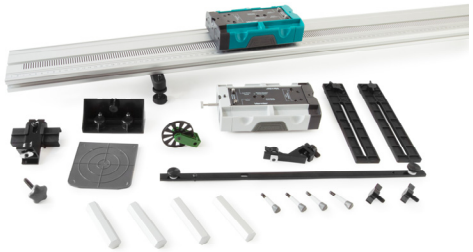
Vernier Dynamics Cart and Track System

(Order Code DTS)



The Vernier Dynamics Cart and Track System consists of a 1.2 m track, two carts, and related accessories. The system is designed for use in physics and physical science courses for motion and energy experiments.

The Dynamics Cart and Track System is designed for use with many data-collection tools, such as the Vernier Motion Detector, Go! Motion, Vernier Photogates, and Vernier LabQuest interface. These sensors, and the supporting interfaces and software, are not included with the Dynamics Cart and Track System.

An optional Optics Expansion Kit (order code OEK) converts the track to an optics bench. A 2.2 m track is also available.

Some typical experiments done with the system include

- Motion under zero acceleration
- Motion under constant acceleration with the ramp inclined
- Inelastic collisions using the included hook-and-pile tabs
- Elastic collisions using the included magnetic bumpers

Parts Included with the Vernier Dynamics Cart and Track System

- Standard Cart with 2 magnetic and 4 plain collision tabs
- Plunger Cart with 2 magnetic and 4 plain collision tabs
- Cart Masses (4) – 125 g
- Combination 1.2 m Dynamics Track/Optics Bench with encoder strip
- Adjustable Leveling Feet
- Mounting hardware for Dual-Range Force Sensor and Low-g Accelerometer (2 large bolts and 4 small bolts)
- Adjustable End Stop
- Motion Detector Bracket
- Motion Detector Reflector Flag with 2 magnetic collision tabs
- 2 Photogate Brackets
- Rod Clamp
- Allen wrench 3/32 inch
- Ultra Pulley
- Pulley Bracket

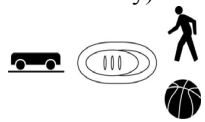
Photogate Bracket

Photogate Brackets are attached to the side of the track. With the nut loosely on the T-handled bolt, slide the nut into the side channel of the track. Attach the photogate using the supplied wing bolt in the long slot. Adjust the gate height so that the beam intercepts the desired portion of the target.

Motion Detector Bracket

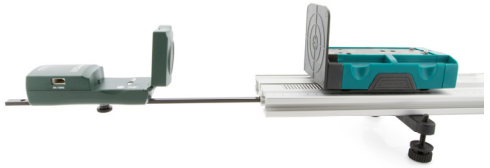
Any Vernier Motion Detector with a hinged head can be attached to the supplied Motion Detector Bracket. The Motion Detector Bracket has a pin to locate the Motion Detector on the bracket. There is a knob, nut, and bolt to attach the bracket to the track underside, and a threaded hole at the end near the pin. To assemble, place the Motion Detector with the back end over the pin of the bracket. Insert the screw through the slot into the threaded insert on the detector with the hinge toward the track, and tighten. Insert the bracket into the slot in the underside of the track as shown in the photo. When the Motion Detector is not attached to the bracket, its mounting screw can be stored in the threaded hole near the pin.

Most Vernier Motion Detectors (green or black case with adjustable sensitivity) can be placed so that the sensor is 15 cm from the end of the track. The carts can then be detected properly all the way to the end. The track mode is appropriate for the dynamics system. Older Motion Detectors that lack a range switch can still be used, but the carts must remain beyond the 45 cm minimum working distance of these older sensors.



Motion Detector Reflector Flag

Some users prefer to enhance the reflectivity of the cart when using an ultrasonic Motion Detector. Use of the Motion Detector Reflector Flag makes the position of the detector less critical, but its use is optional.



The Motion Detector Reflector Flag attaches to the dark gray end of a cart. Insert magnetic collision tabs and snap the flag against the end of the cart, with the metal inserts against the magnet tabs. Place the cart on the track with the flag toward the Motion Detector.

Adjustable Leveling Feet

The Adjustable Leveling Feet slide into the end of the track, with the nut in the center slot of the track underside. Adjust the height as desired. Install the feet before attaching the Motion Detector Bracket.

Adjustable End Stop

The Adjustable End Stop slides into the top slot from the end of the track. Adjust the position as desired. Insert magnets in the End Stop if desired.

Rod Clamp

The Rod Clamp is used to support the track with a user-supplied ring stand. A 12 mm rod is the maximum size accommodated. Insert the Rod Clamp nut into the side of the track. Adjust the height as desired.

Mounting Hardware

The supplied mounting hardware is used to attach devices to the cart, such as a force sensor, accelerometer, or Wireless Dynamics Sensor System.

Additional Mass

The four 125 g masses are used to change the mass of the cart for dynamics experiments. The cart mass is nominally 250 g, but additions such as magnets, hook-and-pile tabs, and sensors increase the total mass. As a result, it is best to weigh the cart as used when the mass is important.

The four masses can be used one at a time or in combination on either cart. The mass trays on the sides allow the addition of masses without removing sensors. It is not necessary to keep the carts balanced with the same mass on each side.

Pulley Bracket and Pulley

The Pulley Bracket and Pulley can be attached to the end of the track to create a half-Atwood machine using user-supplied masses and string. It can be assembled with or without a Photogate for motion measurement.

Insert the oblong nut into the bottom slot of the track and tighten. To attach the pulley without a Photogate, use the short bolt to attach the pulley. Adjust the height of the pulley as needed to keep the string level. To include a Photogate, slide the plastic photogate mount over the vertical portion of the Pulley Bracket, with the open slot outward and upward. Insert the Vernier Photogate into the mount, and pass the long bolt through the bracket, and Photogate, capturing the threads of the bolt with the Pulley.

Collision Tabs

The Vernier dynamics carts are supplied with magnets and hook-and-pile tabs. These parts are attached using removable Collision Tabs. Since the magnets may interfere with certain experiments using force sensors on the carts, only install the magnets if you need them.

The magnets are useful in studying collisions with the magnets positioned so that they are the same polarity on both sides and on both carts. This way the carts will repel one another, and you can arrange a collision in which the carts never actually touch. The collision will be very nearly elastic, unlike a collision using a spring or any kind of contact.

The removable Collision Tabs have two sides. One is marked N, and the other is plain. The plain side is for use with hook-and-pile material on tabs without magnets.

The Collision Tabs can be inserted either way, exposing or concealing any hook-and-pile material. To quickly perform an experiment without magnets, remove the Collision Tabs.

The Adjustable End Stop will hold magnets as well. Note that only low-speed collisions with the End Stop will keep the cart on the track.

To install magnets on the Adjustable End Stop, use the following procedure:

1. Remove the teardrop from the cart end or the End Stop.
2. Insert the silver magnet (supplied with the cart) into the teardrop, oriented so that the outside of the teardrop will attract the south-pointing end of a compass needle.
3. Insert a foam plug (supplied with the cart) into the teardrop.
4. Reinsert the tear drop into the cart end or the End Stop, and fasten the screw.

If you like, test by holding the compass near the cart or End Stop, in the same position as an approaching cart, and verify that the south-pointing end of the compass is attracted to the cart.

The magnets can be removed at any time by reversing this process. Store the magnets away from computers.

To study totally inelastic collisions, place hook-and-pile tabs on the Collision Tabs without magnets. Looking at the end of the cart, place a hook pad on the left-hand plug, and a pile tab on the right-hand side. Center the pad on the round part of the Collision Tab. This way any cart with hook-and-pile tabs will stick to any other. Hook-and-pile equipped carts will stick together, creating a totally inelastic collision.

Plunger Cart

One cart includes a spring-loaded plunger for collisions. To use the plunger, simultaneously press the horizontal button above the plunger and press the plunger in until it locks. To release, press on the pin from the top of the cart. The plunger force can be adjusted. To adjust the plunger release force, rotate the plunger while it is extended. An uncalibrated scale is visible on the underside of the cart. Use this scale to return to a previous setting.

The Plunger Cart is capable of superelastic collisions. To enable this mode, use a small screwdriver to unlock the dark gray plastic plug below the main plunger. Depress the plug using the screwdriver and rotate one-half turn counterclockwise to unlock. The plunger will extend about 2 mm.

Lock the plunger as before to prepare for a superelastic collision. In a collision, the plug will strike first and trigger the release of the plunger.

To disable superelastic collision mode, use a small screwdriver to depress and rotate the plug one-half turn clockwise. It will lock in the flush position.

The plunger cart has a nominal mass of 250 g. Adding accessories such as sensors or magnets will change the mass.

Use of Additional Accessories and Sensors

The following examples show various sensors attached to a Vernier dynamics cart. Sensors are not included with the Vernier Dynamics Cart and Track System.

Attach the Dual-Range Force Sensor (DFS)

1. Place the sensor over the two silver pins as shown on the cart top sheet. Older force sensors may require moving the pins to the wide spacing option.
2. Use the large bolt to secure the sensor to the cart as shown.
3. Configure the force sensor as needed with a hook, bumper, or magnet.

Attach the Low-g Accelerometer (LGA)

The Accelerometer has mounting holes on the cart top sheet.

1. To attach an accelerometer, place the sensor over the mounting holes as shown on the cart top sheet.
2. Use two small mounting bolts to secure the sensor as shown.

Attach the DFS and LGA in Combination

The DFS (Dual-Range Force Sensor) and LGA (Low-g Accelerometer) can be used simultaneously using the same procedures.

Wireless Dynamics Sensor System

To attach a Wireless Dynamics Sensor System (WDSS), remove and store the two silver pins for the Dual-Range Force Sensor. Place the WDSS on the top surface of the cart, and use the large mounting bolt to secure the sensor to the cart.

General Tips for the Vernier Dynamics Cart and Track System

- Do not install the magnets unless you know you want to use them. They will interfere if you perform an experiment with a force sensor riding on the cart, since the force sensor will then not read the total force acting on the cart.
- The magnets are designed for fairly gentle collisions. If the cart is moving too quickly, the magnetic forces may cause the cart to jump off the track to the side. If this happens, use a lower initial velocity for the cart.
- Keep the track clean; if it is dirty the carts will not roll smoothly.
- Use lower speeds and lower inclines than you might initially choose; the physics is the same and students will have more time to observe what is happening.
- Attach the track feet, sliding at least one in about 30 cm before inserting the Motion Detector Bracket.
- Study the Motion Detector Bracket photo carefully and note that the bracket is attached to the underside of the track. A common error is to attach the bracket to the top slot on the track.

Suggested Experiments

Measure Cart Acceleration

The basic motion of a cart on a ramp can be studied. For example, perform Experiment 3 from *Physics with Vernier*, “Cart on a Ramp.” Or, repeat Galileo’s experiment of determining *g* using an object and a ramp. This is Experiment 4, “Determining *g* on an Incline,” from *Physics with Vernier*.

Newton's Second Law
Use a force sensor on a cart to record both applied force and acceleration. The two will be proportional.

Or, set up a half-Atwood machine with a hanging mass and a pulley at the track end. Measure the acceleration of a cart as a function of the hanging mass.

Measure Fan Cart Acceleration
Add a Fan Cart (order code CART-F) to observe the motion of a cart under constant thrust.

Measure Cart Acceleration with Friction
Add a Friction Pad (order code DTS-PAD) to a cart and observe the motion of the cart with varying frictional forces.

Momentum-Impulse
Add a force sensor and a Bumper-Launcher Kit (order code BLK) to observe the relationship between momentum and impulse. Find the impulse by integrating under a force *vs.* time graph.

Conservation of Energy
Use two Vernier Motion Detectors to observe a change in energy due to a collision between two carts.

Conservation of Momentum
Use two Vernier Motion Detectors to observe a change in momentum due to a collision between two carts. Try different kinds of collision: elastic, inelastic, totally inelastic.

Products Related to the Vernier Dynamics Cart and Track System

Vernier Dynamics Cart and Track System with Motion Encoder (order code DTS-EC)
Vernier Dynamics System is a low-friction 1.2 m track and optics bench combination designed for kinematics, dynamics, and optics experiments. It includes two carts. This version includes the Vernier Motion Encoder System, a novel method for measuring cart position without the complications of using an ultrasonic Motion Detector.

Vernier Dynamics Cart and Track System with Long Track (order code DTS-LONG)
The long version of the Vernier Dynamics Cart and Track System includes a 2.2 m track instead of the 1.2 standard track.

Track (order code TRACK)
The Combination 1.2 m Track/Optics Bench comes with the Encoder System Strip installed.

Upgrade the Dynamics Cart and Track System

The Dynamics Cart and Track System can be upgraded by adding the Vernier Motion Encoder System to perform data collection. The track already includes the required Encoder Strip.

Motion Encoder Cart and Receiver (order code DTS-MEC)
This is the simplest upgrade option, including a fully assembled Motion Encoder Cart and the Motion Encoder Receiver.

Motion Encoder Cart Upgrade Kit (order code DTS-MEU)
This kit allows you to upgrade one existing cart to a Motion Encoder Cart. It also includes the required Motion Encoder Receiver.

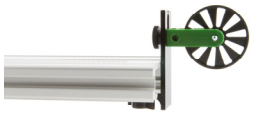
Replacement Parts

Standard Cart (order code DTS-CART-S)

Plunger Cart (order code DTS-CART-P)

Ultra Pulley (order code SPA)
The pulley can be attached to the end of a track using the Pulley Bracket to make a half-Atwood machine.

Pulley Bracket (order code B-SPA)
The pulley bracket allows easy attachment of an Ultra Pulley to the end of a Vernier track.



Suggested Accessories

Bumper Launcher Kit (order code BLK)
The Bumper Launcher Kit includes accessories to integrate the Dual-Range Force Sensor (DFS-BTA) with the Vernier Dynamics Cart and Track System, allowing for many interesting experiments in momentum-impulse study.

Cart Picket Fence (order code PF-CART)
The Cart Picket Fence is a clear plastic sheet printed with black bars for use with a Photogate. Use this to measure precise speed and acceleration.

Dual-Range Force Sensor (order code DFS-BTA)
The Dual-Range Force Sensor measures pushes and pulls up to 50 N.

Wireless Dynamics Sensor System (order code WDSS)
The WDSS is a wireless force sensor and accelerometer.

DTS Cart Friction Pad (order code DTS-PAD)
The DTS Cart Friction Pad attaches to the cart end using the collision tab slots. It adds an adjustable pad that rubs on the track, adding a controlled amount of friction to the cart motion. Use it to study frictional forces.

Fan Cart (order code CART-F)
The three-speed Fan Cart is a large fan on a light-weight cart. It offers students the ability to perform kinematics and dynamics experiments with constant acceleration, variable mass, variable thrust, and variable thrust angle.

Optics Expansion Kit (order code OEK)
The Vernier Optics Expansion Kit extends the Vernier Dynamics Cart and Track System for use in optics experiments.

Color Mixer (order code CM-OEK)
The Vernier Color Mixer Kit consists of a three-color LED illuminator with power supply, a lens, and a double-sided screen. Experiments in additive and subtractive color mixing can be easily and conveniently carried out using this kit. The intensity of the red, blue, and green LEDs can be smoothly controlled from the light source.

Diffraction Apparatus (order code DAK)
Use the Diffraction Apparatus to map light intensity versus position for many-slit geometries.

Warranty

Vernier warrants this product to be free from defects in materials and workmanship for a period of five years from the date of shipment to the customer. This warranty does not cover damage to the product caused by abuse or improper use.

Vernier

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