Your name: | **Your Teacher name:**
Project name: Tri # 1 Essay | **Date:**
Period: | **Grade:**

Essay Topic: Mr. Bari went out to a bike trip for 1 hour and half long & his position function is : P(t) = 40/3 t^2. In 20 mile of the trip, he saw a speed limit sign..25 MPH. Did Mr. Bari Break The Law?

Sample Essay written by Professor Rashidul Bari

Did Mr. Bari Break The Law?

INTRODUCTION:

Motion is simply the change of position with respect to time. For example, when Mr. Bari changes his position from the beginning of his bike trip (t,d) = (0, 0) to the end (t, d) = (30 mile, 3/2 hour), we can denote it as motion. The idea of motion is as old as Aristotle who famously hypothesized that objects in motion stop because it's gets tired. Unfortunately, we obliviously believed Aristotle's claim for over thousand of years, we treated that claim as fact. However, a 23-year man who was student of math at Cambridge has changed our notion of motion by showing us that object at motion never stop just because it gets tired. In fact, he developed a set of laws known as "Law of Motion" that not only explains the kinematics and dynamics of moving objects like Mr. Bari but also sets the foundation of physics. In this essay, we can measure the motion of Mr. Bari at (t,d) = (1.2, 20) to verify whether he broke the law in 20 mile of his trip by speeding over 25 MPH (there is a speed limit sign in 20 miles of his bike trip!). If we apply Aristotelian logic, we will reach a conclusion that Mr. Bari never broke the law because as he move away from the starting point, he will get slower simply because he would get tired. Hence our hypothesis is: Mr. Bari did not break the law and he is absolutely innocent. We will apply Sir Isaac Newton's Mechanics (Kinematics and Dynamics) and Mathematics (Algebra and calculus) to investigate our hypothesis.

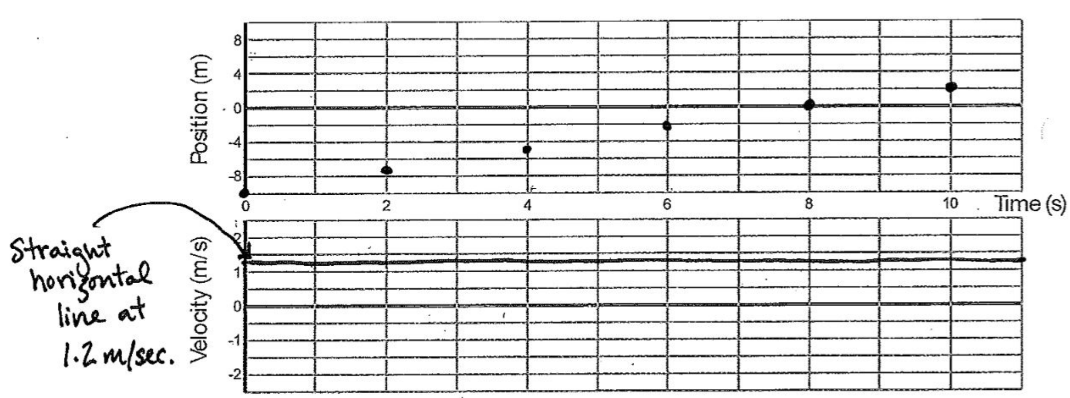
IF APPLE FALL, DOES THE MOON ALSO FALL:

As the story goes, in 1665, Isaac Newton was sitting under an apple tree. All of a sudden he saw an apple fall from the tree. This simple event of a nature motivated him to look at the sky. He saw a moon. He asked a simple question: If apple fall, does the moon also fall. This simple question turned out to be the most important question any human being ever asked since we separated from apes in Africa. Newton wanted to solve this falling moon problem. However, the mathematics of his time was not advance enough to do so. So invented a new branch of math now know as Calculus. He use calculus to formulated mechanics, the main branch of physics that study motion. Mechanics has two parts: (1) kinematics and (2) Dynamics. Kinematics uses a set of four properties (Position, Time, Velocity and Acceleration) to describe motion) and Dynamics uses a set of three laws—known as "Newton's Three Laws of Motion" to explain motion.

Kinematics: In this paragraph, we will use Kinematics to describe the motion of the moving man. During the simulation Lab, we had to use the Position Slider to set the man stand near the tree. His initial position was recorded as -10 meters, which simply mean he was standing on the left side of the reference point. Mr. Bari instructed us to give the man a velocity of 1.2 m/s and an acceleration of 0 m/s^2. We have done so. Then he instructed us to hit the start button. The man started moving until he hit the wall. I have recorded his time: his trip was 10 seconds long. Here's what I have noticed during this trip: (1) I saw the blue position slider increases slowly which means the man was moving to the right and (2) I saw the red velocity sliders stays at zero. Here's what I've recorded:

Time (s)	Position (m)	Velocity (m/s)
0.0	-10	1.2
1.0	-8.75	1.2
2.0	-7.60	1.2
3.0	-6.35	1.2
4.0	-5.20	1.2
5.0	-4.05	1.2
6.0	-2.75	1.2
7.0	-1.60	1.2
8.0	-0.40	1.2
9.0	0.75	1.2
10.0	2.00	1.2

6. Plot your data in the graphs below:



Now I will use the four properties of Kinematics to describe the above graph which represent the motion of the moving man: The shape of the moving man position graph is a positive diagonal line which slope is 1.2. This slope represents the man velocity because the slope of PT graph is velocity. We can use point slope formula to make an equation: Y = mx + b.

<table>
<tr><th>Math Class</th><th>Physics Class</th><td rowspan="3">P(t) = position function
V = Velocity
T = time
D= distance</td></tr>
<tr><td>Y = mx + b</td><td>P (t) = vt + d</td></tr>
<tr><td>Y = 1.2 X -10</td><td>P(t) = 1.2 t -10</td></tr>
</table>

This makes sense because I set the velocity at 1.2 m/s. That means for every second, the man moved 1.2 meters. The VT graph also makes sense because it's a straight line, which makes sense because velocity stayed the same in the entire trip.

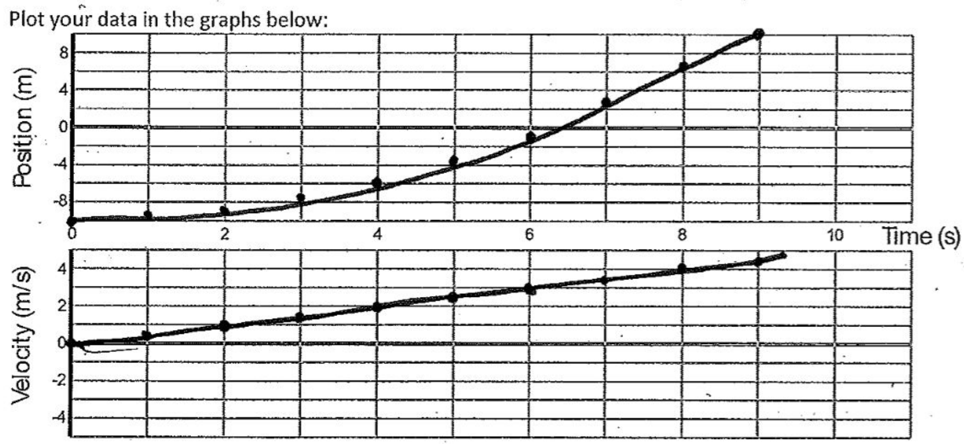
Now I will use kinematics to describe his constant acceleration:

During the simulation Lab Part II, we had to use the Position Slider to set the man stand near the tree, which was -10 meter. Our Physics Teacher instructed us to give the man a velocity of 0 m/s and an acceleration of 0.5 m/s^2. We have done so. Then he instructed us to hit the start button. I saw the man started moving until he hit the wall. However, unlike part one, I saw him moving us at an increasing rate. So I looked at the blue position slider and noticed that it was moving up with an increasing rate. I also observe something else: I saw the red velocity bar moves up with a constant rate. So here's how my graph ended up looking like:

5. Use the playback feature to record the man's position and velocity data.

Time (s)	Position (m)	Velocity (m/s)
0.0	-10	0
1.0	-9.73	0.52
2.0	-9.00	1.00
3.0	-7.81	1.48
4.0	-6.08	1.98
5.0	-3.75	2.50
6.0	-1.12	2.98
7.0	2.40	3.52
8.0	6.17	4.02
9.0	10.00	4.48 ← Hit Wall!
10.0		

6. Plot your data in the graphs below:



Once I plotted all data from the simulation, I got my PT graph is a curved line (Parabolic) and it make sense because every second the man speed was increasing. That means the distance he covered in each second gets bigger and bigger. My velocity graph (see above) also make sense because Mr. Bari asked us to set the acceleration to 0.5 m/s/s which means the Moving Man's speed increases 0.5 m/s.

DYNAMICS:

Now I will use the three properties of Dynamics (Newton's 3 laws of motion) to explain the motion of the Moving Man.

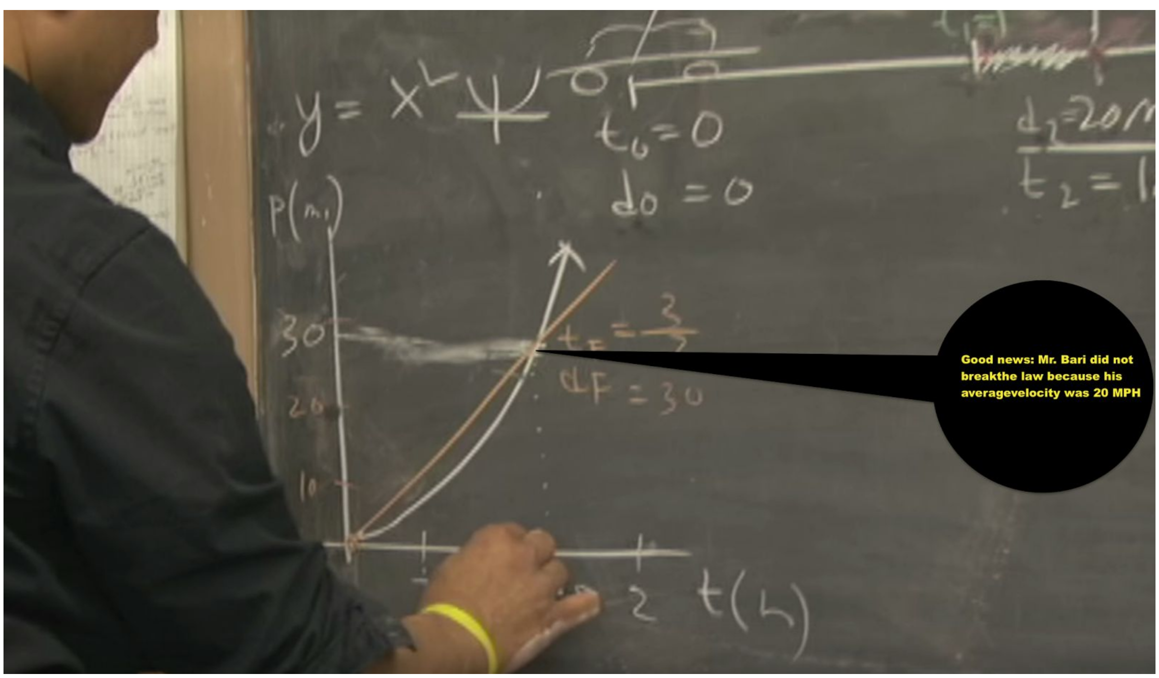
I. **Newton First Law:** Object at rest likes to stay at rest (and object in motion likes to stay in motion) until it experiences an external force, which is known as the law of inertia. So why the object (Mr. Bari) started moving? He started moving because he experienced an external force (created by movement of peddle) **Please watch the movie I created.**

II. **Newton Second Law**: Moving Man acceleration is the net result of all forces acting on the object. I used this definition to understand whether Mr. Bari slowing down or speeding up: Force, which SI Unit is Newton, contains the Acceleration component (m/s^2) in itself. And if we break down N (Newton) we see, KG M/S^2. When I gave the mass (Mr. Bari) acceleration and the mass (mass) started moving because a force acted on him. And it seemed like he was moving faster and faster. (Again, please watch the movie)

III. Newton Third Law: Every action, there is equal and opposite reaction: Have you ever wondered why the moving man had a forward motion? Well, Newton Third Law explain it well. Mr. Bari's Bike Wheel push the ground backward (Action) and the ground push the Wheel forward (Reaction). As a result, Mr. Bari was moving forward. Now the question is how fast he was moving forward—especially when he was approaching 20 Mil?

Aristotelian Approach to support the Hypothesis:

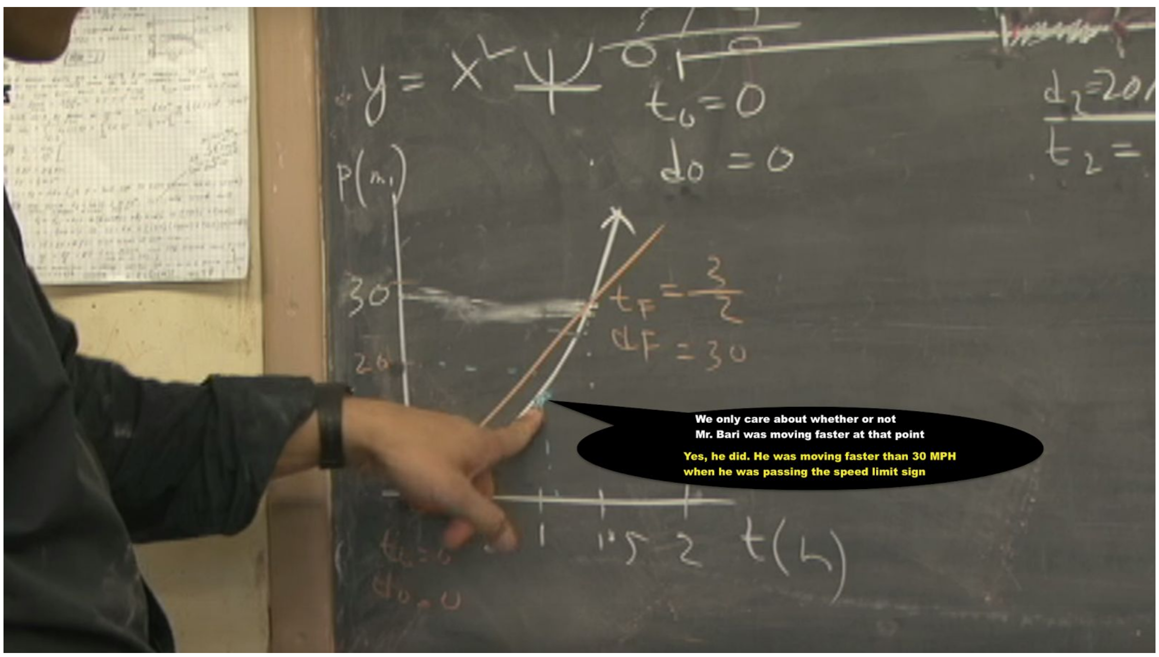
The average velocity is the ratio of displacement to the amount of time required for the displacement: Mr. Bari went out to a bike trip for 1 hour and half long & his position function is : P(t) = 40/3 t^2. In 20 mile of the trip, he saw a speed limit sign..25 MPH. Did Mr. Bari Break The Law? Notice that his average velocity can be calculated by using our simple Distance over Time equation that gives us his average velocity 20 MPH.



Does that mean Mr. Bari did not break the law? Well let's consider this example: during a typical trip to AMS, my car undergoes a series of changes in its speed. When I inspect the speedometer readings at regular intervals, for example, I would notice that it changes often. The speedometer of my car reveals information about the instantaneous speed of my car. It shows speed at a particular instant in time. The instantaneous speed of an object is not to be confused with the average speed. Average speed is a measure of the distance traveled in a given period of time; it is sometimes referred to as the distance per time ratio. Let's consider our trip to AMS on Nov 4th, 2015: During that trip, I have traveled a distance of 5 miles and the trip lasted 12 minutes. The average speed of our car could be determined as 5 MPH (Please see the animation/simulation below). On the average, my car was moving with a speed of 5 miles per hour. Does that mean, I did not break the law? The fact of the matter is, during the trip, a cop pulled over me for speeding over 30 MPH.   Yet, on average, I was moving with a speed of 5 miles per hour. This is why we need to investigate it using more sophisticated toll call CALCULUS.

Newtonian Approach to support the Hypothesis:

The instantaneous velocity is the slope of the tangent to the position function. The idea of instantaneous velocity comes from finding the average velocity over smaller and smaller time intervals. However, algebra becomes useless when we make the time interval too small, leading to zero /zero problem. This is why we need to use a more sophisticated tool to support our hypothesis: Mr. Bari did not break the Law. In the limit as the time interval approaches zero, the instantaneous velocity is



On the graph, the instantaneous velocity is the line that is tangent to Mr. Bari's position curve. The position function of Mr. Bari is a straight line through the origin iins shown on the graph. The equation for Mr. Bari's motion is P(t) = 40/3 t^2. The instantaneous velocity is found by taking the derivative of the position function with respect to time: which turned out to be over 30 MPH.

Conclusion:

Unfortunately I have to reject the hypothesis that Mr. Bari broke the law : Mr. Bari Did not Break the Law. I'm actually forced to reject my hypothesis because Mr. Bari was moving faster than 30 MPH when he was passing the speed limit sign.

Reference:

Moving Man Simulation, Bari Science Lab, URL: http://www.bari-science-lab.com/
Newton's Law of Motion: Did Mr. Bari Break The Law, URL: https://youtu.be/LCr1zJETxOM
Math Video Lecture: Calculus in Action, https://youtu.be/2p2v744XhFU