Intro for Physics I

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1 Introduction

What is physics? Physics is defined as "a science that deals with matter and energy and their interactions" by the Merriam Webster dictionary. However this gives us no objective. What we wish to understand in this introductory class is: how do objects interact with forces around them and each other. This is also known as *mechanics*.

Who and when? (optional) The Greeks were known for their rational philosophy, one of which was natural philosophy. This early curiosity for the natural world as well as their belief in strong logic for proof allowed for the future generations to try to explain and prove the observations which the Greek made. Some of which include:

- Earth existing in space.
- Little things make up big things aka atoms.
- Parallel lines won't intersect, and the postulation of euclidean geometry to describe the world's geometry. [1]
- Heliocentrism: the sun is the center of the universe. [2]
- Antikythera Mechanism: A Mechanical computer to model the motion of the planets.

Further, many Egyptian and Persian influences:

- John Philoponus: Theory of Impetus, the dynamics of forced motion.
- Ibn Sina: The idea of a force.
- Al-Kwarizmi: Al Jabr, or Algebra: the book of calculation and restoration.

Into the 17th century we have:

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[1] This, according to Einstein's theory of relativity is unfortunately not true in our world but it is locally and macroscopically true.

[2] This is close to the truth, just only for our local solar system.

- Kepler: laws of planitary motion.
- Galileo: Inertia and a lot of orbital mechanics similar to Kepler.
- Christiaan Huygens: *Treatise on Light*
- Isaac Newton: Principia Mathematica (Calculus), Newtons Laws of Motion, Newton's law of universal gravitation. [3]

With a very strong end of the 17th century, we get into a the 18th and 19th centuries which consisted of the refining of Newton's mechanics with viewing paths through phase space of different energy levels in the Lagrangian and Hamiltonian Variational methods of physics. They are very complex and will not be discussed here, yet I mention them for the curious.
The 19th century was full to the brim of modern physics, we got extremely curious about light and the electromagnetic phenomena we have have been in awe to for millennia. Maxwell published his work on electromagnetic field theory which revolutionized physics as well as J. J. Thomson discovering the electron, we were excruciating close to having to look quantum mechanics in the eyes.
The 20th century, the intense collaboration and sheer quantity of work here makes it impossible to list every name. Einstein had relativity, rutherford discovered the atomic nucleus, bohr described the atom with electron energy levels, Schwarzchild solved the einstein field equations, Schrödinger got his governing equation, Dirac quantizes and forms a relativistic Hamiltonian and theory for quantum mechanics. We have only made it to the 1930s at this point... to keep it to a minimum, Feynman made his path integral and added to Dirac's work in electromagnetism (QED), electroweak theory, quantum chromodynamics [4] describing the quarks which make up elementary particles.

To put it lightly, we are very much standing on the shoulders of giants. Don't let it intimidate you too much, this isn't easy work, it is conceptually climbing a mountain and you left your rope at home. You may and will have to look at things multiple times before you understand it. However in this course a major objective should be to build your intuition and allow your work to build a picture.

[3]Einstein further developed the theory of gravity as in relativistic terms in General Relativity.

[4]This sounds scary but chromo means color and that is how they named quarks.

2 Where should we start?

Our entry point will be rather awkward, Newton wrote his discoveries in the terms of calculus which you likely haven't learned yet. That is okay though, there is a lot we can learn through specific situations we will learn to model and think through. Let us first look at his three laws.

- Every body perseveres in its state of rest, or of uniform motion in a right line, unless it is compelled to change that state by forces impressed thereon.
- The alteration of motion is ever proportional to the motive force impressed; and is made in the direction of the right line in which that force is impressed.
- To every action there is always opposed an equal reaction; or the mutual actions of two bodies upon each other are always equal, and directed to contrary parts.

I'm leaving you on a cliffhanger here because it is vital you try to make your own connections of these to reality before anyone tells you them explicitly. We will break these down in Investigation 1.

3 Questions:

- How do you interpret the 1st Law in your own words?
- What do you think *motion* really means?
- Can you give an example of an equal and opposite reaction? (Hint: look down)
- How would you mathematically write these statements, approximately, or exactly. (Hint: the symbol for proportional is $\propto$)