is a cultural exchange between the host country and participating countries.

Dr. R. Chidambaram, Principal Scientific Adviser to the Government of India said that the students participating in this competition were highly talented in physics and hence they have to be exhorted to pursue physics as career which will bring honour and satisfaction to them, though

not as much money. Prof. Dinesh Singh Vice-Chancellor, Delhi University also spoke in this occasion. Prof. Jaishree Ramdas, Director of HBCSE said that IAPT and HBCSE have been collaborating ever since India started participating in International Olympiads.

The chief Guest of the day, Shri Kapil Sibal, Honourable Minister for Human Resource Development, Government of India, declared open the 13th APhO. On this occasion he said that pursuit of science has been a tradition in India and cited the names of Sir C.V. Raman, Prof. S.N. Bose and Dr. Meghanad Saha. He said that society needs science and science needs money. Society has to support science to find solutions to its needs. Here we will fail in our duty, if we do not mention that MHRD has been the major sponsor of this event apart from Department of Science and Technology and Department of Atomic Energy. The opening ceremony came to an end with reverberating fusion music comprising of Indian classical and western music. It was a exalting experience for all.

Soon after the opening ceremony, in the afternoon of 1st May the Academic Board convened the meeting of leaders and observers to discuss the experiments. The discussion was initiated by Prof. Vijay Singh, the chairman of the Academic Board. Prof D.A. Desai co-chairperson of the experimental group presented the first experiment on friction. It was a novel experiment in the sense that, by performing this experiment student had to mathematically model how the friction varies with the angle and also the estimation of friction coefficient. Shri Shirish Pathare, Scientific Officer at HBCSE was the coordinator of this experiment. He demonstrated this experiment to the leaders and after a lot of discussions a consensus was arrived at.

The second experiment was on estimation of eddy current losses when an aluminium core was introduced into a coil to which a sinusoidal emf was applied. This experiment was also presented by Prof. Desai and was demonstrated by Dr. Rajesh Khaparde faculty at HBCSE. The experiment appeared very lengthy to all but after a bit of discussion the experiment was optimised for performance by the students.

Day II – May 2: On the second day students had to face the experimental competition which was of five hours duration. They had to perform two experiments. After this session, when interviewed, students expressed the opinion that the experiments were not too tough but the second experiment was lengthy and required more time. When the students were performing the experiments the leaders and observers were taken around Delhi for sightseeing.

After return from this trip the leaders were handed over the experimental answer scripts of their students.

Day III – May 3: On the third day, the theory questions were discussed in the Board meeting. One theory question was designed in honour of S. Chandrashekar, the renowned Astrophysicist and Nobel laureate. The question was on Chandrasekhar limit and the stability of the white dwarfs. Another question was dedicated to Pancharatnam, a student of Sir. C.V. Raman, who died at an early age. This question was on polarisation and was titled Berry-Pancharatnam phase. All three theory questions were quite interesting and challenging for the students. The theory questions were presented by Dr. Praveen Pathak of HBCSE, Prof.H.S.Mani and Prof Vijay Singh. While the theory questions were discussed by the leaders the students were taken around Delhi for sightseeing.

Day IV – May 4: On the fourth day, the students had to face the theory competition. It was a day of relaxation for the leaders after a round of brain storming session of theory discussions, the leaders and observers were taken on an excursion to the great historic places of Karnal and Kurusketra the land of the Mahabharata war. Again on return from this excursion the leaders were handed over the Xerox copies of the answer scripts of the theory examination of their students.

Day V – May 5: Saturday, the fifth day was a hectic day for the for leaders as they were busy evaluating the answer scripts of their students while the students were enjoying the day at Agra, the land of the Taj Mahal. It was the day when the leaders had to hand over the evaluated marks sheets of their students to the organisers and receive the one evaluated by the graders. This was to facilitate a comparison of the evaluation between the two and enable the leaders to prepare for the arbitration on the 6th May in case of any discrepancies in the two gradings. This is the most crucial part of any international competition as a fair and transparent deal is given to the students. The leaders have a look at grading of their students and if necessary can argue for them during the arbitration if there is any significant difference in the markings. This is an important part of the event.

Day VI – May 6: The arbitration was on the 6th of May. Each country was given a slot in the timing for each question and the leaders could meet the Arbitrators and put forth their argument in defence of their students. If the arbitrators feel it was genuine, marks are reallotted. After the Arbitration was over the final marks sheets were handed over to the leaders. The International Board meeting was held in the evening of 6th May to decide on the medals. This year the gold cut-off stood at 35 out of 50, the silver at 31 and the bronze at 25.

Day VII – May 7: At last came the day of joy and honour for the students who worked hard to put their country on

the top, the day of the closing ceremony and medal award day. The ceremony was held on the 7th May again at the Zorawar Hall, Manekshaw Centre. The ceremony began with a welcome address by the President of IAPT, Prof. Satya Prakash followed by a wonderful invocation which was a recital of hymns from the Vedas by the Gandharva School of Music and Dance, Delhi. Dr. R. Chidambaram gave the valedictory address. The Principal of SGTB Khalsa College also addressed the gathering. Prof. Ming-J. Lin, President of APhO also spoke on the occasion. The medal awards began with the honourable mention certificates and Bronze Medals given away by the President of IAPT. The Silver Medals were distributed by Prof. Ming and the Gold Medals were given by Prof. R. Chidambaram. The Chinese stole the show as all the eight students who participated got Gold medals. The highest score was 46.5 out of 50, scored by a student of China. The medal winners of the Indian team were:

- 1) Rahul Trivedi, Lucknow - Gold
- 2) Innala Jeevana Priya, Hyderabad - Gold
- 3) Bijoy Singh Kochan, Chandigarh - Silver
- 4) Kunal Singhal, Delhi - Silver
- 5) Rohit Kumar, Darban, Bihargha - Silver
- 6) R.S.Bharadwaj, Hyderabad - Silver
- 7) R.Krishnan, Chennai - Bronze
- 8) N.S.S.Jagadish, Hyderabad - Bronze

The leaders and observers for the Indian Team were Dr. Pramendra Ranjan Singh, Jadam College, Chappra, Bihar (Leader), Dr. M.K. Raghavendra, Indian Institute of Science, Bangalore (Leader) and Prof. B.N. Chandrika, V.V.S. First Grade College for Women, Bangalore (Observer).

A grand finale was accorded to the event by students of Gandharva School with their dance performances in the three types of Indian classical dance, the Bharathnatyam, Odissi and Kathtak. It was a treat to watch for the audience.

The curtain was drawn with the president of APhO declaring the meet closed and the handing over the flag to Indonesia which is to host the 14th Asian Olympiad. The Indonesian leader Dr. Henree invited all the delegation leaders to participate and visit Indonesia next year. Vote of thanks to all those who made this event a grand success was delivered by Prof. Ravi Bhattacharjee the Organising Secretary. A grand lunch was hosted at Zorawar basement.

This event was a milestone in the history of IAPT and a trendsetter for the forthcoming International Physics Olympiad which will be hosted by India in the year 2015. IAPT is very grateful to all those government departments who generously sanctioned funds for the event and to those who strived day and night for the success of the event. Special thanks and compliments to Prof. Ravi Bhattacharjee for all his untiring efforts.

B.N. Chandrika

Prof. Ved Ratna – Some Reminiscences

I first met Prof. Ved Ratna in 1972, much before the advent of IAPT, at NCERT in a workshop for school teachers. One day, after the evening session, I decided to visit a friend who lived some 7/8 km from the NCERT campus. I requested him to drop me at the nearest bus stop where I could catch a bus. He readily agreed but instead of dropping me at the bus stop he drove the scooter all the way up to my friend's residence. My protests on the way were simply ignored. Reaching there he just smiled and went away. I was overwhelmed by this gesture of his to a new acquaintance. We befriended each other ever since.

His serene looks and gentle manners gave him a likable identity. I never saw him in an agitated mood, in the meetings or elsewhere. In the Executive Council of which he was a member for many years, he would put forth his views on the issue under discussion in a cool and dignified manner and sit down leaving it to others to ponder over.

Perfectionist to the core, even small details would not escape him. I happened to share the room with him at Homi Bhabha Centre for Science Education, Mumbai, on two occasions. Every time, while going out he would ensure that AC and lights were off. After making tea, everything – the pan, tea and sugar pots, the cups and even the spoons would be put in their proper places. Nobody could even suspect that tea had been made here just half an hour ago. Once I found that a button in my shirt was missing. And lo! Prof. Ved Ratna produced, out of nowhere, a sewing kit complete with a needle, sewing thread and buttons. Another time, I needed a stapler and he had it. He always travelled equipped with probable necessities.

Travelling with him was a pleasure as besides his company you would also get plenty to eat from his basket. He would not buy anything from the vendors but carry his own eatables. And, since he was Prof. Ved Ratna, you could expect anything and everything in there - fruits, bread, butter, jam, biscuits and home-made snacks too.

The cause of physics education was very dear to him. In Delhi - Haryana (RC-01) region he initiated /participated in almost every IAPT activity. He had a soft corner for village schools, in particular. Few years ago I organised at a school in my village (Western UP) a district-level programme for school physics teachers to which I invited him. Not only did he come, he brought with him a good quality telescope which he donated to the school for carrying out sky- watch activity at night. Not many people know that Prof. Ved Ratna was an amateur astronomer too.

Some years ago, IAPT started holding the National Competition for Innovative Experiments in Physics (NCIEP).

Prof. Ved Ratna was regularly participating in it and won prizes also. I once told him, "Ved Ratnaji, you have already done your bit. This competition is for younger people. Why tax yourself?" He replied, "The idea of competition stimulates me to think and attempt something new, I get pleasure doing it. Also, I want to show that if people at my age can be creative, why not the younger lot too."

Of late he felt much concerned about the state of physics practicals in our schools and colleges. He wrote about it several times in the Bulletin too. He was particularly distressed with the fact that though the students were not performing the experiments in the lab to the desired extent yet they were being awarded high and very high marks. This raised questions regarding the ethics of the teaching community.

Prof. Ved Ratna had frugal habits and led a disciplined life. One could never have imagined that he would leave us so suddenly. It came as a shock to all of us. To me it is a great personal loss – I have lost a dear friend, philosopher and guide.

U.S. Kushwaha

For publishing IAPT activity reports in the IAPT Bulletin

The report **MUST** contain the following:

1. Name of the activity
2. Date/duration
3. Venue of the activity
4. Organising institute along with collaborators if any
5. Sponsors, if any (IAPT, RC or any other funding agency)
6. Summary of the activity
7. Name of the coordinator/convener/organiser along with address, email id and mobile number

Maximum two photographs, if available, may be sent separately via email, preferably of the activity or audience.

Colours in Nature

by Pramod Kale

(Rohan Prakashan, Pune, 2011, pp. 80, Rs. 195)

It gave me immense pleasure to go through the book *Colours in Nature*, to appraise its contents, and to look at the beautiful coloured photographs printed on high quality art papers. This book is authored by *Padmashree* Pramod Kale, former Director of Indian Space Research Organisation (ISRO) and a Life Member of Indian Association of Physics Teachers (IAPT). Prof. Kale was also the Chairman of 'Muktangan' Exploratory of Bharatiya Vidya Bhavan, Pune, for several years. Muktangan is a quality laboratory institution meant for school children. No wonder Prof. Kale has put in all his experiences in writing such a nice book, which will be primarily useful to high-school and junior-college students, but also to others who are interested to understand the origin of colours.

Prof. Kale has taken immense trouble to gather the high-quality photographs and analyse them scientifically. The book has a 'Foreword' of well-known scientific genius Prof. Yash Pal who has admired the contents of the book. The book has about 35 sections (no chapters) and each section concerns itself in a definite aspect concerning colours and their origins. It has about 105 plates and figures. The coverage of the topics is vast – colours that appear in fabrics, oil paints, water colours, pestal colours, crayons, etc., as also those emanating from volcanic eruptions, Cerenkov radiations, aurora, etc. The natural colours that we find in stones and crystals, rocks and sediments, animals, birds, butterflies are beautifully illustrated in the coloured plates. He has also given a table of colours associated with the source of light for those who would like to know the science behind emission of colours.

The book is well written and both the aesthetic as well as scientific aspects concerning observation of colours are presented in a manner so that children as well as grownups appreciate according to their tastes. I strongly recommend that this book forms an integral part of every library, private or institutional.



Yeshwant R. Waghmare

Pune

Dear Members,

The Executive Body of IAPT in the meeting at Bangalore on 30-31 March, 2012 has decided to increase the membership fee as well as subscription fee of the Bulletin as follows (**w.e.f. 1st July, 2012**).

	Current Fees	Revised Fees
Life Membership	Rs. 1000/- (US \$ 300)	Rs. 1500/- (US \$ 450)
Annual		
Institutional	Rs. 5000/- (US \$ 1,500)	Rs. 10000/- (US \$ 3000)
Library	Rs. 250/- (US \$ 75)	Rs. 500/- (US \$ 150)
Sustaining	Rs. 1000/- (US \$ 300)	Rs. 1000/- (US \$ 300)
Individual	Rs. 150/- (US \$ 60)	Rs. 250/- (US \$ 100)
Student (2 Yrs)	Rs. 250/-	Rs. 250/-

(Payment should be made by DD / Multi city cheque in favour of IAPT, Kanpur)

Sanjay Kr. Sharma

Secretary, IAPT Regd. Office, Kanpur

13th Asian Physics Olympiad, New Delhi, India Experimental Competition

Wednesday, 2nd May 2012

Question 1

FRICITION

If a cord is passed around a post or a beam and the tensions in the two segments are different, friction between the cord and the beam plays a role in controlling the motion of the cord (Fig.1). It is observed that to hold a body suspended at one end of the cord, the minimum force needed at other end of the cord is less than the weight of the body due to the presence of frictional forces. With the increase in the number of turns around the beam the decrease in force is spectacular. Sailors are known to use this idea for arresting the motion of ships by winding ropes tied to ships around posts at the docks.

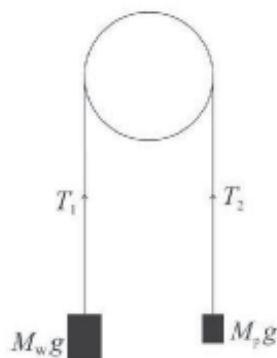


Fig.1

Objective:

To explore the relationship among the three quantities: the load $W (=M_w g)$, the minimum effort $P (= M_p g)$ needed to keep the system in equilibrium and the angle θ subtended by the segment of the cord in contact with one or more beams, by systematically varying these quantities and to express it in the form of an equation.

Apparatus:

Sr. No.	Item	Quantity
1	An apparatus consisting of four pieces of steel pipe on four sides of an identical vertical piece at the centre, all fixed on a wooden platform	1
2	An acrylic sheet (with lines 1.5 mm apart) mounted in front of one of the horizontal pipes	1
3	A plastic pan (including supporting rods) with its mass (M_{pan}) written on its side	1
4	A magnifying glass with torch	1
5	White cord with blue markings (Dial cord)	2 pieces
6	Pink cord	1 piece
7	A weight box containing following weights	
	500.0 g	1
	200.0 g	2
	100.0 g	1
	50.0 g	1
	20.0 g	2
	10.0 g	1
	5.0 g	1
	2.0 g	2
	1.0 g	1
8	A body of unknown mass, M_u	1
9	A hanger of slotted weights with hook (each weight 100.0 g and total weight 800.0 g)	1
10	A piece of cleaning cloth	1

The blue switch can be moved to switch the torch ON/OFF. The acrylic plate with lines rules on it is provided to detect the motion of the cord. The lines on the Acrylic plate can be taken as reference against which the motion of the cord can be observed.

Experimental Procedures

Caution: Do not touch the surface of the pipes with which the cord would be in contact. Any greasy material can change the frictional properties of the surface (surface of the pipes as well as the cord). A cleaning cloth is provided if required.










Part 1:

(Note: Use the dial cord in this part.)

Use the hanger with slotted weights as load M_w . Attach the load at one end of the given piece of dial cord (whose

mass is negligible) and a pan (with known mass) at the other. A weight box with weights is also provided. The angle subtended by the cord can be changed by passing it over/around two or more of the given pipes. (Refer Fig.3).

The minimum value of angle is obtained when the cord passes over two parallel rods without making any contact with the central post (Fig 3) By winding the cord around the vertical post and shifting the position of the effort the angle can be changed by steps of $\pi/2$. The load M_w should be suspended from the pipe to which the ruled acrylic plate is mounted.

		
Fig.2(a) Steel pipes mounted on wooden platform	Fig.2(b) Set of weights	Fig.2(c) Plastic pan
		
Fig.2(d) Dial cord	Fig.2(e) Pink cord	Fig.2(f) Magnifying glass with torch
		
Fig.2(g) Body of unknown Mass, M_u	Fig.2(h) Slotted weights with hook	Fig.2(i) Complete set-up

For increasing the angle the cord is to be turned around the central vertical post. To observe whether the cord suspending the load is slipping over the pipe, the transparent acrylic plate is provided. You can use the magnifying glass with torch to view whether the cord is slipping over the pipe. Ideally one should note the effort

when the load M_w is on the verge of moving down (overcoming static friction). But that is not possible. However, it is possible to determine the interval $[M_{p-}, M_{p+}]$ within which this value lies. Since this interval is a measure of the uncertainty in the magnitude of M_p it should be made as small as possible.

For $\theta = \pi$, take observations over as wide range as possible with the weights provided. Make estimate of the uncertainties in the observations. Plot the necessary graphs and combine the results from the graphs to get the desired equation. On the basis of the analysis of your data write down the quantitative relation giving value of P in terms of W and . The value of P is also dependent on friction between the cord and the pipe. Identify the term in your equation which accounts for friction and equate it to the coefficient of friction for the given system. Estimate the expanded uncertainty in its value.

Part 2:

(Note: Use the pink cord in this part.)

A body of unknown mass and a pink cord is provided. Suspend the unknown mass from one end of the cord and the pan from the other end. Write down the relevant equations to determine M_u and μ_u . With $\theta = \pi$, it, take necessary observations to determine its mass and the coefficient of friction between the pink cord and the pipes using the relationship obtained in the experiment. Estimate the expanded uncertainty in your results.

Note on uncertainty evaluation

1) If it is observed that the magnitude X of a quantity to be measured lies somewhere in an interval $[X_1, X_2]$, and there is equal probability that it can have any value in this interval, then the probability distribution is said to be uniform or rectangular. The standard uncertainty for

such distribution is given by

2) After evaluating the combined standard uncertainty in a measured quantity, the result is stated with an expanded uncertainty. If the expanded uncertainty is taken equal to twice the combined standard uncertainty, the confidence level is approximately 95 %. The number giving

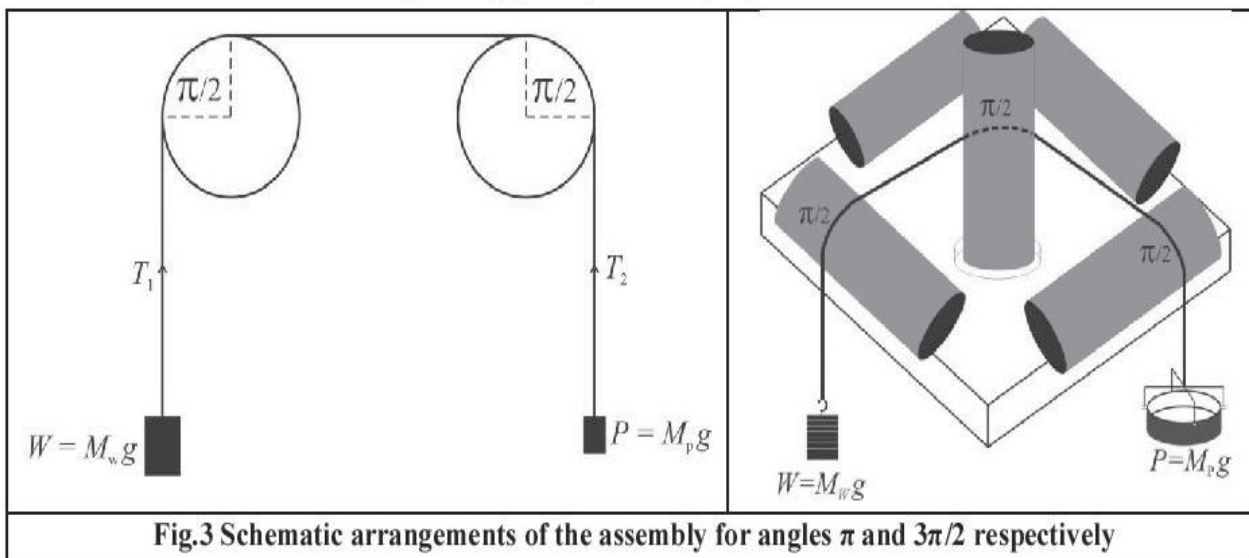


Fig.3 Schematic arrangements of the assembly for angles π and $3\pi/2$ respectively

expanded uncertainty is rounded upwards to retain a single digit (generally) and the number giving the magnitude of the measured quantity is rounded to keep appropriate number of digits such that the last digit has the same decimal place as that of the expanded uncertainty.

Question 2

ELECTROMAGNETIC INDUCTION

The modern technique of eddy current testing employed for detecting defects under the surfaces of metallic objects is based on the principles of electromagnetic induction. The circulating currents induced in conducting bodies due to changing magnetic flux in the region where they are located are called eddy currents. The defects are detected by observing the changes in the resistance and inductance of a coil carrying alternating current when held near the surface of the object.

Unless the core of the solenoid has some ferromagnetic material the magnetic flux ϕ is proportional to the current i . The constant of proportionality is called self inductance of the coil and is represented by letter L . The self-induced emf in a coil with inductance L is, therefore,

given by
$$e = -L \frac{di}{dt}$$

In a coupled system of circuits with current i_1 in one circuit the magnetic flux linked with it is given by

$$\phi = L_1 i_1 + M_{21} i_2$$

Where L_1 is the self inductance of that circuit and M_{21} is the mutual inductance of the coupled system.

Similar equation holds for the reverse, with $M_{12} = M_{21}$

L-R Circuit

A sinusoidal alternating current with angular frequency ω flowing through a series combination of resistance R and inductance L produces a voltage drop across the combination.

If we represent current by $i = i_0 \sin \omega t$, the voltage drop across the resistance is equal to iR and that across the inductance it is $L \frac{di}{dt}$. We can combine these to get the voltage across the $R-L$ combination. The quantity Z is called inductive reactance and is represented by symbol Z . One can readily show that the voltage across the coil is equal to $V = IZ$ where

$$Z = \sqrt{R^2 + X^2} \quad (1)$$

and

$$\theta = \tan^{-1} \left(\frac{X}{R} \right) \quad (2)$$

Alternating voltage as well as current vary continuously in both magnitude and polarity during the course of time but the rms values of these quantities calculated over a cycle are independent of time and the relation $V = IZ$ where both V and I represent the rms values, is analogous to Ohm's law. From this we see that

$$\frac{d\phi}{dt} = \frac{d(Li + Mj)}{dt} \quad (3)$$

(Note:- The concept of resistance is basically related to dissipation of electrical energy and the value of resistance of a coil in ac circuit can be different from its value determined by applying Ohm's law with dc currents.)

When there are additional resistances and/or inductances in series with the coil, we can still consider the voltage drop across the combination as equal to the square root of the sum of the squares of voltage drops across the total resistance and across the total inductance.

Measurement of Inductance and Resistance of a Coil

For measuring alternating current and voltage, generally the rms values are noted. From Equations (2) & (3) we get

$$V \cos \theta = IR \quad (4)$$

and

$$V \sin \theta = IX \quad (5)$$

To obtain the values of R and L of the coil we can use the above equations. Voltage V and current I can be measured. But there being three unknown quantities and we need one more equation.

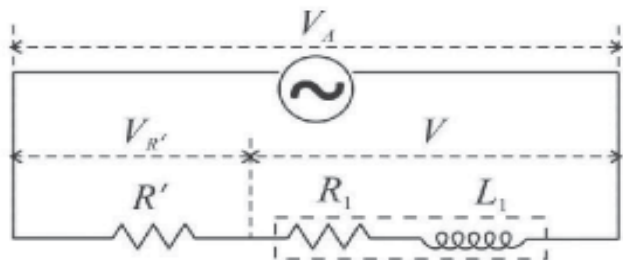


Fig.1

If the applied voltage across the series combination consisting of a known resistor with the coil is V_A , then an expression relating applied voltage to the voltage drops $V_{R'}$ across R' , across the coil and the angle θ is

$$(6)$$

All quantities except θ in Equation (6) are measurable.

Hence measuring the three voltages and V , and using Equations (4), (5) and (6), θ , R and can be determined. Knowing the frequency of the alternating current the value of can be calculated.

Alternatively, from Equations (4) and (6) we can express the value of R in terms of the three measured voltages as

$$(7)$$

The impedance Z of the coil can be calculated using the formula $Z = \frac{V}{I} R'$ and the value of X could be obtained from

$$X = \sqrt{Z^2 - R^2} \quad (1A)$$

Coupled Circuits

The energy supplied by the power source to the primary can be dissipated partially in the primary and the remainder in other mutually coupled secondaries. When no mechanical work is done, the energy dissipation is only in resistances. The inductances store energy in the magnetic field associated with them. With current I (rms value) the average stored energy in inductance is equal to .

When a current flows in the secondary the emf induced due to it in the primary brings about change in the primary current. Seen from the primary side the effect is a consequence of change in the effective resistance and reactance of the primary coil and there is no need to know the parameters in the secondary circuit. The total energy dissipated in primary as well as secondary circuits appears as if it is dissipated in the effective primary resistance when seen from the primary side.

The effective values of resistance R_{PE} and inductance L_{PE} of primary can be related to a 'reflected' resistance R_R and a 'reflected' inductance L_R from the secondary side. The (average) power dissipated in the reflected resistance R_R in the primary has to be equal to that in resistance R_S in the secondary circuit. This gives

$$I_P^2 R_R = I_S^2 (R_S + R_L) \quad (8)$$

Similarly, we can relate the reflected inductance L_R to the secondary inductance L_S from

$$\frac{1}{2} L_R I_P^2 = \frac{1}{2} L_S I_S^2 \quad (9)$$

Considering the fact that the induced emf in the secondary due to an alternating primary current I_p has magnitude equal to $\omega M I_p$ we can write the equation corresponding to Kirchhoff's loop rule for the secondary in terms of rms values of primary and secondary currents as

$$(10)$$

where Z_s is the impedance of the secondary circuit. When the secondary impedance is infinite the mutually induced emf appears as the voltage across the open ends of the secondary.

The apparatus provided for the experiment consists of the following.

1. A sine wave generator with output of about 10 V (rms) at 1000 Hz frequency
2. A digital multimeter (DMM) to be used as a voltmeter
3. A pair of coaxial coils wound one around the other on a

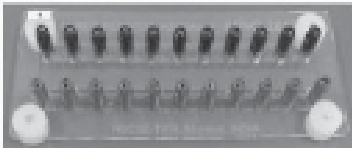


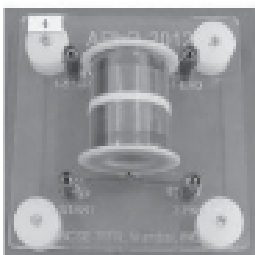

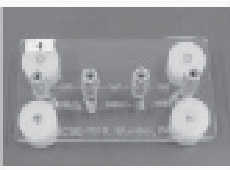
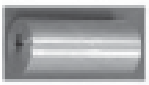
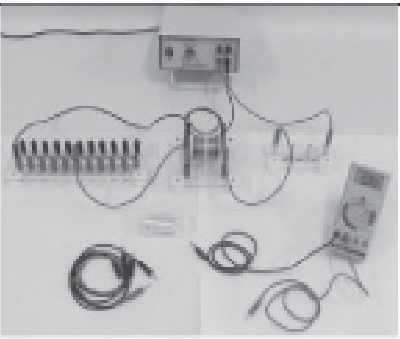
cylindrical hollow piece of non magnetic non conducting bobbin

4. A piece of aluminum rod capable of fitting inside the bobbin

5. Two series of ten resistors mounted on an acrylic board: one consisting of 100 ohms resistors and the other of 10 ohm resistors with banana pin sockets

6. The required resistance for load R_L or sampling resistance R' can be selected using this resistance board and connecting wire pieces. A separate acrylic board with resistance of 300 ohms is provided which can be used for

APPARATUS:

			
Resistance Board	Connecting Wires	Digital Multimeter	Coils wound one over the other
			
Sine wave Generator	Resistance Board	Aluminium Rod	Complete experimental set up

sampling resistor when the other board is used for load resistance.

7. A set of five red and five black wires with banana pins at their ends (the pair of longer red and black wires is meant for use as DMM probes).

The output of the sine wave generator of frequency 1000 Hz is to be used as the alternating source voltage. Use the 20 V range of the DMM to measure rms ac voltages.

The magnitudes of currents I_p and I_s when needed are to be calculated from the measured voltages across known values of R' in primary and R_L in secondary respectively.

EXPERIMENT

PART 1: Determining Resistance and Inductance of a Coil with Air-core and Aluminium Core [3.4]

Connect coil 1 (with blue terminals) in series with a resistor R' (to be selected from the resistance board) across the output terminals of the sine wave generator. The sine wave generator will be on before you start your experiment for stabilization of its output. Do not turn it off. Keep the output voltage amplitude maximum. (The DMM should show the

output about 10 V).

The ac output of the generator may have some asymmetry. In that case, the readings of the DMM will show slightly different readings, when the input polarities of the DMM are interchanged between 'V/Ω' to 'com'. To correct for the error due to asymmetry repeat each reading by interchanging the polarity of the probes of the DMM and take the mean of the two readings.

Choose the value of R' to obtain $V_{R'}$ and V approximately equal so that the systematic error in Z becomes negligible.

a) Measure the voltages V_A , V_R and V as well as V_O across the terminals of the other coil.

Determine the resistance R_1 and inductance L_1 of coil 1 (with blue terminals) and estimate the uncertainties in the values determined. (0.9)

b) Connect the other coil (coil 2 with green terminals), make the necessary measurements and determine R_2 and L_2 . Evaluate the uncertainties in the values obtained. (0.9)

c) Now insert the piece of aluminium rod at the core of the coils and repeat the procedure to obtain the values of inductances L_1^* and resistance R_1^* and the uncertainties in them for coil 1. (0.8)

d) Make necessary measurements and determine inductance L_2^* and resistances, R_2^* of coil 2 when it has an aluminium core. Estimate the uncertainties in the values. (0.8)

Note: Uncertainty calculations need not be done for parts 2, 3 and 4.

PART 2: Mutual Inductance and Coupling Constant [3.0]

e) Mutual inductance M can be obtained from the readings of V_R and V_O (recorded in Part 1). Find the average values for air core as well as aluminium core coils. The relation between the mutual inductance and the self inductances of the coupled coils is given by

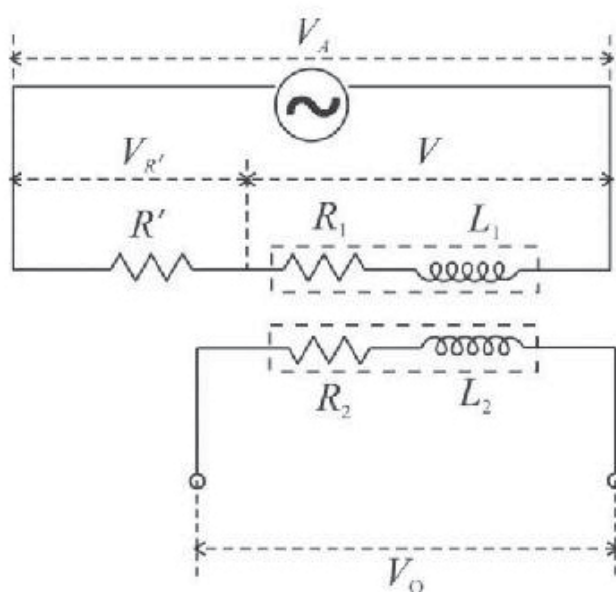


Fig.2

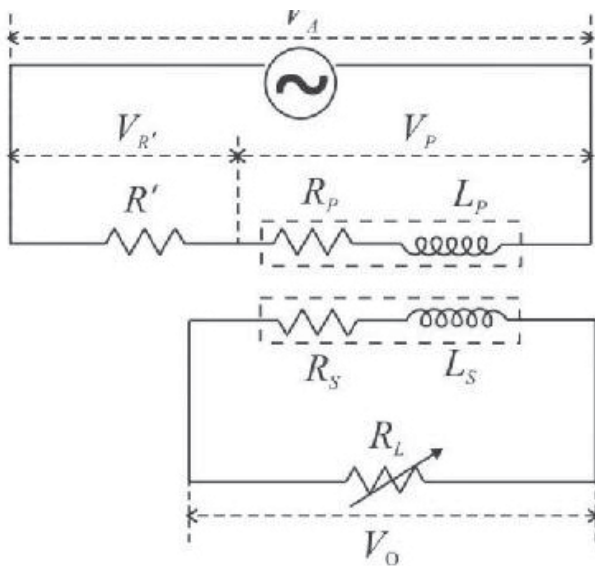


Fig.3

$M = k(L_1L_2)^{1/2}$. Determine the value of k , the coupling coefficient in the two cases. (0.4)

f) Select coil 1 (with blue terminals) as primary and coil 2 (with green terminals) as secondary. Connect the primary in series with the sampling resistor $R' = 300$ ohm across the output terminals of the generator. Connect across the secondary the variable load R_L . The output voltage V_O is to be measured across R_L . Change R_L and measure the voltages V_A , $V_{R'}$, V and V_O , corresponding to each value of R_L . (0.8)

g) A linear graph can be plotted combining various terms appearing in Equation (10) written in expanded form. Write the linear expression for plotting a graph whose slope can be used to obtain the value of M and intercept to obtain the value of secondary reactance X_S . (0.2)

h) Calculate the necessary quantities using data from (g) to plot the graph corresponding to the expression obtained in the step (h) above. (0.9)

i) Plot the graph and obtain the values of M and X_S . (0.7)

PART 3: Relations between Effective Primary Impedance and the Reflected Quantities from Secondary [2.4]

j) Use the data collected in Part 2 to determine the effective resistance R_{PE} and the effective reactance X_{PE} of the primary corresponding to each value of R_L in secondary. (0.6)

k) Use the data of **Part 2** to calculate the values of reflected resistance R_R as defined in Equation (8) and of reflected reactance X_R referring Equation (9) corresponding to the values of R_L . (0.6)

l) Plot graph of X_{PE} against X_R . Taking into consideration the likely uncertainties of the quantities plotted write down the equation giving the relationship between the effective primary reactance and the reflected reactance. (0.6)

m) Represent graphically the relation between R_R and R_L over the range of study and find the value of R_L for which the reflected resistance attains a maximum. *If needed, take some more observations to supplement the observations in Part 2 for locating the point with greater precision.* (0.6)

PART 4: Eddy Current Effects [1.2]

n) A model based on the analysis of the data in **Part 3** suggests how to estimate the ratio of inductance and resistance seen by the eddy currents set up in the core of a coil connected to a power source.

The analysis of the data of **Part 2(i) and (j)** should show that $R_{PE} = R_p + R_R$. The relation between X_{PE} and X_R is obtained from **Part 3(m)**.

Refer to the data collected in **Part 1(c)** and estimate the ratio of inductance and resistance as seen by eddy currents in the aluminium core when the power supply is connected to coil 1 and coil 2 respectively. (0.8)

o) Connect the coils as in **Part 2 Fig.3** and insert the piece of aluminium rod at the core of the coils. Write down the expression giving the power loss ΔP in the aluminium core.

Set $R' = 300$ ohms and $R_L = 1000$ ohms. Adjust the magnitude of V_A equal to 9.0V. Make the necessary measurements and calculate the power dissipation due to the eddy currents in the aluminium core. (0.4)

Model Solution Experiment -1

We will assume the relationship of the form:

Graph of

Slope of the graph : 0.7583

This show that

$$P \propto W \quad (1)$$

M_w represents the mass in the hanger (Load)

M_p represents the mass in the pan + the mass of the pan (i.e. $M'_{p+} + M_{pan}$) (Effort)

The relation between these variables can be found in two parts:

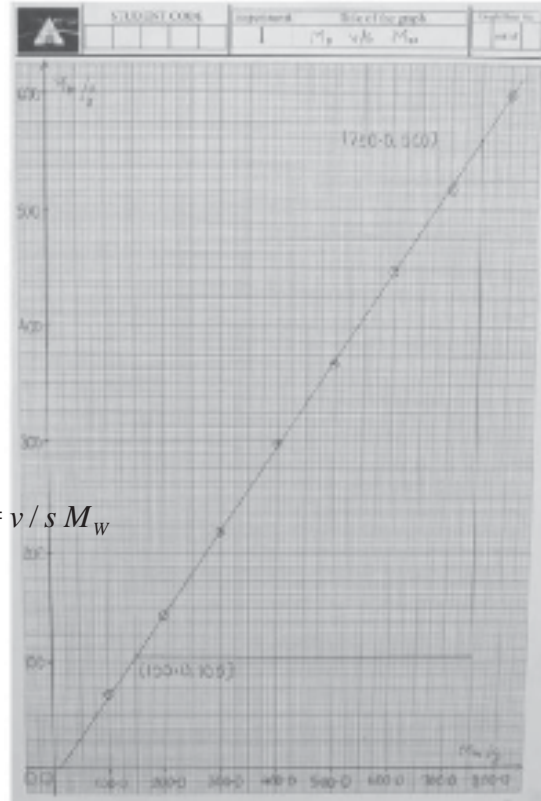
* R Relation between M_p and M_w

* R Relation between M_p and θ

Part 1:

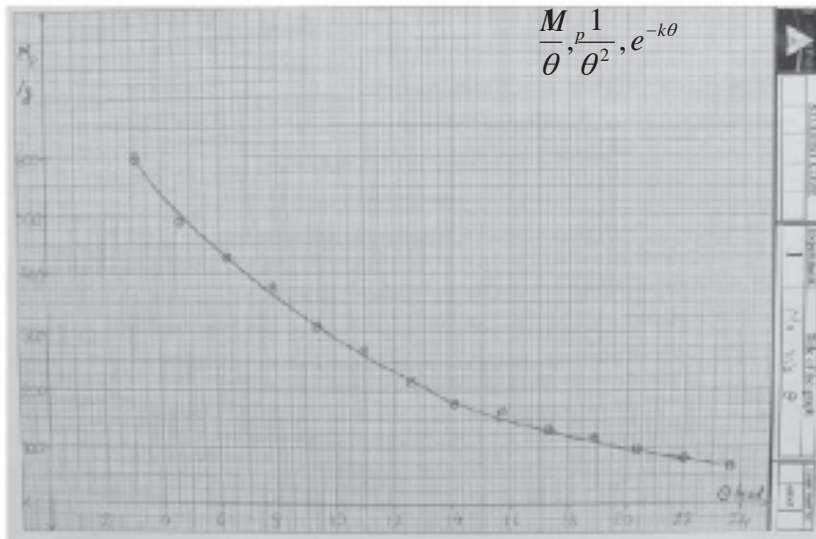
Mass of the pan = 28.6 g

radian (Table below)



Obs. No.	M_w/g	M'_{p-}/g	M'_{p+}/g	$M'_{p(average)}/g$	$M_{p(average)} = M'_{p(average)} + M_{pan}$ /g	$\Delta M_p = \frac{M'_{p+} - M'_{p-}}{2}$ /g
1	800.0	566	574	570	598.6	4
2	700.0	486	494	490	518.6	4
3	600.0	417	423	420	448.6	3
4	500.0	337	343	340	368.6	3
5	400.0	267	273	270	298.6	3
6	300.0	188	192	190	218.6	2
7	200.0	113	117	115	143.6	2
8	100.0	41	43	42	70.6	1

Obs. No.	θ /rad	M'_{p-} /g	M'_{p+} /g	$M'_{p(average)}$ /g	$M_{p(average)} = M'_{p(average)} + M_{pan}$ /g	$\Delta M_p = \frac{M'_{p+} - M'_{p-}}{2}$ /g
1	π	565	575	570	598.6	5
2	$3\pi/2$	455	465	460	488.6	5
3	2π	396	404	400	428.6	4
4	$5\pi/2$	316	324	320	348.6	4
5	3π	276	284	280	308.6	4
6	$7\pi/2$	236	244	240	268.6	4
7	4π	182	188	185	213.6	3
8	$9\pi/2$	147	153	150	178.6	3
9	5π	133	137	135	163.6	2
10	$11\pi/2$	104	110	107	135.6	3
11	6π	88	92	90	118.6	2
12	$13\pi/2$	68	72	70	98.6	2
13	7π	54	56	55	83.6	1
14	$15\pi/2$	39	41	40	68.6	1
15	8π	29	31	30	58.6	1
16	$17\pi/2$	18	20	19	47.6	1



The Graph between M_p and θ shows a curve.

Part 1:

$= 800.0 \text{ g}$

$M_{pan} = 28.6 \text{ g}$ (Table attached next page)

The graph between M_p and θ shows a curve (next page)

There can be possibilities of different functional relationship.

1)

The possible functions can be

For the first two functions mentioned above, at $\theta = 0, M_p$ will reach infinite value which is not possible. For the third function we know that M_p will have some finite value.

2)

If the function is anticipated as exponential one then it can be verified using half value technique whether at every half value of M_p , and then plotting $\ln M_p$ or better

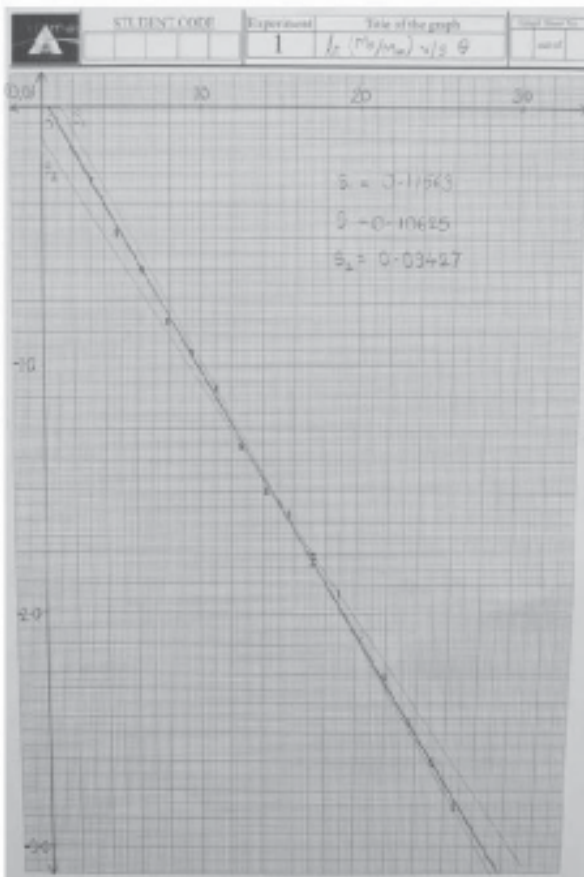
still $\ln \left(\frac{M_p}{M_w} \right)$ against θ .

If it is a straight line with slope , or

$$P \propto e^{-k\theta} \quad (2)$$

From (1) and (2)

$$P \propto W e^{-k\theta} \quad (3)$$



The constant k in the above expression is equated to the coefficient of friction, μ

$$(4)$$

The constant of proportionality in equation (4) is 1. This is because at $\theta = 0$ rad,

$$(5)$$

From the graph,

$$\ln \left(\frac{M_p}{M_w} \right) = -\mu\theta$$

where μ is the slope of the graph.

From the graph, $\mu = 0.106$

$$\frac{\Delta S}{S} = \frac{2}{S} = 0.10049$$

$$\Delta S = 0.1067 = \Delta\mu$$

$$u_c(\mu) = 0.00616$$

$$U(\mu) = 0.0123 \approx 0.02$$

$$\mu = 0.11 \pm 0.02$$

Part 2:

When the pan is moving up:

$$(6)$$

When the pan is moving down:

$$M_{p2} = M_u e^{\mu\theta} \quad (7)$$

M'_{p1}		$M'_{p1(average)}$	$\Delta M'_{p1}$	$M_{p1} = M'_{p1} + M_{pan}$
M'_{p1+}	M'_{p1-}			
164	156	160	4	188.6

M'_{p2}		$M'_{p2(average)}$	$\Delta M'_{p2}$	$M_{p2} = M'_{p2} + M_{pan}$
M'_{p2+}	M'_{p2-}			
49	45	47	2	75.6

For M_u :

Multiplying equation (6) and (7)

$$M_u = \sqrt{M_{p1} - M_{p2}}$$

$$M_u = \sqrt{188.6 \times 75.6} = 119.4075 \text{ g}$$

For μ :

Dividing equation (6) and (7)

$$\mu = \frac{1}{2\theta} \ln\left(\frac{M_{p1}}{M_{p2}}\right)$$

For $\theta = \pi$

$$\mu = \frac{1}{2\pi} \ln\left(\frac{188.60}{75.6}\right) = 0.1456$$

Uncertainty in M_u

$$\frac{\Delta M_u}{M_u} = \sqrt{\left(\frac{1}{2} \frac{\Delta M_{p1}}{M_{p1}}\right)^2 + \left(\frac{1}{2} \frac{\Delta M_{p2}}{M_{p2}}\right)^2} =$$

$$\sqrt{\left(\frac{1}{2} \frac{4}{188.6}\right)^2 + \left(\frac{1}{2} \frac{2}{75.6}\right)^2} = 0.0169$$

$$\Delta M_u = 0.0169 \times 119.4075 = 2.018$$

$$u_c(M_u) = \frac{1}{\sqrt{3}} \times 2.018 = 1.165$$

$$U(M_u) = 2 \times u_c(M_u) = 2 \times 1.165 = 2.33 \approx 3$$

$$M_u = 119 \pm 3 \text{ g}$$

Uncertainty in μ_u :

$$u_c(\mu_u) = \frac{1}{M_{p1}} \cdot \Delta u_u = \frac{1}{2\pi\sqrt{3}} \sqrt{\left(\frac{\Delta M_{p1}}{M_{p1}}\right)^2 + \left(\frac{\Delta M_{p2}}{M_{p2}}\right)^2}$$

$$= \frac{1}{2\pi\sqrt{3}} \sqrt{\left(\frac{4}{188.6}\right)^2 + \left(\frac{2}{75.6}\right)^2} = 0.003117$$

$$U(\mu_u) = 2 \times u_c(\mu_u) = 2 \times 0.003117 = 0.00623 \approx 0.007$$

$$\mu_u = 0.146 \pm 0.007$$

Model Solution Experiment -2

Part I(a):

				Coil Blue (1-1)				AIR CORE		f = 1.000 KHz		
	R'	V _A	V _R	V	V _o	I ₁	Z ₁	R ₁	X ₁	ωM	M (mH)	L ₁ (mH)
	450	10.090	6.760	6.770	4.940							
		10.060	6.700	6.740	4.910							
Avg	450	10.075	6.730	6.755	4.925	0.015	451.67	52.57	448.60	329.31	52.44	71.43

ΔV _A	ΔV _{R'}	ΔV
0.14	0.11	0.11

us(z)	us(R)	ur(Z)	ur(R)	uc(R)	uc(Z)	uc(X)	uc(L)	U(R)	U(X)	U(L)
0.0057	1.1432	0.2747	0.4235	1.2191	0.2748	0.3114	0.000050	3.00	0.7	0.0002

Part I(b):

				Coil Green (2-2)				AIR CORE		f = 1.000 KHz		
	R'	V _A	V _R	V	V _o	I ₂	Z ₂	R ₂	X ₂	ωM	M (mH)	L ₂ (mH)
	350	9.960	6.690	6.610	6.390							
		9.980	6.630	6.680	6.410							
Avg	350	9.970	6.660	6.645	6.400	0.019	349.21	42.96	346.56	336.34	53.56	55.18

ΔV _A	ΔV _{R'}	ΔV
0.14	0.11	0.11

us(z)	us(R)	ur(Z)	ur(R)	uc(R)	uc(Z)	uc(X)	uc(L)	U(R)	U(X)	U(L)
0.0027	0.9057	0.2153	0.3335	0.9651	0.2153	0.2478	0.000039	2.00	0.5	0.0001

Part 1(c)

				Coil Blue (1-1)				Al CORE		f = 1.000 KHz		
	R'	V _A	V _{R'}	V	V _O	I* ₁	Z* ₁	R* ₁	X* ₁	ωM	M* (mH)	L* ₁ (mH)
	290	9.900	5.940	6.010	4.450							
		9.880	5.890	6.050	4.410							
Avg	290	9.890	5.915	6.030	4.430	0.020	295.64	109.68	274.54	217.19	34.58	43.72

ΔV _A	ΔV _{R'}	ΔV
0.14	0.10	0.10

us(z)	us(R)	ur(Z)	ur(R)	uc(R)	uc(Z)	uc(X)	uc(L)	U(R)	U(X)	U(L)
0.0220	1.2498	0.2030	0.3740	1.3046	0.2042	0.5657	0.000090	3.00	1.2	0.0002

Part 1(d):

				Coil Green (2-2)				Al CORE		f = 1.000 KHz		
	R'	V _A	V _{R'}	V	V _O	I* ₂	Z* ₂	R* ₂	X* ₂	ωM	M*(mH)	L* ₂ (mH)
	280	9.860	6.280	6.170	4.840							
		9.830	6.230	6.130	4.860							
Avg	280	9.845	6.255	6.150	4.850	0.022	275.30	71.48	265.86	217.11	34.57	42.33

ΔV _A	ΔV _{R'}	ΔV
0.14	0.10	0.10

us(z)	us(R)	ur(Z)	ur(R)	uc(R)	uc(Z)	uc(X)	uc(L)	U(R)	U(X)	U(L)
0.0173537	0.9509	0.1821	0.3106	1.000	0.1829	0.329	0.000052	3.00	0.7	0.0002

Part 2(f) :

$$\omega M = R' \frac{V_o}{V_{R'}}$$

$$k = \frac{M}{\sqrt{L_1 L_2}}$$

M_{avg} (Air) =	53.00 mH	$k =$	0.844
M_{avg}^* (Al core) =	34.58 mH	$k^* =$	0.804

Part 2(g):

						AIR Core				$f = 1.000$ KHz $R' = 300\Omega$	
	Sr.	R_L	V_A	V_R	V	V_{RL}	I_p	Z_p	R_{PE}	X_{PE}	I_s
	1	100	10.19	5.99	4.97	1.73					
			10.15	6.03	4.94	1.72					
Avg		100	10.17	6.01	4.96	1.73	0.0200	247.34	177.56	172.19	0.017
	2	200	10.12	5.39	5.67	2.77					
			10.09	5.44	5.70	2.79					
Avg		200	10.11	5.42	5.69	2.78	0.0181	314.96	207.03	237.36	0.014
	3	300	10.13	5.17	6.17	3.44					
			10.15	5.11	6.19	3.43					
Avg		300	10.14	5.14	6.18	3.44	0.0171	360.70	216.93	288.18	0.011
	4	400	10.11	5.00	6.51	3.88					
			10.14	5.05	6.53	3.87					
Avg		400	10.13	5.03	6.52	3.88	0.0168	389.25	206.46	329.99	0.010
	5	500	10.15	4.93	6.74	4.20					
			10.12	4.99	6.77	4.17					
Avg		500	10.14	4.96	6.76	4.19	0.0165	408.57	198.08	357.34	0.008
	6	600	10.10	4.98	6.91	4.42					
			10.13	4.91	6.93	4.40					
Avg		600	10.12	4.95	6.92	4.41	0.0165	419.82	183.87	377.41	0.007
	7	700	10.14	4.97	7.05	4.58					
			10.11	4.91	7.07	4.60					
Avg		700	10.13	4.94	7.06	4.59	0.0165	428.74	173.76	391.96	0.007
	8	800	10.09	4.91	7.17	4.74					
			10.12	4.98	7.15	4.72					
Avg		800	10.11	4.95	7.16	4.73	0.0165	434.38	161.90	403.08	0.006

Part 2(h) :

$$(R_s + R_L)^2 = (\omega M)^2 \left(\frac{I_p}{I_s} \right)^2 - X_s^2$$

$$X_p = \left(\frac{I_s}{I_p} \right)^2 X_s$$

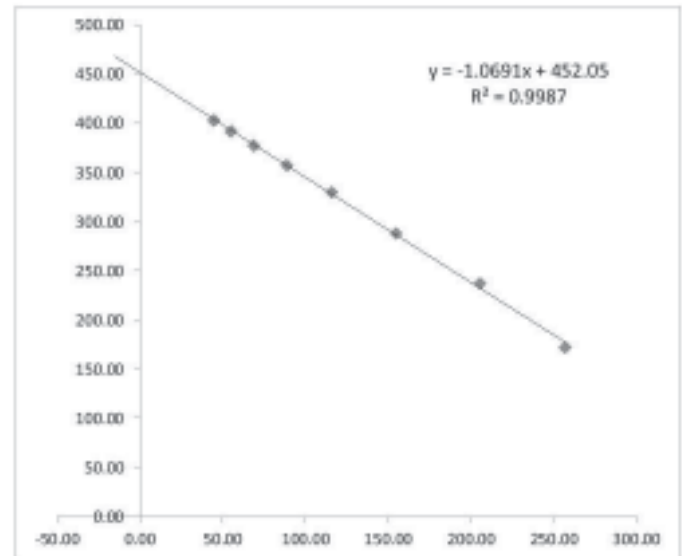
Slope		M
1.07E+05		52.08 mH
Intercept		X ₂
1.23E+05		350.94 Ω

Sr.	R _R	X _R
1	106.00	256.95
2	144.08	205.52
3	153.17	154.78
4	148.17	115.92
5	139.16	88.82
6	127.84	68.91
7	117.81	54.95
8	108.46	44.59

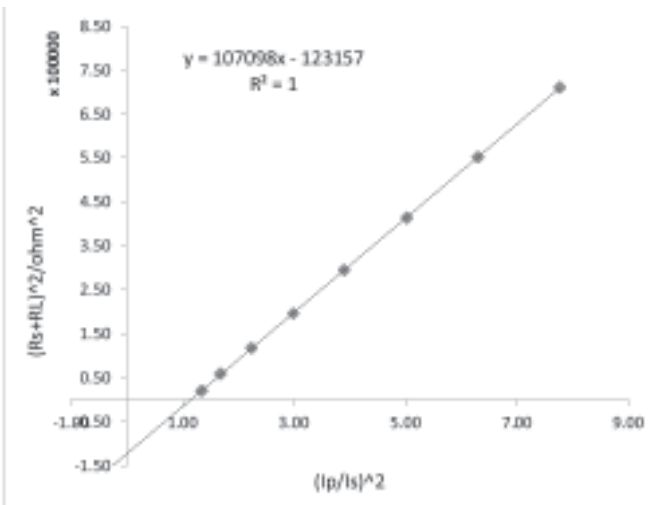
Part 2(i)

(I _p /I _s) ²	(R _s +R _L) ²
1.35	20438.25
1.69	59030.73
2.24	117623.21
2.99	196215.69
3.90	294808.17
5.03	413400.65
6.31	551993.13
7.77	710585.61

Part 3 (m)



Part 2(j)



Inference:

$$X_p - X_R = X_{PE}$$

Part 3(k) and 3(1) :

$$R_R = \left(\frac{I_p}{I_s} \right)^2 (R_s + R_L)$$

Part 3(n) :

Sr.	R _L	V _A	V _R	V	V _O	I _p	I _s	(I _p /I _s) ²	R _R
1	280	10.06	5.11	6.05	3.29				
		10.03	5.16	6.03	3.30				
2	280	10.05	5.14	6.04	3.30	0.0171	0.01	2.12	152.65
	320	10.02	5.09	6.19	3.51				
	320	10.05	5.03	6.21	3.50				
	320	10.04	5.06	6.20	3.51	0.0169	0.01	2.37	153.07

R _L	RR
100	106.00
200	144.08
280	152.65
300	153.17
320	153.07
400	148.17
500	139.16
600	127.84
700	117.81
800	108.45771

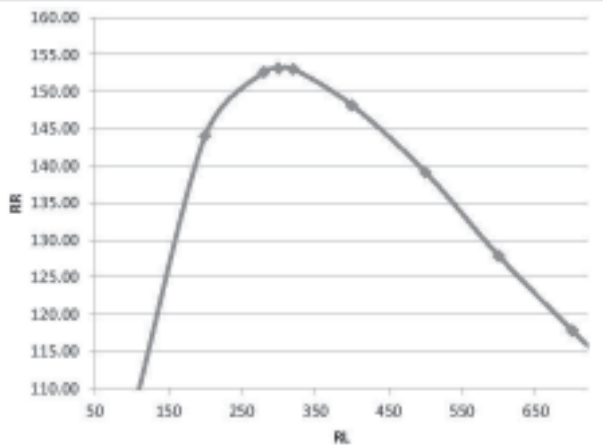
Part 4(o) :

$$R_R = R^* - R_P$$

$$X_R = X_P - X^*$$

$$\frac{X_{core}}{R_{core}} = \frac{X_R}{R_R}$$

$$\frac{L_{core}}{R_{core}} = \frac{1}{2\pi f} \frac{(X_P - X^*)}{(R^* - R_P)}$$



Blue Coil	Green Coil
Lc/Rc	Lc/Rc
4.85E-04	4.50E-04

Part 4(p) :

$$\Delta P = I_P^2 (R_{PE} - R_P) - I_S^2 (R_S + R_L)$$

	R _L	V _A	V _R	V	V _O	I ₁	I ₂	R _{PE}
	1000	9.00	5.32	5.08	3.45			
		9.01	5.27	5.10	3.43			
Avg	1000	9.01	5.30	5.09	3.44	0.0177	0.003	145.23
		Δ P =	1.65E-02 W					

13th Asian Physics Olympiad (Delhi, 1-7 May 2012): Some photographs



9



10



11



12



13



14



15



16

(9) A view of the audience, (10) another view showing student participants, (11) students from Saudi Arabia in their ethnic attire, (12) dance performance at the cultural programme, (13)-(16) sight-seeing by the delegates.

BULLETIN OF INDIAN ASSOCIATION OF PHYSICS TEACHERSFOUNDED BY (LATE) DR. D.P. KHANDELWAL

VOLUME 4 NUMBER 6

JUNE 2012

ISSN 2277-8950

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