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CONSEQUENCES OF ARISTOTLE'S ASSERTION IN FIRST PART OF NEWTON'S FIRST LAW OF MOTION

Ajay Sharma*
*Fundamental Physics Society. His Mercy Enclave, Post Box 107. GPO Shimla 171001 HP. India

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ABSTRACT

Objective: One of the fundamental propositions of Aristotelian philosophy is that there is no effect without a cause. Aristotle justified that force is continuously needed to push or pull bodies. It was contradicted by Philonopus and Buridan, and then Galileo established law of inertia. Descartes and Newton's laws are based on law of inertia. All facts are scientifically and neutrally discussed. However Aristotle's assertion appears in first part of Newton's first law of motion.

Methods/Statistical analysis: The status of Aristotle's, Galileo's, Descartes and Newton's laws is simultaneously reviewed. Basically Aristotle's observation appears to correct in practical systems i.e. when resistive forces (gravitational, frictional and atmospheric) are present. Galileo's law of inertia is applicable for system devoid of resistive forces i.e. for hypothetical systems.

Findings: Aristotle's assertion was criticized by many philosophers such as Philonopus, Buridan etc. Philonopus proposed that motion is due to kinetic force impressed by mover which exhausts gradually. Buridan proposed that motion is due to some property of body. Further Galileo expressed this property as inertia. Consequently Aristotle's assertion was abandoned. However Newton's first law simultaneously accounts for both Aristotle's assertion (first part) and Galileo's law of inertia (second part). Thus even now Aristotle's abandoned assertion is applicable now in Newton's first law of motion. We should try to re-assess its usefulness by formulating mathematical equation based on it.

Applications/Improvements: Practically F =ma is equation of force for extended part of Galileo's inertia i.e. when velocity changes (second part of Newton's law in extended form). Should scientists speculate an equation of force for first part of the law; in this case in system possesses resistive forces. In such an equation, the determination of role of resistive forces must be significant, and equation should reduce to F =ma under ideal conditions. Consequently deriving such noble equation would be definitely tedious process._In Aristotelian Physics [4-5] no such equation is mentioned for 'unnatural or forced motion' relating force with velocities, distance time and resistive forces. When distance or displacement is related with force, then it may explain some more phenomena. Thus it needs serious attempt. Thus many new perceptions are still possible in classical mechanics; some new experiments can be perceived as there is theoretical basis for new speculations. The origin of the proposed equation is consistent with first part of Newton's first law of motion which quotes the Aristotle's assertion (body preserves in its state of rest, unless it is compelled to change the state by impressed forces thereon.) Thus it is both logical and scientific.

KEYWORDS: Aristotle, Galileo, Descartes, Newton, third laws of motion.

I. INTRODUCTION

Aristotle assertion to inertia and first law of motion

Aristotle (384BC-322BC) believed in doctrine of cause and effect [1-5]. It implies that one of the fundamental propositions of Aristotelian philosophy is that there is no effect without a cause. Everything that is in motion must be moved by something. A table is pushed or pulled on the floor then it moves as long as external force acts on it. The table stops when external force ceases to act. Aristotle stated that the rest (velocity =0) is natural

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state of body, and it starts moving when by external force acts on it. Thus heavier the body more force is needed to push or pull it, which is justified in daily life observations. Aristotle and his peripatetic followers held that a body was only maintained in motion by the action of a continuous external force. Thus scientists find Aristotle's early work very significant and even quoted [4] that 'without Aristotle's *Physics* there would have been no Galileo'. Even now Aristotle's assertion is first part of Newton's First Law of Motion.

The limitations of Aristotelian assertion were also highlighted by following scientists. Practically Aristotle put two conditions on moving bodies i.e. There must be some agent who imparts motion and mover must be in contact with it**.** Then why does an arrow continue to fly after it has left the bow-string, or a stone after it has ceased to be in contact with the hand that throws it? Aristotle concluded that the air displaced in front of the projectile somehow rushes round it and pushes from behind, thus propelling the projectile along. Thus in the Aristotelian view, a projectile moving through the air would owe its continuing motion to *eddies* or *vibrations* in the surrounding medium, a phenomenon known as *antiperistasis*. In the absence of a proximate force, the body would come to rest almost immediately.

This theory was still in vogue among Aristotelians of the 16th century; however thousand years ago John Philoponus has proposed in 6th century differently and somewhat erroneously that body moves due to kinetic force which is impressed by mover which exhausts it gradually [6-7]. Any how he was the most ancient which became an ancestor to the concept of inertia.

Jean Buridan, in 14th century following in the footsteps of John Philoponus and Avicenna, proposed that motion was maintained by some property of the body, imparted when it was set in motion. Buridan named the motion-maintaining property *impetus*[8].

Moreover, he rejected the view that the impetus dissipated spontaneously (this is the big difference between Buridan's theory of impetus and his predecessors), asserting that a body would be arrested by the forces of air resistance and gravity which might be opposing its impetus. Buridan stated that impetus is product of weight and velocity. Clearly, Buridan's impetus is closely related to the modern concept of momentum. Buridan saw impetus as *causing* the motion of the object. Buridan anticipated Isaac Newton when he wrote [9]:

...after leaving the arm of the thrower, the projectile would be moved by an impetus given to it by the thrower and would continue to be moved as long as the impetus remained stronger than the resistance, and would be of infinite duration were it not diminished and corrupted by a contrary force resisting it or by something inclining it to a contrary motion.

Thus Buridan set a stage for Galileo to put forth law of inertia on the basis of experimental observations, consequently peripatetic beliefs were halted. It is interesting to note that Newton took first part of his First Law of motion as Aristotle's assertion and second part Galileo's law of inertia.

Galileo perceived experiments in hypothetical system when all resistive forces (i.e. frictional, atmospheric, gravitational etc.) are eliminated from the system, then body once set in motion always remains in state of uniform velocity (constant velocity). For example, on a long smooth glass floor a marble maintains its uniform velocity on the system where resistive forces are reduced as far as possible. Thus Galileo on the basis of such experiments perceived that a moving body maintains its constant speed in straight line unless no external force acts on it. Thus Galileo put forth that movement of body with constant velocity is natural tendency of body, and it stops due to resistive forces Galileo's law of inertia is given by [10]

"A body moving on a level surface will continue to move in the same direction at a constant speed unless disturbed."

Thus Aristotle's assertion (natural tendency of body is to remain at rest) and Galileo's law of inertia (natural tendency of body is to remain in state of uniform motion) are opposite to each other. Newton used both these in his first law of motion and being taught since centuries. Newton extended or extrapolated the Galileo's law of inertia (second part of first law of motion) when velocity is variable in second law of motion. Thus it is proposed that equation of force must be_speculated or formulated first part of Newton first law of motion i.e. Aristotle's assertion [11] as Newton derived for second part of first law of motion, extended or extrapolated form of law of inertia.

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Renne Descartes, in 1644 in his book the Principles of Philosophy gave three laws of motion [12-14] in part II in article 37, article 39 and article 40 of the book. Equivalently, Newton gave new three laws of motion after 42 years of publication of *Principles of Philosophy*. Newton wrote the famous masterpiece *The Mathematical Principles of Natural Philosophy* in 1686; and did not change the laws for next forty years i.e. in second edition 1713 and third edition 1726.

Descartes first two laws of motion are just other form of Galileo's Law of Inertia. Descartes gave third law of motion as independent of any existing law. Thus Galileo's law of Inertia constitutes the rudiments of classical or Newtonian mechanics. Thus the foundation of classical or Newtonian mechanics was laid gradually not abruptly; which is being taught over three centuries and would remain so in future.

Table I Comparison of views on force and motion of scientists/philosophers Aristotle, Philoponus, Buridan, Galileo and Newton.

Sr. No	Scientist/ philosopher	Era	Definition	Merit/ Characteristic	Region of validity
1	Aristotle	384-322BC	Force is required for motion. Resistive force >0	Table moves if pushed by mover	Motion of projectiles, move with contact with mover.
2	Philoponus	600 AD	Moves due to energy imparted. Resistive force >0	Motion of projectile	Motion is due to imparted kinetic force which diminishes.
3	Buridan	1295-1360	Slightly different from Philoponus	Same as above	Motion is due to motion maintaining property , called impetus
4	Galileo	1564-1642	Body moves with uniform velocity if resistive force =0	Ideal or hypothetical system	Not applicable if resistive forces are present, as motion is not uniform.
5	Descartes	1596 -1650	Same as in case of Galileo	Same as in case of Galileo	Same as in case of Galileo
6	Newton	1642-1727	Same as above and also body remains at rest.	Accounts for both Aristotle's assertion and law of inertia	Accounts for both Aristotle's assertion and law of inertia
7	Possible Future	Onwards	Equation must be simultaneously applicable to both resistive and ideal systems.	Proposed equation must be useful for both systems.	Should be applicable for both ideal and practical Systems.

Newton's First Law of motion acknowledges Aristotle's assertion
Everybody perseveres in its state of rest, or of uniform motion in a right line, unless it is compelled to change that state by forces impressed thereon.

Thus Newton's first law of motion has two parts.
Part I (Aristotle's Assertion)

Everybody perseveres in its state of rest unless it is compelled to change that state by forces impressed thereon.

Thus abandoned Aristotle's assertion is silently still part of basic curriculum of science.
Part II (Galileo's assertion)

Everybody perseveres in its state of uniform motion in a right line, unless it is compelled to change that state by forces impressed thereon.

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It is clear that the first part of Newton's First Law (body preserves in its state of rest, unless it is compelled to change the state by impressed forces thereon) is Aristotle's assertion and second part is Galileo's law of inertia (body preserves in its state of uniform motion in a straight line, unless it is compelled to change that state by forces impressed thereon).

The first part of Newton's first law of motion states, the body remains in state of rest (v=0) when no external force (F=0) acts on it; which is Aristotle's assertion. For example, a stone remains in state of rest on ground unless moved by applying force on it. The first part states that force (mover in Aristotelian language) is required for change the state of body from rest; it is nothing but Aristotle's assertion. It implies Aristotle's effect and cause theory i.e. no movement is possible without mover.

The second part of Newton's law assumes validity of Galileo's laws of inertia i.e. body maintains its constant velocity in absence of impressed force (F=0). Thus, Newton's first law of motion is fusion or quotation of two opposite tendencies or perceptions (abandoned and well established) already existing in literature right since days of Aristotle and Galileo.

So in Newton's first law of motion, both Aristotle's assertion and Galileo's law of inertia are contained. It is irony that Aristotle's assertion is abandoned whereas Galileo's assertion is first and foremost part of classical mechanics. If Newton's first law is basis of classical mechanics then so should be Aristotle assertion. Thus Aristotle's assertion is also integral part of Newton's First Law of Motion but not applied in any case. Should we speculate an equation of force for Aristotelian system when resistive forces are present? In Aristotelian Physics [4-5] no such equation is mentioned for 'unnatural or forced motion'. Apparently the force is related with velocities, distance time and resistive forces. As proposed now when distance or displacement is related with force, then it may explain some more phenomena, as it is not case in F=ma. However, apparently it would be in limited range only. There are many macroscopic and microscopic bizarre phenomena in universe. In the beginning the far reaching consequences are not practically evident; the same has been observed numerous occasions in science. But later on importance of scientific pursuits is realised. The equation should explain all phenomena explained by F =ma and should be able to explain all there phenomena as well, thus it should be tedious process [11].

The origin of the proposed equation is consistent with first part of Newton's first law of motion which quotes the Aristotle's assertion (body preserves in its state of rest, unless it is compelled to change the state by impressed forces thereon.) Thus it is both logical and scientific. Whereas for second part of Newton's First Law of motion (i.e. Galileo's law of inertia), Newton himself has given equation.

Newton's Second law of motion or mathematical perception of extended form of Galileo's Law of inertia
Galileo's law of inertia implies that bodies remain in state of uniform motion in straight line when no resistive force acts on the body.

It is equally possible that velocity of body is not always uniform i.e. it can be variable. How does constant velocity of body change? It is not at all addressed by Galileo's law of inertia. The force is not mentioned in statement i.e. it is kinematical in nature.

However in the second law of motion Newton gave the equation to find out the force when velocity changes due to external impressed force (dynamic in nature). So Newton described the dynamical system (force is related with moving bodies). Thus Newton visualized the state when body changes its velocity. The second law of motion as given in the Principia [13] states that "*The alteration of motion is ever proportional to the motive force impressed; and is made in the direction of the right line in which that force is impressed.*"

The prevalent mathematical form of second law of motion implies that force is equal to product of mass and acceleration i.e.

F =ma

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II. CONCLUSIONS

Aristotle stated more than two millenniums ago, the effect and cause theory i.e. force is continuously needed to move body. For example, a book moves as long as we push or pull it. To explain the motion of arrow in air, in 6th century Philonopus proposed that it moves due to kinetic force imparted to body by the agent, which gradually diminishes it. In 14th century Buridan advocated that motion of body is due to some property, known as impetus. Galileo enriched the concept with logical experiments justifying in suitable system (devoid of frictional, resistive, or atmospheric forces), body maintains its constant velocity, when no external force acts on it. Then Newton stated first law of motion, in first part Newton used Aristotle's assertion (body preserves in its state of rest, unless it is compelled to change the state by impressed forces thereon) is and in second part is Galileo's law of inertia (body preserves in its state of uniform motion in a straight line, unless it is compelled to change that state by forces impressed thereon). So Newton's first law of motion is nothing but re-quotation of two contrary tendencies from existing literature. Aristotle assertion implies rest is natural tendency of body and Galileo's inertia is based on the fact that motion is natural tendency of body. Now next genuine question is why Aristotle's abandoned assertion is first part of Newton's first law of motion? Obviously it still has some usefulness in some cases; we should try to highlight the same [15]. In Aristotelian Physics [4-5] no such equation is mentioned for 'unnatural or forced motion'. The force is related with velocities, distance time and resistive forces of the system.

In second law Newton extended Galileo's law of inertia when velocity varies and related as F =ma (prevalent form of second law of motion). Science is not static body. Should scientists speculate an equation for force for Aristotle assertion in presence of resistive forces (frictional, gravitational, atmospheric etc.) when mover moves the body? Now for second part, the prevalent equation is F =ma. Thus newly proposed equation for first part of Newton's first law of motion must reduce to F =ma when resistive forces do not exist, otherwise must lead to noble results and explain phenomena in existing physics. This equation must reduce to F =ma, in absence of resistive forces and should also give logical results (explaining some other observed phenomena) when resistive forces are present. Consequently deriving such noble equation would be definitely tedious process._In Aristotelian Physics [4-5] no such equation is mentioned and this problem is studied under the heading 'unnatural or forced motion'. Thus it would be serious attempt. It in view of the most sophisticated experimentation and theoretical analysis available till date whole situation can be re-assessed and may lead to noble results. Thus theoreticians and experimentalists can still speculate new perceptions in classical mechanics and extend its horizons.

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