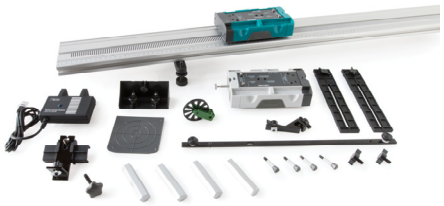
Vernier Dynamics Cart and Track System with Motion Encoder

(Order Code DTS-EC)



The Dynamics Cart and Track System with Motion Encoder is outfitted for the precise study of dynamics cart motion without the use of ultrasonic motion detectors. Instead of a traditional Motion Detector (order code MD-BTD), the system makes use of a novel Motion Encoder System. The encoder consists of several parts:

- A track with an encoder strip along the length of the track
- A dynamics cart with an optical encoder and infrared (IR) transmitter
- A receiver, attached to the end of a track

The encoder strip consists of alternating black and white bars with a 4 mm period, allowing the optical sensor to detect the passage of the bars as the cart moves. With two sensors appropriately placed on the underside of the cart, a change in position with 1 mm resolution can be determined, as well as the direction of travel of the cart. A narrow infrared beam transmits motion data to a receiver.

No alignments or adjustments are necessary, as the receiver attaches firmly to the track, and the cart rides in slots on the track. The IR beam is not disturbed by reflections from nearby objects.

The system is designed for use in physics and physical science courses for motion and energy experiments. 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 with Motion Encoder

- Motion Encoder Cart with 2 magnetic and 2 plain collision tabs
- Motion Encoder Receiver
- 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

Compatible Software and Interfaces

See www.vernier.com/dts-ec for a list of interfaces and software compatible with the Vernier Dynamics Cart and Track System with Motion Encoder.

WARNING: The Motion Encoder Receiver is not compatible with the Texas Instruments TI-Nspire Lab Cradle. Connecting the Receiver to the Lab Cradle will render the Cradle inoperative, requiring repair by Texas Instruments.

Collect Data with the Vernier Dynamics Cart and Track System with Motion Encoder

1. Attach the receiver to the end of the track, matching the encoder strip on the track to the markings on the receiver.
2. Place the track on a level surface.
3. Insert two AAA batteries (not included) into the encoder cart.
4. Connect the receiver to an interface such as a LabQuest 2. If using a computer, connect the interface to your computer and launch Logger *Pro*.
5. Turn on the cart by pressing the power button. It will glow blue when the cart is on.
6. Place the cart on the track, wheels in grooves, with the blue light facing the receiver.
7. Begin data collection, and let the cart roll.

NOTE: Vernier products are designed for educational use. Our products are not designed nor are they recommended for any industrial, medical, or commercial process such as life support, patient diagnosis, control of a manufacturing process, or industrial testing of any kind.

Specifications

Measurement Range	
1 m range	1.2 m track
2 m range	2.2 m track
Accuracy and Resolution	1 mm
Optimum data-collection rate	15–30 Hz

Calibration of the Motion Encoder System

Calibration of the Motion Encoder System is not necessary nor is it possible. The printed bars on the track determine the scale, and the cart encoder counts the passage of the bars. Available units are meters and feet, selectable in the software.

In contrast, it is possible and desirable to zero the encoder. Unlike an ultrasonic motion detector, there is no way for the system to have an unchanging reference position; it can only count bars from the point at which the cart is placed on the track. As a result, you may want to move the cart to the receiver end of the track and zero the reading in the software.

The positive direction can be reversed so that readings increase as the cart moves toward the receiver. A reversed coordinate system is helpful when using two Motion Encoder Systems to monitor the motion of two encoder carts, so that the positive direction is the same in both cases.

Because the encoder strip must be continuous, the Motion Encoder System cannot be used with a Track-to-Track Coupler.

Power

The Motion Encoder Cart requires two AAA batteries. Either NiMH rechargeable batteries or alkaline disposable batteries can be used. Turn on the cart by pressing the clear power button on the cart endcap. It will glow blue when power is on. Press again to turn off. The cart will turn itself off after 20 minutes of inactivity. Any motion on the track will cause the timer to reset. The receiver is powered by the data-collection interface.

Battery life depends on use and the range setting. Low battery level may cause erratic detection of the cart motion, including incorrect velocity signs. Replace the batteries if this is seen.

Range Setting of the Motion Encoder Cart

The IR transmitter on the cart has two power levels available. The default 1 m setting conserves battery power. If the cart is used on a 2.2 m track, set the cart to the higher 2 m power level. If the high-power setting is not used on a 2.2 m track, the receiver will not reliably sense the position of the cart at the far end of the track. The switch is located inside the battery compartment.

Use of Two Vernier Motion Encoder Systems on the Same Track

Some experiments require measuring the motion of two carts. This can be done by purchasing the Motion Encoder Cart and Receiver (order code DTS-MEC) to add a second encoder cart, receiver, and strip to your Vernier Motion Encoder System. A Motion Encoder Receiver is placed at either end of the track, and two Motion Encoder Carts are used on the track, each with its transmitter facing the unobstructed receiver. A second encoder strip must be applied to the track, resulting in one on either side of the center slot.

Consider reversing the direction of one receiver so that the same direction is positive for each system. Put the carts together, and zero both systems. This will put the carts

on the same coordinate system; if they move together in contact, their position readings will be the same.

Use of Multiple Vernier Motion Encoder Systems in the Same Room

Because of the narrow IR beam used for signaling between the cart and receiver, interference should be rare. However, if one apparatus is apparently interfering with another, the problem can be resolved by repositioning one of the tracks.

All Motion Encoder Carts are interchangeable; that is, there is no matching of cart to receiver.

Data-Collection Notes for the Motion Encoder System

- The optical motion encoder can only make relative position measurements, so the zero point is initially determined by the location on the track that the cart is first placed when the power is on. If you want zero to be near the receiver, initially place the cart next to the receiver. This behavior is very different from the ultrasonic Motion Detector, which by default uses a fixed origin near the detector.
- The motion encoder is nearly immune to interference, but it cannot work if the IR beam between the cart and receiver is blocked. Keep your hand away from this region.
- Since the zero position (origin) of the encoder depends on where the cart is placed initially, it is often useful to zero the encoder in the software. Place the cart in the position that you want to declare as zero. On LabQuest, tap the Meter Screen to access the zero command. In Logger *Pro*, use the toolbar button.
- It can also be useful to reverse the direction of the coordinate system, so that values increase as the cart moves toward the receiver. Do this from the Meter Screen on LabQuest, or by using the Sensor menu in the Set Up Sensors dialog box for your interface in Logger *Pro*.
- High data-collection rates are not useful for the motion encoder. Rates above 30 Hz will produce noisy velocity and acceleration graphs because of few counts during each time period.
- Just like the ultrasonic Motion Detector, it can be useful to adjust the number of points used to calculate derivatives for velocity and acceleration graphs. Higher values create quieter graphs, while lower values result in more temporal detail. Adjust this value in LabQuest preferences or in Settings For… from the File menu in Logger *Pro*.

Photogate Bracket

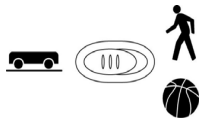
Photogate Brackets are attached to the side of the track. With the nut loosely on the T-handled bolt, slide the nut into the side channel of the track. Attach the photogate using the supplied wing bolt in the long slot. Adjust the gate height so the beam intercepts the desired portion of the target.

Motion Detector Bracket

Although we expect that the motion encoder will be used most often to record motion data, it is also possible to use the Dynamics Cart and Track System with an ultrasonic Motion Detector.

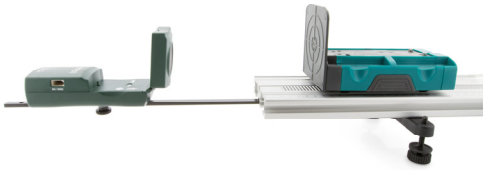
Any Vernier Motion Detector with a hinged head can be attached to the supplied Motion Detector Bracket. The Motion Detector Bracket has a pin to locate the Motion Detector on the bracket. There is a knob, nut, and bolt to attach the bracket to the track underside, and a threaded hole at the end near 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. The End Stop cannot be used at the same end as a Motion Detector or Motion Encoder Receiver.

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, sensors, and the encoder system will 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 Dynamics Cart and Track System with Motion Encoder.

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

The Vernier Motion Encoder System can be used wherever a Motion Detector could have been used with a cart and track. The encoder depends on the presence of the track, so that *only* cart and track experiments can be performed.

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 the encoder 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 opposite the receiver. Measure the acceleration of the encoder cart as a function of the hanging mass.

Measure Fan Cart Acceleration

Add an Encoder Fan Cart (order code CART-FEC) to observe the motion of a cart under constant thrust.

Measure Cart Acceleration with Friction

Add a Friction Pad (order code DTS-PAD) to the encoder 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 Encoder Systems to observe a change in energy due to a collision between two carts.

Conservation of Momentum

Use two Vernier Motion Encoder Systems 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 with Motion Encoder

Vernier Dynamics Cart and Track System (order code DTS)

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. The hardware does not include the Motion Encoder Cart and Receiver.

Vernier Dynamics Cart and Track System with Long Track (order code DTS-LONG)

The long version of the Vernier Dynamics 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.

Replacement Parts

Motion Encoder Receiver (order code MEC-BTD)

The receiver attaches to the end of the track and connects to an interface, such as a LabQuest 2.

Motion Encoder Cart (order code CART-MEC)

This is the complete Motion Encoder Cart, with no assembly required.

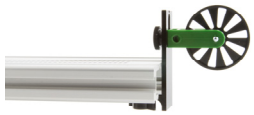
Motion Encoder Long Track Strip (order code METS-LONG)
The strip can be attached to an existing track without an encoder strip, or it can be attached as a second strip for use with two encoder systems. For 1.2 and 2.2 m tracks.

Motion Encoder Transmitter Parts (order code MECT)
The transmitter assembly is used to upgrade an existing cart to a Motion Encoder Cart.

Motion Encoder Cart and Receiver (order code DTS-MEC)
This kit includes a Motion Encoder Cart, a Motion Encoder Receiver, and a Motion Encoder Track Strip. Add it to a Dynamics Cart and Track System with Motion Encoder to track the motion of two carts simultaneously.

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 System or Vernier Motion Encoder 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.

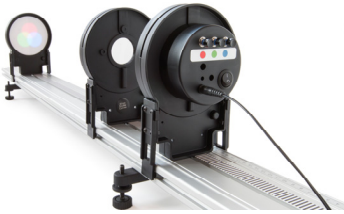
Wireless Dynamics Sensor System (order code WDSS)
The WDSS is a wireless force sensor and accelerometer.

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.

Encoder Fan Cart (order code CART-FEC)
The three-speed Encoder 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. The cart includes a Motion Encoder Transmitter.

Optics Expansion Kit (order code OEK)
The Vernier-Optics Expansion Kit extends the Vernier Dynamics System or Vernier Motion Encoder 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.

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Measure. Analyze. Learn.™
Vernier Software & Technology
13979 S.W. Millikan Way • Beaverton, OR 97005-2886
Toll Free (888) 837-6437 • (503) 277-2299 • FAX (503) 277-2440
info@vernier.com • www.vernier.com

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