Anveshika Experiments

ViBha-IAPT-Anveshika

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Contents

Part I

Mechanics

Experiment 1

How Much is One Newton?

Objective

To develop a feeling of 1 N force.

Equipment

A weighing machine with display of mass on a dial.

Introduction

Everyone has a basic understanding of the concept of force from everyday experience. Physics students know it well that the SI unit of force is Newton (N) and is defined as a force which can produce an acceleration of 1 m/s^2 in a 1 kg mass. But usually students have no idea about how hard a push or pull is 1 N. This simple demo experiment gives them a physical feel of how much 1 N is.

Procedure

Take a weighing machine where the object is placed on the platform and the mass in displayed on a dial or on a digital display. See the reading, if it has any zero error, remove it. Usually a screw is provided on the machine to adjust zero. Now if you push the pan by a force of 1 N, the reading will be close to 100 gram (taking $g = 10$ m/s^2). So, ask the student to press the pan of the weighing machine by a force which he/she thinks is 1 N. To dramatize, ask the student not to see the reading and push the pan. Some other student should read the reading and tell how many Newton of force the first student has applied. The conversion is simple; 100 gram of reading means 1 N. My experience with hundreds of students is that they apply between 6-9 N and think that to be 1 N.

Finally let the students see the reading and adjust the push till the dial reading shows 100 g weight.

Discussion

To measure something is part of science training. Physical laws are relations between the measured quantities. We measure lengths using scales, time using clocks, and mass using balances. Here a balance is used to measure force and hence it becomes a simple “force meter”.

When to do

Class 10 when you are teaching Newtons law

Instrument cost and availability

Dial type weighing machines reading up to 1 kg are easily available for Rs 250-350.

References

[1] Source: http://www.vigyanprasar.gov.in/activity_based_science/Expm1.htm

Experiment 2

Check Newton's third law?

Objective

Check Newton's law for interaction between two ring magnets.

Equipment

Weighing machine, two ring magnets, PVC stand.

Introduction

Newton's Laws are taught from class 9 to 12 in schools. A lot of Physics including whole of mechanics is built on it. Among the three laws of motion given by Newton, the 3rd law is always confusing and creates a lot of problem in making clear mental picture.

A common statement for Newton's 3rd law reads as "for every action there is always an equal and opposite reaction". The important part which is generally missed out that it concerns the forces exerted by two bodies on each other. This demo shows that forces exerted by two ring magnets are equal and opposite.

Procedure

PVC stand is just a pipe fixed on some base with fevicol or any other adhesive. Ring magnets are those used in audio speakers. Weigh the two ring magnets, say A and B, and the stand separately. Let the weights be W_1, W_2 and W_3. Put the first ring magnet A in the stand and place this stand on weighing machine pan, display of the weighing machine will show $W_3 + W_1$. After this put the other magnet B in the same stand in such a way that it will be in the repulsive mode with magnet A. The magnet B will be floating in the air having no vertical contact force with anything. Still the dial reading will be $W_1 + W_2 + W_3$. Although the magnet B is floating in air i.e. it is not on weighing pan and is stationary in air (i.e. net vertical force acting on B is zero), but the scale reading has increased by W_2. That means B is pushing A downwards by the force W_2. Now, B is not falling so some force acts on it upwards to hold it there. This force is from magnet A only. So, magnet A is pushing B by a force W_2 upwards. Thus the two forces exerted by the two magnets on each other are equal and opposite.

When to use

At present Newton's third law is very poorly understood by most of our students even when they pass out class 12. The subject is introduced in class 9 where this demo may be given. You can do it in class 11 too where lot of mechanics is taught.

Instrument cost and availability

Weighing machine with dial display, Ring magnets: Rs 10-20 available at "Kabari" shops or radio repair shops, PVC stand made from junk.

References

[1] Source: http://www.vigyanprasar.gov.in/activity_based_science/Expm2.htm

Experiment 3

Pull the Paper under the Tumbler

Objective

To discuss misconcepts about inertia.

Introduction

Newton's three law of motion are taught in school from quite early times. Though students know the statements of the three laws but when it comes to application, quite often the laws are wrongly interpreted. The experiment described is quite common and is shown to dramatize the concept of Newton's 1st law of motion or inertia. However, a detailed analysis reveals greater insight into the laws.

Required Materials

A glass tumbler, a long piece ofpaper, a table.

Procedure

Near the edge of a table, place a glass tumbler filled with water. Now hold the part of the paper overhanging from the table using both hands. Give a sharp jerk to the paper and pull it quickly. What you find is that the paper comes out from below the glass and the glass just stays on the table with no water spilling out. Try pulling the paper with different speeds and see what happens.

Discussion

The common explanation is that because of inertia, the glass remains at its place and the paper comes. But is it the explanation? Where does this inertia go, when the paper is pulled slowly? Does inertia depend on velocity? It is friction, acceleration and distance moved under this acceleration that have to be roped in for proper understanding.

Hazard

If you are using glass tumber and dont pull it quickly it may fall. Use steel glass to practice.

References

[1] Source: `http://utsahiphysicsteachers.com/resourcematerial/experiments/Mechanics/Pullpaper.htm`

Experiment 4

Weightlessness

Objective

To get a feeling of the phenomena of weightlessness.

Equipment

A slinky.

Introduction

An effect of g is the extension in a slinky. As you must have experienced, a slinky is like a spring but the turns are very flexible and even without a load, it can extend to several times of its natural length under its own weight. If you hold few turns of a slinky in your hand and let the rest of it hang from there, the hanging part also extends through large distances. This extension again is because of g. If the effect of g can be reduced to zero, the slinky in a vertical position will not extend.

Procedure

Hold some of the turns of a slinky in one hand holding some of the turns in one hand Not clear. Let rest of it hang vertically. The hanging part will be extended. By holding appropriate number of turns make this part about 10 cm. Now leave the slinky and let it fall. You may catch the falling slinky at some lower level. The extended turns all shrink. You may do it several times to show the effect clearly.

The slinky shrinks because in the frame of the falling slinky, there is no effect of gravity. The slinky has become weightless as all measurable effects of weight have vanished.

Discussion

You can also perform this demo with a spring-mass system. The spring should have small spring constant so that there is a large visible extension when you hang a load. Dropping it will shrink the spring.

When to do

At class 11, when weightlessness is discussed

Instrument cost and availability

Slinky is available in gift stores or on footpath market or at tourist places for about Rs 30.

References

[1] Source: http://www.vigyanprasar.gov.in/activity_based_science/Expm3.htm

Experiment 5

Balancing the Nails

Introduction

We all are very familiar with iron nails. However, in this experiment we shall use them not to strike them inside the walls but to surprise the audience. Let us see how on a single nail an entire set of nails can be balanced.

Required material

15 equal-sized nails, each about 2-3 inches long.

Procedure

1. Fix a nail on a piece of wood or some lid so that it remains vertical with its flat top up. We will call this arrangement stand.

2. Now, ask your friends to balance the remaining nails on the nail fixed to the stand. Your friends will be a real fix attempting to put so many nails in a very small space. But, you come to their rescue by demonstrating how this can be done.

3. Place a nail on a table so that its head it towards you. We may call it base nail.

4. Now, arrange the remaining 12 nail, over the base nail on the left and right of it in such a manner that the heads of all the nails are towards the base nail. Place the head of the right nail on the base nail then the head of the left nail on the base nail, again the head of the right nail, then the head of the left nail, and so on, till you have placed all the 12 nails on the base nail.

5. Now, place the fourteenth nail on the base nail in such a manner that its sharp end is towards the head of the base nail. In this way all the twelve nail will come between the base nail and the upper nail.

6. Pressing both the base nail and the upper nail against each other and holding them with both you hand carefully place the entire set of nails at the mid print of the base nail fixed to the stand. Withdraw both your hands slowly. The pointed or sharp ends of the nails get lowered on both the left and right sides and their blunt and flat ends get entangled with one another. The entire set of nail resting on the base nail balances on the nail stuck to the stand. Surprising, isn't it?

Discussion

In this experiment the principle of centre of gravity plays its role. According to this principle, due to the weight of the inclined nails on both sides of the base nail the weight of the entire set-up acts below the balancing point. Thus, the entire set of nails balances comfortably. You may gently lower the nails on one side and then remove your hand. This makes the entire set-up quiver but it does not fall down.

Do and think a bit more

If you so desire, you may carefully remove some of the nails from both sides of the balancing point one by one. See how many nails you can remove without disturbing the equilibrium state.

References

[1] Source: http://www.vigyanprasar.gov.in/activity_based_science/Exp11.htm

[2] Arvind Gupta Video in Hindi, http://www.youtube.com/watch?v=lGMq460lRpY

Experiment 6

Why Does it Goes Up?

Objective

Things move in the direction in which the potential energy decreases.

Equipment

Two cycle-spokes, two plastic funnels, adhesives like fevicol or fevi-quick.

Introduction

Bodies put on an inclined plane come down the plane. If it can roll it rolls down. This can be understood in terms of potential energy. By coming down, the gravitational potential energy decreases. A system under given conservative forces moves in such a way that the potential energy decreases. This demonstration emphasizes this principle in a dramatic way as in the first look; the object seems to go up on an inclined plane. A careful analysis reveals that indeed it is decreasing its potential energy.

Procedure

Join two plastic funnels at the rim with the help of an adhesive. You can even use Cello-tape to join them. This makes a double-cone. Arrange to make a rail by two spokes in such a way that the height of the rail as well as the separation between the spokes gradually increases. You can take two pieces of thermocol and push the spokes properly in them to make the structure. The plane of the spokes becomes an inclined plane. You will have to adjust the geometry by trial for the demo to work. The height of the rail increases from A to B.

Place a cylindrical object like a pencil near the top of the rail and see that it comes down as expected. Now place the double cone near the top and it wont come down. Place it near the bottom. It goes up and settles near the top of the rail. Students will enjoy the scene.

Guide them to the Physics of it. Because of the geometry, as the double cone goes from A to B, supposedly up the rail, more and more portion of the middle bulge goes between the spokes and the cone actually dips. You can measure the height of the straight tube part of the funnel above the table when the double- cone is near the bottom of the rail and when it is near the top of the rail. It is less in the later case showing that the double cone is actually going down while it seems to go up.

Discussion

Encourage students to make their own equipment. The double-cone made by funnels has a particularly simple and effective geometry. But they can even do it with spherical balls. The only skill is in making a proper angle between the two spokes so that the object dips as it goes ahead on it.

You can also discuss motion of extended bodies using this apparatus. Different parts of the double cone will move along different paths. Some portions of the cone will come up and some will go down. Gravitational potential energy of some portions will therefore increase and of others will decrease. The overall potential energy of the system is decided by the motion of the Center of Mass. If the height of the center of mass above a horizontal surface increases, the potential energy increases too. Similarly, if the height of the center of mass decreases, the potential energy also decreases. Ask the students to mentally locate and follow the motion of the center of mass as the cone goes up. Indeed these intensive discussions are to be made outside the class where students do the experiments and observe.

When to use

As an interesting demo it can be shown to anyone, even children of age 5 will enjoy. However for Physics teaching you can use it when talking about the potential energy and the fact that system moves in a direction to decrease its potential energy. Most likely this is at class 11.

Instrument cost and availability

Negligible cost. Available easily in any market. In place of cycle spokes, you can use the rods (called SALAI in Hindi) on which ladies knit sweaters.

References

[1] Source: `http://www.vigyanprasar.gov.in/activity_based_science/Expm4.htm`

Experiment 7

Lift a Weight by Moving Another Weight in a Circle

Objective

Study of centripetal force.

Equipment

A thread, two objects with unequal masses, Body of a ball pen.

Introduction

Pass a thread through the both side open plastic body of a used pen. Tie two unequal masses m and M on the two sides of the string. Hold the plastic body in vertical position in your hand with the heavier mass M hanging and the lighter mass m resting at the top of the plastic body. Give motion to the masses by rotating your hand little bit so that the upper mass is set in nearly circular motion. As soon as it acquires sufficient speed it will pull the hanging body up. If you speed up the rotating body the heavier hanging mass can move right up to the plastic body.

You can adjust the speed of the rotating body by manipulating the force provided by your hand. By properly adjusting this force, you can keep the hanging body fixed at a desired height.

Procedure

Pass a thread through the both side open plastic body of a used pen. Tie two unequal masses m and M on the two sides of the string. Hold the plastic body in vertical position in your hand with the heavier mass M hanging and the lighter mass m resting at the top of the plastic body. Give motion to the masses by rotating your hand little bit so that the upper mass is set in nearly circular motion. As soon as it acquires sufficient speed it will pull the hanging body up. If you speed up the rotating body the heavier hanging mass can move right up to the plastic body.

You can adjust the speed of the rotating body by manipulating the force provided by your hand. By properly adjusting this force, you can keep the hanging body fixed at a desired height.

Discussion

You can discuss this phenomenon of the hanging mass going up in a number of ways. The tension in the string, which provides the centripetal force, should be mv^2/r. But this tension should also be Mg, the weight of the hanging body if it keeps in equilibrium. Thus $mv^2/r = Mg$. Now when you increase the speed of the rotating mass m by adjusting the force from your hand, the tension mv^2/r is increased and hence the mass M moves up with acceleration.

The explanation given above is simplistic. As you rotate your hand in a small path, the center of the so called circular path of mass m also moves. The path is therefore not strictly circular.

Another deviation from the above description comes due to the friction between the string and the plastic body at the upper edge. This will make the tensions in two parts of the string different.

But still the difference being small the qualitative explanation is OK. The fact that the simplistic explanation is not heavily in error you can calculate the value of g from the equation $mv^2/r = Mg$ when you adjust your hand force to keep the hanging mass M at a fixed height. This comes out to be quite close to the actual value 9.8 m/s^2.

When to do

Class 11, when you discuss Circular motion.

Instrument cost and availability

Zero cost.

References

[1] Source: `http://www.vigyanprasar.gov.in/activity_based_science/Expm5.htm`

Experiment 8

Conservation of Angular Momentum

Objective

Showing conservation of angular momentum qualitatively.

Equipment

A thread, two objects with unequal masses, body of a ball pen.

Introduction

It is the same set up that I described in experiment 7. If a particle of mass m is moving with an angular speed ω in a circular path of radius r, its angular momentum about the axis of rotation is $m\omega^2 r$. If the radius r is decreased in such a way that there is no torque about the axis of rotation, the angular speed ω will increase to conserve the angular momentum. This demo shows this in a very clear manner.

Procedure

Start in the same manner as in the experiment 7. Pass a thread through the both side open plastic body of a used pen. Tie two unequal masses m and M on the two sides of the string. Hold the plastic body in vertical position in your hand with the heavier mass M hanging and the lighter mass m resting at the top of the plastic body. Give motion to the masses by rotating your hand little bit. Speed up the rotating lighter mass so that the heavier hanging mass moves right up to the plastic body.

Stop the motion of your hand holding the plastic body. The mass m is rotating in a large circle. Using the other hand pull the mass M down. This will decrease the radius of the path of the rotating mass. As the mass M is pulled the angular speed of m increases and this can be very clearly observed. You can do it several times and explain the conservation of angular momentum.

When to do

Class 11, when you discuss Angular momentum conservation.

Instrument cost and availability

Zero cost.

References

[1] Source: http://www.vigyanprasar.gov.in/activity_based_science/Expm6.htm

Experiment 9

Dancing Bottle

Introduction

You might have heard about a sprinkler and also seen water being sprinkled with its help in all directions in the gardens. Usually, a sprinkler is used for irrigation purposes in agriculture or in gardens. Using it a large area of the land can be irrigated at a time. Depending on the requirement different kinds of sprinkler are available in the market. Here, we will make a sprinkler using a plastic bottle and discuss its science. While sprinkling water the bottle also dances which adds to the joy of this experiment.

Required material

Two plastic bottles of square cross-section, thread.

Procedure

1. Place a bottle of square cross-section in front of you. It has four large surfaces. Make a hole on the right lower side of any of these surfaces. To make the hole you may use the spoke of a bicycle, heat it on a candle flame and then insert it into the plastic. The job of making the hole should preferably be done in the presence of some elder persons. Make similar holes in this manner on the right lower sides of all the four surfaces.

2. Unscrew the cap of the bottle and tie a thread near its mouth in say a manner that on hanging the bottle by holding the thread it hangs vertically.

3. With the help of the thread hold the bottle at a height of about 1metre above a plastic tub.

4. Ask your friend to fill water in the bottle using a mug.

5. Water starts flowing out of the bottle and the bottle also starts rotating.

Discussion

Water streaming our of the holes is understandable but why was the bottle start dancing, after all? Actually, the water while flowing out of the bottle exerts a pressure on it in the backward direction. This is in accordance with Newton's third law. Water contained in the bottle pushes the water out near the hole which makes water come out of the hole. As reaction of this, the outflowing water pushes the water in the bottle backward. As the hole has been male at the corner, the force being exerted on this part of the bottle will try to rotate it. The forces acting on the four faces will rotate the bottle in the same direction and so the bottle starts dancing. The water flowing out of the dancing bottle spreads in all the directions and presents the scene of a sprinkler.

Do and think A little more

What will happen if on a bottle of square cross-section, holes one made on the right lower sides of two of its surfaces while holes are made on the left lower side of its remaining two surfaces? Will the bottle rotate? If not why? Think, Try the same experiment with a bottle of hexagonal cross-section having six faces. Is the speed of rotation of the bottle affected? Take another bottle of square cross-section and make holes on left lower sides of its surfaces. Hang this bottle by tying thread on it and fill in with water. What is the difference between dancing of this and the first bottle?

References

[1] Source: http://www.vigyanprasar.gov.in/activity_based_science/Exp9.htm

Experiment 10

The Obedient Bottle

Introduction

Present around us is the pressure due to the atmosphere. We have read this in books and also heard about it. Here, we will perform a single experience to experience it.

Procedure

1. Take a medium sized plastic bottle.
2. Make a large number of small holes at the bottom of the bottle.
3. You may make these holes with the help of a needle or safety pin.
4. Make a small hole also at the upper part of the bottle below its mouth i.e. on its neck.
5. Keep a tub on the ground.
6. Keep the bottle above the tub at a height of about half a metre.
7. Fill the bottle with water and close its lid. The level of water in the bottle must remain below the hole made on its neck.

What will happen?

Certainly, the water will start flowing out through the holes made at the bottom of the bottle. If you so desire, you may even stop the water flowing out from the bottom. Think how this can be done?

Just put your finger on the hole which you made on the neck of the bottle, and the water will shop flowing out Therefore, when you want the water to flow out just remove your finger from the hole and when you want to stop the water flow, simply block the hole with your finger. In this way, making use of only a plastic bottle we are able to make an obedient device using which we can understand the effect of air pressure.

Discussion

Let us try to understand how this happens. When the holes made at the bottom of the bottle as well as the hole on its neck are open, in that case due to the weight of the water column the total pressure on the bottom of the bottle is more that the pressure of the air outside the bottle. As a result, the water flows out from the holes at the bottom of the bottle. The air outside the bottle exert its influence so that water does not flow out while the pressure of water inside the bottle tries to force the water out of the bottle. The hole near the neck. of the bottle being open, the pressure of the air near the neck of the bottle is equal to the atmospheric pressure. This adding to the pressure of water makes the total pressure inside the bottle greater than the atmospheric pressure. As a result, the water flows out of the holes. Now, if you block the hole on the neck of the bottle with your finger, you will see that the water stops flowing out. Does the water stop flowing as soon as you put your finger on the hole? If you carefully observe you will find that the water stops flowing out within just a few moments and not immediately. It happened so because when you close the hole on the bottle's neck, the space above the water column get cut off from the atmospheric air. Consequently, as little water flows out from the holes, the volume of the air locked inside the bottle above the water column increases and due to this increased volumes the pressure of the locked air decreases. Now, the combined pressure of the locked air above the water column and the water column are not able to exceed the atmospheric pressure being executed on the holes. And therefore, the water stops flowing out.

Do and think A little more

Make two instead of one hole on the neck of the bottle. What happens? Repeat the experiment by keeping the lid of the bottle open. It is necessary to make a large number of holes at the bottom? Will only a single hole not do?

References

[1] Source: `http://www.vigyanprasar.gov.in/activity_based_science/Exp12.htm`

Experiment 11

Water Floating on Water

Introduction

We see many things happening in the kitchen. For instance, floating of oil on water and mixing of same type of liquids with one another. Adding a little milk to water it whitens it by getting mixed with the whole of water. Similarly, adding a few drops of ink on a glass filled with water makes the entire water acquire the colour of the ink. But, is it possible that a few drops of ink make only the upper portion of the water coloured? In this experiment we are going to do something of this sort.

Required material

A drinking glass, red (or some other) colour, coffee heater (a device used for heating water).

Procedure

1. Fill a drinking glass little more than half with water.

2. Immense the coffee heater in the glass in such a manner that only some of the upper portion of water is in contact with the heater so that only the upper portion of the water is heated.

3. Take out the coffee heater from the glass in such a manner that water in the glass is not disturbed.

4. Now ad a few drops of red (or some other) colour from the sides of the glass into it so that the water is not disturbed.

After some time, watch if the entire water or only other upper portion of it acquires the red colour? You will sea that only the upper portion of water becomes red while the lower portion of water remains colourless. i.e. the upper portion of water in the glass floats above its lower portion.

Discussion

When we throw a piece of wood into water it floats on it. But, when we drop a steel spoon into water it sinks. It is for the simple reason that the density of wood is less than that of water while the density of steel is greater as compared to water. An object of lower density floats on an object of greater density. The oil because of its low density as compared to water floats on it. In our experiment, the upper portion of the water was heated. Its density, therefore, decreased while the density of the lower portion of water, which did not receive heat, remained the same. So, the upper portion of water kept floating on the lower portion and did not get mixed up with it. As the red colour had first spread over the upper portion of water, it remained there and did not spread to the lower portion.

Do and think A little more

What will happen when water of the upper portion becomes cold? Will you in that case also observe coloured water in the upper portion and clear water on the lower portion? If we add some colour on a glass filled with cold water, will only the upper portion of water be coloured? Think, if densities of both the liquids are same they should remains where they are and should not get mixed up with each other. However, this does not happen and the two liquids get mixed up making the entire water coloured. This is due to the BROWNIAN motion of the molecular of liquids.

References

[1] Source: http://www.vigyanprasar.gov.in/activity_based_science/Exp10.htm

Experiment 12

Rolling is Easier than Sliding

Introduction

These days we find suitcases, cooler stands etc., being fitted with wheels. Have you ever thought what is the reason behind fitting of these wheels ? This is because rolling down an object on a surface is easier than dragging or pushing it. You may clearly have an experience of it in the present experiment.

Required Materials

Two cylindrical pencils, pens or thick ball pen refills, a book with a heavy cardboard cover on it.

Procedure

1. Keep the heavy book on the top of the table.

2. Keep your palm on its upper surface and by applying force with your palm in the forward direction try to move the book on the table, what have you experienced? To push the book on the table some force is needed. The heavier the book more will be the force required moving it.

3. Now, keep two pencils on the table parallel to each other and a little distance apart. Keep the book gently on these pencils. One of the pencils must be almost in the middle of the book while the other one must be near to one of the covers of the book.

4. Now, placing your palm on the book, again try to move it on the table. What have you experienced in this case? This time the book is able to move very easily on the table i.e. very little force is required as compared to the previous case.

Discussion

What is the main difference between the first and the second case? In the first case, a bigger area of the book was in contact with a larger portion of the table. On moving the book on the table both the surfaces rubbed against each other and the book then moved on the table. In this case the frication between the book and the table is very large. As a result, we have to apply a very large force. But, when we kept the book on the pencils and tried to move it, only a small portion of the book was in control with the pencils. When the book moved the pencils rolled down. This means that the surfaces of the pencils and the book were not rubbing against each other. In the same way, only a small surface of the pencils was in contact with the table and when the pencils moved forward they kept on rolling as well. Here also the surface of the pencils did not rub against the surface of the table. The frictions between the surfaces while rolling is much less than the friction during pushing/ dragging. Therefore, we have to apply very little force and the book moves forward during rolling.

Do and Think a little more

Think, while you are walking on the ground what kind of friction acts between your feet/ shoes and the ground? What is the kind of friction between the moving wheel of a bicycle and the ground? Why do the hands get warmed when rubbed against each other?

References

[1] Source: http://www.vigyanprasar.gov.in/activity_based_science/Exp13.htm

Experiment 13

A drop of Water Makes Slides Stick Together

Introduction

We have read in books about cohesive and adhesive forces. When two objects made of the same material are in contact with each other, the force acting between the molecules of the surfaces in contract is called cohesive force. However, when two objects of different materials remain in contact, the force between molecules of the surfaces in contact is called adhesive force. How strong are these forces? Sometimes they are so strong that they may appear to challenge even persons of great physical strength. In this experiment we shall use a drop of water to make two thin slides stick to each other, and study these forces.

Required Materials

Two thin glass plates (Slides), water.

Procedure

1. In biology labs or diagnostic shops meant for blood test, thin rectangular glass plates are used. These plates are called slides. Take two such slides.

2. Place a drop of water on any of the slides.

3. Keep the second slide on the first Moving the slides over each other, spread the water drop between them.

4. Now by putting the slides with your hands try to separate them out from each other. Remember you are not supposed to move the slides against each other in a sliding manner. Are you able to pull the slides apart? You will not be able to do it as both the slides very strongly stick to each other.

Discussion

Here we have a thin film of water between the two slides. The adhesive force acting between the glass and water is responsible for sticking up of the slides. Greater the surface area larger will be this force. It is the adhesive force that creates surface tension. We can also understand the strong sticking up of the slides by means of the formula for surface tension. The water trapped between the slides has a lower pressure as compared to the atmospheric pressure. The outside pressure of the air tries to push the slides towards each other and so we have to apply more force trying the separate the slides from each other.

Do and think a little more

Often, in the early morning we see very minute water or dew drops being spread on the leaves of some trees, On slightly raising or lowering these leaves, these drops slide over the leaves without breaking or spreading. This is because the cohesive force between the water molecules is greater than the adhesive force acting between the molecules of water and leaves and so the drops do not disintegrate or get spread over the leaves.

References

[1] Source: http://www.vigyanprasar.gov.in/activity_based_science/Exp14.htm

Experiment 14

A Game with Nails and Balloons

Introduction

We know that there is strength in unity. For example, if you ask your friend to break a piece of stick into two pieces he will readily do it. Next, give him four-five stick tied together and ask him to break them; surely, he will not be able to do it. We will see just the reverse of this happening in this game. You will see that while a single nail is able to deflate the balloon, a multitude of nails will not be able to deflate it. Does it mean that there is no strength in unity?

Required Material

Balloons, a large number of nails, a large and a small rectangular wooden seat

Procedure

1. First stick a large number of small nails on the large rectangular seat. The nail should be very close together and their heads should be visible with their piercing ends being fixed on the seat. In this way you will be creating, so to say, a bed of nails.

2. Stick only a single nail on the smaller seat in the same manner.

3. Next inflate a balloon and place it on the nail stick to the smaller seat. Press the balloon gently. Does the balloon get deflated? Usually, it will be deflated.

4. Now inflate another balloon and place it this time on the bed of nails. Press the balloon gently. Does the balloon get deflated or not? No, this time the balloon is not deflated. Even if you press the balloon with force it does not get deflated. Think why is this so happening?

Discussion

In the first case when we press the balloon by placing it over a single nail, the balloon exerts a force on the nail. In this case, this force is exerted on a single nail only. The nail by way of reaction, also exerts an equal and opposite force on the balloon. This force is enough to puncture the balloon which, therefore gets deflated. In the second case, when the balloon is in contact with a large number of nails, the force exerted by the balloon (which is almost equal to the force in the first case) gets distributed amongst multiple nails. This means that, in this case, a very small force is exerted by the balloon on the individual nails. The force of reaction exerted by the individual nails on the balloon gets reduced proportionately and attains such a value that is not enough to puncture the balloon. We can also understand this as follows. The force acting on the balloon gets distributed over a large surface area and so the balloon does not get punctured. We can understand from this experiment that when a force is applied on a small surface area, then the pressure on that area is more and when the same force is applied on a bigger surface area the pressure decreases.

In this experiment, if we apply a force equivalent to 10 kg on the balloon, than for the case when there is a single nail, the entire force gets exerted on it. The nail also exerts the full, 10 kg equivalent force, on a very small area of the balloon and punctures it of leading to the deflating of the balloon. However in case there are, say 50 nails then a force equivalent to 10/50 kg or 200 gm is exerted on the individual nails. These nails, in turn, each exert on the balloon a 200 gm equivalent force. This force is not able to puncture the balloon.

Do and Think a little more

Repeat this experiment by sticking instead of one, two, three and even more nails on the small seat and find out how many nails would be needed so that the balloon does not get deflated.

References

[1] Source: `http://www.vigyanprasar.gov.in/activity_based_science/Exp16.htm`

Part II

Thermodynamics

Experiment 15

See Convection Current in Air

Objective

To demonstrate that heat is produced in air, hot air goes up and cooler air from surrounding flows towards this making convection currents.

Equipment

A kerosene lamp, an extra glass cover of the kerocen lamp.

Introduction

When kerosene lamp is lighted, the surrounding air in the glass cover gets heated. The density of hot air is less than the cold air. The gases produced during burning are also hot. All this hot gaseous mass rises and goes out of the lamp through the glass cover. There are holes made in the part below the glass cover. Fresh air from outside enters the lamp through these holes, get heated and goes up. Thus a convection current is set up.

The present demo makes arrangement where one can visually see the flow paths of gaseous mass when a lamp is lighted.

Procedure

Take a kerosene lamp with some kerosene and wick in place. Take a cardboard box, like a shoe box. Place it in a way that the opening side is vertical and is towards you. Cut two holes on the top cover of the box so that the glass covers of the lamp can be fitted in these. Put a lamp inside the box below one of the holes. One of the glass covers should go through the hole and fit with the lamp. Let me call this Cover-1. Put another glass cover in the other hole. I will call it cover-2. Close any gap remaining between the glass covers and the cardboard top cover.

Light the lamp, put it in place and close the box. Light an incense stick. Where is the smoke going? It goes up. That is the natural tendency of smoke. Put the stick near the glass cover-1. The smoke goes up. Now put the stick near the glass cover-2. Here is the real climax. The smoke is pulled down into the glass cover-2 and it come out from the glass cover-1.

Why is the smoke dragged into the glass cover against its natural tendency to go up? This is because the burning wick of the lamp produced hot gases which rose up and went out through the glass cover-1. To fill the void, air should rush in. The only path available for fresh air is through the glass cover-2. So convection current is set up where air from outside goes into cover-2, goes into the box, and then to the wick area. The hot gases formed there go up and come out of cover-1. When the stick is placed near the cover-2, smoke is dragged by the air current that already exist there. The flow path of smoke is just the path of convection current.

When to do

At class 8 level convection currents are introduced.

Instrument cost and availability

Available easily, cost Rs 25 Need to be merged with previous experiment

References

[1] Source: http://www.vigyanprasar.gov.in/activity_based_science/Exph5.htm

Experiment 16

Burning Candle in Limited Air

Objective

To show that burning needs oxygen

Equipment

A plate, three candles, two drinking glasses of same size and one with a bigger size.

Introduction

At lower classes we teach that air contains oxygen and burning needs oxygen. This statement can be supported by this demo experiment.

Procedure

Put a candle vertically in a plate. Light the candle. The candle keeps on burning. Cover the burning candle by an inverted glass. The candle goes off. Now explain that the glass originally had air in it and when covered only that much of air was made available to the candle. This air had some amount of oxygen and when that was consumed, the candle went off. Now use two plates and put one candle each in them. Light them. Take two glasses of quite different sizes (one may be a glass and the other may be a glass jug), in the two hands and cover the candles with these simultaneously. The candle in the smaller glass goes off earlier than the one in the bigger glass. Explain that the bigger glass contains more air and hence more oxygen. Now put one candle in one plate and two candles in the other plate. Light all of them. Take two glasses of the same size in the two hands and simultaneously cover the burning candles in the two plates. The single candle lasts longer than the double candle. Explain that same amount of oxygen was available in the two glasses but two candles together was consuming oxygen faster than a single candle.

Discussion

This is a slight modification of the famous experiment given in most of the science textbooks for lower classes to demonstrate that there is 21% oxygen in air. We haven't put water in the plate in this experiment.

When to do

Class 6 or so.

Instrument cost and availability

Zero cost.

References

[1] Source: http://www.vigyanprasar.gov.in/activity_based_science/Exph5.htm

Experiment 17

Why does water rise in burning candle experiment?

Objective

To study the rise of water in the inverted glass which covers a burning candle placed in water.

Equipment

three plates, four similar candles, three drinking glasses of same size.

Introduction

The experiment described in the first part is very famous and is used by many teachers and students to show that there is 21% oxygen in air. In this demo experiment I will show that the real physics of rising water is very different.

Procedure

Put a candle vertically in a plate. Light the candle. Put some water in the plate so that a small lower portion of the candle is in water. The candle keeps on burning. Cover the burning candle by an inverted glass. The candle goes off and water rises in the glass. How much water will rise in glass depends on the thickness of the candle and how much time you allowed the candle to burn before you covered it. Use a candle and cover it quickly after burning. As the candle goes off, very small amount of water rises in the glass. It could be hardly 5% of the volume of the glass. Leave this set up as it is and take another plate, put a similar candle, pour water, light the candle and wait for some time. If a fan is running nearby put it off. Now cover it with a glass of the same size. This time water rise will be much more.

Now take the third plate and put two candles in it. Pour water in the plate and light all the candles. Wait for some time and then cover both by a glass of the same size as used in the previous trials. This time the water rise will be very high, may be 40-50%.

What is the Physics of this rising water? When candle burns the air surrounding the flame becomes hot. The flame itself is very hot gases. The pressure of this surrounding air is the same as the atmospheric pressure as all air is connected. As pressure remains the same and the temperature rises the density goes down from the gas law $PV = nRT$. For a given volume n will decrease if T increases. When you cover the candle(s) you trap this less dense air. As the oxygen is consumed and the candle goes off, the air (gases in fact) inside the glass cools down. As the number of moles n is now fixed, decreasing the temperature will decrease the pressure and this will suck water in the glass. In equilibrium the temperature in the glass will be the same as the room temperature, the pressure will be $P = P_0 - h\rho g$, where P_0 is the atmospheric pressure and h is the height water rises.

If you cover the candle just after the burning, the air trapped is not that hot. The density is thus not much lowered and hence on candle going off the water rise is not much. On the other hand if you burn two content in air. In fact for each oxygen molecule consumed, you produce a molecule of CO_2 among other products. Also the solubility of CO_2 is lower than that of O_2. So there is no question of decrease in pressure inside due to consuming oxygen.

There is another factor that contributes in rising water in the glass. At higher temperature the saturation vapour pressure of water is also high. As the air in the inverted glass is in contact with water, it will contain saturated vapour. When the candle goes off and the temperature falls, saturation vapour pressure also decreases and some of the vapour condenses. This also decreases pressure inside and helps in rise of water.

Please note that water starts rising only after the candle goes off.

When to do

Class 11 while teaching kinetic theory of gases.

Instrument cost and availability

Few rupees.

References

[1] Source: `http://www.vigyanprasar.gov.in/activity_based_science/Exph2.htm`

Experiment 18

Boiling Water with Cooling It

Objective

To realize that boiling point decreases with decreasing pressure above the liquid surface

Equipment

A heater, a conical flask with tightly fitting stopper

Introduction

Boiling point of a liquid depends on the pressure above its surface. Lower the pressure, lower is the boiling point. Thus you can boil water at a temperature much below the normal boiling point if the pressure above its surface is reduced. In this demo we do precisely this. The demo is very interesting and catches attention of everyone around.

Procedure

Take some water in a conical flask (say half the volume). The flask should be of good quality. I have done the experiment with Borosil flasks. Put the flask on a heater. Let it boil for about 5 minutes. Put off the heater. Now carefully hold the flask from its neck by using a handkerchief and put stopper in it as early as possible. The water stops boiling because it is no more on heater. Put some cold water on the flask, especially on the empty portion. The water starts boiling in the flask. Wait for about a minute and the boiling stops. Again put cold water on the flask. The water in the flask again starts boiling. You can repeat this several times. Why does water boil when cold water is poured on the flask? When initially you boiled the water on the heater, there was no stopper. Vapour generated during boiling replaced air and there was largely only the vapour above the water in the flask. At this stage you fitted the stopper tightly which closed any possibility of air entering the flask. The water has cooled down a little by this time and there is no question of boiling. Even at the boiling temperature it boils only when heat is supplied to it which is used in conversion of water to vapour. You poured cold water at this stage. The vapour condensed to water as a result of cooling due to cold water. This greatly reduced the pressure inside the flask. At such a low pressure, the boiling point of water is quite low and the existing temperature of water is much larger than this new boiling point. Thus water starts boiling and coverts to vapour. The pressure inside again increases due to this vapour. Correspondingly the boiling point increases and the water stops boiling at a certain stage. Then you put cold water again. The same process repeats and water boils.

Discussion

Please take care of accidents. The heater must be a good quality and you should check that there is no current in the body when the heater is put on. Handling hot water should be done with extreme care. Hold the flask from the neck only using sufficiently thick layer of cloth (handkerchief). While putting the stopper, the flask should rest on a firm surface. Though you put cold water several times, the lower portion of the flask remains hot. Don't try to hold it from there without checking. Once the demo is over you may like to open the stopper. This seems to be the most difficult task. Since the pressure inside remains much lower than the atmospheric pressure, it does not come out easily. Heat the flask a little and then take it out if it does not come with mechanical effort.

Instrument cost and availability

Conical flask is available in scientific stores for Rs 50.

References

[1] Source: http://www.vigyanprasar.gov.in/activity_based_science/Exp4.htm

Experiment 19

Why Does Water not Fall?

Objective

To discuss an application of Boyle's law

Equipment

A drinking glass, a plane cover for the glass

Introduction

To show that air exerts pressure, science textbooks at lower classes describe an activity where a drinking glass is filled to the brim with water, is covered by a cardboard and then inverted. The demo consists of seeing that the cardboard does not fall. The explanation is that air exerts force on the cardboard from below and this force is more than that exerted on the cardboard by the water. So the card is pushed up and does not fall. The present demo is a slight modification in this famous activity wherein the water is not filled up to the brim and then it becomes a demo for Boyle's law.

Procedure

Take a drinking glass and fill it up to about half with water. Put a plane cover on the glass. You can use a cardboard, or a plastic cover or any other plane cover. Hold the cover by pressing from top with one hand and invert the glass. Gently remove the hand from the cover. The cover does not fall and holds the water in the glass.

The upper portion of the glass contains air and hence presses the water down. The force on the cover due to water is $A(P_1 + h\rho g)$; where A is the area in the upper portion of the glass, h is the height of the water column and ρ is the density of water. From the bottom the force is $P_0 A$; where P_0 is the atmospheric pressure. The fact that the card does not fall tells that $P_1 < P_0$. How did P_1 become smaller than P_0? When you covered the glass, the air trapped was at the atmospheric pressure P_0. It is the same air that is now in the upper portion (provided you have not allowed air to leak out or leak in during inverting the glass) the volume of air should be the equal to (volume of glass)- (volume of water). If both remain the same, the volume of water should remain the same. The temperature is anyway the same. So from $PV = nRT$, the pressure should remain the same, that is P_0.

But it does not remain P_0. It becomes less than P_0. In fact the cover goes slightly down when the glass is inverted. If it is a cardboard cover, it may buldge at the centre. If it is plastic cover, it goes slightly down and there is a water slice between the glass and the cover. This you can verify by slightly tapping the cover horizontally. You will find that the cover moves quite smoothly. This shows that it is not rubbing the glass surface. Here surface tension also has to play a role.

As the cover goes slightly down, the volume of air in the upper portion increases. This decreases in pressure according to the Boyle's law and the water column stays in equilibrium.

Discussion

Sometimes few drops of water may go out while inverting. If air has not gotten into the glass in this period, the volume of air will increase and hence the pressure will decrease. Sometimes few bubbles of air also gets in. This happens when somewhat larger mass of water comes out during inversion. In such a case right amount of air will go in which can maintain the cardboard in equilibrium. .

Instrument cost and availability

Zero

References

[1] Source: `http://www.vigyanprasar.gov.in/activity_based_science/Exp6.htm`

Experiment 20

Compare Thermal Conductivities of Two Metals

Objective

To play with different materials and compare their thermal conductivities

Equipment

Three metal cans, Rods of different materials but same geometry, small immersion heater, three thermometers

Introduction

Thermal conductivity of a material is one of the key factors which decides how much heat will pass through it if the two ends are maintained at different temperatures. For a cylindrical object, the equation governing the rate of heat flow is introduced in class 11 as $\frac{\Delta Q}{\Delta t} = KA\frac{\Delta T}{\Delta L}$ where K is the thermal conductivity of the material, A is the area of cross section perpendicular to the heat flow, ΔT is the temperature difference across a length of ΔL along the heat flow. In the informal lab, the students can compare the thermal conductivities of different materials in a simple manner.

Procedure

Suppose we wish to compare the conductivities of copper and steel. You have to procure a rod of each material. It could be say 10 cm long and 0.2 cm in radius. The dimensions are not crucial but two rods should be similar except for the material. The cross section also need not be circular. Take three metal cans A, B and C. The cans A and C should be identical, B may or may not be identical to others. Drill a hole in A and C and two holes in B. The holes should be such that the rods may be fitted in them and they should be at the same height from the bottom. Fit the copper rod between the cans A and B, and the steel rod between B and C. Close any gap between the rod and the can at the hole by an adhesive, say araldite.

Fill some water in the cans. The amount of water in A and C should be the same. The ends of the rods should be immersed in water. Put thermometers in A, B and C. Put immersion heater in the can B and switch it on. Be careful, if the heater is faulty it can send electrical current in water and can. Do not touch anything when the switch it on.

In few minutes water in can B will start boiling. Read temperatures in all the cans. Steel is poorer conductor of heat as compared to copper. The temperature rise in A should be more than in B. By comparing the temperature rise in the two cans in a given time interval, you can have an estimate of the ratio of the thermal conductivities of the two materials.

Discussion

The equation for heat flow given above may not be usable in the conditions described. There are losses to the atmosphere at every stage. That is why I insist on having all other conditions identical except the materials of the rod. If the student wishes he/she may modify the procedure to get more accurate results.

Hazards

As mentioned above, if the heater is faulty it can send electrical current in water and can. Do not touch anything when the switch it on.

When to do

Class 11, after you have done thermal conductivity.

Instrument cost and availability

About Rs 100

References

[1] Source: `http://www.vigyanprasar.gov.in/activity_based_science/Exph4.htm`

Experiment 21

Measure Dew Point in Your Room

Objective

To measure dew point.

Equipment

Two steel glasses preferably new ones with shining surfaces, Cold water in a separate bottle, laboratory thermometer measuring up to 500 °C.

Introduction

Air in our surrounding contains water vapour. In general the amount of vapour in a given volume of air is less than that required to saturate it. That is why wet cloths dry, water kept in a shallow plate evaporates and so on. The amount of vapour needed to saturate the air depends on temperature. At higher temperature, larger amount of vapour in needed to saturate the air than that needed at lower temperature. If the temperature of the air in your room is decreased sufficiently, the existing amount of vapour will become sufficient to saturate it. If the air is further cooled the existing amount of vapour will become more than that needed to saturate the air and then some vapour will condense to liquid water. This is what happens during the winter nights in open fields. The water that appears on grass or other objects is called Dew. The temperature at which the existing vapour in air will saturate it is called the "Dew point". Evidently, the dew point will vary with place and time. During rainy season there is lot of vapour in air and the due point will be high. During dry seasons the dew point will be low as there will be only small amount of vapour present in air. The amount of vapour present in air is often represented by the pressure exterted by the vapour molecules. This is known as vapour pressure. If the air is saturated with the vapour the vapour pressure is called saturation vapour pressure. The saturation vapour pressure at different temperatures have been measured carefully and tables are available to give these data. If you know the dew point, you can immediately calculate the relative humidity by the relation:

Relative humidity = (saturation vapour pressure at dew point)/(saturation vapour pressure at the existing air temperature).

Procedure

Put two steel glasses side by side. Keep cold water, taken from a refrigerator or water cooler in a bottle or a jug. It should be cold enough so that you can see large water drops on the outer surface of the bottle. Fill one of the steel gasses with normal tap water up to say one-fourth of its height. Put the thermometer in the water. Ask some one to keep looking at the outer surfaces of the two glasses. Pour a small amount of cold water in the water, stir with the thermometer and ask the person looking at the glasses if she/he can see a difference in the shining of the two glasses. If not pour some more cold water and repeat the observation. When the difference in shining is observed read the thermometer. This is the dew point. Steel is a good conductor of heat and the thickness of the wall is also quite small. So the temperature of the outer surface of the glass, up to the height of the water, quickly becomes the same as that of the water inside. The air in contact with this part of the steel surface also cools down and attains this temperature. When the temperature falls to the dew point and goes slightly below it, vapour in this part of the air starts condensing and small droplets collect on the glass surface. By comparing the two glasses kept side by side, you can easily make out when this condensation has just started. So the dew point can be easily obtained. Using the saturation vapour pressure table, find the relative humidity.

Discussion

The dew point can be measured very accurately using this procedure. If your thermometer reads up to half a degree and you do the experiment carefully, you can get the dew point within the accuracy of half degree. Make sure that your initial water in cold enough. The test is that water drops are very clearly seen on the outer surface of the vessel containing the cold water. You can first do a rough experiment to get an estimate of the dew point and then do a fine experiment by varyuing the mixture temperature in that vicinity to get more accurate value.

Instrument cost and availability

Laboratory thermometer available in any scientific store.

References

[1] Source: `http://www.vigyanprasar.gov.in/activity_based_science/Exph6.htm`

Part III

Optics

Experiment 22

Total Internal Reflection in a Bottle

Objective

To study total internal reflection

Equipment

A dettol bottle, some common salt, a laser torch Introduction: When light goes from a denser medium to a rarer medium, and the angle of incidence is larger than a critical value, called critical angle, whole of the light will get reflected at the surface. If the angle of incidence is smaller than the critical angle, part of the light is reflected and part of it is refracted. In this inexpensive demo we show the light paths as the medium changes and hence all phenomena on refraction can be visually seen. It is very simple and has been widely appreciated wherever we have shown it.

Procedure

Take a dettol bottle and fill water in it up to say three fourths of its height. Put some common salt in it. Tighten the cap. Put on a laser torch and send light from outside into the water obliquely. The front end of the torch should be in contact with the thinner side of the bottle at a height covered by water, and the incline of the torch should be adjusted by tilting the torch with your hand. Adjust the orientation so that the light goes parallel to the flat faces of the bottle, but at an angle to the surface of the water. You should be able to see the path of the laser beam in the water. If it is not clearly visible, invert the bottle for a second. This will bring the salt sitting at the bottom in the whole water and make the path visible. Slowly change the orientation of the laser torch and you very clearly see the total internal reflection. If you make the torch closer to vertical, thus decreasing the angle of incidence, the reflected beam will loose its intensity. A spot will form on the opposite wall of the bottle above the water surface. This tells that a part of the beam is getting transmitted. Now you put smoke of an incense stick into the bottle. It will collect above the water surface. Now when you send laser beam and if it gets transmitted to air side the transmitted beam will also be clearly seen, though it will be hazy. So for angles less than the critical angle you see both reflected and transmitted beams, and for angles larger than the critical angle, only reflected beam is observed.

Discussion

Dettol bottle suites this demo because the walls are flat. This demo can be extended to informal lab, by encouraging students to adjust the torch for grazing angle refraction and measuring the inclination angle from vertical which is also the normal to the surface. This angle is the critical angle.

When to do

Class 10 when you are teaching total internal reflection

Instrument cost and availability

Laser torch

References

[1] Source: http://www.vigyanprasar.gov.in/activity_based_science/Exp1.htm

Experiment 23

Under Water Optics

Objective

To study the effect of water surrounding a lens

Equipment

Two laser torches, a long trough (say 20 cm), a convex lens of focal length about 10 cm or less.

Introduction

The focal length of a lens depends on the curvatures of the two lens surfaces and on the refractive indices of the lens and the surrounding medium. Thus if the lens is kept inside water, its focal length will increase.

Procedure

Take a convex lens and measure its focal length (roughly) by imaging distant objects on a wall or a paper. Put two laser torches parallel to each other on a base and fix them. Connect to power. Take care you do not stare into the laser. You get parallel beams of red light. Put water in a long trough and put a few drops of soap solution in it. Position the laser base so that light goes in water along the length of the trough. The two beams will be clearly visible from the top. If it is not so, you have most likely put more soap solution than required. Adjust it again. The beams are quite narrow and you can treat each of these as a ray of light. Put a convex lens inside the water so that the axis is parallel to the beams of light. The two beams will bend towards each other and will intersect. Measure the distance of the lens from the place where the two beams intersect. This is the focal length of the lens in water. Check that the focal length in water is much larger than that in air.

Discussion

The basic theme is to make the rays visible in water. Once that tool is there you can design many experiments and perform them. Supervise students and repeatedly remind them that laser light should not fall directly into eyes.

When to do

Students may be introduced to this activity generally after they have done refraction at spherical surfaces (Class 11-12). However class 10 students may also do it and learn from experiments that putting a lens in water increases its focal length. They learn the theory later.

Instrument cost and availability

Laser torch Rs 30, convex lens available in scientific stores and may also be found in gift shops with the name magnifying glass. The school laboratory will definitely have it.

References

[1] Source: http://www.vigyanprasar.gov.in/activity_based_science/Exp2.htm

Experiment 24

Images with Glass

Introduction

While sitting in a hair dresser saloon we see in the mirror our many images. This looks very pleasing to us. It appears as though all the images are situated in a long tunnel. But this becomes possible only when a mirror is fixed just at our back which is parallel to the front mirror. We shall explain this with the help of an interesting experiment.

Required material

Two polished and properly framed mirrors, cello tape, scissor, candle.

Procedure

1. Place both the mirrors side by side and fix the junction where they meet with a cello tape. Now you will be able to open and close the mirrors like a book.

2. Place both the mirrors at a small angle apart in the upright position on the floor.

3. Place a lighted candle in the space between the two mirrors. You will observe many images of the candle which makes a very beautiful scene.

4. Now by gradually decreasing the angle between the mirrors observe the images being formed. You will now observe more and more images of the candle being formed.

5. Similarly, if the angle between the mirrors is increased the number of images decreases and when this angle is 180°, only one image will be visible.

Discussion

When the angle between the two mirrors is 180 they together act like a single mirror so that only one image is visible. As the angle between the mirrors gradually decreased, not only the candle but the mirrors themselves get imaged in one another. That is why when the angle between the mirrors is decreased one observe image within image, and image within that image, and so on. In this way one observes a lot many images. if the angle between the mirrors is finally decreased to zero, Infinite images are expected to be formed. The salutation is similar to our sitting at the hair dresser saloon where we see multitude of our images.

Do and think a little more

Fill a transparent glass tray with water and fix two similar mirrors at its opposite ends. See the image being formed. What you see is a very long water canal. Think how this happens?

References

[1] Source: http://www.vigyanprasar.gov.in/activity_based_science/Exp15.htm

Part IV

Electromagnetism

Experiment 25

The Rotating Straw

Objective

Static charge, induced charge

Introduction

As we know, by rubbing or induction electric charge can be produced. By combing your hair you must have tried to attract small pieces of paper. You must also be knowing that charges are of two types- positive charge and negative charge. Like changes repel while unlike charges attract each other. We shall see this with the help of an interesting experiment.

Required Material

Two straws (used for sipping cold drinks), a bottle having a plane surface which has negligible friction.

Procedure

1. Take a plastic bottle whose cap is plane.
2. Take two drinking straws and by holding them from one end rub them well two or three times with the help of a handkerchief.
3. Now, place one of the straws on the top of the bottle cap in such a manner that it remains parallel to the ground and its middle portion sits on the top of the cap.
4. Now take the other straw, holding it from one end bring it near the first straw.
5. As soon as the second straw is brought near the straw resting on the bottle, the latter moves away from the former by rotating on its resting point.
6. If we keep moving the hand held straw in a circular manner towards the straw on the bottle cap, the latter also continuously keeps getting away. While doing so it also rotates presenting a very interesting view of repulsion.
7. Now, instead of the second straw being the handkerchief which was used for rubbing the straws, towards the first straw.
8. The first straw now starts getting attracted towards the handkerchief. Moving the handkerchief away from the straw in a circular manner, the straw also keeps moving towards the handkerchief while making a circular rotation.

Discussion

When both the straws are rubbed with a handkerchief, the same kind of charge is developed in them while the opposite charge is produced in the handkerchief. In the first case, as both the straws hold the same kind of charge they repel each other and so the straw resting on the bottle moves away from the hand held straw. In the second case as the charge on the handkerchief has a sign opposite to that on the straw, the handkerchief and the straw attract each other, Therefore, the straw on the bottle moves towards the handkerchief.

The place where the straw rests on the bottle the friction between the cap and the straw should be least there, so that the straw is free to rotate on the cap.

Do and Think a Little more

During winter people are after found rubbing their hands. When you rub your both hands against each other do they develop charges? Devise an experiment which can answer this question.

References

[1] Source: http://www.vigyanprasar.gov.in/activity_based_science/Exp7.htm

Experiment 26

A Magnet Falling Through Conducting Tube

Objective

To study the effect of eddy currents when a magnet falls through a conducting tube

Equipment

A metallic tube of length about a meter and inner dia about a centimeter, A strong, short, cylindrical magnet.

Introduction

When a magnet falls through a conducting tube, changing magnetic field is produced in the volume of the tube. Not only field is different at different places in the tube, it is also changing with time at any given place. Taking the long axis of the tube along the z-axis, the field change is largely in z- direction. A field changing in z-direction produces electric field in the circumferential direction. The electric field lines are circular, coaxial with the z-axis. This field drives an electric current in the circumferential direction. The energy is lost in joule heating and this comes from the mechanical energy of the falling magnet. The magnet thus experiences an upward force slowing it down. The magnet takes an extraordinarily long time to fall through the tube.

Procedure

Take a strong, short, cylindrical magnet. These are made of certain magnetic alloys like Niobium-iron-boron alloy. The size should be such that it can easily go through the aluminum tube you will be using. Take a similar looking piece of unmagnetized iron such as a nut or bolt and two or three more small objects made of different materials.

Keep the aluminum tube vertical and hold it in one hand. Drop different objects in the tube at the upper end and ask the students to estimate the time it takes for them to emerge from the other end. If your tube is 1 m long, it will take only a fraction of second and estimates will be difficult to make. But they will have in mind that it is much less than a second.

Now drop the magnet in the same way. Students will be amazed to see that the magnet is not coming out. It takes very long time as compared to other objects. The time depends on the wall thickness of the tube and the strength of the tube. For the tube that I use it is about 7 seconds, more than 25 times longer than the other objects.

Discussion

It is instructive to understand where does the upward force come on the falling magnet. To the advanced students you can discuss the direction of current in the tube. The current goes in circular paths on the tube. Above the magnet it is in one sense and below the magnet it is in the other sense. Suppose the north pole of the magnet is up and the south pole is down. The current above the magnet is anticlockwise as seen from the top and that below is clockwise. The axial component of the magnetic field is outward in the portion above the magnet and inward below the magnet. Use to check that in both cases the force is upwards. Is it possible to design this experiment for balancing magnet in air? The answer is no!

When to do

Class 12, when you teach Faraday's Law of electromagnetic induction and especially when you teach the induced electric field due to changing magnetic field.

Instrument cost and availability

The strong magnet will cost something like Rs 100 and have to be purchased from specialized stores dealing with strong magnets.

References

[1] Source: `http://www.vigyanprasar.gov.in/activity_based_science/Exp5.htm`

Experiment 27

How to slow a Rotating Conducting Disk?

Introduction

There are many experiments demonstrating Faraday's law of Electromagnetic Induction. whenever a conductor is placed in a varying magnetic foield or it moves under a magnetic field, emf is induced. If there are conducting paths available, currents start in the conductor which we call Eddy current. This experiment is one nice way to demonstrate eddy currents.

Required Material

An aluminum disc with an attachment to fit in the spindle of a tape motor, a magnet, a tape motor, an adaptor and a power source.

Procedure

Mount the disc on the spindle of the tape motor. Connect the motor to the power source through an adaptor. Switch on the power so that the tape motor along with the connected aluminum disc starts rotating. Soon it will pick up a good speed. Now bring a magnet very close to the rotating disc. A pole should face the disc surface. The disc gradually slows down to almost a halt. Take the magnet a bit away. The disc again picks up speed.

Discussion

The free electrons of the disc also move with the disc. When the magnet is kept near the rotating aluminum disc, the free electrons of the aluminum disc below the magnet experience magnetic force causing a motional emf in the conductor. This produces eddy currents in the disc. Energy is consumed in these currents putting more load on the motor. So the disc slows down.

References

[1] Source: http://utsahiphysicsteachers.com/resourcematerial/experiments/Electromagnetism/Slowing%20Al%20disk.htm

[2] Arvind Gupta Video in Hindi: https://www.youtube.com/watch?v=DaRR740y8UM

Experiment 28

Circuits with aataa (ground wheat) dove

Objective

To use conductivity of salty atta dove.

Introduction

Electric circuits are made with elements like resistances, bulbs, batteries etc. One needs connecting wires to connect the circuits. What about using atta (ground wheat) dove in the place of wires? You can easily change the shape of the dove and hence study the electrical properties of such connecting lines effectively. To make this dove conducting, we suggest putting salt solution while preparing the dove .

Required Material

Atta dove prepared in salt solution, an LED, battery or DC power supply, two connecting wires.A glass tumbler, a long piece of paper, a table.

Procedure

Take two doves and connect them to the two terminals of the battery we call it Power doves. the dove. Take an LED. Put the longer leg into the dove connected to positive terminal of the battery and the shorter leg into the other dove.

Now take a small part of the dove, roll it like short cylinder and connect the two ends to the two power doves. What happened to the LED glow? Why?

Remove one of the legs of the LED from the power dove. Connect the cylindrical dove mode above in series with the LED. What happened to the LED glow?

Change the shape of the cylindrical dove to make it thinner and longer. What happened to the LED glow?

Discussion

Salt solution is conducting because of the ionic character of NaCl. Think of the mechanism of charge flow through the dove when current goes through it.

The electrical characteristic of doves change with time because of bio – degradation. Interesting to study it systematically.

You can make non uniform "wires" from the dove and study their resistance behaviour.

References

[1] Source: http://utsahiphysicsteachers.com/resourcematerial/experiments/Electromagnetism/Attacircuit.htm

Experiment 29

Diamagnet or Paramagnet

Objective

To see dia paramagnetism in action.

Introduction

Magnets attract iron clips, pins, nails etc very strongly. This is because iron is a ferromagnetic material. There are certain materials in which large number of atoms/molecules are magnetically ordered making domains. These are ferromagnetically/antiferromagnetic or ferrimagnetic materials.

In large number of materials, magnetic ordering is absent. In some materials, the individual atom/molecule/ions does not have a magnetic moment. Such materials are diamagnetic and are weakly repelled by magnets. In another class of materials, the individual entity has magnetic moment but they do not much interact with each other and do not form domains, such materials are called paramagnetic.

While ferromagnetic materials ate strongly attracted to a magnet, the attraction or repulsion of a paramagnetic or a diamagnetic material is quite weak. That is why we do not see any effect of magnet on aluminum, copper, glass, plastic etc, In this experiment you will experience these forces and will classify some objects whether they are paramagnetic or diamagnetic.

Required Material

A plastic tub, thermocol piece, two test tubes, materials to be tested, a strong magnet, a long nail/screw to hold the magnet.

Procedure

Take some common household material like salt, sugar, water, oil etc. Some of these are in solid power form and some in liquid form. Use one of the test tubes for solids and other for liquids.

1. Fill the tube with water up to say 3/4 of the height.
2. Make a small hole in the thermocol piece and put a test tube in it so that the bottom 1/4 of the test tube is below the hole and the rest above the hole.
3. Put it in the water btub and check that it floats with the test tube remaining vertical.
4. Fill the material in the test tube up to about 3/4 part and make it float. Make it stay at rest in the middle of the tube . For liquids, you can use the syringe given.
5. Put the magnet on the tip of the nail and hold the nail.
6. Bring the magnet close to the test tube, the pole facing the material in the tube. Go closer to the test tube but short of touching it.

7. See whether the test tube starts going away from the magnet or coming towards the magnet, Write whether the material is paramagnetic or diamagnetic in a nicely formatted table.

Discussion

Thermocol piece has a great role in providing stability. The buoyancy force on the thermocol from the sides of the tube makes the tube stay in vertical stable equilibrium. Salt solution is conducting because of the ionic character of NaCl.

The frictional force between water and thermocol is quite small and that is very important as the force between the magnet and the para dia magnetic material is very weak. If water gets contaminated, friction may increase and you may not see the effect.

References

[1] Source: `http://utsahiphysicsteachers.com/resourcematerial/experiments/Electromagnetism/Diapara.htm`

Experiment 30

Balance a pencil using magnets?

Introduction

Magnets have been fascinating objects for people of all age groups. Like poles repel and unlike poles attract. That is the first lesson that we learn about magnets. But with combination of magnets, you can create regions where another test magnet can stay in stable equilibrium. Stable in the sense that if you displace the test magnet a little in any direction, the magnet comes back to its original position. Here is one attractive toy using a special configuration of the fields.

Required Material

A flat base, a pencil, three wooden cylindrical rods of length somewhat less than the length of the pencil, four ring magnets with diameter slightly more than that of the pencil.

Procedure

Drill three holes in the flat base so that screws can be fixed in them. Drill small holes in the bottoms of the rods. Now fix the rods on the base using screws. Now take three magnets and keep similar poles upwards. Fix the magnets on the top of the rods using quick fix. Fix a ring magnet on the pencil again with the help of quick fix at the same distance from the tip. When placed on the tip, the four magnets should be at the same height and all the upward poles should be of same nature. Fix a two-blade wane on the top of the pencil. Now the apparatus is ready. Place the pencil vertically with its tip on the flat base, right at the center between the three rods. And it stands comfortably. Give a slight sideways push to the wanes to rotate it. The pencil will keep rotating for a long time. You can decorate the pencil so that when it rotates it shows interesting patterns.

Discussion

The three magnets placed at the same horizontal level produce a magnetic field pattern which gives zero field at the center. Thus the magnet does not feel any magnetic force here. But that is as simple as placing the pencil on the tip without any magnet. Important point is that around the center, as you go slightly out of the plane the field increases symmetrically at all sides. The direction is such that it pushes the magnet on the pencil back towards the center. That provides stability and resists its toppling down.

References

[1] Source: `http://utsahiphysicsteachers.com/resourcematerial/experiments/Electromagnetism/Balance%20pencil.htm`

[2] Arvind Gupta Video: `https://www.youtube.com/watch?v=F2lKo40pufk`