Universal Physics Journal

Article V: The Mutual Force Rule

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Publication Date: April 26, 2001
Revision Date: February 22, 2004

Purpose

Article V is an investigation into the mutual force rule whereby each force, of an mutual pair of forces, is predicted to always act on a different object and therefore never do both of these mutual forces act upon the same object. For certain this popular rule places strict limits on our thoughts and therefore our understandings regarding the effect upon objects of the forces present during an event, especially an accelerational one. My goal in Article V is to determine if the mutual force rule is a valid rule.

Article V

In PRINCIPIA, Isaac Newton presents us with a good example where the mutual force rule might be said to apply. In reference to his LAW III regarding mutual forces, Newton describes the event where a horse is pulling on one end of a length of rope with the other end tied to a stone. The pull from the horse is sufficiently strong to cause the stone to be dragged at a steady pace along the ground. In this non-accelerative event, Newton tells us that:
"... the horse will be equally drawn back towards the stone; for the distended rope, by the same endeavor to relax or unbend itself, will draw the horse as much towards the stone as it does the stone towards the horse, and will obstruct the progress of the one as much as it advances that of the other." [1]

(2) During this stone dragging event, at the point where the rope is attached to the horse, the horse is bearing on the rope with a forward-directed force that is equal in magnitude and opposite in direction to the rearward-directed mutual force that the rope is bearing on the horse. The same exchange of mutual forces between objects occurs at the point where the rope is attached to the stone. Here the rope is bearing on the stone with a forward-directed force that is equal and opposite to the rearward-directed mutual force that the stone is bearing on the rope. At this point, when considering the forces present between two contacting objects, the mutual force rule appears to be valid.

(3) Now consider that the mutual force from the horse that is causing the stone to slide along the ground is being transferred in a serial manner along the entire length of the rope to the stone. Just as we have located this forward-directed force at the interface between the horse and the rope, and again at the interface between the rope and the stone, if we choose to study the rope along its entire length, we will notice, as did Newton, that the rope exhibits certain "distended" characteristics that indicate that opposing tension forces are hard at work along its strands. These characteristics are not exhibited when the tension forces in each direction are absent, allowing the rope to remain in a relaxed state. Yet, while under tension, at any point along the rope's length, the forward-directed mutual force from the horse, being transferred back along the rope to the stone, is equally opposed by the rearward-directed mutual force from the skidding stone, being

transferred forward along the rope to the horse. Here the force from the horse and the mutual force from the stone are opposing each other when tested at any point along the same affected object, with that object being the "distended" rope.

(4) Has the mutual force rule failed us so soon? It's prediction that mutual pairs of forces always affect different objects definitely is not true when one considers the forces present at any point along the "distended" rope's length that is located between the rope's two end points. Here it is clear that the mutual force rule only remains valid if one restricts the testing of forces present during an event to the point of contact between two objects. This means that in order to remain valid, the mutual force "rule" needs to be supplemented with a second rule regarding where the mutual force rule applies and where it does not apply and therefore, when it is valid, and when it is not valid. But then of what real value is a "rule" that is wrong at least half of the time?

(5) Before abandoning the mutual force rule as being a rule without merit, I want us to consider how this rule is commonly applied during an accelerative event. Take a stone of manageable size and using a 1/4" diameter masonry bit, drill a 1 inch deep hole in the stone, insert a plastic expansion plug, and screw a metal eyebolt firmly into the stone. Test to see if the eyebolt is secure by inserting a long screwdriver through the eye and pulling sideways on the shank of the screwdriver, while pushing on the stone with a force equal to several times the weight of the stone. Be prepared for the expansion plug to fail during this test. Next tie one end of a light rope to the eyebolt and fashion a large loop in the other end of the rope about 2 to 3 feet from the stone. Now swing the stone in a circle about your person by pulling in a leading manner on the loop in the rope. Once up to a comfortable speed, maintain a constant rate of rotation for the stone. While whirling the stone in a circle, feel and think about the mutual pairs of forces you and the stone are experiencing. Merely reading of this event is not sufficient. It is much better to personally perform this event to complete your experience and understanding of the forces present, provided that you are in possession of all your limbs and are generally in good health.

(6) A force is described in Physics as a "vector" quantity since it has both magnitude and direction. If a force had only magnitude, it would be classified as a "scalar" quantity such as temperature. While whirling the stone, the mutual pairs of forces you are concerned with are the inward-directed forces and the outward-directed forces. These are often referred to as centripetal forces (center seeking) and centrifugal forces (center fleeing). To eliminate confusion, I will use inward-directed and outward-directed when referring to these forces. It is paramount that you understand that these terms refer to nothing more than the direction of the force. An inward-directed force on the stone does not mean that the stone will actually move closer to you during this whirling event. Likewise, an outward-directed force on the stone does not mean that the stone will actually move farther away from you. Inward-directed and outward-directed simply mean that the stone is experiencing forces impressed in these two opposite directions relative to the stone's axis of orbit about your person while the stone's radial distance from this axis remains unchanged.

CAUTION

(7) Perform this experiment at your own risk. Do not attempt it without wearing protective gear such as shoes, long pants, a long-sleeved coat, gloves and a well-padded motorcycle riding

helmet. Do not perform this whirling event over a hard surface, such as concrete. Instead, always perform it over a soft surface such as a level grass lawn. You will experience a dizzy feeling during and after the event that could cause you to lose your balance and fall to the ground. If you think falling to the ground might cause you harm then do not perform this experiment. Instead, ask someone else to perform it while you observe. Then discuss with them the forces experienced. It is important that you ensure that observers of this event maintain a safe distance from the event should the rope be released or the stone pull loose while at speed. A distance of 60 feet should provide a good margin for safety while viewing this event.

(8) In order to accelerate the stone in an orbital manner about your person, you will need to lead the stone with your hand in the direction of orbit. This speeds up the stone by providing a forward-directed component of the inward-directed mutual acceleration/Action force you are applying to the stone. Once up to speed, you will find that only a small degree of "leading" will be required to cancel air friction and thereby maintain the stone's speed and rate of rotation around the circle. When you decide it is time to bring this whirling event to an end, you will need to purposefully slow the stone's speed by trailing it with your hand. This slows the stone's speed around the circle by providing a backward-directed component of the inward-directed force you are applying to the stone.

(9) When you have set up the whirling stone experiment and taken all the precautions, begin whirling the stone about your person by pulling on the rope in a leading manner. Once up to a comfortable orbital speed, notice how you have to lean back in order to keep from tipping forward in the direction of the stone. Also notice that the faster the stone orbits the circle, the harder you must pull on the stone. The inward-directed acceleration/Action force you are applying to the rope is predicted by Newton's absolute force formula, Force = mass * velocity ^2 / radius. Assuming you maintain the stone at a constant radius from the axis of orbit by lengthening your arm at the higher velocity, if you double the stone's orbital velocity, the inward-directed action force you must apply to the stone will increase by the square of the stone's velocity to a magnitude four times its former value! If you could possibly double the stone's velocity a second time it is unlikely you could continue providing the required inward-directed acceleration/Action force which is now sixteen times its initial magnitude!

(10) As you whirl the stone about your person, is it not clear to you that your inward-directed mutual force is opposed by the stone's outward-directed mutual force? The faster you rotate, the harder you have to pull inward on your end of the rope, the harder the stone pulls outward on its end of the rope. Understand that this outward-directed force from the stone is directly proportional to the magnitude of the acceleration that the stone is experiencing. Double the stone's orbital velocity about the circle's axis and the stone's rate of acceleration will increase by four times. As its rate of acceleration increases by four times, so does its outward-directed acceleration/Reaction force increase by four times. This direct link between the stone's acceleration rate and its acceleration/Reaction force is undeniable evidence that the stone's reaction force is an acceleration/Reaction force just as I predict.

(11) We do not need to look with complex thoughts to the distant stars, as did Mach and Einstein, in search of an explanation to the cause of the stone's a/R force. We only need to look

with simple thoughts at the stone's rate of acceleration as the indicator of the magnitude of the action force that is causing the stone's acceleration, according to the formula Force = mass * acceleration, and finally to the Universal Law of Mutual Forces which tells us that the inward-directed pull of the rope on the stone's eyebolt is exactly equal to the outward-directed pull of the stone's eyebolt on the rope.

(12) Now you may think, at this point in our investigation, that the mutual forces present between the rope and the eyebolt are proof that the mutual force "rule" is indeed a valid rule. Furthermore, since these mutual forces are acting and reacting on the different objects of the rope & the stone's eyebolt, you may think that mutual pairs of forces always act on different objects. Nothing could be further from the truth. Understand that this opinion remains valid only if one never looks for mutual forces at any other place than at the mutual point of contact between any two objects. To purposefully limit one's analysis of mutual action and reaction forces by only investigating the presence of mutual external forces at mutual points of contact between objects is to purposefully limit one's understanding of the important role mutual action and reaction forces play in all manner of Universal events.

(13) For example, during this accelerative event, supporters of the mutual force rule first compare the equality of the inward-directed acceleration/Action force the rope is applying to the stone's eyebolt, to the outward-directed acceleration/Reaction force the stone's eyebolt is applying to the rope. They then use the mutual force rule to support their decision that this pair of action and reaction forces are affecting different objects. Using this decision as a basis, they then decide that there is but one inward-directed force acting on the stone, being the action force from the rope, with no force being present that is acting or reacting in the outward-direction on the stone. It is in this manner that supporters of the mutual force rule use this rule in support of the "net force" theory regarding the manner in which they think an acceleration/Action force can cause acceleration for matter.

(14) Here you can see how the mutual force rule provides support for the "net force" theory of acceleration. But in practice, is this flow of logic correct? We already know that supporters of the mutual force rule only look at these mutual forces as being present at the mutual point of contact between the rope and the stone's eyebolt. Since they see these mutual forces as affecting different objects, this curious bit of logic tells them that the inward-directed mutual acceleration/Action force being transferred by the rope on out to affect the stone somehow passes by the outward-directed mutual acceleration/Reaction force being transferred by the stone on in to affect the rope. Accepting that the rope's mutual force has passed by the stone's mutual force at their mutual point of contact with each other, supporters of the mutual force rule think it is logically justifiable to accept that from this mutual point of contact outward, the inward-directed force from the rope is free to affect the stone's matter without having to interface with any remaining portion of the stone's outward-directed force. To think in this manner is to ignore the fact that no force can ever exist without directly interfacing against an equal force (Newton's LAW III).

(15) The "... always affect different objects." portion of the mutual force rule is causing these supporters to mistakenly think that once the a/A force of your pull on the rope has passed

outward beyond the mutual point of contact between the rope and the stone's eyebolt, this inward-directed a/A force somehow becomes unopposed as it causes inward-directed acceleration for the stone. Not only is this "unopposed" assumption false, it is counter to Newton's LAW III and the Universal Law of Mutual Forces whereby there can exist no "unopposed forces". There is a basic misunderstanding of forces at work here.

(16) The truth is that your inward-directed acceleration/Action force cannot "get past" the stone's outward-directed acceleration/Reaction force at the mutual point of contact between the rope and the stone's eyebolt to act in the assumed unopposed manner of a "net force" upon the stone's matter from that point on. No, just as at every point inward along the entire length of the rope where your inward-directed force is equally opposed by the stone's (and the rope's) outward-directed force, at every point outward beyond the juncture between the rope and the stone's eyebolt, the remaining portion of your inward-directed mutual force continues to find equal support in the remaining portions of the stone's outward-directed mutual force. In Article IV we have come to know this outward-directed mutual force as the stone's absolute acceleration/Reaction force, or a/R force, that varies in direct proportion to the absolute acceleration being experienced by the stone, or portions thereof.

(17) To demonstrate how equal and opposite mutual forces are present deep within the whirling stone, suppose we divide the stone in two with the inner half remaining attached to the rope and the outer half attached to the inner half via a short closed-coil tension spring. Now, as you whirl this divided stone around in a circular orbit, neglecting the spring's matter, all should agree that as much as the stone's inner half pulls with an inward-directed acceleration/Action force against the outer half, causing inward-directed acceleration for this outer half, the outer half pulls with an outward-directed acceleration/Reaction force of equal magnitude against the stone's inner half. Proof of the presence of both of these opposing forces is indicated by the "distended" tension spring. Thus all should agree that you have proved there to exist an outward-directed force being applied to the stone's inner half by the stone's outer half. Understand that this outward-directed force is present regardless of whether the stone is divided in two or left whole. Dividing the stone in two simply makes it easier to detect the presence of the mutual action and reaction forces that are equally present deep within the undivided stone.

Conclusion

(18) Realize now that you have just proved that there is indeed an outward-directed force bearing on the stone's inner half. This fact alone stands as proof that mutual forces, equal in magnitude and opposite in direction, are mutually present deep within the whirling, undivided stone making the "mutual force rule" every bit as invalid as the "net force" theory of acceleration.

(19) The truth of the forces present in this whirling event becomes clear when you understand that your acceleration/Action force and the stone's (and rope's) acceleration/Reaction forces provide equal support for each other at any point you choose to investigate along any of the objects in the series. Instead of looking in a faulty manner with the thought that the acceleration/Action force somehow gets past the acceleration/Reaction force to effect on its own an object that lies outward and beyond the point of inspection, one needs to look at this whirling event with the understanding that no matter where one chooses to inspect for the presence of

forces along the series of whirling objects, the forces one finds will always be mutual pairs of forces that are equal in magnitude and opposite in direction. This is always what will be found, in perfect agreement with Newton's LAW III and the Universal Law of Mutual Forces.

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References

[1] Sir Isaac Newton, 1686, 1729, Mathematical Principles of Natural Philosophy and His System of the World, 1934, 1962, PRINCIPIA, University of California Press, Berkeley, Los Angeles, London, page 14.

Author's Commentary

I do not know who is the original author of the "mutual force rule". I do know that this invalid "rule" did not spring from the pen of Isaac Newton. Perhaps it came from a committee of relatively modern scientists and educators concerned with justifying the equally invalid "net force theory of acceleration." Whatever its source, all references to the terms of the "mutual force rule" need to end.

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