International Journal of Advance Research in Science and Engineering
Vol. No.6, Issue No. 09 , September 2017
www.ijarse.com
IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

College and University level Some low cost / No cost Experiments that foster Basic Science and Research Driven Learning

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ABSTRACT

Interest in basic science and quality research has been continually dwindling in our Nation. We find fewer dedicated scientific people and good human beings now a days. This trend needs to be reversed if we want sustain progress of our society. There has been a general deterioration in the level of understanding of science in India in spite of the fact that many research and technical institutions have been established nationwide after independence. This deterioration can be also attributed to a lack of innovation, discipline in teaching & academic activities and scientific outlook. We present here a very effective method, that we have found, creates interest in science – especially in Physics at all of study. It is based on Low-cost / no cost experiments, connected with nature at Undergraduate and Postgraduate levels. The inclusion of such experiments in the curriculum is within the budget of all educational setups, because the apparatus is inexpensive and most of the experiments are well within the means of individual students. These experiments take five to ten minutes to perform for classroom demonstrations. We have demonstrated these experiments in various situations including regular classrooms and public places/ training programme. We have found that they generate tremendous interest among teachers & students right from School level to Postgraduate level. The experiments include experiments in Mechanics, Optics, Electricity & Magnetism, Heat, Waves & Oscillation and other areas of Physics. In this paper we report some of these low-cost experiments and their pedagogical aspects such as their integration with classroom teaching and research inspired learning. These experiments were developed mainly under the guidance of Prof. H. C. Verma, Dept. of Physics, IIT Kanpur, coordinator of Utsahi Physics teachers group (www.utsahiphysicsteachers.com) and National Anveshika Network of India, a unit of Indian Association of Physics Teachers (IAPT)– activities. In last 10 years, we have conducted more than 50 workshops with the help of such experiments. These workshops have attracted attention of students and encouraged them to ask relevant questions in science and innovative activities. Such efforts have also helped in demystifying scientific research and developing scientific thinking in students/ faculty members. The present Indian Government has taken several steps for developing research within the country in frontline areas such as Nanotechnology, Biotechnology, Cognitive Sciences and Information technology, Interdisciplinary science. This innovative method of learning science, supplement this move by helping create interest in basic understanding in science without which cutting edge research is not possible successfully. Creating interest for learning-doing science, peace & harmony among science lovers and dedication for this like scientists done for this nation is the

IJARSE
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important for well developed system and value based scientific society.

Highlights: Low cost Experiment, Basic Science and Applied Research innovation

I. INTRODUCTION

Interest in fundamental science and quality research has been continually dwindling in our nation. We find fewer dedicated scientific people and good human beings today. This trend urgently needs to be reversed if we want a sustained development of our society or nation. There has been a general deterioration in the level of understanding of science and pursuit of research-based career in young minds in India in spite of the fact that many research and technical institutions have been established nationwide in 21st centuries. This deterioration can be attributed to a steady dwindling of scientific outlook and of love for doing innovations.

The population is increasing day by day, and so are the needs of our society. But new innovative knowledge is not available in the same proportion. Most of the young minds have inclination towards wealth generation and employment rather than towards doing scientific research. As the history of Science shows, innovations require a sustained dedicated effort over a certain period of time for their manifestation. Developments in Science and Technology come through a lot of sacrifice on the part of innovators. The outcomes of this sacrifice are visible in the society. Technological advancement have shrunk the globe into a village. Therefore such innovative practices which would inculcate love for scientific research and sustainable development into young minds should be fostered. To the best of our knowledge, according to various reports, the governments in countries like China and U.S.A are able to procure good amount of revenue from academic activities. But our country India is not able to do this. The Hon'ble Prime minister of India has launched *Start-up* program, Skill devlopement and *Make in India* program. Thinking along the same line, The Indian Association of Physics teachers (IAPT) has set up *Anveshika* centers at 22 places in India and working for more than 10 years. These Anveshika centers are advocating experiment-assisted teaching that create an interest in masses of people for learning and doing new science experiments [1]. Senior Resource person of Utsahi Physics Teachers, coordinated by Prof. H.C.Verma, IIT Kanpur, have also Anveshika Centers for such activities [2]. In this article, experiments that we report are the activities of Anveshika and Utsahi Physics Teachers [1,2].

We present here, this very effective method that, we have found, creates interest in science – especially in Physics. This method uses Low-cost/no cost experiments at Undergraduate and Postgraduate levels for creating this interest. The inclusion of such experiments in the curriculum would be within the budget of all educational setups because the cost of these experimental setups is very low – often they can be performed using available household odds and ends. Thus most of these experiments are well within the means of individual students.

These experiments take five to ten minutes to perform in a classroom and have a great pedagogical value in terms of inspiring students towards independent innovative and scientific thinking. These efforts have also helped in demystifying scientific research and developing scientific ethics and encouraging students/ faculty members to inspired research and innovations [3-6]. We describe below some of the experiments that we are doing:

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II. SCATTERING OF MONOCHROMATIC AND POLYCHROMATIC LIGHT THROUGH TRANSLUCENT PLASTIC ROD

When Light beam is passed through a translucent plastic rod it gets scattered. A laser beam shows gradual decrease in intensity without any change in color. But a white light torch beam shows gradual intensity change as well as a change of color. The part near the torch is bluish white in color while the part farther from the torch tends towards a reddish brown hue. This effect is due to different scattering length for different colored light in the medium. Blue light is scattered more than red light. This causes tapering of color with a white light source.

Appreciating in Daily life: For Danger, a red signal is used. This is because red light is scattered less and so can be seen from far off. Green light is used for All Clear signal which is less penetrating. For Fog light Yellow is preferred because it is brightest at any given intensity. Also, it has good penetration depth.

III. THE PROCESSES OF TEMPERING AND ANNEALING OF A METALLIC MATERIAL

3.1. Instruments: Water in a mug, Pliers, Paper clips, heat source- Gas burner

3.2. Procedure- Two paper clips are opened and straightened. One of them is end of a wire is held with pliers from an end and heated for about 2 minute in a flame.

The hot wire is immediately plunged in cold water. This wire is found to be hard like spring steel. The process is known as tempering. The second wire is similarly heated for about 2-minutes in a flame, but is allowed to cool slowly down to room temperature. We note that the wire has become soft and it can easily bend. This process is known as annealing. In Scientific research, generally annealing is to be used for structural feature of the materials.

3.3. Daily life example: The village blacksmiths use tempering to harden knives and scythes. Soft iron is produced by annealing. These processes are commonly employed by metal workers and craftsmen to shape metal objects. In material science, annealing and tempering help in manipulating properties of different materials for their applications in Electronics industry, Medical Science and Environmental science[7].

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3.4. Drinking Duck and involved Scientific principles.

The drinking duck is a very common decoration item people keep in their house. This duck is made up by joining two glass bulbs by tubes open at both ends. The bulb representing head of the duck is covered by cotton and a beak is made by attaching to the upper glass bulb. A liquid with low boiling point (CH_2Cl_2, boiling point 42^oC) is filled in the tube. A vessel containing water is placed between the two ducks on the base frame. The duck dips its beak in the water, as if it is drinking water, vaporization of water take place and phase transition occurs and then starts oscillating with a large amplitude. After some time, the amplitude decreases and momentarily stops. Then water drains from one bulb to the other and this processes repeats. Such motion can continue for days and weeks and months as long as you ensure that there is water in the vessel. This experimets was shown in National workshop of Utsahi Physics Teachers, organized by Deptt. of Physics, IIT Kanpur (www.utsahiphysicsteachers.com).

IV. KEYFEATURES

The toy is fascinating and is a wonderful application of several scientific principles. Some of these are, effect of shift of center of gravity on a balancing body, cooling by evaporation, Phase transition phenomenon, saturation vapor pressure and the motion of the liquid from low pressure to high pressure.

V. WAVE MOTION ON IRON SPRING

Waves are traveling disturbances that carry energy. The propagation of waves requires a medium. Superposition of waves is taught from school level to higher levels. Even the derivation of Schrodinger equation in quantum science needs basic principle of superposition of waves. These days the students have become very specific in their choice of subjects. An Iron slinky can be used to demonstrate the propagation of waves, standing of waves, and other similar wave phenomena.

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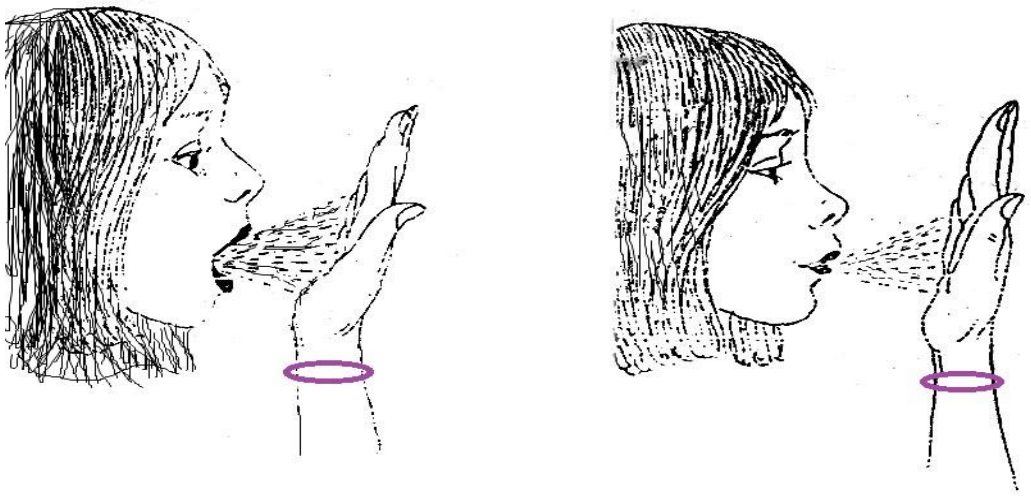
A slinky is put on the floor and two persons are asked to hold it. The slinky is stretched to extend it to about four times its length. Then it is pushed at one end with a jerk. A wave pulse can be clearly seen going along the slinky to the other end. The pulse gets reflected back and forth formed standing wave due to superposition principle and finally dies away. If the slinky is shaken in a transverse (perpendicular) direction, then transverse waves can be observed moving along its length.

VI. COOLING EFFECT PRODUCED THROUGH BLOWING EXPENDED AIR IN MOUTH

Cooling effect was reported by Scientist Joule in collaboration with William Thomson who performed various experiments from 1852 to 1862 and established the existence of intermolecular interactions. According to Joule-Thomson, if a gas at high pressure region is allowed to pass through a thin hole to a region of low pressure, the temperature of gas gets reduced. In this process, the gas carries out an expansion and cool down. A systematic study of liquefaction of gases was done by Faraday in 1823 and by Andrew in 1862.



VII. PROCEDURE

Air is first blown through the mouth on the palm normally and then with pursed lips. In normal situation, with mouth wide open, the palm feels a blow of warm air, but in the second situation, during pursing of the lips, the palm feels cool. This is because the air inside mouth, which is at higher pressure, suddenly expands. The air molecules have to do work against intermolecular forces of attraction. They draw energy from the blown air and this air cools down.

VIII. DAILY LIFE EXAMPLES

Refrigerators, Cryogenics, Freeze etc. is working on low temperature phenomenon.

IX. CONCLUSION

Theory classes in Fundamental and applied sciences at all levels of courses , especially Physics classes are normally dull and laden with mathematics. Often a communication gap develops between the students and the teacher. Students often stop following the class and very little meaningful learning takes place. This situation

IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

can be changed by the use of small low cost experiments as classroom demonstrations that arouse the curiosity of students who then begin asking questions. This way they become active learners. The experiments given above are a small sample from a large list of experiments that can be used for such demonstrations. We have made these demonstrations in rural as well as city schools, U.G, P.G and even Ph. D classes. Such demonstration experiments have generated interest, joy of learning and given the students a motive to discover the scientific principles involved.

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