PHYS 325: Lecture 1

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August 27, 2024

Lecture Span

1. Course Overview
2. Newton's Laws

Course Overview

Logistics

- Lecture attendance via gradescope: answer $> 50\%$ of questions. (NOT GRADED ON CORRECTNESS)
- Bonus points: Must ask question during Office Hours (2pts per week up to 30pts or 3%)

Overview of Course Topics

1. Newtonian Dynamics
2. Conservation Laws
3. Damped & Driven Oscillations
4. Motion in rotating reference frames
5. Lagrangian Mechanics

Ch 1: Newton's Laws

1.1 General Concepts

1.1.1 Space/Position

Choosing a Reference Frame

Note: In general, it's important to choose a coordinate system and use linearly-independent, unit vectors that span all of your chosen vector space. Example includes:

$$\vec{i}, \vec{j}, \vec{k} \tag{1}$$

In this class, we will use mostly Cartesian Coordinates and thus Cartesian Basis Vectors as seen in eq (1). Later, we will use spherical & cylindrical coordinates to describe rotational motion.

Position Vector

We can choose a $\vec{r}$ that goes from $0 \to \rho$. This position vector will be a linear combination of the basis vectors such as

$$\vec{r} = a\vec{e_x} + b\vec{e_y} + c\vec{e_z} \leftarrow \text{Basis vector notation} \tag{2}$$

Another form of notation of listing this vector is

$$\vec{r} = (a, b, c) \leftarrow \text{Vector notation} \tag{3}$$

Important thing to note: Physical Characteristics remain the same regardless of the chosen coordinate frames.

1.1.2 Time

Typically, Time is depicted with the variable t or T. In Classical Mechanics, time is **absolute** unlike Special Relativity. This means that time is measured **equally** by all obsevers.

Consequences

- Information travels at an infinite speed, i.e physical changes are noticed **immediately**
- People can communicate instantly

Thus, Newtonian Mechanics are valid for $v << c$ and $m >> e$ where $e =$ mass of electron and $c =$ speed of light .

1.1.3 Mass

Mass is typically depicted using variables m, M and the units of mass is [kg]. This is an instrinsic property of an object. It characertizes the object's inertia; i.e resistance to acceleration.

1.1.4 Point/Particle

It is an object of mass m but neglected size.

Consequences

- Kinetic Energy is purely translational (no rotational kinetic energy)
- Size of object $<<$ distance to observer

1.1.5 Force

Force is depicted by the symbol $\vec{F}$, and is the cause of an object's motion.

Strategy for describing the motion of an object

- Identify all forces and their directions
- Use vector addition to find the net force

Recap on Vector Calculus

Consider two vectors $\vec{r} = (r_1, r_2, r_3)$ and $\vec{s} = (s_1, s_2, s_3)$.

Properties

- Addition or $\vec{r} + \vec{s}$
- Scalar Multiplication for some $a \in \mathbb{R}$
- Magnitude (norm), basically $r = ||\vec{r}||^2 \iff \sqrt{\vec{r} \cdot \vec{r}} \iff \sqrt{\sum_i (r_i^2)}$.
- Dot Product: $f : \mathbb{R}^n \to \mathbb{R}$. This operation commutes, such that $\vec{s} \cdot \vec{r} \iff \vec{r} \cdot \vec{s}$
- Cross product: $f : \mathbb{R}^3 \to \mathbb{R}^3$. Denoted as $\vec{r} \times \vec{s} = \vec{p}$. Such that $\vec{p} \cdot \vec{r} = \vec{p} \cdot \vec{s} = 0$. In other words, $\vec{p}$ is orthogonal to both $\vec{r}$ and $\vec{s}$. They anti-commute, that is $\vec{r} \times \vec{s} = -\vec{s} \times \vec{r}$.