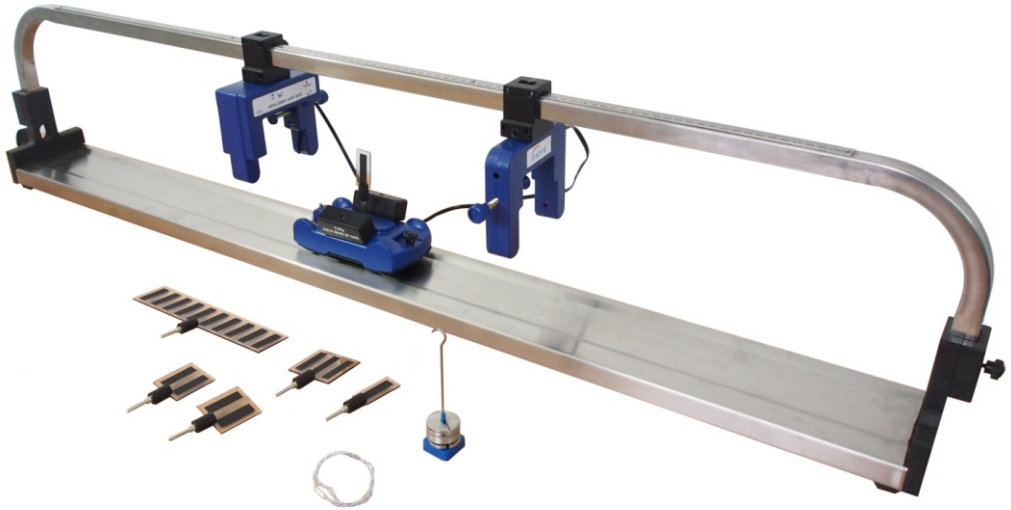
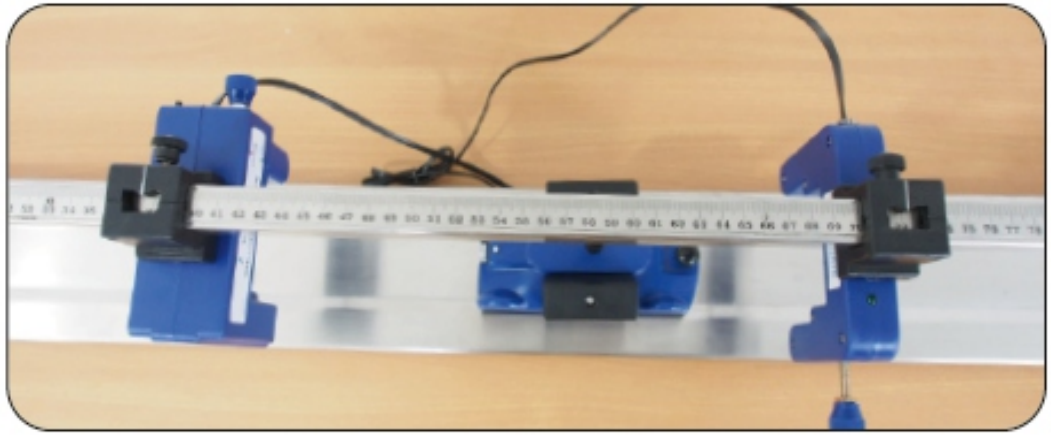
LAW OF MOTION KIT

Law of motion kit has been designed to study the linear motion of an object, Newton's law of motion, elastic and inelastic collision. In the present setup, the runway used for all experiments is made of superior quality stainless steel having smooth surface with linear grooves for smooth motion of trolley. A plastic pulley is fixed at one end to hang a weight.

An inverted U-shaped channel with rectangular cross-section is attached to the two ends of the track. Two sliders can slide over this pipe. Primary and secondary light gates can be attached to the sliders. A meter scale is attached above the channel for accurate positioning of the sliders.





Top view to read Light Gate Position

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EXPERIMENT:

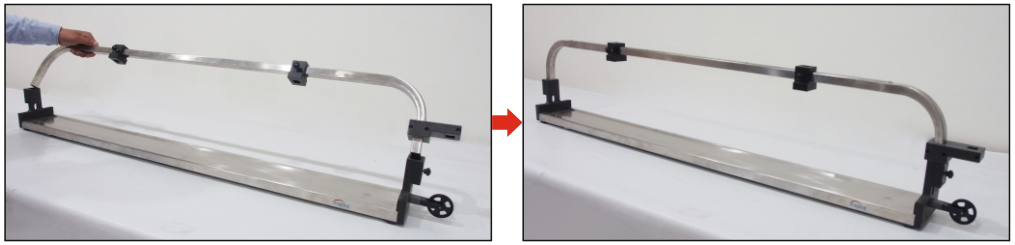
1. Velocity
2. Acceleration
3. Elastic Collision
4. Inelastic Collision
5. Newton's 2nd Law Of Motion

APPARATUS DETAILS:

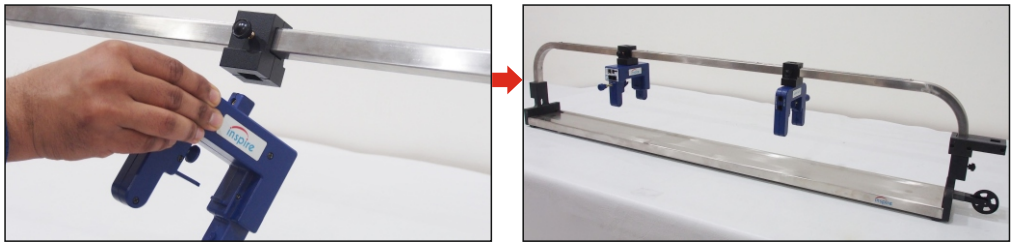
1. Track for dynamic trolley
2. Channel with meter ruler and sliders
3. Dynamic trolley
4. Primary light gate
5. Secondary light gate
6. RJ Connector
7. Attachment for primary light gate for Pulley motion
8. Accessories
9. Slotted Masses
10. Light gate mount

HOW TO ASSEMBLE

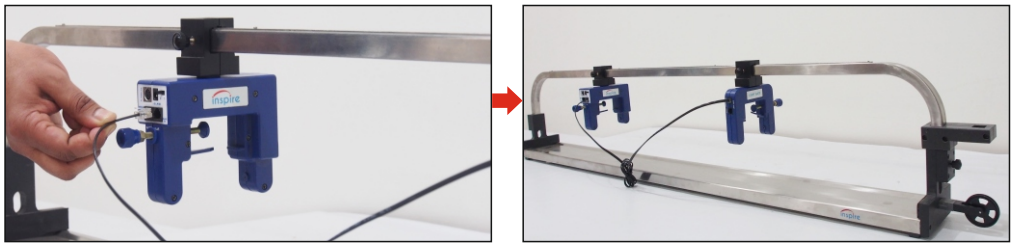
1. Insert the two legs of the U – channel into the slots at the two ends of the dynamics track as shown.



2. Attach Light gates to the sliders.



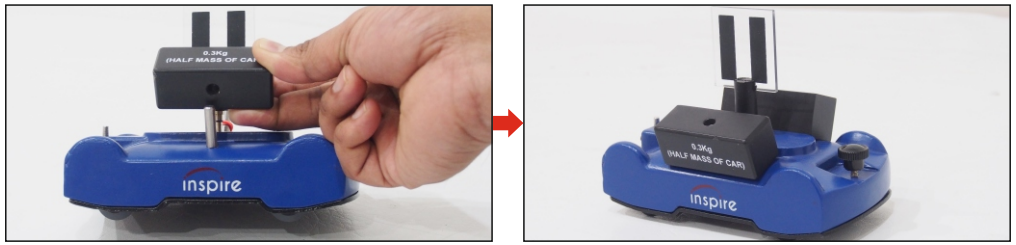
3. Make connection between the Light Gates using BNC - BNC cable.



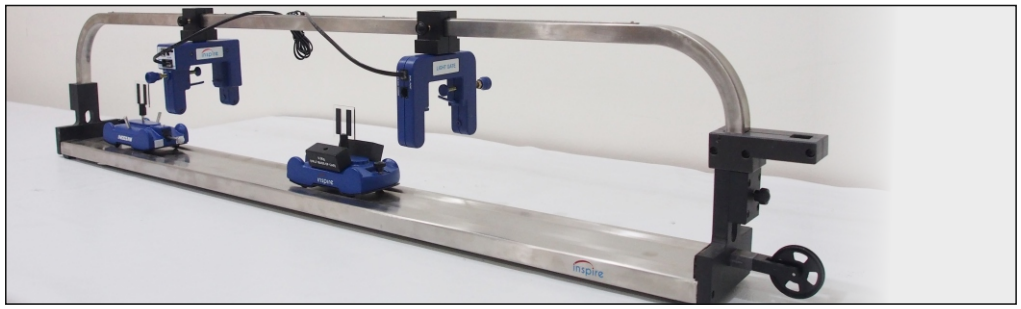
4. Place the two light gates at the desired distance and tighten the knobs.

5. Attach pickets to the trolleys.

6. Mount additional weights to the trolley.



7. Place the trolleys on the dynamic track.



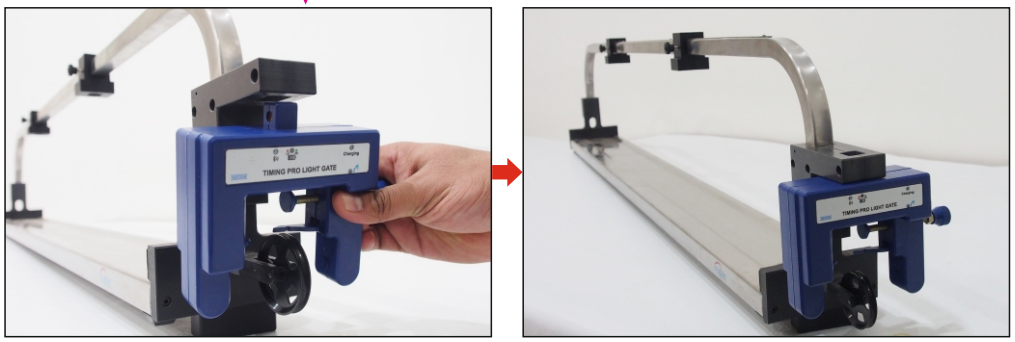
TRACK

The surface of the track is flat and allows the trolleys to move with little friction. The track also guides the trolleys to run in a straight line.

Two sliders can slide through the inverted U-channel. Light gates may be fitted into these sliders.

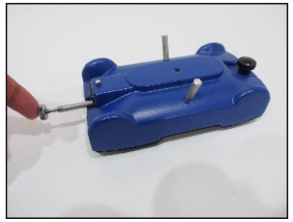
The free-running pulley fitted to one end allows the trolleys to be accelerated by connecting them to a falling mass, using the cord provided.
The pulley has four wheels which interrupts the light gate during the motion of the pulley. A plot of velocity and angular momentum can be obtained in the software.
A separate provision for attaching the light gate above the pulley is shown here:

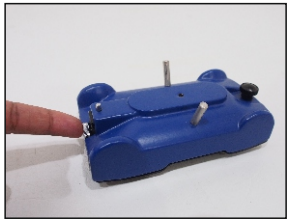
Attach the light gate here for pulley mode

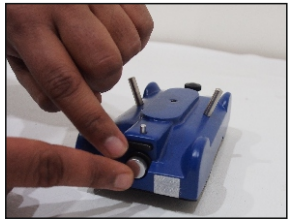


TROLLEY DESCRIPTION

The trolleys have spring loaded wheels.
A knurled knob can be used to attach cord or ticker tape
The central hole in the top surface takes a standard 4mm plug, giving a quick and easy way to attach any picket to the trolley.
Side plugs are used for attaching additional weights.
Each trolley has a spring-loaded plunger. This provides a means to launch either trolley from one of the track end, or to create an “explosion” where the two trolleys fly apart.
Press the plunger into the trolley body, then press the black button above the plunger to arrest the plunger. The release pin pops up.

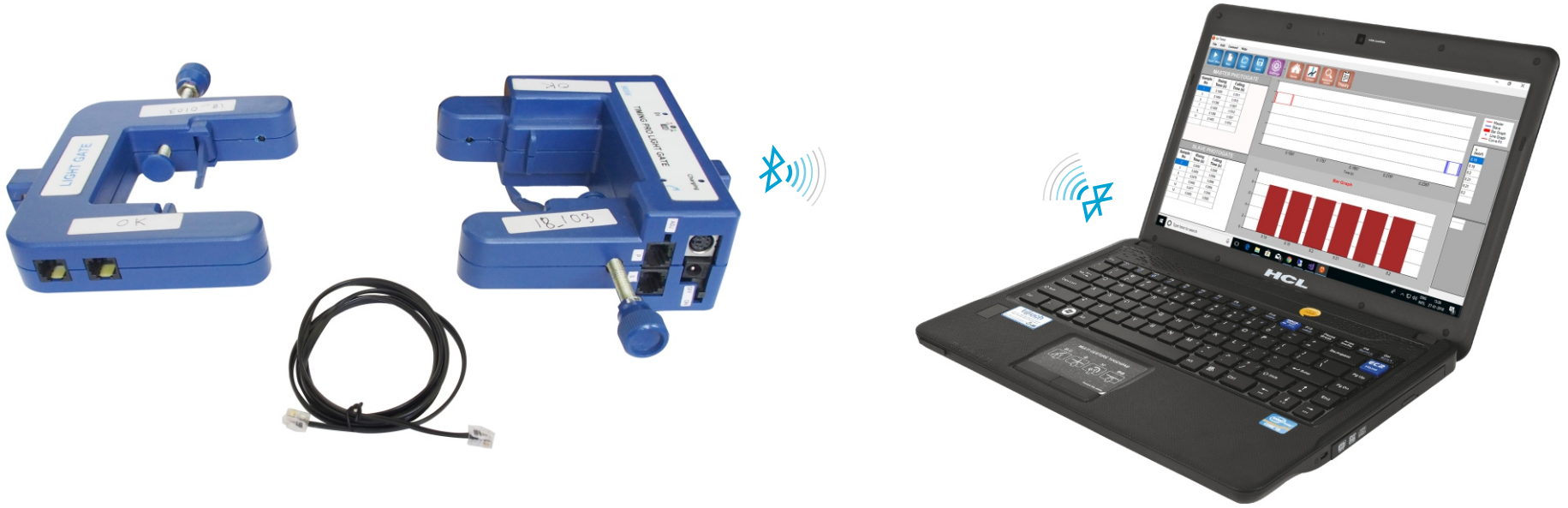






It is released by pressing or striking down on the metal pin above the plunger. A light hammer could be used, taking care not to strike the body of the trolley.
A pair of the velcro pads are attached to both cars to facilitate the inelastic collision.

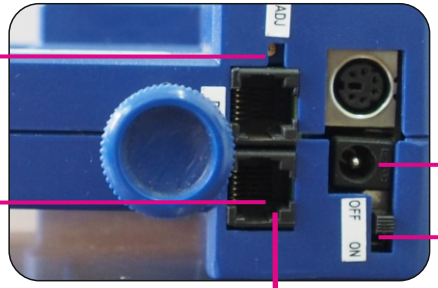
Timing Pro Light Gates consists of a set of Primary and Secondary Light Gates with Bluetooth connectivity to a smart device or PC. The Primary Light Gate has built in timer, solenoid attachment port and two channels(Primary & Secondary) on which unlimited Secondary Light Gates can be daisy changed. It has several advanced features over the conventional Timer by making use of dedicated software on PC and apps for Android/iOS which graphically displays the blocked pulse as a function of time for two channels. The Primary Light Gate contains Micro-controller having crystal controlled time base to accurately measure the time with least count time resolution of 0.1millisecond. Communication between Primary and Secondary Light Gates as well as Primary Light Gate and Solenoid is carried on via wire link and that between the Primary Light Gate and Computer is made through wireless Bluetooth link.



It can be used with Air track and Dynamic Trolleys to comprehensively study several experiments on kinematics and dynamics which requires light gate. An inbuilt rechargeable cell on Primary Light Gate provides power for the set-up. The Primary light gate also provides both power and trigger to an optional solenoid. Special circuits conserve battery power on the Light Gates and Solenoid. The solenoid has sensing circuits to detect object placed and then only energises the solenoid. The Solenoid winding has a resettable thermal fuse to prevent from overheating. The user-friendly software also contains templates for various experiments: Velocity, Acceleration, Collision, Picket Fence. *'g'* by Free Fall and many more.

ATTACHMENT WITH LAW OF MOTION KIT

Sensitivity Adjustment Pot



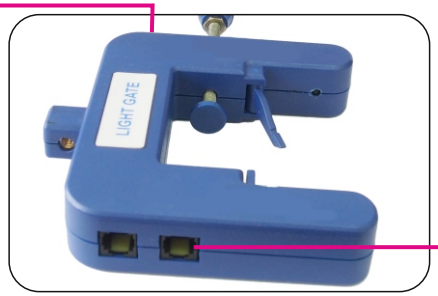
Charging Port

ON/OFF switch

Port for attachment for secondary Light Gates using RJ connector

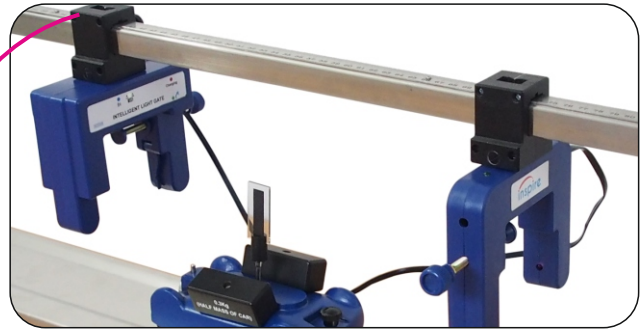
Port for attachment for secondary Light Gates using RJ connector Align cable and insert

Sensitivity Adjustment Pot

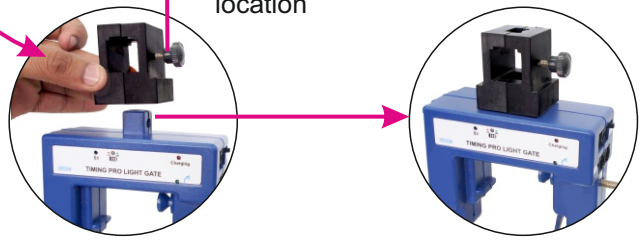


RJ connector from primary light gate will attach here

Timing Pro Light Gate with Inspire Law of Motion Kit maintain perfect alignment for experiments.



Knob to tighten on track at desired location



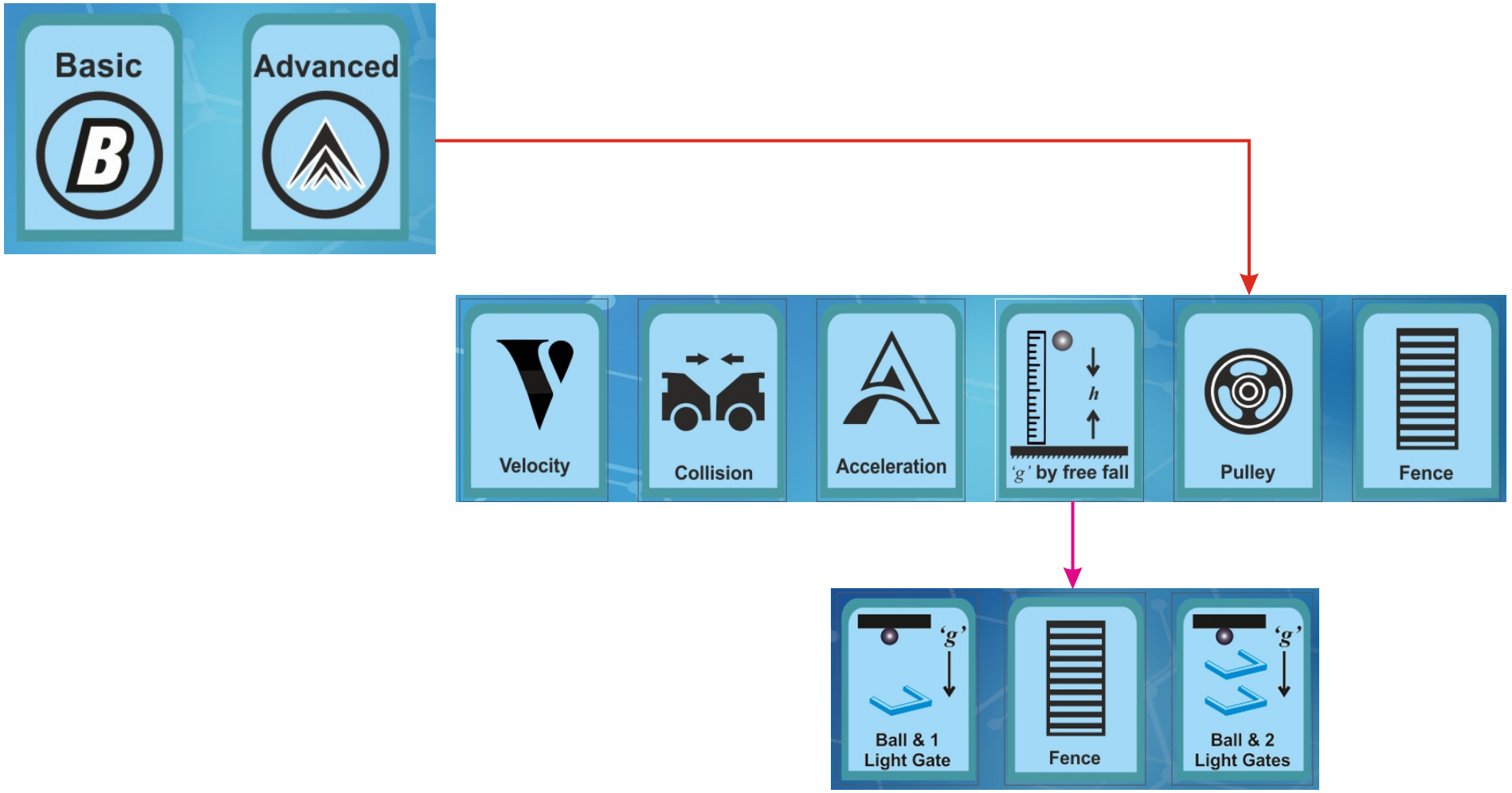
Light Gate can be pressed and attached

BASIC & ADVANCED MODE

To started, you need to install the 'Timing Pro Light Gates Software' in your computer.

Basic & Advanced Features

When the application is launched, a screen appears to allow the user to choose either Basic or Advanced version.

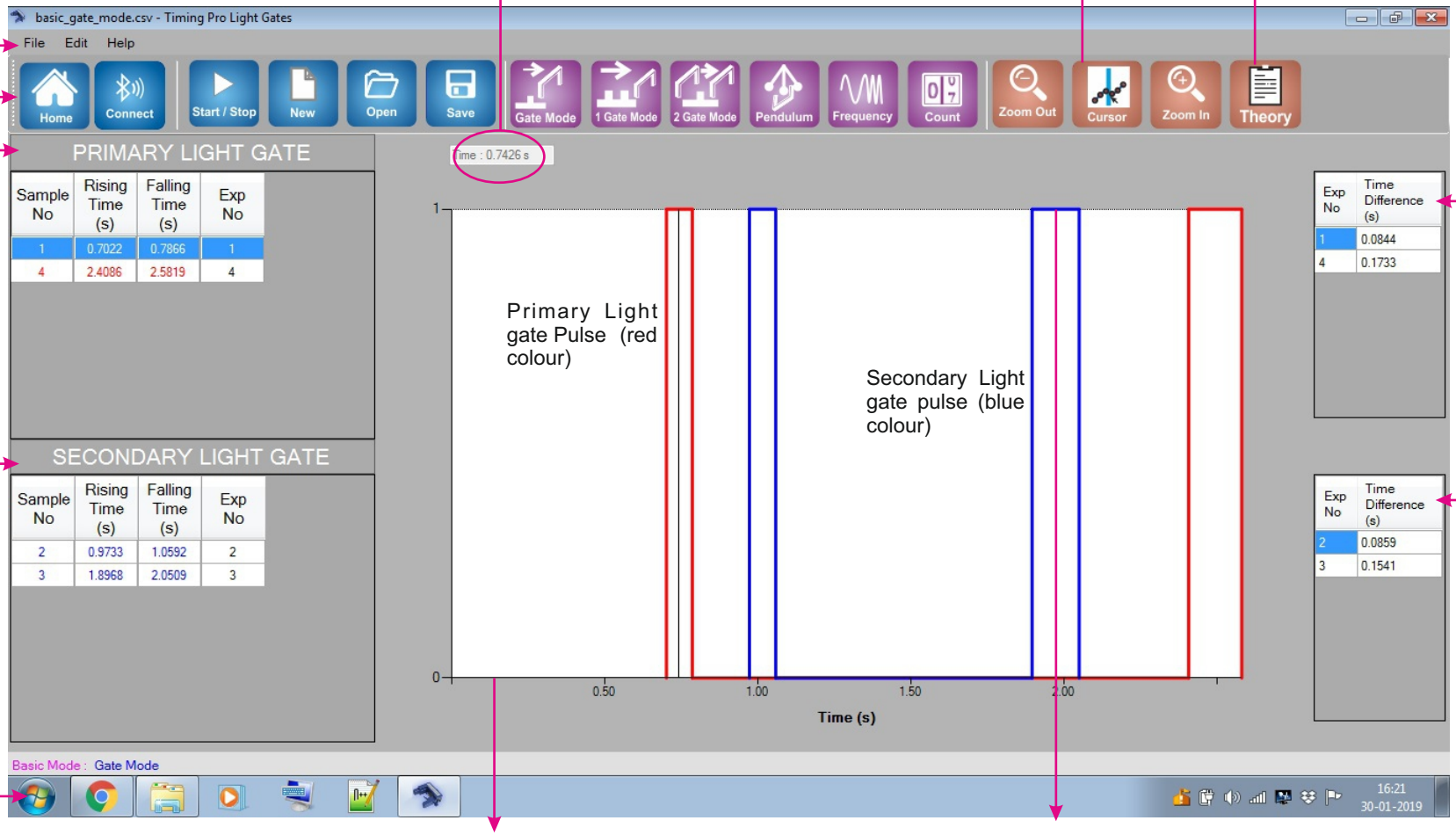


SCREENSHOT

When clicked the Cursor shows the time value of the pointer when moved over the graph area.

The theory of current experiment can be viewed from here.

The time value of the Cursor pointer is displayed here.



Menu Bar

Icon Bar

Table Area

Status Bar

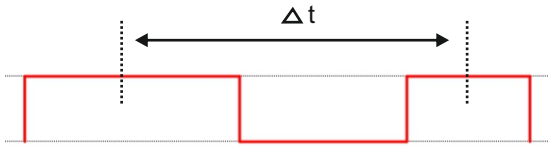
Output Data Tables

Lower level of Light Gates Pulse. It indicates that Light Gate is not blocked.

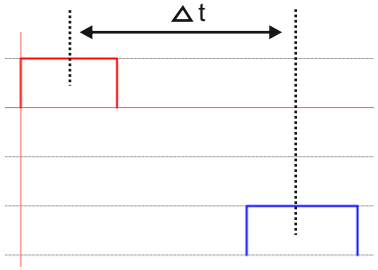
Upper level of Light Gates Pulse. It indicates that Light Gate is interrupted.

BASIC MODE

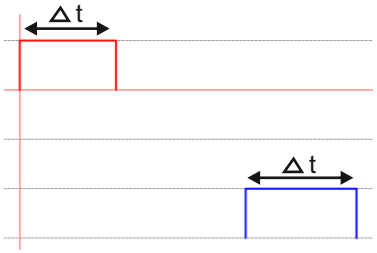
1-Gate mode: Time difference is measured from average time (of rising edge and falling edge) of first interruption to the average time (of rising edge and falling edge) of second interruption. Hence, the timer actually measures the average time between two successive blockings of the beam.

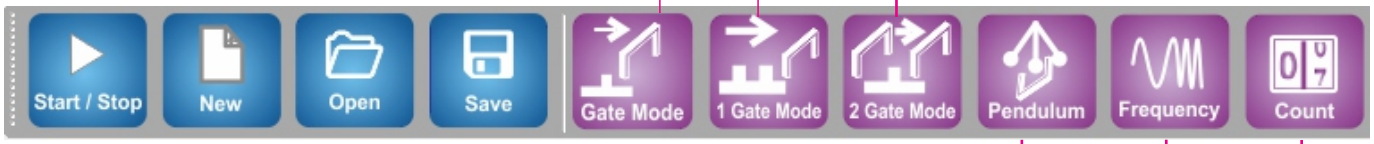


2-Gate mode: Time difference is measured from average time (of rising edge and falling edge) of first interruption at one light gates to the average time (of rising edge and falling edge) of second interruption at second light gate. Hence, the timer actually measures the average time between two successive blockings of the beam at two different Light Gates.

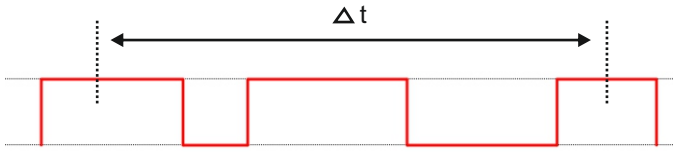


Gate mode: Time difference is measured from rising edge to falling edge.





Pendulum: Pendulum Mode measures time between 1st and 3rd interruptions of the Light Gates beam i.e. from average time (of rising edge and falling edge) of first interruption to the average time (of rising edge and falling edge) of third interruption.



Frequency: Frequency Mode measures the number of interruptions per second of the Photogate beam from leading edge of the first interruption to leading edge of the last interruption.

Count: This mode simply counts the blocking of photogates at regular intervals of time as specified by the user.

COLLISION MODE

This mode helps to find the velocities of cars/trolleys or any other moving objects before and after collision.

You have to use 1b - mask or 2b - mask to find velocities.

1. Go to Advanced ⟶ Collision.

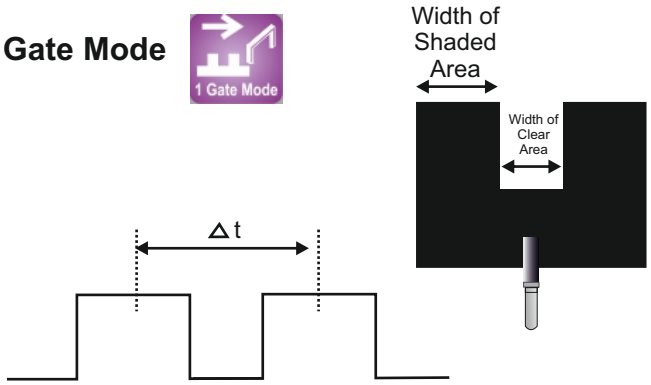
2. Arrange the set-up as per the requirement of the experiment.

3. Mount either the blockage (or 1b - mask) or 2b-mask on the moving objects and ensure that they would block the light gate beams while passing through them.

4. (a) If using 1b - mask or any other blockage card, then click on Gate Mode.

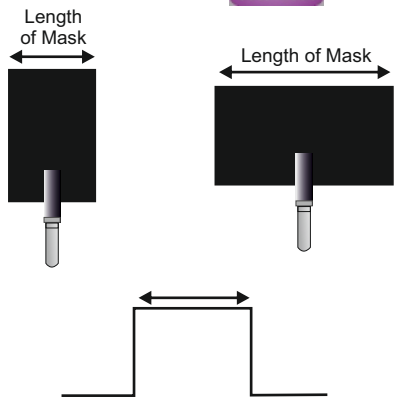
   (b) If using 2b - mask, then click on 1-Gate Mode.

1 Gate Mode



$$\text{Velocity} = \frac{\text{Width of Shaded Area + Width of Clear Area}}{\Delta t}$$

Gate Mode



$$\text{Velocity} = \frac{\text{Length of Mask}}{\Delta t}$$

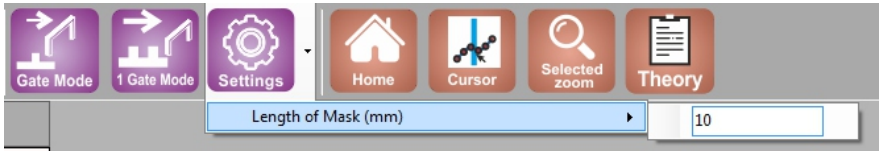
COLLISION MODE

5. Click on Settings:
   (a) If using **1b - mask,** or any other blockage card, then enter length of Mask.

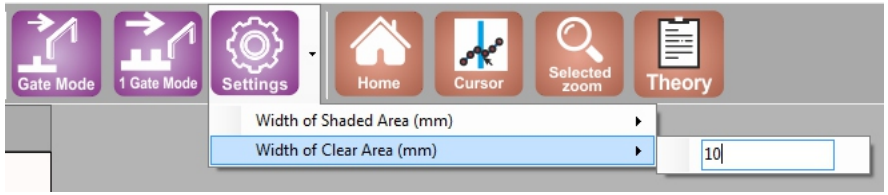
   (b) If using **2b - mask,** then enter Width of Shaded Area & Width of Clear Area.

6. Establish Bluetooth connectivity and Perform collision.

7. Observe velocities before and after collisions in output data tables and analyse those data.



5(a)



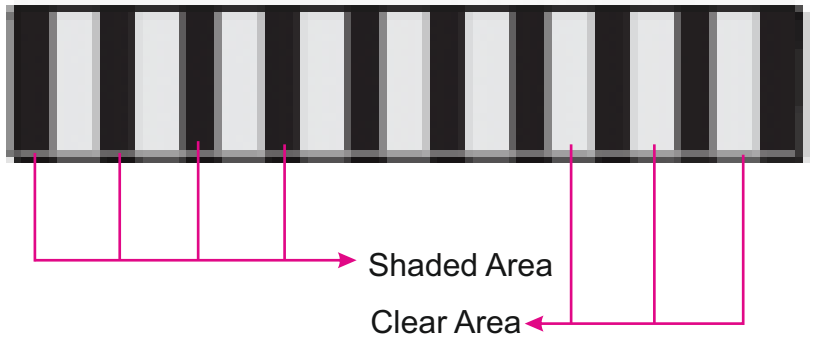
5(b)

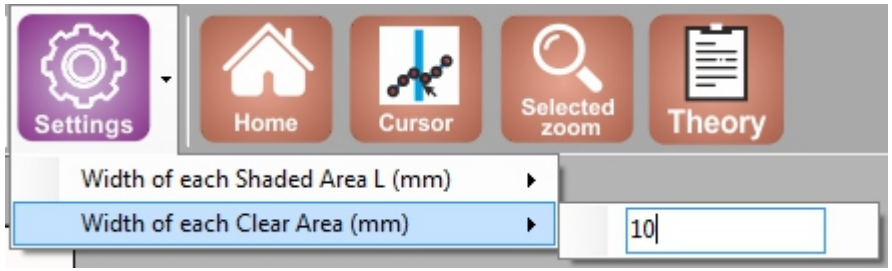
Bar Graph Area: It displays the bar graph of output data (velocity).

Fence Mode

This mode helps to find the acceleration 10-b mask Fence.

1. Go to **Basic / Advanced** ⟶ Fence.
2. Click on Settings: Enter the width of shaded area and clear area as indicated.



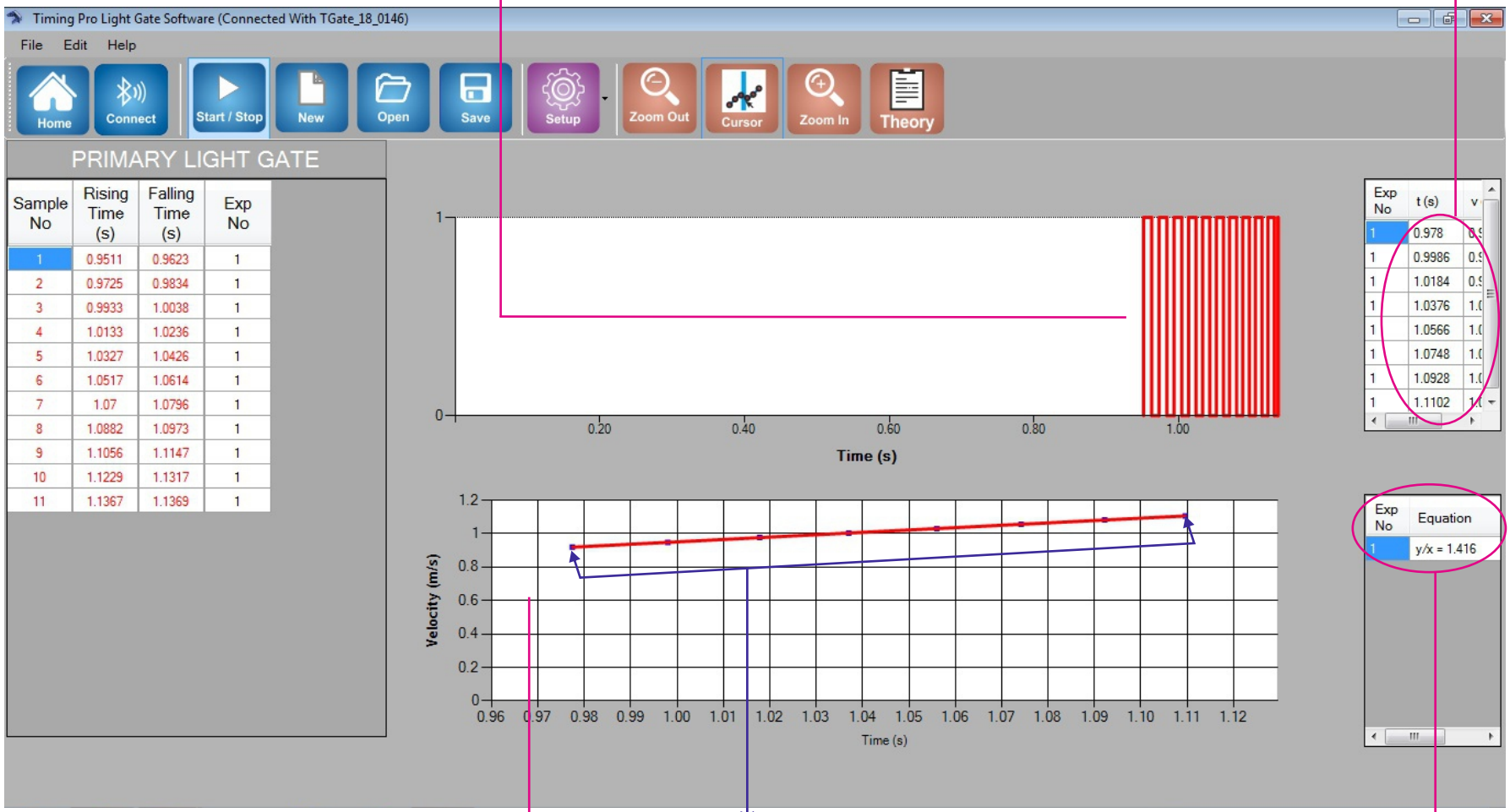


3. Mount the fence into the trolley.
4. Switch on the Timing Pro Light Gate (Primary) and establish Bluetooth connectivity.
5. Perform one run so that the fence passes through the Light Gate.
6. A $v \sim t$ data is displayed in the output data and the corresponding graph is also displayed. A best fitting straight line along with equation is also displayed in the software interface.

FENCE MODE

Timing pulse at the Primary Light Gate

v (velocity) ~ t (time) Data in the Output Data Table



v ~ t Graph

Best fit linear regression line for v ~ t Data

Best fit linear regression line equation for v ~ t Data