# Grade 11 Physics Notes - Dynamics

Aaron G. Kebede

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# The Concept of Force

Dynamics is the study of the forces that cause objects and systems to be in motion. Intuitively speaking(as we did in grades 7,8,9, and 10), we can say force is a *push* or a *pull* on an object or a system.

Force is a vector quantity, hence it needs both magnitude and direction to be fully expressed.

Force is also **always** a result of interaction between different objects, no single object can possess force on its own.

We experience force on a daily basis - whether we are sitting or standing, or even sleeping - it is an inherent part of all of us. We find 4 fundamental forces in nature(aka *The Four Forces of Nature*).

**Strong Nuclear Force**: This is the force that keeps the nucleus intact - keeps protons and neutrons bound together in the nucleus.

**Weak Nuclear Force**: This is the force that exists at an atomic level and is present during atomic fission and fusion (*fission is when an atom is split, for example, during radioactivity. A perfect fusion example is how the sun produces energy by joining atoms in a nuclear process*)

**Electromagnetism**: perhaps, a force we get to experience the most in life. Governs the interaction between magnetic and electric fields.

**Gravity**: Gravity is the weakest out of these 4 and it is the result of the interaction between massive bodies. It is a purely attractive force.

# Computing Forces

More often than not, we find forces in nature to be more complex to understand and compute. A simpler example to get started with is a force vector that acts in two dimensions at a tilt. To compute its interaction with a force of a similar kind, we would have to **resolve** the vector into its components.

For example, consider the vector [0.8,0.8]. Another important idea to make note of is that we can express this same vector using angles. To find the angle(*usually* the angle between the vector and the X-axis) we can use a little bit of trigonometry.

Let's say the angle between the vector and the X-axis is $\theta$, this means that the tangent of the angle between the two vectors is 1, effectively making the angle between them 45 degrees.(*Work on Your Exercise Book Why*)

The magnitude of the vector is $0.8\sqrt{2}$(**why?**). Therefore, another way to describe this same vector would be stating its magnitude and the direction with the angle we just calculated. We can say it is a vector with a magnitude of $0.8\sqrt{2}$ and a direction of $\frac{\pi}{4}$ above the X-axis.

Another thing to note is that the SI unit of force is Newton. Any vector should be accompanied by a magnitude, direction, and a unit to fully be expressed. The dimensional analysis of Newton is, $\mathrm{N} = [\mathrm{MLT}^{-2}]$

# Newton's Laws of Motion

Arguably one of the best physicists the world has ever seen, Newton has contributed a lot to the field of motion, namely Newton's Laws of Motion. These are three laws that we experience in day to day life and seem to stem from logic.

Before we delve into these laws, let's first recall reference frames. A reference frame is a coordinate system or a point of reference from which we observe and study motion. Such a frame that has a uniform motion(*or is at rest - which is a uniform motion*), is called an **inertial reference frame**.

Newton's Laws of Motion hold true in inertial frames of reference.

**Law of Inertia**: This is a law we innately experience. It states that an object will keep its state of motion unless interrupted by an outside force.

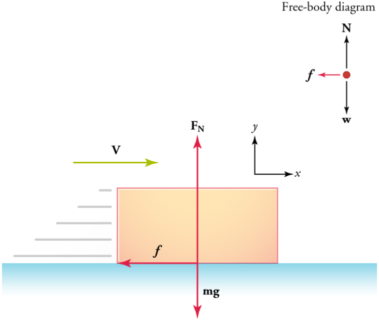
**Law of Acceleration**: This laws states that for an object to accelerate, a net force should act on it, and the resulting acceleration is directly proportional to the net force.

**Law of Action and Reaction**: This is also a logical physical law that we experience day to day; walking is a result of this, for instance. This laws states that if an object acts on another, the other objects acts with an equal but opposite force on the first object.

Now that we have seen these Laws, we can study examples of forces that stem from these interactions. A classic example is friction. Friction stems from two surfaces sliding on one another. It has many forms. The first example that comes to mind is the rubbing of two solid surfaces on each other. However, an object falling down from the sky also experiences friction; it is called drag.

# friction

Friction, as we said earlier, is a result of contact/rubbing between solid surfaces. Experiments show that the friction force arises from the nature of the two surfaces: because of their roughness, contact is made only at a few locations where peaks of the material touch. At these locations, the friction force arises in part because one peak physically blocks the motion of a peak from the opposing surface and in part from chemical bonding ("spot welds") of opposing peaks as they come into contact. Although the details of friction are quite complex at the atomic level, this force ultimately involves an electrical interaction between atoms or molecules. Consider the box in the figure below, for instance.



One very distinctive fact about friction is that it always opposes and acts against motion. Therefore, as we saw in the diagram above, we should assume that the direction friction is acting opposite to the motion of a body. To understand how we can find the friction acting on a body, we first need to find all the forces acting on it. We can resolve the forces into their components(if any) and then add them as vectors along their respective dimensions.

For an object such as the one shown above, we can see all the forces acting on it. When working with forces, you should always define the axes you're working with.

> **Weight** always acts vertically downward regardless of the orientation of the axes you set up.
>
> **Normal Force**, as the definition indicates is a **normal/perpendicular** to the surface it is acting from.

These two important points above will help simplify computing the free body diagram easier, that way we can easily be able to find the friction force.
Now, let's attempt to find the friction mathematically. We can take our axes defined as convention(Y-vertical and X -horizontal)

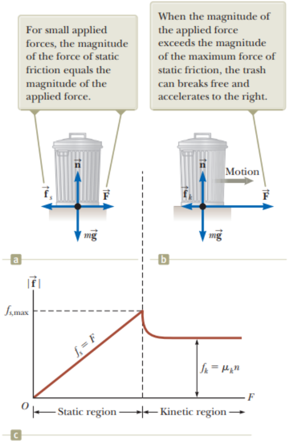
$\Sigma$ Fy $=$ 0, why?(We know the box is not accelerating along the Y, so that means the acceleration is 0. According to Newton's Second Law, if acceleration is 0, it implies that the net force is also 0.)

The forces that are acting along the Y - axis are **Fn** and **mg**, and their sum must equal zero. Fn + mg = 0.

Along the X - axis, however, the only force acting on the object is friction. Thus, the following holds true. $\Sigma$ Fx = ma.

This implies, f = ma. The next step should be how to find the frictional force. Let's think back for a moment and consider two objects rubbing on one another, if the push between the two is increased, it will be harder to move the objects past one another. That means, as the pushing of surfaces increases, the opposition to motion increases as well. This opposition to motion is friction and friction is proportional to the pushing of surfaces on one another(which is the normal force.)

Look at the diagram below to see how friction is related to normal force.




But the atomic-scale view promises to explain far more than the simpler features of friction. The mechanism for how heat is generated is now being determined. In other words, why do surfaces get warmer when rubbed? Essentially, atoms are linked with one another to form lattices. When surfaces rub, the surface atoms adhere and cause atomic lattices to vibrate—essentially creating sound waves that penetrate the material.

The sound waves diminish with distance and their energy is converted into heat. Chemical reactions that are related to frictional wear can also occur between atoms and molecules on the surfaces. Thus, it is the reason why we almost always associate heat and sound with friction.