On the Theory of Special Relativity and Motions in the Universe

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Abstract

The Theory of Relativity is based on the hypothesis of the universal constancy of light velocity. Albert Einstein observed that light travel times over identical lengths of moving and stationary rods were not simultaneous in his imaginary experiment. He concluded that those light travel events must be simultaneous because the same physical facts should be the same regardless of the motions of the observation frames. He pointed out that different light velocities for those rods were responsible for the non-simultaneity. Then, for simultaneity, he asserted the same light velocity *c* for both rods. This was Einstein's justification for the universal light velocity for all observers. However, the stationary and moving rod cases were actually two different events because of the aether-like setting of his stationary coordinate frame. The same light velocity *c* for both rods as set for the coordinate system means both rods are stationary on the stationary coordinate system. No rods are moving. Likewise, the universal light velocity *c* means everything in the universe is fixed to the stationary coordinate system. Nothing moves in that universe. The Doppler Effects of light waves cannot exist if light velocity is universally constant. The Doppler Effects of electromagnetic waves are real life evidence refuting the universal light velocity. He made light velocity the absolute and universal invariant, but that made all physical facts variants. The theory of relativity postulates velocity dependent time, geometry, mass, etc. These controversies are reviewed in detail herein. The review proved that the classic Newtonian mechanics are correct with the preservation of the physical fact invariance. The Newtonian mechanics found no clock synchronicity issue at all in Einstein's experiment. Experiments by Michelson-Morley, Fizeau, Kennedy-Thorndike, etc. are validations of Newtonian mechanics. Immanuel Kant and W. Hoffman noted that motions of bodies are mere potentials with respect to observation references, suggesting the impossibility of universal velocities. No universal motion suggests no universal governance in the universe. Event locality is further evidenced in Newton's bucket example. The laws of conservation in physics are consequences of event locality and independence. Newton's Shell Theorem explains that the event locality is from the featurelessness of an infinite uniform universe. Rotational motions of celestial systems are perpetual and inevitable local stability mechanisms in the non-influential global universe. A finite universe would suffer from non-uniformity and instability. The Epicurean universe is determined to be the most satisfactory universe model.

Key Words: Relativity, Motion, Universe

Notes: Unless specifically noted, the words "velocity" and "speed" are interchangeably used herein without distinguishing a vector from a scalar.

1. Introduction

James Clerk Maxwell postulated in his famous publication "A Dynamical Theory of the Electromagnetic Field" [2] that light travel is the travel of undulation waves of the aether, and the speed is determined by the property of the aether. Maxwell's light travel in the aether is consistent with typical medium reliant wave travel, and the velocity is a property of the medium and, therefore, has to be constant relative to the medium aether. Maxwell concluded that the light travel velocity in the aether is electromagnetic properties of the aether as in the following equation:

$$V = \sqrt{\frac{k}{4\pi}\mu}.$$

Where, V is the speed of light waves with respect to the aether, k is the ratio of electromotive force to the electric displacement properties of the aether, and μ is the magnetic permeability of the medium aether. Note that k and μ are response properties of the aether, respectively, to electric and magnetic fields, and, therefore, V is also a property of the aether. Maxwell back calculated the value of k for the aether using the experimentally measured speed of light in air by Léon Foucault after reviewing several other measurements available at that time. Foucault's value of light speed was 298,000,000 m/sec, which is remarkably close to the recent international consensus of 299,792,458 m/sec.

The above equation can be rewritten in more familiar modern form as,

$$c = \sqrt{\varepsilon\mu}. \tag{1-1}$$

Where, the constant $\varepsilon = \mathrm{k}/4\pi$ is the permittivity of the medium aether. As V in the previous equation, light velocity c is a property of the aether and has to be constant with respect to the aether.

The aether was then believed to fill the universe, permeating all matters, and postulated as isotropic and homogeneous in the property. It was also believed that the aether is static throughout the universe and cannot be moved or dragged by motions of anything. Therefore, the aether is, in fact, the absolute coordinate system of the universe. Note that, if the aether can be dragged by object motions, light travel paths in a vacuum around objects in motion would be dragged accordingly. There had been no evidence of such light dragging by moving objects in a vacuum (the aether).

Although the aether was speculated to be unmovable and non-dragging, Maxwell thought the aether could be vibrated ("undulated") by electromagnetic waves so that light travel was possible. Therefore, Maxwell's speed of light is finite, constant, and the same in any direction since those are properties of the aether. But that would be only with respect to the universally static aether. All moving objects in the universe should have motions relative to the universally stationary aether, and, therefore, the velocity of light for any moving object cannot be c of Equation (1-1). If light velocity is c for any object, the object must be stationary with respect to the aether. Therefore, if the velocity of light is a universal constant c for all objects, all objects are stationary with respect to the aether, and there would be no moving objects in the universe.

In the article "ON THE ELECTRODYNAMICS OF MOVING BODIES" [1], Einstein dismissed the existence of the aether or any privileged coordinate system such as Newton's absolute universal coordinate system or universally static aether. In Reference [1], Einstein determined that the velocity of light is a finite universal constant c for all inertial frames in the universe. This is indeed an unimaginable logical leap, since the statement contradicts the very definition of velocity in physics. Velocity of anything is defined with respect to a specific reference, as Maxwell's light velocity is relative to the reference aether. All reference frames may be in different motions relative to each other. Therefore, velocity of anything has to be different with respect to different inertial states of each frame. This is true whether there is aether or not. Einstein's universally constant light velocity is in violation of this classic logic of velocity. If any object velocity is universally constant, all objects in the universe are in identical motions relative to that object, no relative motions among all other objects, and the universe is motionless.

The hypothetical moving rod experiment in Section 1 of Reference [1] was to justify the universal constancy of light velocity. In that moving rod experiment, oddly, Einstein chose the light travel times between two clocks as the method to determine clock synchronism. Einstein decided the clocks are synchronized if the beam travel times between two clocks satisfy the following equation:

$$t_B - t_A = t'_A - t_B.$$

Where, t_A is the time by Clock A when the light ray is pulsed out initially from Clock A that is attached at one end of a rod, t_B is the time by Clock B when the ray hits Clock B that is fixed at the other end of the same rod and reflected back, and t'_A is the time by Clock A when the reflected ray returns back to Clock A.

Further and critically, Einstein set the velocity of light as constant c relative to his stationary coordinate system in all directions, just like light travels in the aether, although he declared no aether existence. With this light velocity setting, the above clock synchronicity criterion would be valid only when the rod and the clocks on it are fixed stationary on his stationary coordinate system.

If the clocks are on the same rod, but now the rod is moving relative to the stationary coordinate system, the equation cannot be satisfied even if the clocks are in perfect synchronicity. As expected, Einstein found the following light travel times for the moving rod case:

Time for forward light travel, Clock A to Clock B: $t_B - t_A = \frac{r_{AB}}{c-v}$

Time for backward light travel, Clock B to Clock A: $t'_A - t_B = \frac{r_{AB}}{c+v}$.

Where, the velocity of the moving rod is v relative to the stationary coordinate system and the length of the rod is r_{AB}.

Obviously, the above two different results are because they are indeed two different physical events. The first case is the case that the rod is fixed to the stationary coordinate system, and the light speed relative to the rod has to be the same c set as a constant for the stationary coordinate system. On the other hand, the second case is the case that the rod is moving relative to the stationary coordinate system at velocity v, and the light velocity relative to this moving rod cannot be the same c set as a constant with respect to the stationary coordinate system. This is the same as the constant light velocity with respect to the stationary aether in which light velocity cannot be the same c for any moving object relative to the aether.

However, Einstein believed these two events had to be the same, although they could not be so. His rationale was that the same physical events could not produce different results, regardless of the motions of the observation frames. In fact, they were not the same events because of the light velocity set as a constant with respect to his stationary coordinate system. Moreover, the light travel times were not even evaluated relative to the motions of the observation frames. Light travel times between two points have to be evaluated from the perspective of traveling light, as he did correctly here. But his observation comment was incorrect when he related the light travel times with the motions of observation frames. Obviously, this is a mistaken observation.

Without realizing this mistaken observation, Einstein determined that the velocity of light relative to the moving rod has to be also c. This is another astonishing mistake. It is obvious that, if the light speed is c for the moving rod, the moving rod is also fixed to the stationary coordinate system, not moving at all. Now, both rods are identically fixed to the stationary coordinate system.

Likewise, if the light velocity is a universal constant *c* for all objects in the universe, all objects are stationary with respect to Einstein's aether-like stationary coordinate system. Then, there would be no relative motions among objects in the universe. Although Einstein rejected the existence of the aether and the universal coordinate system, his stationary coordinate system is exactly the same as the aether and the universal coordinate system. Therefore, if the light velocity is a universal constant, all objects are fixed stationary on his stationary coordinate system, except light. All these mistakes appear to be due to his misconstrued nature of velocity.

Doppler Effects of electromagnetic waves are wave frequency differences sensed by moving observers due to wave velocity differences for the moving observers. Therefore, if any wave velocity is universal for all inertial observers, there would be no wave velocity differences for all observers and no Doppler Effect of the wave. Doppler Effects are quite familiar real life experiences with all waves, including lights. Therefore, the Doppler Effects of electromagnetic waves are real proofs of rejecting the universal light velocity. It seems that this was the reason why Einstein worked so hard on the relativistic Doppler Effects of light waves to deal with this obvious controversy. However, in reality, the relativistic Doppler Effects are senseless since the relativistic universe is motionless and universal wave velocity would not produce Doppler Effects. Discussion of motion induced Doppler Effects in the motionless relativistic universe is senseless by itself.

Any theory based on a faulty premise or proposition would inevitably produce contradictions. Einstein's proposition of the same light velocity *c* for the moving rod is based on the rationale of physical fact invariance. Here, physical fact invariance for all observers is true, but the same light velocity *c* for the moving rod was faulty. Certainly, these two cannot coexist without contradictions. The theory of relativity postulates velocity dependent variation of fundamental physical quantities such as time, geometry, mass, etc. Now, the theory of relativity may be said to be based on the rationale of physical fact invariance for all observation frames, but the resulted theory produces physical fact variances by velocities of observation frames. The theory itself contradicts the rationale for the theory. The faulty premise here is the universal light velocity. As the final observation, Einstein defined the light velocity as invariance for all but made all physical facts as velocity dependent variants. Moreover, those physical fact varying motions are taking place in the motionless universe!

Einstein's imaginary moving rod experiment is re-examined in detail in Section 2. Section 2.1 reviews Einstein's analysis of the experiment. Section 2.1.1 revisits Einstein's presentation on the moving rod experiment as in Reference [1] for the baseline discussions. Section 2.1.2 discusses issues found in Einstein's presentation with extended remarks. Section 2.2 re-analyzes the hypothetical experiment in detail with Newtonian mechanics. Reanalysis in Section 2.2.1 assumes there is no aether. Section 2.2.2 repeats Section 2.2.1 analysis but assumes there is the aether to examine the effects if it exists. In these two sections, two more inertial cases are added to the original Einstein's two cases in order to broaden the comprehension. Section 2.3 is the concluding observation on the re-analyses.

Both Section 2.2.1 and Section 2.2.2 found that, when the classic Newtonian mechanics were applied, the stationary and moving observers agreed completely on the light travel times for all light travel legs in all cases. These re-examination analyses proved that physical facts are indeed invariant, regardless of the existence of the aether or the motions of observation frames. Also, the analyses showed the fact that the velocity of light is not a universal constant. The re-examination analyses affirmed the classical vector addition principle of Newtonian mechanics.

Section 3 reviews some experimental reports, such as Michelson's aether experiment, that have been regarded as evidence validating the theory of special relativity. The review concludes that the validation claims are unjustifiable. Instead, all those experiments proved that there is no aether in the universe, the light travel is autonomous, and the experimental results are consistent with classical vector addition mechanics. At the same time, those experiments are in verifications of analyses in Section 2.2. The section also concludes that the Doppler Effects of electromagnetic waves are proven evidence of different light velocities for observers in different motions.

The theory of relativity has influenced modern physics so profoundly. However, the theory is based on an obviously illogical proposition, the universal constancy of light velocity, and brought physics to an unimaginable realm. All those seem to be the results of misconstrued velocity. Considering the profoundness, Section 4 explores a wide range of related subjects in an attempt to clarify the true nature of velocity. The explorations include the fundamentals of the travel of waves and material objects, the truth of motions and velocities, forces and motions, interactions, the influence of the universe on event kinematics, models of the universe, etc. The exploration concludes that the non-disjunctive nature of velocities, as stated by Kant, is correct, and the non-disjunctive nature is from the featurelessness of the universe. Such a universe is the Epicurean universe as described by the Greek philosopher Epicurus. Newton's shell theorem provides explanations that the Epicurean universe is such a universe with eternal stability. The featurelessness of the universe cannot determine or influence the locations or kinematics of anything in it. Event locality, independence, and laws of conservation are determined to be inevitable consequences of the Epicurean universe.

The discussions in this article do not require elaborate mathematical treatments, and, therefore, they are replaced with more plain narrative explanations. Also, mathematical treatments of the subjects are commonly available in many textbooks and publications, although their implications and interpretations may differ from this article. Reciting those mathematical treatments is avoided as much as possible. Instead, all descriptions herein are to the fundamentals and elementals as much as possible in order to include logical descriptions more broadly for a wider range of readers. Also, some subject particulars are repeated in an attempt to inter-relate subjects in consideration as they are. This article is a comprehensive review of velocity, since misconstrued velocity seems to be the common source of confusion not only in the theory of relativity but also in many other theoretical and experimental endeavors in physics.

2 Re-examination of Einstein's Hypothetical Moving Rod Experiment

2.1 Einstein's Analysis of Moving Rod Experiment

2.1.1 Einstein's Analysis as in Reference [1]

In Reference [1], Einstein set the following premises as given for his analysis of the imaginary moving rod experiment:

(1) The laws of physics are invariant for all reference frames and translation motions thereof.

> **"1. The laws by which the states of physical systems undergo change are not affected, whether these changes of state be referred to the one or the other of two systems of co-ordinates in uniform translatory motion."**

(2) The velocity of light is a constant *c* relative to the stationary coordinate system in any direction and independent from the inertial states of the emitting body.

> **"2. Any ray of light moves in the "stationary" system of co-ordinates with the determined velocity c, whether the ray be emitted by a stationary or by a moving body."**

(3) All locations and motions are per Newtonian mechanics, Euclidian geometry, and Cartesian coordinate space.

(4) There is no aether or absolute coordinate system in space.

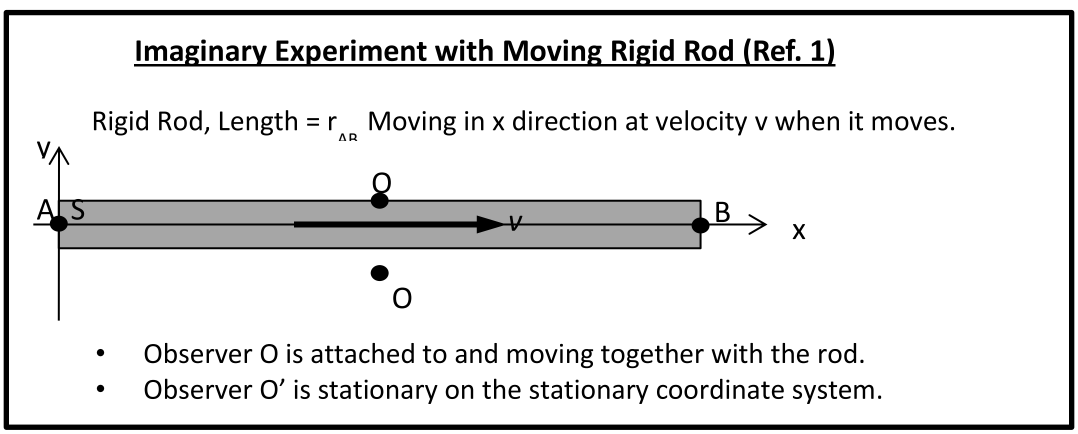
(5) The "stationary coordinate system" is the reference for locations and motions of matters in the experiment.

Figure 1 below is a visualization of Einstein's imaginary moving rod experiment. Clock A is fixed at End A of the rod, and Clock B is at End B. Therefore, the distance between Clock A and Clock B is the rod length r_{AB}. Observer O' is off the rod and stationary with the stationary coordinate system, and Observer O is on the rod and moving together with the rod as well as with the clocks when the rod is in motion relative to the stationary coordinate system.

Einstein used light travel times between two clocks as the criteria to determine the synchronicity of the clocks. According to Einstein, a light ray pulses out from Clock A at time t_A by Clock A toward Clock B, the light beam hits Clock B and reflected back at time t_B by Clock B, and arrives back at Clock A at time t'_A by Clock A. Then, the two clocks are synchronized if the following equation is satisfied:

$$t_B - t_A = t'_A - t_B. \qquad (2\text{-}1)$$

Figure 1 Einstein's Imaginary Experiment



When the rod was stationary, both Observer O and Observer O' confirmed the length of the rod and the synchronicity of clocks A and B per Equation (2-1).

Now, when the rod is moving at a velocity v along the x-coordinate of the stationary frame in the positive direction, Einstein calculated the light ray travel times as observed by Observer O on the moving rod as follows, as in Section 2 of Reference [1]:

$$\left.\begin{array}{l}\text{Time for forward travel, Clock A to B:} \quad t_B - t_A = \frac{r_{AB}}{c-v} \\ \text{Time for backward travel, Clock B to A:} \quad t'_A - t_B = \frac{r_{AB}}{c+v}\end{array}\right\} \qquad (2\text{-}2)$$

Where, the velocity of light is constant *c* with respect to the stationary coordinate system.

According to Einstein, Observer O on the moving rod declared that the clocks are not synchronized since Equation (2-2) does not satisfy the synchronicity criteria of Equation (2-1). Einstein wrote on the Observer O finding as follow:

> "Observers moving with the moving rod would thus find that the two clocks were not synchronous, while observers in the stationary system would declare the clocks to be synchronous."

In this note, it is clear that Observer O with the moving rod judged the light travel events based on the moving rod, while Observer O' stationary with the stationary coordinate system judged based on the stationary rod. Their observations are on each different event. For traveling light beams, the velocity of the light beam with respect to the stationary rod is c since the rod is stationary on the stationary coordinate system and the light velocity is set as constant c with respect to the stationary coordinate system. On the other hand, when the rod is moving at a velocity $+v$ relative to the stationary coordinate system, the light velocity with respect to the moving rod would be $c - v$ for the light travel from Clock A to Clock B and $c + v$ for the travel from Clock B to Clock A. This is because the light velocity was set as a constant c in all directions with respect to the stationary coordinate system.

However, somehow, Einstein observed the results as follow:

> "So we see that we cannot attach any absolute signification to the concept of simultaneity, but that two events which, viewed from a system of co-ordinates, are simultaneous, can no longer be looked upon as simultaneous events when envisaged from a system which is in motion relatively to that system."

Einstein set Equation (2-1) as the clock synchronicity criteria. The clock synchronicity was confirmed when the rod was stationary. But, his analysis in Equation (2-2) showed the clock synchronicity is no longer true per the criteria Equation (2-1) when the rod is moving.

Einstein declared this could not be real because identical physical events had to be identical regardless of the motions of observation frames per Premise (1). He pointed out that the reason for the discrepancy was that the light velocity for the moving rod was different from c. In order to have both events identical per the clock synchronicity criteria in Equation (2-1), he decided the light velocity for the moving rod should also be c.

As the result, the velocity of light became the same c for both rods as well as for the stationary coordinate system. Now, nothing is moving here, except the light. Without recognizing this, he concluded that the light velocity had to be a universal constant for all inertial observers in the universe. This is the hypothesis of the theory of special relativity.

2.1.2 Discussions on Einstein's analysis of the Hypothetical Moving Rod Experiment

Einstein's stationary coordinate system as defined in Premise (2) is exactly Maxwell's aether in Section 1 above. The stationary coordinate system is an absolute universal coordinate system, as the aether is. At the same time, Premise (4) denies the existence of the aether or any privileged coordinate system such as an absolute or universal coordinate system. Therefore, Premise (2) cannot co-exist with Premise (4) in the same analysis.

Einstein's clock synchronicity criteria Equation (2-1) can be true only if the rod and the clocks on it are stationary on the aether-like stationary coordinate system. The criteria cannot be true if the rod and clocks are in motion relative to the stationary coordinate system. Einstein's stationary and moving rod cases are two different events for the traveling light because of Premise (2).

Note that both Equation (2-1) and Equation (2-2) are perspectives of traveling light, which are correct for analysis of light travel times between two clocks. However, Einstein viewed these equations as observations of the stationary and moving frames, respectively. That is a confusion of him on the analysis perspectives. In here, Equation (2-1) and Equation (2-2) are correct for the analysis objective, but his confusion determined that the results are inconsistent with the principle of physical fact invariance.

If the aether-like Premise (2) is ignored, Newtonian vector addition mechanics would find the velocity of the light beam emitted from Clock A is the same c relative to the rod and both clocks on the rod for any observation frame whether the rod is moving or stationary due to physical fact invariance. Therefore, if Newtonian mechanics were applied correctly, both observers would see the light travel times satisfying Equation (2-1) for both cases. The return light travels would be the same. There would be no clock synchronicity issues from the first place. Obviously, Einstein's clock non-synchronicity issue for the moving rod case is simply because of Premise (2), which is in conflict with Premise (4).

Even with the conflicts and erroneous observations, Einstein determined light velocity with respect to the moving rod had to be the same c, the same as for the stationary rod. That would make the moving rod stationary with respect to the stationary coordinate due to Premise (2). That means $v = 0$ in Equation (2-2). The moving rod is not moving and becomes identical to the stationary rod. There is no moving rod anymore in this experiment. Likewise, if the light velocity is c universally for all objects in the universe, all objects are motionlessly fixed to the Einstein's aether-like stationary coordinate system. No moving object in the universe is unreal.

A further mistake of Einstein is the introduction of the coordinate transformation in the later section of Reference [1], which is basically the Lorenz transformation. The transformation maps the entire universe to the world where the velocity of light is universal invariant c. In that transformed universe, the light velocity is the ultimate velocity limit per the Lorenz factor. As a result, all physical facts and all fundamental quantities of physics become velocity dependent variants. The mathematical impression in the transformed universe may be valid only within that universe. That may not be true in the real world without back transformation to the real world. However, his endeavors in his theory of relativity were consistently within the transformed world, without back transformation to the real world. Therefore, all the results of his endeavors may not be true in the real world. The velocity dependent variations of physical facts and quantities in the transformed world are in conflict with real world physics. This is another of Einstein's mistakes.

For example, let's say the velocity of a flying bird at 20 meters per second is set as c in Einstein's transformed universe. Everything would be the same in his theory of relativity except that light velocity is now replaced with flying bird velocity. Then, the bird velocity would become the ultimate velocity that no velocities can exceed in that world. But, that would not be true in the real world. The magnitude of light velocity is one of many possible magnitudes of velocities, and it should not be privileged to change the logic of physics just because of the magnitude. Even if the bird's flying velocity is c in Premise (2), Einstein's analysis in Section 2.1.1 would be the same. Where, it is clear that the magnitude of velocity is irrelevant in the logic. Obviously, the privileged light velocity is yet another misjudgment of Einstein in mathematics and the logics of physics. As a result, fundamental quantities of physics such as time, geometry, mass, etc. became velocity dependent variants, in conflict with Premise (1).

For further clarity on the hypothetical moving rod experiment, let's consider a more common and obvious example. Imagine a train of 100 meters long from the front tip to the rear end is traveling at a velocity of v_{train} m/sec on a flat straight track. The train velocity v_{train} m/sec is defined with respect to the track. Let's mark the front end of the train as point b and the rear end as point a. Also, let's mark points *a'* and *b'* on the track such that the two points are 100 meters apart. The train travels in the direction from *a'* toward *b'*.

Case 1) A cannon is placed at point *a'* on the ground next to the track, and the cannon shoots out a cannon ball *A'* toward point *b'* at the exact moment that train rear end point *a* passes by point *a'* on the track. Let's say the cannon ball muzzle velocity is v_{ball} m/sec, $v_{ball} \gg v_{train}$. For simplicity, assume there is no air resistance or gravity affecting the cannon ball travel velocity or trajectory. Then, the velocity of the cannon ball would remain constant v_{ball} and the trajectory would be horizontal, parallel to the track. Let's say the time the cannon ball departs the muzzle is $t_{a'} = 0$. The cannon ball would arrive at point *b'* on the track at time $t_{b'} = 100/v_{ball}$ and then at point *b* on the front end of the train at time $t_b = (100 + v_{train}t_b)/v_{ball} \rightarrow t_b = 100/(v_{ball} - v_{train})$. Obviously, the cannon ball reaches point *b'* on the track first and then point *b* on the front tip of the train. Cannon ball *A'* arrival time at points *b'* and *b* cannot be simultaneous. The arrival of the cannon ball at point *b'* and point *b* are two different events because these two points are at two different locations when the cannon ball arrives at them. This is because the cannon ball velocity v_{ball} is constant with respect to the track and point *b'* stays at the same location on the track while point *b* on the train moves to another location during the time of the cannon ball travel. For the traveling cannon ball, the travel distance from point *a* to point *b* is longer than the distance from point *a'* to point *b'*.

The cannon ball travel in this example from point *a'* to point *b'* on the ground is analogously the same as light travel from Clock A to Clock B on the stationary rod of Einstein's hypothetical experiment, and cannon ball travel from point *a* to point *b* on the moving train is the same as the moving rod case. The track is equivalent to Einstein's stationary coordinate system. The constant velocity v_{ball} of the cannon ball with respect to the track is equivalent to the constant light velocity *c* with respect to the stationary coordinate system of Einstein's hypothetical experiment, except the light ray is much faster than the cannon ball. Magnitudes of velocities would not change the logic of velocity in physics. As shown in this train example, the light beam arrival times at Clock B on the stationary rod and Clock B on the moving rod cannot be simultaneous if the velocity of light is constant *c* with respect to the stationary coordinate system. With so set light velocity *c*, Einstein's simultaneity proposition that the light beam travels for the moving and stationary rods is incorrect. That would be possible only when the moving rod is also stationary with respect to the stationary coordinate system, which is $v = 0$ in Equation (2-2).

For further analysis, without considering reasonableness, there may be four possible alterations to the scenario in order to have simultaneous cannon ball arrivals at b and *b'*. They are as follows:

Case 2) **Two cannon balls** - The first is that another identical cannon ball *A* is shot from point *a* at the rear end of the train, exactly synchronized with the cannon ball shot *A'* from point *a'* on the ground. The muzzle velocities of both cannon balls are identical. Then, the arrival of cannon ball *A* at point *b* would be exactly synchronized with the arrival of cannon ball *A'* at point *b'*, but different cannon balls would arrive at these two different points.

This two cannon ball case is analogously identical to Einstein's hypothetical experiment, without Premise (2). The Newtonian mechanics of light travel in Section 2.2.1 is the same as in this two cannon ball case. This means that, if Einstein applied the Newtonian vector addition mechanics correctly, there would be no clock synchronicity issue in the first place. But, contrary to Premise (3), he did not. Premise (2) was the cause of his clock non-synchronicity.

Case 3) **Stationary train** – The second case is that the train is not moving at all, that is $v_{train} = 0$ and point *a* at the train rear end is fixed exactly at point *a'* on the track. Obviously, the train front end point b is fixed at point b' on the track as well. This case is the same as when Einstein set $v = 0$ for the moving rod in Equation (2-2). In this case, the cannon ball arrival times at points b and b' would be synchronized for any cannon ball shot from anywhere in the universe since the two points are collocated. Therefore, the velocity of the cannon ball or the location of the cannon would be meaningless. This is the same as constant light velocity c for all inertial frames in the universe, the same as defining all frames are stationary and the universe is motionless. The results would be the same whether the cannon ball velocity is of light or of a flying bird.

Case 4) **Infinite cannon ball velocity** - The third case is that the velocity of the cannon ball is infinite. If the cannon ball velocity is infinite, the cannon ball arrival time at points b and b' will be exactly identical at the moment of the cannon ball's departure from the muzzle, regardless of the location of the cannon. The cannon ball would be everywhere on the trajectory all at once at the exact moment of the shot. Therefore, the location of the cannon or the destination points would be meaningless in this discussion. Infinite velocity is not a velocity at all but omnipresence at the same moment.

Case 5) **Variable length of train or track** - Lastly, the cannon ball may arrive at points b and b' simultaneously if the track or the train length is stretched or shrunk accordingly to satisfy the condition of simultaneous cannon ball arrival time. This stretching or shrinking is mapping to the desired condition and is equivalent to the Lorenz transformation. This may be possible only in a mathematically transformed world and is not possible in the real world.

Einstein's conjecture of universal constancy of light velocity may be true if and only if one of the conditions of cases 3), 4), or 5) is reality. However, none of these cases can be true in the real world.

For Maxwell, the travel velocity of light waves is a property of the aether. There is no logical discrepancy in the constant light velocity c relative to the aether if the aether exists as postulated. Maxwell was completely consistent with the classical mechanics of wave travel in media. Therefore, if the aether exists, the light speed for any moving observer would be different from c. Einstein's stationary coordinate system is exactly the same as Maxwell's aether. But, Einstein denied the aether without realizing that his stationary coordinate system is actually the aether. That was the reason why the light speed c for the stationary rod cannot be the same c for the moving rod. Equation (2-1) and Equation (2-2) are two different events and cannot be simultaneous.

2.2 Re-Examination of Einstein's Hypothetical Experiment by Newtonian Mechanics

2.2.1 Travels of Lights

Section 2.1.2 raised several issues in Einstein's analysis of the moving rod experiment. The discussions to this point should raise the seriousness sufficiently since the experiment was Einstein's justification for universally constant light velocity. Considering the profound impacts of the theory of relativity on modern physics, the experiment deserves a close re-examination.

Velocity of anything is the time rate of location changes relative to a specific observation reference. For illustration, the location of Object A with respect to Object B is mutually identical to the location of Object B with respect to Object A at any moment. Therefore, the velocity of Object A in reference to Object B is exactly identical to the velocity of Object B with respect to Object A at any time. This is classical Newtonian mechanics, in which velocity is defined as a mutual inertial state between two points (two objects).

Travels of all matters in the universe may be categorized by the travel mechanics. They are medium reliant travel and autonomous travel. These two travel kinematics can be readily recognized by the ability to travel in a vacuum. Medium reliant wave travel is the propagation of disturbance waves in the medium and, therefore, is possible only within the medium. Medium reliant waves cannot travel in a vacuum since there is no medium to be disturbed in a vacuum. On the other hand, autonomous traveling matters can travel in a vacuum because they do not need mediums to travel.

An example of medium reliant travel is Maxwell's light travel in the aether. Where, the light velocity c is a property of the aether, as shown in Equation (1-1), and constant only with respect to the aether. On the other hand, a typical example of autonomous travel may be the travel of bullets. Bullets can travel without any medium. Velocities of autonomously traveling entities are constant with respect to the origins and remain unchanged if no hindrances exist after their departure from the origins.

Regardless of the travel mechanics, light velocity $\vec{v}_c$ for any observer may be expressed per Newtonian vector addition as follow:

$$\vec{v}_c = \vec{c} + \vec{v}_s. \tag{2-3}$$

If light travel is autonomous, $\vec{c}$ is the velocity of light relative to the emanating origin, and $\vec{v}_s$ is the velocity of the emitting origin relative to the observer. If light travel is medium reliant, as Maxwell's light waves in the aether, $\vec{c}$ is the velocity of light relative to the medium, and $\vec{v}_s$ is the velocity of the medium with respect to the observer. Therefore, Equation (2-3) is a general description of light velocity for either case of the travel mechanics and is consistent with Newtonian velocity vector addition mechanics.

Light was postulated as waves by the Huygens school of scholars and as corpuscles by the Newtonian schools. More recently, inspired by Max Plank [3], light has been postulated to have so called "heuristic" properties [4, 6, 7, 10, 11]. Juliana Mortenson realized that Plank's constant (divided by 1 second of time in the frequency definition) is the universal energy content of a single cycle of electromagnetic waves [6]. In other words, the energy content contained in one cycle of any electromagnetic wave is universally identical, regardless of the frequencies. She appropriately named the energy contained in one cycle of electromagnetic waves as the "universal energy packet". This observation strongly suggests the quantum property of light waves, the corpuscle-like property. Therefore, tentatively at this time, light has dual properties for some reason: the wave properties of Huygens-Fresnel and the corpuscle like properties of Newton. In any case, evidences of modern physics suggest that there is no aether and light can travel in a vacuum. Therefore, light wave travel can be easily recognized as autonomous.

Also, light waves can be viewed as oscillating Gauss field fluxes in strength and polarity as originated from oscillating sources. In this view, the properties of electromagnetic fields are directly related to the emitting origins, and the field travel velocity c has to be with respect to the origin. Gaussian electric and magnetic fields can propagate in a vacuum. Therefore, this view also characterizes light travel as autonomous.

In view of electromagnetic waves as Gauss fields, the applicability of some current wave theories to electromagnetic waves may need to be reconsidered. Some of the wave theories are based on the mechanics of medium reliant waves and may be incompatible with the autonomous mechanics of electromagnetic waves.

Christiaan Huygens elaborated on the finiteness of light speed based on the analysis of Ole Rømer [9]. Huygens rejected the infinite light velocity theory by René Descartes, a longtime family friend. Rømer's analysis was based on the eclipsing time of the innermost satellite of Jupiter as observed from the Earth.

The finiteness of light speed is also increasingly evidenced in modern times by many measurements since then. Also, the Doppler Effects of light waves suggest the impossibility of infinite light wave velocity. Further, as discussed in Section 2.1.2, infinite velocity is not a velocity.

For completeness, Einstein's moving rod experiment is re-examined by both light travel mechanics. Section 2.2.3 assumes that no aether exists in the universe. On the other hand, Section 2.2.4 assumes the existence of the aether. The classic Newtonian vector addition mechanics are applied in both sections.

2.2.2 Premises for the Re-examination Analyses

The analysis in this section defines the followings as given:

(1) **Velocity**: Velocity is the observation of a mutual inertial state between two bodies. If Object A sees another Object B moving at velocity $+v$ relative to Object A, Object B would see Object A is moving at velocity $-v$ relative to Object B. Where, it is not possible to determine which of these two bodies is truly in motion, and the motions of the objects are determined only in relative terms. If a third Body C observes the velocity of any of the former two, let's say Object A, then the velocity of Object A observed by Body C is a vector sum of the velocity of Object B relative to Body C and the velocity of Object A relative to Object B.

(2) **Stationary Coordinate System**: The stationary coordinate system herein is a Cartesian coordinate system. The location and motion of the stationary coordinate system are arbitrary in the space. This coordinate system is the base reference for the analysis in this section.

Stationary Rod: The stationary rod of length r_{AB} is stationary with respect to the stationary coordinate system, and the length is aligned with the x-coordinate of the stationary system. End A of the rod is attached at the coordinate origin $x = 0$, and End B at $x = r_{AB}$ of the coordinate system. Clock A is on End A of the rod and Clock B on End B.

Stationary Observer: The stationary Observer O' is stationary with respect to the stationary coordinate system and the stationary rod.

(3) **Moving Coordinate system**: The origin of the moving coordinate system is attached at End A of the moving rod, as shown in

(4) Figure 1, and the x-axis is aligned with the x-axis of the stationary coordinate system. Therefore, the motion of the moving coordinate system is always the same as the moving rod.
Moving Rod: The moving rod of length r_{AB} is aligned with the x-axes of both the stationary and moving coordinate systems and moving along the x-coordinate of the stationary systems at velocity $+v$ with respect to the stationary systems. Clock A is on End A of the rod, and Clock B on End B. Therefore, the moving rod is always stationary on the moving coordinate system.

Moving Observer: The moving Observer O is on the moving rod and moving with the rod, as well as with clocks on the rod. Therefore, for Observer O, the moving coordinate system is stationary, and the stationary coordinate system is moving at velocity $-v$.

(5) **Autonomous Light Travel for Section 2.2.3**: Section 2.2.3 analysis assumes there is no aether in the universe. Therefore, the observed light velocity is per Equation (2-3), $\vec{v}_c = \vec{c} + \vec{v}_s$, in which $\vec{c}$ is a finite constant velocity c with respect to the last point from which the light was emitted, and $\vec{v}_s$ the velocity of the last light emitting point with respect to the observer or the observation reference.

(6) **Medium Reliant Light Travel for Section 2.2.4**: Analysis in Section 2.2.4 assumes there is the aether in the universe. Therefore, the observed light velocity is per Equation (2-3), $\vec{v}_c = \vec{c} + \vec{v}_s$, where $\vec{c}$ is a finite constant velocity c that is with respect to the medium aether, and $\vec{v}_s$ the velocity of the aether with respect to the observer or the observation reference.

(7) **Initial Light Launching Point S**: Point S is added as the light beam initial launching point in order to decouple the rod motions from the motion of the initial light beam origin. Therefore, the motions of Clock A and Point S are independent from each other, but they are collocated at the origins of both coordinate systems at the time t_A of the initial light launch.

Forward Light Travel: Light beam forward travel is from the initial launching Point S to Clock B at End B of rods.

Backward Light Travel: The ray backward travel is reflected light travel from Clock B to Clock A.

(8) **Analysis Cases:** In addition to the Einstein's two cases, the re-examination adds two more cases for comprehensiveness. The following four cases are chosen for analyses:

Case 1 Stationary Initial Ray Launch Point S and Stationary Rod

Light source Point S:	Stationary. Fixed at the origin of the stationary coordinate.
Clock A:	Stationary. Fixed at origin of the stationary coordinate.
Clock B:	Stationary. Fixed at $x = r_{AB}$ of the stationary coordinate.

Case 2 Moving Initial Ray Launch Point S and Stationary Rod

Light source Point S:	Moving. Fixed at End A of the moving rod.
Clock A:	Stationary. Fixed at origin of the stationary coordinate.
Clock B:	Stationary. Fixed at $x = r_{AB}$ of the stationary coordinate.

Case 3 Stationary Initial Ray Launch Point S and Moving Rod

Light source Point S:	Stationary. Fixed at the origin of the stationary coordinate.
Clock A:	Moving. Fixed End A of the moving rod.
Clock B:	Moving. Fixed End B of the moving rod.

Case 4 Moving Initial Ray Launch Point S and Moving Rod

Light source Point S:	Moving. Fixed at End A of the moving rod.
Clock A:	Moving. Fixed End A of the moving rod.
Clock B:	Moving. Fixed End B of the moving rod.

2.2.3 Reanalysis of Einstein's Moving Rod Experiment – No Aether in the Universe

Einstein's moving rod experiment is reanalyzed in this section by Newtonian velocity vector addition mechanics. The analysis details are in Appendix A, and the resulting light travel times are summarized in Table I below. Appendix A assumes there is no aether in the universe.

As shown in the table, the moving and stationary observers agree completely on the light travel times for both forward and backward light travel legs in all four cases. The complete agreement of moving and stationary observers demonstrates the invariance of the facts of physical events. No clock synchronicity issues are found, contrary to Einstein's analysis in Section 2.1.1. Appendix A conclusively reaffirms the Newtonian vector addition principle for light travels by concurrence with the physical fact invariance.

Case A1 and Case A4 of Table I are, respectively, the same cases as the stationary and moving rod cases of Einstein's hypothetical experiment. The identical light travel times of these two inertial cases, as shown in the table, are a clear exhibition of physical fact invariance for any inertial observers. That is because Case A1 and Case A4 are indeed identical physical events. Case A1 is a stationary rod case for the stationary observer but moving for the moving observer, and Case A4 is a moving rod case for the stationary observer but stationary for the moving observer. As noticed here, these two cases are the same events but observed from two different inertial perspectives. Analysis in Appendix A confirms these two cases are indeed identical and proves the physical fact invariance.

The analysis in Appendix A shows no clock synchronicity issue. Einstein's clock non-synchronicity in Section 2.2.1 was caused by his aether-like stationary coordinate system. The light velocity *c*, set as a constant in all directions in the stationary coordinate system, cannot be the same c for the rod moving with respect to the stationary coordinate system. Einstein's post-analysis application of the constant light velocity *c* for the moving rod was an additional and even more critical error. As a result, the moving rod became stationary on the stationary coordinate, not moving, the same as the stationary rod.

Table I shows identical return light travel times from Clock B to Clock A for all four cases for both observers. This is because all four return leg cases are physically identical for the traveling light beams. In all these return light legs, the light emitting origin, Clock B, is stationary with respect to the rod and destination point Clock A. In the perspective of the light destination point Clock A, the velocity of the light emitting origin Clock B is always stationary, and $\vec{v}_s = 0$ in Equation (2-3). Therefore, light velocities for Clock B and Clock A are identically $\vec{v}_c = -c$ in all these cases. The light travel distances from Clock B to Clock A are also the same rod length in all these cases. The same light velocity over the same distance resulted in the same light travel times. Also, this observation suggests that the return light travels from Clock B to Clock A are not influenced by the light travel histories prior to being reflected from Clock B or the motions of the rod as long as Clock A and Clock B are stationary to each other.

These logics are consistent with the experimental results of Michelson, Michelson-Morley, Kennedy-Thorndike, etc. In each light travel leg, the light entrance point and the light exit point remained stationary to each other regardless of motions of their devices. The light travel legs in their experimental devices never changed throughout their experiments, irrespective of their device rotations or movements of the Earth. The absence of the aether and autonomous light travel mechanics were the true reasons for their experimental results. There cannot be any other result if the Newtonian mechanics is correct for the light travels and there is no aether. Their experiments demonstrated solidly that light travel is autonomous and follows Newtonian mechanics as in Equation (2-3).

Case A2 and Case A3 of Table I show different light travel times for the forward travel legs, from Point S to Clock B. The reason is the different motions of destination points Clock B relative to the source Point S. These cases demonstrate that light velocities are not universal for all inertial observers when the light travel is autonomous as proven.

Appendix A proved that Einstein's observations in Section 2.1.1 on the hypothetical moving rod experiment were irrational in various aspects of physics as well as in mathematics. The review of analyses in Appendix A concludes the following:

(1) There is no aether.

(2) Light travel is autonomous.

(3) Light travel mechanics obey the Newtonian vector addition principle.

(4) In a vacuum, light travel velocity is constant with respect to the origin, which is concurrent with Gauss field propagation.

(5) The results of experiments, such as Michelson's aether experiment, etc., are evidence of (1) through (4) above.

(6) Velocity of light is not universal for all inertial observers.

Table I Light Travel Times between Clocks, Re-Analysis of Einstein's Moving Rod Experiment

(No Aether Existence, Summary of Appendix A)

Case A1 Light launching point, Point S: Origin of stationary coordinate Location of Clocks A and B: On the stationary coordinate			
	Event Time Duration	**Observer O′** (on Stationary Coordinate)	**Observer O** (on Moving Rod Coordinate)
Forward ray travel	$t_B - t_A$	Equation A1a.1 $\frac{r_{AB}}{c}$	Equation A1b.1 $\frac{r_{AB}}{c}$
Backward ray travel	$t'_A - t_B$	Equation A1a.2 $\frac{r_{AB}}{c}$	Equation A1b.2 $\frac{r_{AB}}{c}$
Case A2 Light launching point, Point S: End A on the moving rod Location of Clocks A and B: On the stationary coordinate			
	Event Time Duration	**Observer O′** (on Stationary Coordinate)	**Observer O** (on Moving Rod Coordinate)
Forward ray travel	$t_B - t_A$	Equation A2a.1 $\frac{r_{AB}}{c+v}$	Equation A2b.1 $\frac{r_{AB}}{c+v}$
Backward ray travel	$t'_A - t_B$	Equation A2a.2 $\frac{r_{AB}}{c}$	Equation A2b.2 $\frac{r_{AB}}{c}$
Case A3 Light launching point, Point S: Origin of stationary coordinate Location of Clocks A and B: On moving rod			
	Event Time Duration	**Observer O′** (on Stationary Coordinate)	**Observer O** (on Moving Rod Coordinate)
Forward ray travel	$t_B - t_A$	Equation A3a.1 $\frac{r_{AB}}{c-v}$	Equation A3b.1 $\frac{r_{AB}}{c-v}$
Backward ray travel	$t'_A - t_B$	Equation A3a.2 $\frac{r_{AB}}{c}$	Equation A3b.2 $\frac{r_{AB}}{c}$
Case A4 Light launching point, Point S: End A of the moving rod Location of Clocks A and B: On moving rod			
	Event Time Duration	**Observer O′** (on Stationary Coordinate)	**Observer O** (on Moving Rod Coordinate)
Forward ray travel	$t_B - t_A$	Equation A4a.1 $\frac{r_{AB}}{c}$	Equation A4b.1 $\frac{r_{AB}}{c}$
Backward ray travel	$t'_A - t_B$	Equation A4a.2 $\frac{r_{AB}}{c}$	Equation A4b.2 $\frac{r_{AB}}{c}$

2.2.4 Reanalysis of Einstein's Moving Rod Experiment – Effects the Aether Existence

Section 2.2.4 is added to examine the effects of the aether on the analyses in Section 2.2.3 if it exists. The analysis details are in Appendix B, and the resulting light travel times are summarized in Table II below. Appendix B applies the Newtonian mechanics for light travel in the medium aether as in Equation (2-3).

Even with the aether, Table II shows that both the stationary and moving observers agree on light travel times for all four cases. Appendix A and Appendix B together demonstrate that physical facts are invariant regardless of the motions of observation frames or the existence of the aether.

The light travel mechanics applied in Appendix B are the Newtonian vector addition mechanics for the medium reliant light travel in the aether, as postulated by Maxwell in Equation (1-1). Equation (2-3) for Appendix B is $\vec{v}_c = \vec{c} + \vec{v}_s$, where, $\vec{c}$ is the light velocity with respect to the aether and $\vec{v}_s$ is the aether velocity relative to the observer.

A stationary coordinate system K is inserted in Appendix B. The coordinate system K is the observation reference, which is differentiated from the aether and can move relative to the aether. Note that Einstein's stationary coordinate system in Section 2.1.1 is exactly the aether itself. On the other hand, the stationary coordinate system K in Appendix B is analogous to any moving object in the universe, such as a point on the Earth surface that moves relative to the aether.

Let's assume the stationary coordinate system K is placed somewhere on the Earth surface with the x-axis oriented in any arbitrarily chosen direction but tangent to the curvature of the Earth surface. If the velocity of the Earth surface at that point is $+V$ relative to the universally static aether in the $+x$ direction of K, the velocity of the aether (the aether wind) is $\vec{v}_s = -V$ relative to that point of the Earth and with respect to the coordinate system K. Then, the velocity of the aether for an Observer O' who is stationary with K would be also the same $-V$. If the velocity of light with respect to the aether is $\vec{c} = \pm c$, with the "+" and "-" signs corresponding to the direction in the x-coordinate of K, Observer O' would see the light velocity per Equation (2-3), $\vec{v}_c = \vec{c} + \vec{v}_s = +c - V$ when the light travel is in the $+x$ direction and $\vec{v}_c = \vec{c} + \vec{v}_s = -c - V$ when the light travel is in the $-x$ direction. If another Observer O is moving at velocity $+v$ in the $+x$ direction relative to the stationary coordinate system K, it can be said that the system K is moving at velocity $-v$ in the perspective of Observer O. Then, the observed light velocity for Observer O would be $\vec{v}_c = \vec{c} + \vec{v}_s = +c - V - v$ if the light travel direction is in $+x$ direction. and $\vec{v}_c = \vec{c} + \vec{v}_s = -c - V - v$ if the light travel direction is in the $-x$ direction of K. These light velocities are applied in Appendix B.

Here, if $V = 0$ in Table II, the coordinate system K is stationary with respect to the aether and becomes the aether itself. Then, the light velocity $\vec{c}$ would be relative to the aether as well as to the coordinate system K and also with respect to the Earth surface where K is located. In this case, the coordinate system K is identical to Einstein's stationary coordinate system in Section 2.1.1. Then, the velocity of the aether with respect to the Earth surface is zero, and the Earth is stationary with respect to the aether. Table II shows that, if $V = 0$, Case B1 is exactly the same as Einstein's stationary rod case Equation (2-1) and Case B4 is the same as Einstein's moving rod case Equation (2-2). Again, this comparison shows clearly that Einstein's stationary coordinate system is the aether. As shown by Case B1 and Case B4, if $V = 0$, the light travel velocities for the stationary rod and moving rod cannot be simultaneous. Applying the light velocity c to the moving rod, which Einstein did, is the same as setting the rod stationary relative to the stationary coordinate. That is also the same as setting the Earth stationary relative to the aether. This Einstein's decision seems to be due to confusions on mechanics and velocities. Then, Einstein extended the same mistaken logic to the universal light velocity for all objects in the universe and made the entire universe motionlessly fixed on his aether-like stationary coordinate system.

Albert Michelson performed experiments to measure the motion of the Earth relative to the aether [17]. Michelson presumed the Earth is moving relative to the universally static aether and light travel velocity in the aether is a constant *c* in any direction. Therefore, in Newtonian mechanics, the velocity of a light ray relative to the Earth should be different from *c*. Michelson expected to find motions of the Earth surface with respect to the aether if he measured light velocity differences in different directions on the Earth surface. However, his experiment did not produce any evidence of light velocity differences in different orientations of his device. The null results of the experiment suggest no Earth motion relative to the aether or no aether at all.

Analyses in Appendix A and Appendix B offer clear explanations about the null results of Michelson's aether experiment. The forward light travel from Point S (Clock A) to Clock B in Case A1 and Case B1 is equivalent to Michelson's observations before his device rotation, and the backward light travel from Clock B to Clock A is equivalent to Michelson's observations after his device rotation by 180 degrees. Case A1 shows identical light travel times for both directions, meaning the same light velocity in both directions of the light travel. On the other hand, Case B1 shows different light travel times for forward and backward travels, meaning different light velocities. Michelson observed no fringe changes before and after the device rotation by 180 degrees. That means no light travel velocity differences before and after the device rotation, which is consistent with Case A1 and disagrees with Case B1. This comparative review concludes that Michelson's observation, no fringe changes by device rotations, was because there was no aether and the light travel was autonomous as in Case A1.

Further, Case A4 also shows identical light travel times as Case A1 for both light travel directions. No light travel differences between Case A1 and Case A4 suggest light travels are identical over the rod lengths whether the rod is in motion or not, as long as the light emitting origin and the destination point in the legs remain stationary to each other. The light emitting origins and the destination points (light entrance points and light exit points) of all light travel legs of Michelson's device remained stationary to each other in all device rotations or motions of the Earth. Therefore, there could not be any light travel changes, and, therefore, there could not be any fringe change by rotating the device. This comparative examination suggests that Michelson's device rotations could not produce any fringe changes because there is no aether in the universe.

On the other hand, analysis of the same case in the aether environment, shown in Case B1 of Table II, produces clear light velocity differences between forward and backward light travels. Also, Case B1 and Case B4 comparisons suggest that, if the aether exists, light travel times over the same rod would be different if a rod is in motion. This is inconsistent with Michelson's experimental observation.

The results of Michelson's experiment are significant since the experiments proved the non-existence of the aether and verified the validity of the Newtonian mechanics of autonomous light travel. Also, Michelson's experiment is a mutual verification with Section 2.2.3.

Table II Light Travel Times between Clocks, Re-Analysis of Einstein's Moving Rod Experiment (With Aether Existence, Summary of Appendix B)

The Reference Stationary Frame K is in Motion relative to Medium Aether at Velocity V.

Case B1 Light launching point, Point S: Origin of stationary coordinate Location of Clocks A and B: On the stationary coordinate			
	Event Time Duration	**Observer O′** (on Stationary Coordinate)	**Observer O** (on Moving Rod Coordinate)
Forward ray travel	$t_B - t_A$	Equation B1a.1 $\frac{r_{AB}}{c-V}$	Equation B1b.1 $\frac{r_{AB}}{c-V}$
Backward ray travel	$t'_A - t_B$	Equation B1a.2 $\frac{r_{AB}}{c+V}$	Equation B1b.2 $\frac{r_{AB}}{c+V}$
Case B2 Light launching point, Point S: End A on the moving rod Location of Clocks A and B: On the stationary coordinate			
	Event Time Duration	**Observer O′** (on Stationary Coordinate)	**Observer O** (on Moving Rod Coordinate)
Forward ray travel	$t_B - t_A$	Equation B2a.1 $\frac{r_{AB}}{c-V}$	Equation B2b.1 $\frac{r_{AB}}{c-V}$
Backward ray travel	$t'_A - t_B$	Equation B2a.2 $\frac{r_{AB}}{c+V}$	Equation B2b.2 $\frac{r_{AB}}{c+V}$
Case B3 Light launching point, Point S: Origin of stationary coordinate Location of Clocks A and B: On moving rod			
	Event Time Duration	**Observer O′** (on Stationary Coordinate)	**Observer O** (on Moving Rod Coordinate)
Forward ray travel	$t_B - t_A$	Equation B3a.1 $\frac{r_{AB}}{c-V-v}$	Equation B3b.1 $\frac{r_{AB}}{c-V-v}$
Backward ray travel	$t'_A - t_B$	Equation B3a.2 $\frac{r_{AB}}{c+V+v}$	Equation B3b.2 $\frac{r_{AB}}{c+V+v}$
Case B4 Light launching point, Point S: End A of the moving rod Location of Clocks A and B: On moving rod			
	Event Time Duration	**Observer O′** (on Stationary Coordinate)	**Observer O** (on Moving Rod Coordinate)
Forward ray travel	$t_B - t_A$	Equation B4a.1 $\frac{r_{AB}}{c-V-v}$	Equation B4b.1 $\frac{r_{AB}}{c-V-v}$
Backward ray travel	$t'_A - t_B$	Equation B4a.2 $\frac{r_{AB}}{c+V+v}$	Equation B4b.2 $\frac{r_{AB}}{c+V+v}$

2.5 Summary of Section 2

It was shown that Einstein's observations on his hypothetical moving rod experiment, as in Section 2.1, were erroneous from the hypotheses to the conclusions. Einstein's aether-like stationary coordinate system caused the non-simultaneity of light travel times for the stationary and moving rods in his hypothetical moving rod experiment. Without recognizing this fact, Einstein stated that the non-simultaneity could not be true for the same physical events in accordance with the physical fact invariance. In fact, the stationary and moving rod events were two different events due to his aether-like stationary coordinate system. The two different inertial events cannot be the same. Disregarding this physical reality, he decided the light velocity with respect to the moving rod had to be the same c to satisfy his irrational clock synchronicity criteria. That was another mistake since, then, the moving rod also became stationary to his stationary coordinate system. Again, he did not realize this mistake either. Rather, he extended the constant light velocity c for all objects in the universe. Now, all objects in the universe have become stationary on his aether-like stationary coordinate system. The entire universe became motionless. The universe of the theory of relativity is a motionless universe except for lights. Obviously, this is unreal.

The theory of relativity made light velocity an invariant for all, and, as the result, all fundamental quantities of physics became velocity dependent variables. This is irrational and a fundamental reversal of physics. A further mistake by Einstein is the coordinate transformation in the later part of Reference [1]. Einstein treated mathematical implications in the transformed world as facts in the real world without back transformation. This mathematical irrationality made the light velocity the ultimate velocity limit for all velocities. If following his rationale, the velocity of a flying bird can be c in the theory of special relativity and the ultimate velocity limit in his transformed universe. This is obviously irrational in the real world.

The re-examination of Einstein's moving rod experiment in Sections 2.2.3 and 2.2.4 showed that, with or without the aether, Newtonian classic mechanics found no disagreements between the stationary and moving observers in any light travel event. That is because light travel time is a physical fact and, therefore, invariant for all observers. The re-examination proved the invariance of physical facts for all inertial observers, whether there is the aether or not. Observer motions are irrelevant to the facts of events in the universe.

Michelson's aether experiment is an experimental verification of Section 2.2.3 and Newtonian mechanics for light travel. Reviewing the results of Michelson's experiment with analyses in Section 2.2.3 and Section 2.2.4 affirmed the Newtonian mechanics of light travel, the physical fact invariance, the non-existence of the aether, and the autonomous light travel mechanics.

3 Review of Experimental Reports Claimed to Support the Theory of Special Relativity

Several experimental reports have been reported as validating the theory of relativity [38]. This section reviews some of them. Specific foci are on experiments related to the universal constancy of light velocity and time dilation. The in-depth discussions on those experiments are avoided herein due to the required volume. However, some of the essential points are raised to a level sufficient for the purpose of the discussions. Various discussions on those experiments are available in many publications and text books, although the views may differ.

3.1 Experiments on Light Travels

3.1.1 Michelson and Michelson-Morley Experiments

Albert Michelson performed experiments to determine the motion of the Earth relative to the aether [17]. Michelson believed light velocity was constant c with respect to the aether in all directions. The aether was believed to be universally static. Then, all moving objects are moving relative to the aether and light velocity would be other than c for all moving objects. The rotation and orbital motion of the Earth would cause the velocity of the aether (the aether wind) different in different directions at any point on the surface of the Earth. Therefore, light velocities at any point on the Earth surface would be different in different directions. Michelson intended to measure light velocity differences in different directions on the Earth surface to determine the motion of the Earth relative to the aether.

Michelson's experimental apparatus was devised to split a single source coherent light beam, send them through two mutually perpendicular paths, and combine them together at the end to observe the resulting interference fringes. The lengths and the optical arrangements of both light paths were virtually identical. If one of the light paths is aligned with the Earth rotation (west to east), for example, the other is aligned in the south-north or north-south direction. If the aether is static everywhere in the universe and the Earth rotates and travels in the aether, the velocities of the aether (the aether wind) would be different in these two mutually perpendicular directions. Therefore, light velocities in these two directions would be different as well. Combining these two light beams at the ends of the light travel paths would produce interference fringes due to shifted phases due to velocity differences in these two paths. If the same experiments were performed with the entire apparatus rotated, the fringes would be changed.

However, Michelson's experiment showed no fringe differences when the device was rotated by 90 degrees. The subsequent observations with 180 degrees and 270 degrees of apparatus rotations did not produce any evidence of light velocity differences in different directions. Therefore, these results produced various opinions, such as aether dragging by moving objects, no aether, universal light velocity, etc. However, the aether dragging is in contradiction with the postulated universally static, non-dragging aether. If the aether is dragged by moving objects, light beam travel paths would be distorted as well in the sky, but no such evidence had been observed. The universal velocity of light would be in contradiction with the known mechanics of velocities. The non-existence of the aether was hardly imaginable at that time since wave travels, including light waves, were believed to require transmitting mediums. Since the aether was such a convincing hypothesis then, Michelson repeated the experiments later with collaboration of other scientists, such as Edward Morley and Henry Gale, with improved apparatus in all aspects [18,19,20]. However, the results were the same as before, no fringe changes in any orientation of the device.

Later, after the theory of relativity came to light, these experimental observations were speculated by many scientists as evidence of the universal constancy of light velocity for all inertial references. The speculation seemed reasonable at first glance since the experiment showed no apparent light velocity differences in different orientations, although the motions of any point on the Earth surface should be different in different directions. Therefore, many scientists regarded these experimental results as validation of the theory of relativity, in which Einstein postulated the universal constancy of light velocity.

However, it was shown in Section 2 that universally constant light velocity would be possible only if there were no relative motions among all objects in the universe. That means a motionless universe. The universal velocity of light or anything else is not possible by definition of velocity.

Section 2.2 above demonstrated that there is no aether and light travel has to be autonomous. Sections 2.2.3 and 2.2.4 proved the null results of Michelson's aether experiment are consistent with the Newtonian mechanics of autonomous light travel in the absence of the aether. Michelson's experimental results are exactly consistent with the identical light travel times in all legs of Case A1 and Case A4 in Section 2.2.3. Cases A1 and Case A4 showed that the light travel times in all legs are identical regardless of rod motions, observer motions, or the light travel directions.

From the perspective of the traveling light, all light travel legs of Case A1 and Case A4 are identical, with the same travel distances and the same travel velocity *c*. The travel mechanics of light in the absence of the aether have to be autonomous, and the velocity is constant with respect to the light emitting origin. In all legs of Case A1 and Case A4, the light origination point on one end of the rod is always stationary with respect to each other end regardless of motions of the rod. Therefore, light velocity was the same *c* with respect to the origin, the rod, and the destination end. These sets of physical facts are the reasons for identical light velocity and the travel times for all light travel legs of Case A1 and Case A4 regardless of the leg motions or the light travel directions or the motions the observation frames. Therefore, the identical light travel times for all those light travel legs are an unquestionable conclusion.

All the light travel legs in Michelson's device stayed exactly the same regardless of the device orientations or the motions of the Earth. Therefore, the light velocities in all legs were never changed by the device orientations or the motions of the Earth, which were exactly the same as light travels in Case A1 and Case A4 in the above paragraph. This was the reason for the null results of Michelson's aether experiment. The results of Michelson's experiment are proofs of Newton's velocity vector addition mechanics in the absence of the aether, as well as the analyses in Section 2.2.3.

Further, Michelson's initial fringe observation prior to the device rotation by 180 degrees is equivalent to the forward light traveling from Point S to Clock B in Case A1 and Case B1 in Section 2.2.3. And, the observation after the device rotation by 180º is equivalent to the return light traveling from Clock B to Clock A. Case A1 of Table I shows, when no aether was assumed, the same light travel times for the forward and backward travel legs in concurrence with no fringe changes in Michelson's device rotation by 180 degrees. However, when the aether existence is assumed, Case B1 of Table II shows different light travel times for the forward and backward light travel legs. Michelson's results, no fringe changes when the device was rotated by 180º, are consistent with Case A1 and inconsistent with Case B1. Therefore, it is fair to conclude that no fringe changes when Michelson rotated his device were due to autonomous light travel in the absence of the aether.

In conclusion, the results of experiments by Michelson, Michelson-Morley, Michelson-Morley-Gale, etc. agree completely with the analysis in Section 2.2.3. The agreements are clear proofs of no aether in the universe, autonomous light travel mechanics, and Newtonian vector addition mechanics. The Newtonian vector addition principle disagrees with the universal constancy of light velocity. Therefore, Michelson's experiment is in fact disproving the universal light velocity. The claims that Michelson's experiment is a proof of universal light velocity are false.

3.1.2 Fizeau Experiments on Light Travel in Flowing Water

Hippolyte Fizeau performed an experiment with flowing water to investigate light travel in moving mediums [13]. A beam of light was split, sent through two equal length tubes of flowing water in opposite directions, and then combined together to form interference fringes to observe. Interference fringes would occur due to the phase differentials of the two beams passed through the water flowing in opposite directions. Fizeau observed smaller phase shifts in his experiment than in his prediction. The average value of his experimentally observed phase shift was 0.23, while his predicted phase shift was 0.47. Fizeau's prediction was based on the assumption that the light waves would be fully carried (dragged) by the moving water. This assumption is consistent with the Newtonian vector addition principle as in Equation (2-3) and also consistent with Huygens light travel in translucent medium.

The experimental results raised various opinions, including doubts about the validity of the classical vector addition mechanics for light travel. Some believed the experiment was a confirmation of the Fresnel coefficient of partial aether drag. Einstein pointed the Fizeau's experiment as an essential motivation for his theory of relativity since the experiment cast doubts on the Newtonian vector addition mechanics for light travel.

Michelson and Morley repeated Fizeau's experiment with improved experimental settings, including much more water supplies for improved stability and extended observation time, and modernized instrumentations [18]. They also included device rotations similar to their previous aether experiments. The results were qualitatively the same as Fizeau's, less phase shifts in the experiment than in the prediction. Their comments on their results are as follows:

> *"It is apparent that these results are the same for a long or short tube, or for great or moderate velocities. The result was also found to be unaffected by changing the azimuth of the fringes to 90°, 180° or 270°. It seems extremely improbable that this could be the case if there were any serious constant error due to distortions, etc."*

As in the quote, they could not determine the reasons for their experimental results. Their predictions were based on Newtonian mechanics, as Fizeau's.

Recently, Henok Tadesse published an article [16] on Fizeau's works, including the flowing water experiment. He viewed the aspirations of the scientific community on issues in Fizeau's works as, in his writing, "unnecessary and wrong trails". Indeed, there have been many such unnecessary and wrong trails of efforts in attempts to explain Fizeau's flowing water experiment alone. In fact, Fizeau's flowing water experiment itself may be such a work of "unnecessary and wrong trail".

Fizeau's experiment was to answer questions about light beam 'dragging' by moving water. However, in reality, there is no light dragging issue after all, according to Huygens. Huygens light travel velocity in water is the refraction property of water. The property of water will be the same whether the water is moving or not. If water is non-turbulent, the experiments and prediction calculations of Fizeau and Michelson-Morley should be the same as experiments with stationary tanks of water on a bench and moving light sources. In which, no light dragging might be speculated. Turbulence factors were not included in the prediction calculations of Fizeau or Michelson-Morley. Therefore, apparently, their predictions assumed the experiments were with steady and still water in which no light dragging issues exist, as in the steady water in the tank example above. If Fizeau had realized this fact, he might not have even contemplated his experiment at all.

The Huygens light travel principle in a medium suggests that the travel velocity of a light ray of a given frequency depends only on the refraction property of the medium. The refraction property of a medium is a combination of factors, including the material element's response characteristics to the light wave frequency and the inter-elemental spacing in the medium. The material element response property is the time required for the elements to be excited sufficiently by the waves to release their own wavelets. The inter-elemental spaces are material structures of the medium, which is also a property of the material. Therefore, the resultant refraction property of a medium is clearly a property of the material for the traveling light waves. For this reason, it may be realized that light velocities in denser materials are slower because there would be more retardation factors and less free travel spaces for the traveling light. Also, it can be imagined that the temperature of a medium changes material element energy status and inter-element spaces and, therefore, changes the refraction properties of the medium. Motions of the medium would not change the properties of the medium.

Excited materials by the incoming waves would release wavelets of the similar properties of the incoming lights. Therefore, the time taken by this energy absorption/wavelet release process would depend on the property of the material as well as the frequency of the incoming light wave. This is the reason for the dependence of the refraction properties of a medium on materials as well as on the frequencies of light waves. Therefore, as long as the properties of the water and the light wave remain unchanged in Fizeau's experiment, the light velocity in the water with respect to the water would be the same whether the water is in motion or not. The motion of water is just perceived judgment by observation from outside of the water, irrelevant to light travels inside the water.

Consider a single wavelet travel leg, an inter-elemental space from a wavelet originating element to the next element. If the water is not turbulent and moving steadily in Fizeau's experiment, the Huygens wavelet emitting origin of the wavelet travel leg stays stationary with respect to the destination next element. Therefore, the light travel time in this inter-element space would remain unchanged by the steady motion of the water. This is the same as identical light travel times in all legs of Case A1 and Case A4 and in the return light travel legs in all cases of Section 2.2.3. This is also the same as identical light velocities in Michelson's aether experiment in Section 3.1.1.

Giuseppe Antoni-Umberto Bartocci [14] and later Delclan Traill [15] explained Fizeau's experiment with the Huygens light travel hypotheses in translucent media. Especially, Traill derived an equation that would predict a phase shift of 0.2373 for Fizeau's experiment. (For some reason, Traill did not present the phase shifts in numbers in his work.) Traill's equation predicts virtually identical phase shifts to Fizeau's experimentally measured value. However, Traill's phase shift equation contains unclear explanations in the earlier steps of the derivation, and, therefore, the exact mechanics are not entirely clear. Further, Traill stated that Huygens wavelet absorption/emission processes are more frequent in water flowing in opposite directions of light travel. This assumption by Traill is questionable. The Huygens principle for the velocity of a light beam within a medium depends only on the refraction property of the medium, irrespective of the motions of the medium or the directions. This principle was demonstrated in Section 2.2.3 and Section 3.1.1. Therefore, the Traill's assumption is not consistent with the Huygens principle.

Light wave frequencies would be changed by Doppler Effect when the waves encounter a moving body of water. The refraction property of a medium would be different for different wave frequencies as explained above. Therefore, the water refraction property can be changed to the altered wave frequency due to the Doppler Effect. However, once the beam is in the water, there will be no additional Doppler Effect within the water, and the water refraction property will not be changed within the water.

The refraction property change caused by Doppler Effect was not included in the prediction calculations by Fizeau or Michelson-Morley. Also, for Fizeau's experiment, it was found that the water refraction property change due to the Doppler Effect was too small to have any significant effects on the phase shift calculation. This is because the velocity of water is negligible when compared to the velocity of light. For example, the frequency change caused by Doppler Effect in Fizeau's experiment is in the order of $\sim 10^{-6}$ %. Accordingly, the change in water refraction property caused by the Doppler Effect frequency change may not be even calculable.

Based on the above review, the true reason for the miscorrelation between the experimental observation and the prediction seems to be not in the prediction method. Another possible and even more likely reason for the miscorrelation may be mismatches between the data for the prediction and the actuals in the experiment. This type of miscorrelation is quite common in experimental works in various fields. In the experiments by Fizeau and Michelson-Morley, turbulence in flowing water might be inevitable. Turbulence in the flowing water can cause evolutions of air bubbles and/or local density changes that would change the overall refraction property of the water by altering overall water densities. The actual refraction property of turbulent water in the experiment could be different from the data used for the prediction, which might be for steady and still water. The wave length of the light and the effective flow velocity used for the calculations could also be inconsistent with those actually in the experiments.

Table III below compares the experimentally measured phase shifts by Fizeau as well as by Michelson-Morley with Newtonian mechanics predictions. The Newtonian mechanics prediction, in the last column of the table, used the same prediction method as in Fizeau's report. As shown in the table, the Newtonian vector addition principle correlates better with all cases of Michelson-Morley's experiment than with Fizeau's experiment. A possible speculation may be that Fizeau's experiment was less consistent with his prediction calculation due to more turbulence in the water. More flow turbulence is likely in the rushed Fizeau's experiment, as mentioned in his report, than in the Michelson-Morley experiments. The experiment by Michelson-Morley should produce steadier water flow than Fizeau's since they had much more water supply and longer observation times.

Note that the phase shifts predicted by Newtonian mechanics in the table assume turbulence free water flows. In reality, any flowing water may be turbulent to some degree and may cause refraction index changes. For example, if the refraction index of water in Fizeau's experiment was 1.30 due to turbulence instead of 1.33 in steady water, the calculated phase shift would be 0.450 instead of 0.471. Further, if the refraction index was 1.25 instead of 1.33416641 for Series 2 of the Michelson-Morley experiment, the Newtonian mechanics would find a phase shift of 0.8605 instead of 0.9803, which is much closer to their experimental measurement of 0.843. The Newtonian mechanics with a refraction index of 1.25 would result in a phase shift of 0.1829 for the normalized Michelson-Morley experiment Series 2, which is practically identical to their normalized experimental result of 0.1838. The light property may be another source of miscorrelation. If the light wave length in the air was 0.00000057 as in the Michelson-Morley report instead of 0.000000526 for Fizeau's experiment, the calculated phase shift would be 0.435 instead of 0.471 in Fizeau's report. Also, if the effective water flow velocity is 6.5 m/s instead of 7.059 m/s in Fizeau's experiment, the Newtonian mechanics would find a phase shift of 0.433, which is closer to the experiment than their prediction of 0.471.

All of the possible data inconsistencies in the above examples are single data mismatch cases without complicating others. These data mismatches can be compounded with others. Therefore, it is not possible to determine the exact reasons for the experiment-prediction miscorrelations. However, such data mismatches are practically unavoidable in experiments of the Fizeau type. Also, the above discussions found no otherwise logical reasons for the miscorrelations in the experiments by Fizeau and Michelson-Morley.

In conclusion, it appears that Fizeau's discrepancies were due to mismatching data between the data used in the prediction and those actually in the experiment. Considering the effects of possible mismatching data and yet reasonable correlations between Michelson-Morley experiments and Newtonian mechanics predictions in Table III, there is no reason to doubt the validity of Newtonian mechanics.

Table III Phase Shift Comparison, Fizeau and Michelson-Morley Experiments vs. Calculation per the Newtonian Velocity Addition Principle

	L	n	v	C	λ_0	Phase Shift	
unit	meter	-	m/s	m/s	m	Phase Shifts, Experiment (Raw data average)	Phase Shifts, Newtonian Mechanics
Fizeau Experiment							
	2.974	1.33	7.059	299792458	0.000000526	0.23	0.4709892
Michelson-Morley Experiment							
Series 1	3.0022	1.33416641	8.72	299792458	0.00000057	0.5027	0.5453942
Series 2	6.151	1.33416641	7.65	299792458	0.00000057	0.8426	0.9803059
Series 3	6.151	1.33416641	5.67	299792458	0.00000057	0.6053	0.7265796
Michelson Morley Experiment (Normalized to 10 meter tube length and 1 meter/sec water velocity as reported)							
Series 1	10	1.33416641	1	299792458	0.00000057	0.1858	0.2083313
Series 2	10	1.33416641	1	299792458	0.00000057	0.1838	0.2083313
Series 3	10	1.33416641	1	299792458	0.00000057	0.1800	0.2083313

As in the words of Tadesse, Fizeau's experiment was studied and incorrectly contemplated. Concept of light dragging by moving water is logically misplaced. The views are born from a misconstrued concept of motion or velocity. In the logic of physics, motions of water in the Fizeau or Michelson-Morley experiments are perceptions of outside observers that are irrelevant to the refraction property of the water or traveling light in the water.

Device rotations by Michelson-Morley in their refined Fizeau experiments should have no effects, as discussed in their aether experiment in Section 3.1.1.

3.2 Time Dilation Experiments

Kennedy-Thorndike [21] claimed that their experimental result proved time dilation as suggested by the theory of relativity. They examined whether variations in the orbiting velocity of the Earth around the Sun would cause light velocity changes on the Earth. They expected, presumably, that light velocity changes due to orbital velocity changes of the Earth could be measured by their monitoring device if they observed through an entire year. The Earth orbital velocity varies throughout the year. Their fringe monitoring device was a variation of Michelson's apparatus. Their year-round observations could not detect any light velocity changes. Therefore, they claimed their observed results as evidence of time dilation with elaborate calculations.

Kennedy-Thorndike experiment could not produce any light velocity changes due to the same reason as the null experimental results of Michelson et al. in Section 3.1.1. Variations of the orbiting velocity of the Earth would not alter the light velocity in the light travel legs of their fixed device assembly. That is because of the absence of the aether and autonomous light travel mechanics, as demonstrated in Section 2.2.3. Again, this experiment produced predictable results per Newtonian mechanics in Equation (2-3). Therefore, Kennedy-Thorndike's experiment cannot be claimed as a validation of the time dilation of the theory of relativity. Time is a fundamental physical quantity that cannot be changed by the motions of any reference frame. Motions of observation frames are irrelevant to physical facts in any event. Their experiment is just a confirmation of this fact.

Time dilation is in conflict with physical fact invariance. Einstein reasoned the physical fact invariance for the universally constant light velocity for all inertial observers. But, the time dilation, a variance of physical fact, is a consequence of the universal constancy of light velocity. The universally constant light velocity defines light velocity as a universal invariant while making all physical facts velocity dependent variants. This is a conflict between the rationale and the consequences of the rationale. Also, as concluded previously, the universal constancy of light or any other velocity means a motionless universe. Discussing the effects of velocity, such as time dilation, is senseless in a motionless universe.

Another time dilation test was reported by Ives and Stilwell [36]. However, without elaboration of the details, as it would add no value, their report contained problems on some fundamental issues such as mentioned by Faraj [37].

Time dilation cannot exist because it contradicts the fact that fundamental quantities are universal invariants for all observers. Time is a fundamental quantity of physics, along with the mass of matter, the geometrical distance between two points, and the charge of electricity. These quantities are universal invariants that cannot be changed by motions of observation frames as long as laws of conservation remain valid. It should be noticed that physical fact invariance coexists with the invariance of fundamental physical quantities. If time dilation is true, then there would be no physical fact invariance.

3.3 Doppler Effect of Electromagnetic Waves

Doppler Effects of light waves are frequency changes as sensed by moving observers due to wave velocity changes with respect to observers. Propagation of light waves is propagation of fluctuation waves of a Gauss electric field. Gauss field propagation is autonomous and in accord with the classical velocity vector addition principle as discussed in Section 2.2.1 and demonstrated in Section 2.2.3. The velocities of autonomously traveling electromagnetic waves, including light waves, in a vacuum are constant with respect to the origins of the waves.

The velocity of light waves in a vacuum is a constant $c_0 = f_0\lambda_0$with respect to the origin, where f_0 is the frequency and λ_0 is the wave length as originated from the source. Here, note that the wave length λ_0 is a geometrical dimension, a fundamental quantity of physics, and an invariant for all observers. For a stationary observer with respect to the wave origin, the wave velocity is the same constant c_0 per Equation (2-3). Therefore, for the stationary observer, the frequency has to be the same f_0 as well. However, observers in motion relative to the origin would experience a wave velocity other than c_0 per the same Equation (2-3). Therefore, with λ_0 being invariant, the frequency has to be changed from f_0 to another frequency. This frequency change is the Doppler Effect of light waves for moving observers.

On the other hand, medium reliant waves, such as acoustic waves, are disturbance waves of mediums. Therefore, the velocities of medium reliant waves are always constant with respect to the medium, since they are material properties of the medium. Therefore, observers in motion relative to the medium may experience Doppler Effect frequency changes. Medium reliant waves can be distorted by distortions of the medium itself, and the distortions can result in wave length changes. The wave length changes can be felt as frequency changes as well for observers. Therefore, Doppler Effects of medium reliant waves are more complex since more parameters are involved. The parameters involved may include motion of the origin relative to the medium, distortion of the medium, property changes due to distortions, and motion of the observer relative to the medium.

The Doppler Effect of light waves is the focus of this section.

For the purpose of illustration, let's imagine a point located in a featureless empty space. Imagine the point emanates visible dusty materials in regular periodic time intervals of a frequency f_0 in all directions. If the spherical dust shells travel at velocity c_0 relative to the source point, the distance of the consecutive dust shell would be $\lambda_0 = c_0/f_0$. Assume further that there are no hindrances to the dust travels in this space. Then, the expansion velocities of all these dust shells would stay constant c_0 relative to the source. All these expanding spherical dust shells would stay concentric with the common centers at the source point.

The expanding spherical shells of dust clouds resemble the peaks of electromagnetic waves emanating from the same source point. Since the travel of electromagnetic waves is autonomous, the above dust shell model is analogously the same as Gauss field waves emanating from the point source.

An observer who is stationary relative to the source point of the dust shells would see the expanding dust shells exactly the same as they are seen at the source since the presence of the observer would not change anything on the traveling dust shells. The observer would see the same shell radial distance λ_0 and the same passing frequency f_0. Therefore, the velocity of shell travel is the same c_0.

$$c_0 = \lambda_0 f_0. \tag{3-1}$$

Imagine now that the observer is approaching toward the source at velocity v_a. Since the source point remains at the same location, the expanding cloud system relative to the source would not be influenced by the motion of the observer. The dust wave velocity c_0, the wave length λ_0, and the frequency f_0 would remain unchanged for the source. However, the approaching observer would experience increased wave velocity as well as increased frequency. The wave velocity change for the observer would be, per Equation (2-3), from c_0 when the observer was stationary with respect to the source to $c_a = c_0 + v_a$ for the observer now approaching the source at velocity v_a. The frequency would also be changed from f_0 to f_a as follows since $\lambda_0$be an invariant geometrical dimension:

$$f_a = \frac{c_a}{\lambda_0} = \frac{c_0+v_a}{\lambda_0} = f_0 + \frac{v_a}{\lambda_0}. \tag{3-2}$$

This is the Doppler Effect of autonomously traveling waves, such as electromagnetic waves, for observers approaching the source. The emphasis here is that Doppler effects are frequency changes experienced by moving observers due to changes in the wave velocities relative to the observers. Waves themselves remain unchanged from the perspective of the source or other observers stationary with respect to the source.

In this empty space, it is not distinguishable whether the observer approaches the cloud system or the cloud system approaches the observer. The Doppler Effects would be exactly the same in these two cases due to the mutuality of velocity, the time rate of mutual location.

If the source and the observer are retreating from each other at velocity v_r, the observer would encounter the wave velocity of $c_r = c_0 - v_r = f_0\lambda_0 - v_r$ per Equation (2-3). Therefore, the wave frequency f_r for the retreating observer is;

$$f_r = \frac{f_0\lambda_0 - v_r}{\lambda_r} = \frac{f_0\lambda_0 - v_r}{\lambda_0} = f_0 - \frac{v_r}{\lambda_0} \tag{3-3}$$

Where, the retreating wave length λ_r is identical to the source generated wave length λ_0 since wave length is a geometrical invariant for all. Equations (3-2) and (3-3) are Doppler Effect frequencies of approaching and retreating electromagnetic waves, respectively.

Accordingly, for the observer, the velocities of light waves emanated from approaching and retreating sources are, respectively, as follows:

$$\left.\begin{array}{ll} \text{Approaching to each other,} & c_a = f_0\lambda_0 + v_a = c + v_a \\ \text{and} & \\ \text{Retreating from each other} & c_r = f_0\lambda_0 - v_r = c - v_r \end{array}\right\} \quad (3\text{-}4)$$

It is clear that the velocity of electromagnetic waves, including light, varies depending on observer motion relative to the wave origin. Doppler Effects of light waves are impossible if the light velocity is a universal constant for all inertial observers. This is clear in Equation (3-4). If the velocity of light is universal, then $c_a = c_r = c$ and $v_a = v_r = 0$. Then, $f_a = f_r = f_s$ in Equation (3-2) and Equation (3-3), meaning constant frequency for all observers and no Doppler Effects. Doppler Effects of electromagnetic waves are solid evidence that the light velocity is not universal. Therefore, the Doppler Effects of electromagnetic waves invalidate the theory of relativity.

Einstein's relativistic Doppler Effects cannot be possible physically. The universe of the theory of relativity is a motionless universe. Doppler Effects of light waves are due to the motions of observers. Therefore, Doppler Effects in a motionless universe are illogical and senseless.

As a side note, Equation (3-2) and Equation (3-3) provide means to determine the true velocity of light relative to the source. Let's say a light beam is pulsed out from a stationary source. A distance away, a frequency measuring device approaches the source at velocity v_a and measures the frequency f_a of the light wave as in Equation (3-2). Next, the device retreats from the source at velocity v_r and senses the frequency f_r as in Equation (3-3). Then, if $|v_a| = |v_r|$ exactly, adding Equations (3-2) and (3-3) would result in $f_0 = \frac{f_a+f_r}{2}$. Subtracting Equation (3-3) from Equation (3-2) would result in $\lambda_0 = \frac{v_a+v_r}{f_a-f_r}$ $(or = \frac{2v_a}{f_a-f_r} = \frac{2v_r}{f_a-f_r})$. Then, the velocity of light relative to the source is $c_0 = f_0\lambda_0$.

Here, the light velocity c_0 with respect to the origin, the wave frequency, and the wave length can be determined by this simple process. The only accuracy required would be measurements of the frequencies f_a and f_r by the same device and the same technique. The device velocities v_a and v_r are controlled motions and can be accurate as required. Alternatively, the beam source can move and the frequency measuring device can be stationary. Also, there can be several variations of methods based on this fact.

3.4 Summary of Section 3

The no fringe changes in the experiments by Michelson, Michelson-Morley, and Michelson-Morley-Gale are proven to validate the Newtonian vector addition mechanics of light travel in the absence of the aether. The autonomous light travel mechanics and the absence of the aether are thoroughly discussed and sufficiently proven in Section 2.2 and Section 3.1.1.

Hippolyte Fizeau reported that light wave phase shifts observed in his experiments were not in correlation with his prediction. Section 3.1.2 concludes that the experiment-prediction miscorrelations were likely caused by inconsistencies between the data used for the predictions and those actually in the experiments. Turbulent water flows in the experiment seem to be the most likely cause of the data mismatch, among other possibilities, that resulted in the experiment-prediction miscorrelations. Turbulences in the water can alter water refraction properties. No irregularities are found in Fizeau's prediction methods. Therefore, the section found no logical reasons to question the validity of Newtonian mechanics and Huygens principle for light travel in flowing water.

Section 3.2 reviewed the Kennedy-Thorndike experiments concerning time dilation. Time dilation claims by Kennedy-Thorndike and others cannot be true for the same reasons as for Michelson's aether experiment in Section 3.1.1. Time dilation is logically impossible due to the invariance of physical facts. Also, time dilation may be valid only in the Lorenz transformed universe per the theory of relativity, but it cannot be true when the transformed universe is back transformed to the real universe. The theory of relativity is based on the hypothesis that light velocity is an invariant universal constant, and, however, that would make all physical facts as velocity dependent variants.

Section 3.3 explains that the Doppler Effects of light waves, or electromagnetic waves in general, are caused by light velocity differences for observers in motion. If the light velocity is a universal constant for all observers, there cannot be Doppler Effects of light waves. Doppler Effects of electromagnetic waves, including light waves, are unmistakable modern real life evidence invalidating the theory of relativity.

Reviews in Section 3, together with analyses in Section 2.2, conclude that experimental reports suggested as validation of the theory of relativity are found to be not true. In fact, they are in affirmation of the classical Newtonian mechanics for light travel and the absence of the aether.

4 Motions and the Universe

It was explained in the previous sections that, if any absolute velocity exists, the universe has to have an absolute spatial feature constituting the absolute coordinate system. If any velocity is universal, the universe is motionless. Einstein's absolute universal light velocity in the theory of relativity defines the universe as having an absolute universal coordinate system, and the entire contents of the universe are fixed stationary on the coordinate system.

A finite universe has absolute features due to the virtue of finiteness. Therefore, in a finite universe, all physical events are governed by the absolute feature(s), which makes the laws of physics dependent on the absolute feature(s) and non-uniform. Non-uniformity means a state of non-equilibrium. Non-equilibrium is a state of instability that always trends toward equilibrium. Therefore, a finite universe is inherently unstable.

4.1 Motions of Matters

Section 2.2.1 discussed travels of matters in general and categorized all travels into two categories; medium reliant and autonomous. Discussions in this section are to be focused on the autonomous travels.

With respect to an observer, the observed velocity of any traveling entity may be expressed by the following simple but universal equation:

$$\vec{v}_c = \vec{v}_m + \vec{v}_s \tag{4-1}$$

This equation is the Newtonian velocity vector addition principle, the same as Equation (2-3) for light, but rewritten with more appropriate notations for this section. Note that the light velocity vector $\vec{c}$ in Equation (2-3) is replaced with the velocity vector $\vec{v}_m$ for general entity travels in Equation (4-1). For medium reliant travels, entity velocity $\vec{v}_c$ with respect to the observer is the sum of the velocity of the entity $\vec{v}_c$ with respect to the medium and the velocity of the medium $\vec{v}_s$ relative to the observer. For autonomous entity travels, the entity velocity $\vec{v}_c$ with respect to the observer is the sum of the velocity of the entity $\vec{v}_c$ with respect to the origin and the velocity of the origin $\vec{v}_s$ relative to the observer.

4.1.1 Travels of Waves

Imagine an electrically charged point source placed in a vacuum as a source of electric field. The Gauss field law determines that the flux of an electric field at a distant point from the source is proportional to the charge strength at the source and inversely proportional to the square of the distance from the source. Therefore, if the source charge strength or polarity is oscillating, the field flux at that distant location is accordingly oscillating. The oscillating electric fields induce the conjugating magnetic fields, and the induced oscillating magnetic fields induce oscillating electric fields, and so on. This wave of mutual induction is known as electromagnetic waves at this time. This flux oscillation at a point may be presented as sinusoidal equations, but not actual spatial undulations of the sinusoidal waves. Rather, they are waves of strength oscillations. The propagation velocity of the waves is, obviously, the field propagation velocity, which is constant with respect to the source. Therefore, the propagation of light waves is autonomous, so as for all electromagnetic waves.

Autonomously traveling electromagnetic waves are different in mechanics from medium reliant waves. Therefore, some wave theories developed for medium reliant waves may not be applicable to electromagnetic waves. Especially, wave interaction mechanics may need to be distinguished.

Light waves can travel in translucent mediums such as a block of glass or a body of water. These light travels are also autonomous and consistent with Newtonian mechanics as elaborated by Huygens [7, 8]. According to Huygens, incoming light waves agitate elements of the medium, and the energized elements emit wavelets as a mechanism to release excessive energy. The wavelets travel to neighboring elements, which are, in turn, agitated and emit wavelets of their own, and so on. This is Huygens' light travel mechanics in translucent mediums, as discussed in Fizeau's experiment in Section 3.1.2. This Huygens light travel mechanics in translucent mediums is similar to the light travel mechanics in the experiments by Michelson et al in Section 3.1.1 and the Kennedy-Thorndike experiment in Section 3.2. The wavelet free traveling spaces in translucent mediums are the same as the light travel legs of those experiments. Here, the actual traveling entities in mediums are light wavelets, not disturbances of the medium.

From the travel mechanics point of view, velocities of both autonomous light waves and medium reliant acoustic waves in a translucent medium are commonly properties of the medium, although they are different properties since the mechanics are different. Velocity of autonomous light waves in a medium I determined by the refraction property of the medium. On the other hand, the structural properties of the medium determine acoustic wave velocity per Newton-Laplace equation. Therefore, the velocity of light in a translucent medium can be calculated the same way as for medium reliant acoustic wave travels. For example, for light travel in Fizeau's flowing water experiment, $\vec{v}_m$ in Equation (4-1) is the velocity of light relative to the water and $\vec{v}_s$ is the velocity of the water relative to the flow reference, the tube. For acoustic wave travel, $\vec{v}_m$ in Equation (4-1) is the velocity of the acoustic wave relative to the water and $\vec{v}_s$ is the velocity of the water relative to the tube. In this example, the water flow velocity $\vec{v}_s$ relative to the tube is common for both light and acoustic waves. Also, the wave velocities $\vec{v}_m$ for both travels are constant relative to the water as they are properties of the water, although they are different properties. Therefore, the velocity calculation processes would be the same, but the results would be different in the magnitudes.

In summary, the medium reliant acoustic wave travels are travels of structural distortion waves. Travels of light waves in the same medium are travels of the light wavelets themselves. When a traveling light wave reaches the boundary of the medium and the incident angle is under the critical angle of Snell's law or angle in Huygens-Fresnel's principle, the light wavelets would continue to travel into the other side of the boundary including into a vacuum. Medium reliant acoustic waves cannot travel into a vacuum.

4.1.2 Motions of Material Bodies

If object B sees object A in motion relative to B, A would see B exactly in the same motion with respect to A. In this mutual and conjugative inertial relation, it can be seen that it is not determinable which of A or B is truly in motion or both are. Locations or motions of objects cannot be determined in the absolute sense but can be determinable only by observers per their chosen references. Therefore, it is fair to say that locations, motions, and velocities are all subjective judgments on mutual inertial states between two conjugated pairs of bodies or points. This is because there are no absolute or universal features in the universe.

The above observation is analogously identical to Newton's third law of motion. In Newton's third law of motion, the acting and reacting forces are exactly the same in magnitude but opposite in direction. At the same time, it is not possible to determine the acting and reacting forces objectively in physical logic. The fact is that the acting force cannot exist without the reacting force, and vice versa. These two forces exist always in conjugative pairs.

These facts are truly important and critical clues about the truth of the universe. A statement from the above examples is that the universe has no universal features to be referenced. No features to reference in the universe mean the universe is featurelessly uniform and infinite space. No geometrical or gravitational force centers or otherwise features affecting global physics in the universe. The conservation laws in physics, the physical fact and quantity invariance, motions of celestial bodies, etc. are the consequences of this statement.

Herbert Litchtenegger and Bahram Mashhoon [26] wrote about Immanuel Kant's view on motions of objects as follows:

> *Kant further notes that the mobility of objects, i.e. the variation of the external proportions with respect to a given location cannot be recognized is simply without recourse to experience and that motion must thus be classified as an empirical term rather than as a notion of pure reason. Whether a body is at rest or in uniform motion is not a disjunctive but an alternative decision and the state of motion is therefore inherently indeterminate and a mere potential quality.*

They also wrote about W. Hoffman on the same subject as follow:

> *W. Hofmann defines motion as any change in the location of a material body with respect to a sensually perceivable reference frame; therefore, all motion is true and relative and there is no way to distinguish between true and apparent motion.*

Clearly, both Kant and Hoffmann viewed commonly that a motion of a body is a judgment based on the perception of the observer with respect to a sensually perceivable reference. The sensually perceivable references are local frames of the observer's choice. Possible references for an observer to choose from are unlimited. And, the motions of those perceivable references are also unlimited. Therefore, the same motion of an object can be seen in infinite numbers of different magnitudes and directions. The statements of Kant and Hoffman suggest essentially that no motions can be absolute or universal, or have any limit in their magnitudes or orientations. Their views are exactly in accord with the classical definition of motion and also consistent with Newton's first law of motion.

The Epicurean universe is an infinite and featureless eternal empty space that has no references to determine the locations or motions of anything from the perspective of the universe. Therefore, in this universe, all references to describe object kinematics have to be local. These local references are the sensually perceivable references of Hoffman, and the numbers are unlimited. The indeterminate nature of object motions of Kant and Hoffman is due to the absence of absolute universal reference(s) in the universe. The Epicurean universe is the only such universe with temporal and spatial uniformity.

Motions of objects in a finite universe cannot be consistent with the motions of Kant and Hoffman. That is because any model of a finite universe has absolute global features such as the boundaries, the gravitational center, the geometrical center, etc. Therefore, the laws of physics in that universe are in conformance with the features. For example, at any moment in time, the kinematics of any object in the Big Bang universe, a dynamic finite universe, would be with respect to the origin of the Big Bang explosion and in conformance with the dynamic features of the universe. Another example is the Stoic universe, a static finite universe, in which gravitation fields are location dependent and that would result in ultimate instability.

Any local coordinate system in the Epicurean universe can describe all kinematics anywhere in the universe, but the universe cannot locate or describe any coordinate system or events in it. This is because a local coordinate system has referenceable features such as the origin, the axes, and the scales to locate anything with respect to it, while the global Epicurean universe has no referenceable features. Therefore, in the Epicurean universe, the location or motion of a local coordinate system can be determinable only in reference to other local systems. All local coordinate systems are equal and uniform in status without privileges. No local coordinate system can influence any event or any other local frame by virtue of the uniformity and equality in the universe. A significant inference from this fact is that, in the Epicurean universe, all events are independent and local.

James Clerk Maxwell stated, "*The kinetic energy of a body is the energy it has in virtue of being in motion…*" [6]. This Maxwell's statement is in the same vein as Kant's note in the above quotation: "*... and the state of motion is therefore inherently indeterminate and a mere potential quality".* Potentials are, by definition, not in-situ physical entities until interaction with specific references. Since the motions of a body are observer specific judgments and mere potentials, the motion born kinetic energies are also observer specific judgments and mere potentials. In other words, motions or energies are not physical facts in-situ and are neither absolute nor invariant. For example, some observers may see that a body is stationary and has zero kinetic energy, but others may see the same body in motion and have kinetic energy. Here, obviously, motions or energies are reference specific and the energy of a body can be realized only when the body interacts with the specific reference.

All energies are potentials in virtue since energies are defined as expected work potentials of a body or of a system that can be delivered to another body or system in reference. As an obvious example, a steel ball of 1000°C temperature weighing 100 kg has zero thermal energy for another nearby steel ball of the same temperature weighing 1 gram. Another may be that a bag weighing 10 kg carried by a passenger on an airplane flying at an airspeed of 250 m/sec has zero kinetic energy for that passenger. As shown, energies are not in-situ physical facts but work potentials in a specified context. Therefore, such a term as "dark energy" would have no meaning as the term presents no specific reference or any context with it.

Motions and velocities are subjective opinions, not physical quantities. The velocity of any object has to be interpreted only with respect to a specific reference, and all references are local. Therefore, there cannot be any absolute or universal velocity. This comes from the virtue of the universe having no absolute universal references. This universe is consistent with the featureless infinite Epicurean universe. Here, time is recognized as another infinite dimension in addition to the spatial dimension of the universe. Time is measurable only with respect to specific temporal references, just as spatial dimensions are measurable with respect to specific spatial references.

4.1.3 Forces and Motions

External force acting on a body of mass would change the inertial state of the body, as stated in Newton's second law of motion. The second law states in essence that, if a constant force F is applied to a body of mass *m* for a time duration *t*, the product of the force and the time interval is equal to the change in momentum of the body. This is the familiar momentum equation $Ft = mv_2 - mv_1$. Application of the force to a body accelerates the body velocity from v_1 to v_2 for a chosen observation coordinate. The velocities may be different for different observation frames because velocities are perceptions of observers, not physical facts. However, the change in velocity is invariant for all observers because that is a physical fact of the event. In the momentum equation $Ft = m(v_2 - v_1)$, the force *F*, the time interval *t*, and the body mass *m* are given constants and invariants for all observers, and, therefore, the change of velocity $(v_2 - v_1)$ has to be invariant also for all observation frames. Therefore, acceleration is an invariant of an in-situ physical event.

Newton's third law of motion states that a body in acceleration also exerts equal and opposite force back to the forcing body. The equal and opposite reaction force is the inertial resistance of the body by virtue of having mass. The inertial resistance of the body is against its inertial state change. Newton's third law of motion implies that, in a force interaction, the acting force exists because the resistance force exists, and the resistance force exists because the acting force exists. This also implies that, in a force interaction, it is not possible to distinguish the acting force from the reacting force. This is in the exact analogy that, when two bodies are moving relative to each other, it is not possible to determine which of these bodies is truly in motion. A force always exits in conjugation with the reacting pair, and the pairs are always equal and opposite. Therefore, if one force of the conjugated pair is real, the other force is real too. Centrifugal forces, Euler forces, etc. are all real forces.

Due to the conjugated nature of forces, the total sum of forces involved in a force interaction event is always zero. No outside forces, including forces of the global universe, are involved in any particular force interaction event. Reversely, no local force interaction events have global effects to influence any other event in the universe. All events are local and independent from all external influences. Laws of conservation in physics are from complete locality and independence of physical events.

Body forces are defined herein as forces involving all elements in material bodies. Every element in an accelerated body resists against its inertial state changes by virtue of having masses. The total sum of the inertial resistance of all elements in a body is the inertial resistance of the entire body against the total external force acting on the body. These inertial reaction forces of material elements are termed herein as 'inertial body forces' as they involve the inertial resistance of all elements in the body. Another form of body force is field force, which acts directly on all material elements. Gravitation, electric, and magnetic fields are examples of such force fields. This type of body force is termed 'field body force' herein. The inertial body forces are the inertial resistance of all elements in the body against their inertial state changes by external forces to the body, and the field body forces are external forces acting directly on all elements in the body.

For further clarification, consider a solid material body of mass *M* subjected to an external contact force F_c and a gravitational field force F_g. For simplicity, let's assume that these force vectors are in line with the body motion vector per an observation coordinate frame. The total external force is $F = F_c + F_g$. Acceleration of mass *M* due to the contact force is $a_c = F_c/M$, and due to the gravitation field force is $a_g = F_g/M$. Therefore, the total acceleration is $a = a_c + a_g = \left(F_c + F_g\right)/M$. The total inertial body force F_{IB} against the total external force F is in the opposite direction of the external accelerating forces and $F_{IB} = -F = -F_c - F_g = -(a_c + a_g)M$. The external gravitation field force is the field body force acting directly on all individual material elements and the sum is $F_{GB} = a_g M$. Therefore, the total body force of all elements is $F_{IB} + F_{GB} = -a_c M - a_g M + a_g M = -a_c M = -F_c$. The inertial body force against the field force cancels the field body force. As the results, the total body force in the body is the inertial body force against the external contact force only. The force fields induce exactly equal and opposite inertial body forces on each and all elements and they cancel each other. Therefore, in a free falling body in a gravitation field, for example, there is no net force in the body.

Gravitation forces are effective on each individual element, but the results are effective on the whole body. Without contact forces, gravitation forces alone cause no inter-elemental forces, i.e. no stresses in the body, because the gravitation force on each element is in exact equilibrium with the element's inertial reaction forces. Imagine that a body consists of five rigid ball elements interconnected to neighboring balls with weightless springs. If each of these balls is also rigidly connected to an external common point away from this five-ball body and the common point is subjected to a force of a certain magnitude, then all of these five balls, the whole body, are pulled by the common point and will be in common accelerated motion. However, there will be no forces on the springs connecting the balls, suggesting no relative movements between the neighboring balls and no internal stresses in the five-ball body. This analogy is for the mechanics of gravitation force in a material body. All elements are at identical acceleration. Therefore, there are no inter-elemental forces.

On the other hand, the contact external forces to a body are transmitted to each element from the neighboring elements through structural bindings. The forces transmitted by structural bindings are stresses in the body.

It would be interesting to consider an object on a desk on the Earth surface. In this case, the body forces in material elements may be considered as the field body forces of the Earth gravitation. However, the body forces may also be considered as the inertial body forces in reaction to the external contact force from the desk top to the object. The body force total is the same in magnitude as the force from the desk surface and opposite in direction. This is exactly the inertial body force as defined above. Therefore, the body forces in this object may be confusing, whether the body forces are field body forces of the gravity of the Earth or inertial body forces against the contact force from the desk. In this case, either of the views may be acceptable since there are no factual controversies. However, in consistency with the above, the body forces on the material elements in this object are the inertial body forces against the contact force from the desk. This observation makes it clear that there would be no net forces on material elements without external contact forces to the body.

For a given observation coordinate system, any acceleration force acting on a body may be divided into linear (or in-line) and centripetal (or perpendicular) components with respect to the object motion vector. The in-line linear acceleration force component contributes to the change of the velocity magnitude, but is not associated with the orientation of the object motion vector. On the other hand, the perpendicular or centripetal acceleration force component changes the orientation of the body motion vector but is not associated with the magnitude of the velocity. However, both force components accelerate the body in their respective force directions without affecting the motions of the body in the respective other directions. Christiaan Huygens stated that a curvilinear motion of an object is due to centripetal forces acting on the object for a time duration, otherwise, the object would move straight [41].

An elemental material volume in a steadily rotating solid disc is forced to move together with the adjoining elements by the structural binding. The steady rotational velocity means there is no force in the direction of the rotation. However, changing the orientation of the motion vector indicates there is a centripetal force. For a volume element in the disc, forces from the neighboring elements to the volume are the Huygens' centripetal forces. The reaction force of the material volume to the centripetal force is the centrifugal force, the reacting inertial force per Newton's third law of motion. Therefore, the centripetal and centrifugal forces are the same in magnitudes but opposite in direction, just like any other force interaction. The centripetal and centrifugal forces are in exact equilibrium.

In this force conjugation, it is not possible to distinguish the acting and reacting forces between the centripetal and centrifugal forces. As discussed above, the centripetal force exists because the centrifugal force exists, and the centrifugal force exists because the centripetal force exists. Therefore, if the centripetal force is real, then the centrifugal force is real as well, not fictitious.

The rotational motion of the disc exerts centripetal forces onto material elements by the structural constraints so that the material elements change the motion vector. If there is no structural binding, then all elements would fly away in the direction of their in-situ motion vector, which is tangent to the rotation. The centrifugal forces of the material elements would be conjugated with the centripetal forces in exact equilibrium. The centripetal and centrifugal forces are perpendicular to the rotational motion vector and do not affect the rotation velocity. This force balance is confined all within the disc. No external forces are involved in this steadily rotating disc. Therefore, the rotation of the disc is perpetual. This phenomenon may be observed in flywheels or gyroscopes. This is the same reason for the perpetuity of rotational motions of celestial bodies or systems in the Epicurean universe.

4.2 Newton's Bucket Experiment

> *If a vessel, hung by a long cord, is so often turned about that the cord is strongly twisted, then filled with water, and held at rest together with the water; after, by the sudden action of another force, it is whirled about in the contrary way, and while the cord is untwisting itself, the vessel continues for some time this motion; the surface of the water will at first be plain, as before the vessel began to move; but the vessel by gradually communicating its motion to the water, will make it begin sensibly to revolve, and recede by little and little, and ascend to the sides of the vessel, forming itself into a concave figure...This ascent of the water shows its endeavour to recede from the axis of its motion; and the true and absolute circular motion of the water, which is here directly contrary to the relative, discovers itself, and may be measured by this endeavour. ... And therefore, this endeavour does not depend upon any translation of the water in respect to ambient bodies, nor can true circular motion be defined by such translation. ...; but relative motions...are altogether destitute of any real effect. ...It is indeed a matter of great difficulty to discover, and effectually to distinguish, the true motions of particular bodies from the apparent; because the parts of that immovable space in which these motions are performed, do by no means come under the observations of our senses.*
>
> — *Isaac Newton; Principia, Book 1: Scholium*
> (From Wikipedia Free Encyclopedia, Bucket Argument)

The above quote is Newton's observation on his imaginary experiment known as 'Newton's Bucket Experiment'. Apparently, Newton viewed the phenomenon of the concaved water surface, ascending on the perimeter and descending around the axis of rotation in pure rotational motion, as not due to translation forces from ambient bodies but as the influence of immovable space in which the experiment was assumed to be performed.

Ernst Mach presented an alternative view that the phenomenon is due to motion relative to ambient celestial bodies, as in the quote below.

> *Newton's experiment with the rotating vessel of water simply informs us that the relative rotation of the water with respect to the sides of the vessel produces no noticeable centrifugal forces, but that such forces are produced by its relative rotations with respect to the mass of the Earth and other celestial bodies.*
>
> — *Ernst Mach, as quoted by L. Bouquiaux in Leibniz, p. 104*
> (From Wikipedia Free Encyclopedia, Bucket Argument)

It is apparent that Mach did not interpret the mechanics of the bucket experiment correctly when he stated, "… sides of the vessel produce no noticeable centrifugal forces". Centrifugal forces exist in all rotating bodies as long as centripetal forces exist, and slippage between the bucket wall and water is only a transitional stage occurrence. Also, influences from other celestial bodies are not in the experimental environment of Newton's description.

These two different observations of Newton and Mach sparked lasting debates among scientists about the origins of inertia and also about absolute vs. relational universes.

Although not mentioned specifically in Newton's description above, there should be a downward gravitation field as if the experiment were performed on the surface of the Earth. Without downward gravitation, hanging the rope or water in the bucket is not possible. Also, the rope top end should be held stationary relative to the Earth, such as by means of structures footed on the ground. This setting would allow the untwisting rope to transmit the rotating force to the bucket, and the downward gravitation would be effective on the water in the bucket so that the experiment could be performed as described. Also, there should be a bottom closure of the vessel (bucket) to confine the water within the bucket by gravitation. Notice that, in this setting, the Earth is a part of the experimental platform.

Imagine a stationary coordinate system K is placed with the origin coincident with the rope top end and the z-axis with the length of the rope. The +z direction of K is set in the direction upward, away from the Earth. Note that forces acting on the bucket system are the rotational force from the unwinding rope, which is reacted by the inertia of the immensely large mass of the Earth, and the rope axial tension is due to the downward gravitation field force from the Earth to the bucket with water. All these forces are within the experimental setting. No other external forces are involved here. With this setting, there are no translational acceleration forces to the bucket in any direction of K.

To examine these opinions of Newton and Mach more objectively, isolation of the experiment from all external influences is necessary. A way to isolate the experiment from outside influences, yet to have the experiment consistent as described, is to have a disproportionally large rotational inertia of the platform relative to the bucket with water. This will simulate the rope top end being fixed in the space without being attached to anything outside of this experiment. The immensely large mass of the Earth can suffice for this objective. This is a way to have the effects of platform rotations so negligible as to be neglected completely in the analysis without doubtable effects.

Note that, even if the experiment is isolated in such a manner, the question about the origin of inertia may remain unresolved because the inertia of material mass is still a parameter of this isolated experiment without defining the origin of inertia. This question has to be answered in relation to the truth of the universe. The answer to this question will become clearer in the discussions on Newton's Shell theorem toward the end of this article. However, the discussion on Newton's bucket experiment in this section provides evidence of event locality and independence in support of conclusions on the universe and, at the same time, the locality of events would be the answer to the question about the origin of the inertia.

Initially, the water in the bucket is stationary relative to frame *K* and the top surface would be flat. When the rope starts unwinding, the rotating bucket inner surfaces would drag the water in contact with the viscous frictions. The viscous friction forces are possible because of pressures in the water against the bucket inner surfaces. Friction forces of a surface are the products of the normal force to the surface and the friction coefficient. The pressures in the water are due to the downward gravity acting on the incompressible water in the confined bucket cavity. Initially, the water masses would resist the inertial state changes by the dragging friction forces of rotating bucket walls. At this stage of the interaction, there should be slippages between the water and the inner surfaces of the bucket wall due to the inertial resistance of the water, but sufficient duration of dragging force to the water would gradually pull the water into motion due to Newton's second law of motion. The dragging friction forces are acceleration forces to the water, and the conjugated inertial reaction of the water mass is the Euler force. This is exactly Newton's third law of motion. If there were no rotational acceleration in the water, the conjugated Euler forces of the water mass would not exist. In this conjugative force interaction, both forces are equally real. The Euler forces are not fictitious.

The water volume elements in contact with the bucket wall are forced to move in the direction of the viscous friction force vector, which is tangent to the curvature of the bucket wall. This straight tangential direction is the innate motion vector of the water volumes. However, this innate straight trajectory of the water motion is reoriented by the bucket wall curvature into curvilinear motion. The reorienting force of the bucket wall to water volumes is the centripetal acceleration force of Huygens and is perpendicular to the wall curvature. If there is no centripetal force from the bucket wall curvature, the trajectory of the water volumes would be straight in tangent to the wall curvature. The centripetal forces of the bucket wall are from the structural binding of the bucket wall materials in ax-symmetric constraints, much like the rotating solid disc example in Section 4.1.3.

The centripetal acceleration force from the bucket wall is reacted by the water mass per the force conjugation principle of Newton's third law of motion, equal in magnitude and opposite in direction. The inertial reaction force of the water mass against the centripetal force is the centrifugal force. For the bucket wall, water masses impinge the bucket wall curvature, and the bucket wall structure resists the impinging forces. As in any other force interaction, it is not possible to distinguish the acting and reacting forces between the centripetal and centrifugal forces. One of these forces cannot exist without the other. Therefore, both the centripetal and centrifugal forces are real forces, not fictitious.

The centripetal-centrifugal interaction force may be expressed as, $F_{centrifugal} = mr\omega^2 = -F_{centripetal}$. This equation suggests that the interaction forces are proportional to the square of the rotational velocity ω and linearly proportional to the radius *r* of the radial location of the mass from the axis of rotation. This is because the higher momentum of water masses ($= mr\omega$) at the outer radius would require higher forces to reorient.

The equation also indicates that, if bucket system rotational velocity ω exists, there will always be centripetal and centrifugal forces. The centripetal and centrifugal equilibrium forces are always perpendicular to the velocity vector of mass *m* and, therefore, do not influence the magnitude of the rotational velocity. Therefore, once the rotation has been initiated, the rotation velocity of the bucket system will remain unchanged if no more external forces are involved. The rotation is perpetual.

When the bucket rotation reaches a certain velocity level and the rope untwisting force is terminated, such as by activation of frictionless bearings at the rope connections, an equilibrium state will eventually be reached. At that equilibrium state, the bucket and the entire water in the bucket will rotate at the same rotational velocity as if they were a single solid body. If any element in the system is out of unison, the interaction forces with the neighboring elements will eventually bring their motions to the same velocity. When all elements in the system rotate at the same rotational velocity, all friction forces in the system will vanish. At this equilibrium state, the Euler forces of water molecules will vanish as well, since there are no more rotational acceleration forces on water molecules. However, the rotation induced centripetal and centrifugal interaction forces will remain unchanged at exact equilibrium as long as the bucket rotates at that velocity.

Similar force interactions take place within the water between the outer and inner water layers. The rotating outer water layers would pull the inner water layers gradually into rotational motions by viscous frictions until the entire water rotates at the same angular velocity. The rotation induced centripetal and centrifugal interaction forces within the water are radial pressures in the water.

The structurally rigid bucket wall can resist the radial pressure from the water with negligible deformation. However, the fluidic outer water volumes would be deformed under the radial pressure. Deformation of the incompressible water would be movement of the water. The centrifugal pressure from the inner water volumes pushes the outer water against the bucket wall, and the outer water is squeezed to move upward, which is the only space available in the confined geometry of the bucket. The squeezing centrifugal pressures are higher at the outer radii, partially due to the higher centripetal-centrifugal interaction pressure and partially due to the cumulative effects from the inner water. That causes higher water levels at the outer radii in the downward gravitational environment. The resulting higher column pressures are in equilibrium with the higher radial pressures in the outer water.

Moving up the outer water volumes would leave spaces for the inner water to move into. The outward movement of the inner water volumes is due to the radial outward component of the innate tangential motion vector. So, the general movement of the water in the bucket is toward the outer radii until pressure equilibriums are established everywhere in the water. This water motion causes the water level recede near the axis of rotation under the downward gravitational pull. The results would be concaved water surfaces. The concave profile of the water surface is to be determined by the radial distribution profile of the centripetal-centrifugal interaction pressures, which are determined by the rotational velocity of the system. In summary, all involved mechanics, including the translational motions of water, are simply due to the mechanics of the incompressible fluid in a confined rotating geometry. There are no other external forces involved in this mechanics.

Once equilibrium is established, the centripetal force and the conjugate centrifugal forces remain unchanged in the exact equilibrium everywhere in the water as long as the rotational velocity is unchanged. The system rotational velocity would not be changed by the centripetal, centrifugal, or gravitational forces since those forces are perpendicular to the water mass rotational velocity vector. This rotating equilibrium of the bucket system will be perpetual as long as no external forces disrupt the equilibrium. This perpetuity is possible only because all mechanics are internal to the system with no involvement of external forces such as influences of the insensible universe of Newton or the distant celestial bodies of Mach.

The bucket experiment would be the same even if the experiment were performed anywhere in the universe because of the isolation. Further, the experiment would not be different even if the platform were in motion. This is because locations and motions are just observed perceptions, not physical facts. Imagine another coordinate system, *K'*, identical to *K* above. When *K'* is coincidentally located with *K*, both coordinate systems would see the experiment the same. If *K'* is moving away from *K*, the moving away *K'* would see the experiment the same as before, except the frame *K* is moving away from *K'* together with the experiment on the platform. This is because the motion of *K'* is not a factor in the experimental event, the platform, or the frame *K*. This illustration presents reasons for the invariance of physical facts for all inertial observers. Also, as discussed in Section 4.1.2, it is not possible to determine whether *K* with the experiment is in motion or *K'* is in motion. This discussion concludes that all physical events are local, invariant, and independent. These are true only in a non-influential, featureless universe.

Mathematical treatments of the concaved water surface in Newton's bucket experiment are abundantly available in many textbooks and publications [39, 40].

4.3 The Universe

The universe may be best described by the word "all", as inferred by "Universus" in Latin or "Cosmos" in Greek. The universe characterized by the word "all" implies that the universe has no inside and outside division or inclusion and exclusion segregation. The universe embraces everything, including, but not limited to, materials, energies, spaces, laws, information, governance, and so on. The word "all" is mutually irreconcilable with the word "finite", as in the finite universe.

4.3.1 Motions in the Universe

It has been elaborated through all of the above sections that the motion or velocity of an object is the mutual inertial state between the object and the observation reference. This means that no velocity can be absolute or universal since all referenceable objects in the universe can be in different inertial relations with the object in consideration. If the velocity of an object is universal, all observers in the universe are in identical mutual inertial states with the object, and there would be no motions among the observers. This universe is motionless. If the velocity of an object is absolute, all physical facts are variants of that velocity, except that velocity. Einstein's light velocity is both absolute and universal. Therefore, the universe of the theory of relativity is a motionless universe, and, in that universe, no physical facts are invariant except light velocity.

Further, velocity is perceived potential and not an in-situ physical fact of any event. Physical facts or physical quantities cannot be changed by perceived potentials. The velocity dependent physical quantities postulated by the theory of relativity are false and contradict physics, mathematics, and reality. It was shown that light wave travels are autonomous as all Gauss field travels are. The velocity of any autonomously traveling entity is constant with respect to the origin, per the classic vector addition principle. Therefore, the velocity of a light wave in a vacuum is constant with respect to its emanation origin. Since the velocity of the light emitting origin is not universal for all observers, as defined in Equation (4-1), the velocity of light waves cannot be universal. These light travel principles have been proven with detailed analysis in Section 2.2 and with experimental examples in Section 3.

No absolute universal velocity means the nonexistence of absolute coordinate systems or absolute governance in the universe. The Epicurean universe is an eternally infinite empty space with no referenceable absolute features. The nonexistence of referenceable features in the Epicurean universe is from the virtue of infinity and uniformity of the universe. The featureless universe cannot offer any universal reference or governance thereby and, therefore, cannot determine the locations, orientations, or motions of anything from the perspective of the universe. The disjunctive nature of velocity as observed by Kant in Section 4.1.2 is because the motions of objects are not determinable in the absolute sense in the universe with no reference. The Epicurean universe cannot distinguish the motion of an object at rest or moving at a velocity of 300,000 km/sec. By observing the nature of velocity, not determinable in the absolute sense, the universe has no absolute references and that universe is the Epicurean universe.

4.3.2 Locality of Physical Events

The Epicurean universe has no referenceable features to determine the locations or motions of anything. However, any local frame in the universe can determine all locations and motions in the universe. Local coordinate systems have definite referenceable features such as the origins, the axes, etc. A local coordinate system can be described by and only by other local coordinate systems. The locality of event kinematics is a direct consequence of the non-referenceable and, hence, non-influential global universe as discussed in Section 4.1 and Section 4.2.

Section 4.2 showed that the physical facts of Newton's bucket experiment are independent from the motions of observation coordinate frames *K* or *K'*. This example explains the reason why physical facts are identical regardless of their locations or motions in the universe. The experiments by Michelson and others verified this fact in Section 3. The fact is that locations, motions, or velocities of events or objects are just perspectives of observation frames. All physical facts of events or objects in the universe are unique and independent and cannot be altered by observation frames in any motion. This is a clear statement of physical fact invariance. This statement rejects the physical quantity variations by velocities as postulated in the theory of relativity.

All fundamental physical quantities are physical facts by themselves. A one meter long bar is one meter long regardless of the location of the observation or the motions of the observation frame. Invariance of the fundamental physical quantities is in the same vein as physical fact invariance. Laws of conservation in physics are direct consequences of the independence and locality of events.

4.3.3 Finite and Infinite Universe

Any model of a finite universe has definite features defined by the virtue of finiteness. Boundaries, geometric centers, mass centers, etc. are examples of such features. Every location in a finite universe is unique and absolute, as defined by the features of finiteness. The laws of physics are spatially and temporally non-uniform in a finite universe. For example, mechanics at the gravitation center cannot be the same as at a location near or on the boundary. The spatially non-uniform laws of physics also mean temporal non-uniformity since a physical event may move from one location to another while the event is still in progress. Consequently, the uniformity of laws of physics is unlikely in any model of a finite universe.

As an illustrative example, a straight line of finite length has absolute endpoints and a midpoint defined by the finiteness. On this line, any point, such as a point located at 1.0 million kilometers from the midpoint toward end A, provided that end A is farther than 1.0 million kilometers from the midpoint, is as unique as the midpoint or the endpoints. Imagine this line as a one-dimensional universe for simplicity. The end points of the line are the boundaries of the universe and the midpoint is the geometric center. Kinematics near the boundary endpoints would be different from those near the midpoint. For example, in the common logic of physics, a body of mass moving at a constant velocity with respect to any point of reference on the line is traveling at a constant velocity for all points on the line. The body would eventually escape one of the boundary endpoints. If material matters can escape through the boundary, the boundary may not be called the boundary of the universe. This controversy may be resolved if the laws and logic of physics are functions of locations. For that reason, the meaning of "constant velocity" or "constant" may be differently defined from location to location. Or, the concept of "length" or "time" may be defined differently for every location to have no material matter to escape through the boundary. Non-uniformity of the laws of physics is inevitable in this finite universe. This example suggests that the laws of physics in this finite universe are not uniform.

On the contrary, a line of infinite length does not have any global reference to measure the location of anything. A line of infinite length has no endpoints or the midpoint. All locations on this line are the same, equal, and undistinguishable from the others. Therefore, a body moving or stationary on this line is not distinguishable or recognizable. All laws of physics are independent of locations and uniform on this line. This is exactly analogous to the uniformity of all laws and logic in the infinite Epicurean universe in Section 4.3.1. However, the motions or locations of any object are recognizable and meaningful for local references.

Therefore, considering the uniformity of kinematics and the laws of conservation in physics, the universe has to be infinite and featureless, as defined by the Epicurean universe.

4.3.4 Big Bang Universe

The expansion model of the Big Bang universe is based on Hubble's observation of light wave redshifts toward lower frequencies. (Some explain the red shift as the light wave length shift. However, this explanation may not be true as discussed in Section 3.3.) In the Big Bang universe theory, the redshifts are interpreted as Doppler effects of light waves from moving away celestial bodies in the expanding universe, and the expansion velocity is postulated as proportional to the distances from the origin of the Big Bang explosion. In other words, the expansion is in acceleration.

The Big Bang universe model is often presented in association with the theory of relativity. However, previous sections, especially Section 3.3, conclude that the Doppler effects of light waves are impossible if the light wave velocity is universal for all observers. Therefore, if Hubble's red shift is due to the Doppler effects of light waves, then the universally constant light velocity has to be false, and so is the theory of relativity. Or, if the theory of relativity is true, then the Big Bang universe theory based on the Doppler effects of Hubble's observation is false. Therefore, the Big Bang universe theory cannot coexist with the theory of relativity.

There are several controversies in the Big Bang universe theory. Also, there are many theories for resolutions to the controversies. However, including the so-called 'Three Pillars' of the Big Bang universe theory, all the resolution theories seem to be not readily convincing without additional controversies.

First of all, the velocities of expelled materials from a single explosion event in an empty space would be at their maximum at the moment of the explosion expulsion. No single explosion in space can create continuous forces to accelerate the explosion products. From the moment of the explosion in empty space and there on, deceleration and eventual contraction would be the inevitable consequences due to gravitation pullback from the origin of the explosion. (See the discussions on Newton's shell theorem and the Stoic universe model below in this section.) Post-explosion cooling of the Big Bang universe theory would cause slower, not accelerated, expansion in time. This logical reality states that the continuous, accelerated expansion of the universe from a one-time Big Bang explosion is unjustifiable. The accelerated expansion may be possible if the cause of the accelerated expansion, such as residual explosions, continues on to the current. In that case, the ongoing explosion has to be uniform throughout the universe in consistency with the uniformity of Hubble's observation. However, no evidence of such residual explosions has been observed.

The cosmic microwave background radiation (CMBR) can come from many possible sources, which are not necessarily bound to the aftereffects of the Big Bang event. The uniform density of CMBR as observed from the Earth may be better explained by the infinite uniform universe than by the Big Bang universe. Also, the accelerated expansion does not support the CMBR logic. If CMBR is from cooling plasma in the cooling universe, as suggested, then the cause of the accelerated expansion becomes controversial since the cooling universe may indicate that the cause of the accelerated expansion cannot be internal to the universe. If the expansion is powered by internal sources, the temperature of the universe should rise instead of cooling. Then, the source of CMBR, cooling plasma, is in conflict. If the expansion is from an external source, the expansion may be irrelevant to the Big Bang explosion. Therefore, CMBR in relation to the Big Bang aftereffects may be unjustifiable in either case. A similar argument may also be applied to the distribution changes of material species, which are also based on the cooling universe. The cooling universe logic cannot be consistent with accelerated expansion.

Most of all, the difficulty with the accelerated expansion theory is such a harmonious and uniform force delivery mechanism to all contents in the universe. Accelerated expansion suggests continuous acceleration forces acting on the entire contents of the universe. Power sources alone cannot accelerate the expansion, but the powers have to be delivered to the constituents in a continuous and uniform manner. Expansion due to increasingly pressurizing gaseous mediums may be such a uniform force delivery mechanism. But that conjecture would be in conflict with cooling temperatures as suggested by CMBR, histories of material species changes, and the emptiness of space. Other than divine power, the only other imaginable harmonious power delivery mechanism across the empty space may be so-called antigravity. If antigravity is the cause, then the strength of the antigravity field should be greater than the gravitation field. There is no evidence of such strong antigravity here on the Earth or in nearby celestial systems. If such strong anti-gravitation is real, no planetary or other celestial systems can exist. In all, no rational explanations exist for the force mechanisms of continuously accelerated Big Bang expansion.

Consequently, as discussed above, the Big Bang universe theory is highly questionable in various aspects of physics. The true reasons for Hubble’s observation of light wave redshift should be found somewhere other than the Big Bang explosion.

Although the Big Bang universe model has been well accepted among many physicists, there are some alternative opinions about Hubble’s redshift other than the Doppler effects of the retreating celestial bodies [32, 33, 34, 35]. It is conceivable that Hubble’s redshift may be due to other optical phenomena than the Doppler effects. Some of the possible causes may be scattering, filtration, interference, selective absorption, or some other unknown reasons in the light travel paths from such distant galactic bodies. There are many atomic particles, debris, clouds, fields, or yet-to-be-known matters that can cause the observed light frequency shifts. Such frequency shift effects would be proportional to the travel distances of lights. The farther the light travels, the more such effects would be exhibited. That would also be consistent with Hubble’s observation.

4.3.5 Epicurean Universe

Edward Harrison discussed Newton’s view of the universe [43]. Possibly, Newton’s abandonment of the Stoic cosmos model, which he believed during his earlier days, might be due to the unresolvable stability problem of the Stoic universe. It is not too difficult to show that any static, finite universe will collapse due to its own gravity unless some forces counter the gravity. For the Stoic universe to be stable, the force in defiance of eternal gravitation has to be eternal as well. Such eternal power and a judicious force delivery system to all constituents of the universe are difficult to imagine for any independent finite universe, such as the Stoic universe. Harrison wondered why Newton did not exert divine power for the stability of the Stoic universe. Newton lived in such a period and believed in divine power. This comment by Harrison is significant in regard to the realism aspects of Newton’s aspiration for the true universe. Also, Harrison’s question implies that there are no logical explanations in physics for the stable Stoic universe other than divine power.

Newton’s shell theorem [45] may be a plausible explanation for Newton’s change of view on the universe from Stoic to Epicurean. The shell theorem provides clear explanations for the instability of the

Stoic universe, while the theorem provides complete explanations for the inevitable stability of the Epicurean universe. However, Newton did not relate his shell theorem to the Epicurean universe.

Interestingly, however, Newton's Epicurean universe may not be true Epicurean since he postulated the existence of the immovable absolute coordinate system in the universe as in his comment on his hypothetical bucket experiment in Section 4.2. The addition is a substantial alteration to the Epicurean universe. In the Epicurean universe, all coordinate systems are indifferent, and there cannot be any absolute coordinate systems. However, Newton's absolute coordinate system is the immovable universe itself, in which all locations are specific to the coordinate system. The immovable universe is in control of all physics in the universe and defines all events as location specific. However, discussions in Section 4.2 concluded that physical events are independent of the locations or motions of the event or of the observation frames. Location dependent physics are incongruent with the laws of conservation in physics, the invariance of physical facts, or even Newton's laws of motion.

The true Epicurean universe is an infinite and eternally empty space that provides no referenceable features or influences to the constituents. This universe provides just empty spaces for all objects to move freely and associate or dissociate as local in-situ conditions call for. For example, excessive accumulation of matters such as overgrown stars may cause situations for dissociations, such as supernovae. A random drift of a galactic system may interact with other systems, from which a variety of new conditions arise. Arbitrary and random motions of such dissociated materials or material systems may bring nearby materials together to form other associations, such as galaxies or atoms. These processes are perpetual since no mechanisms exist to cease them due to the non-influential global universe.

4.3.6 Newton's Shell Theorem

Mathematical proof of Newton's shell theorem is dealt with in many textbooks and publications. Without the mathematical elaboration, Newton's shell theorem may be summarized as follows:

(a) A spherically symmetric body affects external objects gravitationally, as though all of its masses are concentrated at a point at its center.

(b) If the body is a spherically symmetric shell (i.e., a shell with a hollow interior), no net gravitational force is exerted by the shell on any object inside the hollow, regardless of the object's location within the shell (hollow).

(c) Corollary (added by this author): Per (a) and (b) above, the gravitational force of a spherically symmetric body *M* on an independent point mass *m* is only by the portion of *M* enclosed within the sphere of radius *r*, where *r* is the distance of the mass point *m* from the center of mass *M*. The gravitational force on mass *m* by the materials enclosed in this sphere of radius *r* acts as if all material masses within this sphere are concentrated at the center of the sphere. Therefore, the total gravitational force acting on point mass *m* located at a distance *r* from the center of *M* is $F_r = G\frac{mM_r}{r^2} = G\frac{m\rho\frac{4}{3}\pi r^3}{r^2} \propto r$, linearly proportional to the radius *r*, if the material distribution is uniform. All materials in body *M* outside this sphere of radius *r* have no consequential gravitation force to the point mass *m*. If mass *m* is located at the center of *M*, there would be no gravitational forces on mass *m* since the radius of the sphere is zero and the sphere contains no material matter in it.

The Stoic Cosmos model has a finite spherical boundary, and all material masses are enclosed within the boundary. Any material mass *m* located at any distance *r* from the center of this universe would be subjected to gravitational force toward the center of the universe, per the theorem (a) and the corollary (c) above. Therefore, the universe will collapse due to its own gravity since there are no forces counteracting the gravity. The equation in the corollary (c) also suggests that the collapse would be drastic. As the collapsing progresses, the numerator mM_r of the equation remains constant since it is the product of the point mass *m* and the portion of mass *M* enclosed within the sphere of initial radius *r*, but *r* in the denominator r^2 is in situ distance of *m* from the center in the collapsing process and gets smaller by a rate of square as the collapsing progresses. Therefore, the gravitation force F_r on *m* increases as the collapsing progresses in a manner of accelerated acceleration. This collapse would be drastic. This would be true for all finite universes enclosing material matters within the boundary.

An infinite universe with uniform material distributions has the following properties:

(1) The uniform and infinite universe exerts zero net gravitation force on a material mass at any location in the universe. The infinite uniform universe can be considered a sphere of infinite radius, and a material mass of any finite size at any location in the universe can be considered as a point mass located at the center of the universe. Theorem (a) and corollary (c) suggest that there is no gravitational force on materials at the center of a spherically symmetric body.

(2) Due to the uniformity and infinity of the universe, for any sphere containing materials that exerts gravitation force on a material mass *m* anywhere in the universe, there exists always another identical sphere that exerts exactly the same gravity in the opposite direction such that, in totality, the net gravitation force on this mass *m* is zero in all directions.

Therefore, Newton's shell theorem proves that the infinite universe of uniform material distribution does not have global gravitational influences on material bodies anywhere in the universe. Gravitational influences on any material body in this universe are only from other nearby material bodies. Therefore, this infinite and uniform universe is not congruent with Mach's gravitational influence of distant stars on a material body. This featureless universe does not have any globally referenceable feature and, therefore, cannot have an absolute or any otherwise global coordinate system as suggested by Newton. This infinite and uniform universe is the Epicurean universe.

In the Epicurean universe, all events are unascertainable, immaterial, and meaningless in the global perspective. All events, materials, locations, motions, etc. are only meaningful in the perspectives of local frames. This feature of the infinite universe is logically analogous to the infinite line universe in Section 4.3.3. This is the reason why all facts of physical events are local and invariant regardless of the event locations or motions as discussed in Newton's bucket experiment in Section 4.2. The laws of conservation in physics, Newton's laws of motion, the non-disjunctive nature of motions of Kant, physical fact invariance, etc. are all from the virtue of the Epicurean universe.

4.3.7 Celestial Systems in the Epicurean Universe

Section 4.1.3 discusses the perpetuity of rotational motions when there are no external interferences. The perpetual motions of celestial systems are the same as discussed in the solid disk example in Section 4.1.3. In celestial systems, the orbiting bodies and the system barycenter are in centrifugal-centripetal force equilibrium born from the rotational motions, and the rotational motion would not be changed in the non-influential universe. That is the reason for the stabilities of celestial systems in the non-influential universe.

Section 4.1 and Section 4.2 discussed the mechanics of the perpetuity of rotating bodies. Consider two closely passing-by bodies. Depending on the mutual gravitational forces, the relative velocity, and the trajectories between the two bodies, the bodies may collide, escape from the mutual gravitational forces, or be trapped in mutual orbital motions. When the bodies are trapped in the gravitational forces, orbital motions of the bodies are established. The orbits of the bodies are about the barycenter formed by the masses of the bodies. The mutual gravitation force is the Huygens centripetal force. Due to Newton's third law of motion, the centrifugal force of each body will be conjugated with the centripetal force, as explained in Section 4.1 and Section 4.2. When the stable orbital dynamics are established, the orbital motions are perpetual. A celestial system has been established.

Multibody celestial systems may be formed similarly. If celestial systems happen to be located close enough to each other, their gravitation may cause interactions with each other. Such interactions, however, would be resolved eventually as local events in the infinitely vast universe. Therefore, the featureless and non-influential Epicurean universe is essential for the stability of celestial systems.

At any moment in time, a group of material matters, gaseous or solid, in incidental proximity would have a collective gravitation center, the barycenter, for any material body in or near the group of materials. Note that a barycenter doesn't need to have a heavy body presence at the center. For a body, the barycenter is the collective gravitation point of all involved bodies. The motion of a body at any moment is in binary dynamics with the barycenter. For a body, the location and gravitational strength of the barycenter change continuously as the locations of all bodies in the system rearrange continuously. Also, there can be newly joining or escaping bodies. Therefore, the celestial motions of a body are quite complex and continuously evolving. The orderly yet never ending dynamics, seemingly chaotic at times, may be the virtue of the Epicurean universe. Celestial systems are neither orderly forever nor chaotic forever.

In spite of the complexities, celestial mechanics should be within the laws of physics. Some idealized planetary motions are discussed by Kepler, Newton, and many others, as summarized in Reference [46]. Among them, Subrahmanyan Chandrasekhar reviewed the dynamics of celestial systems more comprehensively [48,49,50]. Chandrasekhar viewed dynamic frictions between and among celestial bodies as responsible for the motions of celestial systems as they are observed. His theory explains the dynamics of galactic systems from the formation to the stable establishment. A concise summary of Chandrasekhar's works may also be found in Reference [47].

When initial swirling motions of bodies in proximities settled eventually into stable orbital motions by the dynamic frictions of Chandrasekhar, an axis of rotation of the system would be established gradually. Each body in the system is in centripetal-centrifugal force balance with each respective barycenter in the radial direction of rotation. However, no such force balances exist in the direction parallel to the axis of rotation. Therefore, in the direction parallel to the axis of rotation, all materials would be gradually pulled toward the plane containing the collective barycenter, and the plane would, therefore, settle into the shape of a flat disc that is perpendicular to the axis of rotation. The flat orbital plane of the celestial system is so formed. At the same time, this process would establish a singular axis of rotation in a general perspective. Therefore, the orbital disc plane always contains the general, but not necessarily absolute, barycenter of the system for all bodies in the system. Some smaller systems occasionally merge into larger systems without catastrophic events. In that case, the smaller systems may retain their own systems without major disruptions, and the entire smaller system would behave as if it were a single body in the larger system. However, some may be disintegrated in the process of the merge, leaving spiral traces of materials in the larger system as remnants of the formation history. When merging systems are close in size, the interaction processes are much more complex.

The rotational motions of celestial systems also explain the phenomenon called “Black Hole Jets”. Those observed material streams may not be jets of materials spewing out but rather streams of materials, probably smaller nearby celestial systems, occasionally pulled in toward the gravitational center of the systems. These material streams are materials located on or near the axis of rotation where the centripetal and centrifugal force dynamics are absent or negligible when compared to the gravitational pull in the direction along the rotational axis. This is the reason for the black hole jets being perpendicular to orbital planes.

Celestial systems in the above brief discussions are only possible in a non-influential global universe. The Epicurean universe is such a universe.

4.3.8 Origin of Inertia

Inertia is defined by Britannica Physics as “property of a body by virtue of which it opposes any agency that attempts to put it in motion or, if it is moving, to change the magnitude or direction of its velocity” [5]. In other words, inertia of a body is a property of the body to resist (“opposes”) against its inertial state change by an external agency, as in Newton’s third law of motion. A change in the inertial state of a body is acceleration. The force of the agency is the external acceleration force, and the conjugated reaction force of the body is the inertial resistance. Therefore, the “property of a body” in the Britannica Physics description is precisely the kinetic property of mass in the body.

Obviously, the mass of a body is a fundamental physical quantity confined within the body. The mass of a body is local in all aspects and invariant for all observers. The force of an acting agency and the reaction inertia of the mass are of the conjugated pair and are in exact equilibrium per Newton’s third law of motion. No other forces, global or otherwise external, are involved in this force equilibrium. Therefore, Newton’s third law of motion is exactly the statement of inertia.

The universe has been the subject of long and diverse discussions among many physicists and philosophers [26, 27]. Among those, the most debated universes are Newton’s absolute universe and Mach’s relational universe. Although logical theories of both universes have shortfalls of their own, however, for some reason, Mach’s relational universe has been popular among many physicists in present times. Leibniz [28], Mach [26], Einstein, Sciama, and Hawking are some of the prominent physicists who brought the relational universe theory to its current success.

Among them, Dennis W. Sciama, the doctorate thesis adviser of Stephan Hawking at Cambridge University, brought the Big Bang universe theory, the theory of relativity, and Mach’s relational universe together in search of the origin of inertia [25]. Sciama intended to show that the inertia of a mass particle located at the center of an observable universe is due to the influence of distant celestial bodies per Mach’s relational universe. However, Sciama's universe model was the Big Bang universe. The Big Bang universe is a finite universe and has an absolute coordinate system as Newton’s absolute universe, which is the universe model that Mach denied.

The Big Bang universe theory suggests that the universe is in accelerated expansion. In other words, all objects anywhere in the universe are in expansion acceleration in the radial outward direction from the center of the universe. The acceleration forces are not distinguishable from the gravitation forces of distant stars. The combination of these two force vectors would be the inertia causing external agency of Britannica Physics. The combined force vectors should be location specific in Sciama’s model. At any location in Sciama’s universe model, acceleration forces are not uniform in all directions. However, Sciama’s inertia calculation did not include any of these factors. Sciama’s observable universe is not a general representation of the Big Bang universe. The only location in the Big Bang universe that would be consistent with Sciama's center of observable universe model would be the center of the universe. However, there would be no forces at the center of the Big Bang universe due to the symmetry. Therefore, there cannot be any force causing inertia on any mass at the location of Sciama's observation point.

Britannica Physics states, in essence, that the inertia of a body is the property of the body having mass to react against the external force acting on the body. If there is no mass in the body, there would be no inertial reaction of the body and, therefore, there could be no force from external agency. Newton's shell theorem proves that the universe has no involvement in any force interaction event in the universe. Also shown in previous sections is that all force interactions are local and independent from external involvements. Therefore, it is clear that the inertia of a body is totally of local origin. Seeking the origin of inertia in the global universe is logically on the wrong trail. The inertia of a body is a dynamic property of the mass in the body. This is analogous to the thermal reaction of a body is due to the thermal property of the mass in the body, not from the universe. Therefore, the origin of the inertia of a body is the mass of the body.

4.4 Summary of Section 4

Light waves are oscillating electric fields emanating from energized bodies, as discussed in Section 2.2 and Section 4.1.1. Therefore, the velocity of light waves is the same as the velocity of Gauss fields, which is constant with respect to the origin. The travel mechanics of light waves are autonomous, as evidenced by the ability to travel in a vacuum. Huygens light travel principle in translucent medium is also autonomous and follows the classical vector addition principle.

The velocity of an object is an observation of the mutual inertial state between the object and the observer from the perspective of the observer. From the perspective of the object, the velocity of the observer would be exactly the same. Absolute velocity means the existence of an absolute reference in the universe. The universal velocity of anything means all objects (observation references) in the universe are in an identical inertial state with respect to that anything, and the universe is motionless. Both of these are unreal. The Epicurean universe has no features to be referenced to determine the locations or motions of anything. Therefore, no velocity can be absolute or universal in the Epicurean universe. In the Epicurean universe, all events are local and independent.

Kant stated that the motion of a body is a mere potential, not a physical fact. James Clerk Maxwell defined the kinetic energy of a body as the energy it has in virtue of the body being in motion. Since the motion of a body is potential, the kinetic energy of a body is also potential. Likewise, all quantities born by virtue of a body being in motion, such as velocities or momentums, are potentials. Further, all energies are potentials, not in-situ physical quantities.

The centrifugal force of the water in Newton's bucket is the inertial reaction force of the water mass against its motion vector change by the centripetal acceleration force from the bucket wall curvature. This is Newton's third law of motion. Similar centripetal and centrifugal force equilibriums exist between outer and inner water volumes. The concaved water surface is simply the result of incompressible fluid mechanics in the confined cavity of the rotating bucket, which is the pressure equilibrium between the centripetal-centrifugal pressure and the static pressure from downward gravitation. There is no involvement of Newton's absolute universe or Mach's distant stars in this experiment. It was shown that rotational motion is perpetual if no external forces disturb the rotating system. Also shown is that the phenomena of the bucket experiment are independent of the location of the experiment as well as of the motions of the platform or the observation frames. The experiment proved the total independence and locality of physical events. Also, Newton's third law of motion states clearly that there are no fictitious forces in the universe.

Any finite universe has topological features such as the boundary, the mass center, the geometrical center, etc., which are defined by the virtue of finiteness. These features of finite universes are absolute global references for the universes. These global references determine all locations absolutely, and all kinematics in a finite universe are functions of locations, as in the finite line example in Section 4.3. The laws of physics in a finite universe of any model have to be non-uniform and, therefore, unstable. The Stoic universe is an example of the instability of finite universes, as proven by Newton's shell theorem.

In an infinite uniform universe, the locations and motions of bodies or events are undeterminable due to the featurelessness of the universe. Kant's non-disjunctive nature of the inertial states of a body is due to the featurelessness of the infinite universe. Newton's shell theorem presented clear logical explanations for physical event locality in the infinite universe. The theorem also explains the perpetual stability and uniformity of the infinite universe. The laws of conservation are consequences of physical event locality and invariance. The theorem also provides reasons for the self-governance of local celestial systems as consequences of the non-influential global universe. The rotational motions of galaxies and planetary systems are mechanics of perpetual self-governing stability. All these observations suggest the universe has to be Epicurean.

Inertia of a body is a kinematic property of material mass in the body that resists change of its inertial state by external forces. Inertial state changes of bodies are accelerations of Newton's second law of motion. The reaction of a body of mass against an external acceleration force is defined in Newton's third law of motion. Therefore, the true origin of inertia is the mass of the body, not the global universe.

5. Concluding Remarks

Misconstrued velocity has brought unreal conjectures and speculations to physics. Einstein's universal constant light velocity for all moving frames defines light velocity as an invariant physical entity. The result is that all physical facts and physical quantities are velocity dependent variants. This is a fundamental reversal of physics and also unreasonable. Physical facts are invariant realities, and velocities are observed perceptions. Perceptions cannot change realities. Also, logically, universal light velocity means the universe is motionless, except for lights.

Immanuel Kant stated that the velocity of an object at rest or moving at a constant velocity is not disjunctive. The velocity of light is just a velocity and cannot be privileged. According to Kant, a body at rest or moving at a velocity of 20 m/sec, or 300,000 km/sec is not differentiable in a sense of physical fact. This view of Kant is exactly Newton's first law of motion.

In Einstein's moving rod experiment, replacing the light velocity c with the 20 m/sec velocity of a flying bird would not change his simultaneity issue in the analysis. The issue would remain the same, and the analysis would be still wrong. Also, the flying bird velocity would suffice his theory of relativity in all aspects without logical controversies in Reference [1]. Then, the velocity of the flying bird would be the ultimate velocity limit as well as parameters for all physical quantities and facts per his theory of relativity. If he had realized this, Einstein would not have claimed the velocity of a flying bird as the ultimate velocity limit.

The reanalysis of Einstein's hypothetical moving rod experiment in Section 2.2 concludes that Newtonian mechanics is completely correct without Einstein's simultaneity controversy and consistent with all known logics of classical physics, including the invariance of physical facts. Section 2.2 proved that there is no aether in the universe, light travel is autonomous, and the velocity of light is not a universal constant.

Section 3 examined Michelson's aether experiment, Fizeau's flowing water experiment, and Kennedy-Thorndike's time dilation experiment. Those reports have been claimed, by some scientists, as evidence validating the theory of relativity. On the contrary, Section 3 found that the experimental results are consistent with the Newtonian mechanics of light travel in the absence of the aether. The conclusion is consistent with the findings in Section 2. The Doppler effects of light waves prove that the universal constancy of light waves is not possible. The Doppler effects of electromagnetic waves are real life evidence disproving the universal constancy of light velocity. The relativistic Doppler effects are senseless since it is about velocities in a motionless universe.

Absolute velocity may be possible if there is an absolute reference coordinate system in the universe. Universal velocity may be possible if the universe is motionless. Both of these are not possible in the reality. All finite universe models have absolute features to be referenced and the universe is non-uniform. All locations are uniquely defined not only in the geometry but also in the laws of physics. These finite universes are found to be unstable. The Epicurean universe is a featureless infinite space providing no global feature to be referenced and all objects are moving relative to each other in this universe. Therefore, there is no absolute or universal velocity in the Epicurean universe. In the Epicurean universe, as discussed in Section 4, all physical events are local and describable only with local reference frames. The featurelessness Epicurean universe is the reason for physical event locality and physical fact invariance. The laws of conservation in physics are the consequence of the locality and invariance of physical events.

Newton's shell theorem explains that event locality is an inevitable consequence of the infinity and uniformity of the universe. The rotational dynamics of celestial systems are independent perpetual stability mechanisms in the Epicurean universe. Perpetuity and locality of rotational motions are exhibited in Newton's bucket example. Flat orbital planes, spiral material traces of the formation history, and axial material streams, so-called "Black Hole Jets", are evidence of rotational dynamics in the non-influential global universe. All of these observations suggest that the Epicurean universe is the only plausible universe model consistent not only with logic but also with observed realities. The inertia of a body as defined by the Britannica Physics is from exactly the body having mass. The mass of a body is the origin of the inertia of the body.

This article is all about the re-affirmation of the nature of velocity as defined by the classic mechanics. Newtonian classic mechanics is concluded to be seamlessly correct in all controversial discussions in modern physics.

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Appendix A

Re-analysis of Einstein's Moving Rod Experiment - No Aether Case

Appendix A is a reanalysis of Einstein's hypothetical moving rod experiment with the classical Newtonian velocity vector addition principle. This appendix assumes there is no aether in the universe. Therefore, the light travel mechanics applied in this appendix are autonomous as in Equation (2-3).

Case A1 – Stationary Initial Ray Launch Point S and Stationary Rod

Light source Point S:	Stationary. Fixed at the origin of the stationary coordinate.
Clock A:	Stationary. Fixed at $x = 0$ of the stationary coordinate.
Clock B:	Stationary. Fixed at $x = r_{AB}$ of the stationary coordinate.

Subcase A1a: Observed by the Observer $0'$ Stationary with the Stationary Coordinate System

A1a-1 Forward Light Ray Travel from Point S to Clock B (Observer $0'$)

The forward travel of the ray is from the source Point S fixed at the origin $x_1 = 0$ of the stationary coordinate system to the destination Clock B fixed at $x_2 = r_{AB}$ also on the same stationary coordinate system. The observations are per the stationary coordinate system. Since both the origin and the destination points of the ray travel are stationary on the same observation coordinate system, the light travel distance is $x_2 - x_1 = r_{AB} - 0$ for Observer O′ per the stationary coordinate system.

Since both the ray source Point S and Observer O′ are stationary on the same coordinate, velocity of the light source Point S relative to Observer O′ is $\vec{v}_s = 0$. The ray velocity relative to the emitting Point S is $\vec{c} = +c$ since the light ray travels in the $+x$ direction of the observation coordinate system. Therefore, per Equation (2-3), the resultant light speed is $\vec{v}_c = \vec{c} + \vec{v}_s = +c + 0$ for Observer O′ per the stationary coordinate system.

Per the stationary coordinate system,

Location of Point S (Clock A) at time t_A:	0
Location of Clock B at time t_B:	r_{AB}
Ray travel distance from Point S to Clock B:	$r_{AB} - 0$
Velocity of light ray $\vec{v}_c$ for Observer O′:	$+c + 0$
Ray travel time from Point S to Clock B:	$\frac{r_{AB}-0}{+c+0}$
Clock times:	$t_A = 0$
	$t_B = \frac{r_{AB}}{c}$
Light travel time duration, Point S to Clock B:	$t_B - t_A = \frac{r_{AB}}{c}$

(A1a.1)

A1a-2 Backward Reflected Light Ray Travel from Clock B to Clock A (Observer O′)

The backward travel of the reflected ray is from the source Clock B to the destination Clock A. Both clocks are stationary on the stationary observation coordinate system. Per the stationary coordinate system, the light departs Clock B at $x_1 = r_{AB}$ at time t_B and arrives at Clock A at $x_2 = 0$ at time t'_A. Therefore, the light travel distance is $x_2 - x_1 = 0 - r_{AB}$ for Observer O′ per the stationary coordinate system.

Both the reflected ray origin Clock B and Observer O′ are stationary on the stationary coordinate system. Therefore, velocity of the ray source Clock B relative to the stationary coordinate system and Observer O′ is $\vec{v}_s = 0$. The ray velocity relative to the source Clock B is $\vec{c} = -c$ since the light ray travels in the $-x$ direction of the observation coordinate system. Therefore, per Equation (2-3), the resultant light speed is $\vec{v}_c = \vec{c} + \vec{v}_s = -c + 0$ for Observer O′ per the stationary coordinate system.

Per the stationary coordinate,

Location of Clock A at time t'_A:	0	
Location of Clock B at time t_B:	r_{AB}	
Ray travel distance from Clock B to Clock A:	$0 - r_{AB}$	
Velocity of light ray $\vec{v}_c$ for Observer O′:	$-c + 0$	
Ray travel time from Clock B to Clock A:	$\frac{0-r_{AB}}{-c+0}$	
Clock times:	$t_B = \frac{r_{AB}}{c}$	(from A1a.1)
	$t'_A = t_B + \frac{0-r_{AB}}{-c+0}$	
Light travel time duration, Clock B to Clock A:	$t'_A - t_B = \frac{r_{AB}}{c}$	

(A1a.2)

Subcase A1b: Observed by the Observer O moving with the Moving Coordinate

A1b-1 Forward Light Ray Travel from Point S to Clock B (Observer O)

The forward travel of the ray is from the source Point S to the destination Clock B and both are on the stationary coordinate system. The observation is by Observer O on the moving rod per the moving coordinate system. The moving coordinate system is on the moving rod and, therefore, moves at a velocity $+v$ relative to the stationary coordinate system. Therefore, the stationary coordinate system and both Point S and Clock B on it are moving at velocity $-v$ relative to the moving observation coordinate system. Point S is at $x_1 = 0$ of the moving coordinate system at the beam launching time t_A, but Clock B moves from $x = r_{AB}$ at time t_A to $x_2 = r_{AB} - vt_B$ at the beam arrival time t_B at Clock B. Therefore, the light travel distance is $x_2 - x_1 = r_{AB} - vt_B - 0$ for Observer O per the moving coordinate system.

The ray source Point S is on the stationary coordinate and, therefore, moving at velocity $\vec{v}_s = -v$ relative to Observer O and the moving coordinate system. The light ray velocity relative to the source Point S is $\vec{c} = +c$ since the travel direction of the ray is in the $+x$ direction of the observation coordinate system. Therefore, per Equation (2-3), the resultant light speed is $\vec{v}_c = \vec{c} + \vec{v}_s = +c - v$ for Observer O per the moving coordinate system.

Per the moving coordinate,

Location of Point S (Clock A) at time t_A:	0
Location of Clock B at time t_B:	$r_{AB} - vt_B$
Ray travel distance from Point S to Clock B:	$r_{AB} - vt_B - 0$
Velocity of light ray $\vec{v}_c$ for Observer O:	$+c - v$
Ray travel time from Point S to Clock B:	$\frac{r_{AB} - vt_B - 0}{+c - v}$
Clock times:	$t_A = 0$
	$t_B = \frac{r_{AB} - vt_B - 0}{+c - v} \Rightarrow t_B = \frac{r_{AB}}{c}$
Light travel time duration, Point S to Clock B:	$t_B - t_A = \frac{r_{AB}}{c}$
(A1b.1)	

A1b-2 Backward Reflected Light Ray Travel from Clock B to Clock A (Observer O)

The reflection ray travels from Clock B to Clock A and both clocks are on the stationary coordinate system. Therefore, the clocks are moving at velocity $-v$ relative to the moving observation coordinate system. For the moving observation coordinate, location of Clock B is $x_1 = r_{AB} - vt_B$ at the reflection ray departure time t_B as found in A1b-1 above, and Clock A moves from $x = 0$ at time t_A to location $x_2 = -vt'_A$ at the ray arrival time t'_A. Therefore, the light ray travel distance from Clock B to Clock A is $x_2 - x_1 = -vt'_A - (r_{AB} - vt_B)$ for Observer O per the moving coordinate system.

The reflected ray source Clock B on the stationary coordinate system is moving at velocity $\vec{v}_s = -v$ relative to the moving coordinate system and Observer O. The ray velocity relative to the origin of the reflected ray Clock B is $\vec{c} = -c$ since the ray travel direction is in the $-x$ direction of the observation coordinate system. Therefore, per Equation (2-3), the resultant light speed is $\vec{v}_c = \vec{c} + \vec{v}_s = -c - v$ for Observer O per the moving coordinate system.

Per the moving coordinate,

Location of Clock A at time t'_A:	$-vt'_A$	
Location of Clock B at time t_B:	$r_{AB} - vt_B$	
Ray travel distance from Clock B to Clock A:	$-vt'_A - (r_{AB} - vt_B)$	
Speed of light ray $\vec{v}_c$ for Observer O:	$-c - v$	
Ray travel time from Clock B to Clock A:	$\frac{-vt'_A - (r_{AB} - vt_B)}{-c - v}$	
Clock times:	$t_B = \frac{r_{AB}}{c}$	(From A1b.1)

$$t'_A = t_B + \frac{r_{AB} - vt_B + vt'_A}{c+v} => t'_A = \frac{2r_{AB}}{c}$$

Light travel time duration, Clock B to Clock A: $t'_A - t_B = \frac{r_{AB}}{c}$
(A1b.2)

Case 1 review conclusion: The moving observer and the stationary observer agree completely on the event times and the light travel times for both forward and backward light travels. Therefore, there is no dispute between Observers O and O′ on the clock synchronism or event simultaneity. The physical events are identical for both the moving and stationary observers.

Case A2 – Moving Initial Ray Launch Point S and Stationary Rod

Light source Point S:	Moving. Fixed at End A of the moving rod.
Clock A:	Stationary. Fixed at $x = 0$ of the stationary coordinate.
Clock B:	Stationary. Fixed at $x = r_{AB}$ of the stationary coordinate.

Subcase A2a: Observed by the Observer O′ Stationary with the Stationary Coordinate

A2a-1 Forward Light Ray travel from Point S to Clock B (Observer O′)

The forward ray travel is from the source Point S at End A of the moving rod to Clock B on the stationary coordinate system. Observation is by Observer O′ on the stationary coordinate system. Point S is moving with the moving rod, but the location is at $x_1 = 0$ at time t_A per both the stationary and the moving coordinate systems. Clock B stays at $x_2 = r_{AB}$ on the stationary coordinate system through the light travel time duration. Therefore, the light travel distance is $x_2 - x_1 = r_{AB} - 0$ for Observer O′ per the stationary coordinate system.

The ray source Point S is attached at the End A of the moving rod. Therefore, the light ray source Point S is moving at velocity $\vec{v}_s = +v$ relative to the stationary coordinate system and Observer O′. Velocity of the light ray relative to the source Point S on the moving rod is $\vec{c} = +c$ since the travel direction of the ray is in the $+x$ direction of the observation coordinate system. Therefore, per Equation (2-3), the resultant light speed is $\vec{v}_c = \vec{c} + \vec{v}_s = +c + v$ for Observer O′ per the stationary coordinate system.

Per the stationary coordinate,

Location of Point S (Clock A) at time t_A:	0
Location of Clock B at time t_B:	r_{AB}
Ray travel distance from Point S to Clock B:	$r_{AB} - 0$
Speed of light ray $\vec{v}_c$ for Observer O′:	$+c + v$
Ray travel time from Point S to Clock B:	$\frac{r_{AB}-0}{+c+v}$
Clock times:	$t_A = 0$
	$t_B = \frac{r_{AB}-0}{+c+v} = \frac{r_{AB}}{c+v}$

Light travel time duration, Point S to Clock B: $t_B - t_A = \frac{r_{AB}}{c+v}$
(A2a.1)

A2a-2 Backward Reflected Light Ray travel from Clock B to Clock A (Observer O′)

The backward light travel is from the reflected ray origin Clock B to the destination Clock A. Both clocks are stationary on the stationary observation coordinate system. The light departs Clock B at $x_1 = r_{AB}$ at time t_B and arrives at Clock A at $x_2 = 0$ at time t'_A per the stationary coordinate system. Therefore, the light travel distance is $x_2 - x_1 = 0 - r_{AB}$ for Observer O′ per the stationary coordinate system.

The reflected ray source Clock B and Observer O′ are stationary to each other on the same stationary coordinate system. Therefore, the velocity of the source Clock B with respect to the observer is $\vec{v}_s = 0$. The ray velocity relative to the emitting source Clock B is $\vec{c} = -c$ since the ray travel direction is in the $-x$ direction of the coordinate. Therefore, per Equation (2-3), the resultant light velocity is $\vec{v}_c = \vec{c} + \vec{v}_s = -c + 0$ for Observer O' per the stationary coordinate system.

Per the stationary coordinate,

Location of Clock A at time t'_A:	0
Location of Clock B at time t_B:	r_{AB}
Ray travel distance from Clock B to Clock A:	$0 - r_{AB}$
Velocity of light ray $\vec{v}_c$ for Observer O’:	$-c + 0$
Ray travel time Clock B to Clock A:	$\frac{0-r_{AB}}{-c+0}$
Clock times:	$t_B = \frac{r_{AB}}{c+v}$ (From A2a.1)
	$t'_A = t_B + \frac{0-r_{AB}}{-c+0}$
Light travel time duration, Clock B to Clock A: (A2a.2)	$t'_A - t_B = \frac{r_{AB}}{c}$

Subcase A2b: Observed by the Observer O Moving with the Moving Coordinate

A2b-1 Forward Light Ray travel from Point S to Clock B (Observer O)

The forward ray travel is from the source Point S at End A of the moving rod to Clock B on the stationary coordinate. Observation is by Observer O per the moving coordinate system. The location of Point S at time t_A is $x_1 = 0$ per both the stationary and moving coordinate systems. Since the moving coordinate system is moving at velocity $+v$ relative to the stationary coordinate system, the destination Clock B on the stationary coordinate system is moving at velocity $-v$ per the moving coordinate system. Therefore, Clock B moves from $x = r_{AB}$ at time t_A to $x_2 = r_{AB} - vt_B$ at time t_B per the moving coordinate system. Therefore, the light travel distance from Point S to Clock B is $x_2 - x_1 = r_{AB} - vt_B - 0$ for the moving coordinate system and Observer O.

Both the ray source Point S and Observer O are stationary to each other on the same moving coordinate system. Therefore, the velocity of source Point S with respect to Observer O is $\vec{v}_s = 0$. The ray velocity relative to source Point S is $\vec{c} = +c$ since the ray travel is in the $+x$ direction of the observation coordinate system. Therefore, per Equation (2-3), the resultant light speed is $\vec{v}_c = \vec{c} + \vec{v}_s = +c + 0$ for the moving coordinate system and Observer O.

Per the moving coordinate,

Location of Point S (Clock A) at time t_A:	*0*
Location of Clock B at time t_B:	$r_{AB} - vt_B$
Ray travel distance from Point S to Clock B:	$r_{AB} - vt_B - 0$
Velocity of light ray $\vec{v}_c$ for Observer O:	$+c + 0$
Ray travel time from Point S to Clock B:	$\frac{r_{AB}-vt_B-0}{+c+0}$
Clock times:	$t_A = 0$
	$t_B = \frac{r_{AB}-vt_B-0}{+c+0} \Rightarrow t_B = \frac{r_{AB}}{c+v}$
Light travel time duration, Point S to Clock B: (A2b.1)	$t_B - t_A = \frac{r_{AB}}{c+v}$

A2b-2 Backward Reflected Light Ray travel from Clock B to Clock A (Observer O)

The backward travel of the ray is from the reflected ray origin Clock B to the destination Clock A. Both clocks are on the stationary coordinate system. The observation is by Observer O per the moving coordinate system. Since the moving coordinate system and Observer O is moving at velocity $+v$ relative to the stationary coordinate system, the stationary coordinate system and both clocks are moving at velocity $-v$ relative to the moving coordinate system and Observer O. Therefore, the ray source Clock B moves from $x = r_{AB}$ at time t_A to $x_1 = r_{AB} - vt_B$ at time t_B as shown in A2b-1 and the destination Clock A moves from $x = 0$ at time t_A to $x_2 = -vt'_A$ at time t'_A per the moving coordinate system. Therefore, the light travel distance from Clock B to Clock A is $x_2 - x_1 = -vt'_A - (r_{AB} - vt_B)$ for Observer O per the moving coordinate system.

The reflected ray source Clock B on the stationary coordinate system is moving at velocity $\vec{v}_s = -v$ relative to the moving observation coordinate and Observer O. The ray velocity relative to the source Clock B is $\vec{c} = -c$ since the ray travels in $-x$ direction of the observation coordinate system. Therefore, per Equation (2-3), the resultant light speed is $\vec{v}_c = \vec{c} + \vec{v}_s = -c - v$ for Observer O per the moving coordinate system.

Per the moving coordinate,

Location of Clock A at time t'_A:	$-vt'_A$	
Location of Clock B at time t_B:	$r_{AB} - vt_B$	
Ray travel distance from Clock B to Clock A:	$-vt'_A - (r_{AB} - vt_B)$	
Velocity of light ray $\vec{v}_c$ for Observer O:	$-c - v$	
Ray travel time from Clock B to Clock A:	$\frac{-vt'_A - (r_{AB} - vt_B)}{-c-v}$	
Clock times:	$t_B = \frac{r_{AB}}{c+v}$	(From A2b.1)
	$t'_A = t_B + \frac{rAB - vtB + vt'A}{c+v}$ => $t'_A - t_B = \frac{r_{AB}}{c}$	
Light travel time duration, Clock B to Clock A:	$t'_A - t_B = \frac{r_{AB}}{c}$	

(A2b.2)

Case A2 review conclusion: The moving observer and the stationary observer agree completely on the event times and the light travel times for both forward and backward light travels. Therefore, there is no dispute between Observers O and O′ on the clock synchronism or event simultaneity. The physical events are identical for both the moving and stationary observers.

Case A3 – Stationary Initial Ray Launch Point S and Moving Rod

Light source Point S:	Stationary. Fixed at the origin of the stationary coordinate.
Clock A:	Moving. Fixed End A, $x = 0$ of the moving rod.
Clock B:	Moving. Fixed End B, $x = r_{AB}$ of the moving rod.

Subcase A3a: Observed by the Observer O′ stationary with the Stationary Coordinate

A3a-1 Forward Light Ray Travel from Point S to Clock B (Observer O′)

The forward ray travel is from Point S on the stationary coordinate system to Clock B on the moving rod. Observation is per the stationary coordinate system. At time t_A, Point S is located at $x_1 = 0$ per both coordinate systems. Clock B on the moving rod is moving at velocity $+v$ relative to the stationary observation coordinate system and, therefore, moves from $x = r_{AB}$ at time t_A to $x_2 = r_{AB} + vt_B$ at time t_B per the stationary coordinate system. Therefore, the light ray travel distance from Point S to Clock B is $x_2 - x_1 = r_{AB} + vt_B - 0$ per the stationary coordinate system and Observer O′.

The ray source Point S is stationary with respect to Observer O′ on the same stationary coordinate system and, therefore, the source velocity is $\vec{v}_s = 0$ for Observer O′. The ray velocity relative to the source Point S is $\vec{c} = +c$ since the travel direction of the ray is in the $+x$ direction of the observation coordinate system. Therefore, per

Equation (2-3), the resultant light speed is $\vec{v}_c = \vec{c} + \vec{v}_s = +c + 0$ for the stationary coordinate system and Observer $0'$.

Per the stationary coordinate,

Location of Point S (Clock A) at time t_A:	0
Location of Clock B at time t_B:	$r_{AB} + vt_B$
Ray travel distance from Point S to Clock B:	$r_{AB} + vt_B - 0$
Velocity of light ray $\vec{v}_c$ for Observer $0'$:	$+c + 0$
Ray travel time from Point S to Clock B:	$\frac{r_{AB}+vt_B-0}{+c+0}$
Clock times:	$t_A = 0$
	$t_B = \frac{r_{AB}+vt_B-0}{+c+0}$ => $t_B = \frac{r_{AB}}{c-v}$

Light travel time duration, Point S to Clock B: $t_B - t_A = \frac{r_{AB}}{c-v}$

(A3a.1)

A3a-2 Backward Reflected Light Ray Travels back from Clock B to Clock A (Observer $0'$)

The backward travel of the ray is from the reflected ray source Clock B to the destination Clock A. Both clocks are on the moving rod. The observation is per the stationary coordinate system. Both clocks are moving at velocity $+v$ relative to the stationary coordinate system. The reflected ray source Clock B is at $x_1 = r_{AB} + vt_B$ at time t_B per the stationary coordinate system as determined in A3a-1. At time t'_A, the destination Clock A moves to $x_2 = +vt'_A$ per the stationary coordinate system. Therefore, the light travel distance from Clock B to Clock A is $x_2 - x_1 = +vt'_A - (r_{AB} + vt_B)$ per the stationary coordinate system and Observer $0'$.

The reflected ray source Clock B is moving at velocity $\vec{v}_s = +v$ relative to the stationary observation coordinate and Observer $0'$. The ray velocity relative to the source Clock B is $\vec{c} = -c$ since the travel direction of the ray is in the $-x$ direction of the observation coordinate. Therefore, per Equation (2-3), the resulting light speed is $\vec{v}_c = \vec{c} + \vec{v}_s = -c + v$ for the stationary coordinate system and for Observer $0'$.

Per the stationary coordinate,

Location of Clock A at time t'_A:	vt'_A	
Location of Clock B at time t_B:	$r_{AB} + vt_B$	
Ray travel distance from Clock B to Clock A:	$vt'_A - (r_{AB} + vt_B)$	
Speed of light ray $\vec{v}_c$ for Observer $0'$:	$-c + v$	
Ray travel time from Clock B to Clock A:	$\frac{vt'_A-(r_{AB}+vt_B)}{-c+v}$	
Clock times:	$t_B = \frac{r_{AB}}{c-v}$	(From A3a.1)
	$t'_A = t_B + \frac{r_{AB}+vt_B-vt'_A}{c-v}$=> $t'_A - t_B = \frac{r_{AB}}{c}$	

Light travel time duration, Clock B to Clock A: $t'_A - t_B = \frac{r_{AB}}{c}$

(A3a.2)

Subcase A3b: Observed by the Observer O moving with the Moving Coordinate

A3b-1 Forward Light Ray Travels from Point S to Clock B (Observer O)

The forward ray travel is from Point S on the stationary coordinate system to Clock B on the moving rod. Observation is per the moving coordinate system. At time t_A, the ray source Point S is at $x_1 = 0$ per both coordinate systems. At time t_B, the destination point Clock B on the moving coordinate is stationary at $x_2 = r_{AB}$

per the moving coordinate system and Observer O. Therefore, the light travel distance from Point S to Clock B is $x_2 - x_1 = r_{AB} - 0$ for the moving coordinate system and for Observer O.

The ray source Point S is on the stationary coordinate and, therefore, moving at velocity $-v$ relative to the moving observation coordinate and Observer O. Therefore, the velocity of the ray source Point S is $\vec{v}_s = -v$ also with respect to the moving observation coordinate. The ray velocity relative to the source Point S is $\vec{c} = +c$ since the ray travels in the $+x$ direction of the observation coordinate. Therefore, per Equation (2-3), the resultant light speed is $\vec{v}_c = \vec{c} + \vec{v}_s = +c - v$ for the moving coordinate system and for Observer O.

Per the moving coordinate,

Location of Point S (Clock A) at time t_A:	0
Location of Clock B at time t_B:	r_{AB}
Ray travel distance from Point S to Clock B:	$r_{AB} - 0$
Speed of light ray $\vec{v}_c$ for Observer O:	$+c - v$
Ray travel time from Point S to Clock B:	$\frac{r_{AB}-0}{+c-v}$
Clock times:	$t_A = 0$
	$t_B = \frac{r_{AB}-0}{+c-v} = \frac{r_{AB}}{c-v}$
Light travel time duration, Point S to Clock B:	$t_B - t_A = \frac{r_{AB}}{c-v}$
(A3b.1)	

A3b-2 Backward Reflected Light Ray Travels from Clock B to Clock A (Observer O)

The backward ray travel is from the reflected ray source Clock B at End B of the moving rod to the destination point Clock A at End A of the same rod. Observation is per the moving coordinate system. Since both clocks are stationary with respect to the moving coordinate system and Observer O, the reflected light source Clock B stays at $x_1 = r_{AB}$ at time t_B and the destination point Clock A at $x_2 = 0$ at time t'_A on the moving observation coordinate system. Therefore, the light travel distance is $x_2 - x_1 = 0 - r_{AB}$ for the moving coordinate system and for Observer O.

The reflected ray source Clock B is stationary on the moving coordinate system and Observer O, and, therefore, the source velocity relative to the observer is $\vec{v}_s = 0$. The light ray velocity relative to the source Clock B is $\vec{c} = -c$ since the ray travels in the $-x$ direction of the observation coordinate. Therefore, per Equation (2-3), the resultant light velocity is $\vec{v}_c = \vec{c} + \vec{v}_s = -c + 0$ for the moving coordinate system and for Observer O.

Per the moving coordinate,

Location of Clock A at time t'_A:	0	
Location of Clock B at time t_B:	r_{AB}	
Ray travel distance from Clock B to Clock A:	$0 - r_{AB}$	
Velocity of light ray $\vec{v}_c$ for Observer O:	$-c + 0$	
Ray travel time from Clock B to Clock A:	$\frac{0-r_{AB}}{-c+0}$	
Clock times:	$t_B = \frac{r_{AB}}{c-v}$	(From A3b.1)
	$t'_A = t_B + \frac{0-r_{AB}}{-c+0}$	
Light travel time duration, Clock B to Clock A:	$t'_A - t_B = \frac{r_{AB}}{c}$	
(A3b.2)		

Case A3 review conclusion: The moving observer and the stationary observer agree completely on the event times and the light travel times for both forward and backward light travels. Therefore, there is no dispute between Observers O and O′ on the clock synchronism or event simultaneity. The physical events are identical for both the moving and stationary observers.

Case A4 – Moving Initial Ray Launch Point S and Moving Rod

Light source Point S:	Moving. Fixed at End A of the moving rod.
Clock A:	Moving. Fixed End A, $x = 0$ of the moving rod.
Clock B:	Moving. Fixed End B, $x = r_{AB}$ of the moving rod.

Subcase A4a: Observed by the Observer $0'$ stationary with the Stationary Coordinate

A4a-1 Forward Light Ray Travels from Point S to Clock B (Observer O′)

The forward ray travel is from Point S to Clock B and both are on the moving rod. Observation is per the stationary coordinate system. Therefore, Point S and Clock B are moving at velocity $+v$ relative to the stationary observation coordinate system. The ray departs Point S at time $t_A = 0$ and the location is $x_1 = 0$ per both the stationary and moving coordinate systems. The ray arrives at Clock B at time t_B and the location is $x_2 = r_{AB} + vt_B$ per the stationary coordinate system. Therefore, the light travel distance from Point S to Clock B is $x_2 - x_1 = r_{AB} + vt_B - 0$ per the stationary coordinate system and Observer O′.

The ray source Point S is moving at velocity $\vec{v}_s = +v$ relative to the stationary observation coordinate system and Observer O′. The ray velocity relative to the source Point S is $\vec{c} = +c$ since the ray travels in the $+x$ direction of the observation coordinate. Therefore, per Equation (2-3), the resultant light velocity is $\vec{v}_c = \vec{c} + \vec{v}_s = +c + v$ for the stationary coordinate system and for Observer O′.

Per the stationary coordinate,

Location of Point S (Clock A) at time t_A:	0
Location of Clock B at time t_B:	$r_{AB} + vt_B$
Ray travel distance from Point S to Clock B:	$r_{AB} + vt_B - 0$
Speed of light ray $\vec{v}_c$ for Observer O′:	$+c + v$
Ray travel time from Point S to Clock B:	$\frac{r_{AB}+vt_B-0}{+c+v}$
Clock times:	$t_A = 0$
	$t_B = \frac{r_{AB}+vt_B-0}{+c+v}$ => $t_B = \frac{r_{AB}}{\boldsymbol{c}}$
Light travel time duration, Point S to Clock B: (A4a.1)	$t_B - t_A = \frac{r_{AB}}{c}$

A4a-2 Backward Reflected Light Ray Travels from Clock B to Clock A (Observer O′)

The backward travel of the ray is from the reflection ray source Clock B to the destination Clock A and both clocks are on the moving rod. Observation is per the stationary coordinate system. Both Clock A and Clock B are on the moving rod and moving at velocity $+v$ with respect to the stationary observation coordinate system and Observer O′. The ray departs Clock B at time t_B and the location is $x_1 = r_{AB} + vt_B$ per the stationary coordinate system as determined in A4a-1. The ray arrives at Clock A at time t'_A and the location is $x_2 = vt'_A$ per the stationary coordinate system. Therefore, the light travel distance from Clock B to Clock A is $x_2 - x_1 = vt'_A - (r_{AB} + vt_B)$ for the stationary coordinate system and for Observer O′.

The reflected ray source Clock B is moving at velocity $\vec{v}_s = +v$ relative to the stationary observation coordinate and Observer O′. The ray velocity relative to the reflected ray source Clock B is $\vec{c} = -c$ since the travel direction of the ray is in the $-x$ direction of the observation coordinate. Therefore, per Equation (2-3), the resultant light speed is $\vec{v}_c = \vec{c} + \vec{v}_s = -c + v$ for the stationary observation coordinate system and for Observer O′.

Per the stationary coordinate,

Location of Clock A at time t'_A: vt'_A
Location of Clock B at time t_B: $r_{AB} + vt_B$
Ray travel distance from Clock B to Clock A: $vt'_A - (r_{AB} + vt_B)$
Velocity of light ray $\vec{v}_c$ for Observer O′: $-c + v$

Ray travel time from Clock B to Clock A: $\frac{vt'_A - (r_{AB} + vt_B)}{-c+v}$

Clock times: $t_B = \frac{r_{AB}}{c}$ (From A4a.1)

$t'_A = t_B + \frac{r_{AB} + vt_B - vt'_A}{c-v}$ => $t'_A - t_B = \frac{r_{AB}}{c}$

Light travel time duration, Clock B to Clock A: $t'_A - t_B = \frac{r_{AB}}{c}$
(A4a.2)

Subcase A4b: Observed by the Observer O moving with the Moving Coordinate

A4b-1 Forward Light Ray Travels from Point S to Clock B (Observer O)

The ray forward travel is from Point S (Clock A) to the destination Clock B. Both Point S and Clock B are fixed on the moving rod. Observation is per the moving coordinate system fixed on the moving rod. Point S is fixed at $x_1 = 0$ with Clock A and Clock B is at $x_2 = r_{AB}$ on the moving observation coordinate system through the entire event time. Therefore, the light travel distance from Point S (Clock A) to Clock B is $x_2 - x_1 = r_{AB} - 0$ for the moving coordinate system and for Observer O.

The ray source Point S (Clock A) on the moving rod is stationary relative to the moving coordinate system and Observer O and, therefore, the source velocity is $\vec{v}_s = 0$ relative to Observer O. The ray velocity relative to the source Point S is $\vec{c} = +c$ since the travel direction of the ray is in the $+x$ direction of the observation coordinate. Therefore, per Equation (2-3), the resultant light speed is $\vec{v}_c = \vec{c} + \vec{v}_s = +c + 0$ for the moving coordinate system and for Observer O.

Per the moving coordinate,

Location of Point S (Clock A) at time t_A: 0
Location of Point B at time t_B: r_{AB}
Ray travel distance from Point S to Clock B: $r_{AB} - 0$
Velocity of light ray $\vec{v}_c$ for Observer O: $+c + 0$

Ray travel time from Point S to Clock B: $\frac{r_{AB} - 0}{+c+0}$

Clock times: $t_A = 0$

$t_B = \frac{r_{AB} - 0}{+c+0} = \frac{r_{AB}}{c}$

Light travel time duration, Point S to Clock B: $t_B - t_A = \frac{r_{AB}}{c}$
(A4b.1)

A1.4b-2 Backward Reflected Light Ray Travels from Clock B to Clock A (Observer O)

The backward travel of the reflected ray is from the source Clock B to the destination Clock A. Both clocks are on the moving rod. Observation is per the moving coordinate system. Clock B is fixed at $x_1 = r_{AB}$ and Clock A at $x_2 = 0$ on the moving coordinate system through the entire time of the event. Therefore, the light travel distance from Clock B to Clock A is $x_2 - x_1 = 0 - r_{AB}$ for the moving coordinate and Observer O.

The reflected ray source Clock B is stationary for the moving coordinate and Observer O and, therefore, the source velocity relative to the observer is $\vec{v}_s = 0$. The ray velocity relative to the source Clock B is $\vec{c} = -c$ since the travel direction is in the $-x$ direction of the coordinate. Therefore, per Equation (2-3), the resultant light speed is $\vec{v}_c = \vec{c} + \vec{v}_s = -c + 0$ for the moving coordinate system and for Observer O.

Location of Clock A at time t'_A:	0	
Location of Clock B at time t_B:	r_{AB}	
Ray travel distance from Clock B to Clock A:	$0 - r_{AB}$	
Velocity of light ray $\vec{v}_c$ for Observer O:	$-c + 0$	
Ray travel time from Clock B to Clock A:	$\frac{0-r_{AB}}{-c+0}$	
Clock times:	$t_B = \frac{r_{AB}}{c}$	(From A4b.1)
	$t'_A = t_B + \frac{0-r_{AB}}{-c+0} = \frac{2r_{AB}}{c}$	
Light travel time duration, Clock B to Clock A:	$t'_A - t_B = \frac{r_{AB}}{c}$	

(A4b.2)

Case A4 review conclusion: The moving observer and the stationary observer agree completely on the event times and the light travel times for both forward and backward light travels. Therefore, there is no dispute between Observers O and O′ on the clock synchronism or event simultaneity. The physical events are identical for both the moving and stationary observers.

Appendix B

Re-Examination of Einstein's Moving Rod Experiment - Aether Exists

Appendix B is a reanalysis of the Einstein's hypothetical moving rod experiment with the classical Newtonian velocity vector addition principle. This appendix assumes there is the aether in the universe. Therefore, the light travel is per the medium reliant travel mechanics as in Equation (2-3). Otherwise, all conditions are identical to Appendix A. The stationary coordinate system is defined as moving relative to the universally static aether in the $+x$ direction and, therefore, the aether velocity (the aether wind) with respect to the stationary coordinate system is $-V$ for all cases.

Case B1 Stationary Initial Ray Launch Point S and Stationary Rod

Light source Point S:	Stationary. Fixed at the origin of the stationary coordinate.
Clock A:	Stationary. Fixed at the origin of the stationary coordinate.
Clock B:	Stationary. Fixed at $x = r_{AB}$ of the stationary coordinate.

Subcase B1a: Observed by the Observer with the Stationary System (Observer O′)

B1a-1 Light Ray travel from Point S to Clock B (Observer O′)

The forward ray travel is from the launch Point S (Clock A) to the destination Clock B at the constant velocity c relative to the medium aether. Both Point S and Clock B are stationary on the stationary coordinate system. The observation reference is the stationary coordinate system.

The ray travel direction is in the $+x$ direction of the stationary observation system, and, therefore, the velocity is $\vec{c} = +c$ relative to the aether. The aether wind velocity relative to the stationary coordinate system is $\vec{v}_s = -V$. Therefore, the speed of the light ray relative to the stationary coordinate system and Observer O′ is $\vec{v}_c = \vec{c} + \vec{v}_s = +c - V$ per Equation (2-3).

Both Point S (Clock A) and Clock B are stationary on the stationary coordinate system during the ray travel event. Therefore, the ray travels from Point S located at $x_1 = 0$ at time t_A to Clock B located at $x_2 = r_{AB}$ through time t_B on the stationary coordinate system. Therefore, the distance for the light ray to travel is $x_2 - x_1 = r_{AB} - 0$ per the stationary coordinate system and Observer O′.

Location of Clock A at time t_A: 0
Location of Clock B at time t_B: r_{AB}
Travel distance for the light ray: $r_{AB} - 0$
Velocity of light ray for Observer O′: $+c - V$
Time required for the light ray travel: $\frac{r_{AB}}{c-V}$
Clock times: $t_A = 0$
$t_B = \frac{r_{AB}}{c-V}$
Time duration between events, $t_B - t_A = \frac{r_{AB}}{c-V}$
(B1a.1)

B1a-2 The reflected Light Ray travel from Clock B to Clock A (Observer O′)

The backward travel of the reflected ray is from Clock B to Clock A at the constant velocity c relative to the medium aether. Both clocks are stationary on the stationary coordinate system. The observation reference is the stationary coordinate system.

The ray travel direction is in the $-x$ direction of the stationary observation coordinate system, and, therefore, the ray velocity is $\vec{c} = -c$ relative to the aether. The velocity of the aether relative to the stationary coordinate system is $\vec{v}_s = -V$. Therefore, the velocity of the light ray with respect to the stationary coordinate system and Observer O′ is $\vec{v}_c = \vec{c} + \vec{v}_s = -c - V$ per Equation (2-3).

Both Clock A and Clock B are fixed on the same stationary coordinate system through the entire event duration. The location of Clock B is $x_1 = r_{AB}$ at time t_B and Clock A $x_2 = 0$ at time t'_A per the stationary coordinate system. Therefore, the ray travel distance is $x_2 - x_1 = 0 - r_{AB}$ for the stationary coordinate system and Observer O′.

Location of Clock A at time t'_A: 0
Location of Clock B at time t_B: r_{AB}
Travel distance for the light ray: $0 - r_{AB}$
Velocity of light ray for Observer **O′**: $-c - V$
Time required for the light ray travel: $\frac{r_{AB}}{c+V}$
Clock times: $t_B = \frac{r_{AB}}{c-V}$ (from B1a.1)
$t'_A = t_B + \frac{r_{AB}}{c+V}$
Time duration between events, $t'_A - t_B = \frac{r_{AB}}{c+V}$
(B1a.2)

Subcase B1b: Observed by the Observer with the Moving rod (Observer O)

B1b-1 The light travel from Point S to Clock B (Observer O)

The forward ray travel is from Point S (Clock A) to Clock B at the constant velocity c relative to the medium aether. Both the light launching Point S (Clock A) and the destination Clock B are fixed on the stationary coordinate system. The observation reference is the moving coordinate system.

The ray travel direction is in the $+x$ direction of the moving coordinate system, and, therefore, the velocity is $\vec{c} = +c$ relative to the aether. The aether wind velocity is $-V$ relative to the stationary coordinate system and the stationary coordinate system moves at velocity $-v$ relative to the moving coordinate system. The resulting aether velocity relative to the moving coordinate system is $\vec{v}_s = -v - V$. Therefore, the velocity of the light ray with respect to the moving coordinate system and Observer O is $\vec{v}_c = \vec{c} + \vec{v}_s = +c - v - V$ per Equation (2-3).

Both Point S (Clock A) and Clock B are on the same stationary coordinate system and moving together at velocity – v with respect to the moving observation coordinate. The location of Point S is at $x_1 = 0$ at time t_A, and

Clock B moves to $x_2 = r_{AB} - vt_B$ at time t_B per the moving coordinate system. Therefore, the ray travel distance is $x_2 - x_1 = r_{AB} - vt_B - 0$ for the moving coordinate system and Observer O.

Location of Clock A at time t_A:	0
Location of Clock B at time t_B:	$r_{AB} - vt_B$
Travel distance for the light ray:	$r_{AB} - vt_B - 0$
Velocity of light ray for Observer O:	$+c - v - V$
Time required for the light ray travel:	$\frac{r_{AB}-vt_B}{c-v-V}$
Clock times:	$t_A = 0$
	$t_B = \frac{r_{AB}-vt_B}{c-v-V} \quad => t_B = \frac{r_{AB}}{c-V}$
Time duration between events, (B1b.1)	$t_B - t_A = \frac{r_{AB}}{c-V}$

B1b-2 The Reflected Light Ray travel from Clock B to Clock A (Observer O)

The backward travel of the reflected ray is from the ray source Clock B to the destination Clock A at the constant velocity *c* relative to the medium aether. Both clocks are stationary on the stationary coordinate system through the ray travel event. The observation reference is the moving coordinate system.

The velocity of the ray is $\vec{c} = -c$ relative to the aether since the travel is in the $-x$ direction of the moving observation coordinate. In B1b-1 above, the velocity of the aether relative to the moving coordinate system is determined as $\vec{v}_s = -v - V$. Therefore, the resultant light velocity for the moving coordinate system and Observer O is $\vec{v}_c = \vec{c} + \vec{v}_s = -c - v - V$ per Equation (2-3).

Both Clock A and Clock B are fixed on the stationary coordinate and move together relative to the moving observation coordinate system at velocity – v. For the moving coordinate, therefore, Clock B is located at $x_1 = r_{AB} - vt_B$ at time t_B and Clock A at $x_2 = -vt'_A$ at time t'_A. Therefore, the light ray travel distance is $x_2 - x_1 = -vt'_A - (r_{AB} - vt_B)$.

Location of Clock A at time t'_A:	$-vt'_A$	
Location of Clock B at time t_B:	$r_{AB} - vt_B$	
Travel distance for the light ray:	$-vt'_A - (r_{AB} - vt_B)$	
Speed of light ray for Observer O:	$-c - v - V$	
Time required for the light ray travel:	$\frac{r_{AB}-vt_B+vt'_A}{c+v+V}$	
Clock times:	$t_B = \frac{r_{AB}}{c-V}$	(From B1b.1)
	$t'_A = t_B + \frac{r_{AB}-vt_B+vt'_A}{c+v+V} => t'_A - t_B = \frac{r_{AB}}{c+V}$	
Time duration between events, (B1b.2)	$t'_A - t_B = \frac{r_{AB}}{c+V}$	

Case B1 review: For this case, the moving observer and the stationary observer agree completely on the event times and the time intervals for both forward and backward light travels. Therefore, there is no dispute between Observers O and O′ on the clock synchronism. Observations on the same event are exactly the same for both moving and stationary observers.

Case B2 Moving Initial Ray Launch Point S and Stationary Rod

Light source Point S:	Moving. Fixed at End A of the moving rod.
Clock A:	Stationary. Fixed at origin of the stationary coordinate.
Clock B:	Stationary. Fixed at $x = r_{AB}$ of the stationary coordinate.

Subcase B2a: Observed by the Observer with the Stationary system (Observer O′)

B2a-1 The Light Ray travel from Point S to Clock B (Observer O′)

The ray forward travel is from Point S at the origin of the moving coordinate system on the moving rod to the destination Clock B fixed on the stationary coordinate. The velocity of the ray is constant c relative to the medium aether in any direction. The observation reference is the stationary coordinate system.

The ray travels at velocity $\vec{c} = +c$ relative to the aether since the ray travel is in the $+x$ direction of the observation stationary coordinate. The aether wind velocity is $\vec{v}_s = -V$ relative to the stationary coordinate. Therefore, the resultant light velocity for the stationary coordinate system and Observer O′ is $\vec{v}_c = \vec{c} + \vec{v}_s = +c - V$ per Equation (2-3).

Both Clock A and Clock B are fixed on the stationary coordinate system through the ray travel event. Point S is coincident with Clock A at time t_A of the ray launch. For the stationary coordinate system, the location of Clock A and Point S are at $x_1 = 0$ at time t_A and Clock B stay at $x_2 = r_{AB}$ at time t_B. Therefore, the light ray travel distance is $x_2 - x_1 = r_{AB} - 0$.

Location of Clock A at time t_A:	0
Location of Clock B at time t_B:	r_{AB}
Travel distance for the light ray:	$r_{AB} - 0$
Speed of light ray for Observer O’:	$c - V$
Time required for the light ray travel:	$\frac{r_{AB}}{c-V}$
Clock times:	$t_A = 0$
	$t_B = \frac{r_{AB}}{c-V}$
Time duration between events, (B2a.1)	$t_B - t_A = \frac{r_{AB}}{c-V}$

B2a-2 The reflected Light Ray travel from Clock B to Clock A (Observer O′)

This case is exactly the same as B1a-2 above. Therefore, the light ray travel velocity is $\vec{v}_c = \vec{c} + \vec{v}_s = -c - V$ with respect to the stationary coordinate system and Observer O′ and the light travel distance is $x_2 - x_1 = 0 - r_{AB}$.

Location of Clock A at time t'_A:	0	
Location of Clock B at time t_B:	r_{AB}	
Travel distance for the light ray:	$0 - r_{AB}$	
Velocity of light ray for Observer O’:	$-c - V$	
Time required for the light ray travel:	$\frac{r_{AB}}{c+V}$	
Clock times:	$t_B = \frac{r_{AB}}{c-V}$	(From B2a.1)
	$t'_A = t_B + \frac{r_{AB}}{c+V}$ => $t'_A - t_B = \frac{r_{AB}}{c+V}$	
Time duration between events, (B2a.2)	$t'_A - t_B = \frac{r_{AB}}{\boldsymbol{c+V}}$	

Subcase B2b: Observed by Observer with the Moving rod (Observer O)

B2b-1 The Light Ray travel from Point S to Clock B (Observer O)

The ray forward travel is from Point S at the origin of the moving coordinate system to the destination Clock B fixed on the stationary coordinate system. The observation reference is the coordinate system moving with the rod.

As soon as the ray leaves the launching Point S, the ray travel velocity is a constant $\vec{c} = +c$ relative to the aether since the travel direction is in the $+x$ direction of the moving observation coordinate system. The aether wind velocity with respect to the stationary coordinate system is $-V$ and the stationary coordinate system moves with respect to the moving observation coordinate system at velocity $-v$. Therefore, the aether velocity relative to the observation moving coordinate system is $\vec{v}_s = -v - V$. The resultant light velocity relative to the moving coordinate system and Observer O is $\vec{v}_c = \vec{c} + \vec{v}_s = +c - v - V$ per Equation (2-3).

Point S and Clock A are coincidently located at the moment of ray launch at $x_1 = 0$ at time $t_A = 0$ per the moving observation coordinate system. Clock B on the stationary system moves at velocity $-v$ with respect to the moving coordinate system. For the moving coordinate system, Clock B moves to $x_2 = r_{AB} - vt_B$ at time t_B. Therefore, the light ray travel distance is $x_2 - x_1 = r_{AB} - vt_B - 0$.

Location of Point S at time t_A:	0
Location of Clock B at time t_B:	$r_{AB} - vt_B$
Travel distance for the light ray:	$r_{AB} - vt_B - 0$
Velocity of light ray for Observer O:	$+c - v - V$
Time required for the light ray travel:	$\frac{r_{AB}-vt_B}{c-v-V}$
Clock times:	$t_A = 0$
	$t_B = \frac{r_{AB}-vt_B}{c-v-V}$ => $t_B = \frac{r_{AB}}{c-V}$
Time duration between events, (B2b.1)	$t_B - t_A = \frac{r_{AB}}{c-V}$

B2b-2 The reflected Light Ray travel from Clock B to Clock A (Observer O)

This case is exactly the same as B1b-2. Therefore, the speed of the light is $\vec{v}_c = \vec{c} + \vec{v}_s = -c - v - V$ with respect to the moving coordinate system and Observer O, and the light ray travel distance is $x_2 - x_1 = -vt'_A - (r_{AB} - vt_B)$ per the moving coordinate system.

Location of Clock A at time t'_A:	$-vt'_A$
Location of Clock B at time t_B:	$r_{AB} - vt_B$
Travel distance for the light ray:	$-vt'_A - (r_{AB} - vt_B)$
Speed of light ray for Observer O:	$-c - v - V$
Time required for the light ray travel:	$\frac{rAB-vtB+vt'A}{c+v+V}$
Clock times:	$t_B = \frac{r_{AB}}{c-v}$ (From B2b.1)
	$t'_A = t_B + \frac{rAB-vtB+vt'A}{c+v+V}$ => $t'_A - t_B = \frac{r_{AB}}{c+V}$
Time duration between events, (B2b.2)	$t'_A - t_B = \frac{r_{AB}}{c+V}$

Case B2 review: For this case, the moving observer and the stationary observer agree completely on the event times and the time intervals for both forward and backward light travels. Therefore, there is no dispute between Observers O and O′ on the clock synchronism. Observations on the same event are exactly the same for both moving and stationary observers.

Case B3 Stationary Initial Ray Launch Point S and Moving Rod

Light source Point S:	Stationary. Fixed at the origin of the stationary coordinate.
Clock A:	Moving. Fixed End A of the moving rod.
Clock B:	Moving. Fixed End B of the moving rod.

Subcase B3a: Observed by the Observer with the Stationary system (Observer O′)

BB3a-1 The Light Ray travel from Point S to Clock B (Observer O′)

The ray forward travel is through the medium aether from the launched Point S at the origin of the stationary coordinate system to Clock B on End B of the moving rod. The observation reference is the stationary coordinate system.

The ray velocity with respect to the aether is $\vec{c} = +c$ since the ray travel direction is in the +x direction of the observing stationary coordinate system. The velocity of the aether is $\vec{v}_s = -V$ relative to the stationary coordinate system and Observer O$'$. Therefore, the resultant light velocity relative to the stationary coordinate system and Observer O$'$ is $\vec{v}_c = \vec{c} + \vec{v}_s = +c - V$ per Equation (2-3).

Both Clock A and Clock B are fixed on the moving coordinate system during the ray travel. Point S on the stationary coordinate system is coincident with Clock A on the moving rod at the time t_A of the ray launching. Therefore, for the stationary coordinate system, locations of both Clock A and Point S are $x_1 = 0$ at time t_A=0. Per the stationary coordinate system, Clock B moves from the original location $x = r_{AB}$ to $x_2 = r_{AB} + vt_B$ by the time the ray arrives at Clock B at time t_B. Therefore, the light ray travel distance is $x_2 - x_1 = r_{AB} + vt_B - 0$.

Location of Clock A at time t_A:	0
Location of Clock B at time t_B:	$r_{AB} + vt_B$
Travel distance for the light ray:	$r_{AB} + vt_B - 0$
Velocity of light ray for Observer O$'$:	$+c - V$
Time required for the light ray travel:	$\frac{r_{AB}+vt_B}{c-V}$
Clock times:	$t_A = 0$
	$t_B = \frac{r_{AB}+vt_B}{c-V}$ => $t_B = \frac{r_{AB}}{c-v-V}$
Time duration between events, (B3a.1)	$t_B - t_A = \frac{r_{AB}}{c-v-V} - 0 = \frac{r_{AB}}{c-v-V}$

B3a-2 The reflected Light Ray travel from Clock B to Clock A (Observer O$'$)

The reflected ray backward travel is through the medium aether from Clock B at End B of the moving rod to Clock A at End A of the same rod. The observation reference is the stationary coordinate system.

The light ray travel velocity is $\vec{c} = -c$ relative to the aether since the ray travel direction is in the $-x$ direction of the observation stationary coordinate system. The aether wind velocity is $\vec{v}_s = -V$ for the stationary coordinate system and Observer O$'$. Therefore, the resultant light velocity for the stationary coordinate system and Observer O$'$ is $\vec{v}_c = \vec{c} + \vec{v}_s = -c - V$ per Equation (2-3).

Both Clock A and Clock B are on the moving rod which is moving together at velocity $+v$ relative to the observing stationary coordinate system. Therefore, for the stationary coordinate system, location of Clock B is $x_1 = r_{AB} + vt_B$ at time t_B when the ray is reflected. Clock A moves to $x_2 = vt'_A$ at time t'_A when the ray returns back to Clock A. Therefore, the light ray travel distance is $x_2 - x_1 = vt'_A - (r_{AB} + vt_B)$.

Location of Clock A at time t'_A:	vt'_A	
Location of Clock B at time t_B:	$r_{AB} + vt_B$	
Travel distance for the light ray:	$vt'_A - (r_{AB} + vt_B)$	
Speed of light ray for Observer O$'$:	$-c - V$	
Time required for the light ray travel:	$\frac{r_{AB}+vt_B-vt'_A}{c+V}$	
Clock times:	$t_B = \frac{r_{AB}}{c-v-V}$	(From B3a.1)
	$t'_A = t_B + \frac{r_{AB}+vt_B-vt'_A}{c+V}$ => $t'_A - t_B = \frac{r_{AB}}{c+v+V}$	
Time duration between events, (B3a.2)	$t'_A - t_B = \frac{r_{AB}}{c+v+V}$	

Subcase B3b: Observed by the Observer with the Moving rod (Observer O)

B3b-1 Light Ray travels from Point S to Clock B (Observer O)

The forward travel of the ray is through the medium aether and from Point S at the origin of the stationary coordinate system to Clock B on End B of the moving rod. The observation reference is the moving coordinate system attached to the moving rod.

The ray velocity is $\vec{c} = +c$ relative to the aether since the ray travel direction is in the +*x* direction of the observation coordinate system. The velocity of the aether wind with respect to the stationary coordinate system is $-V$ and the stationary coordinate system moves at the velocity $-v$ relative to the moving observation coordinate system and, therefore, the velocity of the aether relative to the moving coordinate system is $\vec{v}_s = -v - V$. Therefore, the resultant light velocity relative to the moving coordinate system and Observer O is $\vec{v}_c = \vec{c} + \vec{v}_s = +c - v - V$ per Equation (2-3).

Point S is fixed at the origin of the stationary coordinate. Clock B is fixed on the moving rod. The ray launching Point S is coincident with Clock A at the moment of the ray launch. Therefore, per the moving coordinate system, the Point S and Clock A is at $x_1 = 0$ at time t_A=0 and the destination Clock B is at $x_2 = r_{AB}$ at time t_B. Therefore, the light ray travel distance is $x_2 - x_1 = r_{AB} - 0$.

Location of Clock A at time t_A:	0
Location of Clock B at time t_B:	r_{AB}
Travel distance for the light ray:	$r_{AB} - 0$
Speed of light ray for Observer O:	$+c - v - V$
Time required for the light ray travel:	$\frac{r_{AB}}{c-v-V}$
Clock times:	$t_A = 0$
	$t_B = \frac{r_{AB}}{c-v-V}$
Time duration between events, (B3b.1)	$t_B - t_A = \frac{r_{AB}}{c-v-V}$

B3b-2 Reflected Light Ray travels from Clock B to Clock A (Observer O)

The backward travel of the reflected ray is from Clock B on End B to the destination Clock A on End A of the same moving rod. The observation reference is the moving coordinate system attached to the moving rod.

The reflected ray velocity relative to the aether is $\vec{c} = -c$ since the ray travel direction is in the –*x* direction of the moving coordinate system. The aether wind velocity is –*V* relative to the stationary coordinate system and the stationary coordinate system is moving at velocity –*v* relative to the moving coordinate system and, therefore, the velocity of the aether is $\vec{v}_s = -v - V$ relative to the moving coordinate system. The resultant light ray velocity relative to the moving coordinate system and Observer O is $\vec{v}_c = \vec{c} + \vec{v}_s = -c - v - V$ per Equation (2-3).

Both Clock A and Clock B are on the moving rod and, therefore, stationary relative to the moving coordinate system and Observer O. For the moving coordinate system and Observer O, Clock B is stationary at $x_1 = r_{AB}$ at time t_B when the light is reflected and Clock A is also stationary at $x_2 = 0$ at time t'_A when the light returns back to Clock A. Therefore, the light ray travel distance is $x_2 = 0 - r_{AB}$ per the moving coordinate.

Location of Clock A at time t'_A:	0	
Location of Clock B at time t_B:	r_{AB}	
Travel distance for the light ray:	$0 - r_{AB}$	
Velocity of light ray for Observer O:	$-c - v - V$	
Time required for the light ray travel:	$\frac{r_{AB}}{c+v+V}$	
Clock times:	$t_B = \frac{r_{AB}}{c-v-V}$	(From B3b.1)
	$t'_A = t_B + \frac{r_{AB}}{c+v+V}$	=> $t'_A - t_B = \frac{r_{AB}}{c+v+V}$
Time duration between events, (B3b.2)	$t'_A - t_B = \frac{r_{AB}}{c+v+V}$	

Case B3 review: For this case, the moving observer and the stationary observer agree completely on the event times and the time intervals between the events. Therefore, there is no dispute between Observers O and O′ on the clock synchronism. Observations on the same event are exactly the same for both the moving and stationary observers.

Case B4 Moving Initial Ray Launch Point S and Moving Rod

Light source Point S:	Moving. Fixed at End A of the moving rod.
Clock A:	Moving. Fixed End A of the moving rod.
Clock B:	Moving. Fixed End B of the moving rod.

Subcase B4a: Observed by the Observer with the Stationary system (Observer O′)

B4a-1 The Light Ray travel from Point S to Clock B (Observer O′)

The forward ray travel is from Point S to Clock B through the medium aether. Both Pint S and Clock B are on the same moving rod. The observation reference is the stationary coordinate system.

The light ray velocity in the medium aether is $\vec{c} = +c$ since the travel direction is in the $+x$ direction of the stationary coordinate system. The velocity of the aether wind relative to the stationary coordinate is $\vec{v}_s = -V$. Therefore, the speed of the light ray for the stationary coordinate system and Observer O′ is $\vec{v}_c = \vec{c} + \vec{v}_s = +c - V$ per Equation (2-3).

The rod is moving at velocity v relative to the stationary coordinate system. At time t_A, Point S and Clock A are collocated at $x_1 = 0$ on the stationary and moving coordinate systems. Clock B moves to $x_2 = r_{AB} + vt_B$ at the ray arrival time t_B per the stationary coordinate system. Therefore, the distance of the light ray travel is $x_2 - x_1 = r_{AB} + vt_B - 0$ per stationary coordinate system.

Location of Clock A at time t_A:	0
Location of Clock B at time t_B:	$r_{AB} + vt_B$
Travel distance for the light ray:	$r_{AB} + vt_B - 0$
Speed of light ray for Observer O′:	$+c - V$
Time required for the light ray travel:	$\frac{r_{AB}+vt_B}{c-V}$
Clock times:	$t_A = 0$
	$t_B = \frac{r_{AB}+vt_B}{c-V}$ => $t_B = \frac{r_{AB}}{\boldsymbol{c-v-V}}$
Time duration between events,	$t_B - t_A = \frac{r_{AB}}{c-v-V}$
(B4a.1)	

B4a-2 Reflected Light Ray travels back from Clock B to Clock A (Observer O′)

This case is exactly the same as B3a-2 above. Therefore, the light ray travel velocity is $\vec{v}_c = \vec{c} + \vec{v}_s = -c - V$ with respect to the stationary coordinate system and the light travel distance is $x_2 - x_1 = vt'_A - (r_{AB} + vt_B)$ per the stationary coordinate system.

Location of Point S at time t'_A:	vt'_A
Location of Point B at time t_B:	$r_{AB} + vt_B$
Travel distance for the light ray:	$vt'_A - (r_{AB} + vt_B)$
Velocity of light ray for Observer O′:	$-c - V$
Time required for the light ray travel:	$\frac{r_{AB}+vt_B-vt'_A}{c+V}$
Clock times:	$t_B = \frac{r_{AB}}{\boldsymbol{c-v-V}}$ (From B4a.1)
	$t'_A = t_B + \frac{r_{AB}+vt_B-vt'_A}{c+V}$ => $t'_A - t_B = \frac{r_{AB}}{c+v+V}$
Time duration between events,	$t'_A - t_B = \frac{r_{AB}}{c+v+V}$
(B4a.2)	

Subcase B4b: Observed by the Observer with the Moving rod (Observer O)

B4b-1 Light Ray travels from Point S to Clock B (Observer O)

The forward ray travel is from Point S to Clock B through the medium aether. Both Pint S and Clock B are on the same moving rod. The observer reference is the moving coordinate system on the moving rod.

The velocity of the ray relative to the aether is $\vec{c} = +c$ since the travel direction is in the +x direction of the moving observation coordinate system. The aether wind velocity with respect to the stationary coordinate system is $-V$ and the stationary coordinate system is moving at velocity $-v$ relative to the moving coordinate system. Therefore, the velocity of the aether relative to the moving coordinate system and Observer O is $\vec{v}_s = -v - V$. And, the resultant ray velocity for the moving coordinate system and Observer O is $\vec{v}_c = \vec{c} + \vec{v}_s = +c - v - V$ per Equation (2-3).

Both Clock A and Clock B and Point S are on the moving rod. Therefore, for the moving coordinate and Observer O, these points are stationary at the same locations through the event. Point S and Clock A are at $x_1 = 0$ at time t_A and Clock B at $x_2 = r_{AB}$ at time t_B on the same moving coordinate system. Therefore, the distance for the light ray to travel is $x_2 - x_1 = r_{AB} - 0$ for the moving coordinate system and Observer O.

Location of Clock A at time t_A:	*0*
Location of Clock B at time t_B:	r_{AB}
Travel distance for the light ray:	$r_{AB} - 0$
Speed of light ray for Observer O:	$+c - v - V$
Time required for the light ray travel:	$\frac{r_{AB}}{c-v-V}$
Clock times:	$t_A = 0$
	$t_B = \frac{r_{AB}}{c-v-V}$
Time duration between events, (B4b.1)	$t_B - t_A = \frac{r_{AB}}{c-v-V}$

B4b-2 Reflected Light Ray travels back from Clock B to Clock A (Observer O)

This case is exactly the same as B3b-2 above. Therefore, the light ray travel velocity is $\vec{v}_c = \vec{c} + \vec{v}_s = -c - v - V$ with respect to the moving coordinate system and Observer O and the light travel distance is $x_2 = 0 - r_{AB}$ per the same moving coordinate system.

Location of Clock A at time t'_A:	0
Location of Clock B at time t_B:	r_{AB}
Travel distance for the light ray:	$0 - r_{AB}$
Velocity of light ray for Observer O:	$-c - v - V$
Time required for the light ray travel:	$\frac{r_{AB}}{c+v+V}$
Clock times:	$t_B = \frac{r_{AB}}{c-v-V}$ (From B4b.1)
	$t'_A = t_B + \frac{r_{AB}}{c+v+V}$ => $t'_A - t_B = \frac{r_{AB}}{c+v+V}$
Time duration between events, (B4b.2)	$t'_A - t_B = \frac{r_{AB}}{c+v+V}$

Case B4 review: For this case, the moving observer and the stationary observer agree completely on the event times and the time intervals between the events. Therefore, there is no dispute between Observers O and O′ on the clock synchronism. Observations on the same event are exactly the same for both the moving and stationary observer.