Module 10: Newton's Laws

Vocabulary:

Newton's First Law: An object in motion (or at rest) will tend to stay in motion (or at rest) until it is acted upon by an outside force.

Inertia: The tendency of an object to resist changes in it s velocity.

Friction: A force that opposes motion, resulting from the contact of two surfaces.

Newton's Second Law: When an object is acted on by one or more outside forces, the total force is equal to the mass of the object times the resulting acceleration.

Kinetic Friction: Friction that opposes motion once the motion has already started.

Static Friction: Friction that opposes the initiation of motion.

Newton's Third Law: For every action, there is an equal and opposite reaction.

Module Outline:

I. Introduction
II. Sir Isaac Newton
III. Newton's First law of Motion
IV. Friction
V. Newton's Second Law of Motion
VI. Static and Kinetic Friction
VII. Newton's Third Law of Motion

Formulas to remember:

Total force = mass x acceleration

Scientists and Terms suggested in this Module:

Newton = $\frac{kg \cdot m}{sec^2}$ Aristotle, Copernicus, Galileo, Newton

I. Introduction:

The study of motion can be traced back to the 4th Century with Greek Philosopher, Aristotle. Aristotle's opinions and ideas became key concepts which the foundation of science was based upon for a significant amount of time. Even though many of those ideas have been proven wrong, (Spontaneous Generation, Geocentric View of the Solar System, and Motion), his ideas, theories and teachings have continued to be studied and even considered simply because he was a respected scientist.

Three Scientists who spent considerable amounts of time and effort to quell the false teachings of Aristotle, even to the extent of having to be jailed and punished were:

- Nicholas Copernicus
- Galileo Galilei
- Sir Isaac Newton

This chapter will focus primarily on the discoveries of Sir Isaac Newton and his ideas, which eventually became laws, on Motion.

- Brief bios of scientists:

Aristotle –(384-322 BC)- *Father of the Life Sciences*

- Developed the science of Botany, music theory and animal and plant classification.
- He was a philosopher, mathematician, logician and student of physics.
- *His work was important in the advancement of Science because he started the process of putting all the facts in an ordered system.*

Remember: Romans 3:23 " All have fallen short of the glory of God". All humans are flawed and need to have the gift of salvation and oftentimes, w/o the illumination of The Holy Spirit and Scripture our ideas are also flawed. Always read everything with caution asking the Lord to reveal those hidden things only He knows.

- Truly he was a learner…one who studied. A lot of what he concluded was inaccurate, but he was going off of the information he had at the time .

One of those ideas was : Spontaneous Generation. – The idea that living organisms can come from non-living things.

Nicholas Copernicus (1473-1543 AD) – Polish Astronomer

- In 1543, shortly before his death, he wrote the controversial book " On the Revolution of the Celestial"
- The book was written 13 years before but he feared the rule of the church and the authority they had over this area so he chose not to print it till just before his death.

- He is known for his heliocentric view of the universe.
- There were multiple holes in his theory, but what he presented put forth the simplicity of his belief.
- He introduced the concept that the Sun was the center of the Solar System

- Both Copernicus and Galileo lived during the The Golden Age of the Renaissance. (1500-1700 AD)

- Define heliocentric-
- Build your own model of the solar system

OR Build/Draw a model of the Ptolemaic System or the Copernican System

Galileo Galilei (1564-1642 AD) – Astronomer, Mathematician, Scientist, Professor

- With the help of Brawadine, Brahae and Kepler's data (along with the lenses designed by Hans Liershey) Galileo built a telescope in 1609 to "see" the moon and the motion of the stars.
- He challenged the ruling theory, Ptolemaic Theory, accepted by the church.
- He was put on trial and had to publicly denounce his believe in the Copernican Theory.
- For the rest of his life, confined to house arrest, he collected data to prove the Sun was the center of the universe.

Sir Isaac Newton (1642-1727 AD) – Mathematician, Scientist

- He wrote " Principia", built on the principles of Pascals research.
- His work detailed the principles of Gravity and The Three Laws of Motion.
- The "Newtonian Era" of science is named after him.(1670-1734)

Summary of The Three Laws of Motion:

1. The Law of Inertia - an object at rest will tend to stay at rest unless acted upon by an outside force.
2. Force is relative to weight.
    a. To move an object you must use force.
    b. Force = mass times acceleration
    c. Measurement of Newton named after him shows the mass of 1 kg times 1 meter per second ^{2}. 1 N=kg·m/s^2
3. For every action there is a equal but opposite reaction.

- What does it take for an idea to transition from an idea, then into a theory, and finally into a law? – Think of the Scientific Method
    - Observe something
    - Ask a question
    - Make a hypothesis
        - A Hypothesis is an educated guess that answers a question based on observations.
    - Test hypothesis and collect data
    - If Data supports hypothesis, it becomes a theory
        - A Theory is a hypothesis that has been tested with a significant amount of data.
    - If not.. adjust hypothesis and re-test.
    - Collect data over time to support theory
    - Theory becomes a law.
        - A Scientific Law is a theory which has been tested by and is consistent with generations of data.

II. Sir Isaac Newton

Newton was considered a Creation Scientist. He believed in God, studied the Word and wrote many dissertations on his thoughts towards scripture BUT we do not find in his writings anywhere that he believed in the trinity or in the divinity of Christ. From what we read, it would seem that he felt science was an extension of study to know more about God. It is clear that he choose to learn more about the physical forces in creation because he wanted to know God.

- Research Newton and make a list of the accomplishments he achieved in his lifetime.
- Read the book by Jeanne Bendick titled:

III. Newton's First Law of Motion

AKA: The Law of Inertia - this law states that an object in motion(or at rest) tends to stay in motion (or at rest) until it is acted upon by an outside force.

- Newton's findings were contradictory to that of Aristotle who states that all things want to be at rest and it is that desire to rest which causes them to stop. Newton found through his studies that it is a completely different force that causes motion to stop.

- ✓ Consider the results of Experiment 10.1 – What other examples could you think of where the law of intertia is clearly seen. (ie: the book gave the example of a car stopping and the need for a seatbelt to stop the occupant.)
    - Inertia describes the difficulty to change the velocity of an object.

- ➢ Dr. Wile explains how to apply and analyze Aristotle's theory with that of Newton's. Use this deductive reasoning to the examples you come up with above.

- ✓ Looking at Experiment 10.2 – We see the concept of the change not only in the speed of an object but the direction. (do you remember what this is called?). Were you able to correctly predict the path of the marble? Why or why not?

- ❖ Research the Ear:
    - How you can apply the law of inertia to the fluid and the semicircular canals?
    - An interesting concept currently being researched is the effect of music on the brain and learning. Can you explain why this small appendage is so important to our well-being and ability to talk, understand, and comprehend?

IV. Friction

Friction is the force that stops velocity.

Look at example 10.2 and explain why the spaceship has continued on? And why it is still working?

Friction is a force that:

- Fights against gravity
- Changes with physical changed or characteristics of objects
- Opposes motion between 2 objects.

By looking at the example in Figure 10.3 we see that Friction works because of the attraction (both negative and positive) of the molecules in each surface.

Think about what we have learned about Atoms. They are the smallest building block, upon which everything is built. Therefore on an atomic level, every surface is rough or rugged. There is not a smooth surface and because positive molecules (multiple atoms) attract negative molecules the force of friction is strong enough to change velocity.

- ◈ Think about why air resistance is considered a form of friction. Is there any where this concept is not applied?

V. Newton's Second Law of Motion

This law states that when an object is acted on by one or more outside forces the total force is equal to the mass of the object times the resulting acceleration.

Note the formula: Total Force = (Mass) x (Acceleration)

Acceleration is measured in the unit of time divided by the unit squared. (time/unit^2)

We also see force defined: Force is the push or pull upon an object which is intended to change the velocity (speed and often direction) of an object.

The unit which measures acceleration was named after Isaac Newton, called the "Newton", relates the measurement of kilograms x meters divided by second^2. You will want to make a note of this definition and either memorize it or make a note card which you can refer to.

The Newton is the standard unit of force and is defined as a $\frac{kg \cdot m}{sec^2}$.

Force is a vector quantity, which means it has motion or it is the measure in the amount of push or pull on an object.

- Carefully read through Example 10.1 and study Figure 10.4 to understand this concept fully.

VI. Static and Kinetic Friction

There are different types of Friction

- Static Friction opposes initial motion
- Kinetic Friction opposes motion that has already started.

Look at Page 245 paragraph 3 and example 10.3 to see the difference between the 2.

Static friction causes the need for more force to be applied at the beginning stage of motion versus kinetic. We can also consider Law #1 to help explain why more force is required to move a stationary object as opposed to a moving object.

Total force equals the initial force (the force required to move an object) + the force of friction (the force required to overcome friction and keep an object moving). In your book it describes it with example 10.3 ($F_m + F_f$= Total Newtons of Force)

VII. Newton's Third Law of Motion

This law states that for every action there is an equal but opposite reaction.

- This action is a force. Every time a force is applied to an object, this object then applies and equal but opposite force to something else.
- The actions are not applied on the same object but on *different* objects.

- Examples of the law of equal but opposite force.
  - When you jump on a trampoline. (Look at figure 10.5) you exert a force that bends the top of the surface. The opposite force happens when the person jumping accelerates back in the opposing direction.
  - You can also see this law applied when a gun has been fired. The force which pushes the bullet out is reciprocated upon the shoulder person who pulled the trigger.
  - When a rocket is launched the gases from the burning of the fuel causes thrust which propels the rocket up in the opposite direction.