Vernier Projectile Launcher
(Order Code VPL)



The Vernier Projectile Launcher allows students to investigate important concepts in two-dimensional kinematics.

Sample experiments include

- Investigate projectile range as a function of launch angle.
- Measure the launch speed of a projectile.
- Predict the ball landing point from the initial speed of a horizontally launched ball.
- Predict the ball landing point from the initial launch speed and angle.
- Attempt to hit a target.

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
- Vernier Projectile Launcher
- 6 Steel balls
- Hand pump
- 2 Pairs of safety goggles
- Level
- Roll of wax marking paper
- Photogate cable

Compatible Software and Interfaces
See **www.vernier.com/manuals/vpl** for a list of interfaces and software compatible with the Vernier Projectile Launcher.

Getting Started

Computer, Chromebook, or Mobile Device

1. Connect the included photogate cable to the Interface port on the projectile launcher.
2. Connect the projectile launcher to the interface (LabQuest® 2 or newer, LabQuest Stream, or LabQuest Mini).
3. Connect the interface to your computing device.
4. Launch the data-collection software (Vernier Graphical Analysis® or Logger *Pro*™).

LabQuest 2 or newer (as a standalone device)

1. Connect the included photogate cable to the Interface port on the projectile launcher.
2. Connect the projectile launcher to LabQuest 2 or newer.
3. Turn on LabQuest 2 or newer and choose New from File menu.

The software will identify the sensor and load a default data-collection setup. You are now ready to collect data.

For up-to-date connection information for your specific equipment, see

www.vernier.com/start/vpl

Powering the Sensor
Power is required in order for the launcher to fire. The sensor gets its power from the interface. **Note:** Some interfaces such as the LabPro® do not supply power to the sensor ports unless the data-collection software is also running.

Optionally, you may choose to use the LabQuest Power Supply (order code LQ-PS – not included) to power the unit without using an interface.

Using the Product
Follow these steps when using the Projectile Launcher when performing basic launch experiments.

1. Place the launcher on a flat surface and secure it. We recommend placing the launcher on a sturdy table and securing the launcher to the table with table clamps (not included).
2. Connect the hand pump to the launcher.
3. Connect the sensor following the steps in the Getting Started section of this user manual.
4. Loosen the lower knob on the back of the unit and adjust the orientation of the launch chamber until level as indicated by the included level. Tighten the lower knob.
5. Use the upper knob on the back of the unit to adjust the position of the angle markings until the zero marking is aligned with the center of the launch chamber and secure the upper knob.
6. Loosen the lower knob and move the launch chamber to the desired launch angle, then secure the knob.

7. Set the release pressure by adjusting the range knob. Turn clockwise for higher pressure and higher muzzle velocity and counter-clockwise for lower pressure and lower muzzle velocity.
8. Insert one steel ball into the barrel. The easiest way is to insert the ball into the launch chamber with your index finger and guide the ball into the barrel. The ball should seat all the way to the back of the launch chamber.
9. Pump the hand pump until the pressure stabilizes. You should hear a small release sound when that pressure is reached. We recommend listening for at least three small release sounds and then waiting for five seconds to ensure the pressure has fully stabilized.
10. Start data collection.
11. Press and hold the Arm button. While still pressing the Arm button, press the Launch button to launch the steel ball.
12. Observe the range of the ball and position the waxed tape along the line of sight for subsequent data collection.

Videos

View videos related to this product at **www.vernier.com/vpl**

Specifications

Launch angle	0–70 degrees
Launch speed	0–6 m/s
Launch height	146 mm
Maximum launch distance	2.5 m
Internal photogate interval	50 mm
Steel ball diameter	17.46 mm
Steel ball mass	21.8 g
Maximum pressure (pressurizing chamber)	100 PSI

Safety

Two pairs of safety goggles are included for safety. We recommend students and instructors wear the goggles at all times while using this product, including anyone in the vicinity of the projectile launch and landing areas. If needed, additional safety goggles can be purchased from Vernier (see Accessories/Replacement Parts).

The launching system requires simultaneous engagement of the "Arm" and "Launch" buttons to prevent accidental launches. Do not attempt to override or disable this feature.

Other safety considerations

- Do not put your face, hands, or other body parts near the end of the barrel while launching.
- Do not aim the launcher at a person or animal.
- Do not attempt to remove the ball from the launch chamber by hand while the chamber is pressurized.
- Only apply pressure to the chamber using the pump provided.
- **Important**: Do not exceed 100 PSI when pressurizing the chamber.

Care and Maintenance

Storing the Launcher

Do not store the launcher while pressurized. Fire the launcher several times before removing power, or use the release button located on the pump, below the pressure gauge, to release residual pressure. Remove the pump from the launcher.

Storing the Projectiles

The balls are not stainless steel and can corrode over time when exposed to warm, humid environments. To reduce the likelihood of corrosion, keep the balls sealed in an airtight container such as a zipper closure bag. In very humid environments, consider including a desiccant packet in with the balls.

If the balls do corrode, they will need to be replaced. Do not use any kind of oil on the balls in an attempt to remove the corrosion, as oil will damage the launcher.

Cleaning the Projectiles and Launcher

Over time, the projectiles (balls) may transfer some dirt to the inner surface of the barrel. The design of the launcher depends on a close fit between the ball and the barrel, so any additional material will cause friction and launch irregularities.

Occasional cleaning of the projectiles with a clean rag and a commercial solvent such as Goo Gone® or Goof Off® will help keep dirt out of the barrel. Isopropyl alcohol is not recommended for this purpose since it will not remove wax, a common source of the dirt.

If dirt does get into the barrel, use compressed air to remove any loose debris from the chamber. If necessary, wipe the inside of the barrel with a clean rag and solvent as noted above. If the solvent does not remove enough material, wipe the inside of the barrel near the lip with 1500 grit sandpaper. It is important to use very fine sand paper; if a coarser grit is used, the inner dimension of the barrel may change too much, damaging the launcher.

Water Resistance

The Vernier Projectile Launcher is not water resistant and should never be immersed in water or used in wet environments.

If water gets into the device, immediately disconnect any cables from the unit. Allow the device to dry thoroughly before attempting to use the device again. Do not attempt to dry using an external heat source.

How Sensor Works

The Projectile Launcher is used to investigate important concepts in two-dimensional kinematics. A steel ball placed in the launch barrel can be projected with different launch velocities and at different launch angles. A unique pneumatic

launching system provides excellent repeatability at angles between 0° and 70° and up to a distance of 2.5 m. **Note:** As launch angle increases above 70°, the trajectory may deviate from the expected direction of parallel to the vertical plane of the back of the launcher.

The included hand pump is designed for generating the necessary pressure for the pneumatic launching system. The Range turn-knob controls the maximum pressure of the chamber, allowing for different projectile ranges given a constant launch angle. The pump includes a pressure gauge in order to return to an approximate launch speed used earlier. Note that a constant chamber pressure does not guarantee a constant launch speed at different launch angles.

The launching system requires simultaneous engagement of the "Arm" and "Launch" buttons to initiate a launch. This allows the ball to be launched quickly and easily, while ensuring students' safety. For more details on the launch procedure, see Using the Product section in this document.

Two photogates positioned within the launch chamber allow for precise determination of the ball's launch speed using Vernier's software applications. To do this, the software records the time when the ball initially blocks each gate then calculates the difference, known as the pulse time. The launch speed of the ball is then determined from the ratio of the separation distance of the photogates and the pulse time. Alternatively, the software can be configured to record the duration the first gate is blocked, known as the gate time. With this configuration, the average speed of the ball is determined from the ratio of the ball's diameter (0.0174625 m or 11/16 in) and the gate time.

When using the optional Time of Flight Pad accessory, the time between the initial blocking of the first gate and the projectile striking the Time of Flight Pad is used to determine time of flight. **Note:** the Time of Flight Pad connects to the Vernier Projectile Launcher accessory port.

Note: The two embedded photogates and the accessory port are physically linked together (daisy-chained) to provide a single column output from the sensor, reported as Gate State.

Sample Experiments

There are a variety of experiments that can be performed with this Projectile Launcher. Below, you will find several detailed examples. You might want to try them out to learn more about the equipment.

Investigate Projectile Range as a Function of Launch Angle

As a preliminary inquiry activity prior to the study of two-dimensional kinematics, have the students measure the launch range as a function of launch angle.

1. Follow the basic launch procedure for a launch angle of 5°.
2. Launch the ball such that it strikes the tape.
3. Increase the angle 5° for the second trial.
4. Repeat Step 3 up to a launch angle of 70°.
5. Examine the relationship between launch angle and range. Determine which launch angle produces the maximum range. Note any launch angles that appear to have the same range.

Measure the Launch Speed

Most of the experiments involving the projectile launcher require measurement of the initial launch speed.

1. Follow the basic launch procedure for a horizontal launch angle (e.g., 0°), but do not perform the test launch.
2. Position an empty box standing vertically about 50 cm in front of the launcher to catch the ball.
3. Launch the ball into the box.
4. Record the launch speed.
5. Collect nine more readings.
6. Determine the average launch speed and its standard deviation.

Predict the Landing Point from the Launch Speed

Once the launch speed of the projectile is known, students can use their knowledge of two-dimensional kinematics to predict where the projectile will land. This activity can be especially challenging if the students use the technique noted above of catching the ball in a box shortly after it leaves the launcher. This approach prevents the students from visually estimating where the ball will land.

1. Determine the launch speed as described in the section above.
2. Move the setup such that the ball will be launched from the end of a table.
3. Use kinematics to calculate the landing spot.
4. Place one or two pieces of the waxed marking paper at that location.
5. Test your predictions.

Extension 1 – Change the launch speed and repeat Steps 1–5 above.

Extension 2 – Collect nine more readings. Calculate the range spread and the lateral spread from your prediction.

Predict the Landing Point from the Launch Speed and Angle

Perform the same steps as in the previous experiment, but this time launch the ball at various angles.

Attempt to Hit a Target

Challenge your students to launch a ball at a particular target and hit the target on their first trial. For example, challenge them to launch the ball horizontally from a tabletop into an empty soup can. Prior to their only trial, allow them to make as many measurements as needed to best determine the launch speed. In measuring the launch speed, do not allow them to actually project it off the table. Rather, specify that the ball be "caught" by an object such as an open box.

Troubleshooting

For troubleshooting and FAQs, see **www.vernier.com/til/2592**

Repair Information

If you have watched the related product video(s), followed the troubleshooting steps, and are still having trouble with your Vernier Projectile Launcher, 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

Accessory	Order Code
Time of Flight Pad	TOF-VPL
Independence of Motion Accessory	IOM-VPL
Projectile Stop	PS-VPL

Replacement Part	Order Code
Wax Tape (300 feet)	WXT-VPL
Steel Balls (set of 6)	STB-VPL
Goggles (set of 2)	GGL-VPL
Hand Air Pump	PUMP-VPL
BT Photogate Cable	PG-BTD

Warranty

Warranty information for this product can be found on the Support tab at **www.vernier.com/vpl**

General warranty information can be found at **www.vernier.com/warranty**

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.

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

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