



Multi-functional Fourier Dynamics System

With Low Friction Design and Multiple Accessories



The Fourier Dynamics System provides the complete solution for the Physics laboratory. It is designed to give educators and students the most suitable equipment to perform hands-on activities in the field of Mechanics. The System is compatible with all Fourier data loggers and may be used independently or in conjunction with Fourier's wide range of Physics-related sensors such as Distance, Force, Photogate and Smart Pulley. The low friction track allows for accurate and versatile experimentation. The Fourier Dynamics System is ideal for teaching and studying topics such as Kinematics, Dynamics, Newton's Laws, Collisions, Impulse and Momentum, Conservation of Energy and Simple Harmonic Motion.



The System includes a low friction black anodized track, two carts, a pulley and many other accessories.

Typical Experiments

The following experiments which make use of the Dynamics System can be found in Fourier Education's Physics Experiment Book:

- Velocity
- Motion on an Inclined Plane
- Momentum Conservation in Collisions
- Energy Conservation in Collisions
- The Impact of Constant Force on a Moving Body
- Newton's Second Law
- Impulse and Momentum



Dynamics System Contents



- 1 1.2 m track
- 2 Single-foot end stop
- 3 Double-foot stand
- 4 Adjustable end stop
- 5 Plunger cart
- 6 Standard cart
- 7 Two brackets for Photogate and Distance sensors
- 8 Pulley bracket
- 9 Pulley
- 10 500 g mass
- 11 Rod clamp
- 12 Distance sensor fastener for cart
- 13 Generic fasteners - one large and two small
- 14 Two flags
- 15 Two sets of Neodymium magnets (inside carts)
- 16 Mini wrench



Using the Dynamics System

1.2 m Track

The 1.2 m track is a low friction black anodized track. It features a measuring tape for easily measuring displacement along its length. Slots along the sides of the track and down the center allow accessories such as the Photogate brackets, Distance sensor bracket and rod clamp to be easily mounted.



Carts

The Fourier Dynamics System is supplied with two types of carts - a Plunger cart and a Standard cart - as well as two sets of magnets for these carts.



Plunger Cart



Standard Cart



- Each cart has a mass of 500 grams. Adding accessories will change the mass of the cart.
- The magnets are useful in studying elastic collisions. You may choose to attach one or both sets of magnets to the carts.

Using the Plunger cart

The Plunger cart includes a spring-loaded plunger with three different positions, providing reproducible impulses and explosions.

To use the plunger:

1. Simultaneously press the horizontal rectangular button above the plunger and press the plunger in until it locks in either the first or second position.
2. To release, press the button on the top of the cart.
3. The plunger force can be adjusted. First, depress the tabs on the inside of the central plug on the cart end, on the side opposite the plunger. The tabs can be found on the inside of the plug. After depressing the tabs, push outwards on the plug to remove it. The set screw behind the plug can be adjusted with an appropriate hex wrench. The force provided by the plunger is adjusted by adjusting this set screw.

Studying Collisions

To observe elastic collisions, you can use the magnets with the carts. Insert two magnets, both with the same magnetic pole facing outwards. Insert the magnets on the second cart such that they are repelled by the magnets on the first cart. Because the carts will repel one another, you can arrange a collision in which the carts never actually touch. The collision will be very nearly elastic, unlike a collision in which there is contact between the carts.

To observe perfectly inelastic collisions, switch the magnets of one cart so that they attract the magnets on the second cart when the two carts are facing each other. In this way the carts will stick to each other upon collision, creating a perfectly inelastic collision.



Mini Wrench

The mini wrench is used to remove the plugs on the ends of the carts. When the plugs are removed, magnets can be inserted in the plugs.



Detailed instructions on preparing the carts for inelastic or elastic collisions:

1. Use the mini wrench provided to remove the screws from the teardrop-shaped plugs.



2. Place a magnet in each plug, oriented to repel or to attract a magnet in the plug of a second cart.



3. Replace the teardrop plug in the cart.
4. Insert and tighten the screw.
5. Test that the magnets repel or attract one another as needed for your investigation.



Note: The polarity of the magnets in the same cart should be the same. If the polarity is different the cart could leave the track.

Photogate and Distance Sensor Bracket



The Photogate and Distance sensor bracket can be mounted on the side of the track as follows:

1. Loosen the nut attached to the star-knobbed bolt at the bottom of the bracket. Slide the nut into the channel along one side of the track. A second bracket may be mounted either on the same side or the opposite side.



2. Mount the Photogate or Distance sensor on the bracket using the star-knobbed bolt provided.



3. Adjust the Photogate or Distance sensor height as desired.





Pulley and Pulley Bracket

The low-friction pulley is attached to the end of the track using the pulley bracket. Mount the bracket on the track by sliding the nut on the short end of the bracket into the center slot of the track underside. Secure the bracket by tightening the star-knobbed bolt.

Attach the pulley to the long arm of the bracket using the bolt supplied with the bracket. Adjust the height of the pulley to match the needs of the investigation.

Pulley Bracket



Pulley



Pulley connected to track using bracket





Adjustable End Stop

The adjustable end stop slides onto the end of the track. Insert the nut into the center slot on the upper side of the track and tighten with the star-knobbed bolt. Adjust the position as desired. Insert magnets in the end stop if desired.



Single-foot End Stop

The single-foot end stop slides onto the end of the track. Slide the nut on the short end of the bracket into the center slot of the track underside. Secure the single-foot end stop by tightening the star-knobbed bolt.

Adjust the height of the track using the knob on the other side of the single-foot end stop.



Double-foot Stand

The double-foot stand slides onto the end of the track. Slide the nut in the center of the stand into the center slot of the track underside. Secure the stand by tightening the star-knobbed bolt.

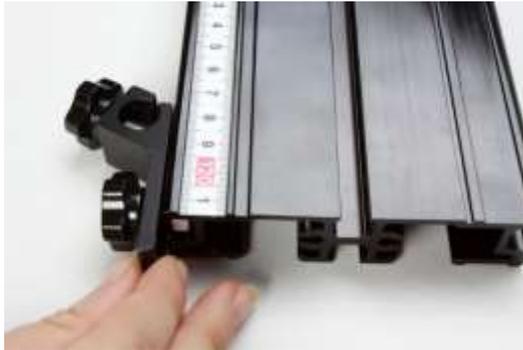


Adjust the height as desired using the two knobs on either side of the stand.



Rod Clamp

The rod clamp is used to support the track with a user-supplied ring stand. Insert the nut into the slot on the side of the track. Secure the track to the ring stand and adjust the height as desired.





Fasteners

The supplied generic fasteners are used to attach devices to the carts. The large fastener can be used with the Photogate in place of a flag. The large fastener's diameter is 9.3 mm.

The large fastener can also be used to mount the Force sensor on a cart.

The small fasteners may be used to mount the flags on top of the carts.

To use a fastener, loosen but do not remove the nut from the shaft. Choose one of the three slots on the top of the cart and insert the nut parallel to the slot. Turn the shaft clockwise to tighten. The fasteners may be inserted at any point along the slot length.





Flags

The two flags, attached to the cart with the fasteners, can serve as targets for the Distance sensor. The short flag can also be used with the Photogate sensor.

To fasten a flag to a cart:

1. Loosen but do not remove the nut from the shaft of the fastener.
2. Insert the nut in the appropriate slot on the cart.
3. Slide the plastic washer over the base of the flag.
4. Turn the shaft clockwise to tighten.
5. Note that a flag may be mounted parallel or perpendicular to the length of the cart.



Distance Sensor Fastener

The Distance sensor fastener is used to attach the Distance sensor to the cart and it may be mounted at any point along the slot length.

To use this fastener:

1. Loosen but do not remove the nut on the bottom of the fastener.
2. Insert the nut into the center slot of the cart.
3. Position the fastener and turn the shaft of the fastener clockwise to tighten.
4. Orient the mounting foot of the fastener and use the bolt on the side to secure it in position. Mount the Distance sensor on the fastener by screwing it in place.



Mass

The 500 g mass is used to double the mass of the cart. Attach the mass by removing the wing nut and bolt, and placing the bolt head in one of the off-center slots on top of the cart. Slide the mass over the bolt, and tighten the wing nut.





Motion on an Inclined Plane

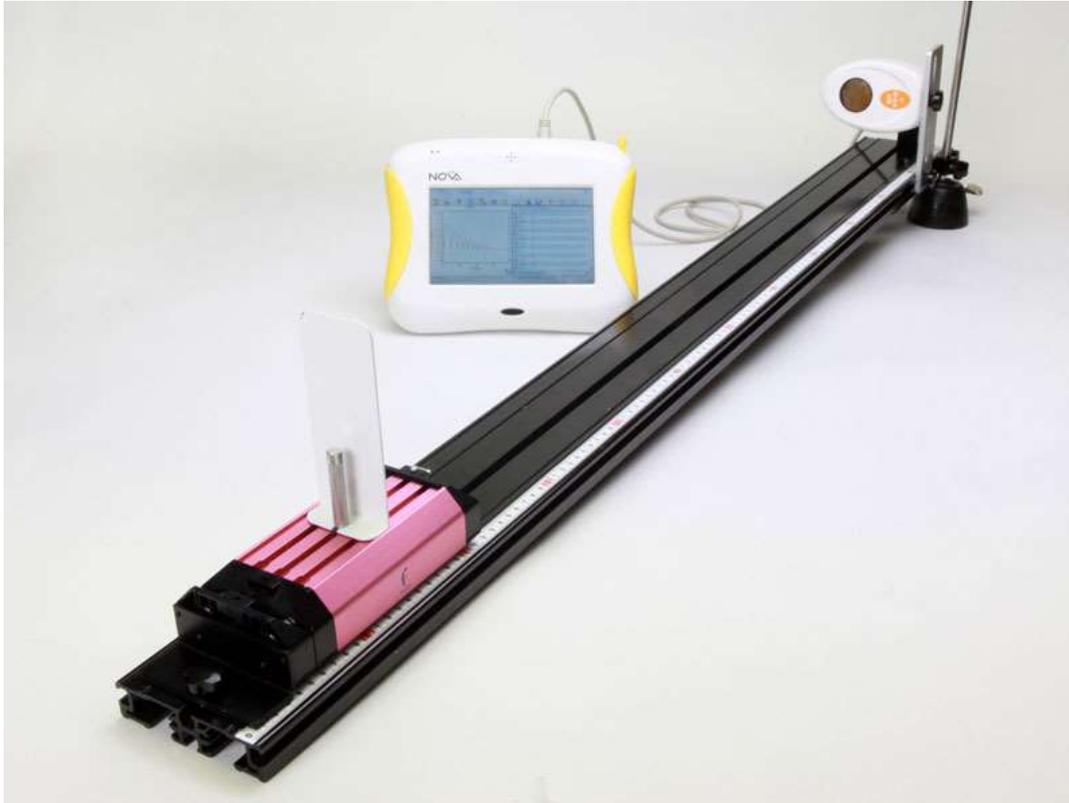


Figure 1

Introduction

When a body is placed on an inclined plane it will move down the slope with constant acceleration. If the body rebounds back up the plane when it reaches the bottom and the plane is friction free, the acceleration of the body up the plane will be equal to the acceleration down.

In this experiment we place a cart on an inclined plane and explore the properties of the motion.

Note: All Fourier data loggers can be used in this experiment.



Equipment

- einstein™ Tablet or einstein™ LabMate™
- Distance sensor
- Dynamics Track
- Dynamics Cart
- Flags with fasteners
- Laboratory stand or adjustable stands to vary the height of the inclined plane



Equipment Setup Procedure

1. Launch MiLAB™ Desktop ()
2. Connect the Distance sensor with the Distance adaptor (if necessary) to one of the ports on the einstein™ device.
3. Assemble the equipment as shown in Figure 1.
4. Place the Distance sensor at the upper end of the Dynamics Track.
5. Place a stopper at the bottom of the Dynamics Track.
6. The starting distance between the cart and the Distance sensor should be at least 50 cm.
7. In the **Current Setup Summary** window choose **Full Setup** and use the table below to set up the experiment. Make sure that only the Distance sensor is selected under **Measurements**.



Current Setup Summary

Program the sensor to log data according to the following setup:

Sensor:	Distance
Measurements:	Distance (m)
Rate:	10 samples per second
Samples:	100
Duration:	10 seconds



Procedure

1. Set the height of the Dynamics Track at ~5 cm. Record the height in your data table.
2. Hold the cart at the top of the Dynamics Track.
3. Select **Run** () to begin recording data.
4. Release the cart when you hear the clicking of the sensor.
5. When the cart reaches the bottom of the Dynamics Track, select **Stop** (). The cart may jump several times before the end of the measurement as it bounces away from the stopper.
6. Repeat steps 3 to 5 two more times. Record all data in the data table.
7. Change the height of the Dynamics Track to 15 cm and repeat steps 3 to 5. Record all data in the data table.
8. Change the height of the Dynamics Track to 20 cm and repeat steps 3 to 5. Record all data in the data table.
9. Save your data by selecting **Save** () from the **Basic Tools** window on the upper menu bar.



Data Table

Height of Inclined Plane (cm)	Acceleration (m/s ²)			Average Acceleration (m/s ²)
	Trial 1	Trial 2	Trial 3	

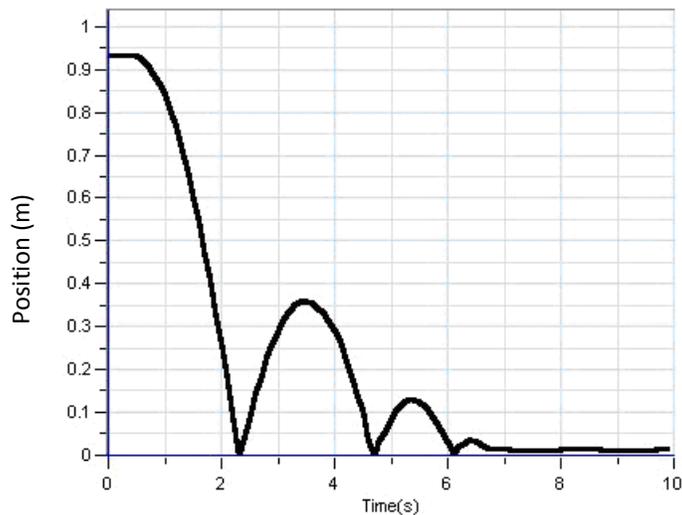


Figure 2



Data Analysis

1. Use two cursors () to mark the downward slope of the graph. If the cart bounced up one or more times, choose the first (and biggest) downward slope on the graph.
2. Select **Math functions** () from the **Analysis** window on the upper menu bar.
3. In the **Math function** window which opens, choose **Derivative** from the **Function** drop down menu.
4. In the **G1** drop down menu select the Distance data.
5. The line which is drawn on the graph represents the velocity of the cart.
6. Use two cursors () to select two well separated points on the derived velocity line.
7. Select **Curve fit** () from the **Analysis** window on the upper menu bar.



8. In the **Curve fit** window which opens, choose **Linear** from the **Curve fit** drop down menu.
9. The graph of the linear fit will appear on the velocity graph and the fit equation will be displayed below the x -axis. The value of the slope of this graph is the acceleration. Record the acceleration in the data table.
10. Repeat this analysis for each height of the Dynamics Track.
What is the relationship between the height of the incline and acceleration?

Further Suggestions

1. You may want to check that the graph of the distance is parabolic:
 - a. Use two cursors () to select only one *jump*.
 - b. Select **Curve fit** () from the **Analysis** window on the upper menu bar.
 - c. In the **Curve fit** window which opens, choose **Polynomial** from the **Curve fit** drop down menu and **2** from the **Order** drop down menu. The fit equation will be displayed in the information bar at the bottom of the graph window.
2. If there is significant friction between the cart and the plane, the cart will move up and down the plane with different accelerations. Measure α the angle of inclination of the plane (see Figure 1) and the acceleration when the cart is moving downwards in order to calculate the friction coefficient between the cart and the plane:

$$\mu = \frac{g \sin \alpha - a_{down}}{g \cos \alpha}$$

3. Start the motion of the cart at different points on the plane and in different directions and try to predict the shapes of the distance and velocity graphs.
4. Place the sensor at the upper end of the inclined plane and try to predict in advance the form of the graphs of distance and velocity.



Technical Support

Please contact Fourier technical support as follows:

Web: <http://einsteinworld.com/contact-form/>

Email: support@einsteinworld.com

Copyright and Warranty

All standard Fourier Systems sensors carry a one-year warranty, which states that for a period of twelve months from the date of delivery, it will be substantially free from significant defects in materials and workmanship.

This Warranty does not cover breakage of the product caused by misuse or abuse.

This Warranty does not cover Fourier Systems consumables such as electrodes, batteries, EKG stickers, cuvettes and storage solutions or buffers.