**Questions and Answers**

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

**Q. 1 What is Newton’s Third Law of Motion as given in the Principia (1686)?**
**Ajay:** Newton defined third axiom or law of motion in *the Principia* [1] 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’*

In mathematical form

 **Reaction = - Action (universally applicable) (1**)
Newton gave two physical examples in terms of push or pull (force) as a stone is pushed by finger , and stone is pulled by horse. In both the cases Newton’s assumed that stone remain stationary and does not move, thus action = - reaction.
The mutual 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) (1)
Force exerted by body B (Reaction) = - Force exerted by body A (Action) (1)
<https://books.google.co.in/books?id=Tm0FAAAAQAAJ&pg=PA1&redir_esc=y&hl=en#v=onepage&q&f=false>
There is no reason (in definition and equation of the law) that third law is regarded as true in limited way rather than universally.

**Q.2 What did Newton mean by ‘body’ in the law?

Ajay:** Newton defined **‘Quantity of Matter’** in Definition I in para 1 of the Principia as
 product of density and volume (bulk)
and quoted examples of snow, powders and air to explain quantity of matter. 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 his law for bulky bodies (defined in Definition I).

**Q.3** **How do you claim that Newton’s third law of motion is universal in nature ?**
**Ajay :** How you can say that it is not universal but has limited nature?
This law is universal as applicable for all pairs of bodies.
**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. But the equality of action (force exerted by body A on body B ) and reaction ( force exerted by body B on body A) is not justified in all cases. It has to be done.

**Q. 4 What are applications of the law in the existing physics ?
Ajay :** Some of the applications of the law are mentioned as
(i) backward movement of gun ( may be called as reaction) when bullet is fired (action)
(ii) rebounding of ball when it strikes the wall or floor
(iii) backward motion of boat in water when person jumps from it towards shore
( vi) book remains stationary on the floor or table ( weight of book is action , force exerted by floor is reaction),
(v) launching of rocket, exhaust moves backward say action and rocket moves forward ( also see section about EM Drive where deviations from law are feebly reported)
(vi) forward movement of person (reaction) by pushing ground backward (action)
 (vii) a swimmer moves in forward direction ( reaction) when pushes water backward with arms (action ) etc.
There are many more examples. All the examples or applications of Newton’s third law of motion need to be experimentally confirmed quantitatively.

**Q.5 What specifically you want to add NEW in Newton’s 335 years old Third Law of Motion which is regraded as true by billions of people of world.**
**Ajay:** Some applications of the law need to be quantitatively studied e.g. the law is not studied quantitatively for falling and rebounding bodies of different shapes.
**Shapes of bodies:** Spherical, semi-spherical, umbrella shaped, triangular, square, hexagonal, cone, long pipe, flat, irregular or any feasible typical shape etc.
For such bodies law is not quantitatively studied for falling and rebounding bodies. In daily life observations the spherical suitable body (rubber or plastic of mass 0.2 kg, say) may rise to height 1 meter if dropped from the same height. However, bodies of different shapes (rubber or plastic of mass 0.2 kg, say) rebound to lesser heights. The action is same (0.2 g or 1.96 newton) in all cases.

**Q.6 How do you explain the effect of shapes of bodies in observations of falling and rebounding bodies?
Ajay:** Purposely the law has been generalized (within domain of Newtonian mechanics) as
*“To every action there is always proportional reaction, depending upon the shape, characteristics of bodies etc. of the interaction 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 bodies i.e. universally, depending upon various involved factors.
Mathematically,
 Reaction  Action or Reaction = - Q Action (3)
 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 or constants in science. Thus there is no mathematical and conceptual rigidity in eq.(3) like in eq.(1), which implies that action and reaction are precisely equal and opposite for all bodies in all cases i.e. universally.
 If Q =1, then Generalized equation of third law = Original Newton’s law.

**Q.7** Newton’s law is also applied for explanation motion of rocket ? What is your typical observation about it?
 **Ajay :** The History of Rockets … Newton’s law is applied to explain motion of rocket in standard text books.Initial discovery and use of rockets : **Song Dynasty 10th century .**

**Third law** of motion given by Newton in 1686 i.e. after 600-700 years.
**Hyder Ali** and Tipu Sultan used **MYSOREAN rockets** in 1761-1790.
**Tsiolkovsky** derived modern rocket equation 1903 ….it does not involve acceleration due to gravity g. Third law was used for first time
**Geddard** initiated lunching of **modern rocket** I 1926 .Roger Shawyer implied in 2001 , rocket can be launched by other method contradicting Newton’s Third Law.
NASA scientists 2016 confirmed Roger Shawyer’s method …..but under fire there may be experimental error or push is due to other reasons.
 Nothing is confirmed either way.

**Q.8. Scientists are also doubting the validity of Newton’s Third Law of Motion in Electromagnetic Drive experiments?
Ajay**: In simple words it means rockets would be launched with use of microwaves (no exhaust); rather than traditional fuel (visible exhaust). Idea was given by British Space Engineer Roger Shawyer in 2001. In 2017 NASA scientists reported experiments supporting the perception. <https://arc.aiaa.org/doi/pdf/10.2514/1.B36120>
Many experiments are conducted to validate idea finally. If it is validated then Newton’s law will be de-validated by other method.
 **Q 9 What do you finally conclude from Newton’s original form of Third law of motion and generalized form of Third law of Motion ?**
**Ajay :** Limitation of Newton’s Law :
 Neglects SHAPE of body in described experiments .
Reaction = - Action ( would be applicable for special cases only)
Improvement /modification /generalization
Reaction = - Q Action (universally applicable for all cases)Q : coefficient, accounts for all factors elusive to Third Law, can be experimentally measured.

**Ajay Sharma Mobile 95184 50 899 Email** **ajoy.plus@gmail.com**