TIME AND PENDULUM

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In the chapter "An Eye in the Sky", you made two kinds of sun dials. It is midday (high noon) when the shadow of a perpendicularly fixed stick is the smallest on a flat ground. The period of time from noon one day to noon the next day is called a **solar day**. You may perhaps remember, from the experiments performed in that chapter, that the time of the smallest shadow fluctuates a little every day. This means that duration of the solar day also keeps changing every day. The average of duration of all solar days of an entire year is called the **mean solar day**. The duration of this mean solar day has been divided into 24 equal units of time called hours. Each hour is further divided into smaller units called minutes and each minute is divided into seconds.

In the chapter, "An Eye in the Sky", you learned how to tell time by looking at the position of the stars. Phases of the moon are also a means of measuring time. The regular spacing of the full moon and new moon tell us how many days have elapsed. Similarly, the changing seasons, too, are an indication of passage of time. When mango trees come into bloom, then we know that about a year has passed since they bloomed last. There are other such manifestations of nature all around us which happen periodically and at regular intervals. All such occurrences are useful to us in measurement of time.

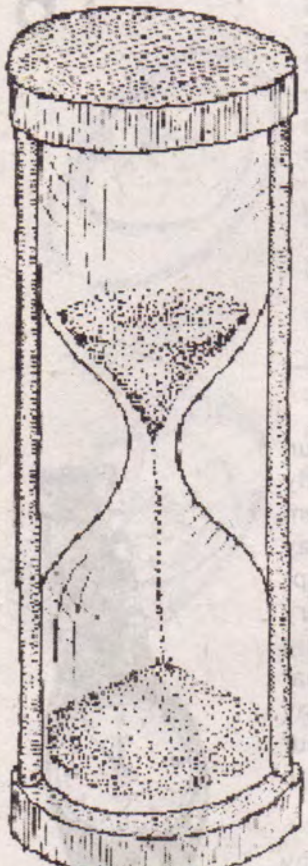
You must have noticed numerous such natural processes around you.

Make a list of such processes. Also write down the length of time which can be measured using each process. (1)

What all actions appear to repeat over and over in a wristwatch? After what lengths of time do these repetitions occur? Look at a wristwatch or clock and answer. (2)

You must have seen different kinds of clocks such as water clock, sand clock, candle clock, etc. at science fairs or elsewhere.

Let us now build some clocks and see which processes of theirs help us measure time.



Experiment 1

Make your own water clock

In this experiment we shall learn an easy method of making a water clock. Obtain an open mouthed can and in the middle of its bottom make a tiny hole with a nail. Fill a bucket with clean water and float the can in it. The water will enter the can through the hole. If it does not enter the can, make the hole a little bigger. The hole should be so big that the can sinks in about 5 minutes. Now remove all the water from the can and float it again in the bucket. Using a clock or a watch, find out how long it takes for it to sink.

Write down how long it took for the can to sink. (3)

Repeat the above procedure at least 5 times. Before each attempt, remove all water from the can.

Does the can always take roughly the same amount of time to sink? (4)

What is the average time it takes to sink? (5)

Can we use this can to measure time intervals equal to this average duration? (6)

Using this clock, how would you measure time intervals smaller than the clock's average time? (7)

Why is it necessary to fill the bucket with clean water? (8)

Experiment 2

Another Clock- Make at home

Take two empty injection bottles with their rubber caps. Glue the caps together on their flat sides using some strong adhesive.

Figure-1a

Make a hole in the middle of the caps, using an acacia (*babool*) thorn or a nail.

Cut approximately a half centimetre piece of an empty ball pen refill. Insert this piece in the hole made above by pushing it in with the tip of the refill. The piece of refill will go in very easily if slightly wet. Now you will see a nice clean hole through the caps. Fill one bottle with fine dry sand. On this, fix the glued caps and the other bottle.

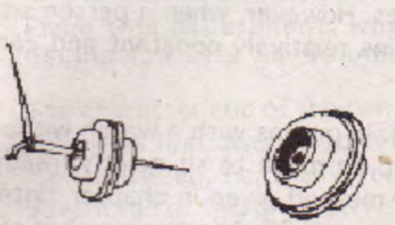


Figure-1b

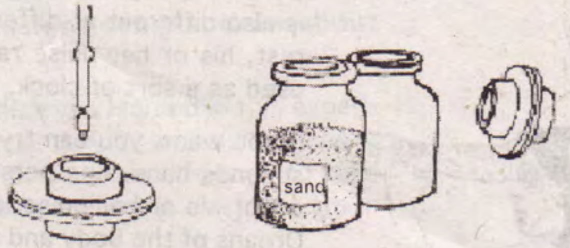


Figure-1c

Now turn the bottles upside down. The sand will fall from the bottle on top into the empty bottle below through the refill. Allow the sand to fall for one full minute, timing it with a clock. Throw out the sand which remains in the bottle on top. In this way we have a one-minute sand clock.

Figure-1d

We have told you two simple ways to make a clock. Think of even better ways of making clocks, make them and send your ideas to Sawaliram. It is not easy to use the water clock or sand clock for measuring very small periods of time.

Let us now do an experiment to measure small intervals of time easily and correctly.

The Pendulum

Experiment 3

Tie a piece of stone tightly on one end of an about 2 metres long string. Suspend this stone from the hook on a doorframe. If there is no hook or if it is loose, hammer a nail into the doorframe and tie the string to this. You shall need to change length of the string during the experiment. Tie the knot keeping this in mind.

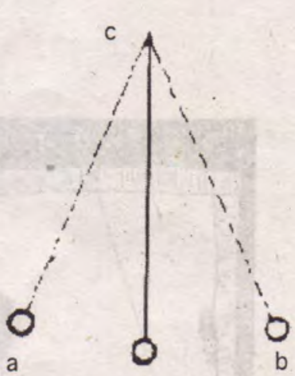


Figure-2

A weight hanging this way is your pendulum. Move the stone sideways a little and release it. Upon doing so the stone should swing freely. Swinging of a stone in this manner is called **oscillation**. When the pendulum swings from 'A' to 'B' and back to 'A', this is called one complete oscillation (Figure 2). Remember that the pendulum is not to be set in motion by giving it a push. Simply move it to one side and let go.

The body's clock: the pulse

In order to perform experiment 3, every team must have a clock or watch which shows seconds. If this is not possible, then all experiments dealing with pendulums in this chapter will have to be performed in the following manner.

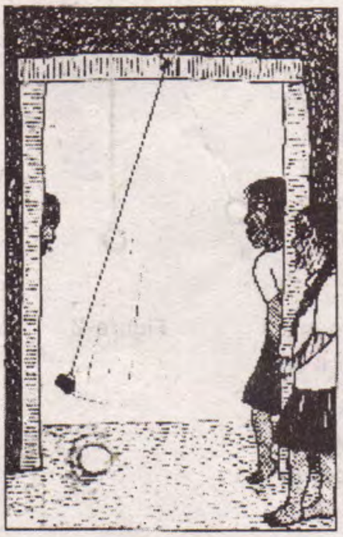
Different people have different pulse rates. An individual's pulse rate is also different at different times. However, when a person sits at rest, his or her pulse rate remains relatively constant and can be used as a sort of clock.

If you want, you can try this out. In groups with a watch without a seconds hand, one person should be made to sit quietly, ready to count his or her pulse using the method given in chapter "Internal Organs of the Body and their Functions -2". Another member of the team should hold the pendulum away from the mid-point and wait for signal from the student who is taking the pulse. Upon receiving the signal, he or she should release the pendulum and start counting the number of complete oscillations. At the same time, the person taking the pulse should start counting it quietly. Remember that the counting has to start from zero. When a certain number of oscillations is complete, the member taking the pulse should stop counting. The time of oscillation, instead of being recorded in seconds, will be in pulse-beats.

At the end of this experiment, obtain a watch or clock with a seconds hand from any other student in the class or from the teacher and find out the pulse rate of your team member. In order to find out the pulse rate, wait til the second hand of the clock reaches twelve. Then have the pulse taking member of the team start counting his or her pulse and continue counting until the second hand goes all the way around to twelve again. Repeat this at least three times and compute the average pulse rate of your friend. With this information, you will be able to convert your observations taken in pulse beats into seconds.

The above activity can also be done with the sand clock.

Find out how much time it takes for your pendulum to complete one oscillation. (9)



This time is called the **time period** of the pendulum.

Did any difficulties occur in measuring the time period? If yes, what? (10)

Now measure ten oscillations.

How long did it take the pendulum to complete ten oscillations? (11)

On this basis, tell what is the average time for one oscillation? (12)

Measure the time it takes to complete 20, 30, 40, and 50 oscillations.

Make a table and record your data. (13)

Calculate the average time period from each experiment and record this in your table. (14)

Is the period of oscillation about the same each time? (15) From this experiment, what conclusions can you draw about oscillation of a pendulum. (16)

The characteristic of the pendulum which you learned in this experiment was first discovered in the 17th century by an Italian scientist named Galileo. For many years, wall clocks were designed to take advantage of this characteristic of the pendulum. Such clocks are in use even today.

In the above experiment, we saw that the average time period of a pendulum remains fairly constant, time after time. Does this time period depend upon the length of the string or the weight of the stone hanging from the string? We shall explore this question in the next two experiments.

Experiment 4

effect of length of pendulum on time period

The distance between the point at which the pendulum is suspended and the stone is the length of the pendulum. Set the length of the pendulum at 20 cms and measure the time for 50 oscillations. Do this thrice and compute the average time. Divide this average by 50 to arrive at the average time period of the pendulum. Increase the length of the pendulum by 10 cms and do the experiment again. Keep repeating this way, increasing the length by 10 cms each time till you have reached 100 cms.

Make a table like the one shown below in your note book. Record your data for length of pendulum and period of oscillation in this table. (17)

S.No.	Length of string (cm)	Time of 50 oscillations is seconds				Average time period
		1	2	3	Average	
1.	20					
2.	30					
.	..					
.	..					
	100					

Those students who measured the period of oscillation using their pulse, should convert the figures in the last column of the table into seconds. The method of doing this was explained in experiment 3.

What effect does increasing the length of the pendulum have on the time period? (18)

How long should a pendulum be whose time period is two seconds? Estimate on the basis of data in your table. (19)

With such a pendulum, time can easily be measured in seconds. This is called a **seconds pendulum.**

Experiment 5

The relationship between weight of the stone and the time period

How would average time period vary if stones of different weights are suspended on pendulums of equal lengths. Do an experiment to answer this question. Keeping the length of the pendulum constant, hang stones of different weights and find average time periods.

Make a table and record your data from the experiment in it. (20)

What is the effect of suspending stones of different weights on the average time period? (21)

Why was length of the pendulum kept constant in this experiment? (22)

An exercise

Jagdish made a 50 cm long pendulum and found its average time period. He repeated the experiment after increasing the length of the pendulum to 100 cm and found out the average time period again.

Compared to the first, the time period of the second pendulum -

increased,

decreased,

or remained the same? (23)

Compared to the first, the time period of the longer pendulum was:

half,

double,

more than double,

or less than double? (24)

Let us do a couple of interesting pendulum experiments.

The Effect of one pendulum on another

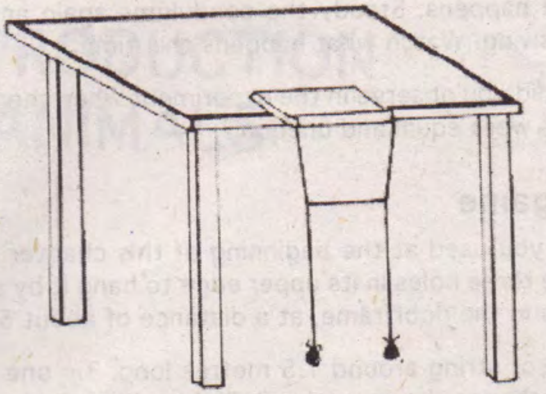


Figure-3

You will need a string about two metres long. Tie a small stone on each end of the string. Get a thick book and insert the string in the middle of the book such that two pendulums of equal length hang out of the book at two sides. Set the book on a table sticking out a little so that both pendulums can swing freely. If necessary, you can lay a brick or some other heavy object on top of the book so that it does not fall. Slide the string to make the lengths of the two pendulums equal. Now tie a string horizontally between the two pendulums in order to connect them (Figure 3).

Steady both pendulums. Pull one of them perpendicular to the horizontal string and let go. What happened? Watch carefully. Repeat it two or three times.

Now pull the string in one direction so that lengths of the pendulums become different. Steady both pendulums and swing the longer

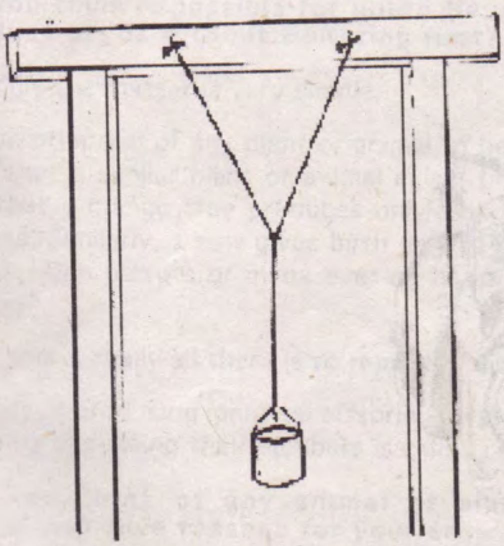


Figure-4

one. Watch what happens. Steady the pendulums again and make the shorter one swing. Watch what happens this time.

What difference did you observe in the experiment when the lengths of the pendulums were equal and unequal?

A swinging game

Take the tin can you used at the beginning of this chapter for the water clock. Make three holes in its upper edge to hang it by strings. Hammer two nails in the doorframe, at a distance of about 50 cms.

Now take a piece of string around 1.5 metres long. Tie one end to one nail and the other to the second nail. Right in the middle of this string, hang the tin can with another piece of thread so that it is about 5 cms above the floor (Figure 4).

Now filter some sand with fine cloth and pour it into the tin can. Make this pendulum swing in different directions and watch what sort of patterns flowing sand makes on the floor. The can should not be too high above the floor, otherwise the sand will scatter all over the floor and a clear pattern will not be formed. If you want you can apply glue or paste on some paper and place it below the swinging can. By doing this, you will end up with a permanent pattern of sand on your paper.

NEW WORDS:

solar day

time period

oscillation

average period of oscillation

pendulum