Answers to Questions asked about Generalization (extension/improvement) of 'Newton's Third Law of Motion' by various scientists in 105th Indian Science Congress 2018 (16-20 March) held at Manipur University, Imphal, INDIA.

I am highly indebted to organizers of the Indian Science Congress 2018 and Sectional President, Physical Sciences Professor Manisha Gupta for providing me opportunity to present the paper.

Ajay Sharma, author, Email ajoy.plus@gmail.com Mobile 94184 50899

The question are suitably arranged for understanding and expression.

Link to Newton's Principia

Newton , Isaac *Mathematical Principles of Natural Philosophy* (printed for Benjamin Motte, Middle Temple Gate , London) pp.19-20, 1727 , translated by Andrew Motte from the *Latin*.
http://books.google.co.in/books?id=Tm0FAAAAQAAJ&pg=PA1&redir_esc=y#v=onepage&q&f=false

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Q1 How do you say Newton's third law is incomplete whereas scientists feel it is experimentally confirmed?

Ajay Sharma: Yes, Newton's law is established in many cases. It is regarded as true ALL other cases, but without quantitative experiments in many cases. The third example of Newton's third law of motion is qualitative. Newton stated applications of third law in third example without any equation. Its critical analysis reveals many things.

Earlier we understood that there are 3 or 5 planets in solar system, sometimes we say it 8 or 9 or 10. The number varies with investigations. Similarly investigation of the third law compels us to say it is incomplete not completely studied yet. There are so many examples when law is applicable but not studied quantitatively in existing literature.

I requested ISRO and NASA number of times, please give me information about 'loss in mass' / 'ejected mass' and 'velocity of rocket' at any instant as it involves third law. But the information was neither given by ISRO nor by NASA. Unless such quantitative information is not available, no quantitative conclusions can be finally drawn about third law in this regard.

We can otherwise check it ….keep a toy gun at table, fire bullet from gun (specifically by electronic methods) …note the forward momentum of bullet and backward momentum of gun. Both must be equal, this experiment is NOT reported anywhere QUANTITATIVELY. Electronic toys move without any backward emissions. NASA has reported peer review experiments in EM Drive where engine moves forward without recoil i.e. reaction less device is confirmed in 2016. Thus in many respects the law is qualitative and philosophical.

Q2. What is the basis of generalization of Newton's Third Law of Motion?

Ajay Sharma: The law is stated for all bodies but true for ideal projectile (say ball) and ideal

target (say wall). The weird characteristics and shapes of projectile and target are ignored. Newton's law is applicable for all bodies of characteristics and different shapes i.e. universally.
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, characteristics, flexibility, elasticity, plasticity, rigidity, magnitude, shape, size, distinctiveness of interacting bodies or mode of interactions, and other relevant factors.
Shapes of bodies: Spherical, semi-spherical, triangular , square , cone, long pipe, irregular etc
The action must be equal to reaction, but without quantitative experiments law is regarded as true
Drop a rubber and steel balls of mass 0.1kg , the rubber ball rebounds but steel ball does not.

Q3. What shapes and characteristics Newton justified the third law in the Principia?

Ajay Sharma: Newton applied third law of motion in general way without mentioning SHAPES and CHARACTERISTICS. So it (action =reaction, universally) is true for all shapes and characteristics. In first two examples as given in the Principia at page 20 are

(i) Let finger pushes stone, it does not move. Newton stated action of the finger is equal to reaction of the stone (Action =Reaction). When force is applied then self adjusting force of friction ($f_r = \mu R = \mu mg$) acts. The limiting force of friction becomes equal to applied force (action in Newton's law) when body is at rest but at verge of moving. Newton did not address it.

Galileo states in frictionless ($f_r = 0$ as $\mu = 0$) surface body when once set in motion, will uniformly keep on moving. Thus coefficient of friction is equally important. Newton related reaction with external push or pull and did not mention about uniform motion of body on frictionless surface, and presence of friction. Initially laws of friction were given empirically by Leonardo in 1493; further laws were rediscovered and elaborated by Amontons in 1699.

(ii) Let stone is pulled by horse, the stone does not move. Thus Newton has expressed action (push or pull i.e. force) applied on stone by finger or horse. The reaction is due to stone. Newton stated both are equal, Action= - Reaction.
These are only two examples given by Newton and law is regarded as universally true. In these two examples Newton expressed action and reaction **in terms of push or pull (force).**

(iii) In third example, Newton described collisions but qualitatively. It follows from third example that action and reaction can be measured **in terms of velocity.**

About Target

Q.4 Does target also affect reaction? Action is same in many cases. The reaction is inherently caused when projectile (first body) interacts with target (other body).

Ajay Sharma: Newton stated for every action there is equal and opposite reaction (when projectile and target interact). Newton should have mentioned about properties of target, as numerous number of targets are possible with weird characteristics. For same action, reaction cannot be same for every target (possessing different properties).

(i) When a rubber ball of mass (0.1kg) is thrown at the concrete wall. It rebounds, such that action = reaction

(ii) When the same rubber ball is hit on the cardboard with same action (depends on mass) , then it does not rebound as in case of concrete ball. The card board may be broken or torn.

Thus Newton should have mentioned the characteristics of target and projectile. Also Descartes third law of motion given in 1650 in the book Principles of Philosophy, points out about characteristics of target.

Further characteristics of target are taken in account in mathematical equations of one dimensional elastic collisions. Thus we find that characteristics of target were taken in account in understanding of collisions, before and after Newton. But Newton blatantly ignored the same.

About Action and Reaction

Q.5 How do you understand ACTION in Newton's Law?

Ajay Sharma: In first two examples Newton meant action and reaction as push or pull i.e. **force.** In the third example, Newton represented action and reaction in terms of **velocity.** Action directly depends on mass.

If we have bodies of SAME MASS (0.1 kg, say) but of different SHAPES (as defined in Question 2), pushed with same velocity then action is same. If velocity = uniform, acceleration =0 . Further S =Vt, the time t can be calculated to reach at target or rebound to original point.

Whereas when bodies of different shapes but of same mass are dropped on the surface of the earth then they fall with same acceleration (variable velocity) due to gravity i.e. 9.8 m/s^2 or weight mg or force,

However the body of double, triple or quadruple mass have double triple or quadruple force (2mg, 3mg, 4mg). When a body (irrespective of mass) falls from rest (u=0), then when it just touches the ground it has velocity, v = $\sqrt{2x9.8x1}$ = 4.23m/s

Q.6 **How do you understand REACTION in Newton's Law?**

Ajay Sharma: According to third law reaction is inherent and natural when one body acts on the other. If a ball is dropped from height 1m on the floor, then it rises to same height in same time, then is reaction is same.

Similarly if a body is pushed on the wall then it is action, if the body returns to same point in same time, then reaction is same. According to the law action and reaction are UNIVERSALLY equal. The reaction is also measured in terms of force and velocity which arise after interaction of projectile and target.

Newton gave philosophical and qualitative interpretation of the law as he did not quantitatively measure action and reaction in terms of physical quantities due to lack of mathematical and conceptual basis existing at that time.

Q.7 You have been stressing the SHAPE of body leads to deviation from the third law?

Ajay Sharma: Yes it is true.

(i) If you drop a spherical rubber ball (say mass 0.1kg) on the ground or horizontally push or throw it on the wall it strikes target in time t. It rebounds to original point in the same time, t then Action =Reaction (Newton's third law holds good).

(ii) If bodies of same mass (0.1kg) and material (rubber) are dropped on the same ground or pushed towards the same wall. But SHAPES are different e.g. semi spherical, triangle, square, cone, long thin pipe, twisted or arbitrary shapes. Then they do not rebound to same point, as reactions are different.

Thus for bodies of same material (rubber) and mass (0.1kg) posses different reactions due to different shapes. Thus reaction varies with SHAPE as other factors are precisely same. Had all bodies been risen to same height irrespective of SHAPE, then reaction would have been SAME, there would have been no need for discussion.

Q.8 Newton's third law states it is universally true for all bodies irrespective of shape and characteristics of bodies. How do you say that the CHARACTERISTICS of bodies play significant role in this regard?

Ajay Sharma: Newton stated the law in general way, for all bodies having weird characteristics. But did not discuss the issue experimentally. Newton did not change this perception right from first edition (1686) of *the Principia* in third edition in 1726 i.e. in 40 years. Thus universal equality of action and reaction are independent of shape of body and its characteristics. But it is not experimentally true.

Consider bodies of mass 100gm having different bodies may be of different inherent composition, nature, characteristics, flexibility, elasticity, plasticity, rigidity, magnitude, distinctiveness of interacting bodies, shape, size or mode of interactions, and other relevant factors etc. In spring balance, the spring used is of specific type NOT any ordinary type, thus characteristics are important.

Further bodies may be different materials e.g. wool, wood, cloth, spring, steel, rubber, wool, clay, kneaded flour, chewing gum, sponge, typical plastic, porous material, air / fluid filled artifact. In no way reaction is same in all cases as stated by Newton. If the experiments are conducted even at gross level, then action is not precisely equal to reaction UNIVERSALLY. Thus third law is violated.

Drop a rubber and steel balls of mass 0.1kg , the rubber ball rebounds but steel ball does not.

Elastic collisions on one dimensions

Q.9 You are applying Newton's third law of motion for elastic collisions in one dimensions.

Is it correct?

Ajay Sharma: Yes, scientists are already applying the third law of motion in one dimensional elastic collisions. I quote one case from the general equation, when mass of target is very-2 greater than that of projectile, and target is rest , then we get

initial velocity of projectile = - final velocity of projectile

Action =-Reaction (Third law is obeyed)

There are numerous such cases depending upon masses of projectiles and targets; and their velocities have to be experimentally determined yet. In such cases in these equations the characteristics and shapes of bodies play significant role, as in Newton's third law of motion.

In third examples Newton applied the law for colliding bodies. But no equations were given by Newton as there was no tradition for writing equations at that time.

The conservation laws were defined after Newton. The kinetic energy, work were defined in 1829 by Coriolis . So it became feasible for writing equation of colliding bodies (which Newton described in **terms of change in momentum**), but in elastic collisions the equation for colliding bodies are written in terms **of conservation of momentum and kinetic energy**. Under certain conditions both types of equations give similar results and in both cases shape and characteristics of bodies play significant role.

Q 10 What would be impact of generalization of Newton's third law of motion on science/physics?

Ajay Sharma: Firstly science is not static body, it is dynamic. The paper simply extends third law of motion to explain those examples where it is applicable but not quantitatively checked. Newton's law states shapes, characteristics etc. of projectile and target are INSIGNIFICANT, but their impact may be very significant. It does not refute the law from roots, it simply suggests experiments where law is regarded as true but not confirmed.

This discussion simply implies critical analysis of SHAPES and CHARACTERISTICS of bodies has not been carried out in numerous cases. It follows that the same is true for equations of one dimensional elastic collisions which involves conservation of linear momentum and kinetic energy.

The significant aspect is that same equations can be experimentally put to test in classic mechanics which has far reaching importance in basic laws of science.

Thus there is generalization of laws from idealization.

Comments suggestions for improvement are humbly requested (full paper pp.26 attached) :

Ajay Sharma, author : Email ajoy.plus@gmail.com Mobile 0091 94184 50899