From Newton to Einstein

---GREETINGS--

Namaste. Thank you Honorable Principal Jose John and thank you Nijo Anthony for inviting me here, I am very honored to be here at Sacred Heart College. Today I will be talking about Relativity and looking at it from a Narrative Perspective. I will be using the stories and discoveries of 4 scientists as a bridge to Relativity, from Newton to Einstein and everything in between. So it was 1905, and Einstein was sitting at his patent office, in Switzerland, and he had published 4 papers, and one of them was on special relativity. But, well, his ideas weren't accepted very widely, they were actually rejected by the general public. People were like, "Hey! Sir Isaac Newton is right! Stop with your debauchery!" Two Nobel Laureates in Physics who were Nazi aligned even attacked Einstein with a racist thesis. His theories that time, distance, speed, mass, hell, almost everything was relative, were toppling the throne that Newton had held for so long. And people objected from every corner, every nook n' cranny. But before I go in-depth about *how* he revolutionized physics, I must talk about Newton first. And to talk about Newton, I must talk about a story from 2014, when I was 2.

---GREETINGS--

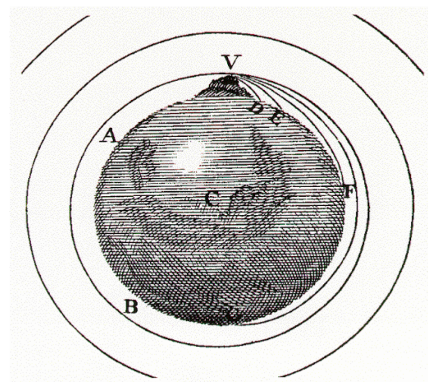
CHAPTER 1: ROOM ZERO

On April 8, 2014, I asked my father for a task, a puzzle, anything, really, something to challenge. I don't quite remember what happened then, but I have a vivid memory of what happened next. My father took me to Room Zero. What was Room Zero? Well, Room Zero used to be our garage. However, one day, my father hired a garbage man to drain the room of all its items -- empty paint buckets, gone. Rotten food cans, gone. Cobwebs, dust, gas, everything? Gone. Well, except the car. We had to put that in the driveway. And since there was nothing in the garage anymore, my father decided to name it "Room Zero", inscribed via Sharpie onto the wall. Then, he made the name completely redundant by sticking up a blackboard with nails, putting a chalk and an eraser, so it should've been named "Room Three".

Anyway, when I walked outside, looking at Room Zero from a distance, there seemed to be something on the floor, and the writing on the board had changed. It now said:

"Find the name of the book's writer and the name of the book. You have one hour. Start."

I laughed. So easy! I just had to climb the stool, look at the cover, and voila! I'd do it! I did the first step masterfully, but the second step was, well, less than smooth. The thing was, he had put black paint over where the author's name and the book's name was. My dad really did try and challenge me! I flipped through the pages, looking for a name. This seemed to be some old-timey 1700s book, so I noted that. I tried to flip the pages, but to no avail. Suddenly, the garage door closed behind me, the light in the room turned on, and an alarm said:
"TIMER HAS BEGUN. 59:59. 59:58. 59:57. 59:56. 59:5…"
The things ahead of me were just now dawning on me. I heard one minute pass by, and I dropped the book and got off the stool. Maybe a more comprehensive read will give something. I suddenly found something pivotal; a picture. This picture showed me the basics of all of gravity. First a cannonball is shot from point V to D, then, with slightly larger force, it lands on F, and then, it goes around half the planet, but still fails. Then, suddenly, the force of the cannon is so strong that the cannonball suddenly goes around, its orbit increasing distance, until eventually it orbited around the planet and never came back. This is the perfect velocity to escape, but gravity pulls on just enough that the cannonball never leaves orbit. And then hits some random alien in the face. This was questioned by Newton himself. He asked: If an apple falls, does the moon fall? So I knew the name of the author. Meanwhile, the clock kept ticking.



"20:38. 20:37. 20:36. 20:35…"
I obviously didn't have much time, so I thought and thought of the right answer. Ah! The answer *must* be Cannonball! Why else would there be a picture of a cannon? So with 15 minutes left, I wrote cannonball and was confident. After a few minutes, the camera started working again, and my father saw I was done. The light turned off… and the door opened. However, I found out that cannonball was the wrong answer. Well, it was alright. But what about the author of that book? Newton?

CHAPTER 2: NEWTON

Sir Isaac Newton was born to a single mother; who would've been his father, a rich, wealthy, uneducated farmer named Isaac Newton Sr. died 3 months earlier, and his mother, who died in 1679, gave Newton to his maternal grandparents when Newton was 3. Newton heavily disliked his stepfather. He distinguished himself from others by building sundials and model windmills. In 1665, he discovered the binomial theorem and started working on calculus. Later that year, while he was sitting next to an apple tree, an apple fell right next to him. If he was a normal person, he'd probably think about the close-called concussion. But instead, he thought that if an apple could fall, could the moon fall? And the answer was yes. The moon constantly falls from the reference frame of space, it just never hits the Earth. Gravity keeps it from going away from the Earth, and the escape velocity of the moon is just about high enough to keep it from falling into the Earth or escaping into space. Any higher and the moon would be gone, causing mass flooding and *lots* of long term consequences that are unfixable. Meanwhile, the moon crashing into the Earth due to less velocity would be, well, catastrophic, and you can figure out why. What was gravity? Well to Newton, it was this mysterious force that affected every body, and even the smallest objects that are the farthest they could be had some amount of gravitational attraction. It was defined by $\frac{Gmm}{r^2}$. It had some issues, but it was much better than any other physicist could do at the time, and so it was widely accepted. During Newton's time, Ampere was experimenting with current, and a few decades later, Volta invented the battery. Then Ohm discovered the relation between the two, and Hans Ørsted discovered the joy of dancing in his office.

CHAPTER 3: ELECTROMAGNETISM BOUND

One day, Hans Ørsted left his compass near a wire in his classroom. But when he turned the current on to demonstrate Ampere's experiment, he noticed his compass suddenly deflecting. He dismissed class immediately, got 7 other compasses, and placed them near his wire. And suddenly, they *all* deflected. So now the world knows: electricity and magnetism can both be generated by a current carrying wire. But electricity and magnetism were yet to be connected.

CHAPTER 4: FARADAY

Michael Faraday was uneducated when he was young. He was illiterate and poor until he was 14, where he learned how to read and write from a Sunday church school. Still, he was poor, and his education was dull. He applied for Sir Humphrey Davy's chemistry class, one of the best classes of the time. And he was accepted! An incredible step for the young man. He applied to work under the elbow of Sir Davy, and was accepted again! Now, having a more thorough knowledge in chemistry than almost everyone in the world, he was able to experiment with anything he wanted. One day, he wrapped two copper coils around an iron ring. And when he moved the magnet through the coil, it generated a spark of electricity. How did this happen? Well, first, an electromotive force was generated, then, that potential difference generated current, then the current generated magnetic field, and the magnetic field generated an electric field. You can try it! First, get a copper coil, then, take two wires and attach them to the coil, then plug the other side in a galvanometer or ammeter, and move a magnet inside. The blade should move. Keep in mind that for small scale experiments trying to light up a lightbulb with this will not work because only small amounts of current are generated. Otherwise, the galvanometer/ammeter would freak out due to the high electric field. That was Faraday's great discovery. But more was to come for electromagnetism.

CHAPTER 5: MAXWELL

James Clerk Maxwell was one of the greatest scientists in the world. He contributed 4 grand equations that unified two of the largest subjects in physics: electricity and magnetism. They are stated as follows:

1) We know that the electric flux, otherwise written as $\oint E \cdot dA$, since electric flux is how much electric field goes through an area , is equal to $\frac{q}{\varepsilon_0}$, epsilon naught being a constant and q being a charge. In other words, the electric flux of a surface is proportional to the charge enclosed within the space. We write this as $\int E \cdot dA = \frac{q}{\varepsilon_0}$: electric field times (dot product) area is equal to charge divided by some constant. That is the integral form of Maxwell's first equation.
2) There is no magnetic monopole, so all charges cancel each other out, meaning that the net magnetic flux is zero, thus we get the equation $\nabla \cdot B = 0$, or Gauss' Law for magnetism.
3) We know that magnetic flux is equal $\int B \cdot dA$, and we can write$\varepsilon = \int E \cdot dA$, meaning that since $\varepsilon = -\frac{d\Phi_B}{dt}$, as long as you have only one ring, as in Faraday's experiment. Plugging in gives us $-\frac{d}{dt}\int B \cdot dA = \int E \cdot dA$. According to Stokes' Theorem, the line integral of a vector field over a loop is equal to the *flux of its curl* through the enclosed surface. Applying Stokes' Theorem gives us ∇(curl)$\times$ E(electric field) = $\frac{dB}{dt}$
4) Ampere's Law is a bit difficult. However, a very basic synthesis is that Maxwell argued by symmetry, if magnetic flux generates electric field, can electric flux generate magnetic field? That paves the way for the equation $\nabla \times B = \mu_0 j$.

Those are all the Maxwell Equations. Those are Maxwell's biggest contributions to physics.

CHAPTER 6: SPEEDINESS

Speed is relative, not absolute. Say you're biking at 15 mph on a perfectly smooth, empty road, at least to someone on the street. But to you, you think you're at rest and the street man is traveling at -15 mph. And suddenly a car zips past. To the street man, the car's at 30 mph, but you see the car is traveling at 15 mph. How? What? This is because speed is relative. 30 - 15 = 15 mph, that's why the car seems to be at 15 mph. So speed is relative. And we can't tell if we're moving or not if we have a constant velocity (acceleration doesn't count). But when we go at high speeds, something more happens. It seems like time gets longer? Length gets smaller? What happens when we go *too* fast?

CHAPTER 7: SPEED OVERLOAD

In this chapter we talk about 3 things that happen when you go at insane speeds: time dilation, length contraction, and mass dilation. First, time dilation. Say a man is standing on Earth, at rest from his perspective, and he sees a spaceship a few light seconds away made of glass traveling at light speed. This spaceship has one laser projector and one mirror. For the man in space, the time taken to travel from the projector to the original light source is $t_0 = \frac{2D}{c}$, assuming D is the distance between laser and mirror. But for the man on Earth, the spaceship is moving, and the distance L is $\frac{v\Delta t}{2}$, assuming Δt= the time taken for the light to return to its original position. This means that the distance the light has to travel for the man on Earth is $2\sqrt{D^2 + L^2}$, where we use the Pythagorean Theorem. This means $c = \frac{2\sqrt{D^2+L^2}}{t}$, assuming t is not t-naught and rather the time that the Earth observer measures. Now, squaring both sides, we get $c^2 = \frac{4D^2+4L^2}{t^2}$, and we expand L, giving us $c^2 = \frac{4D^2+4\frac{v^2t^2}{4}}{t^2}$, and so $c^2 = \frac{4D^2+v^2\ t^2}{t^2}$, and when we split the fraction, we get $c^2 = \frac{4D^2}{t^2} + v^2$. Now, when we solve for t, we should find that $t^2 = \frac{4D^2}{c^2+v^2}$. If we factor out c^2 from the bottom, we get $t^2 = \frac{4D^2}{c^2(1-\frac{v^2}{c^2})}$. If we square root, we get $t = \frac{2D}{c\sqrt{1-\frac{v^2}{c^2}}}$, and 2D over c is equivalent to t-naught, so we get the equation for time dilation:

$t = \frac{t_0}{\sqrt{1-\frac{v^2}{c^2}}}$. But this also happens with length. Velocity of light does not change, even at unreal speeds. So length, or distance must change. $t = \frac{l_0}{v}$, so $l_0 = vt$. Now let's say we measure the distance between two planets. For a rocket traveling at the speed of light towards Neptune, it seems Neptune is heading towards them, but for an Earth observer, the rocket is heading for Neptune. Since the time is less, distance is also less, so let's say L is the distance between Earth and Neptune for the rocket. This means $L = v\Delta t_0$, which is $L = \frac{vt}{\gamma}$, or $L = \frac{L_0}{\gamma}$. Finally, here comes mass and momentum dilation. To conserve the law of momentum, we must write γmv, which is the actual equation for momentum. It's just that for all everyday situations, gamma is basically 1. Some people also think that there is relativistic mass, equal to gamma times rest mass, but some other scientists disagree, so hell no, I'm not opening that darned can o' worms. There is also the idea presented in general relativity where gravity is no longer some mysterious force, but a distortion in spacetime, like if you had a hammock strained to 4 sticks and placed some small beads, they would create a tiny pit that would drag anything really close in, but if you had something unimaginably massive, it would create a much bigger pit, and attract all the other beads. Thank you for giving me the opportunity to talk here. Now I will host a five minute Q & A.