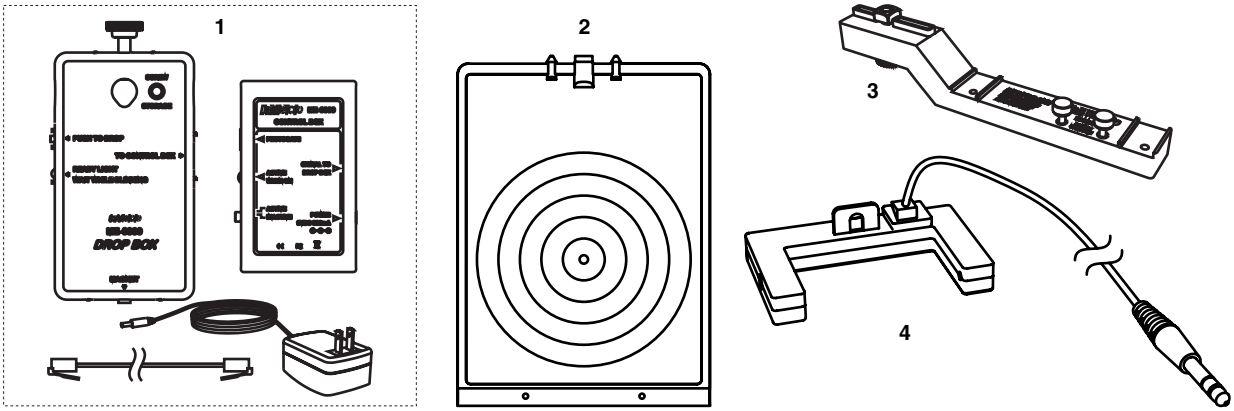
Shoot-the-target Accessory

ME-6853



Included Equipment	Part Number
1. Drop Box assembly:	ME-6839
Drop Box, main unit	
Control Box	
AC Adapter	
Cable (7.6 m length)	
2. Target	ME-6852
3. Photogate Bracket	ME-6821A
4. Photogate	ME-9498A
Required Equipment	
Projectile Launcher	ME-6800, ME-6801, or ME-6825A
C-clamp	SE-7286 (6-pack) *or similar*
Steel ceiling or rod for drop box mounting (see page 3)	
Optional Equipment	
Laser Sight	OS-8527A

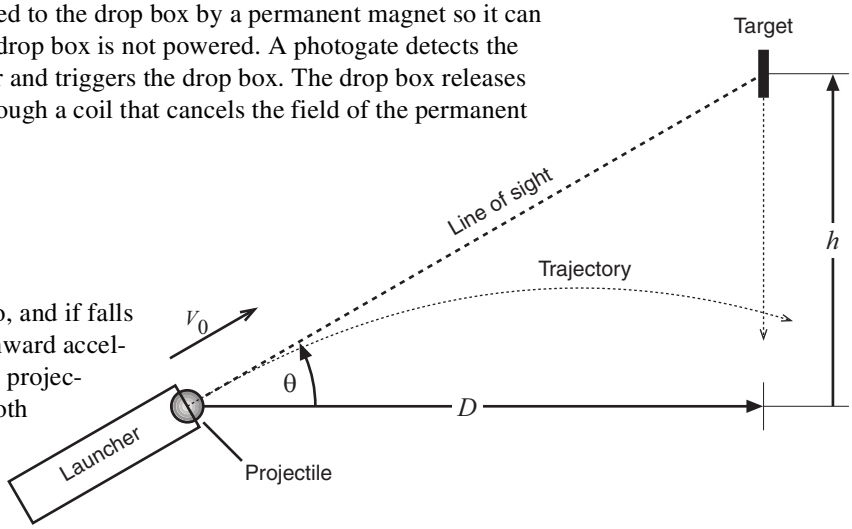
Introduction

The PASCO Shoot-the-target Accessory, in combination with a projectile launcher, demonstrates that acceleration is constant for all objects in free-fall regardless of initial velocity. A target is initially suspended near the ceiling, and a projectile launcher is aimed directly at it. As soon as the projectile is shot from the launcher, the target is released. The projectile hits the target as it falls, proving that both objects accelerate downward at the same rate.

Before it falls, the target is attached to the drop box by a permanent magnet so it can hang indefinitely, even when the drop box is not powered. A photogate detects the projectile as it leaves the launcher and triggers the drop box. The drop box releases the target by driving a current through a coil that cancels the field of the permanent magnet.

Theory

The target's initial velocity is zero, and if falls straight down with constant downward acceleration. The initial velocity of the projectile as it leaves the launcher has both horizontal and vertical components, but it undergoes the same acceleration as the target.



At elapsed time t, the vertical position of the target is given by

(eq. 1) $$y_T(t) = h - \frac{1}{2}gt^2$$

where h is the initial height of the center of the target (measured from the elevation of the end of the launcher), and g is the gravitational field strength.

The vertical and horizontal positions of the projectile are given by

(eq. 2) $$y_P(t) = v_0 \sin(\theta)t - \frac{1}{2}gt^2$$

and

(eq. 3) $$x_P(t) = v_0 \cos(\theta)t$$

where v_0 is the launch speed of the projectile as it leaves the launcher.

If the horizontal distance from the launcher to the target is D, and the projectile will reach the target's horizontal position at time t', then

(eq. 4) $$D = v_0 \cos(\theta)t'$$

By examining the diagram, we can also see that

(eq. 5) $$D = \frac{h}{\tan(\theta)}$$

Combining equations 4 and 5 and using the trigonometric identity $\tan(\theta) = \sin(\theta)/\cos(\theta)$ yields

(eq. 6) $$v_0 \sin(\theta)t' = h$$

Substituting equation 6 into the first term on the right side of equation 2 yields

(eq. 7) $$y_P(t') = h - \frac{1}{2}gt'^2$$

By comparing equations 1 and 7 it is evident that at time t' the target and projectile will be in the same place.

The formula for the height of collision (measured relative to the launcher) is

(eq. 8) $$y' = h - \frac{1}{2}g\left(\frac{D^2 + h^2}{{v_0}^2}\right)$$

Note that increasing h (the initial height of the target) while holding the other parameters constant may increase *or* decrease y', depending on the values of g, D and v_0.

Drop Box Mounting Options

Typically, the drop box is mounted close to the ceiling with the launcher aimed at the target from a lower position.

One option is to attach the drop box to a steel part of the ceiling using the magnets embedded in the top of the drop box (see Figure 1). The suspension grid of a tile ceiling, the top of a metal door frame, or a ceiling vent would work well for this purpose.

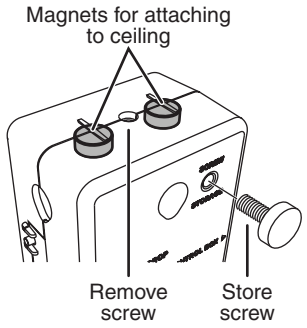


Figure 1: Magnets for attaching to ceiling

Alternatively, the drop box can be mounted on a horizontal rod attached to a wall or tall vertical rod (see Figure 2).

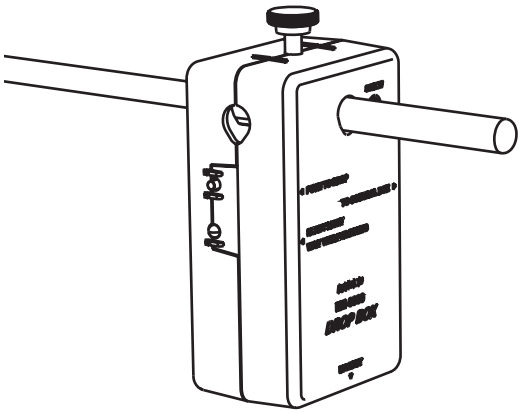


Figure 2: Drop box mounted on horizontal rod

Equipment Set-up

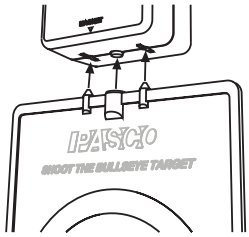


Figure 3: Key the protrusions on the target into the holes in the drop box

1. Connect the included AC Adapter to a wall outlet and to the **POWER** jack on the control box.
2. Connect the photogate to the **PHOTOGATE** port on the control box.
3. Use the included 7.6 m cable to connect the **SIGNAL TO DROP BOX** jack on the control box to the **TO CONTROL BOX** jack on the drop box.
4. Mount the drop box as described on page 3.
5. Hang the target from the magnet on the underside of the drop box. Key the protrusions on the target into the holes in the drop box on either side of the magnet (as shown in Figure 3).
6. Install the photogate mount and photogate on the launcher as shown in Figure 4. Position the photogate so it will be blocked as soon as the projectile leaves the launcher.
7. Clamp the base of the projectile launcher to a bench or other stable object. The launcher should be close enough to the drop box for the projectile to pass under the drop box before it hits the floor.
8. Aim the launcher directly at the target. Look into the back of the launcher and through the two sights inside the launcher. Adjust the angle of the launcher to align the sights with the center of the target.

   Alternatively, if you have the optional Laser Sight, install it on the launcher (see included instructions) and aim the laser at the target.
9. Set the **ACTIVE/INACTIVE** switch on the control box to **INACTIVE**.
10. Place the projectile in the launcher and use the included pushrod to push it into the first, second, or third setting (for as slow, medium, or fast launch).
11. Set the **ACTIVE/INACTIVE** switch on the control box to **ACTIVE**.
12. Pull the launcher trigger to fire the projectile and make the target drop.

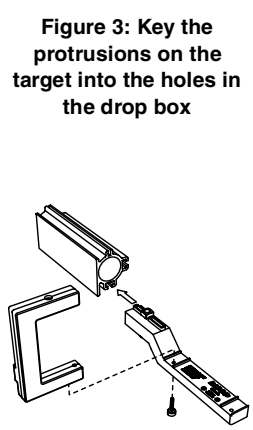
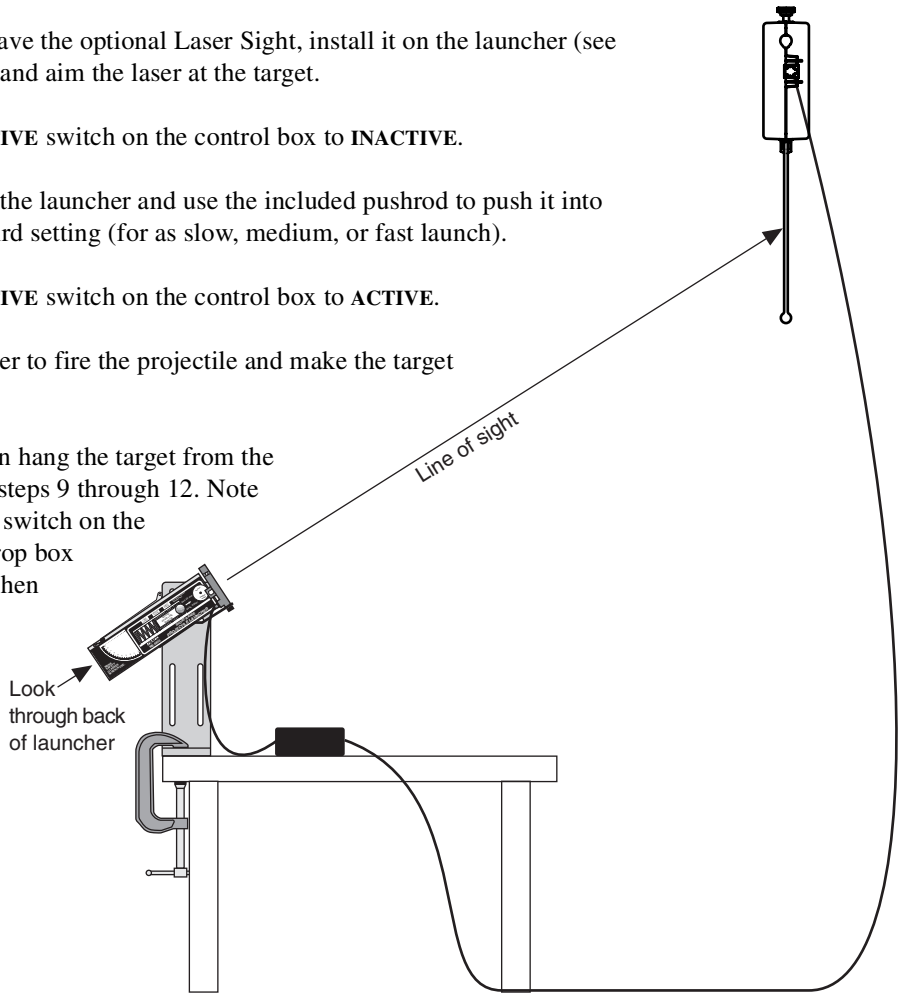


Figure 4: Install photogate mount and photogate on launcher

To repeat the demonstration hang the target from the drop box again and repeat steps 9 through 12. Note that the **ACTIVE/INACTIVE** switch on the control box prevents the drop box from releasing the target when you block the photogate while loading the launcher.

Immediately after the target drops, a green light on the drop box blinks for several seconds to indicate that drop box is recharging. Wait until it stops blinking before launching the projectile.

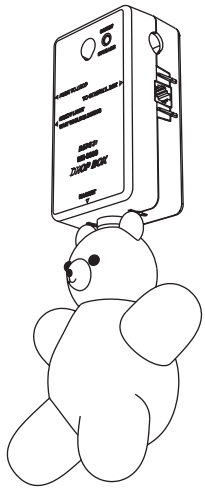


Troubleshooting

Problem	Possible Cause	Solution
Projectile and target hit floor before they collide	Elapsed time for projectile to traverse horizontal distance between launcher and target exceeds time for target to reach floor	Possible solutions: • Use faster launch velocity. • Move launcher closer to target and re-aim. • Mount launcher higher and re-aim. • Move drop box up or down and re-aim (see equation 8).
Target does not drop	**ACTIVE/INACTIVE** switch set to **INACTIVE**	Set the switch on the control box to **ACTIVE**.
	READY light is blinking	Wait until the **READY** light glows steadily.
	Cable disconnected	Ensure that the cables from the photogate to control box and from the control box to the drop box are properly connected.
	Control box not powered	Ensure that the AC adapter is powered and connected to the control box.
	Projectile does not pass through photogate beam	Adjust photogate position.
	Target is too light (if using a target other than the included one)	Add weight to target
Projectile misses target	Launcher badly aimed	Remove projectile from launcher, hang target from drop box, and re-check aim by sighting through back of launcher or using optional laser sight.

Alternative Targets

Instead of the included target, you can have the drop box release a different object such as a toy stuffed animal. The object should be massive enough to fall with constant acceleration, but not more than about 400 g. Attach a piece of steel to the object so that it can be suspended from the permanent magnet of the drop box. Use a larger piece of steel for a heavier object.



Technical Support

For assistance with any PASCO product, contact PASCO at:

Address: PASCO scientific
10101 Foothills Blvd.
Roseville, CA 95747-7100

Phone: 916-786-3800 (worldwide)
800-772-8700 (U.S.)

Fax: (916) 786-7565

Web: www.pasco.com

Email: support@pasco.com

Limited Warranty For a description of the product warranty, see the PASCO catalog.

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