PARTICIPATORY SCIENCE EXHIBITS

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Foreword

It has always been a great delight to go to the Science Centre and see in its corridors children of all ages working with the participatory science exhibits on their own. These exhibits best reflect the spirit of the Science Centre showing these children learning while having such a nice time. People have often asked why this experiment and its ideas cannot be made more widely available. There has been a growing demand from a variety of organizations, schools, teachers, and students interested in science projects to know more about these participatory exhibits. It is, therefore, a long-felt need that this book will be fulfilling, and I am sure it will initiate creative thinking amongst all those who come in contact with these ideas. We would like to thank the Ministry of Education and Culture for their generous financial support that has made this publication possible.

Kartikeya V. Sarabhai
31-3-84

INTRODUCTION

Vikram A. Sarabhai Community Science Centre started conducting programmes for students and teachers during the year 1967-68. Several programmes such as 'Science Learning Through Inquiry', 'Introductory Physical Science' 'Motivated students' Programmes' and 'Teachers' Programmes' were tried out. In some of them teaching aids and simple science toys were developed. By the year 1972-73 we had developed and displayed exhibitions on themes such a 'man and space, heart, molecules, pollution etc.

During the year 1972-73 a project entitled 'Science Communication Project' was undertaken by Dr. Minal Sen. She collected and designed some simple experiments and installed them in the courtyard of the Centre.
These were called 'DO-IT-YOURSELF EXPERIMENTS'.

Gradually these do-it-yourself experiments occupied the whole of the Centre's courtyard. The exhibits were designed with the following questions in mind.

1. Is the exhibit interesting?
2. Does it involve action?
3. Can it withstand repeated handling by visitors!
4. Is it low cost?
5. Can it be displayed in an attractive way?

The exhibits were not primarily designed to teach some concept in science or mathematics but to result in interaction with the exhibit leading to fun and joy. The learning in this case is a pleasurable and voluntary activity. The exhibits may be divided into the following categories : Puzzles and playthings Interactive Science Exhibits Science Playground Illusions

Display for observation and study (aquarium, birds, rabbits, tortoise, etc.) Charts on History of Textiles, History of Mathematics etc.

Several of the exhibits are solitary games in which the aim is spelt out on a small card. Some of these solitary games involve the assembling of given pieces into a simple object such as a cube or a given shape while others involve doing a certain task in the least number of moves.

Apart from simple experiments, toys and puzzles, we have also put up an aquarium and an aviary in the courtyard for observing birds, fishes, tortoises and other living organisms.

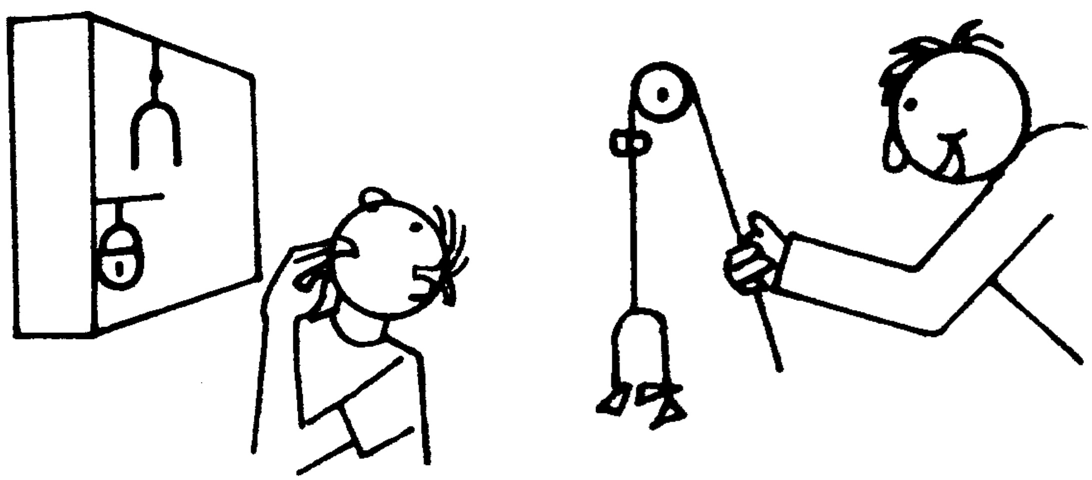
We have also used items such as periodic table, which was converted to a form in which each element was represented by a cube which could rotate on its axis. The various properties of elements were painted on different faces of the cube using a colour code. We have also made large scale models of molecules such as sodium chloride, caesium chloride, and DNA. for display.

We have been trying for some time to get support for setting up interactive games based on mini computers. This area has seen a tremendous growth in the last decade especially after the advent of the microchip.

This also led to video parlours and hand held single purpose games. Since 1980 the personal home computer is available cheaply. We are in the process of installing a minicomputer for use by children. Many versions of the games can be put on cassette tape or floppy discs for use on home computer. During 1981 several hundred games were available, many of them with colour and sound effects for personal home computers. They are now used for instruction, graphics, simulation and problem solving. Although it may not be possible for an individual or schools or colleges to avail of this facility individually, a centralised facility can always be shared. Thus the youth in the country can acquaint themselves with technology which is taking over rapidly.

The participatory exhibits are very important for schools as they pro- vide a simple low cost method of generating student interest in science and mathematics and teach them problem solving.

Designing A Participatory Exhibit



Exhibits in a Science Centre or a Museum are not only to be seen but they have to fulfil an educational role.

What can be a participatory element in an exhibit? When we talk about a participatory exhibit each one of us is thinking about it in a different way. The designer thinks from design point of view, while a curator or educator thinks from the content point of view.

Here are some features of a participatory exhibit :

a. A participatory exhibit is one with which the participant interacts. He or she handles the exhibit, tries out several times and creates his or her own understanding about it. It throws light on an idea or a group of ideas.

b. There may be a descriptive label on it or it may have a few questions. There may be operational charts or symbols.

c. It satisfies certain curiosity and raises further questions.

d. It is open and not a black box.

e. It can be so designed that one can operate it without much complexity.

f. it has to he sturdy so that it can bear wear and tear of visitors' constant use.

g. As far as possible it should not have highly sophisticated mechanisms. It should be easy to repair.

The basic elements of a participatory exhibit

Content

The first and foremost element of participatory exhibit is idea or concept. It must have a clearly detectable idea.

It must have good visual communication elements like colour, symbols.

It should have obvious operation system.

Display of a participatory exhibit

Participatory exhibit have a strong visual and operational appeal and therefore display will have following characteristics

- Simple and uncluttered
- Reasonably spaced so that people can use the unit well.
- Non-dramatic :

To most of the participants an object is attractive from action point of view and therefore dramatic display is not needed.

Correlated Display :

If there are several exhibits in a total display they can be grouped in such a way that they can be conceptually related. For example, an exhibit like parrot and cage, moving pictures wheel or a flip book.

— Available light display :

It is found that simplicity of lighting gives directness to participatory exhibits.

Area of Display :

As far as possible semi open area is a very workable proposition. The area can be a chawk or a broad corridor.

When a room is chosen it should be a large enough room where groups of visitors ca n freely move and can stop over at the exhibit of their choice. In fair weather certain displays can be in open areas like gardens. Standardization and variety in display of participatory exhibits

Many participatory exhibits can have four schematic parts.

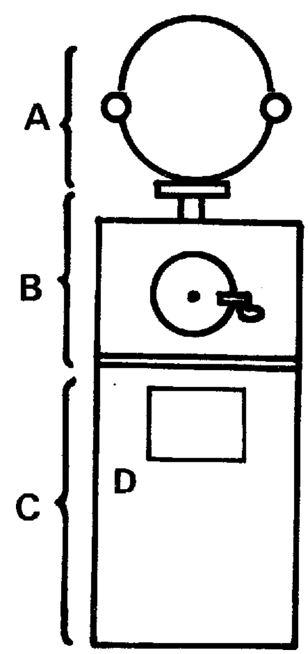
A= Display

B = Operating mechanism

C= Stand

D = Caption

Parts A and B will go together. Part C should be detachable and interchangeable. Caption should also have a short write up on the exhibit.



How ideas generate in the process of development of Participatory exhibit Design.

There are various ways in which the ideas about science participatory exhibits generate.

1. From an experiment
2. From an observation of an existing gadget.
3. Improvement on a system used.
4. From an exhibit existing somewhere else.
5. From 'how to do' magazines or books.
6. From science project by students.
7. Purely from imagination.

Whatever the source may be, designing of a participatory exhibit, may involve the following steps.

Idea
Contents
Trial and feedback
Trial model
Final exhibit

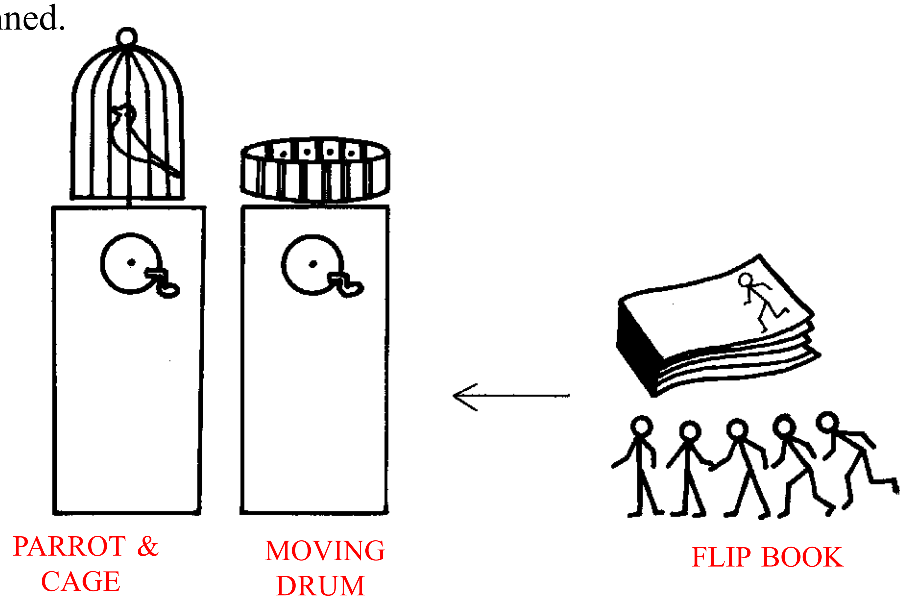
Presentation from the human mind and body point of view:

Putting an idea in the form of an interactive exhibit is very different from an equipment or experiment in the laboratory. The process of design involves two major aspects :

1. Contents
2. Form. After contents are analysed and broad presentation is ready, the exterior form is designed.

One basic principle of exterior design is 'FROM INSIDE OUT'

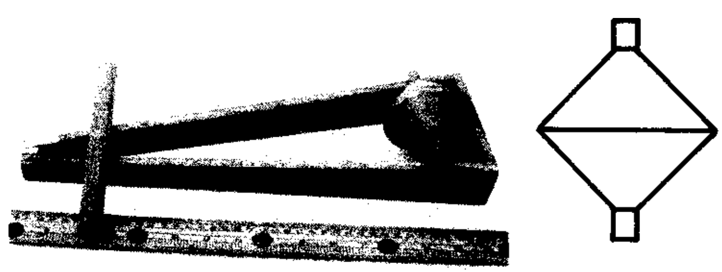
The structure design has to take ca re of the inside system first and then outside design is planned.



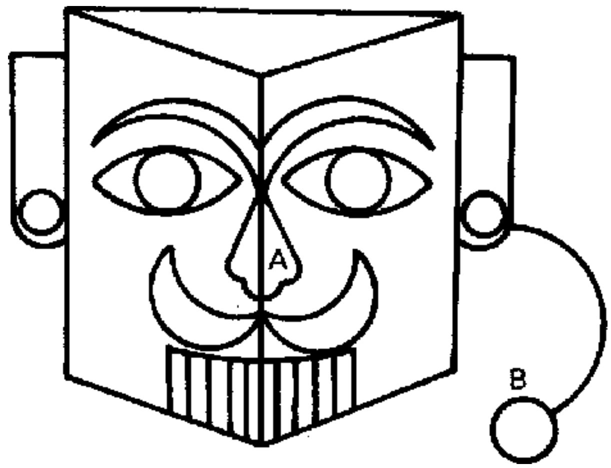
Here are some questions which will arise in the designer's mind.
1. Will this attract visitors?
2. Will this be easy in handling?
3. Are human body and mind getting involved with the exhibit?
4. Does it convey the idea or concept?
5. Is it sturdy enough?
6. Has it aesthetic appeal?
7. Would it need trials in fabrication?
8. Are materials local?
9. What are the alternative uses of this exhibit?
10. Is it accessible to children?

DOUBLE CONE

Principle: This exhibit works on the principle that the centre of gravity of a body tends to move from a higher level to a lower level.
Construction: The exhibit consists of a triangular sloping frame, and a double cone as shown in the diagram.
Description: To begin with a cylindrical rod is kept at the broader end (which is at a higher level) of the frame. One sees the rod rolling down. The double cone is kept on the frame where the rod was kept earlier. The double cone does not roll down. The double cone is now kept on the other end of the frame (lower end). One can see that it rolls up unlike the cylindrical rod.
Remarks: Due to the typical shape of the double cone the centre of gravity is at a higher level when it is kept at the lower end of the frame than when kept at the higher end. When the double cone rolls up, the centre of gravity comes down, so, in effect, therefore, the double cone is rolling down. The cylindrical rod, however, moves only from the higher end of the frame to the lower end of the frame, since the centre of gravity of the rod is at a higher level when kept at the higher end than at the lower end.
Material required: A wooden triangular sloping frame, a double cone made of uniform wood cylindrical rod.



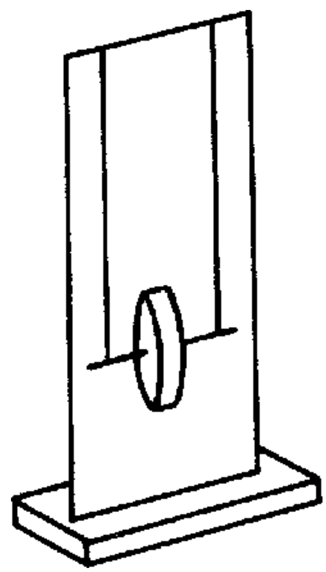
STUBBORN MAN



Magnets having ‘similar poles repel each other. Magnets having opposite poles attract each other. In ‘Stubborn Man’ -the nose is cut out and separated. Nose spot is A, and cut out is B. Now the viewer of the exhibit has to stick the cut out portion of the nose on the nose spot A. Both have magnets with like poles facing each other. This exhibit is 45 cm tall and colourful. 12mm Ply-board is the material used. Magnets can provide many ideas for participatory exhibits.

GIANT YO YO

Principle: This simple exhibit works on the principle of inertia and conversion of potential energy to kinetic and rotational energy and vice versa. Construction: The giant YO YO basically consists of a wooden disc of about 15 cm in diameter. Through the centre passes a rod as shown in the figure. The disc and the rod should be fitted tightly. At equal distance on either side of the disc, strings are attached to the rod as shown in the figure. The disc is hung from the two ends symmetrically. The disc is twirled to some height and then released. As it comes down, it moves faster. After reaching its lowest point it rises again retaining the same sense of rotation. The process continues for quite sometime. The disc is able to roll down and up again retaining the same sense of rotation by itself due to inertia and conversion of potential energy into kinetic energy and rotational energy and vice versa.



Remarks : One may notice that the disc does not achieve the same height from where its was released earlier. This is due to friction and hence the precess eventually stops.

Material required : A wooden disc of diameter 15 cm and thickness 0·5 cm A rod of length 15 cm string (thick nylon strings work well), a wooden or metallic frame as shown in the diagram.

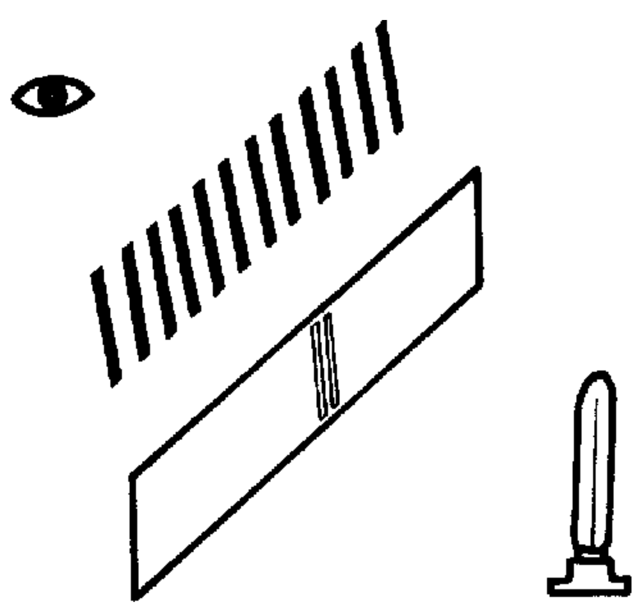
INTERFERENCE OF LIGHT WAVES

Principle : This exhibit is based on interference of waves emanating from two coherent sources of light. If the waves arrive in phase at a particular point, they interfere constructively giving rise to a bright band. If they arrive out of phase, they interfere destructively and a dark band is seen. Here two thin slits parallel and close to each other serve as two coherent sources of light.

Description : One glass plate is taken and painted with optically opaque solution. With the help of a razor blade, two thin slits are made close to each other. Another glass plate is taken and placed over the double slit to protect it. A single filament lamp is now taken and covered half with a gelatine colour filter. Holding the double slit close to the eyes, if one looks at the electric lamp through the coloured filter, one can see dark and bright bands of the same colour as that of the filter at regular intervals. These bands are called fringes. If one looks at white light through double slit, one can see coloured fringes. It may be noted that two coherent sources are derived from a single source of light.

Remarks : It may be necessary to take Several glass plates and make double slits in order to select one with which the best effect is obtained, i.e. the one through which the bands are seen most distinct. If optically opaque solution is not available, one can use smoked glass plate. Smoked glass plate can be obtained by holding a glass plate over the yellow flame of a candlestick and forming a thin uniform layer of soot. The double slit experiments was one of the earliest experiment on interference of light waves proving that light is a wave motion. This was performed by Young in the year 1801.

Material : Some glass plates, razor blade, optically opaque solution, Single filament electric lamp, some transparent gelatine papers of colours.



CENTRIPETAL FORCE

Principle : This exhibit works on the combined effect of centripetal force, gravitational-force and the normal reaction. Construction : This exhibit consists of a circular frame made from a thick wire passing through two beads. The frame is connected to a pivot as shown in the figure, and rotated with the help of a drill or a mechanism similar to a spinning wheel. The beads tend to rise more, the faster the frame rotates. Both the beads rise symmetrically to a maximum height equal to the radius of the circular frame. The beads do not rise beyond this point even if the frame is rotated very fast.

Remarks: The beads attain particular position on the frame under the combined action of centripetal force to which they are subjected, gravitational force and the normal reaction due to the frame. When they achieve a height equal to the radius of the frame, centripetal force and gravitational force, both are at right angles to each other. The gravitational force on the bead is balanced by the frictional force in the opposite direction. Material required: A circular frame with two beads as shown in the frame, a drill, mechanism to rotate the frame.

NEWTON'S CRADLE

Principle : Newton's cradle works on the principle of conservation of energy and linear momentum. Construction: Newton's cradle is made with five similar chrome-plated steel spheres all having the same diameters and hung symmetrically by strings from two horizontal rods. These two rods remain parallel and horizontal on a wooden stand. The spheres should be so suspended that they should be in contact with each other.

Description : One sphere at one end of the cradle is slightly drawn aside and then released. On impact, the impulse is carried by the spheres in between and transferred to the sphere at the other end, which bounces with almost the same energy as the sphere released earlier. This sphere again strikes the sphere next to it and the impulse is carried through the spheres in between up to the last sphere which again bounces. The process continues for quite sometime. Next, the two spheres are pulled together and released simultaneously. When they hit the sphere at the centre, the two spheres at the other end bounce. The process is repeated as in the case above when only one sphere was pulled and released. One can try this experiment by pulling three or even four spheres on one side and releasing them simultaneously. One interesting observation is when one or more spheres on each side are pulled (either same or different number of spheres on either side) and released simultaneously. Remarks: The spheres are identical and negligible amount of energy is dissipated in the form of sound or heat due to the impact of these spheres, this represents a case of nearly elastic collision. Elastic collision is one in which kinetic energy before and after collision is conserved. Hence after collision, the sphere that bounces has almost the same energy as the sphere that hit the system. Since the collision is not completely elastic, some energy is lost by way of sound and heat, and hence the process stops after some time.

Material required : A wooden stand with two horizontal rods as shown in the figure, five identical chromium-plated steel spheres, thick string to hang these spheres symmetrically from the two horizontal rods.

GRAVITY TOWER

Principle : The scientific principle involved in this exhibit is that when a body is in equilibrium, the vertical line (i.e. plumb line) passing through its centre of gravity falls within its base.

Construction: This is a simple toy, flexible so that its inclination with respect to the vertical can be changed. (see figure). The centre of gravity of the tower is approximately at the centre of the middle rod. The plumb line passing through this point describes a vertical line earring through the centre of gravity. One can observe how this line shifts as inclination of the tower is changed. The tower is made out of aluminium strips connected with nuts and bolts that the inclination can be easily changed.

Description : The tower is kept upright and then slowly the inclination of the tower is changed. The tower remains stable, until the vertical line passing through the centre of gravity (also called gravity line) falls within its base. When the inclination is such that the gravity line (plumb line) falls outside the base, the tower falls down.

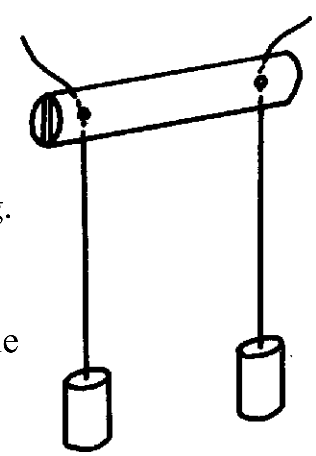
Remarks : The gravity tower ca n be used to illustrate the concept of stability. The stability of the leaning tower of Pisa can be well explained with the help of this tower.

Material required : Aluminium strips, nuts, bolts; plumb line.

COUPLED SYSTEMS

Principle: The exhibit illustrates the different modes in which a system can vibrate. The coupled system described here has two basic modes of vibration 1) one in which the energy is transferred gradually from one pendulum to another and vice versa and 2) another in which no exchange of energy takes place.

Construction: In this exhibit, two identical pendulums are taken and suspended on a horizontal string which is connected with a wooden frame (See figure). It is necessary that both the pendulums be identical. Now one of the pendulums is set into motion by pulling it towards the performer (keeping the other stationary) and then released gently. The amplitude of the pendulum set into motion decreases slowly, while the other pendulum starts oscillating, with its amplitude gradually increasing. The first pendulum comes to rest eventually when the other one oscillates with the maximum amplitude. After this, second pendulum oscillates with a gradual decrease in its amplitude, while the previous one oscillates with a gradual increase in its amplitude. In this manner the process is repeated for quite sometime. In another mode, both the pendulums are pulled either in the same direction or opposite directions and then simultaneously released. The exhibit thus shows that a system may vibrate in more than one way.



Remarks : In the system we discussed here, there are two modes of vibrations. The vibrations eventually die down due to friction.

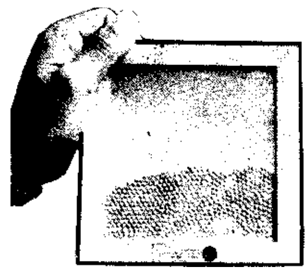
Material required: Two identical spheres or objects, small wooden rod, threads, stand, etc.

STATES OF MATTER BOX

Principle : This exhibit can be used for describing arrangement of molecules in solids, liquids or gases.

Construction: A large number of small steel balls (bicycle ball bearings) are kept in a small wooden frame as shown in the figure, fixed with a transparent plastic sheet at the top.

Description : If the frame is tilted, the balls come closer and give rise to a pattern similar to arrangement of molecules in a crystal lattice of solids. If the frame is kept at the small angle horizontally and rotated gently, the balls do not form a regular pattern, but, show some traces of regular arrangement at some places. This represents the arrangement of molecules in a liquid. If the frame is vigorously shaken, the balls are set into motion violently, the distances between the balls also being larger than the previous two cases. This represents arrangements of molecules in gases.



Remarks : State of matter box can be used to visualise the arrangement of molecules in the three states of matter viz., solids, liquids and gases in a qualitative manner.

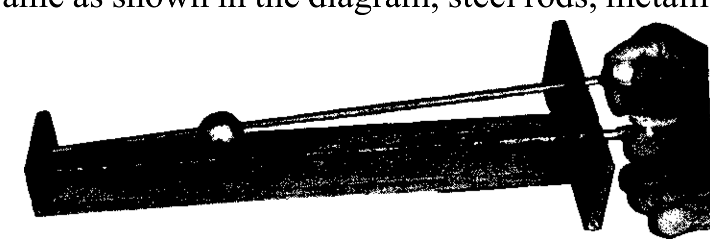
MOON PROBE

Principle: Moon probe can be described as a game requiring some degree of skill. It consists of a wooden frame having some slots at the base with scores marked on them. It works on the combined effects of gravity and the mechanical force applied by the performer.

Construction : Two steel rods of the same length are fixed at one end with handles at the other end. The rods are arranged in such a way that the free ends are moveable in a rectangular slit are at a slightly higher level than the fixed ends. Both the rods are close to each other. A steel ball is placed between them at the end where both the rods are fixed. As one widens the gap between the free ends, the ball tends to roll down and fall into a slot. The free ends of the rods are now manipulated in such a way that the steel ball rolls u p to the maximum height and falls in the slot as close to the free end of the rod as possible (i.e. to a distance as far as possible from the fixed ends).

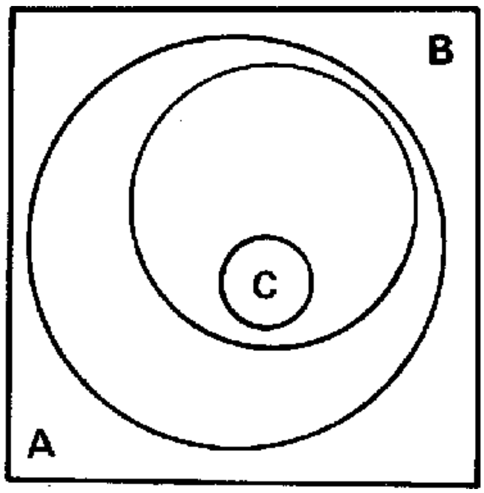
Remarks : The ball tends to roll down under the influence of gravity. Un- less a jerk is given to the ball with both the rods, the rolling ball would fall down as the gap between two gradually increases. The skill lies in giving jerks to the rods so that the ball moves to the maximum height and falls into slot as close to the free ends of the rods as possible. One successful in bringing ball farthest from the fixed end in minimum number of attempts gets maximum marks.

Material required : Two steel rods, with handle at the free ends as shown in the diagram, wooden frame as shown in the diagram, steel rods, metallic ball.

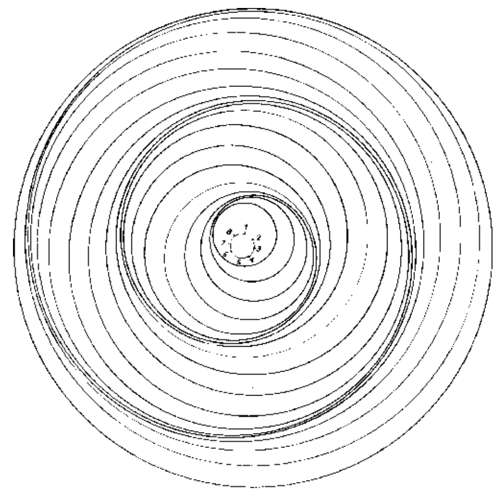


MOVING SPOT

Three circles having different centre as shown in the drawing provides an excellent illusion. Hold two knobs at A & B move the board clockwise and anticlockwise. Look at the spot C. This idea may help you to create an excellent optical illusion display.



MOVING SPOT



CROVA'S DISC

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Principle : This interesting exhibit helps in visualising the changes taking place in a medium when longitudinal waves pass through it, such as sound waves propagating in the air. As sound waves propagate in the air there a re regions formed called condensations, the layers or shells of molecules of air moving close together and the regions called rarefactions, the layers or shells of air molecules moving farther apart.

Construction : Crova's disc can be made out of a large thick paper of size 25 cm x 25 cm A circle is drawn in the middle of the disc with a radius of 4 mm. and divided into 8 equal parts and numbered sequentially from 1 to 8. Now the compass is placed on point number 1 and a circle is drawn with a radius of 20 mm. Next, the compass is placed on number 2 and a circle with radius of 24 mm. drawn. In this manner the circles are drawn from the successive points every time increasing radius by 4 mm. After drawing the 8 successive circles, one continues to draw circle as before on the circumference of the inner circle a second time, increasing the radius by 4 mm. every time. one may continue a third time also. The disc is cut out and a hole is made in the centre of disc of the width of a drinking straw. The straw is inserted in the centre of the disc and spun. If a hand drill is used as shown in the diagram to rotate the disc, the effect can be much more spectacular.

Description : As one rotates the disc, one sees layers moving together and moving apart, draw together and separate again, just as when the sound waves pass through the air.

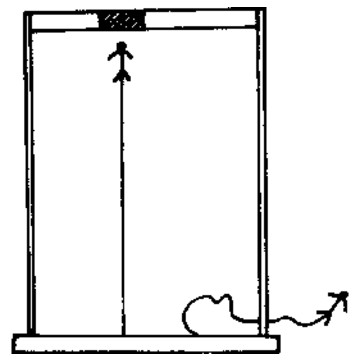
Remarks : This effect can be observed best by looking through a narrow slit and covering the disc when it is spun. Material required : A large card 25 x 25 cm drinking straw or a hand-drill.

INDIAN ROPE TRICK

Principle : This exhibit involves the use of a magnet concealed in a wooden frame.

Construction

Description : Construction of this exhibit is extremely simple. It involves a wooden frame as shown in the diagram. Two threads are fixed to iron- pins, or some human shapes cut out from thin iron foils. The length of the threads should be such as is slightly short of reaching the top of the frame. A small magnet is concealed at the top. The pin under the concealed magnet would remain suspended in the air while the other one would not. The pin suspended in the air appears highly mysterious since apparently there is nothing visible which can keep it suspended by pulling it upwards.



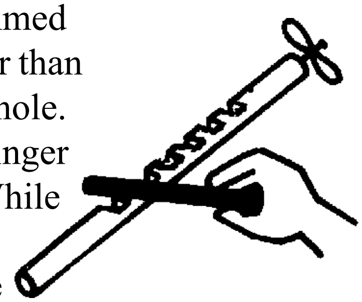
Remarks : It is desired that the magnet concealed in the wooden frame be of high strength (Alnico or ceramic magnet) since the force with which the pin is pulled up should be more than the weight of the pin itself.

Material required: Wooden frame as shown in the diagram, a small magnet, threads, pins etc.

MAGIC WINDMI LL

Principle : This exhibit employs the vibrations in a stick that produce different rotation phases.

Construction: A wooden stick is taken and notches are made on it at regular intervals as shown in the figure. At the end of the stick small propeller: cut from a thin aluminium foil or a thin sheet of wood is attached with the help of a nail. The nail should, be straight and jammed into the stick. The hole in which the nail is jammed should be bigger than the diameter of the nail so that the nail is able to rotate freely in the hole. With the help of another stick, the notches are struck with the forefinger and thumb by running it back and forth as shown in the diagram. While stroking notches, if the forefinger is pressed against the stick, the propeller will turn in one direction. If, the forefinger is lifted and the thumb pressed against the stick stroking back and forth, the propeller will turn in the opposite direction, One can interchange the thumb and the forefinger in a sly manner causing the propeller to spin in opposite directions and thus making a great mystery of the whole process.



Remarks : The nail should be able to rotate freely into the hole in which it is jammed. Otherwise, the magic windmill will not be successful. The propeller can be made from thin aluminium foil, or a thin wooden sheet.

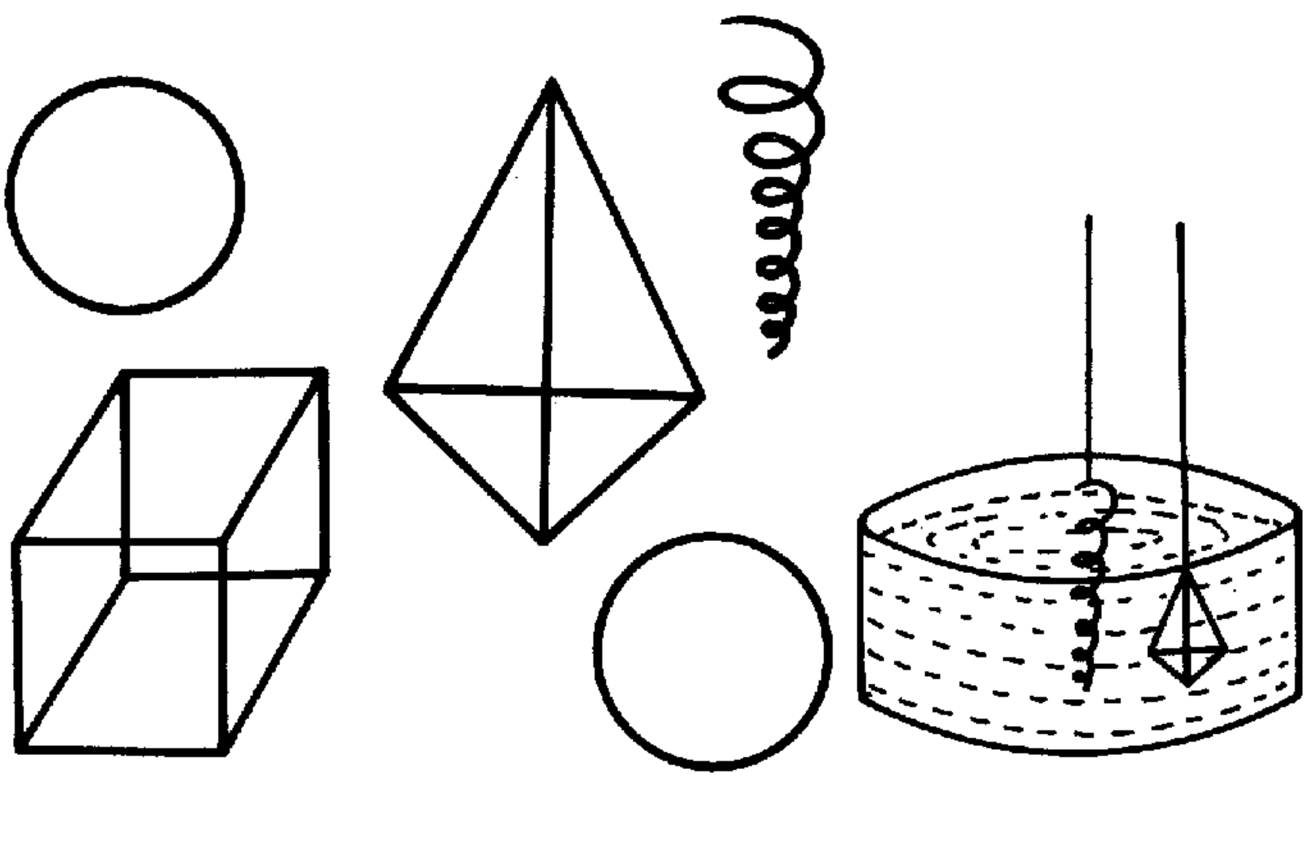
Material required : A stick with notches at regular intervals, a nail jammed at one end of the notch, stick, small aluminium foil for propeller.

SOAP FILMS

Principle : Soap films are formed due to surface tension. The films behave like stretched membranes and are formed such that their surface area is a minimum for a given boundary. Different types of frames can be prepared from the metallic rods and beautiful patterns can be obtained with the help of soap films.

Construction : One requires a strong metallic wire such as used in *Diwali* sparklers and bent into various shapes as shown in the diagram. For making a particular shape as shown in the diagram, one may need to solder at some points. Each frame is of different shape. These frames are dipped into 10% soap solution containing glycerine 15%. When it is lifted one sees beautiful shapes the soap films make.

Remarks : Observe the shapes of the soap films obtained with each frame carefully. By dipping a frame twice in the soap solution, one may be able to obtain a similar additional shape within the previous shape of films. Observe the surfaces of the films obtained, for the inner and outer films. All the surfaces represent surfaces of minimum area. The answers to many difficult mathematical problems can be given with the help of soap films (as obtained with the help of different frames in this experiment).
Material required: Some thin metallic rods used in *Diwali* sparklers, strong soap solution and thread to suspend the metallic frames.



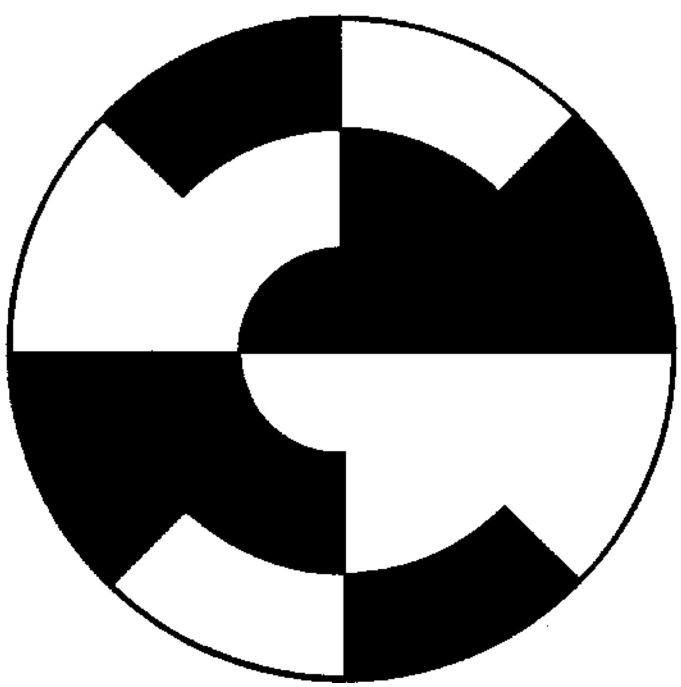
COLOURS IN BLACK AND WHITE DISC

Principle : Certain parts of our eyes are sensitive only to certain range of colours depending on the background. The total effect depends on the simultaneous activation of different part~ of our eyes sensitive to different colours and intensities, and therefore, the colours we see are the overall effect of these various aspects.

Construction & Description : A disc with alternate black and white sectors on a white sheet of paper is made (see figure). The disc is spun at low speed to begin with and one concentrates on it ignoring the individual sectors. The leading edges of the white sectors would turn red and the trailing edges blue. One can see different colours for different illumination levels. At faster speed, the whole white sector would be pink red and a green blue will cover part of the black section. At a still faster speed the colours cannot be distinguished, but, little sparks of violet pink and green grey light seem to jump about. The disc shown here would give all three effects simultaneously.

Remarks: There can be several dozens of black and white discs giving rise to different patterns. When one concentrates on a portion of the disc, the background alternates between black and white and what one sees is the total effect. To rotate the disc, one can use a hand drill. One can also use a disc top instead of using a wooden disc.

Material required : Black and white disc as shown in the diagram or having any other design. A mechanism to rotate the disk (a hand drill would do quite well).



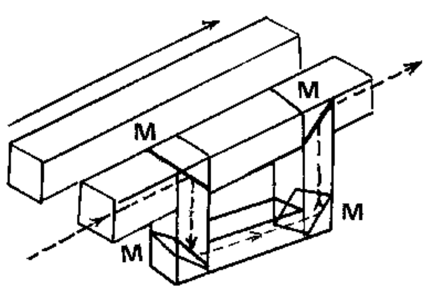
DOUBLE PERISCOPE

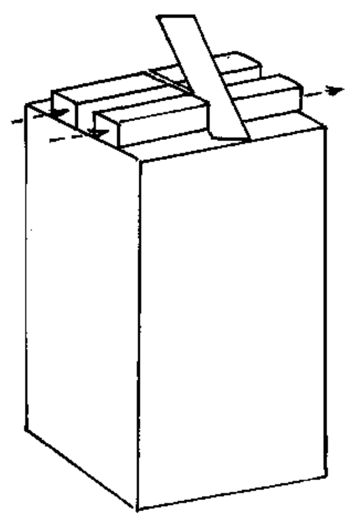
Principle : This gadget works on the laws of reflection of light and really two periscopes combined into one as shown in the diagram.

Construction : The double periscope and a straight tube are placed side by side at the same level as shown in the diagram. The double periscope is concealed in such a manner as to make it appear as a single tube. The common stopper is put as shown in the figure. When the Stopper is absent, one can see through both the tubes. However when the stopper is inserted one can see only through one tube. The insertion of the stopper, however, does not affect the double periscope in any way and hence one continues to see through this tube. This apparently gives rise to a paradoxical situation that though the stopper is present in the line of sight, one is still able to see through it.

Remarks : In this exhibit, it is important to arrange the tubes of the double periscope in such a manner as to give the impression of two straight tubes placed side by side. The entire assembly can be mounted on a platform at a convenient level. Here, it is necessary to construct the double periscope in a manner such that the mirrors are placed as close to each other as possible arid at 45-degrees with the horizontal. This is necessary as larger the path travelled by light, the smaller would be the image. The exhibit should be made in a manner that the sizes of the image seen through straight tubes or through double periscope are not significantly different.

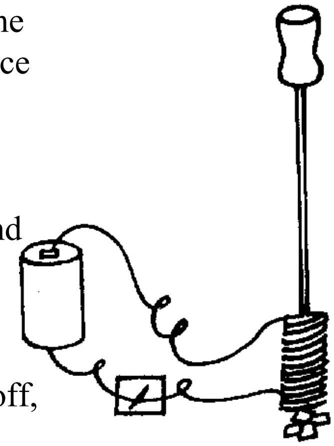
Material required: Four plane mirrors, rectangular straight tubes.





M-MIRROR

ELECTRO MAGNET



Principle : This exhibit utilises magnetic effect of electric current. The current carrying conductor is associated with a magnetic field and hence acts as a magnet.

Construction: In this exhibit an electric wire is wound around an iron shaft and both the ends of the wire are connected to an electric cell. Arrangement needs to be provided so that the shaft can be moved up and down. Near the bottom of the shaft, iron pieces are kept. When the current is switched on the coil works as an electromagnet and thus attracts pieces of iron. When lifted, keeping the current on, the iron pieces will stick on the electromagnet. When the current is switched off, the iron pieces will fall down since the coil no more acts as a magnet. This exhibit thus vividly depicts the magnetic effect of current and the use of electromagnets for lifting heavy cargo at a seaport or at places having heavy traffic of goods.

Remarks : The pieces of iron should be made from a thin iron sheet. The arrangement for preparing shaft connected with the electromagnet is shown in the diagram.

Material required : Electric wire, shaft, electric cell, switch, iron pieces or iron filings.

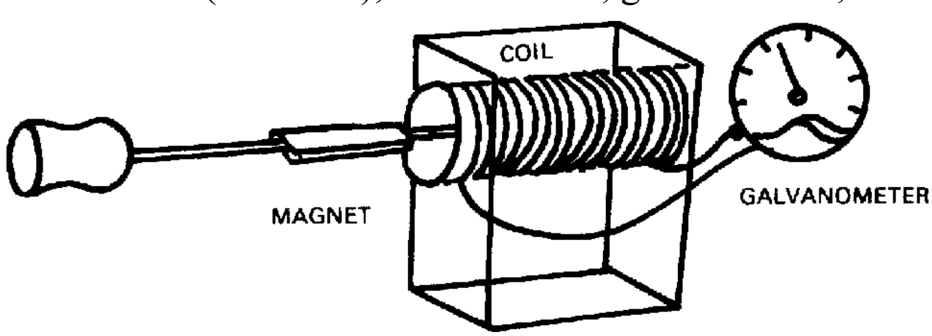
ELECTROMAGNETIC INDUCTION

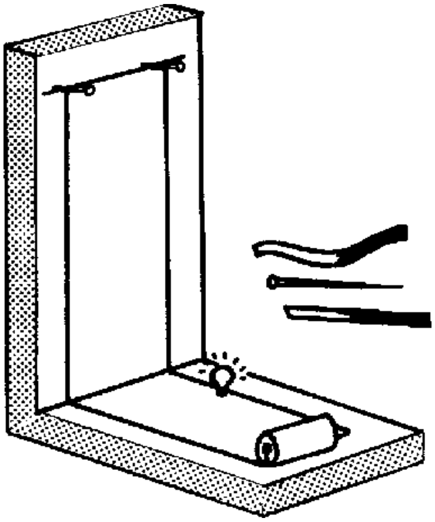
Principle : This exhibit depicts the phenomenon of electromagnetic induction through the movement of a magnet inside a coil made out of copper wire.

Construction : The ends of the coil made out of copper wire are connected to a galvanometer. The magnet is connected to a handle with which it can be moved back and forth inside the coil. As the magnet moves inside the coil, one can see the deflection in the galvanometer showing the current produced due to electromagnetic induction. While the magnet is pulled out, one can see the deflection in galvanometer in the opposite direction than when it is pushed inside. One also may note the amount of deflection which is proportional to the current flowing through the galvanometer when the magnet is pushed in or pulled out at higher speeds. One may note that the current flows through the galvanometer only as long as the magnet is moving inside the coil.

Remarks : A coil can be made from a n ordinary single core electric wire by winding it on a metallic tube with a diameter sufficient to allow the free movement of the magnet inside the coil (see figure). A bar magnet is connected to a metallic rod serving as a shaft. It is also desirable to have a magnet of high strength to give a better visual effect.

Material required : Electric wire (insulated), metallic tube, galvanometer, bar magnet, shaft.





Equipment indicating electrical conduction through materials like wood, plastic, iron wires, etc. The equipment has a torch battery attached to electrical circuit. The electrical circuit is incomplete having two ends A and B, when two terminals A & B are connected by materials like iron or aluminium the circuit becomes complete and the bulb on the line lights up. If the material is a bad conductor, the light does not light up

DIFFRACTION WITH A SINGLE SLIT

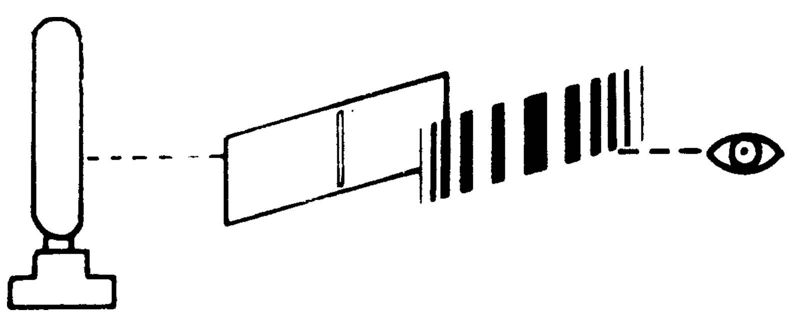
Principle : Diffraction is a phenomenon in which the waves are bent past an edge. This is why one does not see shadows of objects sharply. If light is passing through a slit, secondary waves from the same slit interfere and give rise to fringes which are somewhat similar to interference fringes, as observed in the case of the double slit. The fringes obtained with the help of a single slit have a bright fringe in the middle and fringes on either side which fade in intensity as one goes away from the middle fringe. Also the fringes are not equi-spaced as in the case of interference fringes obtained with a double slit.

Construction : The construction of single slit is basically the same as that of the double slit, the only difference being that instead of two slits, one makes a single slit on a glass plate painted with optically opaque solution. As a matter of fact, the index finger and the middle finger can also be used to form a single slit and observing through it would give exactly similar effect.

Description: If one looks at the lamp through the single slit, one can see a bright fringe in the middle, while the fringes on either side fade in intensity as one goes away from the middle fringe. If one looks at the white light the middle fringe is white and on either side of it the fringes appear coloured. However, if one looks at light coming through a colour filter one sees fringes only of that colour.

Remarks: Diffraction pattern observed with a single slit is different from the interference pattern obtained with a double slit. The fringes are equi-spaced and of almost same intensity in an interference pattern, while the spacing and intensity of fringe change in diffraction pattern. Both diffraction and interference are two typical tests of wave motion.

Material required : Glass plate, optically opaque solution, single filament lamp, blade, coloured gelatine filters.



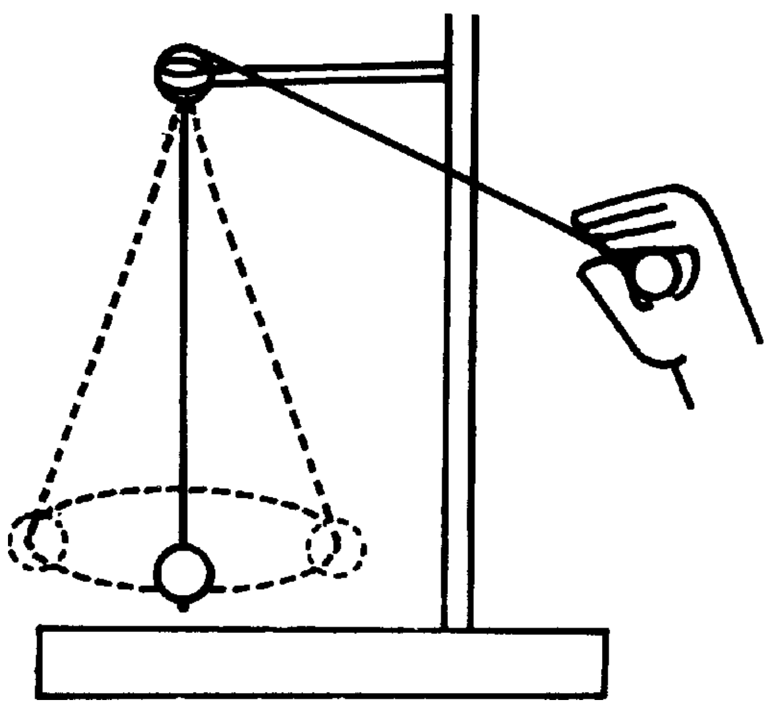
CONSERVATION OF ANGULAR MOMENTUM

Principle : This simple exhibit illustrates the law of conservation of angular momentum in the absence of external torque.

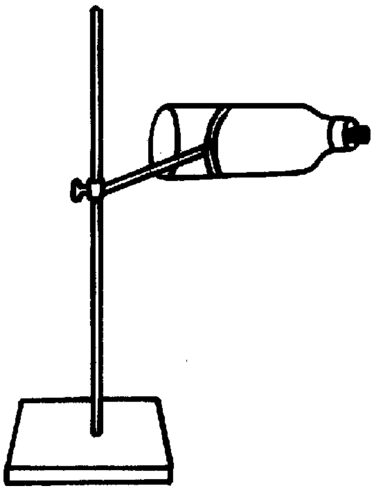
Construction / Description : This exhibit is basically a conical pendulum. Three beads each with a hole are taken and a thread passed through all of them. The thread is tied to both the- beads that are at either end and the middle bead is held in a clamp as shown in the diagram. Now the hanging bead is set in motion so that the thread describes the surface of a cone while the bead moves uniformly on the circumference of a circle. The free bead at the top is then slowly pulled up so that length of the pendulum and thereby the radius of circle is gradually decreased. One can notice that as the radius of the circle decreases, the bead rotates faster.

Remarks: In this experiment, one may notice that the thread is pulled upwards and hence no torque is acting on the bead moving uniformly in a circle. According to the principle of conservation of angular momentum, so far as there is no external torque acting, the angular momentum re- mains constant (i.e. product of mass, the square of the radius and the angular velocity remains constant). Hence as the radius decreases, the angular velocity of the bead increases and hence it moves faster.

Material required : Three beads, each one with a hole through its centre, twine, clamp.



BOTTLE AND CORK



Principle: This simple exhibit is based on Bernoulli's principle which states that a fluid in motion exerts less pressure compared to the fluid at rest or moving at smaller speeds. The faster it moves, the less pressure it exerts.

Construction: This experiment requires a wide mouthed bottle and a small cork much smaller than the mouth of the bottle.

Description: The bottle is kept horizontally and the cork is placed in its mouth. The performer is asked to push the cork inside the bottle by throwing it. When he tries, instead of the cork going in, it flies out of the bottle causing a great surprise. As one blows, the pressure in the vicinity of the neck of the bottle is reduced. Since the air inside the bottle exerts more pressure it tries to gush out blowing the cork out of the bottle.

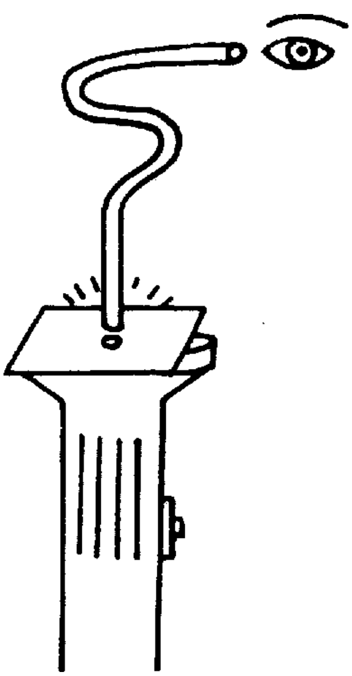
Remarks : It is necessary to have a cork of the size much smaller than the. diameter of the neck of the bottle, otherwise the effect may not look spectacular.

Material required : A wide mouthed bottle, small cork, a stand to hold the bottle.

DOES LIGHT TRAVEL IN A STRAIGHT LINE ?

Principle : Total Internal Reflection.

Description



Construction : A glass rod is bent in an irregular fashion as shown in the diagram. It is then fitted with a clamp so that one can look at one end of the rod while the other end is illuminated with the help of an electric lamp. One can see the light emerging from the rod due to total internal reflections taking place inside the tube at bends. The exhibit makes the visitors inquisitive to understand this phenomenon as it apparently defies their belief that light travels in a straight line and hence would not pass through this irregularly bent glass rod.

Remarks : When light passes from a denser medium to a rarer medium, the light rays get refracted and are deviated from the normal to the interface. However, for rays incident at angles greater than the critical angle with respect to the normal to the interface of both the media, light gets reflected within the denser medium itself. This is known as total internal reflection. At each bend in the glass rod the light gets totally reflected and hence passes through this irregularly bent glass rod. Care must be taken to reduce the intensity of the ambient light so that the effect is seen most spectacularly. A glass rod can be bent in any shape by holding it on a kerosene or gas flame.

Material required : Glass rod, a light source.

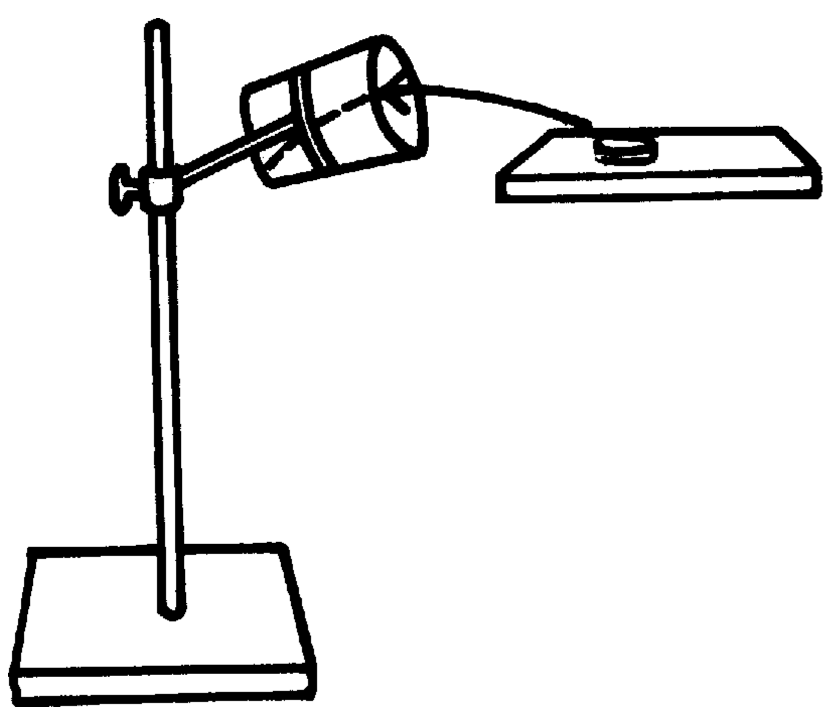
GLASS AND COIN

Principle : This exhibit is based on Bernoulli's principle which states that a fluid (liquid or gas) in motion exerts less pressure compared to fluid at rest or flowing at smaller speeds.

Description : A glass is held in a stand as shown in the diagram. A thin metallic disc similar to a ten paise coin is kept about 10 cm away from it, on a table or a plain surface. The visitor is asked to put the coin in the glass without touching it. If he cannot do it he is asked to blow over it. In a spectacular fashion, the coin flies into the glass. When one blows over the coin, the air in the vicinity is set in motion and the pressure drops. The coin is lifted by the air below it which is at a higher pressure (since it is at rest), gains momentum due to the air in motion above and flies into the glass.

Remarks : It requires some skill to blow the coin into the glass. This exhibit can also be presented in the form of a game. One is asked to blow the coin into the glass for the maximum number of times in the minimum number of attempts.

Material required : A coin, a glass and a stand.



MOIRE PATTERNS

Principle: A Moiré pattern can be obtained by superimposing two pat- terns of slightly different periodicities. It can be used to study the structure of crystals, interference phenomena and also to study defects of lenses. Moiré patterns have served several other interesting applications in fabric Industry.

Construction : In this exhibit, two Moiré patterns have been described. One has equally spaced parallel lines on two transparent sheets. The lines may be marked with the help of magic markers on the sheets. The sheets are held one over the other and moved relative to each other or rotated. Intersection of the two figures produce large changes in the spacing of the Moiré fringes. Another simple Moiré pattern can be prepared by drawing equally spaced parallel lines when the spacing on one set differs from that of another.

Beautiful Moiré can be prepared based on circles. Identical sets of circles are drawn on two transparent sheets by increasing radius at regular intervals. The circle should be somewhat thick. One sheet is placed over the other. As two sets of overlapping circles move apart, one sees a radiating Moiré pattern. These Moiré duplicate interference patterns produced when light waves from a common source pass through two pinholes.

Remarks : Moiré is a French word for ‘watered’, in English it is most frequently heard in the term of ‘Moiré Silk’, a fabric that has a shimmering appearance resembling the reflections on the surface of a pool of water. One can see Moiré pattern by folding nylon cloth and seeing through it. Two identical photographic negatives also can be used to produce Moiré patterns. It is possible to produce Moiré pattern by overlaying pattern on a transparent sheet onto a pattern on an opaque sheet.

Material required : Transparent sheets, magic markers, etc.

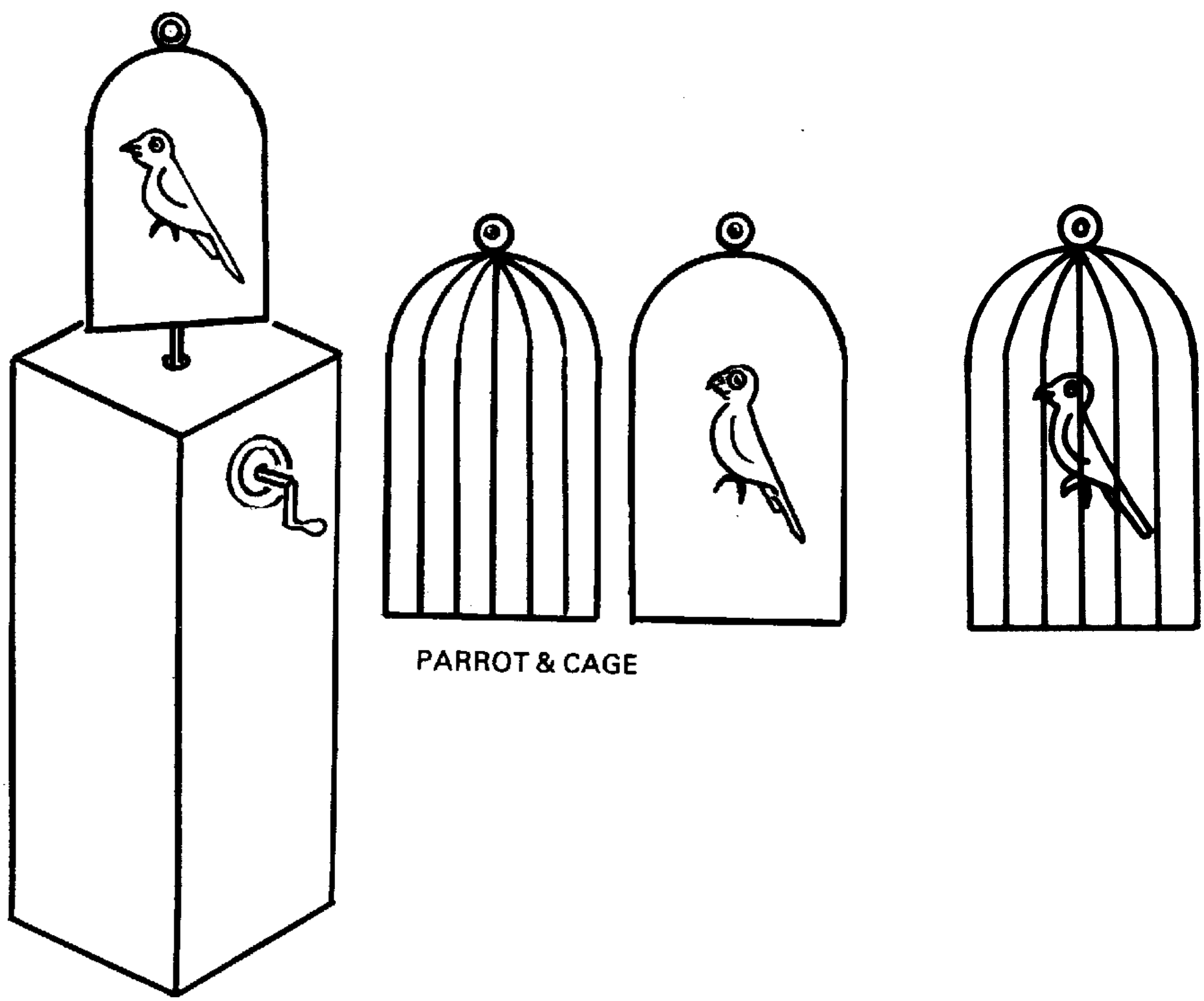
PARROT AND CAGE

Principle : Persistence of Vision

Construction : This exhibit is based on an old traditional toy called (Popat Pinjar) In this toy a coin would have a parrot image on one side and cage image on other side. Keeping its popularity in mind the present revolving plate with parrot on one side and cage on another side was designed. A metal plate about 25 cm. in height 18 cm. in width (approx.) is fixed on a revolving circular base. The plate has on side A, PARROT figure and on side B, CAGE figure. The Plate is turned by revolving head of a hand drill which is fixed on the top of the pedestal. Almost all pedestals have 60 cm to 75 cm height.

Remarks : Along with this big sized exhibit we also have a very inexpensive carry home toy 'Parrot and Cage'.

Materials : Metal plate, iron wire, hand drill, wood, colour.

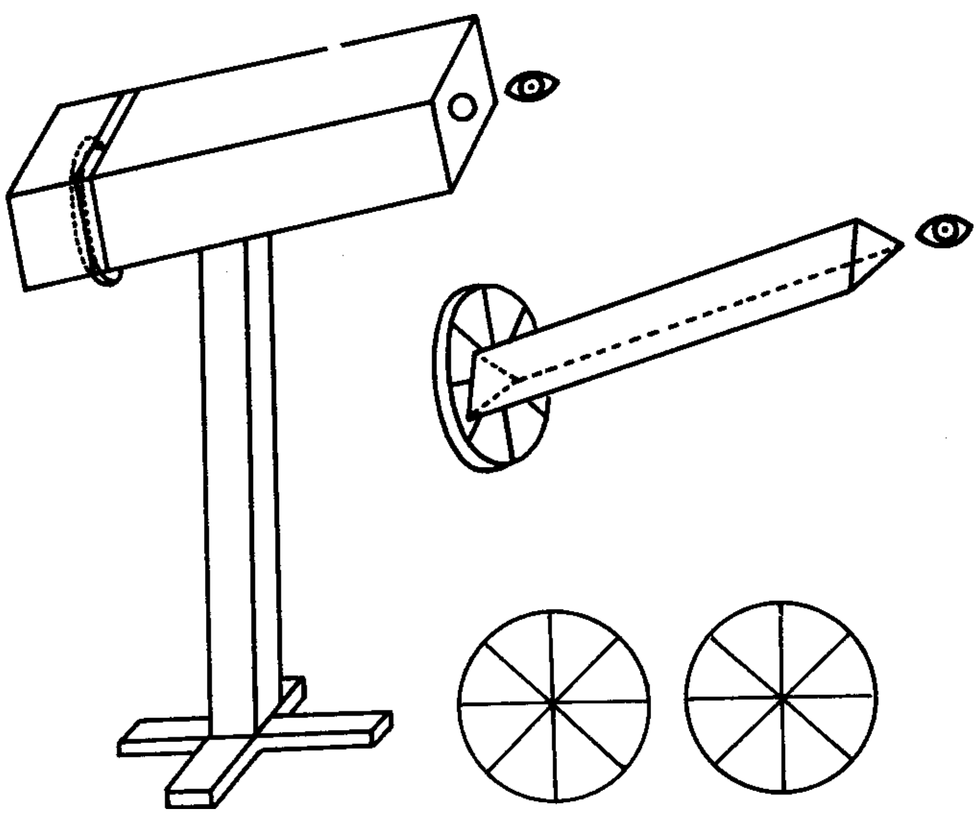


KALEIDOSCOPE

Principle: Multiple reflection in three mirror strips placed at 600 to one another.

Construction / Description : Three long mirror strips having same width and length are joined to form a triangular tube. (600 angle). The tube is fitted in a box. Near one end a plain glass piece is fixed as an eye piece. At the other end two wheels are fitted. One wheel has acrylic sheet pieces of different colours, fitted on it. The second wheel is made from two acrylic sheets forming small compartments in which small pieces of coloured glass are placed. The two circular discs are mounted on a shaft in such a way that one can see through the mirror tube the reflections of coloured pieces. Rotating discs change the background colour as well as design formed by multiple reflectors. Back lighting with a frosted bulb enables one to use this kaleidoscope at all times.

Remarks: Kaleidoscope always fascinates children and adults alike. A large and sturdy kaleidoscope with artificial lighting is an interesting exhibit.



KALEIDOSCOPE CONSTRUCTION

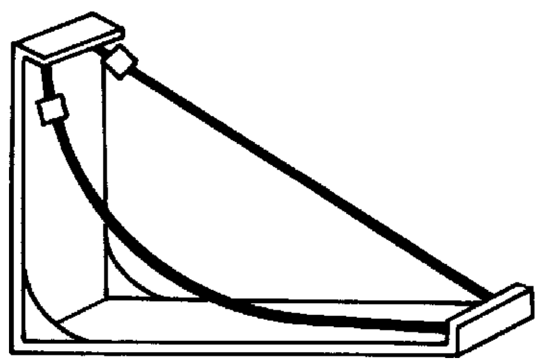
QUICKER DESCENT

What it is? : It is a gadget to illustrate the paradox that the shortest distance (straight line) between two points need not be the path of quickest motion.

A big wooden frame in the form of a right angle has two points, one at the upper end and the other at the lower extremity, joined by smooth rods, one perfectly straight and the other in the form of an are of a curve called cycloid. There is a heavy knob which can slide smoothly on each rod.

How it works : There is a contrivance which can hold both knobs at the highest point and can release them at the same time. Release them in this way and let them slide down the rods under gravity. You may be surprised to see that the knob sliding down the cycloid reached the other extremity earlier than the other knob sliding down the straight rod. A longer distance is covered in a shorter time under similar conditions.

Conclusion: Though the straight line is the shortest distance between two points at different levels, the time of descent form one point to the other is less along a cycloidal are joining the points than along the straight line.



PERIODIC TABLE

Principle: The properties of elements change gradually in vertical and horizontal rows of the periodic table.

Construction : A framework is made from wood in the form of a periodic table. In place of each element a cube can be inserted. This cube can move about a vertical axis on a pivot. The four faces on the cubes exposed to viewer are painted with four colours, e.g. yellow, red, green and blue. On same coloured face similar properties of elements a re painted e.g. symbol, physical state, atomic number and atomic weight are painted on yellow face. The periodic table in toy form is then assembled.

Remarks : Several questions can be put near the periodic table.

a) Which elements are metals? (hint metals have low ionization energy)

b) Which is the densest element?

c) Which elements are gaseous?

DO ALL LIQUIDS MAINTAIN LEVEL?

Principle: All pure liquids or homogeneous liquids maintain the same level. In second U tube the levels are different because one arm contains alcohol while the other arm contains water. Both have different densities. As liquids are coloured to the same extent and they are miscible in one another, no interface is seen and they look like the same liquid. The tube maintains different levels for more than three months. The alcohol solution evaporates out and a fresh solution should be added every two weeks.

Exhibit: Mount U tubes on a plywood panel keeping the bottom bend visible. Make a solution of a pinch of methylene blue in about 30 ml alcohol. Take-100 ml water and 100 ml alcohol in two separate beakers. To both water and alcohol add equal amounts of methylene blue solution say 10 ml each. Shake the solutions to make them homogeneous. To one U tube add methylene blue solution in water. This solution will maintain same level. To the other U tube add methylene blue solution in water till the tube is about half filled. Now fill the remaining portion by adding methylene blue solution in alcohol. This tube will have different levels of liquid in the two arms.

Material required : 2 U tube of about 1 meter height, ethyl alcohol, water, methylene blue.

ELECTROLYSIS OF WATER

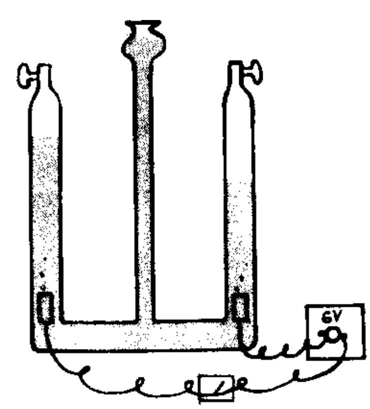
Principle : Passage of 6 Volt D.C. electric current through water leads to its electrolysis resulting in the formation of hydrogen and oxygen gas.

$4\ H+ + 4\ e$——— $2H_2$

$4\ OH$—$2H_20 + 0_2 + 4e$

Construction

Description : This glass equipment is made from coming or Pyrex glass by a glass blower. The electrodes are 1 cm x 1 cm platinum and are fused into the glass as shown in the diagram. The two arms are constructed from burettes.



Activity: The electrodes are connected to 6 V D.C. supply. The 6 V D.C. supply can be obtained from a battery eliminator or from a battery box in which four, 1.5 volt cells are joined in a series. The electrolysis apparatus is filled with water and a small amount of sulphuric acid. On pressing the switch electrons flow through electrodes and split water into hydrogen and oxygen. The relative volumes of hydrogen and oxygen gases could be read from the burette.

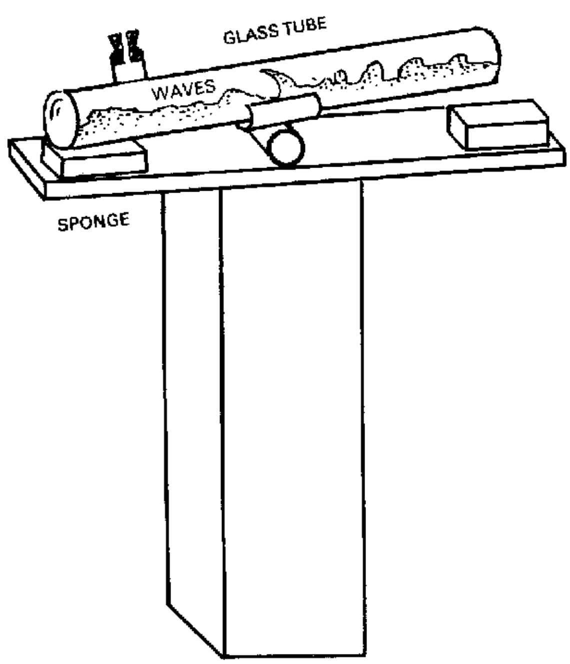
WAVES

Principle : Conversion of potential energy of two liquids to kinetic energy results in the opposite movement of liquid layers which result in wave formations.

Construction / Description : A long narrow platform is made form a wooden plank. In the Centre of this platform is fitted a pivot. A long glass tube with one opening is fined on a plank and joined to the pivot. On the two ends of platform are placed foam rubber cushions which keep the glass tubing in horizontal position. The end of the tube can be pressed down over foam rubber. On releasing, the two liquids in the tube move in opposite direction forming waves.

Material : Methanol, liquid hydrocarbon such as petrol or kerosene, a small amount of methylene blue.

Setting up: Take methanol add a small amount of methylene blue to make a transparent blue solution. Add to the glass tube with a funnel till the tube is filled nearly half. Fill the tube completely with hydrocarbon liquid and stopper with a glass stopper having a hole in it. Some liquid is lost due to evaporation. Fill the tube completely by injecting hydrocarbon liquid through the hole with the help of a syringe as and when necessary.



MAGIC BOTTLE

Principle : Methylene blue is reduced to a colourless form by the action of glucose in an alkaline solution. On shaking the methylene blue in contact with the oxygen in the air, it gets oxidised to a blue form. This can be repeated several times during 24 hours with the same solution. If the liquid does not become blue on shaking,· remove the cork and allow fresh air to get into the bottle.

If liquid does not become colourless in the beginning add a small amount of glucose and
or sodium hydroxide and wait for 2-3 minutes. Using Indigo carmine instead of methylene blue gives two changes of colour - yellow on one shake and red on vigorous shaking.

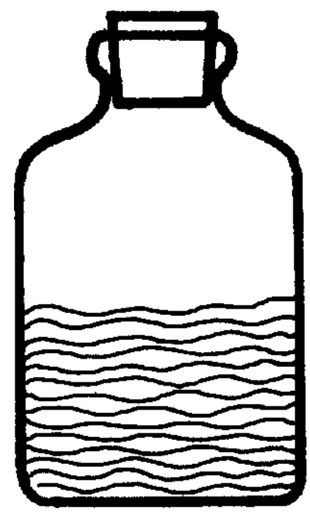


Exhibit: Take about 150 ml water in the bottle. Add sodium hydroxide, glucose and a small pinch of methylene blue to the bottle. Shake and allow to stand. After a few minutes, the liquid will become colourless. Shake the bottle. The liquid will turn blue. Again on standing, the liquid becomes colourless.

Material required: Narrow mouthed bottle of about 500 ml capacity. 5 gm sodium hydroxide, 5 gm glucose, pinch of methylene blue, cork to close the bottle.

WINDOW READER

What is it ? This consists of an open square box, three square slotted plates and a plate containing all the numbers from l to 64.

What it does ? Think of any number from 1 to 64. Using these plates we can see the chosen number through a small window.

How to use it ? Find on which edge of the three plates the chosen number occurs. Arrange the plates in the box in any order so that these edges are at the top. Cover the box with the numbered plate and turn the whole gadget to see the chosen number through a small window.

How it works ? Note that each slotted plate covers three-fourths of the visible numbers on the number plate. When all the three plates are thus used the number of numbers exposed to view is 64 x 1/4 x 1/4 x 1/4 = 1.

Examine the pattern and shape of the slots in each plate.

$$64 \times \frac{1}{4} \times \frac{1}{4} \times \frac{1}{4} = 1$$

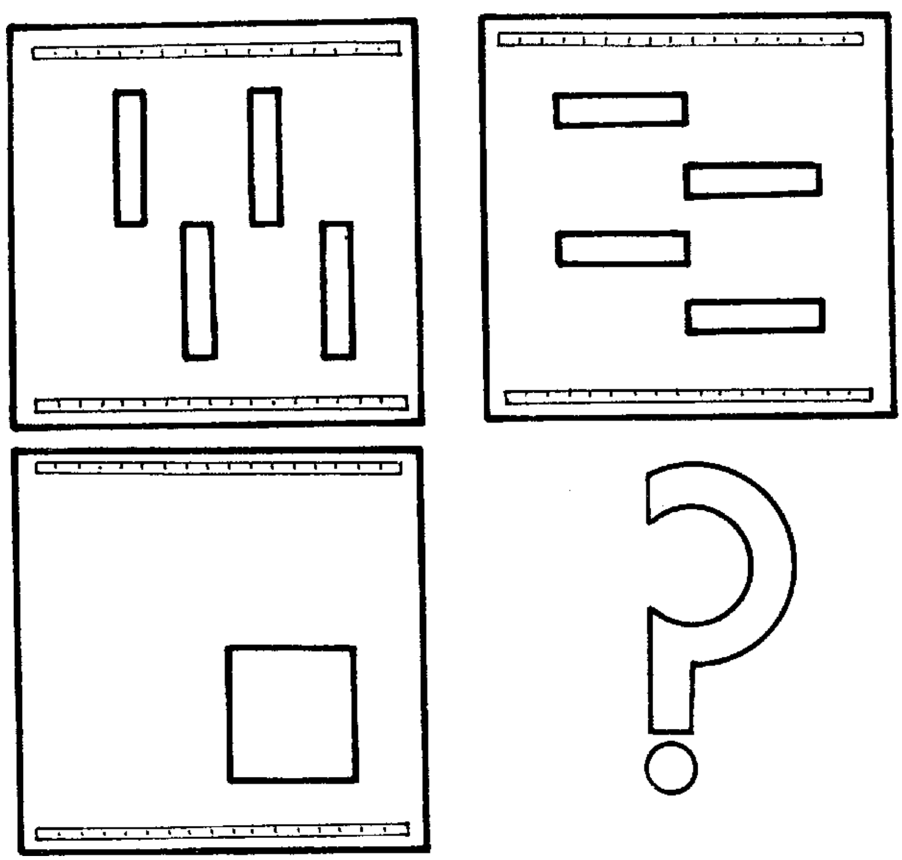
BICUBES

Principle: A 3 x 3 x 3 cube is made up of 27 1 x 1 x 1 cubes. 13 bicubes are given. Each bicube is made up of two cubes having different colours (say yellow and blue). Two single cubes, one yellow

Construction / Description : A long rectangular wooden piece is cut on a Cutting machine. The side are sanded and markings done for single cubes. Bicubes are cut on a machine and sandpapered. The pre-coat applied and the pieces are coloured with two colours. Several extra pieces are made for replacement as and when needed. Single cube pieces are also cut from above stick. Half the cubes are painted one colour and the remaining painted with other colour.

Activity: 1) The 13 bicubes and a single cube have to be assembled to form a 3 x 3 x 3 cu be, whose six faces show a checker pattern. 2) Can we make a cube using 13 bicubes which has a vacant hole in place of a cube in the centre ?

Remarks : This is a simple activity for children's below 10-years in age.



BULL'S EYE

What is it ? This consists of eleven square wooden plates and a 3 x 4 rectangular tray which can accommodate these square plates leaving one square space empty.

The Problem : Arrange the plates in the tray in such a way that the white circle is formed by the arcs on eight of the plates, the centre of the circle being occupied by a blank square, all in the top nine squares. In the bottom row, the left hand square is blank, the middle square is the one which contains the dot and the right hand square space is empty. Beginning with this position, slide the squares successively in the empty spaces until the circle is restored and the dotted so u a re is in the centre of the circle.

Solution :

G	H	
F	E	D
A	B	C

The four unmarked squares are not to be disturbed. The plates occupying The squares denoted by the following letters are to be successfully moved in the adjacent empty spaces.

D E H G F E B
A F G H E D C

ROLLING CUBES

What is it ? There are eight cubes placed in a square tray in 3 x 3 formation with the space for the central cube vacant. Each cube has a red face and a blue face opposite each other and the remaining four faces are white.

The Problem : Begin by placing the cubes with all the red faces on top, with the central space empty. Roll the cubes one after another about a lower edge in the empty space. Do this until all the blue faces are on top and the empty space is in the centre. Note that no sliding of the cubes is allowed, only rolling about a lower edge is to be done.

Solution: The solution is given below. There are 36 moves. Each letter represents a move of the cube with reference to the empty space

A R B L L B R R A L B L   A= Above
A R B R A L B L A A R B   B = Below
R A L B R B L A L B R A   L =Left R =Right

Comments : The problem had appeared some time back in the "Scientific American". The solution given above was first obtained with the aid of a computer. Solutions by human effort were also there, but the number of moves was more than 36. The problem is generally considered very difficult.

PARKING PUZZLE

What is it ? This is a wooden box-like gadget in which there are grooves as shown in the figure. There are six counters which can move along the grooves.

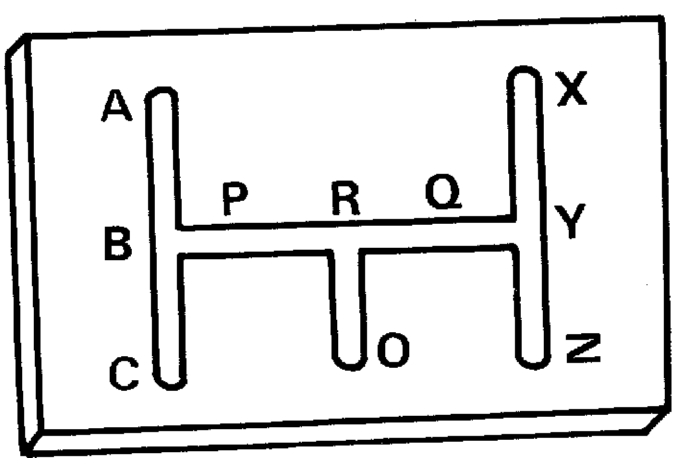
The Problem : Place the three yellow counters on A, B, C and the blue counters on X, Y, Z. Move the counters one by one until the three yellow counters change places with the three blue counters, moving one counter at a time.

Hints : Use the parking place 0, and B,P,Q,Y as parking places whenever They are available. Any counter left at R will be a hindrance to the movement of the other counters.

Solution : In the following solution each pair of letters indicates the move of a counter from the first letter to the second. The minimum number of moves is 17.

BO	YB	ZP	OZ	PY	BQ
CO	OC	YB	XP	OX	PY
BO	AO	QA	YB	OY	

Comments: There is an extended form of this problem. We may have, instead of three yellow and three blue counters, five yellow and five blue counters on the two sides. Here the number of moves required for the exchange of the counters is greater and the solution is naturally more difficult but it is worth trying.



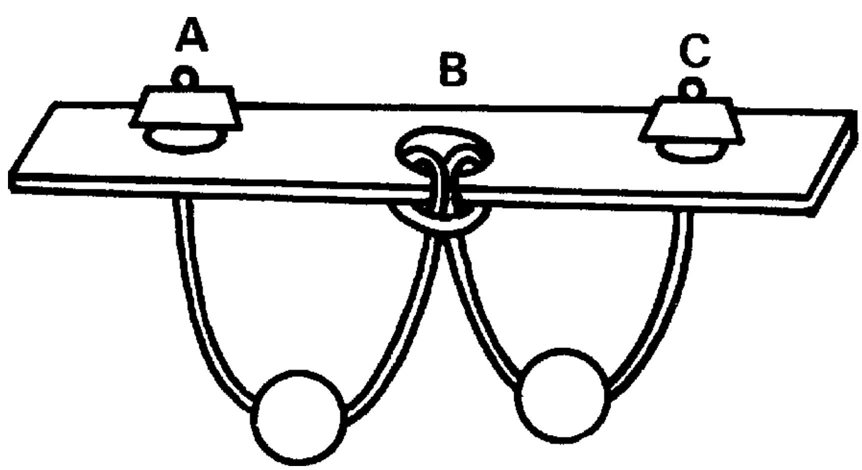
STRING BEAD PUZZLE

What is it? it consists of a frame with three holes A, B, C on the top board. A long string with two large buttons attached to the two ends, pass through the holes A and C and with the middle portion of the string is looped through the middle hole and back on itself. There are two beads through which the string passes in each of the two loops as shown in the figure. The two beads are thus kept separate by the middle loop.

The Problem : Undo the middle loop and bring the beads together. Solution : Catch hold of the middle loop, put it under the left bead, thread it up the hole A, pass it over the button and pull it down. Repeat this process for the other bead. Pull down the thread and you will see the two beads coming together.

Comments : This is a topological problem and is one among many string and bead puzzles.

> 'You know what I like about this place is that I can lay my hands on things I want to do !'
>
> —a child's opinion



BRAHMA'S TOWER

What is it? It consists of 3 pegs 1, 2, 3 and five circular discs of different sizes and preferably of different colours, each with a hole in the centre.

The Problem : To start with, all the five discs are placed on peg 1 with the largest disc at the bottom and the smallest on the top in the order of their sizes. The problem is to transfer the five discs from peg 1 to peg 3 using the peg 2 for intermediary moves. The following conditions must be followed

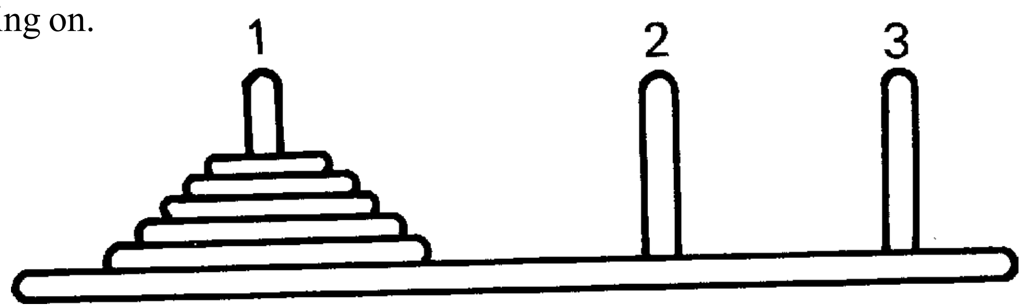
1) Move only one disc at a time
2) No disc can be placed over a smaller one.

Solution : The transfer can be effected in 31 moves. In the following solution each pair of digits indicates a move of a top disc from the peg given by the first digit to the peg indicated by the second digit.

13	12	32	13	21	23	13	12
32	31	21	32	13	12	32	13
21	23	13	21	32	31	21	23
13	12	32	13	21	23	13	

Comments : Had there been only four discs the number of moves would be 15. For three discs the number is 7 and for 6 discs the number is 63. Mathematicians many be interested in proving the general formula for the number of moves for n discs. This number is $2^n - 1$.

History: Mythologists say that Brahma had ordained a tower like this with 64 discs. It is said that a number of great Rishis sitting around a sacrificial fire were asked to transfer these discs according to rules from one peg to another using a third peg for intermediary moves, so that all the discs are transferred in the above manner. The number of moves required for this is $2^{64} - 1$. Calculating at the rate of ten discs per minute the total time required for the complete transfer of discs will be several billions of years. The work of transfer of the discs was stipulated to start when the earth' was created. It is said that when the last disc will be transferred, there will be a thunderclap and a deluge and the earth will vanish. The process of the disc transfer is supposed to be still going on.



INTERLOCKED LOOPS

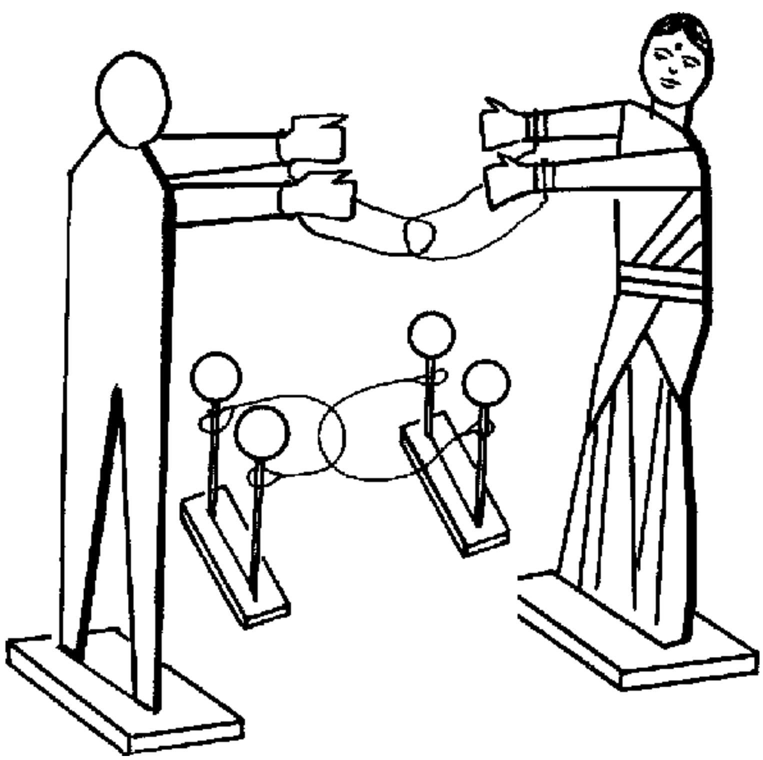
What is it ? It is a topological problem. Two long ropes which are tied to the hands of a boy and a girl standing opposite to each other are interlocked.

Problem : Undo the interlocked loops, that is, separate the boy and the girl.

How is it done ? First note that the knotted loop round each of the four wrists is wide enough to let more than a rope pass through, but not so wide as to let the loop come off the hand.

Now at the place of the interlock, catch hold of the rope that lies below the other take it towards the hand on the same side, pass it through the knotted loops below that hand from behind, pull it over the fingers above the hand and finally draw it through the knotted loop, releasing it from the interlock.

Comments : After separating the two ropes, you have the reverse problem of interlocking the ropes back to the original position.
In the beginning of the solution, if you had picked up the other rope (i.e. the one which lies above) and proceeded as above what will happen? You will make the interlock more complicated. Try and see. How will you then resolve the complication ?



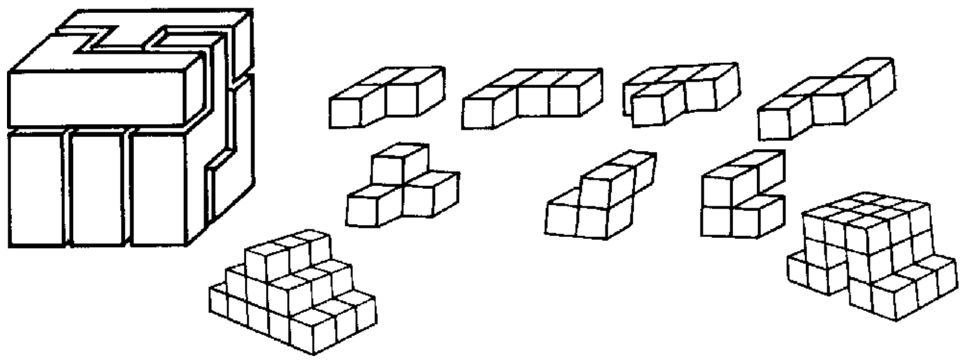
SOMA CUBE

What is it ? Seven wooden shapes made up of small cubes as shown in the figure are given.

The Problem : These blocks are to be assembled together to make a cube. As there are 27 small cubes in all, the final cube will be a 3 x 3 x 3 cube.

Hint for Solution : See the figure

Comments : These blocks can be used to make many other shapes. Some of them are given below.



INSANITY BLOCKS

What is it ? Four equal cubes have their faces coloured by four different colours in different ways and they are placed in a small long tray.

The Problem : The cube should be so arranged in the tray so that all the four colours appear on each long side of assembly.

Hints : Count the number of each colour on the face of each cube. As four of each colour have to appear on the long sides of the assembly, we know what colours should go on the faces in contact (invisible) and on the two ends. After this, arrange the cubes with this condition satisfied and turn the cubes about the long axis of the assembly until the condition of the problem is satisfied.

Solution : A solution is shown in the figure.

Comments: There is also a beautiful solution using graph theory. But this solution cannot be given here.

	CUBES			
Faces	1	2	3	4
Top	R	Y	G	B
Bottom	G	R	B	Y
Front	B	G	R	Y
Back	Y	B	G	R
Left	R	R	B	G
Right	R	B	Y	G

R = RED
B = BLUE
Y = YELLOW
G = GREEN

TROMINO FITTING

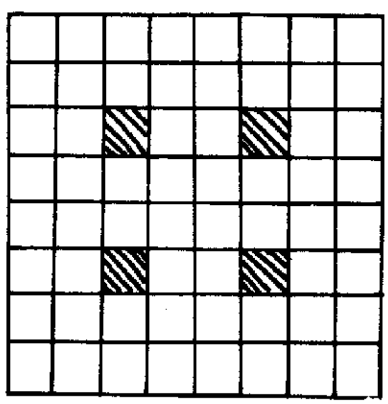
What is it ? A tromino is a 3 x 1 rectangle i.e. three unit squares joined edge to edge in a straight line. An 8 x 8 square tray and 21 trominoes are given. Problem: Accommodate the trominoes without overlapping in the tray leaving one unit square space vacant.

Hint: The trominoes cannot be fitted in the tray if the vacant square is arbitrarily chose n. The vacant square has to be one particular square in the tray or any of the three symmetrically situated with this square. You will have to find one of these four squares.

Solution : You may arrange the trominoes in any one of many ways provided the vacant square is one of the four shaded square shown in fig u re 1. One solution is shown in figure 2.

Comments : Here we give the reason why only a shaded square in figure 1 can be vacant for a successful solution. Let us mark every unit square in the tray by one of the digits 1,2 or 3 according to the scheme shown in figure 3. Then note that a tromino placed anywhere in the tray so as to cover three unit squares, will always cover each of the three digits 1,2,3. So, in the correct solution, 21 of each of the digits will be covered. However, it is seen that in the tray, the number of 2's and 3's a re each 21, but the number of 1's is 22. Hence the vacant square must bear the number 1 and all the other three squares symmetrical with this must also bear number 1. It is easy to see that the only squares which ca n be vacant are those shown in figure 1. Fig. l

Fig 1



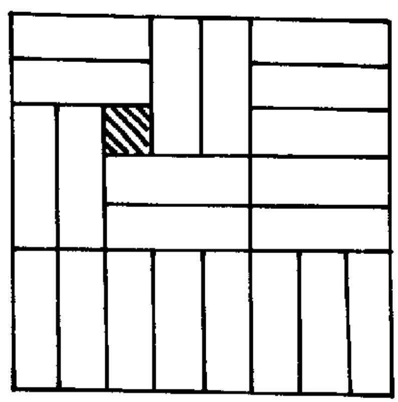
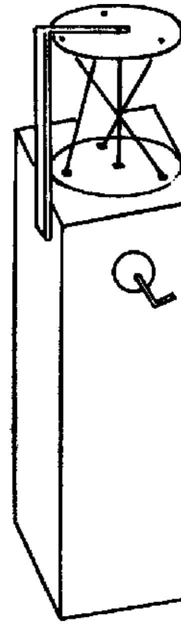


Fig 2

1	2	3	1	2	3	1	2
3	1	2	3	1	2	3	1
2	3	1	2	3	1	2	3
1	2	3	1	2	3	1	2
3	1	2	3	1	2	3	1
2	3	1	2	3	1	2	3
1	2	3	1	2	3	1	2
3	1	2	3	1	2	3	1

Fig 3

HYPERBOLOID



What is it ? This is a gadget which an help one to visualise the surface of a Hyperboloid of one sheet.

Construction : Two equal circular discs a re connected with each other by a straight vertical rod joining the centres of the discs which are in horizontal positions. Three points equally spaced on the rim of the upper disc are joined to three points equally spaced on the rim of the lower disc by means of three slanting rigid rods. The whole gadget is mounted on a turntable.

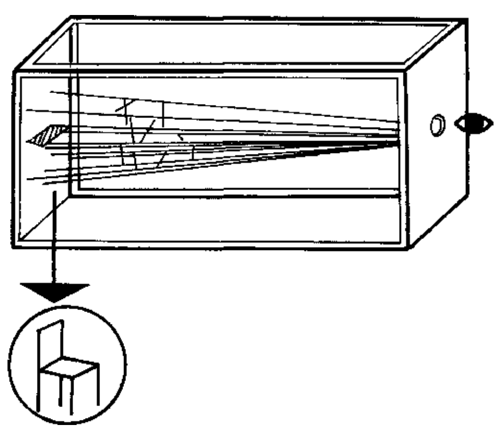
How it works ? Rotate the gadget rapidly by turning the handle. The successive positions of the slanting rods in motion give the impression of a curved surf ace which is known as a Hyperboloid of one sheet.

AME'S CHAIR

What is it ? An optical illusion. Look through the eye-piece. Inside the box, you see what appears like a little chair. Now, open the side-door and look inside. You see no chair, but a number of short sticks haphazardly suspended, and a picture of a seat on a black vertical screen. Explanation: The illusion caused by the perception is due to conical projection .

Construction : A number of thin straight black wires emanate from near and behind the eye-piece and end at certain points on the black vertical screen at the far end of the box. These points are certain critical points on the outline of a chair, previously drawn on the back of the screen. Then, a suitable number of thin white sticks are placed in any convenient position between such pairs of wires as will correspond to the limb of a chair, an arm, a leg etc., gluing the ends of the sticks with the wires. A picture of a seat of the chair drawn on a paper suitably as to size and shape is either pasted on the screen at the appropriate place or placed with the four corners on the appropriate wires.

How and Why it works: To enhance the illusion, the screen and wires should be preferably black and the sticks white (match-sticks with the phosphorous removed may be ideal). Greased glass or translucent paper may be used for the sides of the box, so that the inside of the box gets diffused light. The single eye piece allows only one-eye-view and eliminates stereoscopic (or depth) effect. Thus, the 3-D objects are identified with their 2-D projections on the screen.



PARTICIPATORY EXHIBITS FOR YOUNG ONES

Although basic principles of design remain the same, there are certain special considerations for the younger age group.

1. The dimensions of the exhibit should fit with the height of the children. For example, the texture platform designed for an adult group would have 75 cm height but the same thing designed for younger children below 9 will be around 45 cm.

2. It should be attractive from colour and texture point of view.

3. As far as possible, protruded parts should be avoided.

4. All edges should be rounded and exposed wood should be smoothened.

5. The basic contents should be properly considered but should not overrule play or participatory possibilities.

6. The content should have immediate environmental relationship.

7. Safety aspects from the point of view of avoiding bodily injuries as well as mental fear should be considered while designing.

8. In a participatory exhibit, movement is an useful element.

9. It should be imaginatively designed.

The following few exhibits are selected from a variety of participatory exhibits designed at Vikram A. Sarabhai Community Science Centre for primary level.
In our country, museums and science centres will be benefited by providing specially designed corners for the young ones. Luckily, science experiences give easy, almost spontaneous design possibilities.

TEXTURE PLATFORM

Objectives : To provide experiences of various textures to young ones. — To make them feel and recognise differences in various textures.

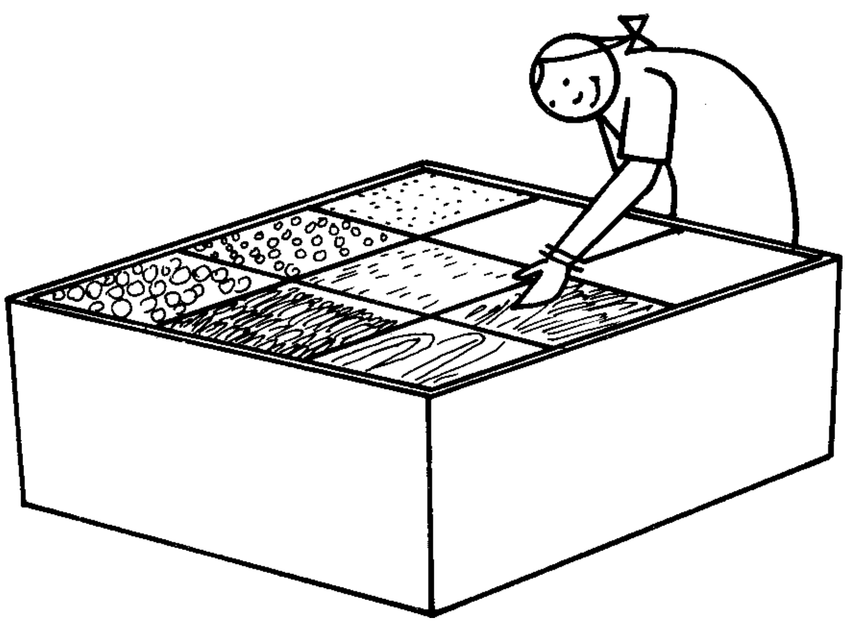
Construction : 90cm x 90cm. surface divided into 9 equal parts. Each part will have texture like 1. Silk 2. Velvet 3. Wool 4. Rough sand surface 5. Medium rough sand surface 6. Very rough sand surface 7. Wood 8. Rubber 9. Plastic Height is approximately 45 cm.

The surfaces are made in different ways. i.e. — Sand is sieved into three different grades and applied to wood with synthetic adhesives.
— Silk, wool and velvet fabrics are stretched on 12 mm. ply and then the ply is nailed to the hardboard base of the platform.
— Rubber, wood and plastic surfaces were the original pieces of materials.

Description: Even though the child will use the surfaces by himself or herself, a little interaction or questioning will make the experience more involving.

Questioning can vary with various age groups, e.g. 4 to 5 years age groups will be willing to answer the following types of questions:
a) Which is the roughest surface? b) Which do you think is the cloth here?
Note : Materials for textures may change from time to time, to keep up novelty. Height and other measurements may also slightly vary according to materials available.

Materials : Plywood or old packing wood, synthetic adhesive and various materials with differing textures.



TOUCH AND JUDGE BOX

Objectives : To make children feel different things without seeing them and connect this experience with things they can spot in the surrounding. Things like stone, coconut, shells, feathers, cotton.

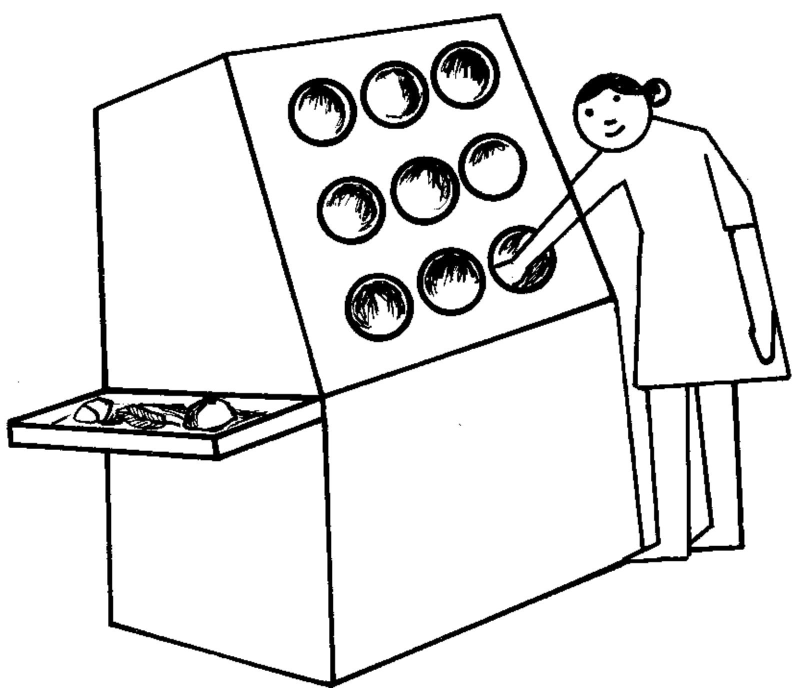
To provide younger children an exercise for judging materials through Blind box experience.
To provide a "hand on things" exhibit for juniors in a general display area.

Construction : Box has following broad dimensions.
Height : 120 cm Breadth : 90 cm
Holes : 15 cm No. of holes : 9 per box
All wood work will have rounded edges. Each hole has detachable cotton washable bag in which different objects can be hidden.

Description : The box can be used by two to three children at a time. The child is asked to put the hand into the hiding bag via the hole. After feeling an object, the child will judge the object and select an identical object from the tray nearby. Each object in the tray will have a string and the child will put an object on a relevant peg near each hole.

Note: The objects can be changed from time to time to suit levels and relative complexity:

Materials: Ply wood or any used cotton cloth, wood, paints, things like feather, cotton, stone, seeds.



'SEEING BIG' TABLE

Objective : 1) To provide a device through which children can see magnified images of different things. 2) To satisfy children's curiosity in observing details of different materials.

Construction: A table with approximately the following dimensions. Height - 45 cm length and breadth - 90 cm The table will have a central rod on which a revolving handle with a magnifying glass can be fitted. The height of the rod can be fixed according to the focal length of the lens used.

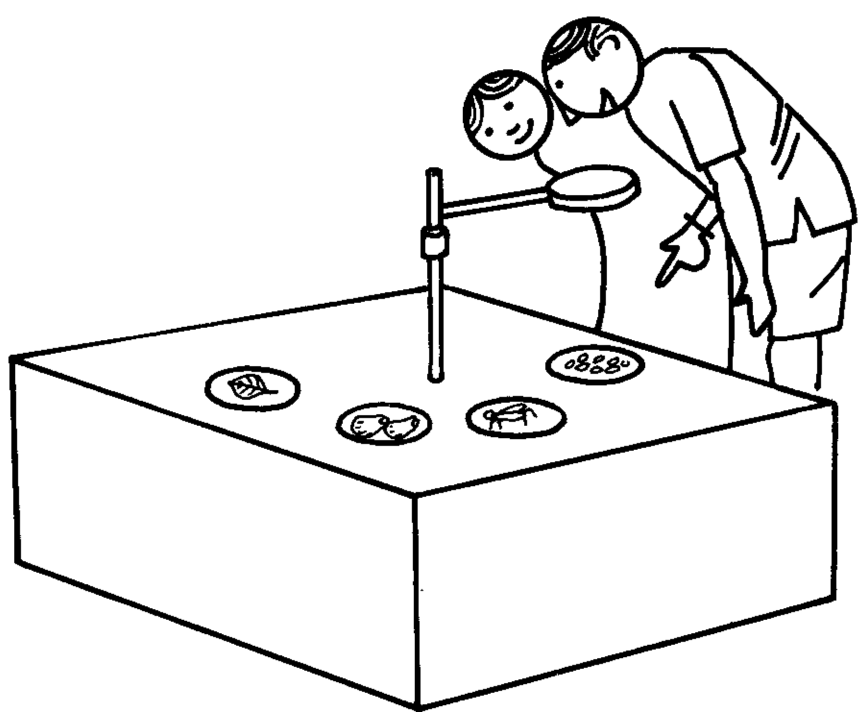
Materials can be placed on clean surfaces. They should be on the circles which will fall under the rotation of the lens. This gives them a certain easiness and pleasure in handling.

Description: The things can be chosen according to the age level and environment. Children can be given an activity to observe these things magnified and then they can write or draw those things. Things like a live cockroach or an ant interests children for observing structure, and movement. Veins in different leaves can also be studied.

Note : 1) The construction should be extremely sturdy because it is noted that this sort of device has great wear and tear. 2) Spare magnifying lenses are required.

Materials : Plywood or packing crates wood, metal rods, magnifying glasses, display plates with lids.

Thing s like insects, leaves, flowers, pebbles, sand, seeds, wood.



NUMBER PATTERN

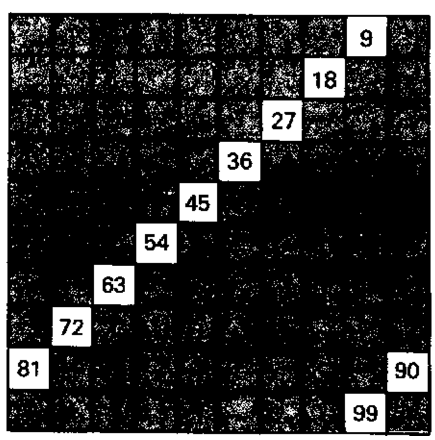
Objective : 1) To provide experiences of finding out the patterns in numbers appearing on the tray. 2) To make children think of numbers and their relations with other numbers and to find out the correct position of a plate on the tray.

Construction : There is a wooden tray. 1 to 100 numbers are written on it. There are 10 wooden plates which can be placed on the tray only one at a time. On these plates, the re a re h o les at different points.

Description : A child can take one plate at a time and put it on the number tray. He has to find out the pattern in the appearing numbers. If he can not make out the pattern, he can change the position of a plate. He has to find out the mathematical relations among all the numbers appearing. One plate can have holes for prime numbers, others have holes for multiplication tables, and so on. A plate with holes using multiplication table 9 will look as shown when placed correctly on the tray.

Note: Children can make their own plates with some number patterns. Pattern plates can be made using some series of numbers and can be given as problems.

Materials : Plywood, old packing wood, ink to write numbers on the tray.



OPTICAL ILLUSION EXHIBITS

Optical illusions make excellent participatory exhibits. 45 x 45 cm square modular is suitable for many static graphics.

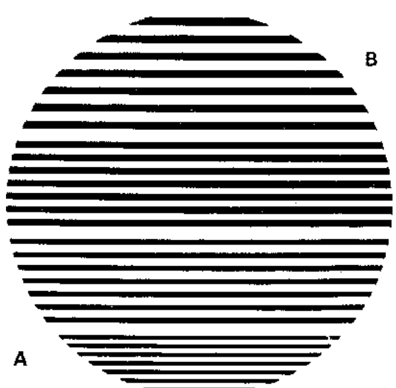
Exhibits which require turning or making upside down position can be fixed on a sturdy panel with turn table type of pivot.

For measuring width of parallel lines a measuring scale can be hung by the side of an exhibit.

The graphic should be suitably enlarged according to the size of the board.

FIND OUT THE HIDDEN MEN

WHICH CIRCLE IS BIGGER? JUDGE AND THEN MEASURE.



Hold the board with above graphic at A and B. Turn it clockwise and anti-clockwise. Do it at various speeds. Observe the centre of the circle and see what happens to the lines.

This is a traditional optical illusion. Turn it upside down and see.

REVOLVING WINDOW

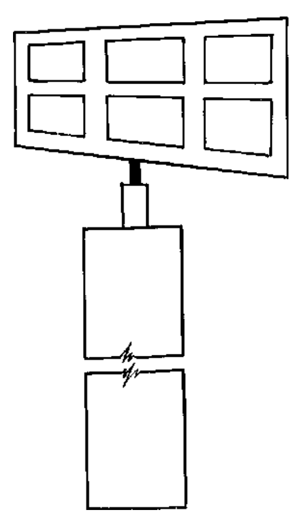
What is it ? It is a model of a window frame mounted on a vertical axis about which it can turn. An example of an optical illusion.

What is the illusion? Stand at a distance of about 5 meters from the gadget and look when the gadget is switched on. Do you see the window frame wobbling ? It appears to turn from one side to the other and back alternately. Walk up and stand close to the gadget and look again. You see it is not wobbling, but, in reality, revolving about its axis continuously. Why did it appear like wobbling when seen from a distance?

Explanation: This is based on the simple fact that any object appears Smaller from a greater distance and bigger from a lesser distance. Note that The window frame has not the normal rectangular shape, but is a trapezium, the two vertical edges having slightly unequal lengths. Every time the longer vertical edge moves further away from observer, it appears a little shorter, while the opposite edge looks a little longer, when seen from a distance. This occurs repeatedly in a continuous revolving motion of the window frame and thus produces the illusory wobbling effect. Experimentally find out the optimum distance where one should stand at which a slight displacement of the observer switched the wobbling effect into the real revolving effect.

a. The playground equipment should excite the children to play.
b. It should give them some physical activities like climbing, bending, running, etc.
c. The child should be able to experience some scientific phenomenon during the play.
d. The playthings should be simple and sturdy and should provide varying play opportunities.
e. It should work as a prototype for establishing similar playgrounds elsewhere.

‘If museums are in communication business as they purport to be, it is worth inquiring what is in fact, being communicated!’



SCIENCE PLAYGROUND

"Science Playground" is a recent experiment to initiate children into the world of science through interesting outdoor participatory activities.

India is a vast country with a bewildering variety of socio-economic groups. The Indian rural scene is very different from the Indian urban scene. Each group has its own characteristic traditions and needs. Vikram A. Sarabhai Community Science Centre (VASCSC) broadly keeps the needs of rural and urban groups in mind in organising its programmes. Science playground is one programme which is developed and designed in a way that it can be used by groups with various backgrounds. As such, there are really no organised playgrounds in Indian cities. Some of them do have playgrounds; but a playground as an essential need for the growth of mental faculties of children has still to be recognised and therefore the playground as a facility does not have a priority in the educational programme. Yet a few conscious groups have recognised this very vital aspect o' children's life and have developed a few playgrounds. VASCSC science playground is one with such an objective.

What are the features of a science playground vis-à-vis an ordinary playground? The present playground is exactly a play strip measuring about 12m x 30m. It is on the west side of the premises and children go to the play ground very informally whenever they like a change of the activities which take place at the Centre. Morning times are cooler and shadier. The playground is basically designed with the following objectives in mind.

The VASCSC science playground has the following

1. Colour Filters
2. Colour Mixers
3. Temperature Blocks
4. Singing Pipes
5. Measuring Sand pits
6. Evolution Pillar
7. Simple machines
8. Gears, Pulley
9. Texture block (Vegetation, Shells and geometric patterns)

Before designing a plaything, two major aspects are considered

1. Content Aspect
2. Design Aspect

The content aspect is handled by the designer and scientific collaborate together.
The design aspect is handled by the design fabrication draughtsmen. The team consists of three basic skills :

1. Science Collaborator having science educational activities background.
2. Design collaborator having educational activities background
3. Fabrication draughtsmen.

Most of the methods and materials used in fabrication are of local origin and particular stress is given to materials like bricks and sand. For the materials are used for their sturdiness and cleanliness. Gujarat region where we have been developing these ideas, has a rich craftsmen tradition. The point of view of the craftsmen is also considered while deciding the details of the design.

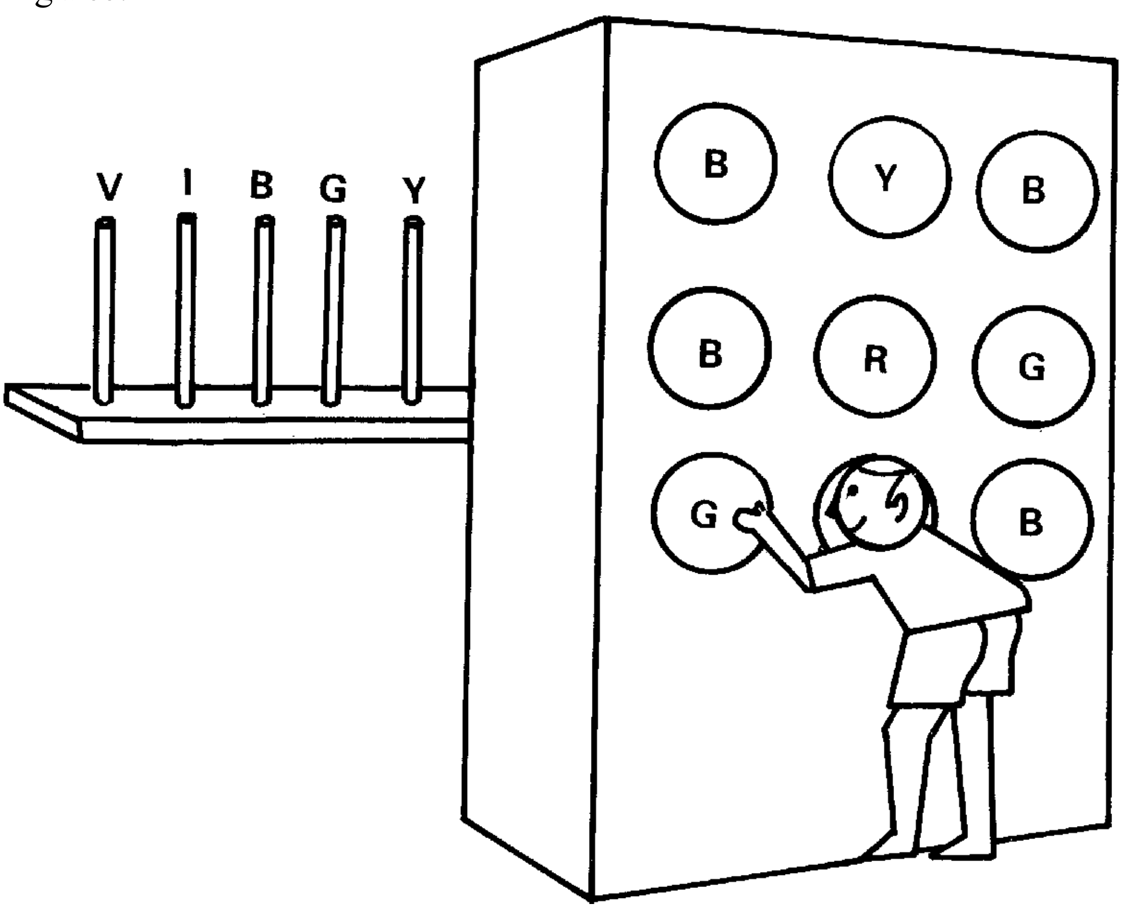
COLOUR FILTERS

Colour Filters are a group of 3 block structures having several peeping holes cast in concrete. These holes have various colour filters. Children and adults alike enjoy the play activity while peeping in the different colour viewers to look at pillars painted in seven different colours. There are several colour filter viewers provided and a group of children can use them very informally.

COLOUR MIXER

These also are fixed structures, very simple and sturdily built which will permit colour mixing of primary colours. These playthings give perpetual pleasure to most of the children. Average height of these colour filter structure is 165 cm.

Colour Filter structures basically permit physical activities like seeing, manipulating, bending, touching. Apart from the pillars having colour filter play factors, they also have hide and seek facility and quite sometimes children use it as a hide and seek plaything also.

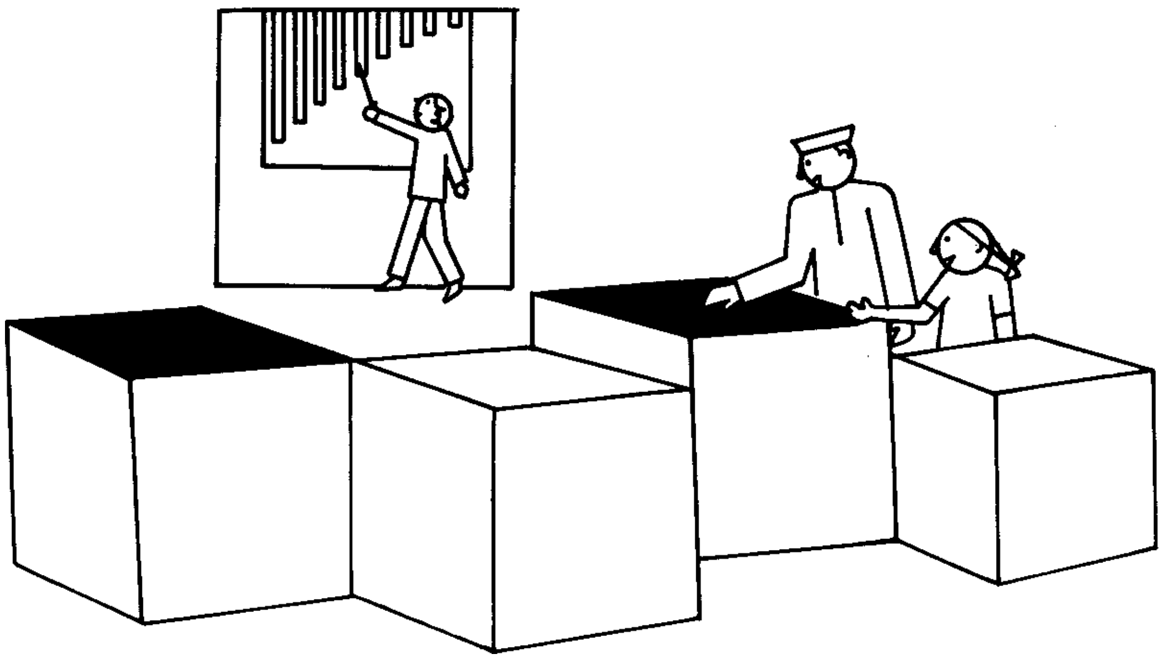


TEMPERATURE BLOCKS

This is a group of four blocks - two of them having black surfaces and two having white surfaces. Ahmedabad is a town where brilliant sunshine is available for most part of the year. Temperature plays an important role in Ahmedabad’s life pattern. While playing in this area, children would touch these black and white surfaces and immediately realise that the black surfaces feel hotter to touch in comparison to the white ones. Through this play a very good correlation can be made to the type of clothes suitable for the weather. Temperature blocks are also used by children as climbing devices.

Along with temperature blocks, metal ladders are placed. The basic Purpose of the metal ladder is to provide a basic activity of going up and down.

Metal steps are coloured alternately black and white. The children would unconsciously make out the different heat absorption by white and black colours.



THE SOUND UNIT

The Sound Unit is a pillar structure having 5cm. wide metal tubes which are of progressively increasing lengths. Children’s natural tendency to strike the tubes is being taken care of in this plaything. Once a child strikes one tube, he is tempted to strike another tube. Thus the desire to make different sounds is satisfied. At the same time, the child is likely to realise the cause and effect phenomenon in production of different sounds. India has a large variety of temple bells, cattle bells, musical gongs etc. In the plaything such devices could also be incorporated.

MEASURING SAND PITS

The present playground "Measuring Sand Pit" provides scope not only for sand and water play but also for play activity to learn measuring. Children have a desire for activities like measuring, playing and observing. "Measuring Sand Pit" has provided an opportunity to satisfy this.

EVOLUTION PILLAR

Evolution Pillar is a wood-carved totem like pole having various symbols of evolutionary development. The basic project was conceived as an art and science project and a group of students along with a traditional craftsman developed a 5-meter tall carved pillar. Students enjoy touching it and observing it. It also raises quite a few questions on evolution.

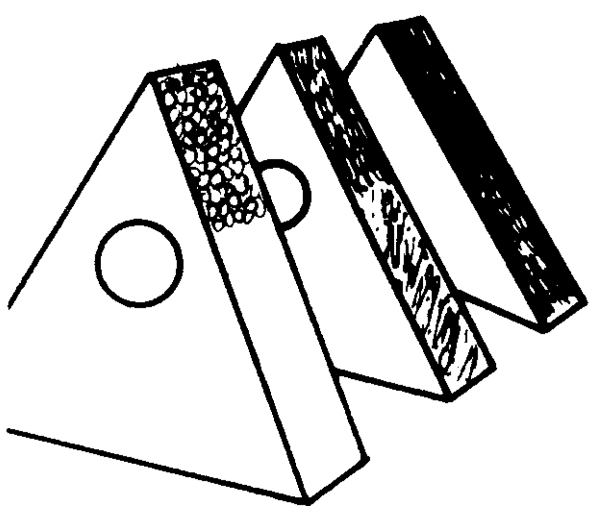
SIMPLE MACHINE PLAY AREA

This is a 150 cm. tall modern structure having simple machines like screws, nuts, bolts, gears, pulleys and levers. Machines are the important components of our life. An opportunity to play with machines in childhood fulfils the need in child's life for preparation for the future.

In developing countries where machines are still things people are scared of. This sort of opportunity would be of great practical use. An element of colour is also exploited in this plaything.

FOLIAGE IMPRESSION BLOCKS

One of the purposes of the playground is to relate the child with his immediate environment. The playground has a small garden area in its neighbourhood. This area is very near to the natural form having grass, flowers and shrubbery. It has also various animal holes and a small water tank. The Centre is on the edge of the town within a few kilometres, children can collect a variety of familiar and unfamiliar vegetation. The Foliage Impression Blocks are created out of cement and children would make impressions of foliage on it which once cast would remain there for years. This would give them several nature play activities like identification, impression-taking and pattern drawing.



TEXTURE BLOCKS

One of the purposes of this plaything is to provide insights to younger children regarding basic science principles. Texture blocks are blocks having several types of textures like simple, rough, wavy and smooth. The children would be able to feel the textures and create educational games out of it. In future, several play experiences like basic shapes, basic numbers and simple puzzles would be created.

1. Common facility for pre-school and primary school children in the surrounding area.
2. Basic Science experiences relating to younger age group.
3. Demonstration Laboratory for pre-school and primary school teachers. The above uses are planned and need a specific approach. Of course, at this point the playground use it transformed into the laboratory use. The teacher may start the work by observing the playground and then can decide the usage of various areas. For example, the teacher may start with the Sound Bars and can observe the differences in sounds. After this play experience, the teacher can initiate the group in observing different sounds in immediate surroundings. Colour Filters can work as science apparatus for mixing colours.

As a common playground facility, this spot would be a boon to several small and congested nursery schools in the immediate surroundings.

RURAL ADAPTATION

The play structures described above can be easily adopted to suit several areas in India.

The Rural areas in India have their own playground items. They produce them from rural materials like tree branches, mud and bamboos. They also make several game patterns in soil.

Through organised leadership several interesting and functional ideas for Science Playground can take shape.

End of book