

# Bumper and Launcher Kit

(Order Code BLK)

The Bumper and Launcher Kit contains accessories used to perform experiments involving the Vernier Dual-Range Force Sensor (DFS) or the Vernier Wireless Dynamic Sensor System (WDSS) and the Vernier Dynamic System. The Vernier Dynamics System consists of a track, two low-friction dynamics carts and hardware. The accessories allow you to perform a wide range of experiments in kinematics and dynamics. Experiments include



- Forces during elastic collisions with contact
- Forces during elastic collisions without contact
- Forces during inelastic collisions
- Impulse and change in momentum
- Spring potential energy
- Hooke's Law
- Work and energy

## What is Included with the Bumper and Launcher Kit?

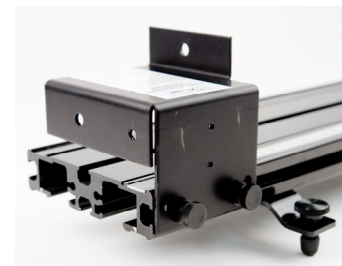
- (1) Dynamics Track Bracket
- (1) Dual-magnet bumper including a nylon bolt for securing magnetic bumper to DFS or the track bracket
- (1) DFS end mount screw
- (2) Single-magnetic bumpers
- (2) Rubber bumpers
- (2) Hoop bumpers (one stiff and one weak)
- (2) Clay holders
- (1) Clay



**NOTE:** This kit contains very STRONG permanent magnets. Keep them away from objects that may be affected by strong magnetic fields.

## Performing Experiments with the Dynamics Track Bracket

A number of the experiments described below use the Dynamics Track Bracket that attaches to the side of the Vernier Dynamics Track. Attach the bracket to the track by loosening the two nuts and sliding them into the groove on the side of the track. Once in place, tighten the thumb screws.

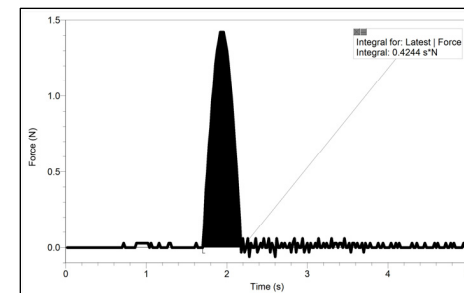
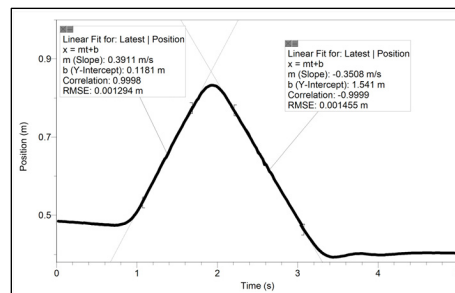


## Performing Experiments with the Bumper and Launcher Kit

This kit contains a number of bumpers that allow you to perform a variety of experiments. The bumpers allow you to investigate contact and non-contact forces. Experiments involving non-contact force use the dual-magnet bumper or the single-magnet bumpers. Elastic collisions can be performed with the loop springs. Inelastic collisions are performed with clay holders and clay. Here are some ways to use the equipment.

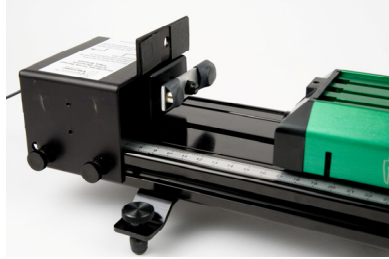
## Impulse and Change in Momentum

The following arrangements are excellent ways to explore the relationship between impulse and the change in momentum. In each experiment a cart's direction of motion is changed by an external force. A DFS is used to measure force during the collision, and a Motion Detector is used to collect motion data. Using the position vs. time plot or velocity vs. time plot, you can determine the velocity before and after the collision. Knowing the mass of the cart, you can determine the change in momentum. Using the integral feature of the software, you can integrate the force curve over the region of the collision and determine the impulse, and then compare it to the change in momentum. There are a couple ways that the experiment can be performed.

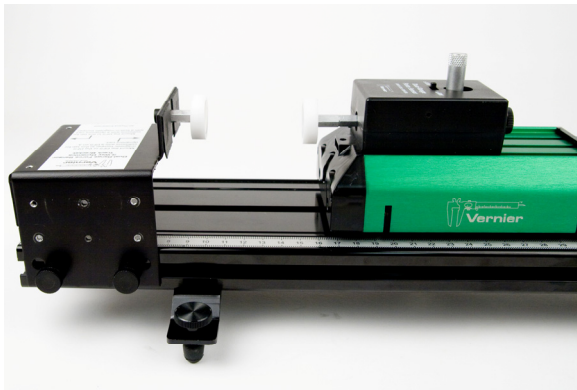


1) Fixed DFS - This method uses a Vernier Dynamics Cart with internal magnetic bumpers. Fasten the DFS to the down-turned tab of the bracket with the long thumbscrew that came with your DFS. Using the square nuts on the Track Bracket, mount the bracket on the side of the dynamics track with the up-turned tab closest to the track end. Mount a dual-magnet bumper to the DFS using the shortest

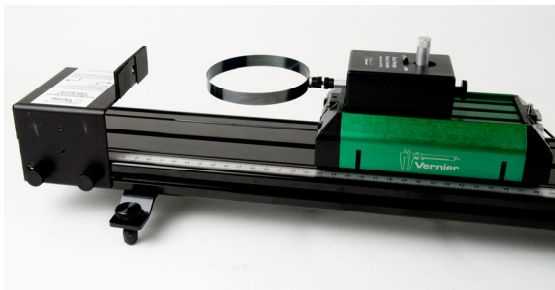
thumbscrew. Carefully adjust it to be parallel to the track surface with the magnets 1-2 mm higher than the magnets on the Dynamics Cart. During data collection, give the cart a gentle push toward the DFS. (If you push it too hard, it will jump the track.)



2) Sensor on Cart – Another way to collect the data is to attach a single magnet bumper to the up turned tab of the Track Bracket. (The single magnet can be attached using the small nut that holds the dual-magnet bumper to the Track Bracket.) Attach another single magnet bumper to the DFS and attach the DFS to the cart. Give the cart a gentle push toward the Track Bracket.



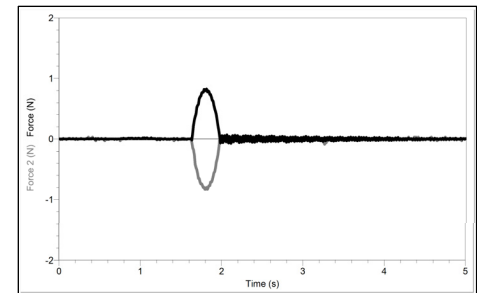
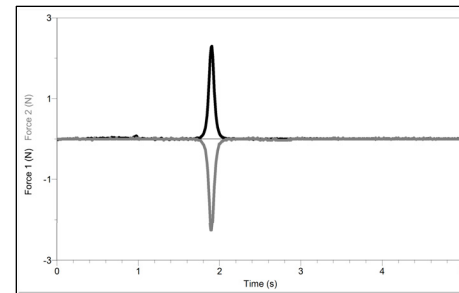
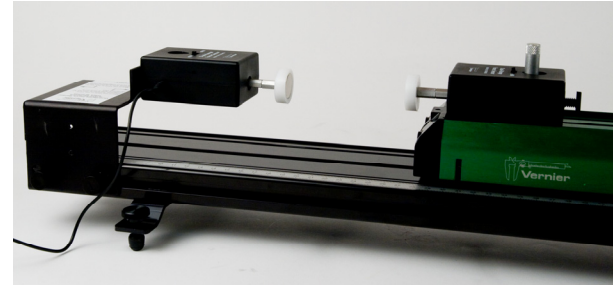
3) Collision with a contact force – Perform the same experiment described above, but instead of the magnets put a loop bumper on the track bracket or the cart.



## Studying Newton's Third Law

Attach the Track Bracket to the track with the down-turned tab closest to the track end. Mount a DFS on the Dynamics Cart. Attach a single magnet bumper to the DFS. Mount a second DFS to the up-turned tab of the Track Bracket. Collect data as the cart is pushed toward the other DFS.

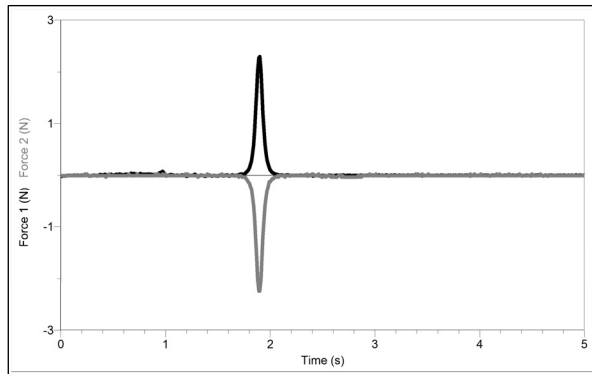
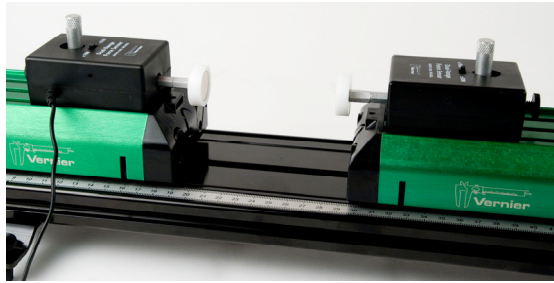
Instead of using two magnets, you could put one loop bumper and a rubber bumper.



## Forces During Collisions

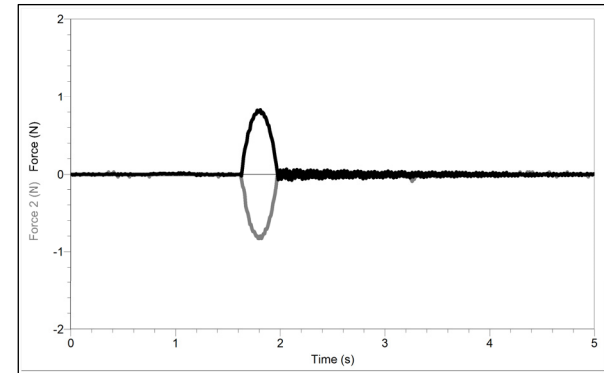
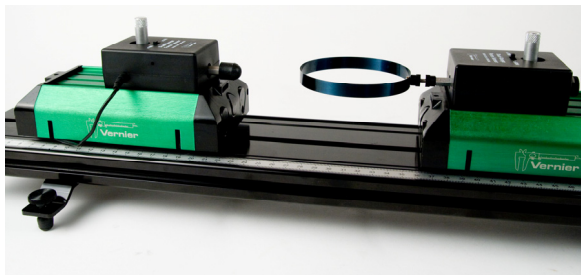
### Elastic Collision with Magnets

Attach magnetic bumpers to two Dual-Range Force Sensors. Attach each DFS to different Vernier dynamics carts. In the software, reverse the direction of positive force for one of the sensors. With the DFS far apart, zero both sensors. Start data collection and give one of the carts a small push toward the other.



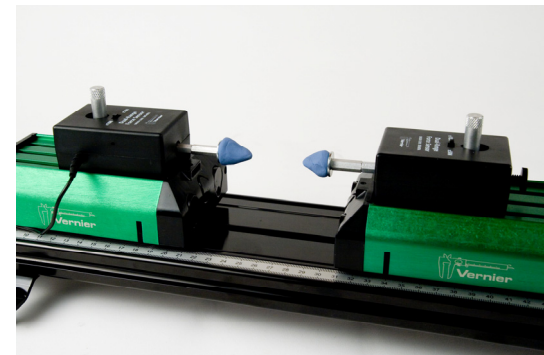
### Elastic Collision with a Spring

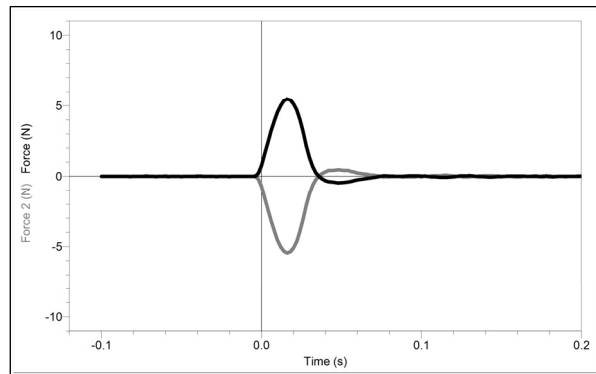
Attach a hoop spring bumper to a DFS. Attach a rubber tip bumper to another DFS. Attach each DFS to a Vernier dynamics cart. In the software, reverse the direction of positive force for one of the sensors. Zero both sensors. Start data collection and give one of the carts a small push toward the other. Examine the graph. How does the shape of the curves compare to the shape of the curves generated with the magnets?



### Inelastic Collision Using Clay

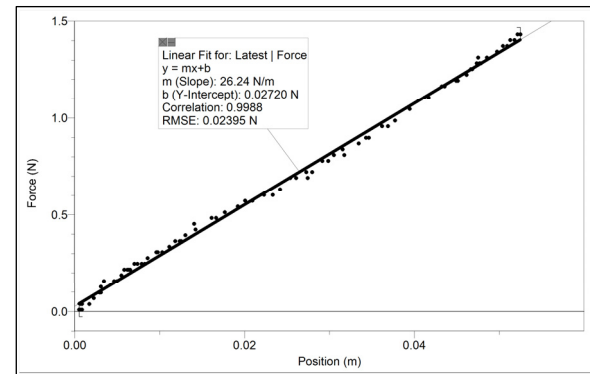
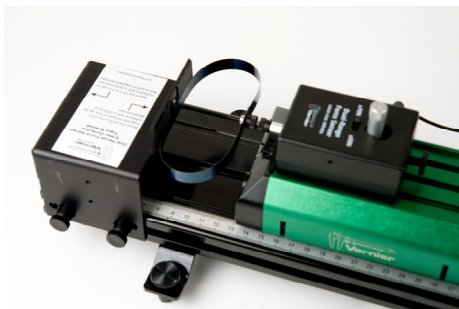
Attach clay holders to two DFS. Attach each DFS to a Vernier dynamics cart. Fashion a cone out of clay and attach one to each tip. In the software, reverse the direction of positive force for one of the sensors. Zero both sensors. This collision will be very brief, on the order of a few tenths of a second. Set the data collection rate to 500 samples/s and the experiment length to 0.3 s. Set the experiment to start with Triggering. For example, data collection will start when the force measured by one of the sensors is increasing, and it reaches 0.2 N. Also choose to collect data before the trigger event. (In the example below, 50 data points were collected before the trigger event.) Start data collection and give one of the carts a small push toward the other. Examine the graph. How do the curves compare to the above experiments? Can you explain the nature of the graph?





### Hooke's Law

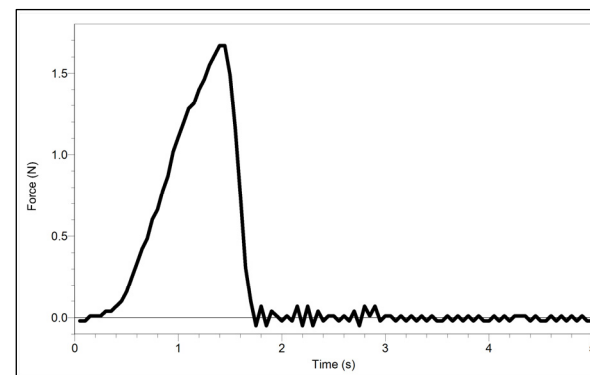
Attach the Track Adapter to the track. Attach a hoop spring bumper to a DFS. Attach the DFS to a Vernier dynamics cart. Position a Motion Detector at the other end of the ramp pointing toward the Track Bracket. In the software, reverse the direction of positive force for the DFS. Position the cart such that the bumper is almost but not quite touching the end stop. With the cart in this position, zero both sensors. Start data collection and slowly move the cart toward the Track Bracket, compressing the spring. Slowly move the cart back out toward the zero position without going past the zero position. Create a scatter plot of force vs. position. Fit a straight line to the data to determine the force constant of the hoop spring. Notice the linear response of the hoop spring.

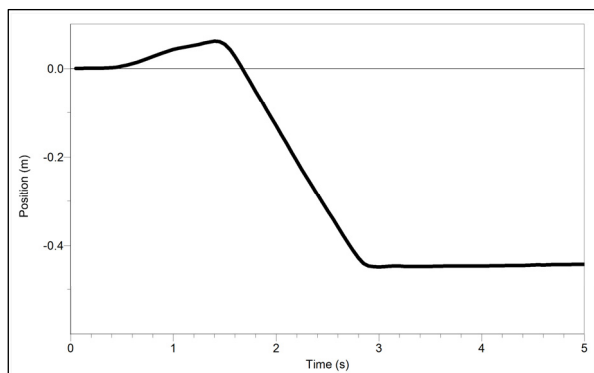


### Spring potential energy, work and kinetic energy

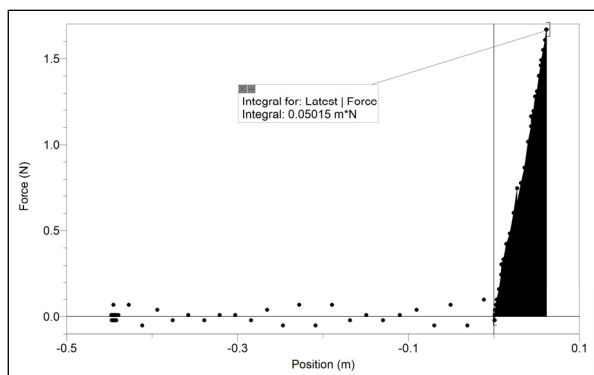
The hoop spring acts as an excellent cart launcher on the dynamics track. By combining the hoop spring, a DFS and Motion Detector, students can investigate the relationship between spring potential energy, work and kinetic energy.

Place the Track Bracket on one end of the track. Attach a hoop spring bumper to a DFS. Attach the DFS to a Vernier dynamics cart. Position a Motion Detector at the other end of the ramp pointing toward the Track Bracket. In the software, reverse the direction of positive force for the DFS. Position the cart such that the bumper is almost but not quite touching the end stop. With the cart in this position, zero both sensors. Start data collection and move the cart toward the Track Bracket, compressing the spring a few centimeters, and then release the cart.





Create a scatter plot of force vs. position. The section of the plot with a positive slope represents the compression of the spring, i.e., when work is being done on the spring. The area under the curve for that portion of the plot is the work done on the cart. You can determine the integral using *Logger Pro* software as long as you sort the data on the position data.



If you don't have *Logger Pro* software or if you don't want to use the integral function of the software, you can simply calculate the area of the triangle created by that set of data.

From the position vs. time graph, students can determine the launch velocity of the cart. Knowing the mass of the cart, they can determine the kinetic energy and compare it to the work.

### Momentum and Energy Studies

The Vernier Dynamics System comes with two carts and associated hardware that allow you to study elastic and inelastic collision. You can use the equipment in this

kit to also perform those studies. Simply attach DFSs to the carts and then attach the bumpers to the carts. Use Motion Detectors placed at the ends of the track to collection position and velocity data during the collision.

### Using the Bumper and Launcher Kit with the WDSS

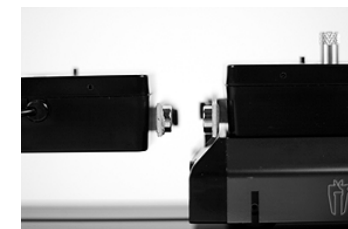
All of the bumper accessories can connect to the force sensor end of the Wireless Dynamic Sensor System. This allows you to perform experiments without the added frictional force due to wires.



### Special Notes Regarding Mounting

When using the dual-magnet bumpers, alignment of the magnets is very critical in preventing the dynamics cart from “jumping” the track. The fixed magnets should be 1-2 mm higher than the moving ones. This helps hold the cart down on the track. Horizontal alignment is complicated by the fact that the wheels and axles of the cart can slide from side to side about 1.5 mm, which is enough to cause derailment during harder collisions. Results will be best if the wheels are on the side that gives the best horizontal alignment.

If the configuration you are using does not require the cart to have internal magnets, be sure that you either are using a cart with no magnets or remove the magnets from the cart. This may be done by removing the two screws in the end cap. Lift the end cap, let the magnets drop out, and replace the end cap. This will change the mass slightly.



## Other Adapters for the Vernier Dual-Range Force Sensor

### Air Track Adapter (ATA-DFS)

The Air Track Adapter allows the DFS to be mounted on the end of an air track for collision studies. It is compatible with most air tracks distributed or made by PASCO Scientific, Central Scientific, or Daedalon Corporation. It includes two magnetic bumpers.

### Force Table Adapter (FTA-DFS)

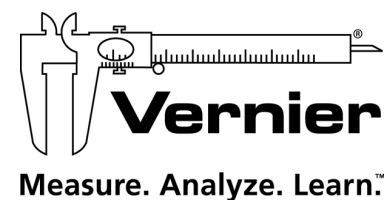
Use your DFS with your force table for resolution of vector experiments. The adapter includes a mounting clamp for tables up to 3/4 inch thick.

The Dual-Range Force Sensor Dynamics Track Adapter was designed by Bruce Lee of Andrews University and is manufactured by A.U. Physics Enterprises.

Special recognition goes to Rex Rice, Clayton High School, Clayton, Missouri who shared with us the idea of the loop spring.

## 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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