Name:______________________________ Date:_____________________

Mr. Croom's Physics — Chapter 4: Force and the Law of Motion

Types of Forces

In the mid to late 1800s, there were five types of forces in nature:

1. gravitational force.
2. electric force.
3. magnetic force.
4. strong nuclear force.
5. weak nuclear force.

Michael Faraday

James Clerk Maxwell

Work was done by famous scientists such as Michael Faraday and James Clerk Maxwell to unify the electric and magnetic forces into a single interaction called the **electromagnetic force**.

By the early to mid 1900s, there were now four types of forces in nature:

1. gravitational force.
2. electromagnetic force.
3. strong nuclear force.
4. weak nuclear force.

Sheldon Glashow

Abdus Salam

Steven Weinberg

Further research was conducted by breakthrough scientists Sheldon Glashow, Abdus Salam, and Steven Weinberg that unified the electromagnetic and weak nuclear forces into a single interaction called the **electroweak force**. For their contributions, the three eminent scientists were awarded the Nobel Prize in Physics in 1979.

By the latter part of the 1900s, there were 3 types of forces in nature:

1. gravitational force.
2. electroweak force.
3. strong nuclear force.

What does the future bring? Scientists are racing to find a single theory that unifies the remaining three forces. So far, scientists are close to unifying the electroweak and strong nuclear forces into a single interaction. However, gravity is the elusive force. Its mechanics are so different from the others that some scientists wonder if all three can *ever* be unified.

Niels Bohr

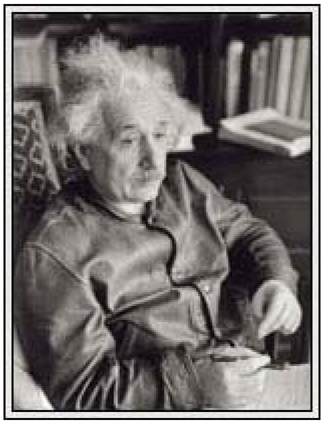
Erwin Schrodinger

An early 20th century revolutionary theory completely decimated the Newtonian determinism of the 18th and 19th centuries. Quantum mechanics, proposed by leading scientists of the day like Niels Bohr, Erwin Schrodinger, and Max Planck theorized that all subatomic interactions were probabilistic in nature.

In other words, there was an internal randomness in all subatomic particle interactions. For example, consider a metal atom like iron, with its 26 electrons in orbit about the nucleus. Classical (18th and 19th century) theories predicted that electrons move in definite orbits around the nucleus. Quantum mechanics, on the other hand, more accurately predicts that electrons have only a certain probability of being in certain orbits at certain times.

Max Planck

This idea, that atoms and subatomic particles moved according to probability, upset, for lack of a better term, one of the forefathers of modern scientific thought, Albert Einstein. Albert Einstein was famous for his theories on relativity and the photoelectric effect.



Quantum Theory advanced steadily through the early 20th century—and so did Einstein's discontent with it. The theory predicts how discrete packets of energy, called quanta, will behave based on statistical probabilities instead of direct observations. Einstein liked some aspects of Quantum Theory, but he never accepted its statistical basis as a means to completely describe the physical world. **He thought this new branch of physics did not embrace the harmonious way in which God created the universe**: "Quantum mechanics is very worthy of regard. But an inner voice tells me that this is not yet the right track. The theory yields much, but it hardly brings us closer to the Old One's secrets."

In the twilight of his career, instinct drove Einstein to perform research on unifying the remaining forces into a single force interaction called a **grand unified field theory** (GUT for short). His gut feeling eventually gave in to doubt. "All my attempts, however, to adapt the theoretical foundation of physics to this [new type of] knowledge failed completely," he wrote. "It was as if the ground had been pulled out from under [me]...." **Yet Einstein hoped that his work would point modern physics in a new direction.** Physicists today still pursue the Grand Unified Theory.

Today, other scientists extended Einstein's theories to include a theory that would include EVERY interaction, physical, chemical, biological, atomic, subatomic, nuclear, sub nuclear, and beyond. Since this new theory would incorporate every interaction in the universe, it has been dubbed a T.O.E., or **theory of everything**. So far, attempts to unify all relevant theories into a single, coherent theory have proven unsuccessful, but current research is still in progress.