ACTIVITY 6

AIM

To study the conservation of energy of a ball rolling down an inclined plane (using a double inclined plane).

APPARATUS AND MATERIAL REQUIRED

A double inclined plane having hard surface, (for guided motion of the ball on the double inclined plane it is suggested that an aluminium channel or rails of two steel wires be used for it), a steel ball of about 2.5 cm diameter, two wooden blocks, spirit level, tissue paper or cotton, and a half metre scale.

PRINCIPLE

The law of conservation of energy states that 'energy can neither be created nor destroyed but can only be changed from one form to another'.

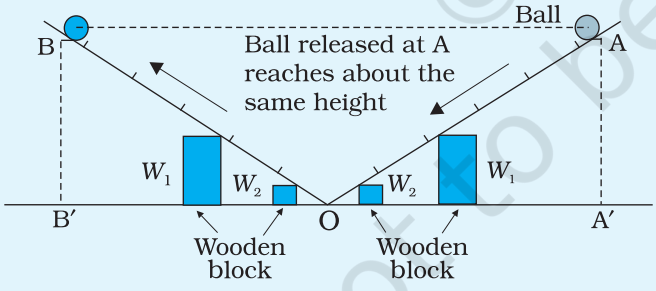

Fig.A 6.1: *Set up for studying the conservation of energy using double inclined tracks*

For a mechanical system, viz., the rolling of a steel ball on a perfactly smooth inclined plane, the energy of ball remains in the form of its kinetic and potential energies and during the course of motion, a continuous transformation between these energies takes place. The sum of its kinetic and potential energies remains constant provided there is no dissipation of energy due to air resistance, friction etc.

In this experiment, the law of conservation of energy is illustrated by the motion of a steel ball rolling on a double inclined plane. A steel ball rolling on a hard surface of inclined plane is an example of motion with low friction. When the ball is released from point A on inclined plane AO, it will roll down the slope and go up the opposite side on the plane OB to about the same height h from which it was released. If the angle of the slope on right hand plane is changed, the ball will still move till it reaches the same vertical height from which it was released.

At point of release, A, say on the right hand inclined plane, the steel ball possesses only potential energy that is proportional to the vertical height, *h*, of the point of release and has a zero kinetic energy. This potential energy transfers completely into kinetic energy when the steel ball rolls down to the lowest point O on the double inclined plane. It then starts rolling up on the second inclined plane during which its kinetic energy changes into potential energy. At point B where it stops on the left hand inclined plane OB, it again has only potential energy and zero kinetic energy. The law of conservation of mechanical energy can be verified by the equality of two vertical heights AA′ and BB′.

PROCEDURE

1. Adjust the experimental table horizontally with the help of spirit level.
2. Clean the steel ball and inclined planes with cotton or tissue paper. Even a minute amount of dust or stain on the ball or on the plane can cause much friction.
3. Keep the clean double inclined plane on a horizontal table.

   Note: In order to reduce friction and thereby reduce loss of energy due to it one can also design an unbreakable double inclined track apparatus, in which the steel ball rolls on stainless steel wire track. In a try outs with such an inclined plane it has been observed that the rolling friction is extremely low and it is very good for this Activity. It also does not develop a kink in the centre, unlike the apparatus presently in use in many schools.
4. Insert identical wooden blocks W_1 and W_2 underneath each plane at equal distance from point O. The two planes will be inclined nearly equally, as shown in Fig. A 6.1. The inclined plane should be stable on horizontal table otherwise there would be energy losses due to the movement of inclined plane as well.
5. Release the steel ball from A, on either of the two inclined.
6. Find the vertical height AA′ *(x)* of the point A from the table using a scale.
7. Note the point B up to which the ball reaches the inclined plane on the other side and find the vertical height BB′ *(y)* (Fig. A. 6.1). Record the observations. While observing the highest position of the steel ball on other plane, observer has to be very alert as the ball stays at the highest position only for an instant.
8. Shift the wooden block W_1 and W_2, kept under either of the two planes, towards the centre point O by a small distance. Now the angle of the slope of one of the planes would be larger than that of the other.
9. Release the ball again from point A on one of the two planes and mark the point B on the other plane up to which the steel ball rolls up. Also find the vertical height BB′.

10. Repeat Steps (8) and (9) for one more angle of the slope of the inclined plane.

11. Repeat the observations for another point of release on the same inclined plane.

OBSERVATIONS

Table A 6.1:

S. No.	Reading on inclined plane from which the ball is rolled down		Reading on the inclined plane in which the ball rolls up			Difference $(x - y)$ (cm)
	Position of mark A	Vertical height AA′, x (cm)	Position of mark up to which the ball rolls up	Vertical height, y (cm)	Mean, y (cm)	
1			B =			
2			C =			
3			D =			
1			B =			
2			C =			
3			D =			

RESULT

It is observed that initial vertical height and final vertical height upto which the ball rolls up are approximately same. Thus, the rolling steel ball has same initial and final potential energies, though during the motion, the form of energy changes. The total mechanical energy (sum of kinetic and potential energies) remains same. This is the verification of law of conservation of energy.

PRECAUTIONS

1. Steel balls and inclined planes must be cleaned properly with cotton/tissue paper.
2. Both wings of the inclined plane must lie in the same vertical plane.
3. Both the planes must be stable and should not have any movement due to rolling of the ball or otherwise.
4. The position of the ball at the highest point while climbing up the plane must be noted quickly and carefully.

SOURCES OF ERROR

1. Some energy is always lost due to friction.
2. Due to lack of continuity at junction of two inclined planes, rolling ball usually suffers a collision with second plane and hence results in some loss of energy.

DISCUSSION

1. The key to the success of this Activity for the verification of law of conservation of energy is in keeping the rolling friction between the steel ball and inclined plane as low as possible. Therefore, the ball and inclined plane surfaces should be smooth, clean and dry.
2. The dissipation of energy due to friction can be minimised by minimising the area of contact between the steel ball and inclined plane. Therefore, it is advised that the inclined planes should be made of polished aluminium channels having narrow grooves.
3. The surface of inclined planes should be hard and smooth so that role of friction remains minimum.
4. If the inclination of the planes is large then the dissipation of energy will be more (how)? Therefore inclination of the planes should be kept small.

SELF ASSESSMENT

1. Can this Activity be performed successfully with a steel ball of smaller diameter?
2. If the ball is not reaching exactly up to the same height on the other wing, comment on the observations?

SUGGESTED ADDITIONAL EXPERIMENTS/ACTIVITIES

1. Study of the effects of mass and size of the ball on rolling down an inclined plane.
2. Study the effect of inclination of the planes on coefficient of rolling friction.