TIMING PRO DYNAMICS CAR

DESCRIPTION

Timing Pro Dynamics Car set and accessories is a unique and innovative tool for experimental studies that involve physics principles of motion in kinematics, dynamics, momentum and energy on any kind of track.

The Primary car can be used to study motion on curved tracks, inclined plane and even on student developed special tracks. Special motion encoding and timing is in built with wireless transmission to PC.

TimingPro Dynamics car with accessories

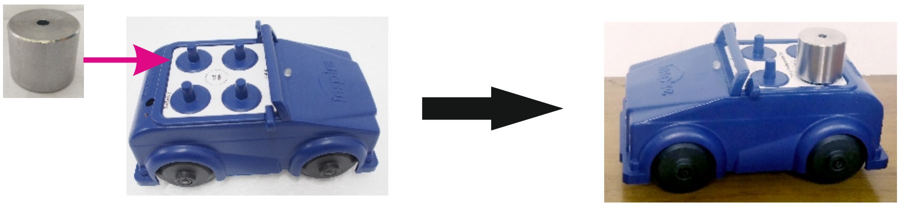
Primary car receives motion data of Secondary Car through IR. They can be used together to study collision experiments on a linear track.
An inbuilt software for graphing is also provided along with.

The cars have spring loaded wheels.

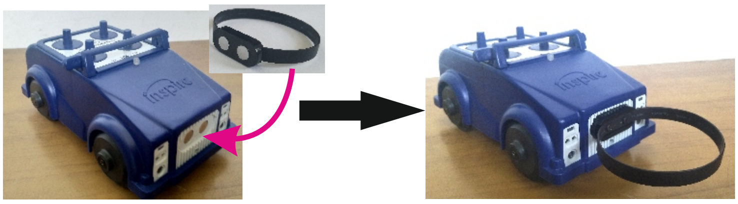
Without pressed wheel shown

Pressed wheel shown

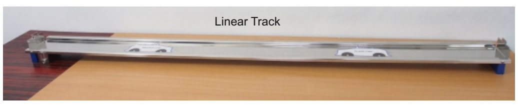
There is a provision to place four weights of 150gm each to car top.

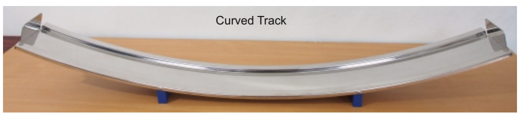


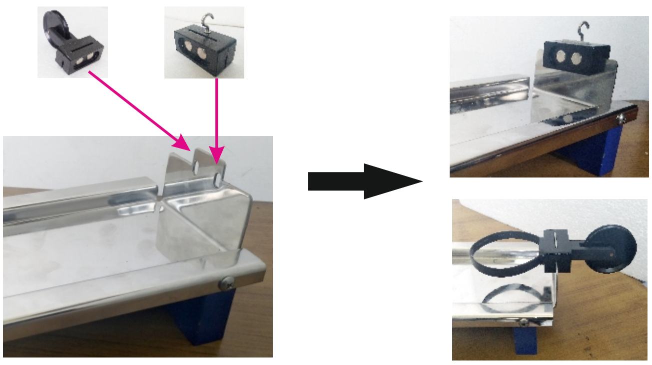
A number of accessories provided in the kit can be easily attached to the car magnetic bumpers.



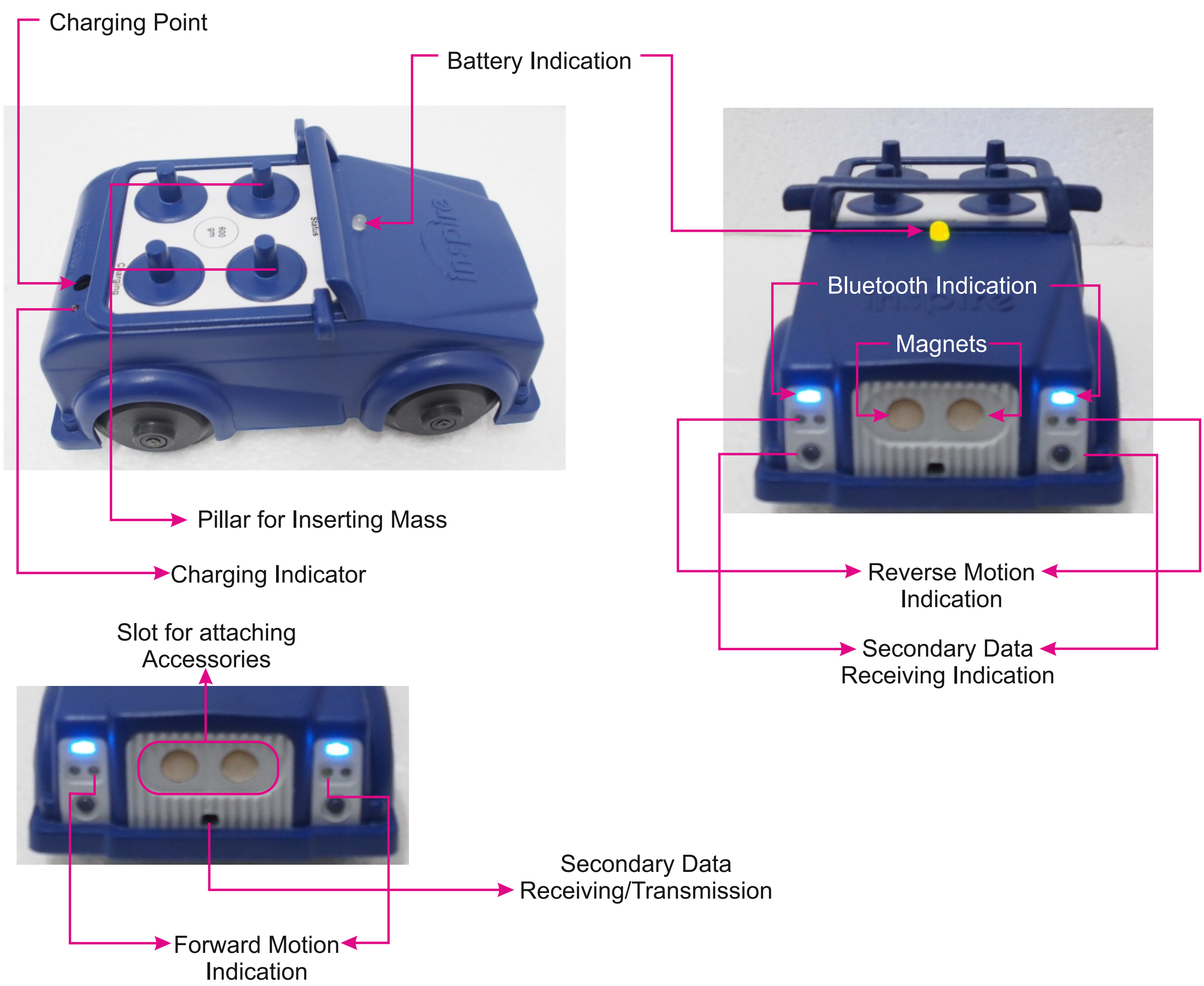
A number of accessories provided in the kit can be easily attached to the track ends.







LEDs IN CAR


Charging Point
Battery Indication
Bluetooth Indication
Magnets
Pillar for Inserting Mass
Charging Indicator
Reverse Motion Indication
Secondary Data Receiving Indication
Slot for attaching Accessories
Secondary Data Receiving/Transmission
Forward Motion Indication

TRACK ACCESSORIES

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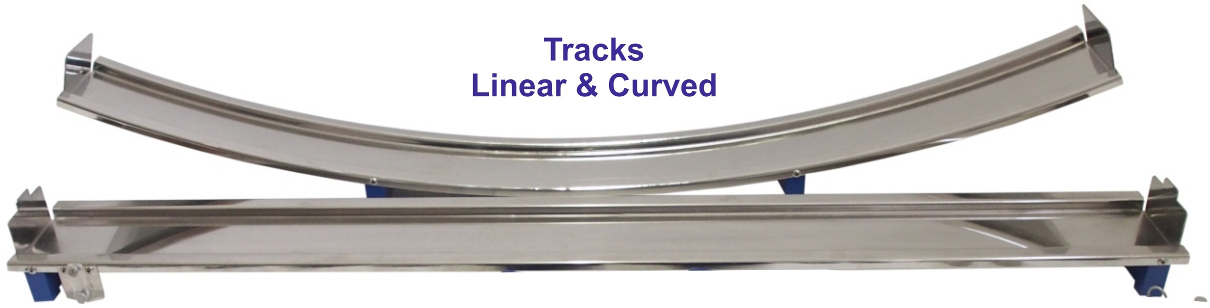
Tracks
Linear & Curved



Track
Accessories

Hook attachment
to Track (big)

Pulley attachment

Inclination block

Track
Weights

Additional weights

Slotted weight

Bumper Attachments
Accessories

Hook attachment
to Car (small)

Spring Elastic Bumper

Velcro Inelastic
Bumper

Large Rectangular
Bumper Attachment

Explosion bumper

Miscellaneous
Accessories

Hammer

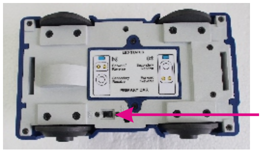
Elastic string

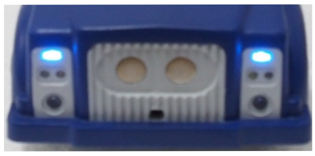
Double side tape

Thread

FIRST TIME BLUETOOTH PAIRING

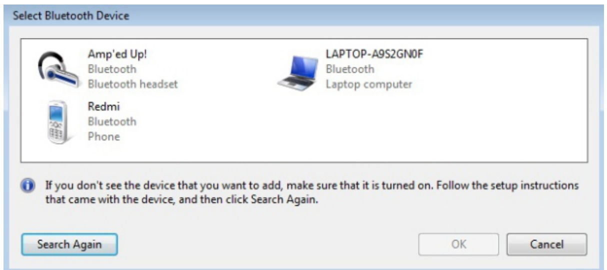
Power on the Timing Pro Dynamic Car. The On/Off Switch is located at the bottom of the car.

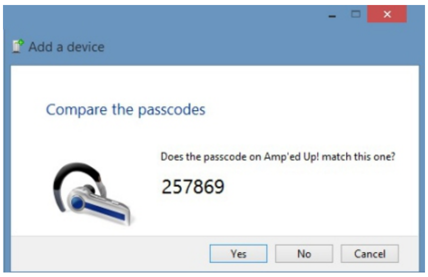




1. Click on Start. A list of available bluetooth devices will be displayed.
   - Name of the Dynamic Carwill appear in this format : Tball_yy_srno.
   - If the name of the Dynamic Car doesn't appear in the list in the first instance, you may need to tap on “Search again” to get a more extended list.

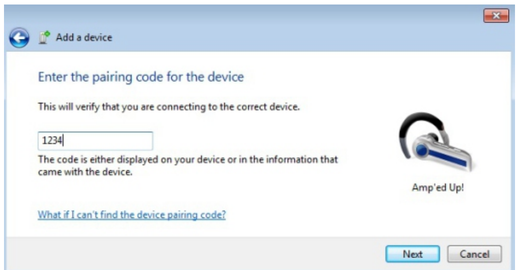
2. Select the respective Dynamic Car.
   Click no OK/Next.





A Bluetooth pairing request will appear with a pairing code.
Click on Yes button.

or,



Alternatively you may need to enter 1234 as pairing code.
Click on Next button.

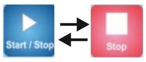
Dynamic Car will be paired. A beep sound ensures Bluetooth connectivity For data collection [while the car (s) is (are) in motion, just click on the Start/Stop button again].

After pairing the Dynamics Car, you may proceed to perform any experiment.
Now, once the Dynamics Car has been paired with computer, we don’t need to pair it again for next time use. Instead, we may just connect it during each use. For, this click on Start/Stop button, select the Dynamics Car and click on OK.

TIMING PRO DYNAMICS CAR SOFTWARE OVERVIEW

The software is intuitively organised to collect data for an experiment session with Timing Pro Dynamics Car. It is organised vertically as **Menu Bar, Icon Bar, Table Area with Side Bars, Status Bar** and **Graph Area**. We can use mouse left button for clicking on desired items or icons. The Track type, Mass of cars, Inclined angle etc. can be entered through the **Setup** item in Menu bar. The activated selections are displayed in the Status bar at bottom. The time for data collection and the graphs to be displayed in graph area can be selected from Icon bar. The Bluetooth connectivity of car with software can be done using **Start/Stop** item in Icon bar. Once connected the same button can be used to conduct the experiment for the desired time. Data gets collected in Table area and activated graphs are simultaneously displayed.

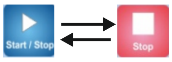
Use this button to Connect or Collect Data with an experiment session with Timing car. It has two functions:



Bluetooth Connectivity

Short Beep

At start of session and when Car Bluetooth lights are blinking, the **Start/Stop** icon shows the car is not connected. When clicked it connects via Bluetooth and the icon will momentarily change to **Stop** icon & then back to **Start/Stop**. There will be a short beep on car & Bluetooth lights will glow in stable condition.



Data Collection

Long Beep

After Car is connected then **Start/Stop** icon is used to collect data for a predefined time input in the adjacent text box. When clicked the icon changes to **Stop** for the time duration data is collected and displayed along with a long beep on Car. After elapsed time it changes back to **Start/Stop**.

Use left mouse button click to display Cursor and graph values and corresponding table rows are also highlighted

Use with left mouse button to select a region on graph and Fit a Polynomial equation.

Use with left mouse button click to show a Summation line on momentum and energy graphs.

Data Collection time in seconds for experiment sessions.

Menu Bar

Icon Bar

Table Area

Status Bar

Add New Graph

Graph Area

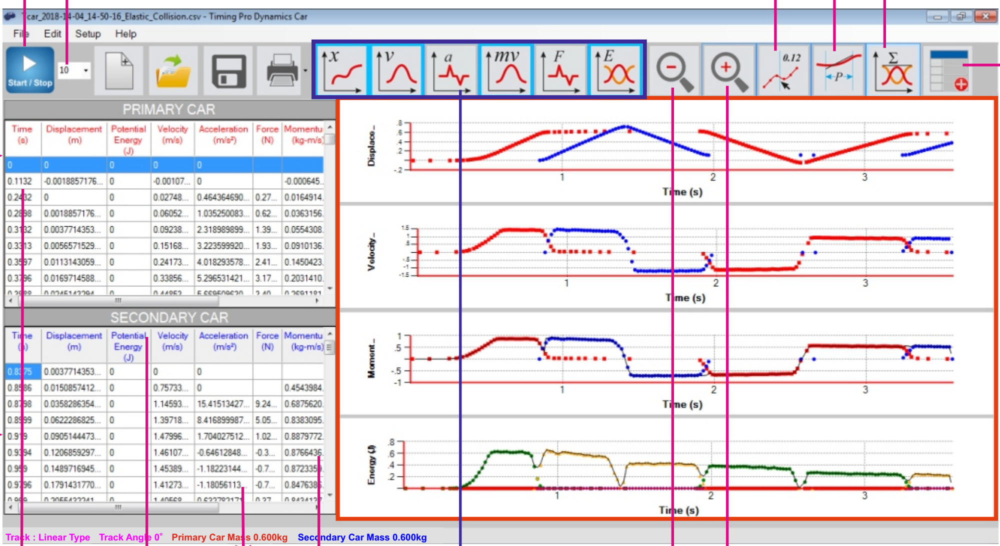


Table scroll Side Bars

Data Table Primary Car

Data Table Secondary Car

Contains Time, Displacement, Potential Energy, Velocity, Acceleration, Force, Momentum and Kinetic Energy values for Primary & Secondary cars.
Right and Bottom Side bars have scroll functions.
Appropriate Rows get highlighted when Cursor function is active.

Select to intuitively add or remove Displacement, Velocity, Acceleration, Momentum, Force, Energy graphs in Graph Area.
If a particular graph is already displayed it gets removed from the Graph Area else it gets added.

For **Zoom In** select a region on graph with mouse left button click and hold. Region is highlighted. Upon release all active graphs are displayed with the Zoomed In region.
For **Zoom Out** left mouse button click would show the full view of graphs for the experiment time.

SETUP MENU

In order to derive meaningful interpretations the software needs to know the setup of the experiment conditions. For example the track (Curved or Linear) and the Mass of Primary (Master) and Secondary (Slave) cars. This information can be given through the **Setup** menu before conducting the experiment and collecting data. The setup data is displayed in the bottom Status bar of the software. The **Setup** menu options are illustrated below:

Curved Track
Linear Track
No Track

Select the track on which the car would move.

0.600

Manually enter the precise mass of the car when additional weights are attached to the car or You wish to enter the precise mass of the car along with attachments.

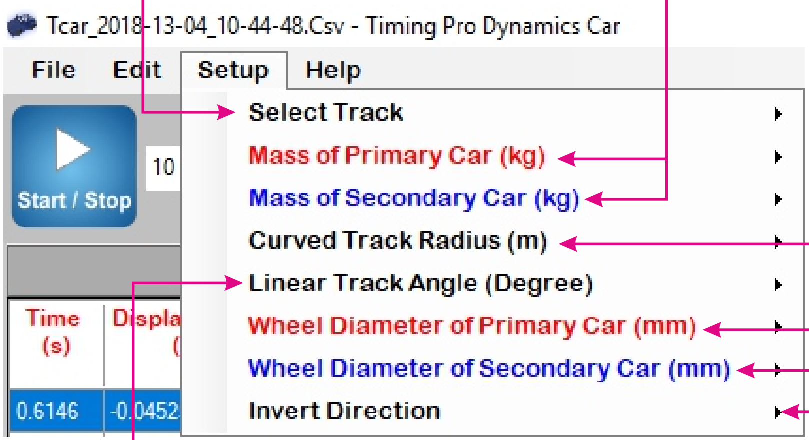
1.390

While using Curved track, please enter the exact radius of curvature of the curved track for perfect potential energy curve.

43.20

When no track is used the outer wheel diameter is to be used.

When car is used on track, wheel diameter to be taken is slightly less.



0

Enter the angle of inclination while the car is moving on an inclined plane.

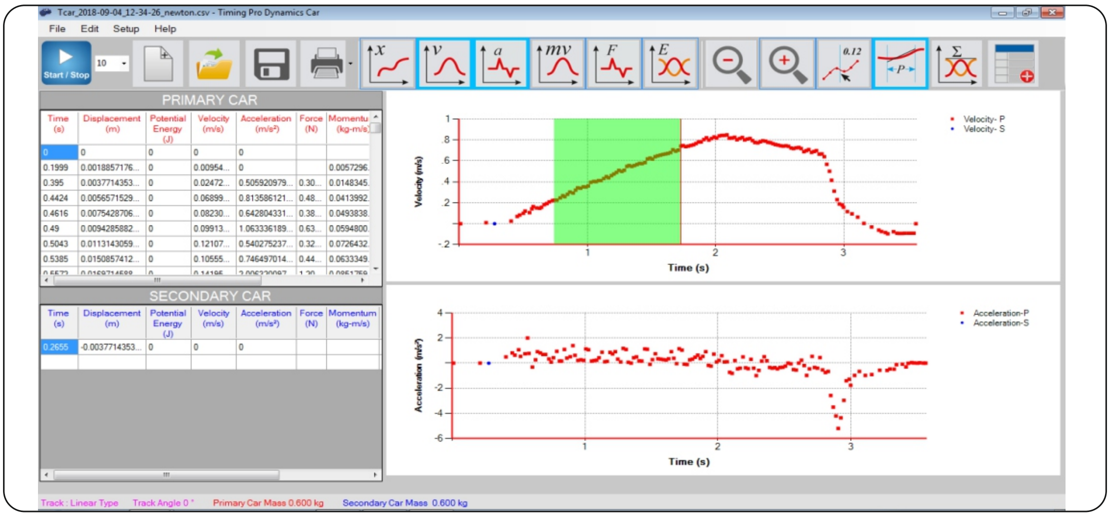
Master
Slave Car

You may reverse the direction of car motion (by multiplying the displacement data of car by a factor of - 1) when the need arises.

POLYNOMIAL FIT

Use mouse left button and click on Polynomial Fit icon to activate mode. Then move mouse to desired location on graph and click & hold mouse left button to select region dynamically the region gets highlighted. Upon release of mouse button the Polynomial fit popup appears.

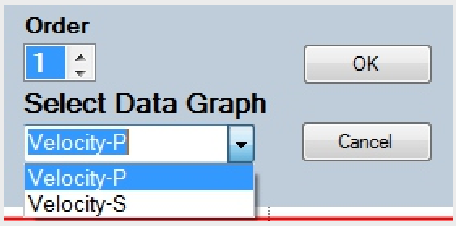
Zoom In is also achieved by the same procedure.



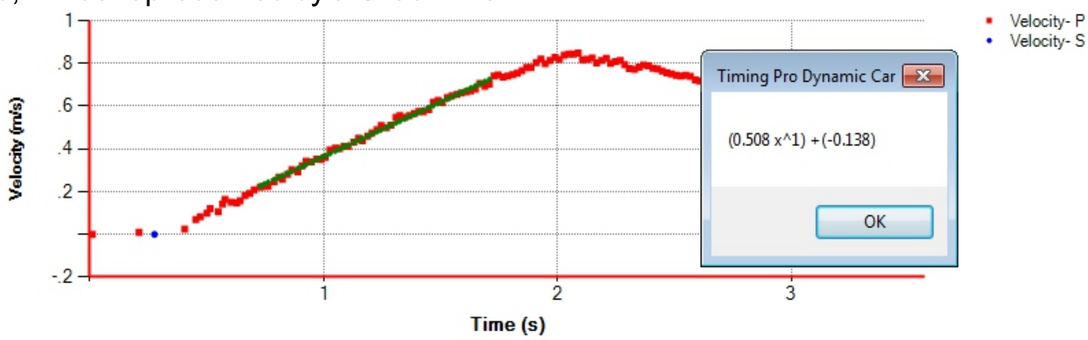
Select the Primary curve or Secondary car data (on which the Fit would be applied). For e.g. here, Velocity-P denotes the velocity data of Primary car & velocity s denotes the Velocity-S data of Secondary car.

Select the order No. For e.g.,
for Linear Fit, order = 1;
for quadratic Fit, order = 2 etc.

Click on OK button.



A dialogue box will be open depicting the Base Fit Line equation. In the graph the Base Fit Line, will be represented by a Green line.

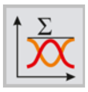


SUMMATION

The summation button is used to show the conservation of momentum and energy for various collisions and many other experiments. When this button is clicked, it displays the sum of momentum and energy in the momentum and energy graphs by a black line:

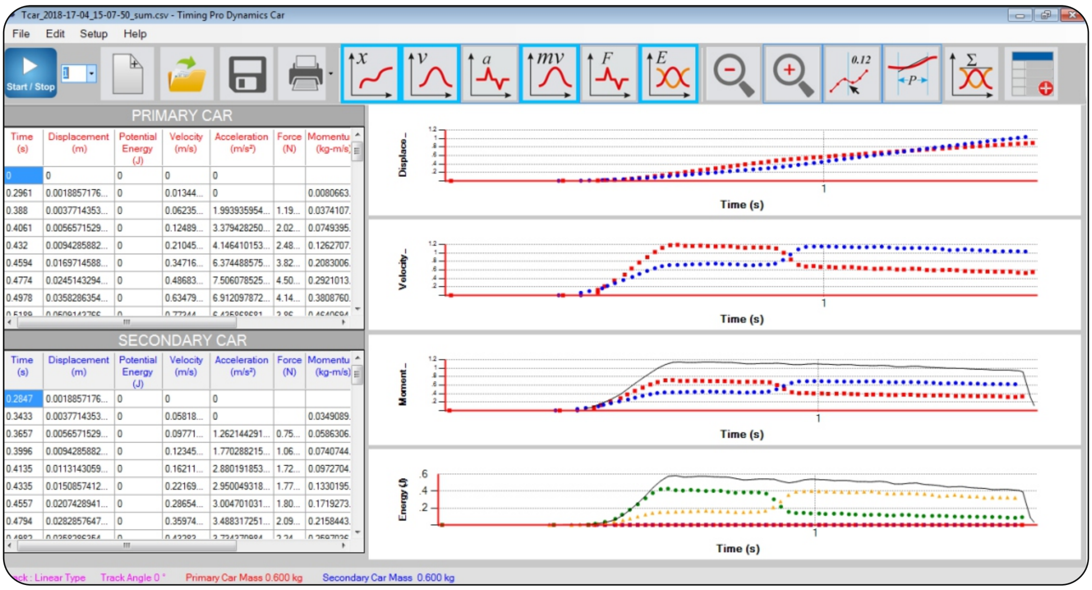
1. In the momentum graph : It denotes the sum of the momentum of Primary car and the momentum of the Secondary car.
2. In the energy graph : It denotes the sum of both potential energy and kinetic energy of both the cars.

BEFORE



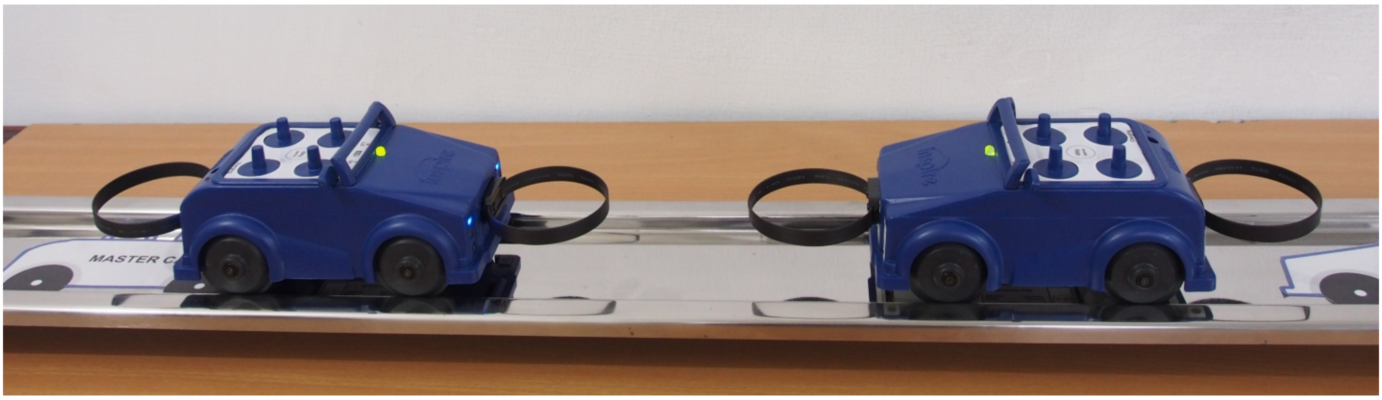
Graphical interfaces before and after clicking the Summation button. Notice the black line in momentum and energy graph. The black lines represent the respective sum

AFTER



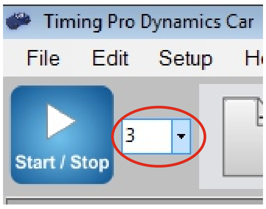
ELASTIC COLLISION

1. Place the cars on the linear track so that their front sides face each other. Attach spring elastic bumpers to the cars as shown.



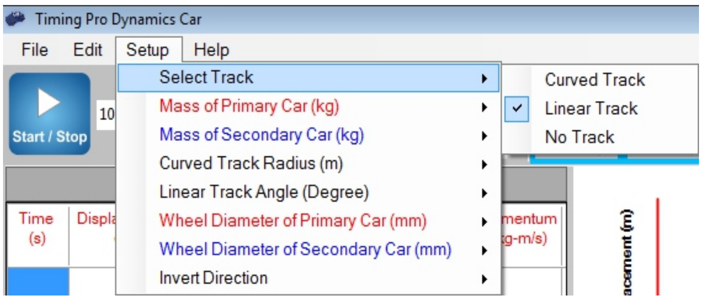
2. Establish Bluetooth connectivity as mentioned before.

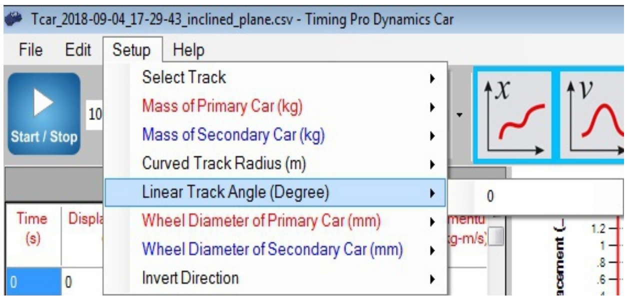
3. Set the Data Collection Time.



4. Required settings:

Setup ⟶ Select Track ⟶ Linear Track
Setup ⟶ Linear Track Angle (Degree) ⟶ 0

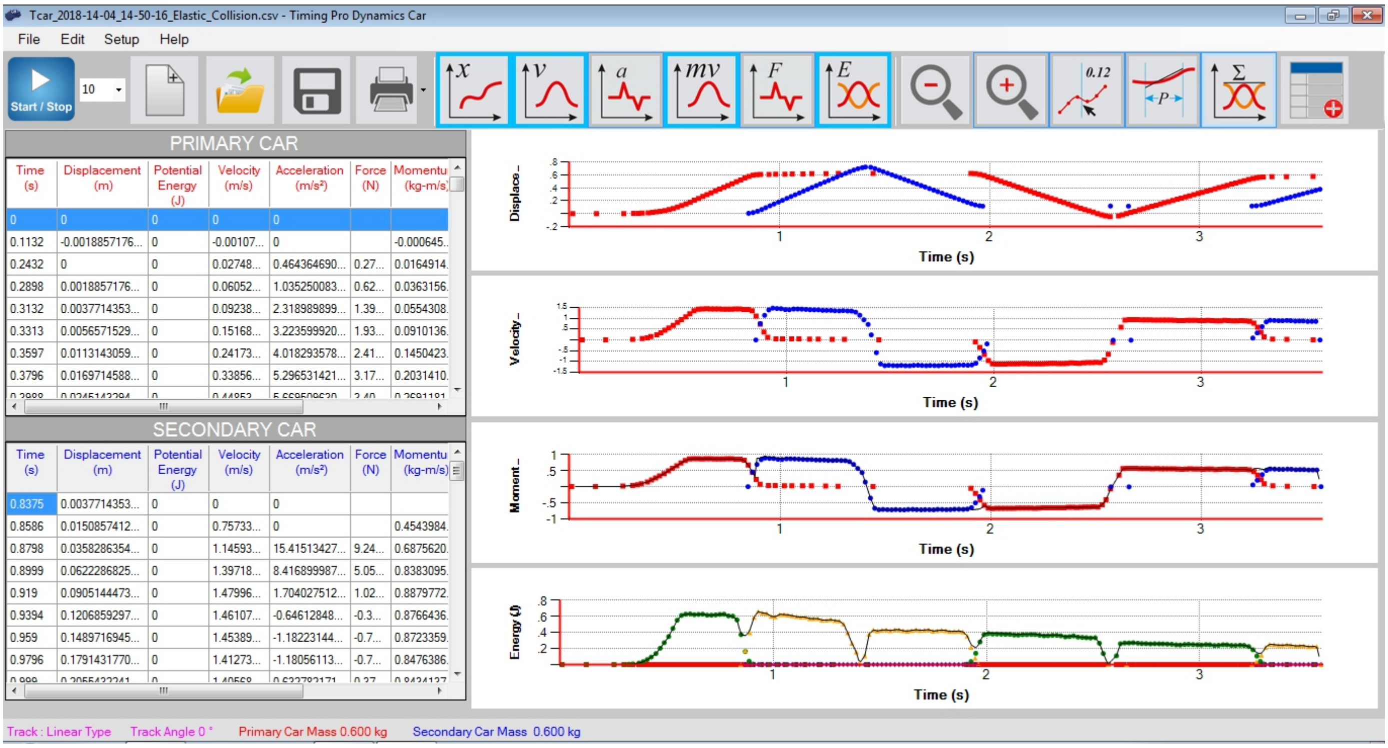




5. Click on Start/Stop button for data collection.

6. Perform collision (push any of the cars or both cars to collide with each other).

ELASTIC COLLISION



In an elastic collision between two bodies, total kinetic energy as well as momentum is conserved before and after the collision. If the bodies have equal mass, they simply exchange their velocities in an elastic collision as evident from the velocity graph. In this case, both master and slave cars have almost equal mass and before collision one car is at rest and the other is moving with a velocity. The black line in the momentum graph represents the sum of the momentum of both cars. It is therefore noticeable that the total momentum of both the cars is same in a particular direction before and after collision. Similarly, the black line in the energy graph represents the sum of the energy of both cars which manifests that the total energy is also unaltered before and after collision.

INELASTIC COLLISION

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1. Switch on both Primary and Secondary cars.

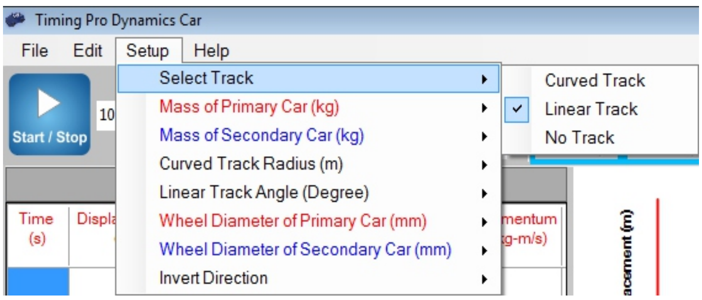
2. Attach velcro pads to the cars as shown.

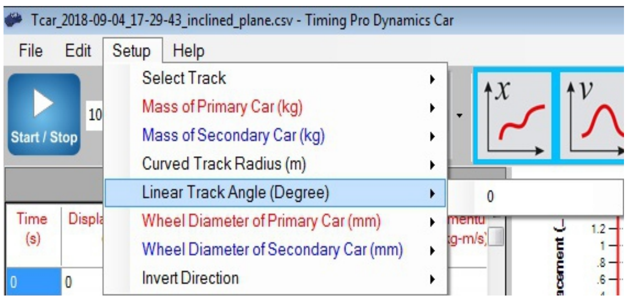
3. Place the cars on the linear track so that their front sides face each other.

4. Establish Bluetooth connectivity as mentioned before.

5. Required settings:

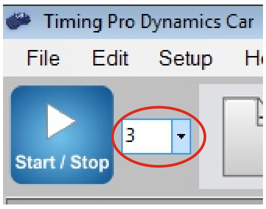
Setup → Select Track → Linear Track
Setup → Linear Track Angle (Degree) → 0





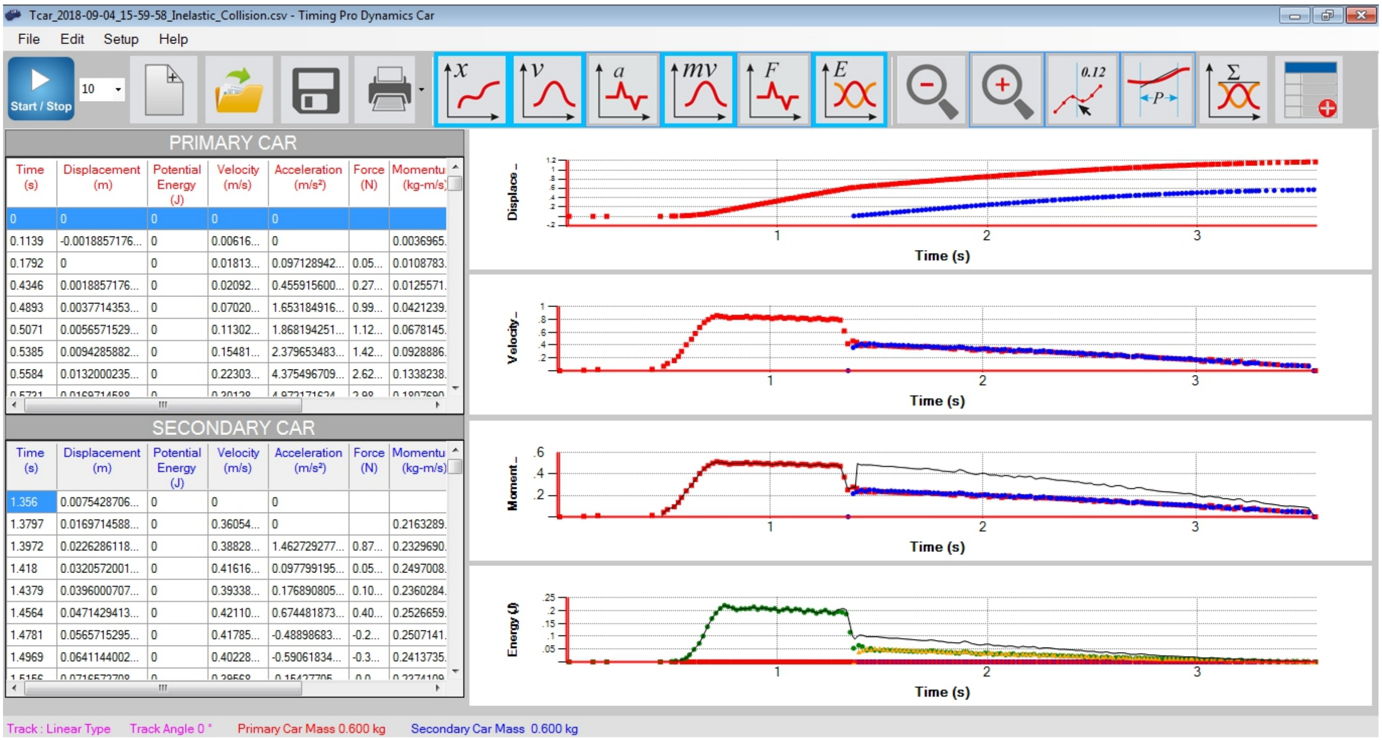
INELASTIC COLLISION (Continued)

5. Set the Data Collection Time.



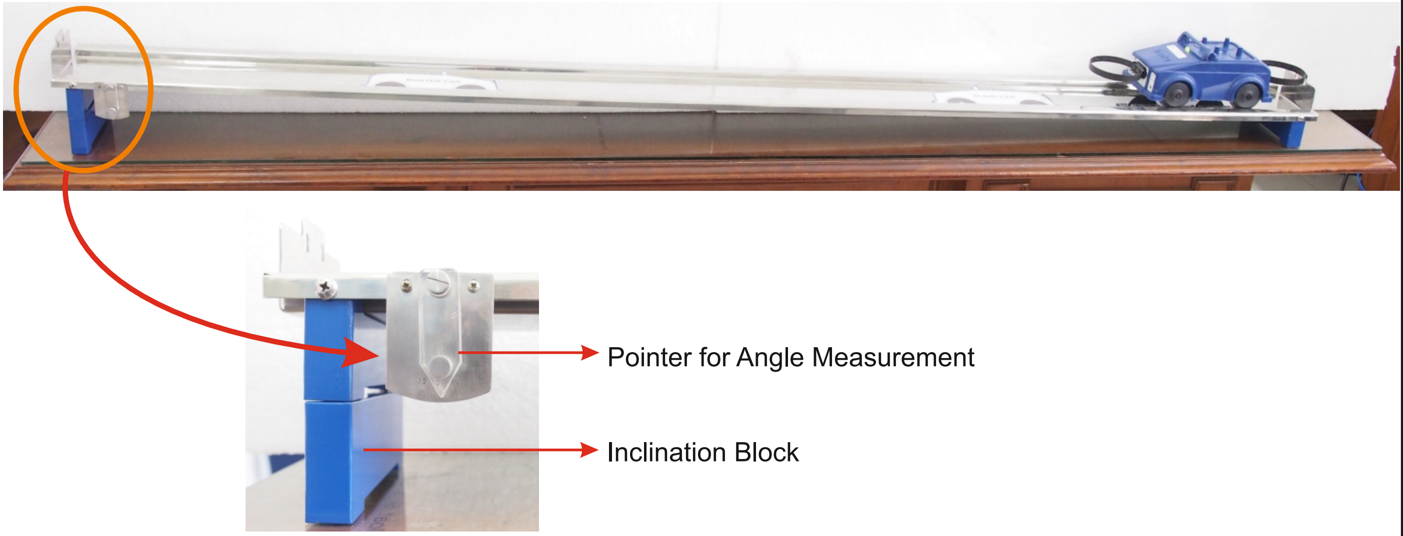
6. Click on Start/Stop button for data collection.

7. Perform collision (push any of the cars or both cars to collide with each other).

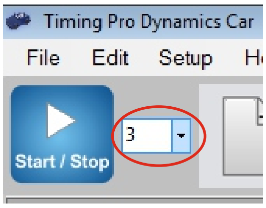


In an inelastic collision between two bodies, total kinetic energy is not conserved before and after the collision. In a perfectly inelastic collision, the colliding bodies stick to each other. In this case, before collision one car is at rest and the other is moving with a velocity. We know that momentum is conserved in any collision when external forces are negligible. Since, both cars have almost equal mass, the velocity of the moving car before collision is twice the velocity of the both cars (who are sticking together) after the collision (as evident from velocity graph). The black line in the momentum graph represents the sum of the momentum of both cars. It is therefore noticeable that the total momentum of both the cars is same before and after collision. Similarly, the black line in the energy graph represents the sum of the energy of both cars which manifests that the total energy is not conserved before and after collision. Truly speaking, elastic and perfectly inelastic collisions are limiting cases. Most of the collision lie somewhere between them.

MOTION IN RAMP

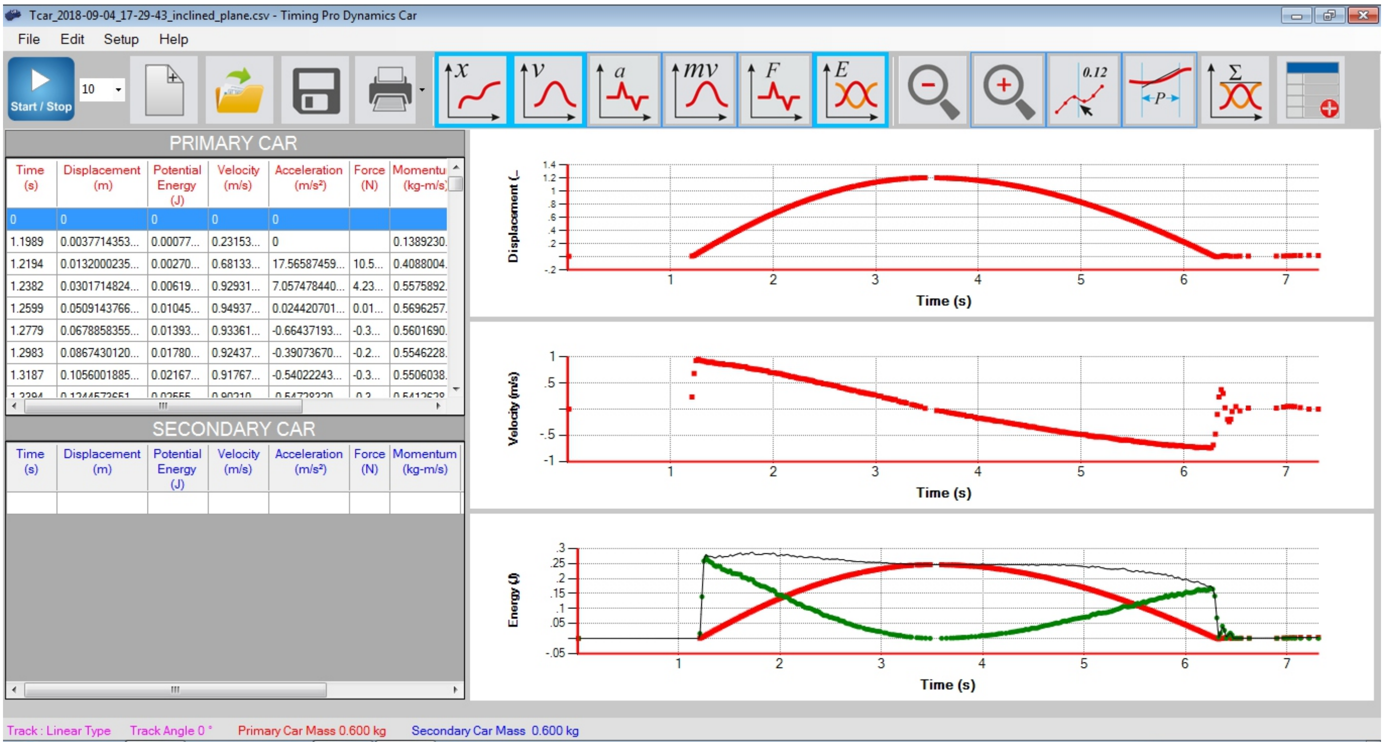


1. Incline the linear track using inclination accessory.
2. Switch on the Primary Car.
3. Establish Bluetooth connectivity.
4. Attach spring elastic bumpers to both sides of the car and place the Primary Car at the bottom of the inclined plane.
5. Set the Data Collection Time.



6. Click on Start/Stop button for data collection.

7. Start the data collection.
8. Give the Primary Car an upward push. The car would move up and down the track periodically and finally comes to rest.
9. Select displacement velocity and energy graph and observe the conversion of kinetic energy into potential energy (during upward movement) and conversion of potential energy into kinetic energy (during downward movement).
10. Click on Summation button the black line in the energy graph indicates that the sum of kinetic and potential energy is conserved.

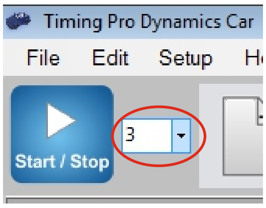


Observe the conversion of kinetic energy into potential energy (during upward movement) and conversion of potential energy into kinetic energy (during downward movement). The black line in the energy graph indicates that the sum of kinetic and potential energy is constant throughout the motion. This is expected because gravitational force, being a conservative one $(\nabla \times F = 0)$, associates a potential energy with it. This potential energy is called gravitational potential energy. The work done on a particle by a conservative force is independent of the path taken by the particle and is equal to the change in the potential energy. As a result, total mechanical energy (sum of kinetic and potential energy) is conserved in a motion along an inclined plane (under low friction conditions). However, due to the dissipative forces (which are non-conservative), a slight decrease in total energy is noticeable.

MOTION IN CURVE TRACK

1. Place the curved track on a perfect horizontal table.
2. Switch on the car.
3. Place the master car in the middle of the track.

4. Establish Bluetooth connectivity between the software interface and the Primary Car.
5. Set the Data Collection Time.



6. Click on Start/Stop button for data collection.

6. Displace the car from the mid-position along the track. During perturbing the car from mid-position, Allow the car to move back and forth in the curved track. The car will come to rest after a few oscillations.
8. Check the displacement, velocity and acceleration data and note the following points:
   I. When displacement is maximum, then velocity will be zero.
   II. When displacement is maximum, then acceleration will also be maximum but they will be completely out of phase (Phase difference = 180^0).
   III. When displacement is zero, then velocity is maximum (either in positive or negative side).

9. Select the energy graph. Then click on the energy graph. Now click on the summation function. A black dotted line will appear which represents the total energy (sum of kinetic and potential energy). The total energy of course slightly decreases with time due to the dissipation. But for a small time interval, it is almost constant.

MOTION IN CURVE TRACK

NEWTON 2ND LAW OF MOTION

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Pass a piece of string with a mass hanging on one end over a pulley. Attach the other end to the Primary car so that, when the mass is released, it causes the car to accelerate. Choose a length of string such that the mass does not touch the ground until the car nearly reaches the pulley. Fix a 1 kg mass on the car with Blu-tack to make the total mass (car plus mass) of about 2 kg. This produces an acceleration which is not too aggressive when the maximum force (4 N) is applied.

The force is conveniently increased in 1 newton steps when slotted masses of 100 g are added. Place the unused slotted masses on the car. Transfer them to the slotted mass holder each time the accelerating force is increased. This ensures that the total mass experiencing acceleration remains constant throughout the experiment.

Fit a double segment black card on to the trolley. Clamp the light gate at a height which allows both segments of the card to interrupt the light beam when the trolley passes through the gate. Measure the width of each segment with a ruler, and enter the values into the software.

Connect the light gate via an interface to a computer running data-logging software. The program should be configured to obtain measurements of acceleration derived from the double interruptions of the light beam by the card.

The internal calculation within the program involves using the interruption times for the two segments to obtain two velocities. The difference between these, divided by the time between them, yields the acceleration.

A series of results is accumulated in a table. This should also include a column for the manual entry of values for 'force' in newtons. It is informative to display successive measurements on a simple bar chart.

Procedure

Data collectiona Select the falling mass to be 100 g. Pull the trolley back so that the mass is raised to just below the pulley. Position the light gate so that it will detect the motion of the trolley soon after it has started moving.

Set the software to record data, then release the trolley. Observe the measurement for the acceleration of the trolley.

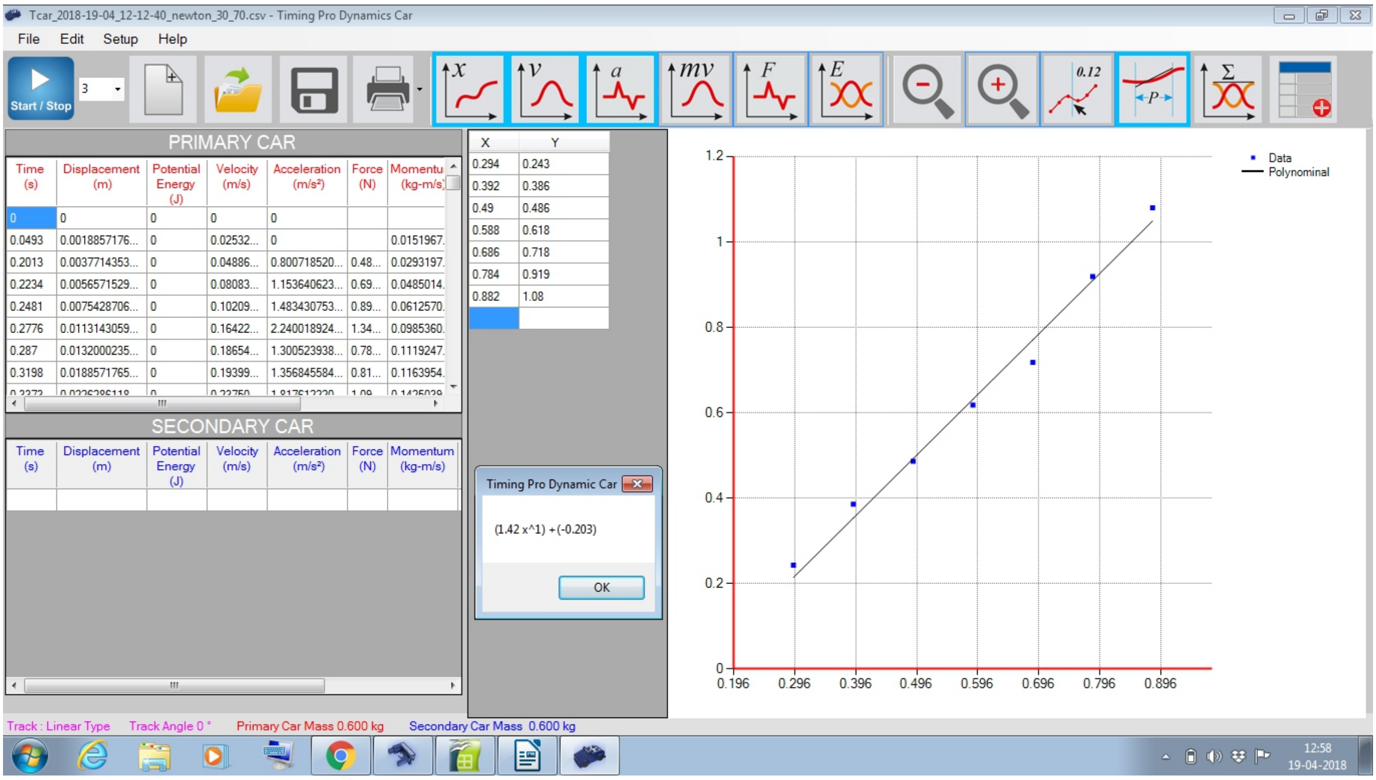
b Repeat this measurement from the same starting position for the trolley several times. Enter from the keyboard '1'(1 newton) in the force column of the table.

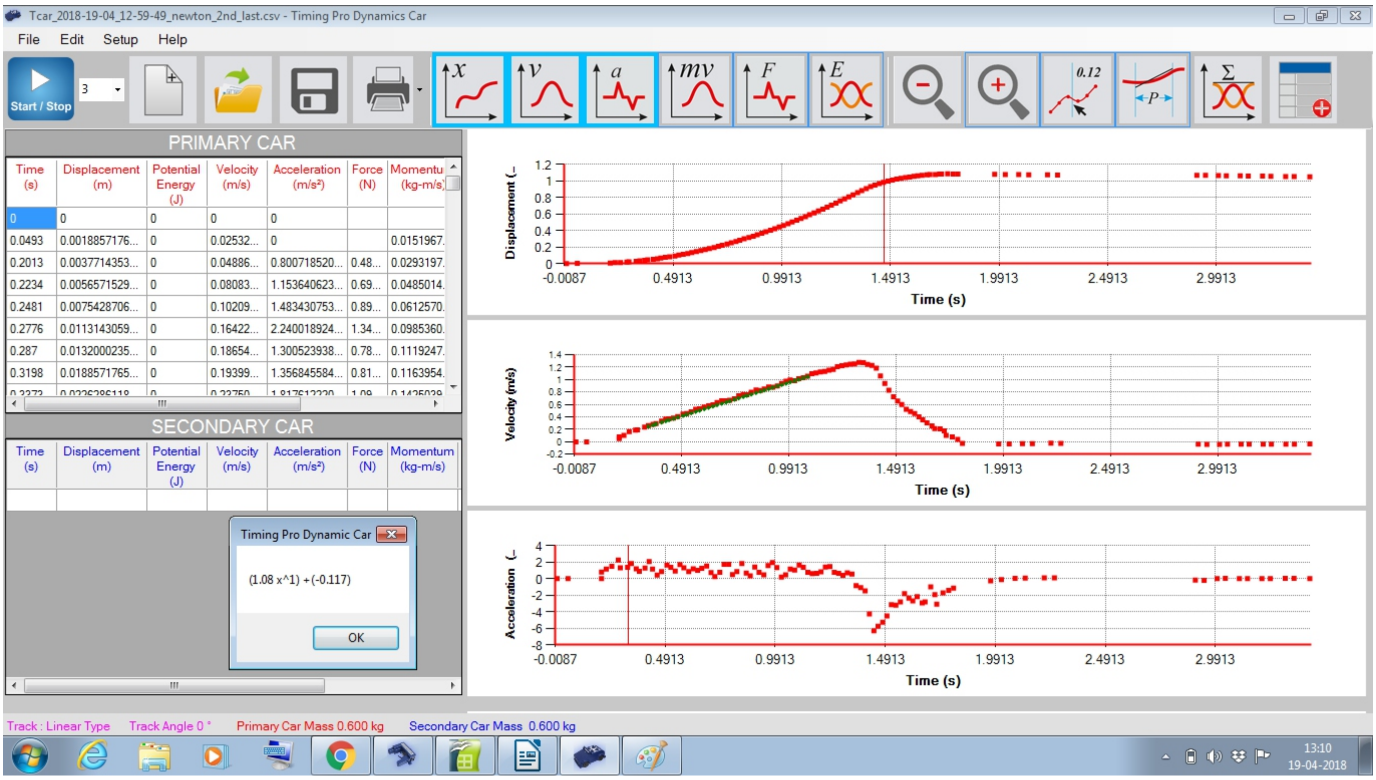
c Transfer 100 g from the trolley to the slotted mass, to increase it to 200 g. Release the trolley from the same starting point as before. Repeat this several times. Enter '2' (2 newtons) in the force column of the table.

d Repeat the above procedure for slotted masses of 300 g and 400 g.

Analysis

NEWTON 2ND LAW OF MOTION





NEWTON 2ND LAW OF MOTION

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1. Attach ************** to the car as shown.

2. Arrange the experimental set-up as shown.

3. Establish the bluetooth connectivity and have the following settings before data collection.

4. Start data collection and release the hanging mass and allow the car to accelerate.

5. Determine the slope of the velocity data for that specific portion of time duration while the car is in motion under constant acceleration. Use polynomial fit of order 1 to determine the slope.

6. Click on new graph icon and note down the applied force and acceleration in X and Y column respectively.