Conor Hunt
Lab Practicum - Hooke's Law

Brief Overview of the Chosen Lab:

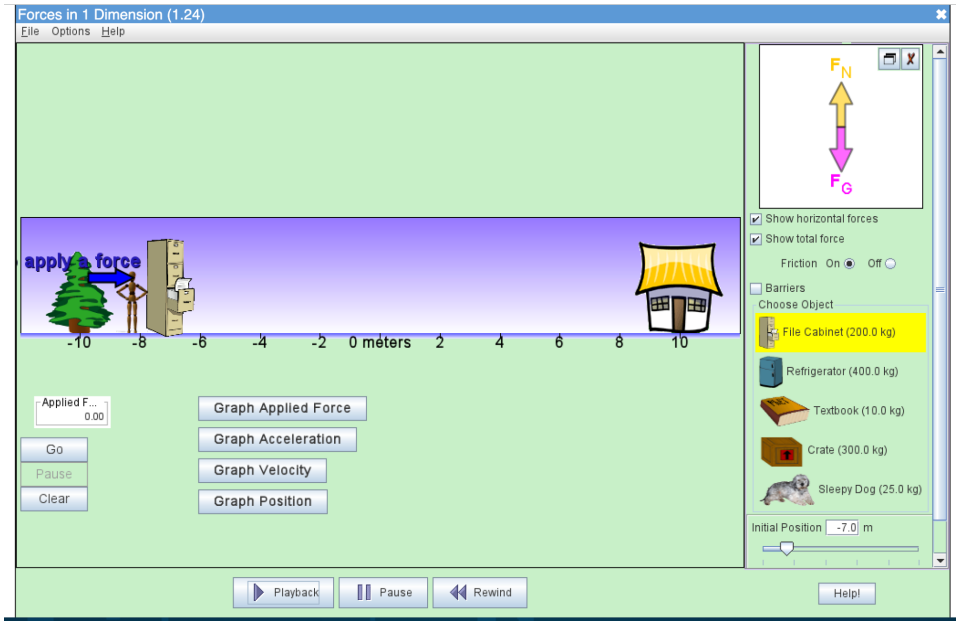
This lab is designed to help students investigate the relationship between net force and an object's velocity. It is intended to get at student misconceptions surrounding Newton's 1st and 2nd Law. Namely, it is common for students to think that a force is needed to keep an object moving at a constant speed. These student models are developed from real life experience where friction is usually present. When students see objects rolling across a floor, they expect it to come to a stop. They might not necessarily be able to identify this because of friction's presence. This 5E lesson is intended to address this misconception through data collection, repetitions, and pattern identification

According to the lab, there major objective of the lab is to describe an object's motion under the influence of an unbalanced force

The experimental set up involves a stick figure, by a tree, who is about to push an object in front of them. These objects include:

- A File Cabinet (200.0 kg)
- A Fridge (400.0 kg)
- A Textbook (10.0 kg)
- A Crate (300.0 kg)
- A Dog (25.0 kg)

The user can vary the amount of Force Used, the initial position of the object, and whether or not friction is present. **Friction is not present for this entire 5E Lesson.**



Once the user hits play and the object is under the influence of a force, they have access to the following graphs:

- Force (N) vs. Time (s)
- Position (m) vs. Time (s)
- Velocity (m/s) vs Time (s)
- Acceleration (m/s^2) vs. Time (s)

Other quantities that users can obtain/change include

- Acceleration due to Gravity (m/s^2)
- Coefficient of Static and Kinetic Friction

Includes series of photographs/screenshots or video that document that you completed the activity in full and/or had your students complete the activity:

Name [redacted]

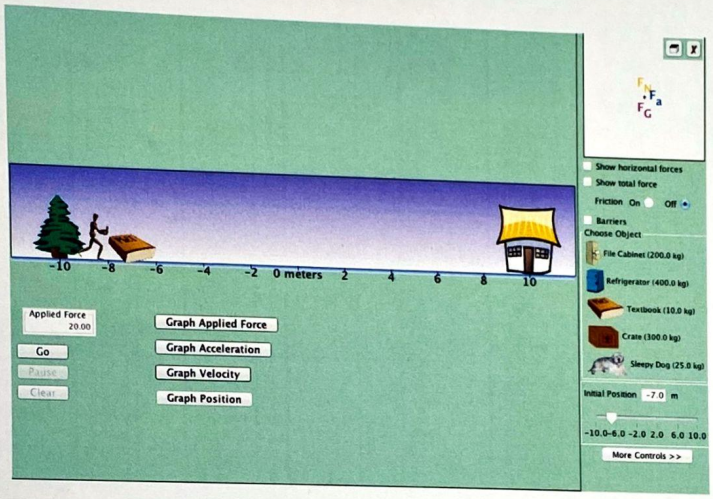
Date_____

5E Lesson: Forces in 1 Dimension

1. ENGAGE

A force is a push or a pull. When unopposed, forces will affect an object's motion. Today, our aim is to thoroughly describe an object's motion under the influence of an unbalanced force

Consider the following online simulation (image attached below). In this simulation, we can apply forces to various objects (book, file cabinet, textbook, crate, etc) to understand and determine resulting motion in the **absence of friction.**



Make a Predication:

1. What *will* happen to the velocity of a 10.0 kg book when pushed to the right with a constant force of 20N?
2. What *will* happen to the velocity of a 10.0 kg book when this force is removed?

① The Book will Move to the Right, and it will Speed Up

② When the Force is Removed, the Book will Continue to Move @ a Constant Speed, if there is No Friction

Observations:

1. What *happened* to the velocity of a 10.0 kg book when pushed to the right with a constant force of 20N?
2. What *happened* to the velocity of a 10.0 kg book when this force was removed?

① It Sped Up! The Velocity Increased

② The Velocity Remained Constant in the Absence of the 20N Force

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2. EXPLORE

Directions: Describe and **sketch** the velocity of different objects under the influence of an unbalanced horizontal force.

We are going to gather data from **my laptop** in groups of 3 (Groups decided in a moment)

When your group comes up to my laptop, you are to apply a horizontal force to 4 objects

1. 25.0 kg Sleepy Dog
2. 200.0 File Cabinet
3. 300.0 kg Crate
4. 400.0 kg Refrigerator

For each object:

- Provide a rightward force and hit **GO**
- **Before** the object reaches the house, **click on the object**. This will eliminate the presence of the force.
- Graph the velocity vs. time
- Write your qualitative observations

Graph checklist:

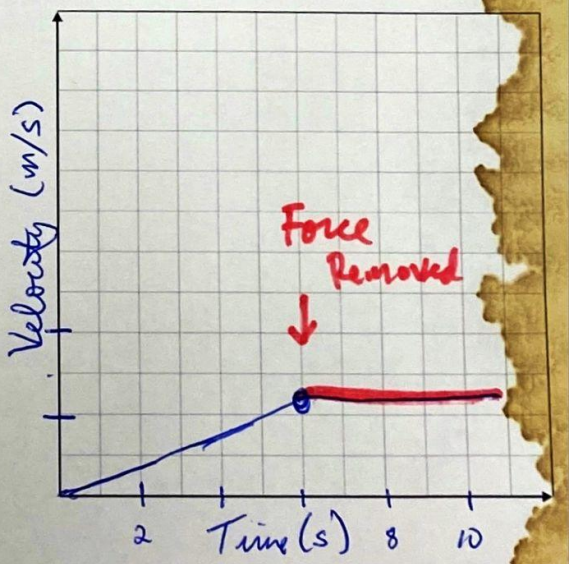
- Graph has clear title
- Each axis is labeled correctly
- Appropriate units on each axis
- Scale is consistent
- Graph is neat and legible

1. 25.0 kg Sleepy Dog

   Applied Force = 10 N

   Qualitative Observations: What are you noticing?

Dog's Velocity Increases when the Force Was Present... Then moved @ a Constant Velocity when the Force Was Removed (After 6s)



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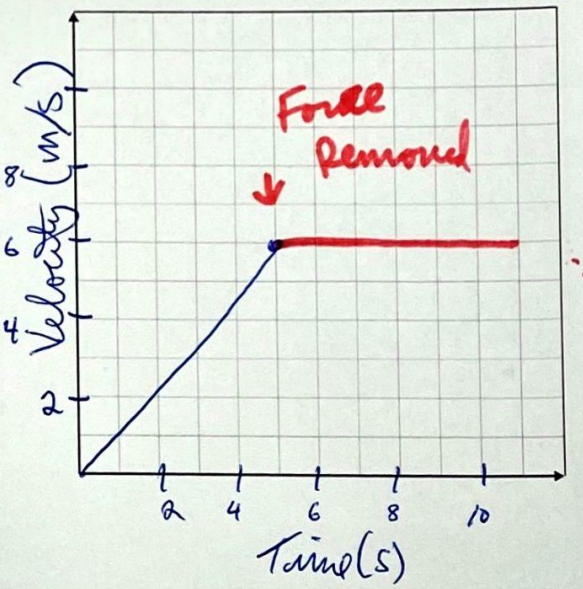
2. 200.0 kg File Cabinet

Applied Force = 300 N

Qualatative Observations: What are you noticing?

Same as Before, the File Cabinet moved w/ Increasing Velocity Until the Force was Removed @ 6 seconds

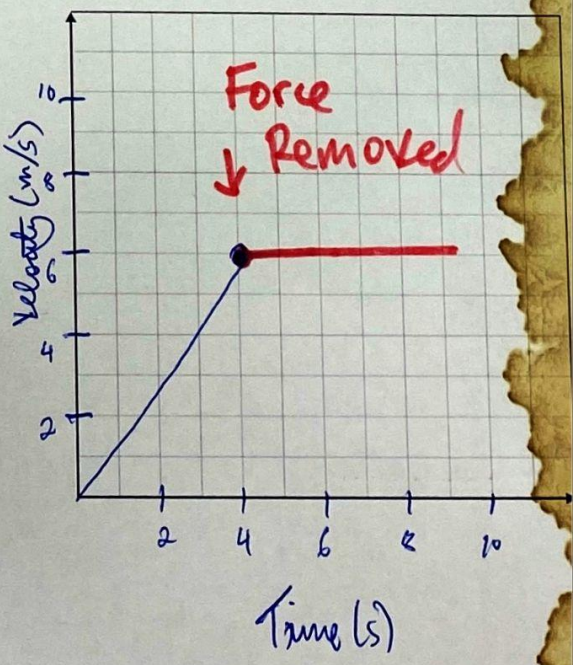


3. 300.0 kg Crate

Applied Force = 500 N

Qualitative Observations: What are you noticing?

Same as the Previous Examples, Velocity Increased in the Presence of our Force, and Stayed the Same when the Force Was Removed (@ 4s)



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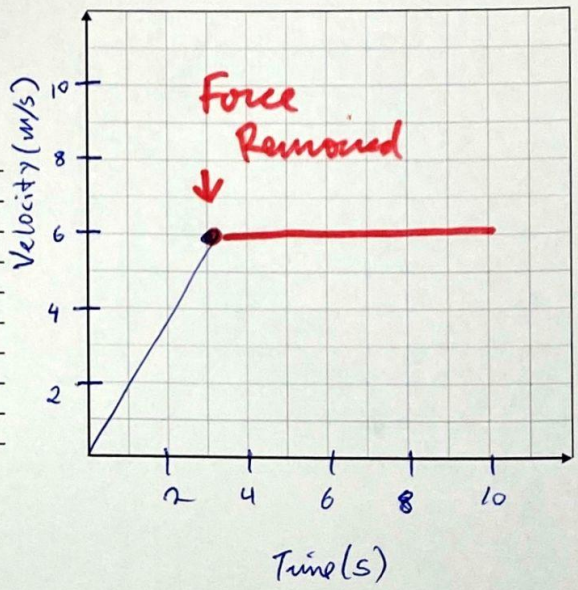
4. 400.0 kg Refrigerator

Applied Force = 800 N

Qualitative Observations: What are you noticing?

Same as the Previous 3, Velocity increases in the Presence of the Force, & Velocity Remains Constant when the Force is Removed (@3s)



Draw a Conclusion:

Under the influence of a constant horizontal force,

the Velocity increased for all 4 objects

When the constant horizontal force is eliminated,

the objects Proceed to Move @ a Constant Velocity

The evidence for this is

seen in the Velocity Graphs for all 4 objects. For Example, When the Force is Removed after 3 Seconds for the 400.0 kg Refridgerator, the Fridge Proceeds to Move @ 6 m/s for the Remainder of the Time Shown on the Simulation Screen.

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3. EXPLAIN

What is the relationship between an applied constant force and an object's velocity? Provide an ~~exam~~ Example from your Explore

An Applied Force Will Change an Object's Velocity We saw this in all 4 Examples ... the object's velocity went from 0 m/s to some Positive Value after a few Seconds

In the presence of a constant force, ↑ Increase

an object's Velocity Changes

In the absence of a constant force, a moving object will

move @ a Constant Velocity / Speed (in the same Direction)

Check For Understanding (Everybody Writes): Describe the motion of a 40.0 kg desk under the influence of a *leftward* constant force? What would happen if this force were eliminated?

the 40.00 kg desk would move to the left w/ an increasing speed. Once the force is eliminated, the desk would continue moving to the left @ a Constant Speed.

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4. ELLABORATE

Strongmen are athletes that exhibit remarkable feats of strength through a variety of circus-like tasks. One of the most notorious tasks is the **truck pull**. A picture of this task is shown below:

We are going to investigate the motion of the truck under the influence of the athlete's pull. The data tables below show the force exerted by on a 3500 kg truck two different athletes towards the end of the motion. The velocities of the trucks are also shown.

Athlete #1

Time (s)	Force (N)	Velocity (m/s)
20	300	4
21	300	6
21	300	8
23	300	10
24	0	10
25	0	10
26	0	10

Athlete #2

Time (s)	Force (N)	Velocity (m/s)
20	250	3
21	250	4
21	250	5
23	250	6
24	0	6
25	0	6
26	0	6

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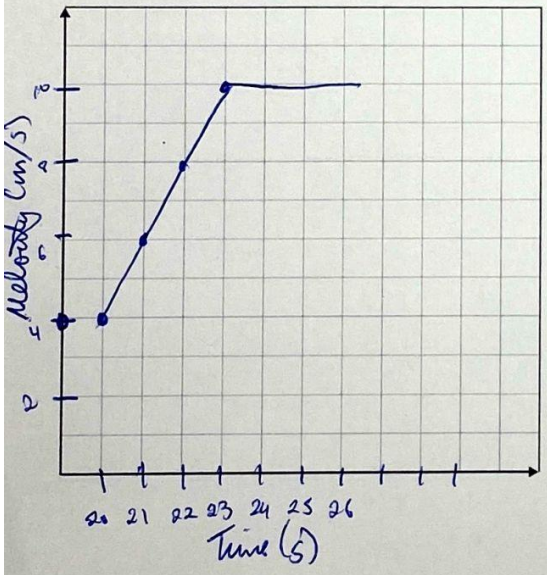
On the graphs below, plot the velocity vs. time for both athletes

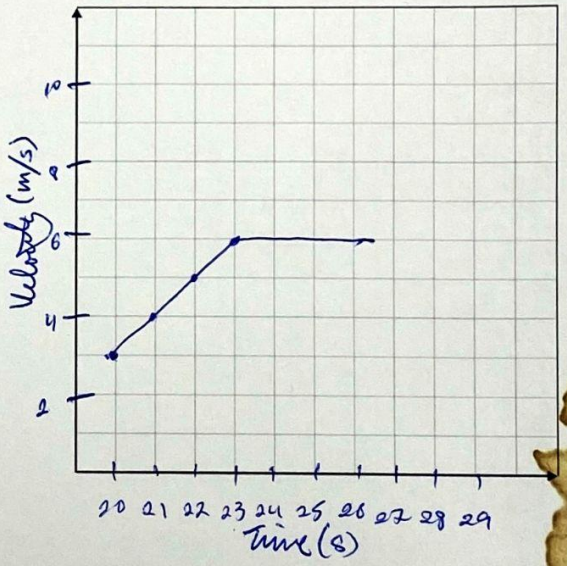
Graph checklist:

- Graph has clear title
- Each axis is labeled correctly
- Appropriate units on each axis
- Scale is consistent
- Graph is neat and legible

Athlete #1



Athlete #2



Patterns: Is the relationship between the force and velocity consistent for both athletes? Support your answer with data from your table and graph.

The 300 N Force Caused Athlete #1's Velocity to Increase @ a Faster Rate Compared to Athlete #2.

With that Said, Both Athlete's Velocity Increase Under the Influence of a Net Force.

Patterns: What would happen to the speed of both trucks if the athletes continued to pull with a constant force?

Both of their Speeds Would Continue to Increase

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5. EVALUATE

1. Describe the motion of a 50.0 kg desk under the influence of a rightwardconstant force? What would happen if this force were eliminated?

the 50.0 kg Desk would Move To the Right @ an Increasing Speed. If the Force were Eliminated, the Object would Continue Moving @ a Constant Speed.

2. A Promise Junior made the following statement:

   "It's impossible for an object to move at a constant speed unless some force acts on it, that's just common sense."

   Do you agree or disagree with this statement? Provide evidence from our activity today to justify your answer.

I Disagree. In the Absence of Fractions, Objects will Move @ the Same Speed, Unless Under the Influence of a Constant Force

3. Describe how your thinking about force and motion has changed from the beginning of the lesson. If your thinking hasn't changed, describe why you think that it.

Describes how the activity connects to physics learning outcomes:

This 5E lesson is designed to have students directly confront their possible misconceptions regarding force and motion. In the Engage portion, students are asked to predict what will happen to an object's velocity under the presence of a rightward force. In addition, they are asked to predict what happens when this force is removed. After making these predictions, students compare these predictions to what actually happens. If their predictions don't match what they see, this serves as the intended inspiration and grounding for the next stage of the lab.

In the Explore section, students are asked to graph velocity (m/s) vs time for 4 different objects with different masses, under the influence of an applied force. Students have the freedom to choose any force that will result in rightward movement. In addition to making these velocity graphs, students are asked to maken qualitative observations about what they see. By the end, the pattern becomes clear to the user: an applied force results in a velocity change, and an object's velocity stays constant in the absence of an applied force. Before moving onto the Explain section of the lab, students are asked to draw a few conclusions based on the data they collect. In my experience, the major takeaway felt remarkably redundant by the end, which is the intention of this series of data collection activities.

The Explain section is intended to be a whole class discussion or mini lesson, so it directly follows the individual conclusions section at the end of the Explore section.

The Elaborate section is intended to have students work with additional Force, velocity, and time data. This time, the data is provided in a table, as opposed to a graph. Students are asked to create graphs from the data tables. After creating the graphs, students are, once again, asked to identify the relationship between force and an object's velocity. They are also asked to predict what would happen to a truck if it were to be pulled by a constant force.

The evaluate section is like an exit ticket, where students are asked to make claims and predictions about an object; motion under the influence of a constant force. They are asked to agree or disagree with another student's claim about an object's motion, as well as to reflect on how their understanding of force and motion changed following the lesson cycle.

Reflects on the pros/cons and age/development appropriateness of the activity to your own students:

This 5E activity does a great job at addressing student prior misconceptions about force and motion. Namely, it asks students to graph velocity vs. time graphs for a number of different objects under the influence of a force. Using this data, students are asked to make claims regarding an object's motion in the presence of and in the absence of a net force. This data collection gets to a point that feels repetitive, but really helps drive home the major takeawa about the conditions needed to satisfy Newton's 1st and 2nd Law. To that end, this activity alights with this NGSS performance expectation:

Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.

[Clarification Statement: Examples of data could include tables or graphs of position or velocity as a function of time for objects subject to a net unbalanced force, such as a falling object, an object rolling down a ramp, or a moving object being pulled by a constant force.] [Assessment Boundary: Assessment is limited to one-dimensional motion and to macroscopic objects moving at non-relativistic speeds.]

Another pro is that this lab ultimately asks students to reflect on their prior knowledge of force and motion and how that compares to their new understanding. This question, once again, asks students to address their misconceptions head on.

One aspect of this lesson that I am wondering about is the Elaborate section. I feel like there was a missed opportunity for students to engage in a free or bounded inquiry lab, instead of a directed activity or assignment. The prompt could have been, "Design an experiment to demonstrate what happens to an object's motion under the influence of an unbalanced force" or what happens to an object under the influence of a balanced force. If the aim of the Elaborate section of this lesson was to get students to make connections across multiple representations of data, this revised Elaborate section could ask students to represent their data in 2 or more ways.