**Unit 4 - Reading 1**

**Types of Forces and Force Representation**

For our purposes in this unit on forces, we will define “**force”** as any interaction between *two* *objects* that results in a *directional* push or a pull. Given this operational definition for a force, it will be helpful to introduce a special notation for dealing with the concept of force. We will use the symbol to denote a force. We will further classify the force according to the type of force, and which objects are interacting with the force.

There are four basic types of forces that occur in nature. Of the four, only two are part of our common experience. The four interactions that we call forces are:

* Gravitational Force
* Electromagnetic Force
* Strong Nuclear Force
* Weak Nuclear Force

**Gravitational**

A gravitational force exists between any two objects that have mass. It is always an attractive force, pulling the objects toward one another. This force is very weak unless at least one of the objects is very, *very* massive. This is why you don’t notice that you attract your pencil, or another person, or the desk gravitationally. Since the only noticeable gravitational interaction we sense is that between the earth and other objects, this is the gravitational interaction that we will use repeatedly in this unit.

**Electromagnetic**

Electromagnetic forces are involved in every other interaction (force) that we deal with in our everyday life. Electromagnetic forces occur between objects because they have electric charge. They can be attractive or repulsive because charge comes in two varieties: positive and negative.

* Repulsive - Whenever two objects have the same kind of charge, either both positive or both negative, they will electrically repel each other.
* Attractive - Whenever two objects have opposite charges, they will electrically attract each other.

Nearly every push or pull that you are likely to think of that is not gravitational is electromagnetic in nature. When you push on a cart, it is the interaction of the negative charge surrounding the atoms in your hands with the negative charge surrounding the atoms in the handle of the cart, that are responsible for you being able to push on the cart.

**Strong and Weak Nuclear Forces**

The strong and weak nuclear forces have to do with holding the nuclei of atoms together and with radioactive decay, and don’t appear in ways that are noticeable in our everyday lives.

Therefore we can describe most of the forces we notice in terms of only *gravitational* and *electromagnetic* interactions.

**Macroscopic Forces**

There are so many ways that objects interact electromagnetically, that we sometimes give the various electromagnetic interactions their own names. For instance, when surfaces rub on each other, or flow (as in liquids and gases) past objects, there is an electromagnetic interaction we sometimes call *friction* or drag. When an object rests on a horizontal surface, that surface pushes up on the object as a result of an electromagnetic interaction we sometimes call a *normal* (normal means perpendicular in this context) force. When a string or rope pulls on an object we sometimes call the electromagnetic interaction responsible for the pull a *tension* force. The list of common forces that fit into the electromagnetic category goes on and on.

This brings us back to our notation for describing forces. Any directional push or pull (force) will begin with the symbol for force. We will then follow the with a subscript that denotes the type of interaction. If the interaction is *gravitational*, like the earth pulling down on you or a student or the car or the hover puck, we will use the symbol ***g*** as a subscript. If the interaction is a *frictional* force, we will use a subscript ***f*.** A *tensional* force applied by a rope, string or other similar material will use a subscript ***T***. The support force from a surface, known as *normal* will use a subscript ***N***. Since there are so many other ways to classify other forces, we will call any other interaction just a *push* or a *pull*, and will use the subscript ***P*** to denote the push or pull.

* A gravitational force would therefore look like
* A frictional force would be symbolized with
* A tensional force would be symbolized with
* A normal force would therefore look like
* Any other push or pull will be denoted

There are two more subscripts that we will add to the end of the symbol for a force. These subscripts denote the objects that are interacting. For any force, there must be at least two objects interacting. One object exerts the force while the other object experiences the force. We will call the object that exerts the force the “agent” or the “dealer” of the force. This is the “pusher” or “puller.” We will call the object that experiences the force the “object” or perhaps the “feeler” of the force. This is object being pushed or pulled. We will put the symbols that represent the dealer (agent) and feeler (object) in a specific order. The first of the final two subscripts is the dealer of the force; the object that exerts the force. The second of the final two subscripts is the feeler of the force; the object that experiences the force. This order of the final two subscripts is sometimes called by/on notation. The dealer of the force the object that is exerting the force; the object that the force is “by.” The feeler of the force is the object that the force is “on.”

In the generic case, the symbol for the force would therefore contain for force, followed by ***T*** for the *type* of force, followed by ***A*** for the *agent* of the force, followed by ***O*** for the *object* of the force.

It would look like this:

Here are some more specific examples:

* The gravitational force on a person by the earth would be denoted
* The frictional force on a car by the road could be denoted
* The push on a wall by a person might be represented as
* The upward push on a person by the floor might be represented as

Visually, we will represent forces with an arrow. Since we are concerned about two major aspects of a force, magnitude (size) and direction, arrows work nicely for this. We can represent the magnitude of the force by how long we draw the arrow, and the direction of the force by which way we point the arrow.

Consider the gravitational force by the earth on a 180-pound teacher, and the gravitational force by the earth on a 90-pound student. Since the gravitational interaction between the teacher and the earth is attractive, the gravitational force by the earth on the teacher is toward the center of the earth, which is defined as ‘downward.’ The same is true of the gravitational force by the earth on the student. The graphical representations of these forces would be as follows:

F

g by E on T

g by E on S

F

Notice that the two arrows point down since the gravitational force is downward. Notice also, that the arrow for the teacher is twice as long as the one for the student since the gravitational force is twice as strong on the teacher.