Go Direct®
Sensor Cart
(GDX-CART-G) - Green

(GDX-CART-Y) - Yellow

Go Direct Sensor Cart can be used for hands-on kinematics and dynamics demonstrations but can also be used as a force or acceleration sensor. Hang a mass and spring from the force sensor to study simple harmonic motion, or attach the cart to a turntable to study centripetal acceleration.

Each dynamics cart includes

- Encoder wheel to report position
- 3-axis accelerometer to measure independent acceleration
- 50 N force sensor to measure push and pulls
- Mass trays for changing total mass
- Plunger for collision and impulse studies
- Low friction wheels for uniform motion
- Anti-roll peg

The Go Direct Sensor Cart can be used in a variety of experiments:

- Collect position, velocity, and acceleration data as the cart rolls freely up and down an incline.
- Observe collisions between two carts, test for the conservation of momentum, or measure energy changes during different types of collisions.
- Investigate the relationship between force, mass, and acceleration.
- Examine the energies involved in simple harmonic motion.
- Measure a cart's momentum change and compare it to the impulse it receives.

Go Direct Sensor Cart connects directly to your mobile device, Chromebook™, or computer using our free Graphical Analysis™ 4 app.

Go Direct Sensor Cart is available in green and yellow in order to facilitate classroom discussions about collisions. The two colors are designed to be distinguishable by many color-blind viewers.

Data column names have a suffix of Y or G so that you can tell the carts apart in a data table. When only one cart is used, disregard the suffix.

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.

What's Included

- Go Direct Sensor Cart
- Hook
- Flat-top rubber bumper for force sensor
- Anti-roll peg
- 4 empty collision tabs
- Micro USB Cable

Compatible Software

See **www.vernier.com/manuals/gdx-cart** for a list of software compatible with the Go Direct Sensor Cart.

Getting Started

Please see the following link for platform-specific connection information:

www.vernier.com/start/gdx-cart

Bluetooth Connection

1. Install Graphical Analysis 4 on your computer, mobile device, or Chromebook™. See www.vernier.com/ga4 for software availability.
2. Charge your Sensor Cart for at least 8 hours before first use.
3. Turn on your Sensor Cart by pressing the power button once. The Bluetooth® LED will blink red.
4. Launch Graphical Analysis 4.
5. Click or tap Sensor Data Collection.
6. Click or tap your Go Direct Sensor Cart from the list of Discovered Wireless Devices. Your sensor's ID is located near the barcode on the sensor. The Bluetooth LED will blink green when it is successfully connected.
7. The active channel is listed in the Connected Devices Sensor Channels list. To change channels, select the check box next to the Sensor Channel(s) you would like to activate.
8. Click or tap Done to enter data-collection mode.

Charging the Sensor Cart

Connect the Go Direct Sensor Cart to the included Micro USB Cable and any USB device for eight hours.

You can also charge up to eight Go Direct Sensor Carts using our Go Direct Charge Station, sold separately (order code: GDX-CRG).

Charging	Orange LED next to battery icon is solid while sensor is charging.
Fully charged	Green LED next to battery icon solid when sensor is fully charged.

Powering the Cart

Turn on the cart	Press button once. Red LED indicator next to Bluetooth icon flashes when unit is on.
Put the cart in sleep mode	Press and hold button for more than three seconds to put into sleep mode. Red LED indicator stops flashing when sleeping.

Connecting the Sensor Cart

See the following link for up-to-date connection information:

www.vernier.com/start/gdx-cart

Connecting via Bluetooth

Ready to connect	Red LED next to Bluetooth icon flashes when sensor is awake and ready to connect.
Connected	Green LED next to Bluetooth icon flashes when sensor is connected via Bluetooth.

Connecting via USB

Connected and charging	Orange LED next to battery icon is solid when sensor is connected to Graphical Analysis via USB and the unit is charging. LED next to Bluetooth is off.
Connected, fully charged	Green LED next to battery icon is solid when sensor is connect to Graphical Analysis via USB and fully charged. LED next to Bluetooth icon is off.
Charging via USB, connected via Bluetooth	Orange LED next to battery icon is solid when sensor is connected to charger via USB and the unit is charging. Green LED next to Bluetooth icon flashes when sensor is connected via Bluetooth.

Identifying the Sensor

You can make the Bluetooth LED flash red and green by clicking Identify in Sensor Information. This is useful to distinguish between two identical sensors.

Using the Sensor Cart

Connect the sensor following the steps in the Getting Started section of this user manual.

Channels

Go Direct Sensor Cart has five measurement channels. The channel names are

- Position
- Force
- X-axis acceleration
- Y-axis acceleration
- Z-axis acceleration

Position

The default channel that is active when the cart is first connected is position. Graphical Analysis calculates velocity and acceleration data from the position information. The position reading changes as the encoder wheel turns. If the cart is picked up and moved to a different location without rolling the encoder wheel, the position reading does not change. The behavior is like the mouse on a computer.

Force

The default channel that is active when the sensor is connected is force. The force channel measures pushes and pulls along the main axis of the sensor body. Use the hook attachment for pulling and the bumper attachment for pushing. Pulls are registered as positive forces and pushes are registered as negative forces, unless sensor readings are reversed in Graphical Analysis 4.

Do not twist or remove the hex barrel of the force sensor. Removal will damage the load cell.

Acceleration

There are three acceleration channels, measured by a single chip, which is located under the 3-axis icon on the label. The icon shows the positive direction for each axis, with the x-direction of acceleration parallel to the pulling force on the force sensor and the z-direction straight up through the label. Each direction of acceleration can be measured separately.

If you choose to activate all three acceleration channels at once, you can create a calculated column for the total acceleration magnitude.

Track Usage Notes

The Sensor Cart can be used with or without a track. Using the cart on a tabletop or floor allows very easy experiment setup, but a track allows more careful experiments, including collisions, to be performed.

The Sensor Cart is compatible with many common dynamics tracks, including the Vernier Combination 1.2 m Track and Optical Bench.

Anti-Roll Peg

The cart includes an anti-roll peg. The peg rides in the center groove of a Vernier Track, allowing the cart to roll freely. When the cart is placed on a table, the peg keeps the cart from rolling. If you want to use the cart on a table or floor, remove the peg by pulling and twisting.

Plunger

The 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-quarter turn counterclockwise to unlock. The plug 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-quarter turn clockwise. It will lock in the flush position.

Available Sensor Cart Accessory Kit (order code GDX-CART-AK)

An accessory kit for the Vernier Go Direct Sensor Cart is available. The kit is recommended for more advanced users. It includes

- Hoop spring bumper (heavy)
- Hoop spring bumper (light)
- Magnet tabs (4)
- Hook-and-pile tabs (4 pair)
- Masses (4 hex)
- Magnetic disk bumper for force sensor (2)
- Additional metal hook and nut for force sensor (3)
- Additional flat-top rubber bumper (3)
- Additional anti-roll pegs (3)

Calibrating the Sensor Cart

Position in m

The position channel does not need to be calibrated, nor can it be calibrated. The position channel can be zeroed. This is useful to establish a zero position on a track. Do not pick up the cart after zeroing to avoid disturbing the zero. The position sensor can also be reversed. This is useful when using two carts in collision mode with force sensors facing one another. To put the two carts on the same coordinate system, reverse the direction of the position and force sensors on one cart, and zero the cart positions with the carts in contact.

Force in N

This sensor is factory calibrated. If you would like to calibrate the force sensor yourself, use a two-point calibration: no force applied and a known force applied. It is easiest to simply hang a mass from the hook. We recommend a 1 kg mass. Do not exceed the maximum of 50 N during calibration.

The force sensor can be zeroed. This is useful after calibration to remove the weight of the hook. The force sensor can also be reversed so that push is positive.

X, Y, and Z Acceleration in m/s^2

This sensor is factory calibrated.

Specifications

Position resolution	0.25 mm, displaying to nearest 1 mm
Nominal mass	275 g excluding accessories
Accessory port	Available for future expansion
Force response time	1 ms
Force range	±50 N
Acceleration range	±160 m/s^2
USB specification	USB 2.0 full speed
Wireless specification	Bluetooth v4.2
Maximum wireless range	30 m (unobstructed)
Dimensions	Length: 16.6 cm, not including accessories mounted to the force sensor Width: 9.6 cm Height: 4.7 cm
Battery	650 mAh Li-Poly Rechargeable
Battery life (single full charge)	~10 hours continuous data collection
Battery life (long term)	~300 full charge cycles (several years depending on usage)

Safety

The wheels are spring-loaded so that they will retract when excessive force is applied, as when stepping on the cart.

Care and Maintenance

Battery Information

The Go Direct Sensor Cart contains a small lithium-ion battery. The system is designed to consume very little power and not put heavy demands on the battery. Although the battery is warranted for one year, the expected battery life should be several years. Replacement batteries are available from Vernier (order code: GDX-BAT-650).

Storage and Maintenance

To store the Go Direct Sensor Cart for extended periods of time, put the device in sleep mode by holding the button down for at least three seconds. The red LED will stop flashing to show that the unit is in sleep mode. Over several months, the battery will discharge but will not be damaged. After such storage, charge the device for a few hours, and the unit will be ready to go.

Exposing the battery to temperatures over 35°C (95°F) will reduce its lifespan. If possible, store the device in an area that is not exposed to temperature extremes.

Water Resistance

The Go Direct Sensor Cart is not water resistant and should never be immersed in water.

If water gets into the device, immediately power the unit down (press and hold the power button for more than three seconds). Disconnect the sensor and charging cable and remove the battery. Allow the device to dry thoroughly before attempting to use the device again. Do not attempt to dry using an external heat source.

How the Sensor Works

Position

The position channel uses an optical encoder system. As the sensing wheel rotates, the position of attached disc with radial markings is detected by a pair of optical sensors. From counting the events and their sequence, the angle turned as well as its sense of rotation can be determined. The angle is converted to a change in position using the diameter of the sensing wheel. Since the wheel does not turn if the cart is not on a surface, the reading will not change if the cart is repositioned by lifting.

A result of the design is that there is no natural zero for the sensor. The position when the cart is first connected to software is thus used as a zero. The position channel can be zeroed in software as desired.

Velocity and acceleration are calculated in software from the position and time data.

Force

The force channel uses strain gauge technology to measure force based on the bending of a beam in a load cell.

Accelerometer

The accelerometer is a microelectromechanical device (MEMS device) consisting of a cantilever and a test mass. As the mass is accelerated, the cantilever bends, generating a signal proportional to the acceleration. Three orthogonal axes provide three channels of acceleration information.

Additional Information about Acceleration

Since the accelerometer is sensitive to both acceleration and the Earth's gravitational field, interpreting accelerometer measurements is complex. A useful model for understanding accelerometer measurements is a spring-based scale with a reference mass (or object) attached to the scale. If the scale is pointing upward (the usual orientation for such a device) the weight of the mass causes the spring to compress, and you get a non-zero reading. If you were to turn the scale upside down, the spring will be extended, instead of compressed, and we get a reading of the opposite sign. If you turn the scale so it points sideways, and keep it motionless, then the spring will just be at its relaxed length, and the reading will be zero. If you accelerated the scale toward the mass, then the spring would compress. If you accelerate the scale away from the mass the spring would stretch. In each case the scale is reading a value corresponding to the normal force on the mass. This reading can be made relative by dividing out the mass, giving units of N/kg, which is the same as m/s^2.

Troubleshooting

For troubleshooting and FAQs, see **www.vernier.com/til/4131**

Repair Information

If you have followed the troubleshooting steps, and are still having trouble with your Go Direct Sensor Cart, contact Vernier Technical Support at support@vernier.com or call 888-837-6437. Support specialists will work with you to determine if the unit needs to be sent in for repair. At that time, a Return Merchandise Authorization (RMA) number will be issued and instructions will be communicated on how to return the unit for repair.

Accessories/Replacements

Item	Order Code
Sensor Cart Accessory Kit	GDX-CART-AK
Dynamics Cart and Track System with Go Direct Sensor Carts	DTS-GDX
Dynamics Cart and Track System with Go Direct Sensor Carts and Long Track	DTS-GDX-LONG
Replacement Battery	GDX-BAT-650
Micro USB Cable	CB-USB-MICRO
USB-C to Micro USB Cable	CB-USB-C-MICRO

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. This warranty covers educational institutions only.

Disposal

When disposing of this electronic product, do not treat it as household waste. Its disposal is subject to regulations that vary by country and region. This item should be given to an applicable collection point for the recycling of electrical and electronic equipment. By ensuring that this product is disposed of correctly, you help prevent potential negative consequences on human health or on the environment. The recycling of materials will help to conserve natural resources. For more detailed information about recycling this product, contact your local city office or your disposal service.

Battery recycling information is available at **www.call2recycle.org**

Do not puncture or expose the battery to excessive heat or flame.

The symbol, shown here, indicates that this product must not be disposed of in a standard waste container.

Federal Communication Commission Interference Statement

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

Reorient or relocate the receiving antenna.

Increase the separation between the equipment and receiver.

Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.

Consult the dealer or an experienced radio/TV technician for help.

FCC Caution

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions:

(1) this device may not cause harmful interference and

(2) this device must accept any interference received, including interference that may cause undesired operation

RF Exposure Warning

The equipment complies with RF exposure limits set forth for an uncontrolled environment. The antenna(s) used for this transmitter must not be co-located or operating in conjunction with any other antenna or transmitter. You are cautioned that changes or modifications not expressly approved by the party responsible for compliance could void your authority to operate the equipment.

IC Statement

This device complies with Industry Canada license-exempt RSS standard(s). Operation is subject to the following two conditions:

(1) this device may not cause interference, and

(2) this device must accept any interference, including interference that may cause undesired operation of the device.

Industry Canada - Class B This digital apparatus does not exceed the Class B limits for radio noise emissions from digital apparatus as set out in the interference-causing equipment standard entitled "Digital Apparatus," ICES-003 of Industry Canada. Operation is subject to the following two conditions: (1) this device may not cause interference, and

(2) this device must accept any interference, including interference that may cause undesired operation of the device.

To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that permitted for successful communication.

RF exposure warning: The equipment complies with RF exposure limits set forth for an uncontrolled environment. The antenna(s) used for this transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes :

(1) l'appareil ne doit pas produire de brouillage, et

(2) l'appareil doit accepter tout interférence radioélectrique, même si cela résulte à un brouillage susceptible d'en compromettre le fonctionnement.

Cet appareil numérique respecte les limites de bruits radioélectriques applicables aux appareils numériques de Classe B prescrites dans la norme sur le matériel interférant-brouilleur: "Appareils Numériques," NMB-003 édictée par industrie Canada. L'utilisation est soumise aux deux conditions suivantes:

(1) cet appareil ne peut causer d'interférences, et

(2) cet appareil doit accepter toutes interférences, y comprises celles susceptibles de provoquer un disfonctionnement du dispositif.

Afin de réduire les interférences radio potentielles pour les autres utilisateurs, le type d'antenne et son gain doivent être choisie de telle façon que l'équivalent de puissance isotrope émis (e.i.r.p) n'est pas plus grand que celui permis pour une communication établie.

Avertissement d'exposition RF: L'équipement est conforme aux limites d'exposition aux RF établies pour un environnement non supervisé. L'antenne (s) utilisée pour ce transmetteur ne doit pas être jumelés ou fonctionner en conjonction avec toute autre antenne ou transmetteur.

Note: This product is a sensitive measurement device. For best results, use the cables that were provided. Keep the device away from electromagnetic noise sources, such as microwaves, monitors, electric motors, and appliances.

Vernier

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