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### The Physical World

Marie, a high school aged girl is preparing for a test for her physics class. She has not been doing too well and is really stressing out about it. It is introductory level material, a basic mechanics course. She has especially been having problems with forces, and mass. Gamma, a magical anthropomorphic photon, appears to help her out.

#### **Character Designs:**

*Art credited to Emily Chang, PO '12*

Marie Mayer

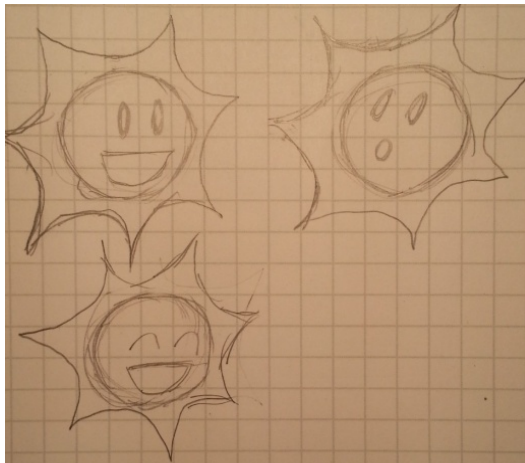


Marie is an average high school aged girl, trying to get through an introductory physics class as best she can. She has long dark hair and can usually be seen wearing a school uniform. Her hobbies include writing, video games, and sleeping. She can be quite lazy, but she does have a knack for physical activities, more so than academic

work. She enjoys occasionally playing baseball with her younger brother and friends. She's easily distracted and has trouble focusing her attention.

She is about to take a physics exam in a couple of weeks and she has not been doing too well in the course as her focus has been on other, more fun pastimes. It is also difficult subject material for her to understand as she learns best through example and her current teacher is not the most understanding person when it comes to her learning type. The teacher gives incredibly dry lectures that do not help her at all. She is currently trying her best to cram for the exam, but the subject matter just isn't sinking in.

Gamma (Photon)

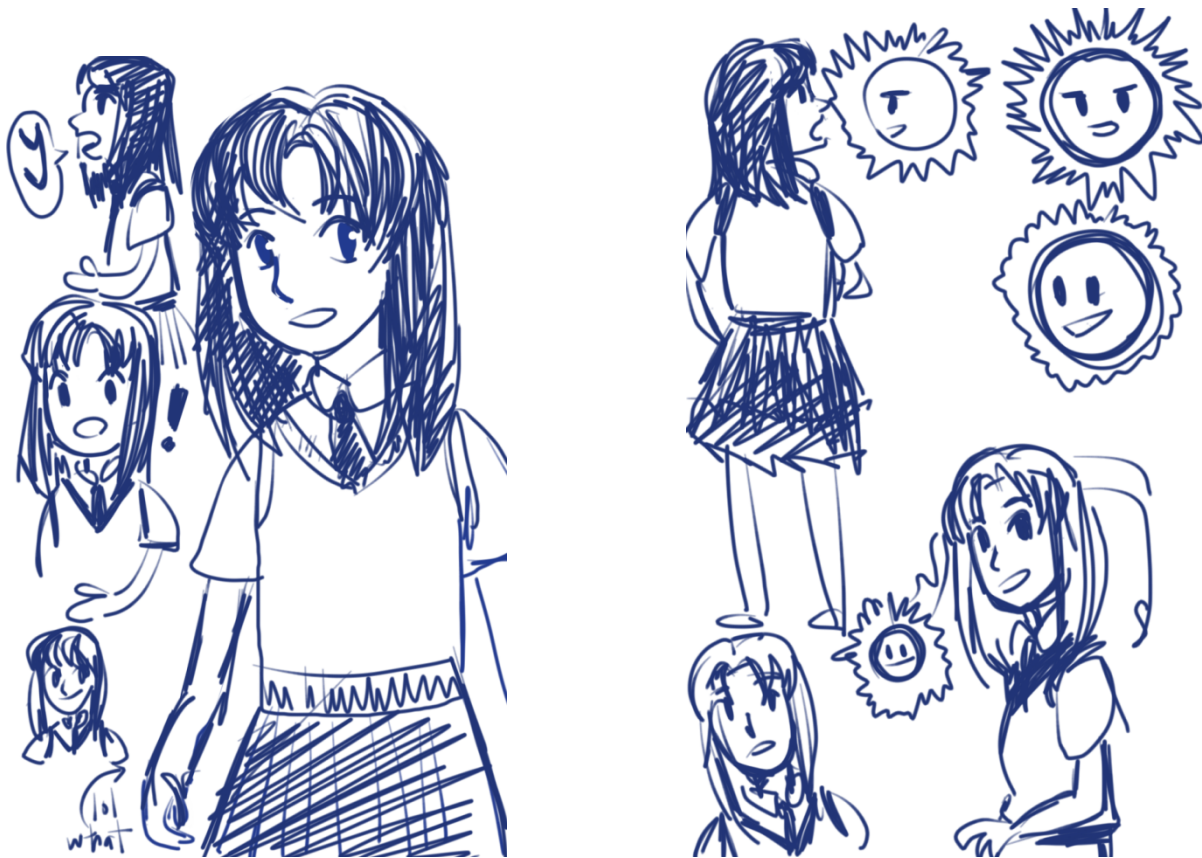


Gamma is a small ball of light with a deep innate understanding of the workings of the physical universe. He is an omnipotent being with near-godlike powers. He comes to people in need of help with learning physics and tries to convey his knowledge using his amazing powers. He physically manifests as a small ball of shining white light with a face, and is very adorable. He is about the size of a soccer ball, although he can

shrink and grow as need be. A smile never leaves his face and he keeps a sunny disposition even with the most difficult student.

He has come to Marie in order to assist her in time for her test and show her that physics can be fun and interesting to learn. The material that she is learning holds great power and he hopes that he can get her to understand how the world functions

Sketches:



Script notes:

- SFX is short for Sound Effects
- Each page corresponds to a single page of the comic. Panel refers to an individual panel scene (not necessarily enclosed in a panel)
- Character dialogue starts with the character's name
- Pages highlighted in red refer to pages that were drawn

PAGE 1 (6 Panels)

Panel 1. Scenic view looking of the front of a high school. It is a bright sunny afternoon, sometime after school has ended.

Panel 2. Aspect scene change to the inside of a classroom. The scene is looking into the classroom from the entrance. There is a girl sitting at a desk in the back with her face in a book. She is wearing a high school uniform. The rest of the room is empty

Panel 3. Aspect change focusing on the book she is reading. It is a Physics textbook. A big, generic, bulky, dry textbook.

Panel 4. Focus on Marie sitting at her desk. She has her face buried in the physics textbook.

Panel 5. Same scene as panel 4. She is visibly fuming this time, with a popping vein near her head.

Panel 6. She slams the book down on the desk, frustrated. She is yelling out above her. The panel visibly shows her frustration, using action lines around the panel.

Marie: I don't get it!

SFX: (book hitting desk) THUMP!



PAGE 2 (6 panels)

Panel 1. Marie sits with her face buried in her crossed arms on the desk. This is a profile view. The book is on the desk as well, next to her.

Panel 2. Same perspective as the last panel but we see her head shift from buried in her arms, to her eyes popping up and glaring at the book.

Panel 3. Zoom in to her face as she looks judgmentally at her physics textbook

Panel 4. From Marie's perspective staring at the book. It's sitting on the desk existing as a book.

Panel 5. Marie slumps across her desk letting out a visible sigh.

Panel 6. Marie is slumped over her desk, looking defeated

Marie: I just don't get it. Newton's Laws, forces. This stuff doesn't make any sense to me. I don't know what I'm going to do about this test.



PAGE 3 (5 Panels)

Panel 1. She is slumping over her desk, and she looks exasperated, with her eyes closed, open mouth. The book lies to her side on the table

Marie: Ugh, this is useless. I'm never going to get any of this stuff in time for the test.

Panel 2. She is now cradling her head in her hand that was underneath her, and she is looking very annoyed. As she is complaining, the book lets out a crackling sound and a small spark comes out of it.

Marie: This is all so pointless! I don't see how this dumb class is going to have any impact on my life. All this physics stuff doesn't even affect-

SFX (from book): crackle

Panel 3: Same as the last panel but Marie now has a confused look on her face

Panel 4: Marie has picked up the book and is holding it in her hands quizzically.

Marie: What the...

Panel 5. The book is now letting out a lot more sounds, and going crazy. The girl looks incredibly freaked out and drops the book. There are sparks and magical bolts flying out of it as it falls and hits the desk.

SFX (from book): CRACKLE! SIZZLE! ZZZT!



PAGE 4 (2 Panels)

Panel 1. This is just a small panel showing the book hitting the desk and falling open still spewing energy and sparks.

Panel 2. This “panel” is more of a near full page spread, with the girl sitting at the desk, with an expression of shock, and a huge plume of magical smoke coming out of the book with Gamma, the magical photon guide, coming out of it. He has a big smile on his face.

Gamma: Hello Earth!

PAGE 5 (4 Panels)

Panel 1: The smoke has subsided and the ball of light is now in front of the girl addressing her. She is visibly in a state of frozen shock.

Gamma: Hello! My name is Gamma and I am here to help you out.

Panel 2: Focus on Marie, she is still frozen in shock. Panel effects could work here, like those hashed lines of shock, or question marks in the background. The panel is silent.

Panel 3: The reader is looking at Marie's back, with Gamma floating in front of her.

Panel 4: Same as the last panel, but Marie's hand is reaching out and pokes him. A giggle escapes him.

Gamma: Hehe!

SFX: poke

Panel 4: Same as the last panel, but Marie is now poking gamma a lot. Gamma is laughing a lot

Marie: What the heck is this thing?

Gamma: Hahahaha! Stop it! That tickles!

SFX: poke poke poke



PAGE 6: (5 Panels)

Panel 1: Marie is turned away from Gamma, facing the audience; she is looking really distressed, thinking that she has gone insane. Gamma is jollily floating in the background, happy as can be.

Marie: Oh no. I've gone insane, haven't I? I knew this would happen someday...

Panel 2: Gamma floats around to her face and is addressing Marie directly. Sound comes from Gamma whizzing around.

Gamma: You haven't gone crazy, silly! My name is Gamma.

SFX: whoosh (sound from Gamma)

Panel 3: Gamma, talking and looking very smug.

Gamma: I am a magical photon that has come to help you with physics! I hold boundless knowledge of the workings of the physical world...

Panel 4: Looking at Marie and Gamma. Gamma continues his explanation, with Marie looking very overwhelmed. This is all too much for her to take in. Gamma's speech is long and fills up most of the page, eventually decaying into blahs.

Gamma: From quantum mechanics to relativity I know it all! And with my help you will be able to master the material and fall in love with the physical universe. I will show you how amazing and powerful the laws of nature can be! Blah blah blah

Panel 5: Marie has turned her back on Gamma and is preparing to leave. Gamma reacts. We see both characters from behind. I'm imagining sweat drops coming off of Gamma and a shocked expression on his face.

Marie: It's getting late, I should probably get going. I wonder what's for dinner at home...

Gamma: Hey! Wait a minute!

Panel 5: I'm not picturing this as a boxed panel, just an illustration on the edge of the page maybe. Gamma makes her an offer she can't refuse, catching her attention. She stops in her tracks and a twinkle appears in one of her eyes.

Gamma: I can also help you ace your test!

PAGE 7 (3 panels)

Panel 1: Gamma addressing Marie.

Gamma: I overheard that you were having problems with your physics class. I can help you out with that!

Panel 2: Focus back on the girl

Marie: And how exactly can you help me out? I'm not all that great with lectures and I'm pretty sure you're not real...

Gamma: No boring lectures here! You could learn much better by...

Panel 3: The room has suddenly changed. Full shot of an empty white space. This is like, a physics simulator. Imagine a frictionless infinite plane of nothing. Things float, there is no up, or down, or air resistance, or gravity. It's an introductory physics course's dream come true. Gamma and the girl are just floating in this space. Marie looks really confused. Text is huge, stretching across the panel.

Gamma: Example!



PAGE 8 (4 Panels)

Panel 1: Marie is freaking out. She's looking around the space distressed.

Marie: Wha- Huh- What!? Where are we?!

Panel 2: Gamma is explaining where they are and Marie is listening to him.

Gamma: This is a plane of existence I like to call Zero Space.

Panel 3: Gamma and the girl are staring off into the abyss of nothingness as Gamma continues to explain

Gamma: The laws of physics apply here, but we are far away from anything with a sizeable gravitational field. You can imagine that we are floating in space, with no friction of any kind and no outside forces acting on you. A perfect environment to perform basic physics!

Panel 4: Gamma asks Marie what is giving her the most difficulty.

Gamma: So, what is giving you the hardest time in class?



Page 9 (4 Panels)

Panel 1: Deciding to humor Gamma, Marie is pondering what has been giving her the hardest time.

Marie: Hmm... I guess I've been having problems with forces. I'm especially confused by Newton's third law.

Panel 2: Gamma responds to Marie's comment about Newton's third law. I am imagining bolding the statement of the law's definition, in order to make something along the lines of keywords in a textbook.

Gamma: Ah, Newton's third law! For every action, there is an equal and opposite reaction!

Panel 3: Focus on Marie. She is explaining her difficulty with the material.

Marie: Yeah, I don't get it. I can think of a lot of situations where the forces are definitely not equal.

Panel 4: Marie is thinking back to playing a baseball game with her friends. I am picturing having a false force diagram that she is daydreaming about, one that shows that the force on the ball from a player throwing the ball is far greater than the force on the nameless baseball player throwing it. This is false because it is wrong. Her head is popping out from the bottom of the panel and the diagram takes up the background.

Marie: When I'm playing baseball, for example. According to that law, the forces on the ball and the person throwing the ball are equal, but I don't see how. The force on the ball is way bigger! The person doesn't move an inch!



Page 10 (6 Panels)

Panel 1: Gamma addressing Marie.

Gamma: Nope, the forces are indeed equal. Let's try something out.

Panel 2: Focus on Marie, a baseball magically appears in front of her. There are lines around it to indicate that it just magically appeared out of nowhere.

Gamma: Here, grab this baseball.

SFX: Pop! (near the ball)

Panel 3: Gamma is hovering near Marie. She has the ball in her hand. He is directing her with what to do with the baseball.

Gamma: Now. Throw this ball as hard as you can directly in front of you.

Panel 4: Marie is winding up her pitch, profile view.

Panel 5: Marie tosses the ball as hard as she can.

Panel 6: We see the ball fly off, but Marie is also moving in the opposite direction, ala Newton's third law. There are motion lines indicating the direction that each object is moving. There is a question mark coming from Marie

PAGE 11 (5 Panels)

Panel 1: Marie is shocked to realize that she is moving.

Marie: Hey! I'm moving!

Panel 2: Gamma hovers towards Marie, explaining what is going on

Gamma: That's right! You are moving because the ball exerted a force on you as it left your hand causing you to accelerate!

Panel 3: A diagram showing the ball player again, this time with the force of friction acting on him from his feet. Gamma is floating over the panel.

Gamma: The reason a baseball player on earth doesn't feel this acceleration is because of friction. The gravity from the earth keeps the baseball player grounded, preventing him from accelerating from throwing the ball.

Panel 4: Marie is still skeptical, she is confused about why she is moving so much slower than the ball.

Marie: But why am I moving so much slower than the ball, if we each exerted an equal force on each other, shouldn't we fly away at the same speed? It just flew away!

Panel 5: Gamma begins to explain the reason for this discrepancy.

Gamma: Ah, the reason for that is Newton's second law!

Page 12 (4 Panels)

Panel 1: Gamma continues explaining.

Gamma: Newton's second law states that the acceleration of an object is proportional to the force on that object.

Panel 2: Explanation continued. I'm picturing  $F = ma$  floating in the background of this panel.

Gamma: But you also have to consider the mass of the object. Newton's second law is expressed as  $F = ma$ .

Panel 3: Gamma at the bottom of the panel explaining. A diagram is at the top of the panel, showing the ball and the girl side by side, the a greater than sign showing that Marie's mass is much greater than the balls mass.

Gamma: You have a lot more mass than the baseball, so since the force on you and the ball has to be equal, you have to accelerate less, as shown by  $F=ma$ .

Panel 4: The images from the last two panels are still floating around, the  $F=ma$  and the diagram. Marie and Gamma are in the frame as Marie realizes that she understands.

Marie: Oh! I get it. That makes sense now!

PAGE 13 (4 Panels)

Panel 1: Marie and Gamma. Marie now understands the lesson, and is further solidifying it with her own example.

Marie: It's like, if something is bigger, it's harder to move. That means it's harder to accelerate.

Gamma: Exactly!

Panel 2: Gamma extrapolating on the example that Marie just brought up.

Gamma: The bigger something is, the harder it is to move. How much an object resists movement is called inertia. So a bigger object has more inertia.

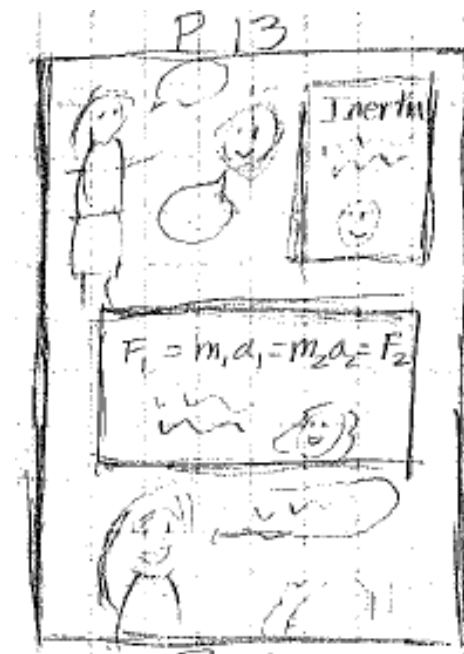
Panel 3: Gamma explaining force balance with a diagram showing that  $F_1 = m_1 a_1 = m_2 a_2 = F_2$

Gamma: In an interaction between two forces, the mass and acceleration have to balance to make Newton's third law work.

Panel 4: Marie shows her appreciation for Gamma.

Marie: Wow, I thought you were just a weird hallucination, but you're actually really helpful!

Gamma: Thanks...





PAGE 14

Panel 1: Marie is contemplating the grander implications of this lesson.

Marie: So forces really do balance, but wait... Back home, the earth is exerting a gravitational force on me, correct?

Gamma: That's right!

Panel 2: Focus on Marie, going through this thought puzzle in her head. In the background, we see a force diagram between a person and the earth, showing a balance of forces.

Marie: But then that would mean that I am also exerting some sort of force on the earth, right?

Gamma: That's right!

Panel 3: Marie is skeptical about this fact.

Marie: No way, I exert gravity on the earth?

Gamma: Correct! That is another property of mass. It has gravity!

Panel 4: Gamma with a diagram of a planet showing its gravitational field with arrows

Gamma: Objects with mass have a gravitational field that attracts other objects with mass. It is one of the fundamental aspects of our universe. This attraction depends on two main things. The product of the masses and distance



Page 15 (5 Panels)

Panel 1: Gamma explaining why Marie doesn't exert a very powerful gravitational field.

The reason your gravitational field isn't very strong is because you have very little mass. The strength of gravity depends on the mass of the object, so between you and the earth, which is A LOT bigger than you, the earth wins.

Panel 2: Two spherical masses poof into existence in between where Marie and Gamma are floating.

Gamma: To better understand gravity's dependence on distance, let's bring out two masses, one with mass  $m_1$  and the other with mass  $m_2$ .

Panel 3: Gamma continues his demonstration. We can see that the masses are moving towards each other.

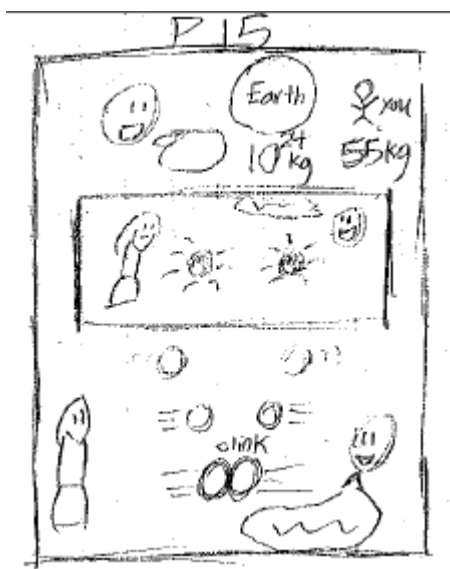
Gamma: I've made it so that gravity is really strong between these two masses, even though they are very light. We can see that they are slowly moving towards each other.

Panel 4: Objects are getting closer together faster.

Gamma: We can also see that as the objects get closer, they also move faster, until...

Panel 5: The masses quickly collide with each other.

SFX (masses colliding): clink



Page 16 (4 Panels)

Panel 1: Marie explaining what just happened.

Marie: The strength of two object's gravitational interaction increases the closer they are!

Panel 2: Gamma brings up the Law of Universal Gravitation, with the law written in the background.

Gamma: This is the Law of Universal Gravitation, which says that gravitational force is proportional to the product of the masses of the two objects and inversely proportional to their separation.

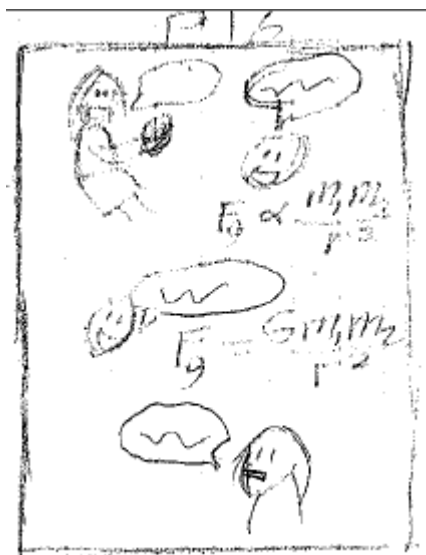
Panel 3: Similar panel to the last, now showing the full law, with the constant G.

Gamma: The full law is expressed with a constant G, called the gravitational constant. This full law expresses the gravitational interaction between any two bodies of mass.

Panel 4: Marie asking another question, about where all these laws came from.

Marie: Geeze, how did all these old fogies come up with all this stuff?

Gamma: They were able to find all this stuff out from observation and experimentation!



Page 17 (3 Panels)

Panel 1: Gamma explaining the basic scientific method. In the background, we see Marie at a telescope looking at the sky.

Gamma: Many of the basic laws of physics are found from repeated observation and the testing of hypotheses. The Law of Universal Gravitation was thought up when scientists looked at the movement of planets. They came up with some basic ideas that matched their observations and voila!

Panel 2: Gamma continuing his explanation. We now see Marie wearing a lab coat looking into a microscope.

Gamma: Scientists take data on the observations that they make and try to make the data make sense with an equation. With continued observation, scientists can better refine their methods and laws.

Panel 3: Return the focus to Gamma and Marie. She is now happily floating around listening very intently to Gamma..

Gamma: This is how the most basic science works.



Page 18 (4 Panels)

Panel 1: Focus on Marie. She's not in a panel, more floating in front of the panels.

Marie: Oh, I get it! So scientists try to explain what they see happen in the world. That's where all these equations come from.

Panel 2: Marie showing her "appreciation" for Gamma by patting him on the head, condescendingly. It's like an owner petting their dog.

Marie: Wow, you're really helpful little guy!

Gamma: Yeah, no problem...

SFX (near Gamma): pat pat pat

Panel 3: Marie is facing away from Gamma. Gamma is in the background. Marie has an evil look to her as she plots her way to score big on the upcoming exam. Gamma looks dejected, hoping she will also gain an appreciation for the subject.

Marie: With your continued assistance I can eliminate everybody make my way to the top of the class.

Gamma: That's not exactly my goal here.

Panel 4: Gamma talking to Marie in a borderless panel at the bottom of the page.

Gamma: I also hope that, beyond succeeding in your class, you will also gain an appreciation for the way physics works and the awesome power of science.



Page 19 (4 Panels)

Panel 1: Gamma is finishing up his lesson.

Gamma: Anyway, I think this has been enough of a lesson for today.

Panel 2: Gamma, flying outside of any panel, with streaking motion lines from the last panel, and going towards the next panel

Gamma: I'll take us back to earth, and you can go on home.

Panel 3: Focus on the open book, back in the classroom, and streaking lines showing that Gamma has returned to the book.

Gamma: But remember, If you ever need me, I'll be here in this book. Just call out my name and I'll be back in a jiffy!

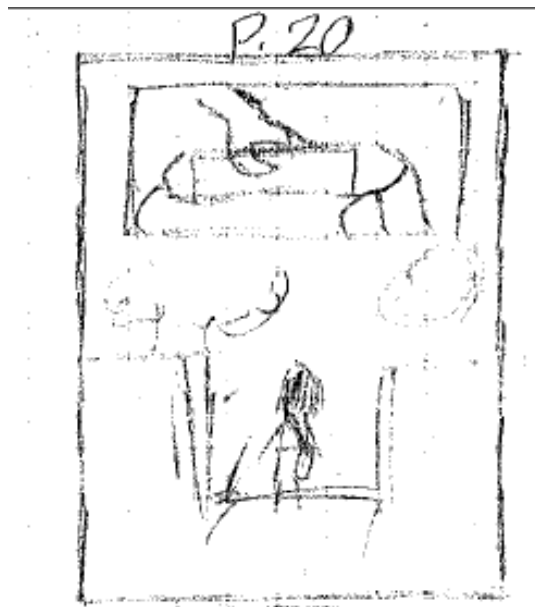
Panel 4: Marie picking up the book and smiling.



Page 20 (2 Panels)

Panel 1: Focus on Marie packing her bag, with the physics book showing.

Panel 2: Marie exiting the high school grounds, walking off on her way home. This takes up most of the page.



**Critique:**

## Questioning the Effectiveness of Educational Manga

When teaching a subject, the presentation of the subject matter is a critical aspect of how the material is received by the student. A modern medium that has shown potential as a teaching tool is the art of the Japanese comic books, known as *manga*. Educational manga exists in many forms. A common type would be manga that take on traditional academic topics, such as math, chemistry, and physics. The subject of this critique is an educational manga focused on teaching introductory physics. Daniel Contreras's The Physical World is a short educational piece that teaches the reader about force, mass, and gravity using a narrative structure. The story revolves around a young high school aged girl, named Marie. She has been having issues learning the material in her introductory physics course. A magical anthropomorphic photon appears to assist her in her studies, and teach the audience physics in the process. My main critique of the work will deal with the pedagogical effectiveness of the manga as well as how the educational aspects fit within the narrative structure of the story. In the end, the manga serves its purpose well, effectively pointing out some of the issues that introductory students may face with the material. However, the lack of a stronger narrative structure and the focus on teaching may limit the appeal of this work.

First, as an educational piece, this work uses an approach that is useful for students who may see concepts in an introductory course as unintuitive. The character of Gamma, the anthropomorphic photon who is Marie's guide in the world of physics, is an omnipotent being who has access to another dimensional plane of existence, known as Zero Space. In this dimension, friction is nonexistent and there is no gravitational force to interfere with demonstrations. This is useful for teaching introductory physics, as many of the concepts in these



introductory courses center around Newton's Laws. These laws are ideally described in an environment such as this extra-dimensional space, free of gravitational interaction and friction. Students may have a difficult time with these concepts due to being stuck on earth, and this setting could benefit the students to conceive the proper environment when thinking about physical laws. The setting of the piece makes it effective in demonstrating physical concepts that are not intuitive given these student's daily experiences.

Moving on to character usage, Marie is an effective character that is relatable to student readers. Throughout the work, Contreras uses Marie to voice concerns and difficulties with the subject matter. Marie initiates the lessons by discussing her greatest difficulties, and asks questions throughout Gamma's explanations. She voices skeptical concern about certain facts, such as force balances between objects and gravitational interaction. This is useful as these are common misconceptions and questions that students may have in these introductory courses. By having Marie voice her concerns, it allows the student to place themselves in her position and ask these same questions. As part of a scientific education, skepticism is an important lesson to learn, and Marie provides a skeptical voice to assist students in asking questions.

Despite these positive points, because of the focus on teaching, there are other aspects that may suffer in the manga, such as the narrative structure. The story begins by introducing Marie, and showing the issues that she is having with the material. Gamma then magically appears from her physics textbook in order to help her with the material. They teleport into the Zero Space dimension and commence with demonstrations and lessons. The pacing of the story is slow after this point, once the author begins focusing more on teaching. This is an issue that educational pieces may face, as the goal of these pieces is to present a subject rather than focus on narrative elements. This issue may limit the appeal of the work to a broader audience. It may

be beneficial to attempt to find a better balance in the structure of the piece between the narrative structure and the educational aspects.

There is also an issue with the length of the work as its briefness limits the subject matter covered and character development. The piece covers three basic topics over twenty pages, forces, mass, and gravity. There is a focus in the latter half of the manga on the learning aspects. Due to its length, any long term character development is nonexistent. There is potential for the story to continue and have the characters further grow and interact together. Expanding the storyline will also allow for the author to teach more complex ideas and concepts that one may encounter in an introductory physics course. The brevity of the piece is a major limiting factor for the work that keeps it from getting into more complex topics and character development

In conclusion, this manga can serve as an effective medium for teaching, but it may lack an interesting plot to attract an audience. The use of manga as a teaching tool opens possibilities to explore the physical world in surreal and interesting ways. These possibilities allow for demonstration of concepts not possible in the classroom. Also, characters such as Marie give a relatable personality for the student reader. However, the focus on teaching slows down the plot and character development in the series. It is necessary to find an ideal balance between teaching and story development in order to give this manga a widespread appeal. It would be interesting to see the manga expand into more issues, as it may have the potential to create a more complex plot over the course of a longer storyline. There are many more topics that can be covered using this teaching method and in these continued lessons it would be possible to create a longer overarching narrative in which Marie and the student reader gain an appreciation for science and inquiry.