Physics Summer Reading Assignment:

Over the summer, read the book "The Clockwork Universe" by Edward Dolnick.

The purpose of this assignment is to give a sense of the human story of physics. Who were the people that discovered physics? What motivated them? How did physics change the mindset of the world?

The first section of the book describes the world of 17th century England, when physics was discovered. What was the world like? What were people's lives like? How did they understand what was going on around them?
The second section goes through the personalities and stories of each of the major people that discovered physics, preceding Isaac Newton.
The third section specifically tells Newton's story of discovering physics. Isaac Newton brought together the works of previous generations of scientists and constructed a new vision in which the universe workings of the universe extend from a small number of mathematical rules.

I broke the book up into about 20 pieces, and wrote one or more questions for each section. *Chose 6* of the questions to answer. Answer each question in a paragraph of about 5-6 sentences, and then. Chose questions that show you have read the entire book! Do not chose the first six questions or the last six questions.

Prologue and chapter 1: introducing characters
No question on this section.

Chapters 2 – 6: Introducing the World of 17th Century England
1. Today, people expect many things to work out that people 400 years ago could not. For example: if you are sick, you expect to get better. You feel safe from getting a plague and dying at any moment. You do not expect entire cities to burn down in a fire. Scientists and engineers have discovered ways of solving those problems.
From the book, find two specific ways in which the *mindsets* of people are different today than in the past.

Chapters 7 – 9: Motivations and Mindsets of the Greatest Mathematicians
2. The author (Edward Dolnick) points out a key irony: that in a world that appeared so random and disordered, mathematicians and "natural philosophers" (as early scientists were called) imagined a universe that followed perfectly ordered mathematical laws. Find *two* motivations for scientists to discover this.

Chapters 10 – 14: Culture of Science in the 17th Century
3. The Royal Society and other academics began setting out guidelines for how scientific work would be conducted. Write two guidelines for science that are absolutely necessary for science to work properly. Give one example of something the Royal Society did that would not be considered good science today.

Chapters 15 -16: Mathematical Physics vs. Common Sense Physics
4. When a problem is *counterintuitive*, the answer seems like simple common sense, but the answer that you think is actually wrong. Before the scientific revolution, Aristotle and other writers designed a way of approaching "physics" based on common sense. Isaac Newton and others replaced their method by using not common sense but mathematical laws. Often, the mathematical laws came to a different conclusion than common sense.
Give 2 examples of common sense results that Aristotle or other writers had *wrong*, and what correct answer did Newton replace it with.

Chapter 17: New Developments in Astronomy
5. Before about 400 years ago, people called what we call space "the heavens." The heavens were meant to be perfect, beautiful, and unchanging. Then, certain discoveries during the 1500s challenged this "fact." Give two examples of things that were discovered which showed the heavens were not perfect and unchanging.

Chapter 18: The Microscope
No question on this section.

Chapter 19 – 20: Science's Threat to the Traditional World Order
6. Each society of humans, throughout history, has had to determine ways in which humans relate to each other and the universe around them. New discoveries, like physics, have forced people to change such ideas. Give one example of a piece of social understanding from before the scientific revolution that has not lived.

Chapter 21 - 23: Beauty and Logic of Science/ Ancient Greek Mathematics
7. Why did the Ancient Greeks study mathematics? Why did the Ancient Greeks hold mathematical proof in such high esteem? The author, Edward Dolnick, gives an imaginary story of how someone may have, first discovered the Pythagorean theorem. Give your own answer to this question, and explain your answer: "Is mathematics invented or discovered?" [write 5-6 sentences on this topic]

Chapters 24 – 27: Johannes Kepler and Tycho Brahe
8. Tycho Brahe took observations of the stars and planets every night for decades. In the next generation, his student Johannes Kepler used his data to prove three laws (Kepler's Laws) that describe how planets move around the sun. A century after he discovered them, Isaac Newton proved them using his laws of motion and theory of gravity, showing that "the heavens" and the earth followed the same, fundamental, physical laws. Thus, Kepler's Laws were fundamental to the formation of science.
However, when Kepler discovered these laws, he was trying to accomplish something totally different! What questions was Kepler originally trying to answer? How did he go about answering such questions? In the end, how did he feel about his accomplishments?

Chapters 28 – 31: Galileo (and Newtonian orbits)

9. In the 16th century, Copernicus and other astronomers began saying that the sun does not revolve around the earth, but the earth around the sun. People refuted with a simple statement: "The earth cannot be moving. If it were, and you dropped something, that thing would not land at your feet, but somewhere else!" Galileo, in a thought experiment involving the cabin of a ship, refuted this statement. Explain Galileo's argument, using a ship or any other moving thing. Explain how this shows that the earth may in fact be moving.

10. Objects that are dropped do not fall at a constant speed: they accelerate (at 9.81 m/s^2 or 32 ft/s^2). However, this is a difficult fact to grasp because objects hit the ground so quickly. Galileo first discovered this fact using balls rolling down ramps. Explain his experiments and how he conducted them.

11. Something to just think about: Clocks had no second hands in the 17th century, in fact, they really didn't think about "seconds" at all! The idea of "seconds" was discovered after basic physics! Just imagine, trying to learn physics without knowing what a second was!!! Galileo invented a system of using water clocks in his experiments on motion.

Fun Fact:
Chapter 29 is titled Sputnik in Orbit, 1687. Sputnik was the first satellite ever launched, which was launched by the Soviet Union on October 4, 1957. Isaac Newton first developed the idea of a satellite in a thought experiment in 1687. Hence, the title of the chapter. If you want to learn more about Sputnik this summer, watch the movies "October Sky" or "Bridge of Spies," which both address the hysteria in the United States in the years after Sputnik was launched.

Chapter 32 -33: Descartes and the nature of abstraction

12. Much of physics and science involves imagining objects in the *abstract*. For example, a car on the highway is not a family driving to Florida, is an object moving at a constant velocity. Rene Descartes's discovery of graphing was a great leap forward in ability to provide abstraction. Explain the story how he first had this idea. Then, think of a similar story in your life where you can describe the motion of something using a graph.

Fun fact:
Whenever, in math class, you graph a point (x, y), it is called a "Cartesian Coordinate," because Descartes invented this system.

Chapters 34 – 37: infinity, and how the problem of infinity relates to the nature of motion

13. A "paradox" is a statement that seems logically to make sense, but arrives at a conclusion that is obviously nonsense. Every paradox has some explanation as to why the logical reasoning is in fact false.

Zeno's paradox is a perfectly logical argument that, if you are standing in the middle of a room, you could never, ever reach the wall. (It is also called the paradox of Achilles and the Tortoise). First, explain Zeno's argument. Then, explain the mathematical reality (related to infinite series) that disproves Zeno's argument.

Bonus! Can you explain this joke?

14. [This question involves both chapters 34 – 37 and 41 – 42 on simple calculus]

To do advanced physics, you need to understand the concept of "instantaneous speed." What does the word "instant" really mean? What exactly is instantaneous speed?

Chapters 38 – 40: Newton and Leibniz creative years

15. Pick either Newton or Leibniz. Tell the story of how this scientist solved the problems of motion. What things did he need to learn before discovering new mathematics? How did he go about learning these things? What sort of place did he live while making discoveries, and what sorts of events surrounded him?

Chapters 41 – 42: very simple conceptual calculus

16. To do advanced physics, you need to understand the concept of "instantaneous speed." What exactly is instantaneous speed? What does it mean for something to be an "instant?" [Look back to chapters 34 – 37 on infinity to help answer this question.]

17. The speed of something is the slope of its distance-time graph. To calculate instantaneous speed, you must find the slope of a curved line at one point. Describe the process used to find this slope. This process is illustrated with a series of graphs in these chapters.
[This is a *very good* question to explore if you are also signed up for AP Calculus this year!]

Chapters 43 – 44: Newton's and Leibniz – the feud
18. Isaac Newton and Gottfried Leibniz both discovered calculus independently of each other. Since then, a feud has existed over who deserves more credit. Edward Dolnick draws many contrasts in how Newton and Leibniz approached their work. While both geniuses, they had *very* different styles. Whose intelligence impresses you more? Give a few reasons why.

Chapters 45 – 51 (and chapter 29, which is related): Developing the Law of Gravitation and writing the Principia

19. The story, you may have heard, that Isaac Newton invented the theory of gravity because an apple fell on his head is silly and of course false. A better story (which may or may not be true), is that he saw comparisons between the way an apple falls and the way the moon moons. Explain what Newton noticed. To help answer this question, look back at chapter 29: Sputnik in orbit 1687.

20. The strength of the force of gravity is given by this equation:

$$F = \frac{Gm_1m_2}{r^2}$$

For our story, the most important part of this equation is the r^2 in the denominator. That makes this an "inverse square law," the strength of the force of gravity decreases with the square of the distance between two objects.

21. Edward Dolnick tells many stories about the invention of this theory, and how it was proven that gravity follows an inverse square law, and how it showed that an inverse square law let Newton's theory perfectly fit Kepler's observations.
Tell your own version of this story. As part of your story, explain why an inverse square law is intuitive. [Look on pages 274 and 275 for an idea of this.]

22. The most important scientific book of all time is Isaac Newton's *Philosophae Naturalis Principia Mathematica*, or Mathematical Principles of Natural Philosophy, which is typically called the *Principia*. By relating motion on both heaven and earth to a small number of basic laws, the book began a new era of human thought in which humans feel they can understand and control the world around them.
Give examples of 4 crucial scientific ideas that first appeared in Newton's *Principia*. Be descriptive: most of Newton's ideas were in response to those of other scientists and mathematicians. Whose work did Newton build upon? With whom did he disagree?

Chapter 52 and epilogue: religion and physics, and the legacy of the scientific revolution

No questions on this section