1 Evaluation

The principle of conservation of mechanical energy states that the total mechanical energy (potential plus kinetic) of an object at any position during its motion always remains constant. This is true if the only forces acting on the ball are conservative forces. We investigated this theory by allowing a metal ball to slide down an incline, go through a circular loop, and then continue its motion normally along a straight path.

When the ball is at the top of the incline at rest, the ball possesses only potential energy due to its height. When the ball is let go, it slides down the incline. During this time, the potential energy of the ball is converted into kinetic energy. The ball then goes through the circular loop. As the ball climbs up now, the kinetic energy is slowly converted back into potential energy. Once the ball completes the loop, and moves straight, the ball no longer has any potential energy, but only kinetic energy due to its velocity. The *sum* of the potential and kinetic energies, ie. the total mechanical energy, at any given point will however remain constant.

The conservation of mechanical energy holds true only if conservative forces act on the ball. Here, this conservative force would be the force of gravity. However, we find that we have errors in our results. This is primarily due to the fact that we have failed to take into account certain non-conservative forces, namely, the force of kinetic friction and air resistance in our calculations. In addition, there is the normal force acting on the ball, which is also a non-conservative force. But the normal force does not affect our results, as it always acts perpendicular to the surface, and thus does no work.

By using the principle of conservation of mechanical energy and some basic concepts of uniform circular motion, we were able to calculate the minimum height that the ball must be let from, in order for it to be able to complete the circular loop. The calculations for this are shown under the 'Questions' section in the Data Analysis. We find, from our calculations, that this minimum height h(0) does not depend on the mass or size of the ball, provided no non-conservative forces act on the ball[1]. As a matter of fact, the initial height does not even depend on the acceleration caused due to gravity. This means that the initial height required, will be the same even on the moon or on other planets. The mass and the acceleration due to gravity g are algebraically eliminated from the equation. The initial height only depends on the radius of the loop and nothing else. Furthermore, the initial height required in order for the ball to be able to complete the loop is directly proportional to the radius of the curve. This is perhaps an important relationship to be noted:

> The minimum height required by an object in order for it to be able to complete a curve is five-halves the radius of the loop, provided the net work done by the non-conservative forces is zero.

[1] Technically speaking, the law of conservation of mechanical energy will also hold true if non-conservative forces act on the object, provided the net work done by these forces is zero.

2 Conclusion

In the above experiment, we have validated the principle of conservation of mechanical energy. This principle will work no matter the path taken, as only conservative forces are being applied. Also, this principle could be put to use in several practical situations where it is difficult to measure certain quantities accurately. The conservation of mechanical energy requires us to know only the height and velocity of the object at specific points. Further, we have even found a relationship between the initial height required and the radius of a circular loop, with the help of the principle of conservation of energy. Such relationships will be of utmost help when we go to build circular structures, a roller coaster, for example. Finally, the principle of conservation of mechanical energy helps us eliminate the mass from the equation, thereby saving us from the task of measuring the mass of the moving object.