Class Three: General Physics 3114
Kigali Institute of Science and Technology

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Outline for Today:

1. Kinematics: Graphical approach
2. Kinematics: Algebraic approach
3. Introduction to Dynamics: Newton's Laws

Kinematics: Graphical Approach: The key idea here is visualizing position x, velocity v, and acceleration a on graphs. You should be able to do so qualitatively (i.e., without numbers) and quantitatively. You should be able to go "forward": starting with $x(t)$, find $v(t)$ and $a(t)$. And you should be able to go "backwards": starting with $a(t)$, figure out $v(t)$ and $x(t)$. See the handout "The slopes of motion graphs" for details.

Kinematics: Algebraic Approach: Here we use algebra (and calculus) to find relations between $x(t)$, $v(t)$, and $a(t)$. If the acceleration has a constant value of a, then:

$$v(t) \;=\; v_0 + at \;, \tag{1}$$

$$x(t) \;=\; x_0 + v_0 t + \frac{1}{2}at^2 \;, \tag{2}$$

These are important formulas which you should memorize and know how to use. See the handout titled "Chapter 2: Motion" for details and examples.

Introduction to Dynamics: Forces and Newton's Laws: So far we have been concerned with *describing* motion. E.g., given $x(t)$, we can find $v(t)$ and $a(t)$. Buy *why* do things move the way they do? This is the topic of dynamics. The basis of dynamics are Netwon's Laws:

1. An object's motion is unchanged unless a force acts on it. Thus, in the absence of forces, motion does not change.
2. $$\vec{F_{\rm net}} \;=\; m\vec{a} \;. \tag{3}$$

   The term on the left is the net, or total, force acting on an object of mass m. The arrow on top of the F indicates that force is a vector; it depends on direction. We will usually focus on one-dimensional motion, and so we won't have to worry too much about different directions.

   This equation relates forces to acceleration. Forces cause acceleration.
3. If objects A and B interact, the force tha tA exerts on B is equal and opposite to the force B exerts on A.

A force is a push or a pull. From Newton's second law we see that the units are:

$$F \;=\; ma \;=\; {\rm kg}\frac{\rm m}{\rm s^2} \;\equiv\; 1{\rm Newton} \;. \tag{4}$$

A force results from an interaction between two objects. It is not a property of a single object.
Examples:

1. You push against a wall with a force of 100 N. What force does the wall exert on you?
2. A 20 kg object is dropped from an airplane. After it falls for a while it is moving at a constant speed. What is the net force acting on the object?

The force due to gravity on an object is called its **weight**, F_g. Weight is a force that is due to the gravitational interaction between the object and the earth. Weight is given by

$$\text{Weight} \;=\; F_g \;=\; mg \;. \tag{5}$$

On earth, $g = 9.8$ m/s^2.