EDU-LAB
SCIENTIFIC RESOURCES

Linear Air Track
With Accessories 2m
LINTRC

Instruction Manual

INTRODUCTION

The linear air track provides a nearly frictionless surface with which one can study a multitude of physical processes in ideal conditions. The air track gliders float on a cushion of air pushed out through small holes in the top of the air track. Using the many included accessories in this kit, experiments can be performed exploring Conservation of Energy, Conservation of Momentum, Elastic and Inelastic collisions, Newton's Second Law, amongst many other topics.

COMPONENTS

Included Equipment:

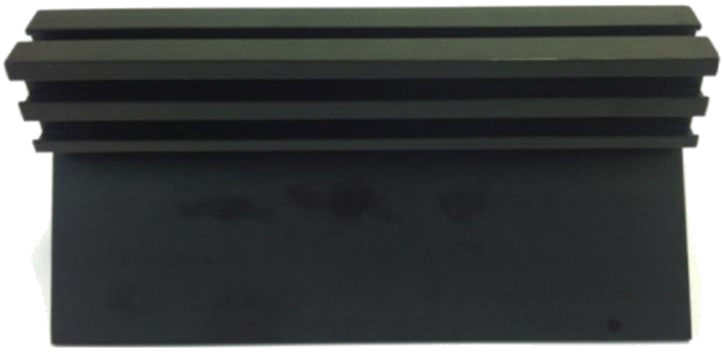
2m Linear Air Track
(2) Sliders 120g
(10) Bolt and wing nuts
(4) Spring attachments
(4) Spring/string attachment
(4) Springs
(2) Velcro attachment pairs
(2) Pulley and (2) String
(4) Slotted mass and (1) Hanger
(8) Photogate flags
(2) Photogate arms
Launching cradle / bumper
(4) Additional masses
(8) Risers
Single foot
Dual foot bar

Required Equipment not included:
Rubber band
Timing device, such as a photogate timer (recommended), spark timer, or ticker tape timer
Air Blower (Included with 153-601)

COMPONENT DESCRIPTIONS

SLIDER (2):

Once the air track is connected to an air supply, the sliders are able to move nearly friction free. Brackets are included on both sides of the sliders, which allow for several attachments to be secured for various experiments. The mass of each slider is 120 grams.

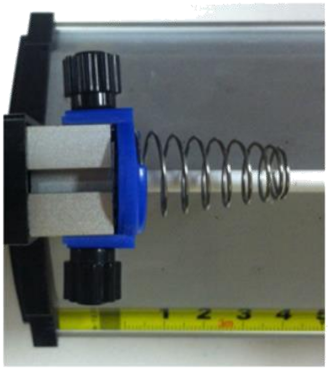
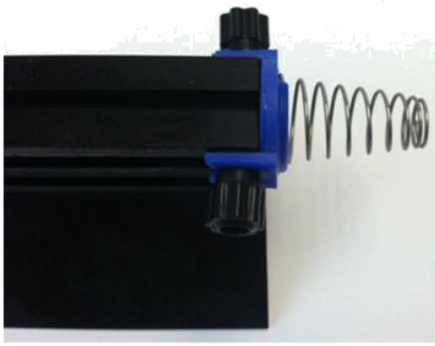


BOLT AND WING NUT (10):

These are provided to secure the various attachments to either the sliders or the air track. The head of the bolt fits inside the bracket and the wing nut twists to tighten or loosen the bolt.

SPRING ATTACHMENT (4):

The spring attachments can either be secured to the air track or to the sliders. The use of the springs result in a minimum loss of energy during collisions. To attach the spring attachments, slide the bolt inside of the bracket of the air track or the slider and place the spring attachment over the bracket. Tighten the wing nut.

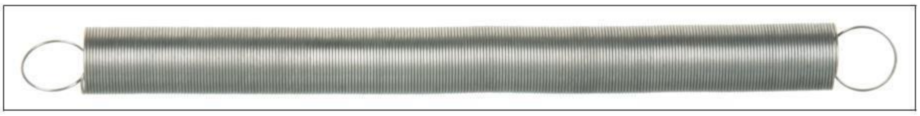
SPRING/STRING ATTACHMENT (4):

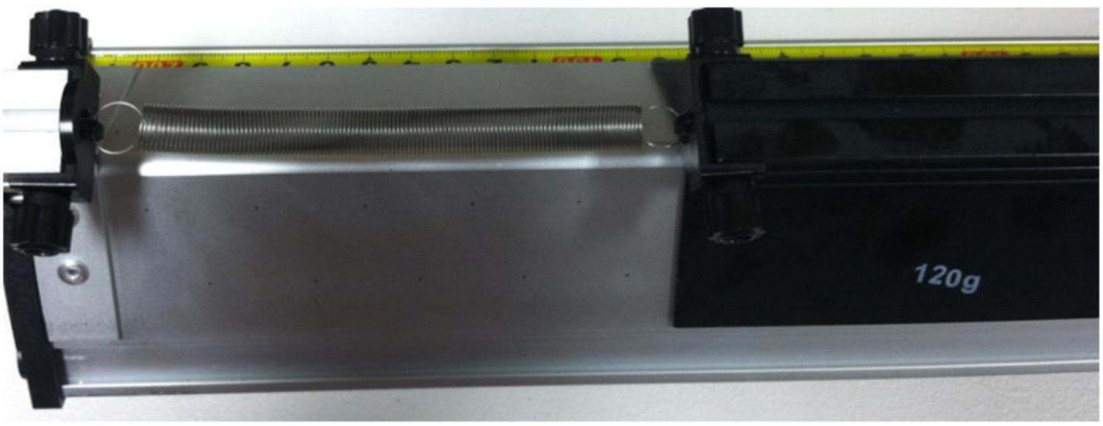
The spring/string attachment allow for the air track or the sliders to be attached to a spring or string. To connect the end of a spring to the attachment, slide the end of the spring through the small hole of the attachment. To connect the end of a piece of string to the attachment, slide the end of the string through the small hole of the attachment and form a knot to secure the string to the attachment.

The attachment is then connected to the air track or a slider by means of the bolt and wing nut. Slide the bolt inside of the bracket of the air track or slider and place the attachment over the bracket. Tighten the wing nut.

SPRINGS (4):

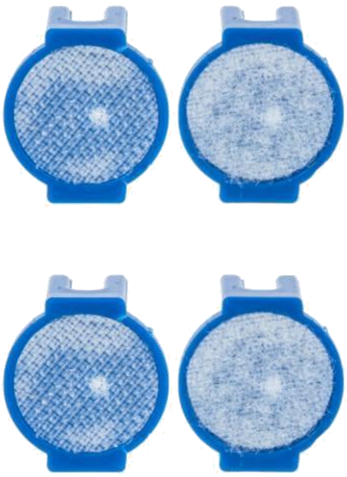
Springs are provided for various experiments involving spring constant and potential energy. Each end of the spring must first be connected to the spring/string attachment. One of the spring/string attachments is then connected to the air track and the other one is connected to the slider.

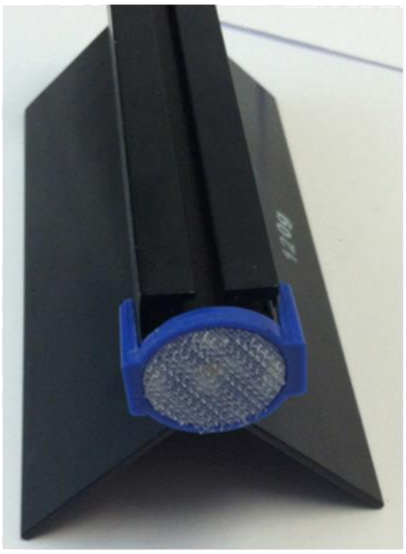




VELCRO ATTACHMENT PAIR (2):

The Velcro attachment pair allow for the sliders to stick together to simulate a totally inelastic collision. Each Velcro attaches directly to the slider by sliding into one of the holes on the front of the slider, and can be secured by means of the bolt and wing nut. Slide the bolt inside of the bracket of the slider and place the Velcro attachment over the bracket. Tighten the wing nut.



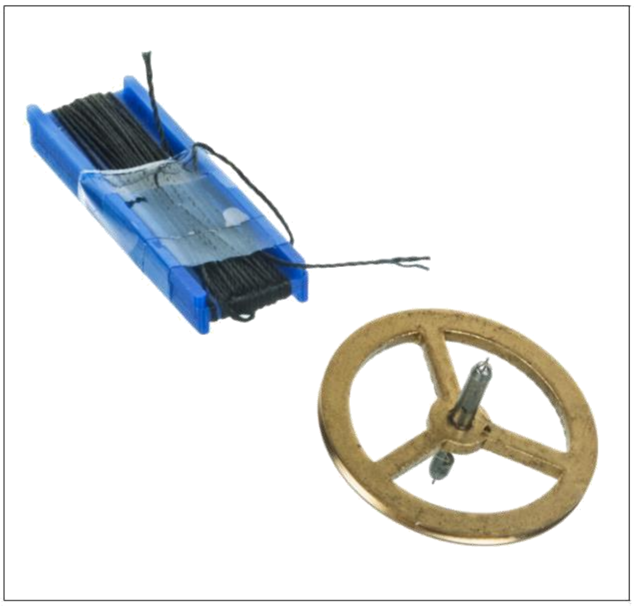


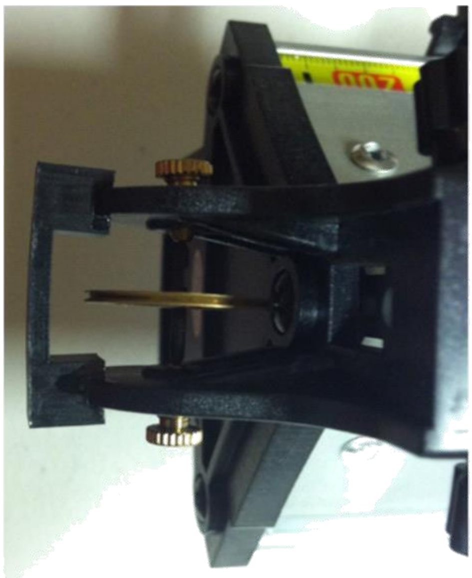
Velcro 'hook' Attachment

Velcro 'loop' Attachment

PULLEY (2) AND STRING:

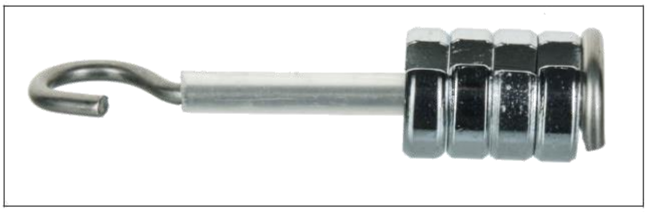
The air track comes with a pulley already mounted at one end of the air track. A replacement pulley is provided. String can be placed over the pulley and attached to both a slider (by spring/string attachment) and the hanger for the slotted mass. This allows for variations of the Atwood's Machine experiment to be performed. Do not over tighten the screws that attach the pulley to the air track. This will prevent the pulley from spinning freely.





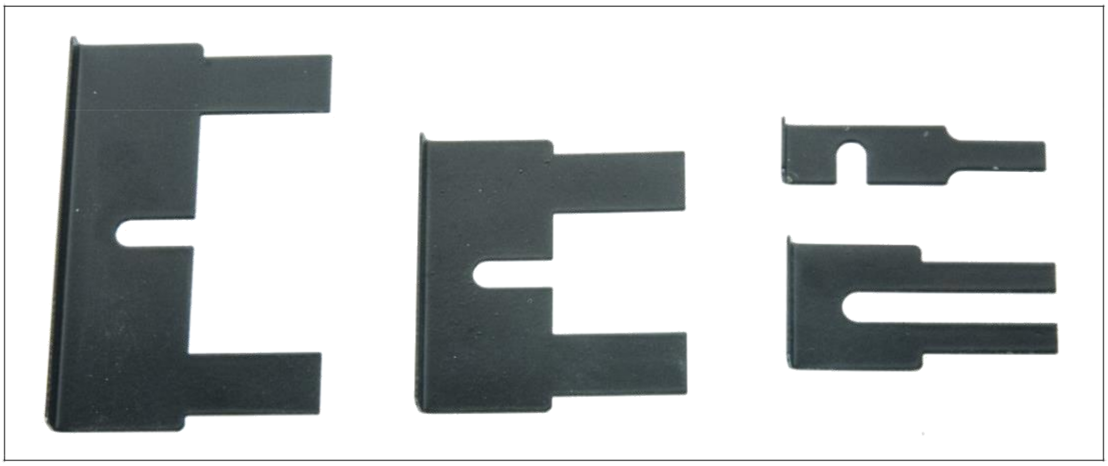
SLOTTED MASS (4) AND HANGER (1):

The slotted mass and hanger are meant to attach to the other end of the string that is placed over the pulley that is attached to a slider. The slotted mass can easily be put on and removed from the hanger to change the force acting on the string. Each slotted mass is 5 grams, as is the hanger.



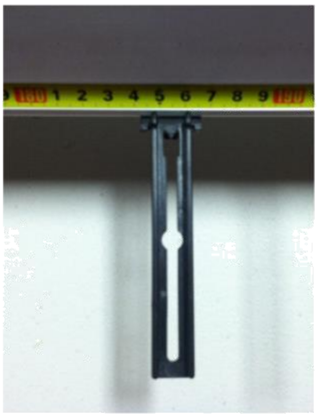
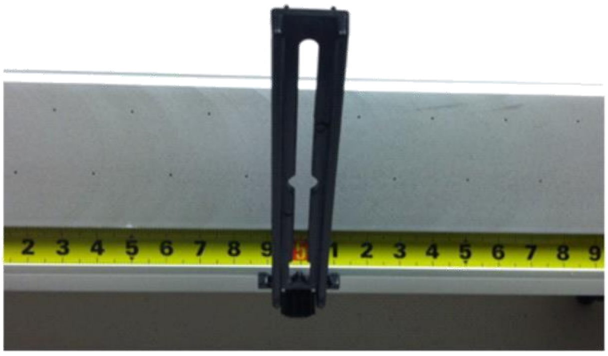
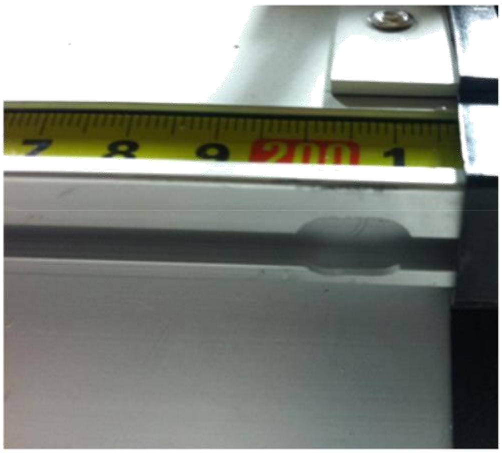
PHOTOGATE LIGHT BLOCKING GATE (8):

Photogate light blocking gates can be attached to the top of the sliders for use with photogate timers. Slide the bolt inside the top bracket of the slider and place the wedge of the photogate light blocking gate between the bolt and wing nut. Tighten the wing nut. The photogate light blocking gates may be attached so they are vertical or horizontal with respect to the table, depending on the placement, orientation, and type of photogate timers being utilized. Included are two of the large dual version, two of the medium dual version, two of the small dual version, and two of the single version.



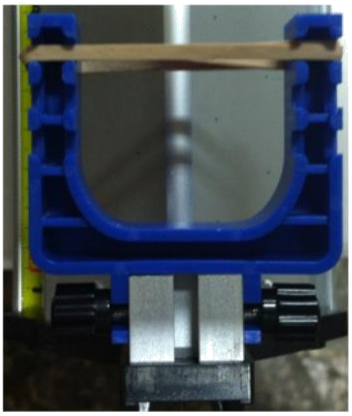
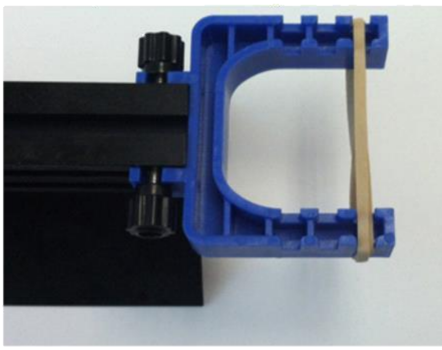
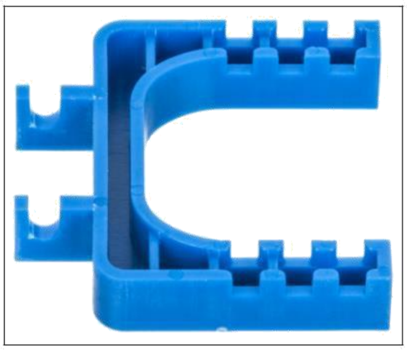
PHOTOGATE ARM (2):

The photogate arms attach directly to the air track by means of the bolt and wing nut. A small opening (shown below) is located at the end of the air track that allows the head of a bolt to slide along the air track. The photogate arm is designed to hold many different versions of photogates. The photogate arm can be arranged in one of two ways depending on the photogate used.


LAUNCHING CRADLE/BUMPER:

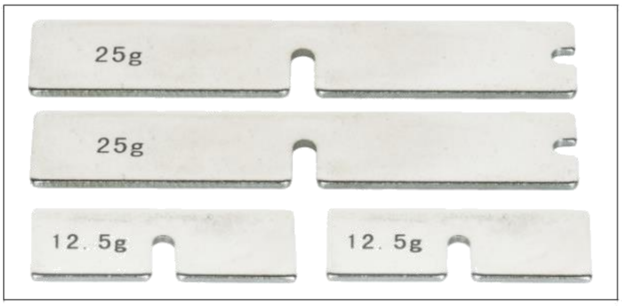
This attachment can be used to propel the slider along the air track or as a bumper. A rubber band (not included) needs to be stretched between the arms of the attachment. The attachment can be connected to either the end of the air track or to the sliders by means of the bolt and wing nut.

ADDITIONAL MASSES (4):

Additional mass is provided to study the effect of increasing the mass of a slider during various collision experiments. There are two 25 gram masses and two 12.5 gram masses. The masses can be attached to the upper bracket of the slider, the lower bracket of the slider, or across the top of the slider. Placement depends on how much weight is required and if other accessories are to be used. Symmetric placement of the masses is essential to keep the slider balanced and moving properly. The mass connects to the slider by means of the bolt and wing nut. Slide the bolt inside the bracket of the slider and place the wedge of the mass in between the bolt and wing nut. Tighten the wing nut.

No matter the placement of the masses, be sure that the weight is evenly distributed between the front and back of the glider to ensure even movement.



RISERS (8):

Included are round plastic disks for setting the air track at an angle. They can be stacked for additional height. The piece with an indent in the center should be placed directly under the single foot as it has been constructed to cradle the single foot.

ATTACHING THE FEET:

In order to ensure that the air track is level, it is recommended that the leveling feet are attached. For shipping purposes, the feet are stored together as shown below.

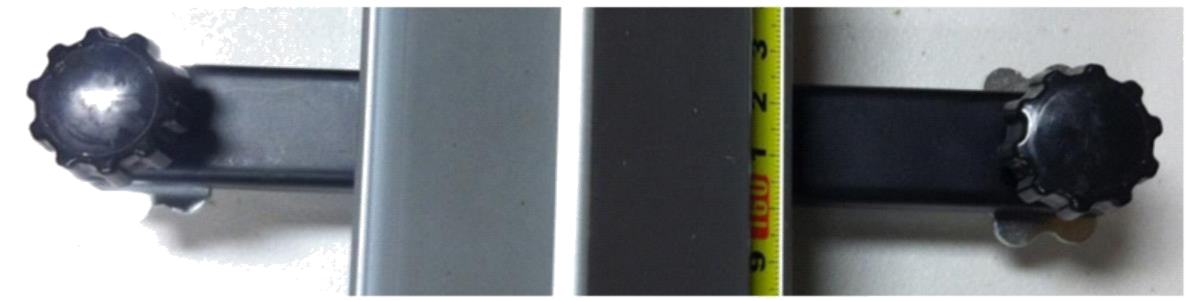
First, remove the single foot from the bar holding the other two feet.

Single Foot

On the bottom of the air track you will find two threaded holes. One of them has a bolt in it. Remove the bolt and thread the single foot into the hole. The underside of air track should look like the following when the single foot is attached.

Second, use the bolt that was just removed to affix the bar containing the other two feet to the air track. The underside of the air track should look like the following when the bar is attached.

The height of these two feet are adjustable. This allows you to quickly and easily level the air track, regardless of the table you are using.



AIR VALVE:

The air track includes an air valve at the end of the track that will accept hoses 1 inch (25 mm) in diameter. Due to the high pressure generated inside the air track, it is essential that your hose fit tightly to prevent leaks.

PREPARING THE AIR TRACK:

1. Attach the feet as instructed above.

2. Connect an air blower to the track with a hose. Plug in the blower and turn on.

3. It is better to have too much air pressure rather than too little, so increase the blower setting to high if possible.

4. To ensure the track is level, place a glider on the track. If it slides instead of resting in place the track is not level. Adjust the height of the two footed bar using the feet screws to raise or lower that end of the air track as necessary.

5. Secure any attachments to the gliders or tracks as required to perform the specific experiment. Remember to protect the track and gliders from any metal to metal collisions. Use bumpers, springs, or Velcro on the end caps of the gliders and rails to prevent damage to either the air track or gliders.

6. When securing attachments to the gliders, do so with the glider held in your hand, not on the track or on a table or other flat surface so that the gliders retain their shape.

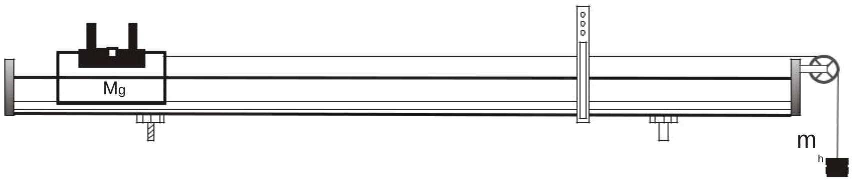
ACTIVITY 1: Acceleration due to a variable force

Set-up:

Prepare the Air Track as detailed above, making sure the track is level. Attach the bumper with rubber band to the pulley end of the air track. Attach the string attachment to one side of a glider. Tie one end of a string to the hanger, thread the free end of the string around the pulley, and then tie to the string attachment on the glider. Note the string length needs to be less than the height of the air track off the floor.

Attach a photogate bar to the air track at least two cart lengths from the pulley end of the air track. Secure one of the dual sail photogate flags to the glider. Attach a photogate timer (not included) to the photogate bar such that the flag will pass through the timer when the cart passes through the gate.

Set the photogate timer to record the time between two consecutive flag interruptions (the photogate records the time from when the first sail interrupts the IR beam, to when the second flag interrupts the beam.



Procedure:

1. Move the glider as far away from the pulley as the string allows. Make note of this position and be sure to release the glider from this same spot every time.

2. With a 5g mass on the hanger, release the glider. Allow to travel through the photogate, but don't let it rebound back through.

3. On a table record the mass of the glider, M_g, the combined mass of the hanger and attached mass, m_h, the effective distance between the sails (from right side of the first sail to the right side of the second sail), l, the length the glider travels (from the edge of the glider to the photogate), L, and the time it takes the sails to pass through the photogate, t.

4. Repeat for several values of mass on the hanger (e.g. add 10 g for each trial run). Record m_h and t for each run.

Analysis:

1. For each run, calculate the average velocity of the glider as it passes through the photogate (v = l/t).

2. Starting from the equation $2aL = v_f^2 - v_0^2$ to determine the acceleration of the glider, a. Since the initial velocity of the glider is zero, the acceleration is thus given by $a = v^2/2L$. Calculate the acceleration for each run.

3. Newton's second law states tells us that given a force on a system, that force will be equivalent to the mass of the accelerating system times its acceleration, F=ma. Here the force on the system is provided by the gravitational pull on the hanging mass. The mass of the accelerating system, however, is not just the mass of the glider but the combined mass of the glider and the hanging weight. Thus we can see that Newton's second law gives, $m_h g = (M_g + m_h)\,a$. Solving for g, we get:

$$g = (M_g + m_h)a/m_h.$$

   Calculate g for each run. Calculate the average value of g. Compare this to the standard value of 9.81 m/s^2.

ACTIVITY 2: Inelastic Collisions

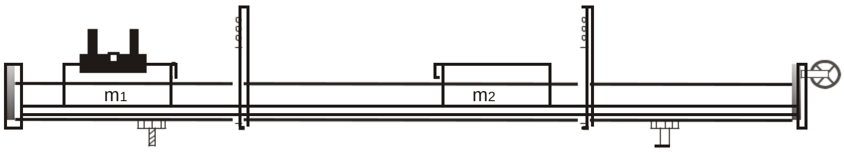
Set-up:

Prepare the Air Track as detailed above, making sure the track is level. Attach the bumper with rubber band to the pulley end of the air track.

Attach both photogate bars to the air track at least two cart lengths end of the air track. Secure one of the dual sail photogate flags to each glider. Attach a photogate timer (not included) to each of the photogate bars such that the flag will pass through the timer when the cart passes through the gate.

Set the photogate timer to record the time between two consecutive flag interruptions (the photogate records the time from when the first sail interrupts the IR beam, to when the second flag interrupts the beam.

Attach a Velcro pair to one side of each glider ('hook' Velcro type on one, 'loop' Velcro type on the other). Attach one of the spring attachments to the opposite side of each glider.



Procedure:

1. Place the gliders on the cushioned air track with the Velcro sides facing one another. Start with one glider in between the end of the track and one of the photogates. Call this Glider 1, with mass, m_1. Place the second glider, with mass m_2, in between the photogates, a cart length away from the photogate further from glider one.

2. By hand start the motion of Glider 1 towards Glider 2. It will pass through the first gate with average velocity v_1. After it strikes and sticks to Glider 2, they will pass through the second gate with average velocity v_2.

3. On a table record the mass of each glider, m_1 and m_2, the effective distance between the individual glider's sails (from right side of the first sail to the right side of the second sail), l, the time it takes the sail on Glider 1 to pass through the first photogate, t_1, and the time it takes the sail on Glider 2 to pass through the second photogate, t_2.

4. Repeat for several values of mass attached to Glider 1.

Analysis:

1. For each run, calculate the average velocity of the gliders as they pass through each photogate ($v_1 = l/t_1$ and $v_2 = l/t_2$).

2. Calculate the initial momentum of the system ($p_1 = m_1 v_1$) and the final momentum ($p_2 = (m_1+m_2) v_2$) for each of the runs. Is momentum conserved?

3. Calculate the initial kinetic energy of the system ($T_1 = m_1 v_1^2$) and the final kinetic energy ($T_2 = (m_1+m_2) v_2^2$) for each of the runs. Is kinetic energy conserved?

ACTIVITY 3: Elastic Collisions

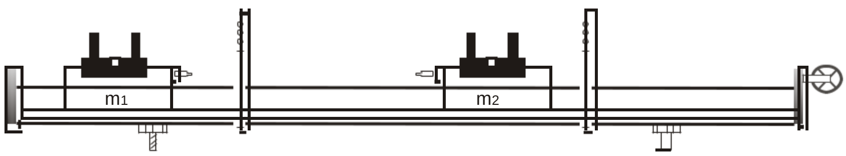
Set-up:

Prepare the Air Track as detailed above, making sure the track is level. Attach the bumper with rubber band to the pulley end of the air track.

Attach both photogate bars to the air track at least two cart lengths end of the air track. Secure one of the dual sail photogate flags to each glider. Attach a photogate timer (not included) to each of the photogate bars such that the flag will pass through the timer when the cart passes through the gate.

Set the photogate timer to record the time between two consecutive flag interruptions (the photogate records the time from when the first sail interrupts the IR beam, to when the second flag interrupts the beam.

Attach one of the spring attachments to each side of both gliders.



Procedure:

1. Place the gliders on the cushioned air track. Start with one glider to in between the end of the track and one of the photogates. Call this Glider 1, with mass, m_1. Place the second glider, with mass m_2, in between the photogates, a cart length away from the photogate further from glider one.

2. By hand start the motion of Glider 1 towards Glider 2. It will pass through the first gate with average velocity v_1. Upon striking Glider 2, its motion will either continue in the same direction and pass through the second photogate, bounce backwards and pass through the first photogate a second time, or stand still and not pass through either photogate. After Glider 2 passes through the second photogate, remove Glider 2 from the air track so the gliders do not collide again.

3. On a table record the mass of each glider, m_1 and m_2, the effective distance between the individual glider's sails (from right side of the first sail to the right side of the second sail), l, the time it takes the sail on Glider 1 to pass through the first photogate, t_1, the time it takes the sail on Glider 2 to pass through the second photogate, t_2, and the time it takes the sail on Glider 1 to pass through either photogate after the collision. If the motion of Glider 1 stops after the collision, make note that it has zero velocity for that run.

4. Repeat for several values of mass attached to Glider 1 (e.g. do a run for an additional 50 g, then another 50 g). Remove the mass from Glider 1. Repeat for the same values of mass attached to Glider 2.

Analysis:

1. For each run, calculate the average velocity of the gliders as they pass through each photogate ($v_1 = l/t_1$, $v_2 = l/t_2$, and $v_3 = l/t_3$). If Glider 1 stopped after the collision, mark down $v_3 = 0$.

2. Calculate the initial momentum of the system ($p_1 = m_1 v_1$) and the final momentum ($p_2 = m_1 v_3 + m_2 v_2$) for each of the runs. Remember velocity, and thus momentum, is a vector component. Is momentum conserved?

3. Calculate the initial kinetic energy of the system ($T_1 = m_1 v_1{}^2$) and the final kinetic energy ($T_2 = m_1 v^2{}_3 + m_2{}^2 v_2$) for each of the runs. Is kinetic energy conserved?

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