Project Proposal - Group 2

Neil Vaishampayan, Charles Zhang, Claire Chung, Ryan Rossmango, Brendan Rossmango

Introduction

We are planning to explore the many facets of friction, a retarding force, through a series of setups which cover several interactions that motion has to offer. In our experiments, we will look at traditional frictional forces that manifest between objects and surfaces. For further research, we will look at a topic which physicists often deem negligible - friction due to air resistance. Finally, we will seek to understand the effects of air resistance on a rotating object, a phenomenon known as the Magnus effect[1]. The idea for this project came from the previous experiments we have run, in which a significant amount of energy was lost to friction.

First, we will analyze the coefficients of friction of objects whose frictional interactions with certain surfaces are lesser known. Using multiple setups with different objects, we will attempt to determine the coefficients of friction between several combinations of objects and surfaces and confirm the following relation:

$$F_k = \mu_k F_n$$

We plan to run experiments with inclined and flat surfaces, as well as with both rolling and sliding objects. Thereafter, we will further categorize the objects based on their foundational material, so that we can define more general physical properties of everyday objects. Our list will include common objects such as books and empty water bottles, and we expect to add materials to our list in the coming weeks. We will determine the masses of our objects to find normal force, apply an initial force to the object, and use Tracker to analyze the resultant acceleration on the object due to the frictional force. Alternatively, we can use the work-energy theorem, with Tracker's velocity data collector and a known stopping distance, to find the average frictional force. We know some application of this alternative method will be used for rolling objects, which also have rotational energy.

For the more advanced research on air fluid resistance, we plan on dropping and throwing objects from a certain height, observing the effects of air resistance that physics equations tend to ignore. We will compare our findings and predicted lower velocities to the predictions made by Newton's Second Law and Energy Conservation principles, and we will seek to find drag forces of air resistance on several different objects. In short, there will be a weight that brings the object down opposing an upward drag force, which we will calculate with a known mass and acceleration.

[1] https://en.wikipedia.org/wiki/Magnus_effect

Lastly, for the Magnus effect research, we will instead spin the objects from a certain height, and compare the rotating objects' trajectories to the more linear ones of non-rotating objects.

Materials

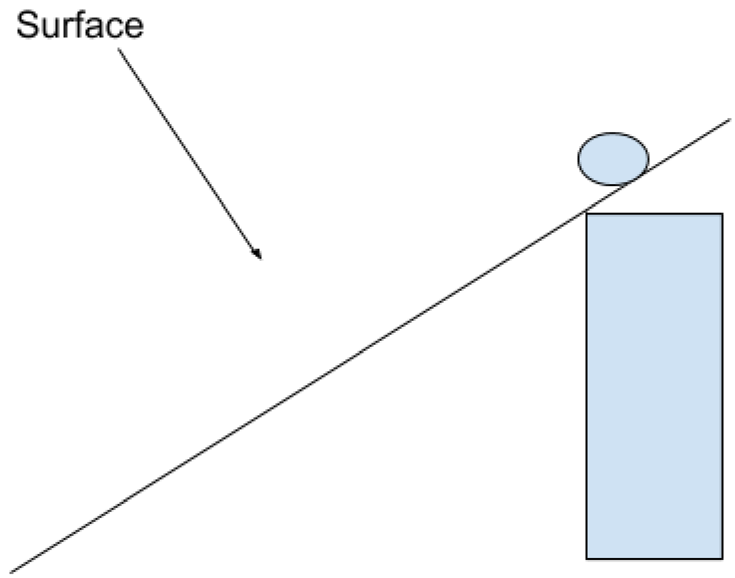
- Tracker Software
- Scale

Objects

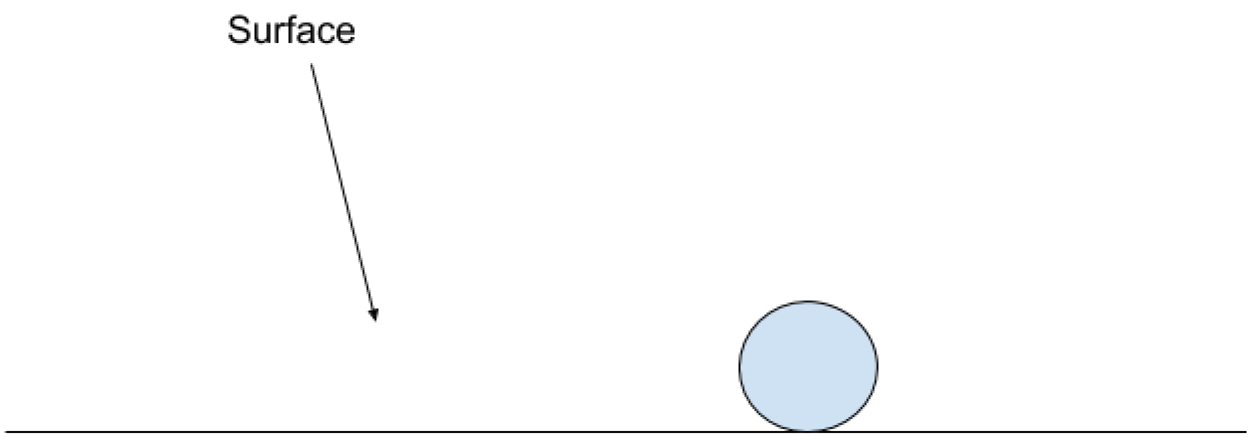
- Water Bottles
- Books (Hardcover)
- Meter Stick
- Baseball
- Tennis Ball
- Basketball
- Golf Ball
- Binder
- Laptop
- Eraser

Surfaces

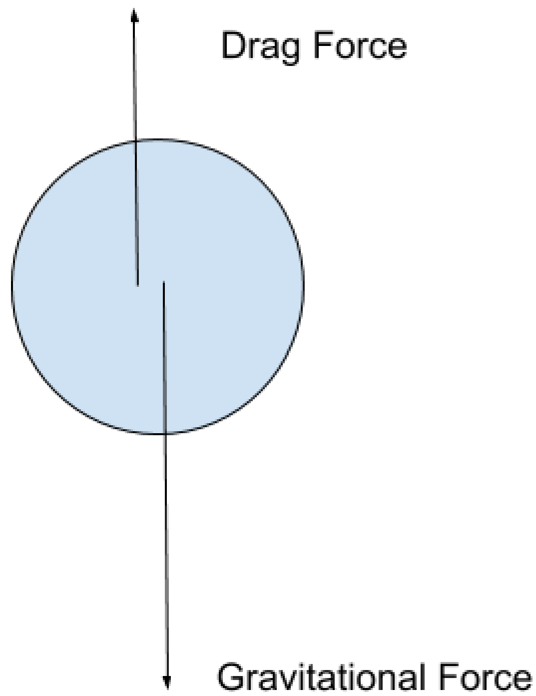
- Carpet
- Cardboard
- Smooth wooden table
- Rough wood



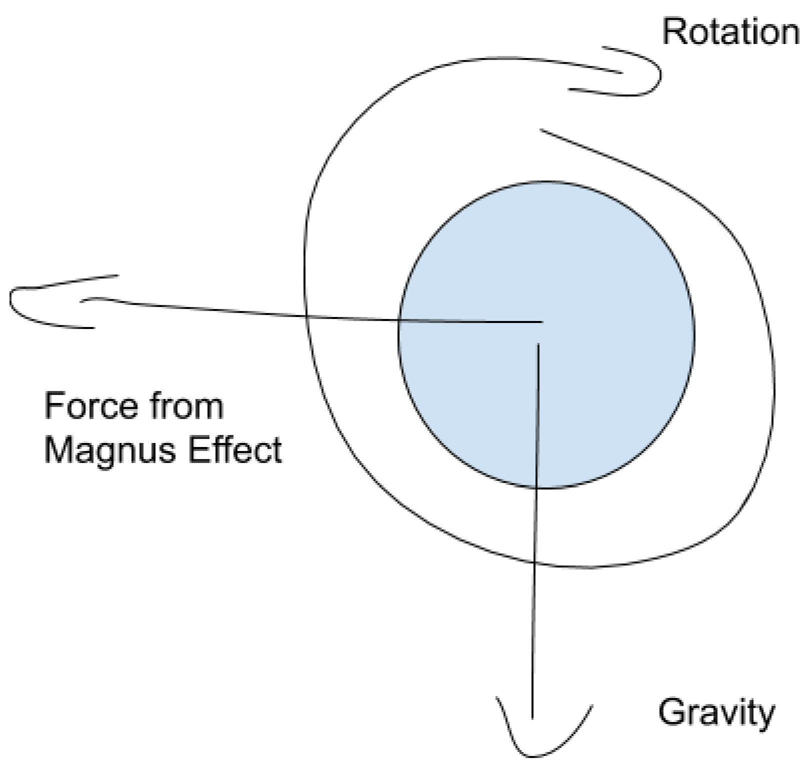
Setup 1: Inclined Surface



Setup 2: Flat Surface



Setup 3: Air Friction Measurement, by dropping balls of various sizes from a roof



Setup 4: Magnus Effects Setup, same as Setup 3 but dropped with spin

Methods, Predictions, and Analysis

Based on our goals of finding the coefficients of kinetic friction for multiple surfaces, we predict that rougher surfaces will have a higher coefficient of friction than do the smoother surfaces. Since it takes a larger push (a larger applied force) to get the object moving on a rougher surface, then we predict rougher surfaces to have a higher coefficient of static friction. From there, we predict that surfaces that have a high coefficient of static friction will also have a high coefficient of kinetic friction in relation. Thus, the coefficients of kinetic friction are predictable.

We will employ Newton's second law, $\Sigma F = ma$, the work-energy theorem, $W = \Delta E$, or $F*d = \Delta E$, where ΔE is the final kinetic (both translational, $K = 0.5mv^2$, and rotational, $K = 0.5I\omega^2$ in the case of rotating objects) and gravitational potential energy, $U = mgh$. Finally, we will use the relation between the frictional force and normal force, $F_k = \mu_k F_n$. After giving the object an initial applied force and letting go, the only force acting on the object in the horizontal direction (or at an angle in the case of inclined planes) is the force of friction, and this force can either be found using Newton's second law or the work-energy theorem. After finding the force, we can use the relation between the normal and friction force to find the coefficient of kinetic friction.

As for our air resistance experiments, we anticipate the drag force to increase linearly with the square of velocity as well as with the surface area of the object. In regards to trials involving rotating objects, we expect the objects to experience an acceleration in the horizontal direction due to the Magnus Effect. Similar to our experiments with friction, we will be attempting to use a setup where only gravity acts on the objects, allowing us to assume that the only forces acting on each object are drag and gravity. Since the force due to gravity is constant, any variation in acceleration can be roughly attributed to drag. Using the same physics principles mentioned above, we can extrapolate the relationship between drag, surface area, and velocity.

Timeline

Week	**Monday**	**Tuesday**	**Wednesday**	**Thursday**	**Friday**	**Saturday**	**Sunday**
8 (5/18)		**Data Collection**		**Data Collection**		**Data Collection (buffer)**	**Data Collection (buffer)**
9 (5/25)		**Data Analysis**		**Data Analysis**		**Data Analysis (buffer)**	**Data Analysis (buffer)**
10 (6/1)		**Report & Slides**		**Report & Slides**		**Report**	**Report**

Task Allocation

All of us will collaborate on the report.

Neil:

- Data Analysis
- Graph Creation
- Slides

Charles:

- Coefficient of Friction Data Collection
- Slides

Claire:

- Coefficient of Friction Data Collection
- Slides

Ryan/Brendan

- Air Friction Data Collection
- Magnus Effect Data Collection
- Slides