Quantitative experiments about falling and rebounding bodies of different shapes in view of Newton’s Third Law of Motion.

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Research Article

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Abstract

Newton stated third law of motion in the Principia implies that action and reaction are always equal and opposite in all possible cases (i.e. universally). The action and reaction occur in pairs simultaneously and inherently. In the Principia Newton gave examples to elaborate statement of the law expressing action and reaction in terms of push or pull (force). In the current physics the action and reaction as such are not regarded as physical quantities because units and dimensions are not assigned to action and reaction directly. Practically Newton initiated physics (without mathematical equations) separating it from natural philosophy.

Here very sensitive aspect of the law is elaborated. In experiments we may have bodies of different materials such as wool, wood, cloth, spring, steel, rubber, clay, kneaded flour, chewing gum, sponge, typical plastic, porous material, air / fluid filled artifact, etc. The intrinsic characteristics of various bodies (inherent composition, nature, flexibility, elasticity, plasticity, rigidity, magnitude, size, distinctiveness of interacting bodies or mode of interactions, and other relevant factors like surfaces on which bodies interact.) may be different.

Likewise, bodies may have different shapes (spherical, semi-spherical, umbrella shaped, triangular, square, cone, long pipe, flat, irregular or any possible shape). It has to be verified in all cases specifically. Newton has not mentioned about characteristics of target.

The third law must be specifically confirmed in various simple experiments with the latest technological equipment. The quantitative nature of falling and rebounding bodies (preferably in vacuum) must be studied. In some qualitative observations the shape of bodies appears to be a significant factor. So, the law has been theoretically modified as reaction is proportional to action i.e. Reaction =- Q Action, where Q is coefficient of proportionality (accounts for shape of body and other factors which are not accounted for original form of the law). The effect of shape is equally applicable in one dimensional elastic collision. The collisions are theoretically studied but in typical experiments, shape of bodies play significant role.

In 2016 in EM Drive experiments some deviations have been reported by NASA from third law, but the results are still inconclusive. Thus, the proposed experiments may lead to significant results in Newtonian Mechanics.

1.0 Descartes Third Law Of Motion (1644) Precedes Newton's Third Law Of Motion (1686)

Renne Descartes **[1-2]** has discussed his three laws of motion in *Principles of Philosophy* (1644) about 42 years before Newton's *Principia (1686)* using existing terminology existing at that time.

Descartes third law of motion as stated in his book is given by
"*When a moving body collides with another, if* ***its power of continuing*** *in a straight line is less than* ***the***

resistance of the other body*, it is deflected so that, while the quantity of motion is retained, the direction is altered; but if its power of continuing is greater than the resistance of the other body, it carries that body along with it, and loses a quantity of motion equal to that which it imparts to the other body.* (Principles Part II, article. 40)

In the present form of the law, the action may be regarded in terms of 'power of continuing' and reaction as resistance of body in some sense (the nearest resemblance). So, these two forces are competitive in nature. Obviously in Descartes terminology body does not move i.e. remains stationary if power of continuing is equal to resistance of body.

Further Newton stated the third law of motion in more specific, compact and scientific way. If critically analysed then applications of both Descartes law and Newton's law may have theoretical resemblance.

2.0 Newton's Third Axiom Or Law Of Motion

Newton defined third axiom or law of motion in *the Principia* **[3]** at page 20 as,

'*To every action there is always opposed an equal reaction; or the mutual actions of two bodies upon each other are always equal, and directed to contrary parts*'

Mathematically,

Reaction = - Action (universally applicable) (1)

However in modern terminology action and reaction are not physical quantities as they are not associated with units and dimensions (like displacement, velocity , work etc.). Newton expressed action and reaction in terms of push or pull (force) as discussed in first two examples or illustrations of third law by Newton **[3] .**

The mutual simultaneous actions of two bodies on each other may be regarded as forces exerted by bodies on each other ,

Force exerted by body B (Reaction) in opposite direction = - Force exerted by body A (Action) (2)

Force exerted by body B (Reaction) = - Force exerted by body A (Action) (3)

The negative sign is externally used to indicate direction only. Thus, third law implies action is *precisely equal* to reaction, irrespective of other conditions of the system i.e. universally. The third law implies that action and reaction are equal and opposite for all pairs of bodies; as there is no mathematical or conceptual constraint neither on definition nor mathematical equation of the law. The reaction (force exerted by target on projectile) arises due to mutual interactions of projectile and target inherently and simultaneously. Thus, action and reaction forces act in pairs. Newton justified the law in simple examples without mathematical equations, hence may be called qualitative explanation.

Newton's law does not put any constraints on precise equality of action and reaction force; both are in exactly opposite direction. The law implies that action and reaction has to be equal in all cases universally without any exception. There is no reason that Newton's third law of motion is regarded as applicable in limited cases only. Thus, third law implies that action is *precisely equal* to reaction, irrespective of other conditions of the projectile and target.

In definition of the law Newton used term 'body' defined in Definition I

In the most familiar part of definition Newton stated that action and reaction are always equal and opposite. Then in other part of definition Newton stated that *' the mutual actions of two bodies upon each other are always equal, and directed to contrary parts '*

Thus, Newton has specifically defined third law of motion for interacting bodies. In explanation Newton explained that when a stone is pushed with finger or a stone is pulled by horse. Earlier Newton has defined quantity of matter or mass or body in Definition I at first page, first paragraph of the Principia.

Newton has defined quantity of matter (Definition I in the Principia) as product of density and bulk (volume) and quoted examples of snow, powders and air. Newton further clarified that it is this quantity (of matter) that I mean hereafter everywhere under the name of body or mass.

It is this quantity that I mean hereafter everywhere under the name of body or mass.

Thus, obviously Newton meant third law for bulky bodies (defined in Definition I).

The purpose of mentioning this is that Newton has defined third law of motion for interacting bodies as defined above. This aspect (of definition of body) is useful in understanding of the applications of third law.

3.0 Newton's First Two Applications Of The Principia Book I (P.20)

"Whatever draws or presses another is as much drawn or pressed by that other. If you press a stone with your finger, the finger is also pressed by the stone. If a horse draws a stone tied to a rope, the horse (if I may so say) will be equally drawn back towards the stone."

When a body A draws or presses body B, then body A will be equally drawn or pressed by body B, thus both bodies remain at rest. So, Newton justified that action and reaction are equal and opposite.

Action and Reaction in terms of force: Thus theoretically, action (Force exerted by body A i.e. the finger or horse on stone) and reaction (Force exerted by body B i.e. stone on finger or hand) are always equal and opposite for all bodies under all conditions i.e. universally. It may be regarded as the simplest case. Here action and reaction are expressed in terms of force (push or pull) or the mutual interactions on bodies is also regarded as force,

Force exerted by stone (Reaction) = - Force exerted by finger (Action) (2)

Force exerted by stone (Reaction) = - Force exerted by horse (Action) (3)

Further Newton has discussed the case that when a finger pushes the stone such that stone does not move. So both forces are equal as in eq.(2,3) . In this case Newton concluded that

Force exerted by stone (Reaction) = - Force exerted by finger (Action)

In this case force is applied on stone (both by finger and horse) but stone remains stationary. The law implies that action (force applied by finger on stone) and reaction (force applied by stone on finger) must be stringently equal and opposite. Thus in this particular situation as the stone remains at rest (when pushed by finger or pulled by horse).

We also visualize it as book rests on floor. The book exerts force equal to weight (mg) on floor and floor also exerts equal force (mg) as reaction on the book **[4].**

Newton did not discuss the case when a child pushes the stone and it moves, also horse pulls and displaces the stone. These cases should have been discussed for completeness. Such cases are previously discussed by Descartes in his third law of motion.

4.0 Universal Applicability Of The Law.

The definition or equation of Newton's third law of motion i.e. eq.(1) is applicable for all bodies or all pairs of bodies irrespective of shape and characteristics. There is no reason that law is regarded as true for specific cases only i.e. for typical spherical or square body. The law is applicable for all bodies of different shapes (all perceivable shapes) and characteristics as described below.

Various bodies: wool, wood, cloth, spring, steel, rubber, clay, kneaded flour, chewing gum, sponge, typical plastic, porous material, air / fluid filled artifact, etc.

Characteristics of bodies: inherent composition, nature, flexibility, elasticity, plasticity, rigidity, magnitude, size, distinctiveness of interacting bodies or mode of interactions, and other relevant factors like surfaces on which bodies interact.

Shapes of bodies: Spherical, semi-spherical, umbrella shaped, triangular, square, hexagonal, cone, long pipe, flat, irregular or any feasible typical shape etc.

The law is quantitatively applicable in all possible perceivable cases and must be quantitatively justified **[5-10].** There is no reason (in definition and equation of the law) that third law is regarded as true in limited way rather than universally (for suitable spherical body say).

Role of target

Newton's third law of motion is *'the mutual actions of two bodies upon each other are always equal, and directed to contrary parts'* The law holds good for all pairs of bodies. In the law one body is projectile and other target. Newton did not define characteristics of targets. The law holds good for all targets. Thus, Newton implies reaction arises due to interaction of two bodies (projectile and target) but the characteristics of bodies and target are not defined in the definition of all. It implies Newton meant his law for all bodies (projectile and target) indiscriminately. Thus, action and reaction should be equal and opposite for all pairs of bodies. Or mutual forces exerted by bodies on each other must be equal and opposite for all interacting bodies. Practically Newton should have described the role of targets separately for various projectiles.

The law states that action and reaction are universally equal i.e. for every projectile and target under all conditions. Newton did not define or specify the characteristics of target, like projectile (thus defined fairly general law). So, this law requires further interpretation as it is applicable in many cases. Further the law does not put any constraint on anybody to act as target.

The target may be heavy body, floor, surface of table, stretched sheet of cloth, stretched sheet of paper etc. A book is supported on the table (action and reaction are equal and opposite) but not on the stretched sheet of paper. Insect rests or walks of table and paper. Both the table and paper are targets. Newton did not specify that sheet of paper is target for insect and not for book. Thus, target should have some optimum properties. But Newton's law is fairly general and holds good in all cases.

Newton has discussed finger pushes stone and horse pulls stone. So in Newton's case the stone may be regarded as target. This law has number of applications, as bodies (projectile and target) interact in various ways. The surface of table and stretched sheet of paper cannot be identical targets for everybody. It would have been prudent if Newton had discussed characteristics of target in regard to projectile. Newton did not specifically mention the characteristics of targets. The shape, size, magnitude and tensile strength of target must be considered relative to projectile. If the body strikes at the edge of the target then body may not rebound exactly in opposite direction. However, the body strikes at middle of the target then it rebounds. Thus, point of collision is also equally significant in case of interacting bodies. The role of target needs to be studied **[5]** as law has many applications.

5.0 Various Applications Of Third Law Of Motion In Existing Science

Newton has stated the law in early days of physics when concepts and experiments were at very initial stages comparatively. Newton initiated physics as subject separating it from natural philosophy in 1686 in the Principia. In definition of third law Newton used terms action and reaction; and mutual interactions of bodies on each other. For practical demonstration of the law Newton himself used terms 'push' and 'pull'; these are regarded as 'force 'now in mathematical equations. The concepts of units and dimensions was developed by Fourier **[11,12]** in 1822. Newton did not give any mathematical equation for the law for demonstration.

The one body exerts force on the second body; the second body also exerts equal and opposite force on the first body.

Force exerted by body B (Reaction) in opposite direction = - Force exerted by body A (Action)   (1)

Thus, statement of Newton's third of motion has wide range of applications when one body exerts force on the other in different ways in various physical phenomena. For complete understanding of the law all applications must be quantitatively studied and eq.(1) must be scientifically verified experimentally; like other laws of science. The qualitative explanation is not sufficient for complete understanding of any law.

The law has many applications in the existing physics (science) e.g.

backward movement of gun (may be called as reaction) when bullet is fired (action),

rebounding of ball when it strikes the wall or floor

backward motion of boat in water when person jumps from it towards shore

book remains stationary on the floor or table (weight of book is action , force exerted by floor is reaction)

launching of rocket, exhaust moves backward say action and rocket moves forward (also see section about EM Drive where deviations from law are speculated),

a swimmer moves in forward direction (reaction) when pushes water backward with arms (action)

forward movement of person (reaction) by pushing ground backward (action) etc.

All the examples or applications of Newton's third law of motion need to be experimentally confirmed quantitatively.

5.1 Quantitative discussion of free fall and rebounding of spherical ball

This phenomenon (falling and rebounding bodies of different shapes) is not quantitatively studied in literature. It is very important to understand it experimentally taking all possible factors in account. Here we try to understand an example i.e. free fall of suitable rubber (plastic) ball on suitable floor and its rebounding quantitatively. Consider a rubber ball of uniform composition of mass 0.2 kg falls freely in vacuum. Let it falls freely from height of 1meter. The ball is attracted by gravitational force of earth i.e. weight (mg, 0.2 g or 1.96 newton), it is action. The time taken by body to fall through distance of 1m can be determined by equation $S = ½ gt^2$ as 0.45s.

As the ball touches the floor, both interact with each other and reaction arises due to mutual simultaneous interactions of ball and floor; as stated in the third law. Thus, obeying third law of motion the ball rebounds in upward (opposite) direction. Newton's third law of motion implies equal and opposite action and reaction, so spherical ball rebounds to height of 1meter, apparently under certain conditions. In such cases action and reaction are equal in magnitude but opposite in direction.

Obviously falling of ball due to gravity is action, and rebounding upward of ball after mutual simultaneous interactions of both (ball and floor) is reaction. To understand the law completely, action and reaction have to be quantitatively measured. The experimental confirmation of some other applications of Newton's third law of motion is quite tedious and complicated process.

5.2 Discussion on falling and rebounding bodies of different shapes e.g. semispherical, cone, flat, irregular or typical shape etc.

Now a suitable body of rubber (plastic) of uniform composition of mass 0.2 kg may have different shapes e.g. spherical, semi-spherical, umbrella shaped, triangular, square, hexagonal, cone, long pipe, flat, irregular or any other typical shape are considered. etc. These bodies can be precisely fabricated. The composition and mass of these artefacts are precisely same as that of rubber (plastic) ball. Thus, inherent characteristics of bodies remain the same. The bodies are such that they are not deformed during interactions.

In case of falling bodies, action (force, weight or mg) is independent of shape: Let all bodies are dropped in vacuum like spherical ball in vacuum under exactly identical conditions (on the same floor) like sphere of same mass. The action is same. All the bodies are attracted by the gravitational force of earth with same force as mass of each body is same. Like spherical ball, the bodies of different shapes fall freely in vacuum as upthrust does not exist. Thus force (weight), mg or action in each case (like spherical ball) is the same (0.2g or 1.96 newton) for bodies of different shapes. Action (force or weight or mg) is independent of shape.

Now Newton's Third law of motion as in eq.(1) implies that reaction is precisely equal and opposite to action for all pairs of bodies. In definition or equation of third law of motion there is no factor, that action and reaction may have different magnitudes. Newton's third law does not put any constraint on reaction of body due to orientation (i.e. angle at which bodies are dropped.) Thus, as all bodies (of different shapes) would have same reaction (0.2g or 1.96 newtons) as action is the same (0.2g i.e. 1.96 newtons).

Reaction must be precisely equal to action irrespective of other factors. Thus, all bodies have same action i.e. force or weight (0.2g or 1.96 newtons) like spherical ball so all bodies should rebound to height of 1meter as reaction should be the same; according to Newton's Third law of motion i.e. eq.(1). For example a spherical ball under some conditions rebounds to original height 1m . Thus law is obeyed , action = -reaction.

But the bodies of different shapes (as cited above), do not rebound to original height of 1 meter i.e. point they are dropped. It is observed even in daily life observations and is motivation for the quantitative experiments.

In some cases (flat or irregular shape body), may rebound to least height. Thus, reaction (force arises due to interaction of body and floor) appears to be less in body of different shapes; however, action for all bodies of different shapes is same as that of spherical body. Realistically action (force or weight) i.e. 0.2g or 1.96 newtons, is same for all bodies (different shapes) but reaction (force) is different as bodies rebound to lesser height. The distance can be calibrated in terms of reaction, as action is same for all bodies.

Area of contact of falling or rebounding bodies with floor. This aspect can be understood by fabricating bodies such as cone (pointed base), long pipe, typical body etc. such that area of contact of each body with floor is same as that of sphere.

Thus, even in case of different shapes, area of contact (projectile and target) can be same as that of spherical ball. The law is silent about symmetry of bodies if action is same then reaction has to be equal in magnitude and opposite in direction, according to law i.e. eq.(1). However, some bodies may not rebound precisely in opposite direction.

If the area of contact of body with floor is more then sound energy, heat energy (mass x specific heat x rise in temperature) need to be measured. It causes dissipation of fraction of energy. The rise in temperature of body when body falls on the floor is regarded as negligible. The temperature of target can be regarded as lower for observations. This aspect is required to be critically, specifically and quantitatively studied. It is not scientific to just understand the phenomena qualitatively.

Qualitative Observations: In qualitative observations the bodies rebound to different heights depending on its shape and size. Now with sensitive equipment, these experiments must be conducted to understand the phenomena quantitatively.

Newton's law rigidly implies that action and reaction both must be equal; when body rebounds upward then acceleration due to gravity is regarded as -g as in projectile motion and other phenomena e.g. understand book rests on table. This aspect requires specific quantitative observations.

The vertical and horizontal distances travelled by bodies should be tabulated in repeated experiments using bodies of different shapes along with various trajectories while rebounding. In past 335 years this issue is not studied as there are no specific experimental data quantitively. Again, for understanding effect of shape, the mass and composition of bodies need to be precisely same.

In this case experimentally orientation (angle at which bodies fall) and symmetry (distribution of mass of body due to shape) appear to be equally significant factors; even if force of action is same (0.2g, 1.96 newtons) in all bodies. It is assumed that bodies are not deformed during interactions.

Limitations of the law quoted in existing physics. In applications of Newton's third law of motion, some deviations under some conditions have been quoted in quantitative study of electric and magnetic forces **[4].** But the noble and new facts quoted above need to be conducted.

5.3 Composition of all bodies is precisely same.

Here it must be noted that specifically bodies of precisely same composition (suitable rubber or plastic) but of different shapes are considered or fabricated. So, the results would test the dependence of shape of bodies on third law of motion, as composition hence inherent characteristics of bodies (projectile and target) are same. As the composition is same so that the other characteristics of body do not affect the results only shape is the significant factor in experiments. Purposely the mass of all bodies of different shapes (e.g. spherical, semi-spherical, umbrella shaped, triangular, square, hexagonal, cone, long pipe, flat, irregular or any other typical shape are considered.) is regarded as same for simplicity. Thus, anomalous results would be observed due to shape of bodies only. The other bodies having different characteristics can be chosen but it may be somewhat difficult to draw concrete conclusions. Taking bodies of similar composition, the effect of other factors is eliminated and only shape would be the significant factor.

6.0 Electromagnetic Drive

The first rockets were used as propulsion systems for arrows, and may have appeared as early as in 10th century in Song dynasty China. The rocket moved forward as it emitted exhaust (as solid fuel burnt) in backward direction. Newton published third law of motion in the Principia (1686) after about 600-700 years but did not mention about launching of rockets. Russian scientist Konstantin Tsiolkovsky derived ideal rocket equation in 1903 and launching of modern rockets was initiated in 1926 by Geddard. The rocket science is extremely conceptual and complicated, but launching of rockets is based on third law as exhaust moves in backward and rocket moves in forward direction i.e. action and reaction law is applicable.

This perception of Electromagnetic Drive is fairly simple if successful may lead to re-writing basic laws of physics. A radio frequency (RF) resonant cavity thruster is a device concept that is claimed to be a future spacecraft thruster. It is purported to generate thrust by reflecting microwaves internally in the device, in violation of the law of conservation of momentum and other laws of physics. The device is also known as an **EmDrive** and has been often referred to by the media as the **Impossible Drive**. It was introduced in 2001 by Roger Shawyer. The EM Drive moves forward without any exhaust in the backward direction. But scientists find this perception inconsistent with Newton's third law of motion.

Scientists of NASA Johnson Space Center **[13]** justified the above perception and obtained thrust (1.2 millinewtons per kilowatt of thrust in a vacuum) in Electromagnetic Drive by reflecting microwaves without using exhaust (as in rockets). Whereas the same in convectional rocket is 70 ±0.1 mN/kW. So, it appears to be new humble beginning. It implies forward movement of EM prototype is without exhaust (no conventional fuel is used; only microwaves are bounced inside a closed, cone shaped cavity) which is clear violation of third law of motion.

Similar thrusts were obtained repeatedly in many other experiments but scientists doubt it (forward movement without exhaust) may be due to other unknown effects, efforts are being made to discuss possible external effects and draw concrete conclusions **[14].** But no such external effect is confirmed till date. Thus, issue is still scientifically inclusive and open for critical analysis. So, the third law of motion is being critically studied in different ways.

7.0 Speculative Or Postulatory Form Of Third Law Of Motion

The definition and equation of third law of motion implies that action and reaction are precisely equal in all cases i.e. universally. As some new experiments are being proposed so the generalized form of Newton's third law of motion has been put forth. Neither Newton nor following scientists have studied the law quantitively in some applications. So, to take effect of shape and various other involved factors the law can be generalized. Further the validity of generalized form of the law will depend on precise experimental confirmation. Newton had justified the law in specific cases (finger pushes stone, stone is pulled by horse) but its applications have been extended in many cases with expansion of scientific phenomenon.

Newton had stated second law of motion, law of gravitation, speed of sound in fluids, law of cooling etc. in proportionality form. In all above cases when laws or equations are changed to equality then constant or coefficient of proportionality comes in picture which accounts for all elusive factors. If third law is expressed in proportionality form then it becomes further useful, as coefficient of proportionality takes in account all factors which are significant but not taken in account by eq.(1). The effect of these factors can be taken in account by generalizing the Third Law of **Motion [5-10**] within domain of Newtonian Mechanics.

"To every action there is always proportional reaction, depending upon the shape, characteristics of bodies etc. of the process." Or

"the mutual actions of two bodies are proportional to each other depending upon shape and characteristics of bodies etc., and directed to contrary parts."

Thus reaction may or may not be equal to action for all interacting bodies, depending upon various involved factors.

Mathematically,

$$\text{Reaction} \;\alpha\; \text{Action} \quad \text{or} \quad \text{Reaction} = -Q\,\text{Action} \qquad (4)$$

where Q is coefficient of proportionality. It accounts for shape, characteristics of interacting bodies, nature of surface on which interactions take place i.e. all elusive factors which are not accounted for by the law. The value of Q is determined experimentally, like numerous coefficients in science. Thus there is no mathematical and conceptual rigidity in eq.(4) like in eq.(1), which implies that action and reaction are precisely equal and opposite for all bodies in all cases i.e. universally. There is no other factor in eq.(1) except action and reaction. The eq.(4) implies the action may be equal , less or more than reaction depending shape, characteristics of bodies, surface of interactions etc. The value of Q is not always unity. Hence there is just extension in the law depending upon experimental parameters to broaden scope of its applicability. The eq.(4) implies reaction may be equal, less or more than action, but eq.(1) implies the reaction is always equal to action.

Newton's law i.e. eq.(1) does not accommodate any other external factor, as it implies action and reaction must be precisely equal universally for all pairs of bodies. But generalized form implies reaction may be different from action due to other weird effects. It appears that practically in most cases in daily life, the generalized form is supported. Newton's third law is inadequately studied in such applications. The generalized form requires precise experiments for confirmation [5-10].

The reaction can be calibrated in terms of distance. If a typical body is thrown from original height 1meter and after striking floor it rebounds to distance of ½ meter; then reaction would be half. Then value of Q will be ½. If ball rebounds to same original height (1m, say) under suitable conditions then value of Q may be regarded as unity.

Thus, the generalized form just extends validity and limits of Newton's third law of motion within its domain in classical mechanics. Some experiments would confirm the generalized form of third law of motion.

8.0 One Dimensional Elastic Collisions And Shapes Of Projectiles And Targets.

In elastic collisions the linear momentum (third law of motion) and kinetic energy are simultaneously conserved. The ideal mathematical equations are based on simultaneous conservation of momentum and kinetic energy.

Let a projectile of mass m is moving with velocity $U_{initial}$ collides with target of mass M moving with velocity $V_{initial}$. After collision (as $U_{initial} > V_{initial}$) the projectile moves with velocity U_{final} and target moves with velocity final, V_{final} . Then the velocities of projectile and target after collision are determined **[15]** as

$$U_{final} = \frac{(m-M)U_{initial} + 2MV_{initial}}{(m+M)} \qquad (5)$$

$$V_{final} = \frac{(M-m)V_{initial} + 2mU_{initial}}{(m+M)} \qquad (6)$$

For simplicity symbols U and V represent velocities of projectile and target, subscripts initial and final represent velocities before and after collisions.

The simplest case is when target is at rest ($V_{initial}$ =0) or initial momentum of target is zero.

$$U_{final} = \frac{(m-M)U_{initial}}{(m+M)} \quad (7) \qquad V_{final} = \frac{2mU_{initial}}{(m+M)} \quad (8)$$

Ideal or standard conditions: It must be noted that above mathematical calculations or predictions are under ideal or handpicked conditions in textbooks. The various characteristics of bodies and surfaces are not mentioned in calculations of eqs.(5-8).

Experimental validity: For general or universal validity, the mathematical equations must be experimentally justified or confirmed under all conditions (taking all relevant variables in account) specifically.

In actual experiments projectile and target may have different shapes, compositions, sizes, magnitude, state of roughness, may interact on different surfaces etc. etc. All these factors need to be taken in account such observations are not available in the existing literature over wider range of parameters. Apparently, these equations would be confirmed in special cases only. Thus, critical discussion on third law of motion leads to other useful deductions in classical mechanics as well. The importance of such experiments (may be on third law of motion and one dimensional elastic collisions) can be realised form the fact that experiments involve conservation laws at macroscopic level.

Declarations

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Compliance with Ethical Standards.

(i) The study is self-funded. So, grant is available from anywhere.

(ii) There is no conflict of interest about this study

(iii) No animals or human experiments are involved in the research

(iv) There is only one author (submitting) of the paper.

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