LECTURE 11: Types of forces

Select LEARNING OBJECTIVES:

i. Introduce various types of forces used to describe interactions between objects.

TEXTBOOK CHAPTERS:

- Giancoli (Physics Principles with Applications 7th) :: 4-6, 5-10
- Knight (College Physics : A strategic approach 3rd) :: 4.2, 5.6
- BoxSand :: Forces (Equations, Definitions, Notation)

WARM UP: Briefly describe Newton's laws of motion…

1st

2nd

3rd

In this section we will introduce some of the force types that we will encounter when analyzing systems in the next few lectures. This is not a complete list of all the forces that we will use in this class. We will introduce a few more types of forces which add slight complexity to our systems of interest as we begin to develop our problem solving skills. Then, in the later series, PH212 and PH213, we will add even more types of forces to consider when analyzing a system.

Force of gravity near the Earth's surface (often called weight)

Any two objects with mass will attract each other via a gravitational interaction. If the two objects of interest are the Earth and any other object with mass that is near the surface of the earth, the force we use to describe this gravitational interaction is the force of gravity.

Our notation for the force of gravity near the Earth's surface is the following:

$$\vec{F}^{g}_{E1}$$

The magnitude of this force is equal to:

$$\left|\vec{F}^{g}_{E1}\right| = m_1\, g$$

Where "g" is called the "acceleration due to gravity". Its value is 9.8 m/s^2.

This gravitational force is considered to be a "non-contact" force. That is to say that the force that the Earths exerts on an object is still present even if the object and the Earth do not seem to be physically touching, hence "non-contact". The direction of the force from the Earth on the object near its surface points straight down to the center of the earth, in other words it points radially downwards.

*In a later lecture we will explore the more general force of gravity which allows for objects to be near or far from the Earth's surface.

Electromagnetic force

Although we won't cover electric and magnetic interactions until much later in the series, it is beneficial to point out that the following forces we will talk about below are all manifestations of the electromagnetic interactions between atoms and/or molecules. The electromagnetic force is generally a non-contact force. However, the interactions often happen on such short length scales that to our eyes the interaction between the two objects seems to happen on contact. Thus the following forces listed below under this section are considered contact forces, even though their underlying interaction is electromagnetic which is non-contact in nature.

Normal force

When two objects get so close to each other that they look like they touch each other, they exert a normal force onto each other. We denote normal forces as such…

$$\vec{F}^{N}_{12}$$

….where we read this as, "the normal force from object 1 on object 2". But do not forget, forces are just our way of describing interactions, thus if the normal force above exists, then there also exists a normal force from object 2 on object 1 that has the same magnitude of the former.

There is no fundamental mathematical relationship for what the magnitude of the normal force is like there was for the force of gravity. Therefore the magnitude of the normal force is derived for each new system we analyze. Although we can't readily write down the magnitude of the normal force without some sort of analysis first, we do know the direction in which the normal force acts.

That direction is always perpendicular to the contact surface between the two objects that are touching. For example…

PEN HERE

Tension

Imagine hanging an object from the ceiling via a very light rope or string. The object interacts with the Earth, giving rise to our familiar definition of the force of gravity. This force of gravity wants to pull the object towards the center of the Earth. However, the object does not accelerate towards the Earth since the object is connected to an string which is anchored to the ceiling. The string itself stretches, often times by an unobservable amount. Electromagnetic interactions within the string prevent the string from stretching past a certain distance. Since the string is connected to our hanging object, so we then say that the string provides a force of tension which prevents the object from accelerating towards the earth.

Anytime an object is connected to a string and the object is attempting to stretch that sting, we say that the string exerts a force of tension on the object. Again, remember that the tension force is really an electromagnetic interaction within the string; meaning that the actual interaction is non-contact in nature. However, since our eyes can't see on the scale of atoms and molecules, we only notice tension forces if objects are physically touching, thus we say the force of tension is a contact force. We denote the force of tension as shown below…

$\vec{F}^{T}$

We will introduce an approximation at this time for the force of tension in strings. Unless otherwise clearly noted, all strings presented to you in this course can be assumed to be very light. By making this assumption, we are dictating that the force of tension in a string holding an object from a ceiling is constant throughout the string's length. If the string has a significant mass, then the tension would not be constant throughout the length of the string. Can you guess qualitatively how the tension might change throughout the string in this case? *See "a closer look at tension" for a bit more detail about tension.

Generic forces

There are times where the physical scenario we wish to analyze is not any more conceptually enhanced if we leave out details about what type of interactions are occurring. However, we cannot just ignore the interactions altogether, thus we just use generic forces that could represent any one of the forces we have already covered or have yet to cover. These forces are…

Force applied

$$\vec{F}^{A}$$

Force push

$$\vec{F}^{P}$$

Take the force applied for example, it could mean that there is a hand applying a normal force on our object, or perhaps our object has some electric charge and is being pushed away from another similarly charge object. In either case, perhaps the knowledge of the actual interaction does not provide us with any more insight into the problem, so we just slap a generic force label on the interaction and continue on with our analysis.

FORCE INVENTORY

For a larger list of types of forces check out the "force inventory" list.

Conceptual questions for discussion

1) A cat sits on top of a box which sits on top of a table. List all the force-pairs for this situation.
2) When you shake hands with someone, what type of force is present on each hand? What interaction does this force represent?
3) A string with non-negligible mass is hung from a ceiling. How does the tension in the string qualitatively differ at the top compare to the tension of the string at the bottom?