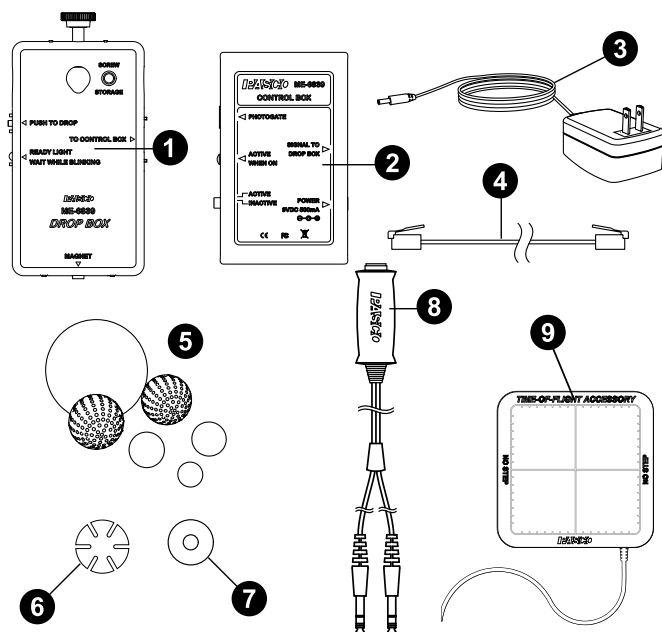# Discover Free Fall System (ME-9889)

Introduction

The PASCO Discover Free Fall System consists of the Drop Box (ME-6839) plus three accessories: the Free Fall Ball Accessory (ME-9890), the Timer Switch (ME-9819), and the Time-of-Flight Accessory (ME-6810A).

The Discover Free Fall System allows students to precisely time falling objects. The system includes several balls of various sizes and masses, ranging from about 6 g to 70 g. Other objects of similar masses can also be used. The object to be dropped is suspended from a magnet. When the Timer Switch is pushed, the object is released and the timing starts. Timing stops when the object hits the Time-of-Flight pad. The system also includes steel washers and adhesive stickers to allow non-steel objects to be suspended from the magnet.

The Timer Switch is a push-button device that simultaneously causes the Drop Box to release the object and triggers the timing device to start timing. The Time-of-Flight Accessory is a pad that triggers the timing device to stop timing when an object hits it.

Equipment

Included equipment:

❶ Drop Box (main unit)
Hang the object to be dropped from the magnet on the underside of this box.

❷ Drop Box control box
Coordinates signals between the components of the Discover Free Fall System.

❸ Drop Box AC adapter
Connect to the Drop Box control box and plug into an electrical outlet.

❹ Drop box cable
Use to connect the Drop Box main unit to the control box.

❺ Free Fall Ball Accessory balls
Includes all of the following:

- Smaller stainless steel ball (1.6 cm diameter, 16 g)
- Larger stainless steel ball (2.5 cm diameter, 70 g)
- Yellow nylon ball (2.5 cm diameter, 10 g)
- Practice golf ball (4.2 cm diameter, 6 g)
- Regular golf ball (4.4 cm diameter, 50 g)

❻ 50× release washers

❼ 50× release stickers
Use the washers and stickers together to attach non-steel objects to the Drop Box.

❽ Timer Switch
When pressed, sends a signal to the Drop Box to drop the object and another to the timing device to begin timing.

❾ Time-of-Flight Accessory
When hit by a falling object, sends a signal to the timing device to stop timing.

Required equipment:

- Timing device (see **Timing device options**)
- Mounting rods and base, or equivalent (see **Mounting options**)

Mounting options

The main unit of the Drop Box can be mounted on a horizontal rod attached to a vertical rod with a multi-clamp. Figure 1 shows a typical setup using a large rod base (ME-8735), a vertical 120 cm rod (ME-8741), a horizontal 45 cm rod (ME-8736), and a Multi-Clamp (ME-9507). Other similar configurations will work just as well. For a greater fall height, place the rod stand on a table and the Time-of-Flight Accessory on the floor.
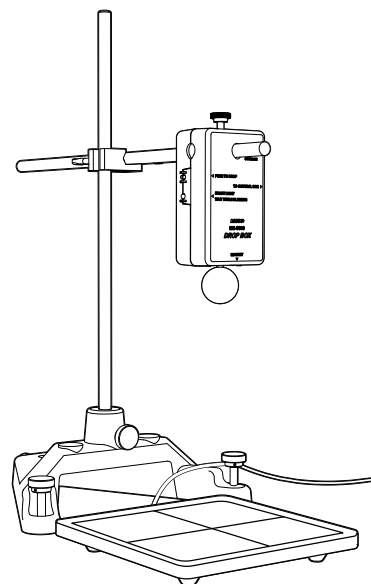

Figure 1. Drop Box mounted on a rod stand. To increase fall height, attach the clamp higher on the rod.

The Drop Box can also be attached to a steel part of the ceiling via the magnets on top of the main unit (see Figure 2). This mounting method works well to maximize the height from which objects are dropped.
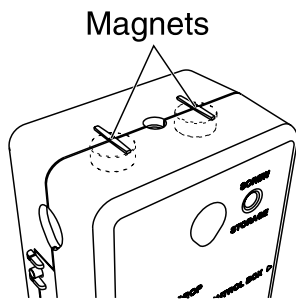

Figure 2. Magnets for attaching the Drop Box to the ceiling. Remove the screw from the top of the box when attaching the box in this way.

Timing device options

In order to time the object's fall, the system must be connected to one of the following timing devices:

- Smart Timer (ME-8930)

- 550 Universal Interface (UI-5001) *or* 850 Universal Interface (UI-5001) connected to PASCO Capstone or SPARKvue data collection software

- PASPORT interface with a Digital Adapter (PS-2159). Any PASPORT interface can be connected to a computer running PASCO Capstone or SPARKvue.

To download PASCO Capstone or SPARKvue, visit pasco.com/downloads.

Equipment setup

1. Connect the included AC adapter to the **POWER** port on the Drop Box control box. Plug the adapter into an electrical outlet.

2. Connect one plug of the Timer Switch to the **PHOTOGATE** port on the control box.

3. Use the included cable to connect the **SIGNAL TO DROP BOX** port on the control box to the **TO CONTROL BOX** port on the Drop Box main unit.

4. Mount the Drop Box as desired.

5. Place the Time-of-Flight Accessory directly below the Drop Box.

6. If the object to be dropped is not steel, attach one of the included washers to it using one of the included stickers, as shown in Figure 3. The sticker is pressure activated; press hard to make it stick permanently.

Figure 3. Attaching a washer to a non-steel object

7. Hang the object from the Drop Box magnet.

8. Set the **ACTIVE/INACTIVE** switch on the control box to **ACTIVE**.

9. Select one of the timing options (Smart Timer, SPARKvue, or PASCO Capstone) and follow the instructions in the corresponding sections below to configure the timing device and take data.
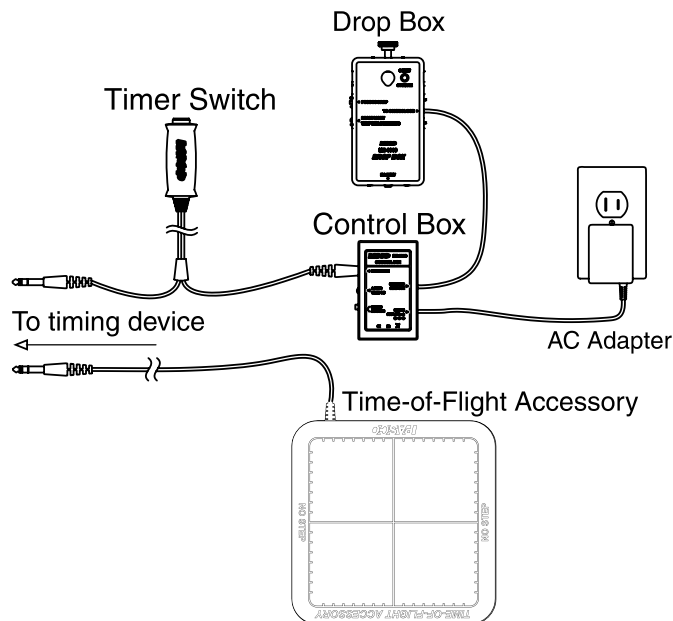

Figure 4. Proper equipment setup for the experiment

Test drop

1. Press the **PUSH TO DROP** button on the Drop Box control box.

   - If the object drops immediately, no adjustment is necessary.

   - If the object does not drop, or if it drops after a delay, add a sticker to the object to increase the space between the washer or steel part of the object and the Drop Box magnet.

2. Hang the object from the Drop Box again. Retest if necessary.

Timing option 1: Smart Timer

Setup

1. Connect the Smart Timer's AC adapter to its power port and plug the adapter into an electrical outlet, *or* use four AA cell batteries.

2. Turn on the Smart Timer.

3. Connect the remaining plug of the Timer Switch to channel **1** of the Smart Timer.

4. Connect the Time-of-Flight Accessory to channel **2** of the Smart Timer.

5. On the Smart Timer, press the **1 Select Measurement** button once to select **Time**.

6. Press the **2 Select Mode** button three times to select **Two Gates**.
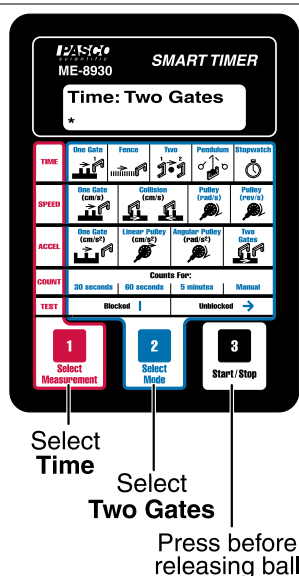
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Figure 5. Smart Timer

Data collection

1. On the Smart Timer, press the **3 Start/Stop** button. This will cause the Smart Timer to beep and an asterisk (*) to appear on the display, indicating that the device is ready to start timing.

2. Press the Timer Switch button to release the button from the Drop Box. When the object hits the Time-of-Flight pad, the Smart Timer will display the fall time.

To time another object, hang the object from the Drop Box, wait until the LED on the Drop Box stops blinking, and repeat the previous two steps.

Timing option 2: SPARKvue with computer interface

Setup

1. Start SPARKvue on your computer, then click **Sensor Data**.

2. Connect the interface to your computer or tablet. SPARKvue may automatically recognize the interface; if it does not, connect the interface to SPARKvue. (For precise instructions, see the manual for the individual interface or the SPARKvue online help.)

3. Connect the remaining plug of the Timer Switch to Digital Input **1** of the interface.

4. Connect the Time-of-Flight Accessory to Digital Input **2** of the interface.

> **NOTE:** If you are using a PASPORT interface with a Digital Adapter (PS-2159), connect the Digital Adapter to a PASPORT port of the interface, then plug the Timer Switch and Time-of-Flight Accessory into Digital Inputs 1 and 2 of the adapter.

5. In the **Select Measurements for Templates** column, click the **Settings** icon next to the listing for the interface's **Digital Channels**.

6. From the **Assign Digital Channels** menu, open the **Two Photogates** submenu, select **Photogate Timing (Two Photogates)**, and click **OK**. (See Figure 6.)
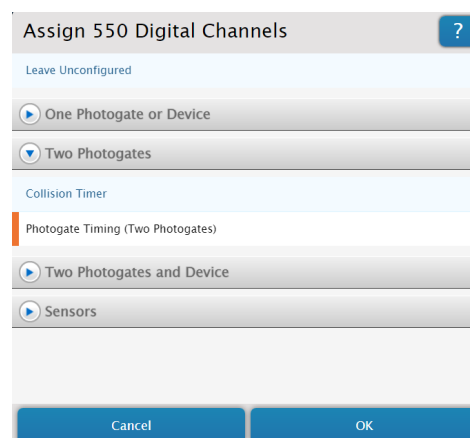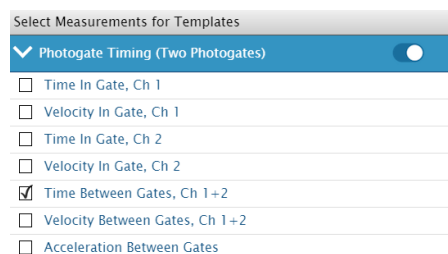

Figure 6. Configuring the digital channels of a 550 Universal Interface (UI-5001) for this experiment in SPARKvue.

7. Click **OK** again to skip assigning Flag Length and Photogate Spacing, as those values do not apply to this experiment.

8. Under **Photogate Timing** in the measurement selection column, deselect **Time In Gate, Ch 1** and select **Time Between Gates, Ch 1+2**.

9. In the **Templates** section, select **Digits** to enter the Experiment Screen. The display should automatically be set to measure **Time Between Gates** in units of seconds.

Data collection

1. In SPARKvue, click **Start** 🟢. This will start the experiment clock, indicating that the program is ready to collect data.

2. Press the Timer Switch button to release the object from the Drop Box. When the object hits the Time-of-Flight pad, the display in SPARKvue will record the fall time.

To time another object, hang the object from the Drop Box, wait until the LED on the Drop Box stops blinking, and repeat the previous two steps.

Timing option 3: PASCO Capstone with computer interface

1. Start PASCO Capstone on your computer, then click **Hardware Setup** in the **Tools** palette.

2. Connect the interface to your computer or tablet. Capstone may automatically recognize the interface; if it does not, connect the interface to Capstone. (For precise instructions, see the manual for the individual interface or the Capstone online help.)

3. Connect the remaining plug of the Timer Switch to Digital Input **1** of the interface.

4. Connect the Time-of-Flight Accessory to Digital Input **2** of the interface.

NOTE: If you are using a PASPORT interface with a Digital Adapter (PS-2159), connect the Digital Adapter to a PASPORT port of the interface, then plug the Timer Switch and Time-of-Flight Accessory into Digital Inputs 1 and 2 of the adapter.

5. On the visual representation of the interface in **Hardware Setup**, click the yellow circle over Digital Channel 1 and select **Photogate** from the list. Then click the yellow circle over Digital Channel 2 and select **Time Of Flight Accessory**.
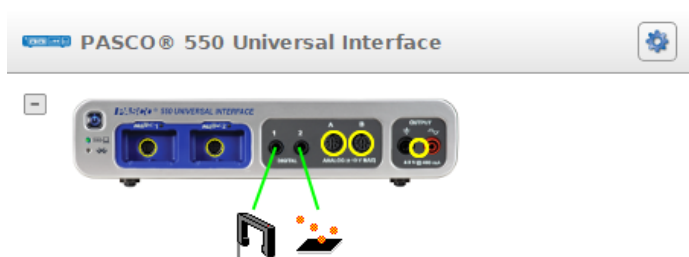

Figure 7. Configuring the digital channels of a 550 Universal Interface (UI-5001) for this experiment in PASCO Capstone.

6. Select **Timer Setup** from the **Tools** palette, then select **Pre-Configured Timer** and click **Next**. (See Figure 8 for this and the following few steps.)

7. Make sure that both **Photogate, Ch 1** and **Time Of Flight Accessory, Ch 2** are checked, then click **Next**.

8. Select **Time Of Flight (1 gate)** and click **Next**.

9. Make sure that **Time Of Flight** is selected from the list of measurements to make visible, then click **Next**.

10. Enter a custom name for the timer if desired, then click **Finish**.

11. Create a Digits display by double-clicking the **Digits** icon in the **Displays** palette.

12. Click **<Select measurement>** and select **Time of Flight** to assign the display to measure the fall time.

Data collection

1. In Capstone, click **Record** ⏺. This will start the experiment clock, indicating that the program is ready to collect data.

2. Press the Timer Switch button to release the object from the Drop Box. When the object hits the Time-of-Flight pad, the display in Capstone will record the fall time.

To time another object, hang the object from the Drop Box, wait until the LED on the Drop Box stops blinking, and repeat the previous two steps.
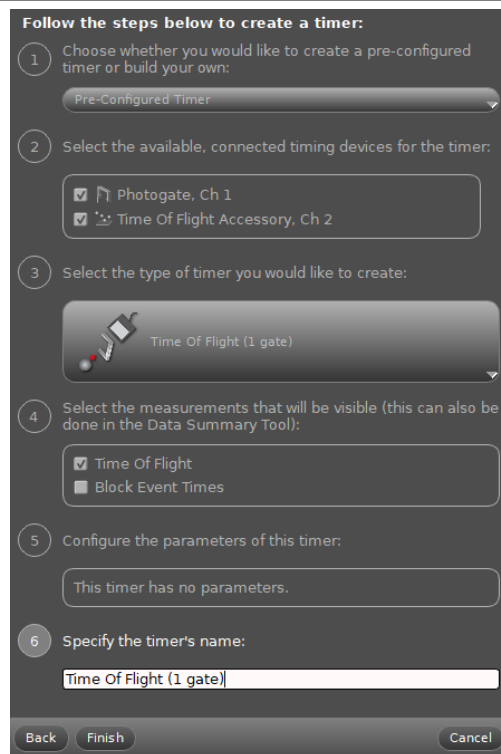

Figure 8. The proper timer configuration for performing experiments with the Discover Free Fall System in Capstone.

Suggested experiments

Fall time of different objects

Keeping the drop height constant, measure the free fall time of different objects. Measure the drop height from the Time-Of-Flight pad to the *bottom* of the object when it is hanging from the Drop Box. You will need to adjust the Drop Box position slightly for differently sized objects to ensure this height stays constant. Time each object several times to make sure you get an accurate measurement.

Compare objects of various sizes, masses, and densities. How does each factor seem to affect fall time?

If the *only* force acting on the objects is gravitational force, you would expect the fall time to be the same for every object. Do you find this to be the case?

Fall time versus height

Time a stainless steel ball dropping from several different heights. Use as wide a range of heights as possible.

Plot fall time (*t*) versus height (*h*) on a graph. Is the relationship linear?

Plot t^2 versus *h*. Is this relationship linear?

For an object falling with constant acceleration *a*, the relationship between *t* and *h* is given by:

$$t^2 = \frac{2}{a}h$$

Use your data to find *a* in this case.

Repeat the procedure with the large hollow ball. Does it accelerate at a constant rate? How can you tell?

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Software help

The SPARKvue and PASCO Capstone Help provide additional information on how to use this product with the software. You can access the help within the software or online.

⠞ SPARKvue

Software: Main Menu ☰ > Help

Online: help.pasco.com/sparkvue

◣ PASCO Capstone

Software: Help > PASCO Capstone Help

Online: help.pasco.com/capstone

Specifications and accessories

Visit the product page at pasco.com/product/ME-9889 to view the specifications and explore accessories. You can also download support documents from the product page.

Technical support

Need more help? Our knowledgeable and friendly Technical Support staff is ready to answer your questions or walk you through any issues.

☐ Chat	pasco.com	
☎ Phone	1-800-772-8700 x1004 (USA)	
	+1 916 462 8384 (outside USA)	
✉ Email	support@pasco.com	

Regulatory information

Limited warranty
For a description of the product warranty, see the Warranty and Returns page at www.pasco.com/legal.

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