# CONSTRUCTION OF AN IMPROVISED DEVICE TO DEMONSTRATE THE PRINCIPLES OF CONSERVATION OF LINEAR MOMENTUM (INELASTIC COLLISION)

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## ABSTRACT

*The focus of this study is to experimentally determine if momentum and kinetic energy are conserved throughout an entire linear inelastic collision. To achieve this, a model was constructed using locally sourced materials in the environment. The momentum of an object moving in a straight line is given by* ***P = mdv****. The constructed model was used in carrying out explicit practical. The result obtained from calculation using relevant formula, and graphical relationship between mass and the reciprocal of velocity, confirmed that with this model kinetic energy is not conserved. This agrees with the principle of conservation of momentum (inelastic collision). This constructed model would serve as an illustrative tool for further enhancing the knowledge of students in this topic.*

**Keywords:** Momentum, Collision, inelastic, conservation

## INTRODUCTION

Linear momentum is a vector quantity defined as the product of an object's mass, m, and its velocity, v. It is denoted by the letter p and it is called momentum, having an S.I unit of kgm/s. It could also be defined as mass in motion.

A semi- truck has a large momentum because it is very massive, but also has a large speed which influences momentum as well. The bike also has momentum because it has a large speed, but because its mass is less than that of the truck, its momentum is also less. This mass- velocity relationship is expressed mathematically as p = mv which is an extract from Newton's second law. From the relationship above it is clear that an object at rest has no momentum.

*According to Okeke P.N.* et *al.* (1989), linear momentum is defined as the product of mass and its velocity. Olumuyiwa A. et al. (2008) also defined linear momentum of a body as the product of the mass of the body and its velocity. When a thing is kept from change, loss and decay, it is said to be conserved Mcginnis, P. (2005). Conservation of momentum expresses the idea that an object in motion retains its total momentum, provided there is no external force acting on it. Anyankoha M.W. (2013) explained the principle of linear momentum in different ways. He said firstly, "In any system of colliding objects the total momentum is always conserved provided that there is no net external force acting on the system". Secondly, "The total momentum of an isolated or closed system of colliding bodies remains constant" and thirdly, "If two or more bodies collide in a closed system, the total momentum after collision is equal to the total momentum before collision". According to Serway, R.(2012), the conservation of linear momentum equation in which one body is motionless is expressed as $m_1u_1 + m_2u_2 = (m_1 + m_2)\,v$ This connotes an *inelastic collision*, where kinetic energy is not conserved and momentum before impact is the same as momentum after impact.

This paper focuses on the construction of an improvised device to demonstrate the principles of conservation of linear momentum(Inelastic collision), because in third world countries, like Nigeria, students have always been left at the mercies of their imagination, when certain topics are been taught. Also, this improvised device will be used to verifying if momentum before impact is equal to momentum after impact for an inelastic collision. Data generated using this improvised device will be used to represent a graphical relationship between mass and the velocity and also give reasons as to why kinetic energy before impact is greater than kinetic energy after impact.

## MATERIALS AND METHOD

1. The equipment shown in Figure 1.
2. Steel ball
3. Waxed paper.
4. A 30cm ruler.
5. Known masses of wooden blocks.
6. Meter stick.
7. Electronic balance

### Determination of the Velocity of the Sphere before Impact

The principle of conservation of linear momentum is to be tested as follows: a steel sphere is allowed to slide down the track, and immediately after leaving the end of the track plunges into a hole in a wooden block and becomes stuck within the block. The block, which is suspended by four strings, is initially at rest, but swings as a pendulum because of the impact. The momentum of the sphere before the collision is compared to the momentum of the sphere and block just after the collision.

The wooden block placed between the track and box of the device is removed to allow the steel ball which is rubbed slightly with oil, roll freely on the track into the box along a parabolic path. A strip of waxed paper was fixed to the floor of the box so as to make the imprint of the steel ball visible. The end of the track is horizontal.

To determine the height h, through which the steel ball fell; it was noted that the track is a channel, and the lowest point of the sphere is below the upper edges of the channel. Three or more trials run of the steel ball was carried, and the average value of the range r was determined. From these data, calculation of the time of flight, and the velocity of the centre of the sphere as it leaves the track was made.

## RESULT

The constructed device was used in performing simple experiment. An electronic balance was used in measuring the masses of the steel ball and various boxes of wood. To determine the final velocity after impact of both masses, the conservation law was applied...

$M_1U_1 + M_2U_2 = (M_1+M_2)V$……. eqn 1a

$M_1$ = mass of the steel ball

$U_1$ = initial velocity of the steel ball

$M_2$ = mass of the wooden block

$U_2$ = initial velocity of the wooden block

V = final velocity after impact

But since the wooden block is at rest, $U_2 = 0$, from the expression 1a, making v subject of formula becomes…

$$V = \frac{M_1U_1}{(M_1 + M_2)}$$

| Mass of ball (kg) | Masses of wood (kg) | Final velocity after impact V (m/s) | 1/V [1/(m/s)] |
|---|---|---|---|
| 0.110 | 0.270 | 0.116 | 8.643 |
| | 0.290 | 0.110 | 9.090 |
| | 0.310 | 0.105 | 9.551 |

| | | | |
|---|---|---|---|
| | 0.380 | 0.089 | 11.148 |
| | 0.430 | 0.081 | 12.285 |

An important parameter that was also measured was the initial velocity of the ball. The vertical height of the track was measured to be 0.163m.

To find the range, where the ball landed after leaving the track, three run trials were made and the average was taken.

$$X = \frac{6.9 + 8.0 + 7.1}{3}$$

X = 7.3cm, or 0.073m

**Determination of the initial horizontal projection velocityof the ball**

the second equation of motion was applied.

$S = ut + 1/2at^2$ -------1

But the initial vertical velocity of the ball = 0, this means the equation above can be reduced to

$S = 1/2at^2$. ......2

Taking s = h and a = g equation 2 becomes

$H = 1/2gt^2$.......3

If T is made the subject of the formula,

$$T = \sqrt{\frac{2H}{g}}$$

in the horizontal projection g = 0, inserting g = 0 in equation 1, where T represents total time of flight and S = R = Range,

R = uT........5

Inserting equation 4 into 5, gives

$$R = 2u\sqrt{\frac{2H}{g}}$$

given that R = 0.073m, and H = 0.163m, g =9.8m/s$^2$, the initial velocity, U, of the ball becomes = 0.4m/s

**Verification of the principle of conservation of momentum**

The wooden block of mass 0.27kg was used...

The law states that,

$M_1U_1 + M_2U_2 = (M_1+M_2)V$

0.11 x 0.4 = (0.11 + 0.27) x 0.116

Momentum before collision was **0.044kgm/s** and momentum after collision was also **0.044kgm/s.**

**Conservation of Kinetic energy**

Kinetic energy of the ball before impact was determined using the formula

$K.E = \frac{1}{2}mv^2$

M1 = 0.110kg

U1 = 0.4m/s

Therefore the K.E before impact =0.0088J

And the K.E after impact can also be determined from formula $1/2(M_1+M_2)V^2$

$M_2$ = 0.27kg

V= 0.116m/s

From calculation the kinetic energy after impact = 0.0026j and this is less compared to that before impact, showing that it was not conserved.

Finally, plotting a graph of the relationship between mass and the reciprocal of velocity from the table above gives a slope showing that the momentum was conserved.

**The slope of the graph (fig 1)**

The gradient of the graph which gives us the momentum produced the same result as the formula.

$$\text{slope} = \frac{\text{change in mass}}{\text{change in reciprocal of velocity}}$$

$$\Delta s = \frac{0.380 - 0.10}{11.0 - 3.0}$$

$\Delta s = 0.04 kgm/s$

## CONCLUSION

After using this crude device to carry out practical, gradient of the graph plotted and calculations done using relevant formula agreed that momentum before impact is equal to momentum after impact. Furthermore, calculations proved that kinetic energy was not conserved from the noticeable variations which can be attributed to the conversion of kinetic energy into sound energy.

## RECOMMENDATIONS

Consideration in this work was only given to one case of inelastic collision where one of the objects is at rest. Further work should be done to bring up other construction that can be used as illustrative tools in explaining linear momentum to curb the situation of leaving students at the mercies of their imagination.

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