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Teaching Motion with the Air Puck

Objective:

In studying motion of objects, many times it is difficult to quantitatively measure objects on Earth because of ever-present friction issues. Often, our data and results are skewed due to these factors and generalization of the data is required in order to reach successful conclusions. The ability to minimize friction is a constant problem throughout the Physics lab; using "frictionless" carts or cars with "frictionless" ball-bearings frequently do not ease the errors that occur during any motion experiment. By using the Arbor "mini" Air Puck, many of the experiments that are performed in the lab requiring accurate data readings and results can now be attained. Using the Air Puck which can best simulate a "frictionless" surface, you and your partner can investigate and determine the following in a 4 part series of experiments:

1. Newton's Laws of Motion
2. Significant Figures and Units for Motion
3. Initial Velocity, Final Velocity & Average Velocity
4. Acceleration

Helpful Equations:

$$\bar{v} = \frac{\Delta d}{\Delta t} \qquad a = \frac{\Delta v}{\Delta t} \qquad F_{net} = m\,a \qquad F_f = \mu\,F_n$$

$$\bar{v} = \frac{1}{2}(v_i + v_f)$$

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Part I: Newton's 1st Law… The Law of Inertia

For Part I, you and your team will need…

- **Air Puck**
- **Smooth surface (example tile floor)**

Using one of the "mini" Air Pucks, turn on the Air Puck and give it a slight push.

1. During the push, what happened to the speed of the puck?

    a) Quickly slows down
    b) Speeds up
    c) Maintains a steady speed

2. After the push, what happened to the speed of the puck?

    a) Quickly slows down
    b) Speeds up
    c) Maintains a steady speed

3. What are the Forces on the puck as it is traveling on the floor?

The only Force acting on the Air Puck is the Force of Gravity (Fg.. the puck's weight). Once set into motion, the puck experience NO other forces. (Other than a SLIGHT friction force due to fluid friction/air.)

4. Using the diagram below, draw ALL the **<u>Forces</u>** on the Air Puck while AT REST on the tile floor. Use properly drawn and labeled vectors (Magnitude and Direction) on the Air Puck. (Use the Force designations… **F_f, F_g, F_n)**

5. Using the diagram below, draw ALL the **<u>Forces</u>** on the Air Puck while IN MOTION (after the push). Use properly drawn and labeled vectors (Magnitude and Direction) on the Air Puck. (Use the Force designations… **F_f, F_g, F_n)**

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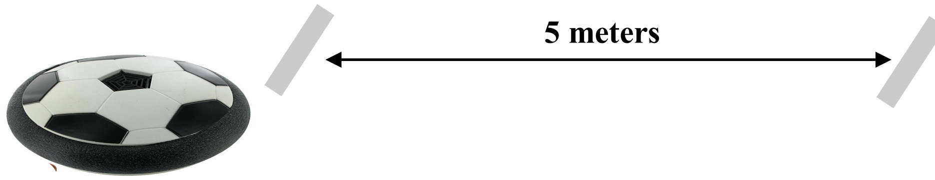
Part II: Determining Average Velocity

For Part II, you and your team will need…

- **Calculator**
- **Measuring Tape or Meter Stick**
- **Masking tape**
- **Air Puck**
- **stopwatch**



1. As in the diagram above, place one of the "mini" Air Pucks on the tile floor. If your floor does NOT have tiles, you will be able to perform this station as long as the floor has a smooth surface.
2. Place a piece of tape at the "Starting Line" and measure **5.0 meters** from that line. Place another piece of masking tape on the floor as the "Finish Line".
3. Turn on your Air Puck and beginning BEHIND the starting line, initially slide the Air Puck along the floor so that it has enough speed to pass between the Start and Finish lines and continue on PAST the Finish Line. (The Air Puck MUST move through the entire 5 meters and NOT stop within that distance.
4. Have your partner record the time from when the Air Puck passes the Start line to the instant it passes the Finish line. Record the time to the nearest **0.01 seconds**.
5. Find the **Average Velocity** of the Air Puck from the **Start Line to the Finish Line**.
6. Use Significant Figure rules when calculating Average Velocity. **Remember your Units!**

	Time(t)	**Distance(d)**	**Average Velocity (v)**
Average Velocity Trial			

- ***REMEMBER…Measure 1st, THEN Significant Figures!***

CALCULATIONS

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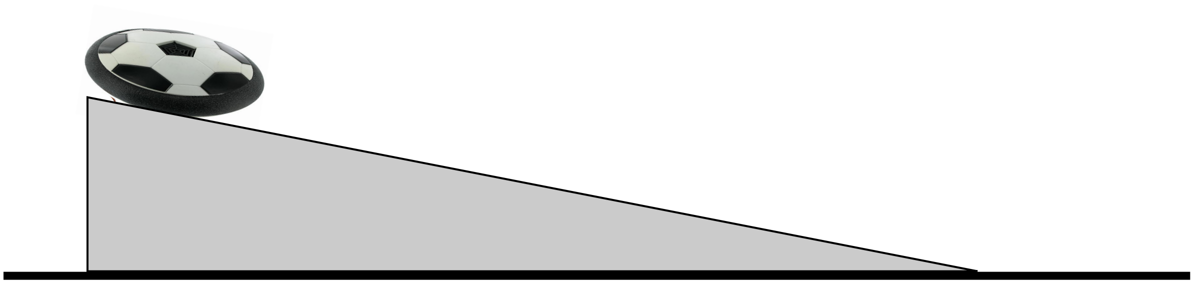
Part III: Determining Initial Velocity, Final Velocity, Average Velocity, and Acceleration

For Part III, you and your team will need…

- **Calculator**
- **Measuring Tape or Meter Stick**
- **Air Puck**



1. As in the diagram above, secure a ramp from your Physics teacher and place it on a stack of physics textbooks or secured to a ringstand.
2. Measure the distance from the top of the ramp to the end of the ramp. Be certain to **measure the distance** to the nearest **0.1 cm.**
3. Set your ramp at 15^o to the horizontal by measuring with a protractor.
4. Hold your Air Puck at the top of the ramp.
5. Upon release have your partner record the time from when the Air Puck begins its motion to when it strikes the bottom of the ramp. Record the time to the nearest **0.01 seconds**. Make certain to stop timing the moment the car exits the ramp!
6. Using your Physics Reference Table of Motion equations, calculate the **Initial Velocity, Final Velocity, Average Velocity & Acceleration** for your Air Puck.
7. Record your measurements in the table below. Show all your calculations.
8. Repeat the experiment with the ramp set at 30^o and at 45^o. Calculate the **Initial Velocity, Final Velocity, Average Velocity & Acceleration** for your Air Puck for EACH trial.
9. Use Significant Figure rules when calculating your results. **Remember your Units!**

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**** REMEMBER…Measure 1st, THEN Significant Figures!***

	t (time)	**d (distance)**	**V_{ave}**	**V_i**	**V_f**	**a**
Ramp Trial #1 15^o						
Ramp Trial #1 30^o						
Ramp Trial #1 45^o						

<u>CALCULATIONS</u>

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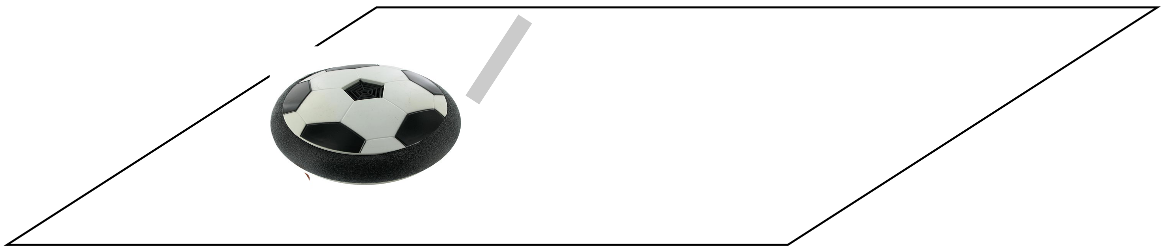
Part IV: Determining Deceleration

For Part IV, you and your team will need…

- **Calculator**
- **Measuring Tape or Meter Stick**
- **Masking tape**
- **Air Puck**
- **Stopwatch**



- As in the diagram above, place one of the "mini" Air Pucks on the tile floor. If your floor does NOT have tiles, you will be able to perform this station as long as the floor is a smooth surface.
- Place a piece of tape at the "Starting Line" and be certain that you have a long hallway, which extends well beyond the Start Line.
- Turn on your Air Puck and beginning BEHIND the starting line, initially slide the Air Puck along the floor so that it has enough speed to pass the Starting line.
- Have your partner record the time from when the Air Puck passes the Start line to the moment that the Air Puck stops. Record the time to the nearest **0.01 seconds**. It will take your Air Puck some time to come to complete stop since the motion is enhanced by a "frictionless" surface.
- Measure the distance your Air Puck traveled from the Start Line to rest (V_f=0).
- Using your Physics Reference Table of Motion equations, calculate the **Initial Velocity, Final Velocity, Average Velocity & Acceleration (Deceleration)** for your Air Puck.
- Record your measurements in the table below. Show all your calculations.
- Use Significant Figure rules when calculating your results. **Remember your Units!**

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**** REMEMBER…Measure 1st, THEN Significant Figures!***

	t (time)	d (distance)	V_{ave}	V_i	V_f	a
Deceleration Trial						

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Lab Questions and Analysis

1. An Air Puck or object on a horizontal frictionless surface has been given a push and released, what will happen to the object?
   - a) Slowly come to a stop
   - b) Continue with constant acceleration
   - c) Continue with decreasing acceleration
   - d) Continue with constant velocity
   - e) Immediately come to a stop

2. How does your experiment in **Part I** compare with the ACTUAL answer to question #1. Does it behave as you predicted?

3. Until the time of Galileo, people believed that a **constant force** is required to produce a **constant speed**. What does a constant force produce?

4. What would have to be done in order to have the Air Puck continue with a Constant Acceleration?

   - a) push the **Air Puck** harder before release.
   - b) push the **Air Puck** longer (for more time) before release.
   - c) push the **Air Puck** continuously with a constant force.
   - d) change the mass of the **Air Puck** (add clay to the Air Puck)
   - e) it is impossible cause the Air Puck to accelerate.

5. Jane Equation and Joe Fizziks are arguing in the cafeteria. Joe says that if he flings his chicken nugget with a greater velocity it will have a greater inertia. Jane argues that inertia does not depend upon velocity, but rather upon mass. Who do you agree with? Explain why.

6. Supposing you were in space in a weightless environment, would it require a force to set an object in motion?

7. For your results in Part III, what effect did the angle have on the acceleration of your Air Puck?

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8. Johnny is being chased by an rogue elephant which he was attempting to photograph. The enormous mass of the elephant is extremely intimidating. Yet, if Johnny makes a zigzag pattern as his runs away, he will be able to use the large mass of the elephant to his own advantage. Explain this in terms of inertia and Newton's first law of motion.

9. Where do you have **greater INERTIA**: …on **Earth** or on the **Moon**? Explain why?

10. Two closed containers look exactly the same but one is filled with gold and the other is filled with feathers. How will you able to tell the difference between them in a "gravity-free environment?

11. If you were in a spaceship and fired a cannonball into frictionless, gravity-free space, how much **force** would have to be exerted on the cannonball **to keep it going** at a **constant velocity**?

12. Using the acceleration (deceleration) from Part IV calulate the coefficiant of kenetic friction μ_k

13. When calculating the values for acceleration and deceleration in Parts II and IV, what assumption must be made about the nature of the acceleration of the Air Puck? How did the Air Puck undergo acceleration? Was the acceleration rate constant or did it vary?

