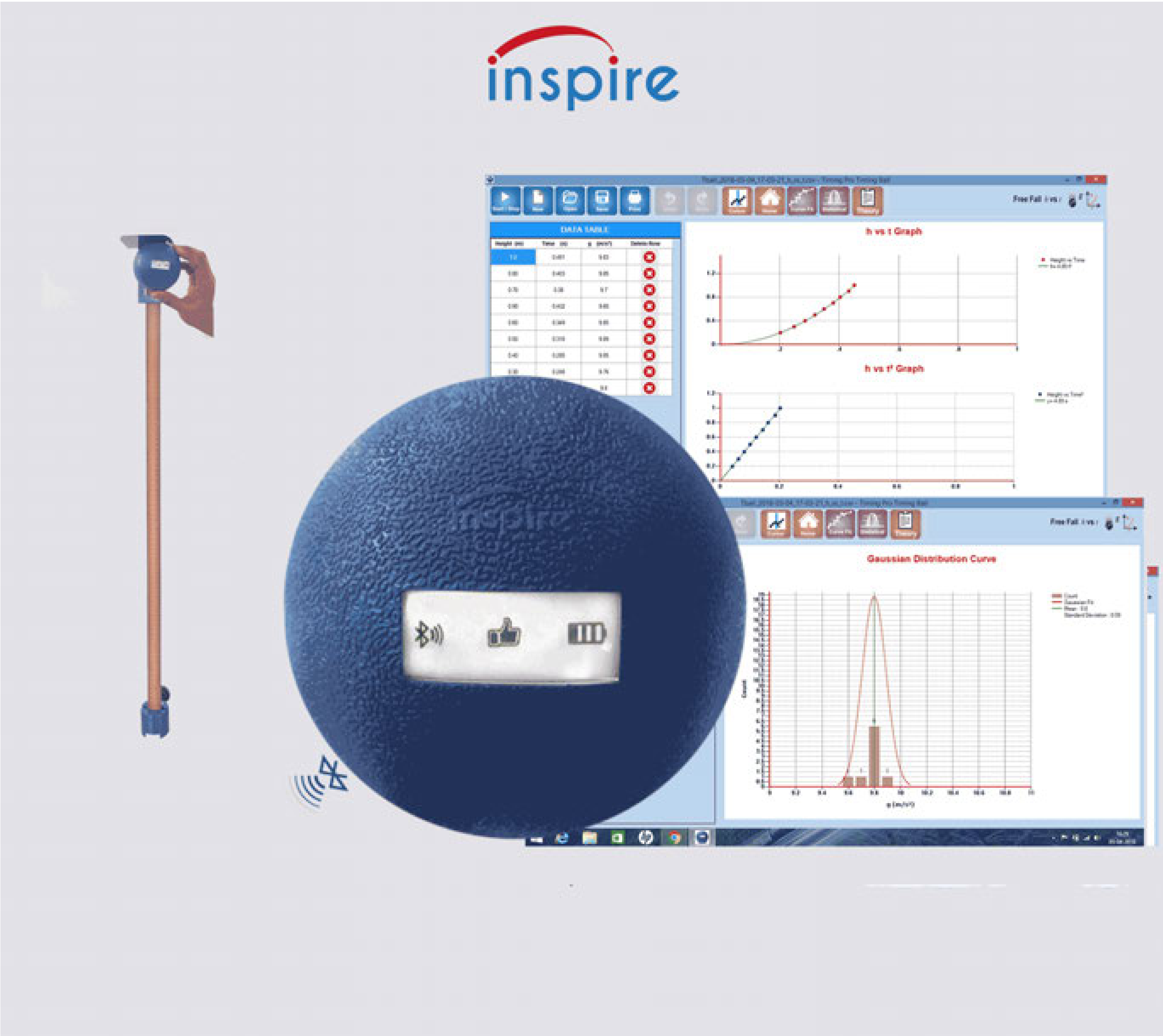
TimingPro Timing Ball



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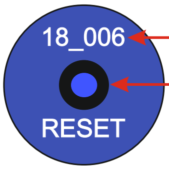
TimingPro Timing Ball

The Timing Ball records time from the moment the ball is released to the moment of impact.
It can be used to conduct experiments involving acceleration due to gravity (g) and time of flight.
It contains electronics which accurately measure time, detect impact or the moment the ball is caught, and communicate the data via Bluetooth to TimingPro software on a PC or smart device.

The Timing Ball is intended for educational use. It is not a toy. The maximum drop on to a soft surface should be 2 metres. Dropping the ball on to hard surfaces invalidates the warranty. The ball should be dropped or thrown and caught within Bluetooth range, approx 5 metres.

WAKE UP This button has two functions: Power ON and ARM.
It needs only light pressure to operate it.



Ball serial number, identified on connection to TimingPro software.

Recessed RESET switch:
In the unlikely event the Ball 'hangs' or stops responding, it can be reset by pressing the switch with a pen or pencil point.

LED INDICATORS:

Press the WAKE UP button.

This LED (blue) indicates Bluetooth connection to TimingPro software.
Blinking indicates the ball is powered but not connected.
When connection is established this LED glows continuously.

Pressing the WAKE UP button again, ARMs the Timing Ball, if it has been connected to the software.
This LED (green) indicates the device is ready to record an event.

This LED (orange) blinks when the internal battery is low.
The Timing Ball is charged using the 5 V 1 A adaptor supplied.
During charging this LED glows continuously.
Overcharge protection is built in.

Auto shut down: When the TimingPro software is closed, the Timing Ball automatically shuts down after about 90 seconds of inactivity. During this period, the bluetooth LED blinks.

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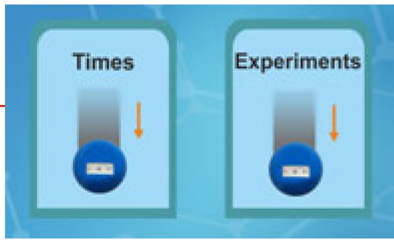
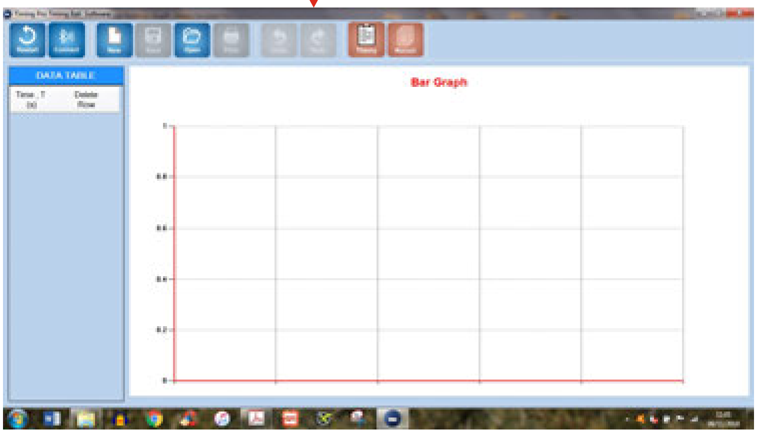
Introducing TimingPro software

You need to download and install the TimingPro Timing Ball software on your computer.

TimingPro software can be downloaded using the link
https://www.inspirephysics.com/downloads/
then click on INSPIRE TIMING-PRO BLUETOOTH TIMING BALL SV748.
The software is downloaded as a .zip folder.

When TimingPro is launched, the home screen gives the choice of Times or Experiments.





Times mode provides simple capture and display of times from the Timing Ball.
Data can be edited, saved and printed.

Three experiment modes are available:
- g by Free Fall
- Free Fall *h* vs *t*
- Time of Flight

Data can be edited, analysed, saved and printed.
These modes are described later.

The complete icon bar is shown here for all modes.

Some icons only appear in the relevant experiment modes, and are greyed out if they are not currently active within any mode.

For example, Save and Print are greyed out if you have not yet captured any data.

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Icon bar functions

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Go back to the Home screen

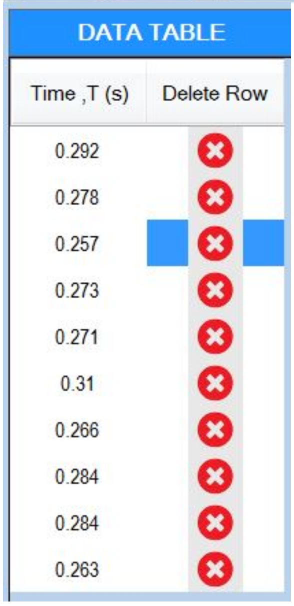
Connect to the Timing Ball

Clear the current data, ready for a new session

Save the current data

Open a saved file or a sample file

Print a screenshot, including data table and any graphs



DATA TABLE

Time ,T (s)	Delete Row
0.292	
0.278	
0.257	
0.273	
0.271	
0.31	
0.266	
0.284	
0.284	
0.263	

In the data table, any row can be deleted by clicking on the ⊗ icon

Undo and Redo allow the user to change their mind, in case of accidental deletions

Show the theory page for the current experiment

The Timing Ball manual can be viewed

The Cursor works only in Free Fall h vs t mode. When the Cursor is moved over the graph area the value of t or t^2 is displayed

This switch only appears in g by Free Fall and Free Fall *h* vs *t* modes

Click the Graph button to go back to the default view

Click on Statistical to show a Gaussian distribution of data in g by Free Fall and Free Fall *h* vs *t* modes

Curve Fit works only in Free Fall *h* vs *t* mode.
When clicked, best fit lines and best fit equations are added to the *h* vs *t* and *h* vs t^2 graphs

In all modes, the data table is displayed.
A bar graph is displayed in g by Free Fall and Time of Flight modes.
In Free Fall *h* vs *t,* the graph area shows h vs t and h vs t^2 graphs.

The best way to learn and understand the facilities of TimingPro software is to open the sample files provided and use the functions to edit and analyse the data.

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First time Bluetooth pairing

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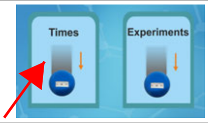
Switch on the Timing Ball by pressing the **WAKE UP** button once. The LED on the Ball starts flashing.

WAKE UP

Launch the Timing Pro Timing Ball Software.
Click on **Times** mode.

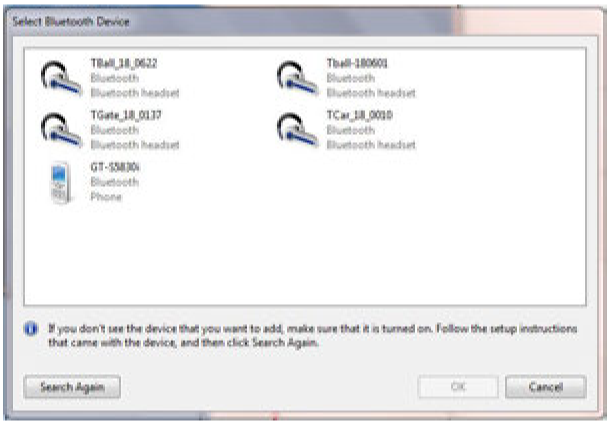


Click on Connect and a list of available Bluetooth devices will be displayed.

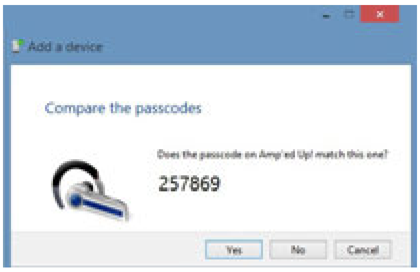
The Timing Ball's name will appear in this format : Tball_yy_nnnn

If your Timing Ball does not appear in the list, click on "Search again" to refresh the list.

Check the serial number on your Timing Ball. Select the matching Timing Ball. Click OK.



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



or

You may need to enter 1234 as a pairing code. Click **Next.**

The Timing ball will now be paired. The LED on the ball will glow continuously.
After pairing the timing ball, you are ready to start any experiment.
Once the Timing Ball is paired with a device, it is not necessary to pair it again.

At the end of a session, when you exit TimingPro, the LED on the ball will flash and shut off automatically after 90 seconds of inactivity.

When a new session is started, clicking on the Connect button will establish connection with an already paired Timing Ball.

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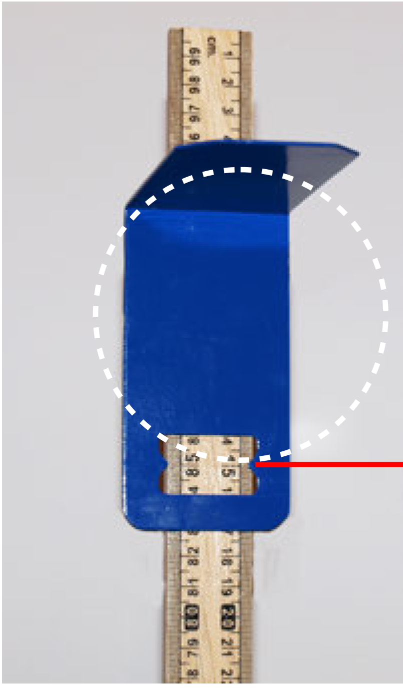
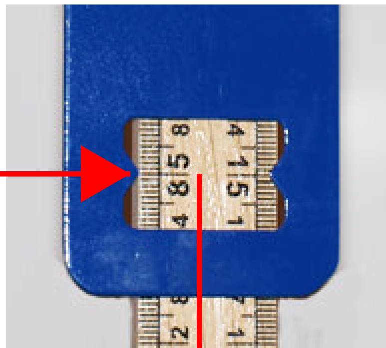
Timing Ball Pointer Accessory

The Pointer Accessory makes it easy to measure the drop height accurately.
Holding the Timing Ball up against the flat plate aligns the bottom of the ball with the pointer, which indicates the drop height on a standard metre rule.

The pointer accessory slides on to the metre rule and is clamped at the chosen drop height.



Holding the ball up against the flat plate gives accurate alignment with the scale.



When the ball is touching the flat plate, press the WAKE UP button to Arm the ball.

The green LED lights.

Release the ball by opening your hand rapidly.

The ball will fall 0.85 metre to the floor.

The impact must be cushioned by some soft material, e.g. a square of carpet, or some bubble wrap packaging.

You might need to allow for the thickness of the material you use, when entering the drop height into the software.

When the Timing Ball has been Armed, the green LED stays on for several seconds, allowing for a short delay before the ball is released or thrown.

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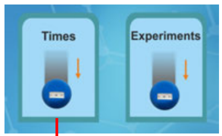
Using the Timing Ball

You will use the Timing Ball, the Pointer Accessory, a metre rule and a clamp stand, to practise holding, arming and dropping the Timing Ball. Don't forget some soft material for the ball to land on.

Attach the Pointer Accessory to the metre rule and clamp the rule in a vertical position.
Choose a drop height and set the pointer.
Place the soft material at the bottom of the rule, where the ball will land.

Launch TimingPro software and click on **Times** in the Home screen.



Press the WAKE UP button on the Timing Ball.
The blue LED starts flashing.

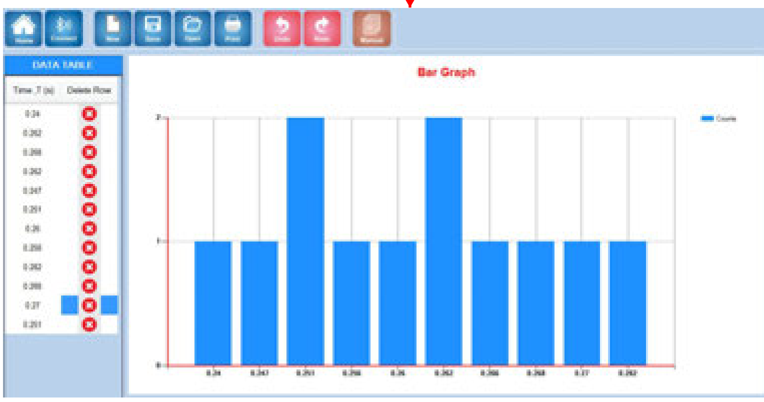
Click Connect in the icon bar to connect to the Timing Ball.
The blue LED glows steadily.

Hold the ball up against the Pointer Accessory.
Press the WAKE UP button again, to Arm the Timing Ball.
The green LED lights.

Drop the ball and look at the Times screen.

The time taken for the ball to fall is recorded in the data table and on the bar graph, which counts repeated values.

Repeat the procedure, from above, until you achieve times that are consistent.



This activity will test the consistency of your dropping technique, enable you to develop the technique for later experiments, and help to reduce errors that may arise in that part of the experiment.

The data can be saved and the file can be opened in Excel, if you wish.

You can use the data to calculate *g* manually, before moving on to the experiments.

You are now ready to tackle the individual experiments.

Go to the Home screen and select **Experiments**.

These are described in the following pages.

The *g* by Free Fall experiment requires the same apparatus that was used in this activity.

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g by Free Fall

In this mode, the ball is armed and dropped from a measured height. The value of *g* is calculated from the free fall time. A popup window prompts the user to enter the height in metres after each drop.

In the example here, the ball was dropped several times from a height of 1 metre.
You may choose to do that, or drop the ball from a range of heights.
In both cases, the value of *g* is calculated after each drop and an updated mean is displayed.

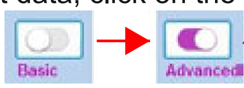
Comparison and discussion of the two approaches should include the issue of error.

DATA TABLE

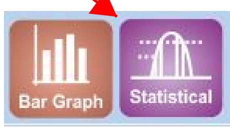
Height, h (m)	Time, t (s)	$g = 2h/t^2$ (m/s²)	Delete Row
1.0	0.453	9.75	
1.0	0.453	9.75	
1.0	0.453	9.75	
1.0	0.453	9.75	
1.0	0.451	9.83	
1.0	0.451	9.83	
1.0	0.447	10.01	
1.0	0.448	9.96	
1.0	0.451	9.83	
1.0	0.451	9.83	
1.0	0.456	9.62	
1.0	0.457	9.58	
1.0	0.452	9.79	
	0.236	0	

The data table offers the facility to delete any row. 
This allows you to remove any times that you think are in error.
For example, if the ball struck the metre rule as it fell, or if the ball was not released cleanly.

When you have sufficient data, click on the Basic switch to reveal the Advanced functions.



Now you can click on Statistical to look at the distribution of values in your data.
Bar Graph returns you to the default view.

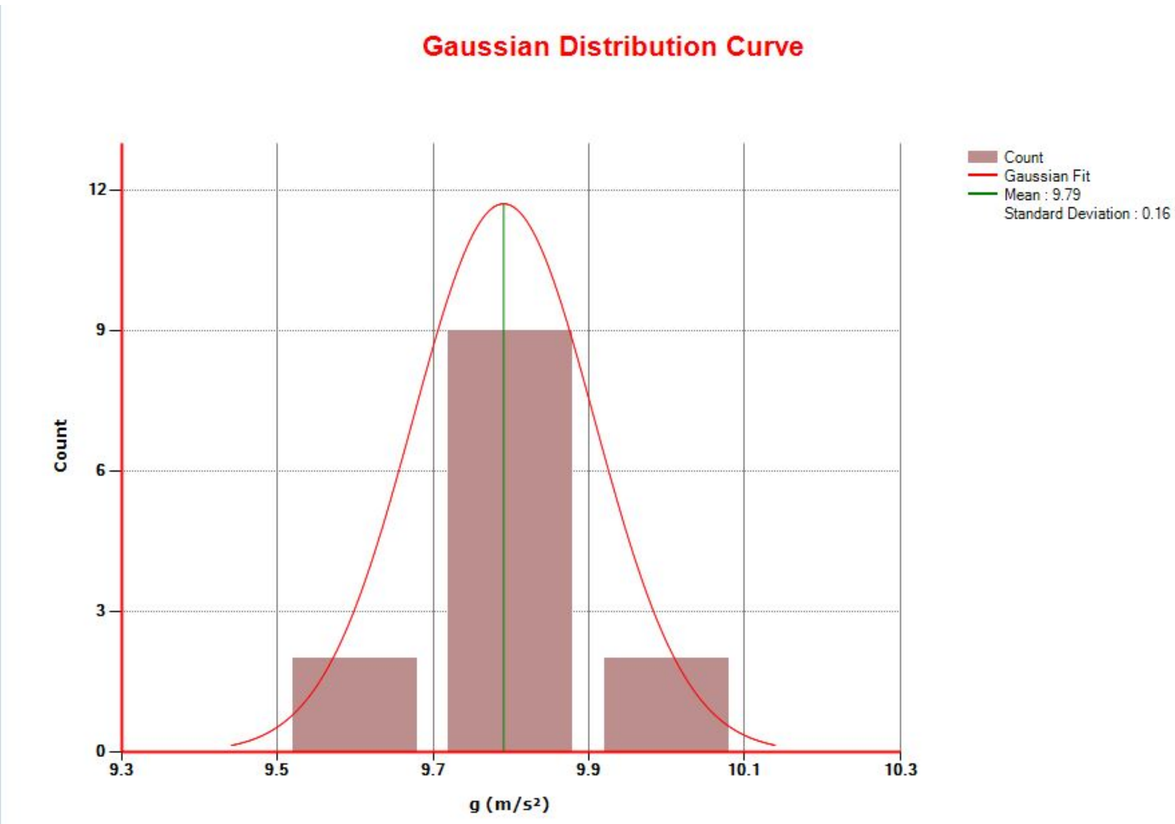


It is likely that the result of your experiment will be different from the true value due to random or systematic errors.
The effect of random errors can be minimised by repeating observations many times and computing the arithmetic mean.

Clicking on the Statistical button shows the data plotted as a Gaussian distribution.

The histogram of values of *g* shows how the values from your experiment are distributed. The mean value is marked and a red curve shows the Gaussian fit. This curve is sharp if the data is clustered around the mean, which also means that the standard deviation, σ, is small. If the curve is wide and flat σ will be larger, meaning that your data has a wide range.

Depending on the shape of the curve, you may need to consider the errors in your method.



The basic g by Free Fall experiment can be extended by taping two metre rules together, end to end and supporting them securely. In this way the drop height can be increased to 2 metres.

If you have alternative apparatus available for determining *g* it is interesting to compare and contrast the methods, considering the random and systematic errors involved in each method.

Using the Inspire Light Gates with *g* by Free Fall accessory, a steel ball or dowel is dropped from a solenoid, through one or two Light Gates. Times are captured and *g* is calculated from a variety of graphs.

The Light Gates can also be used to accurately capture the period of a pendulum, from which *g* can be calculated.

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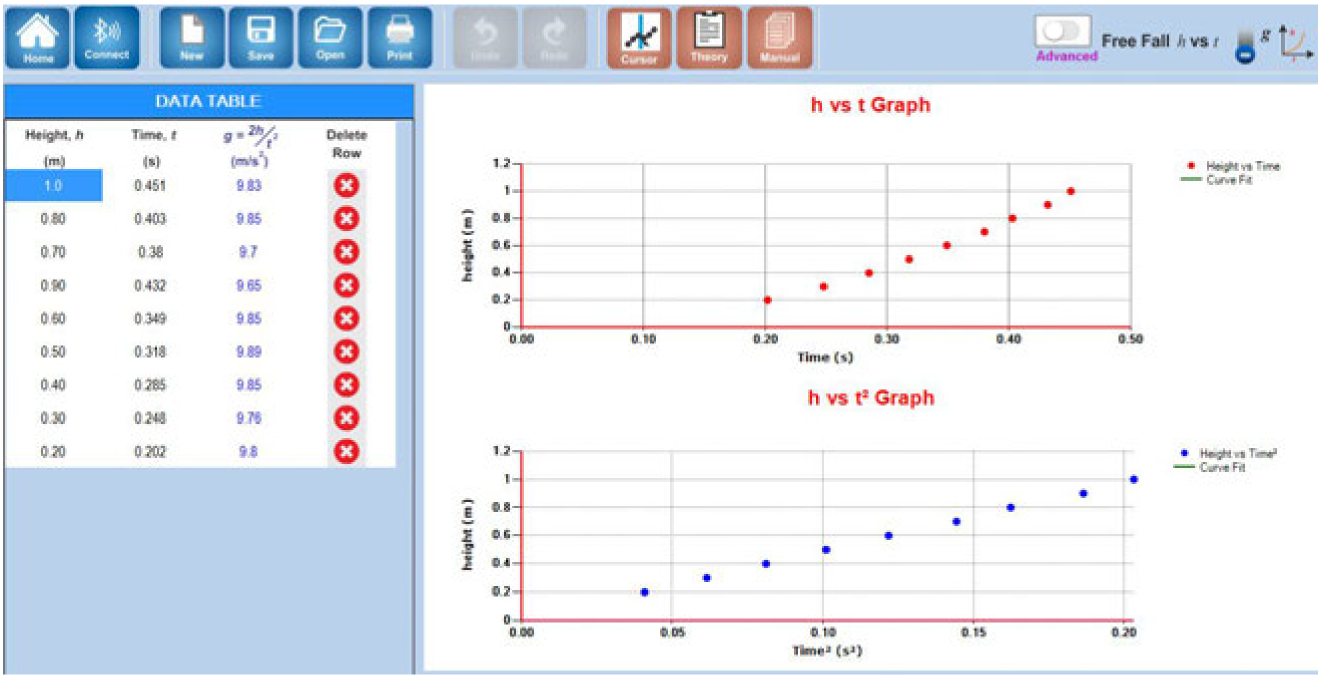
Free Fall h vs t mode

In this mode, the variation of free fall time, t, with height, h, can be studied.

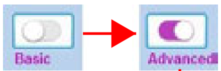
Under constant acceleration, h is related to t by the formula $h = \frac{1}{2} g t^2$

In the example, the ball was dropped from 1 metre and the value of g was calculated from the time data. The height was decreased by 0.1 m after each drop and the variation of h as a function of both t and t^2 is presented graphically.



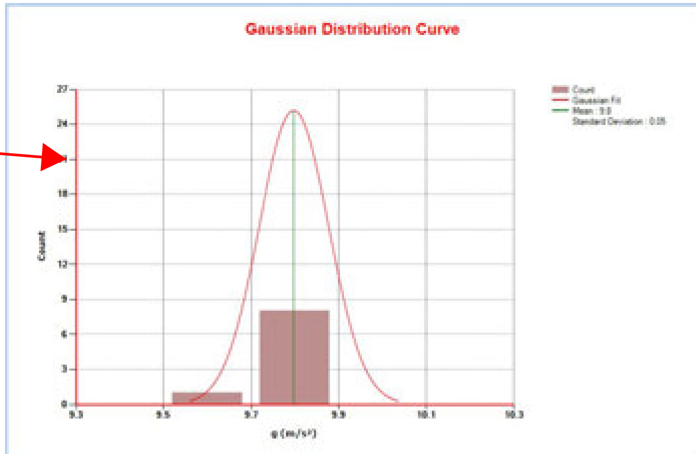
Height, h (m)	Time, t (s)	$g = 2h/t^2$ (m/s²)	Delete Row
1.0	0.451	9.83	
0.80	0.403	9.85	
0.70	0.38	9.7	
0.90	0.432	9.65	
0.60	0.349	9.85	
0.50	0.318	9.89	
0.40	0.285	9.85	
0.30	0.248	9.76	
0.20	0.202	9.8	

Click on the Basic switch

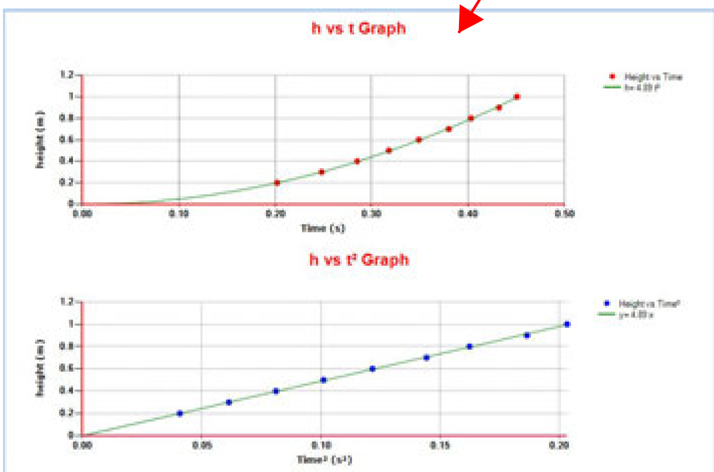


to reveal the Advanced functions.
You now have three icons:

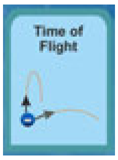
Graph is the default plot.



Statistical gives a Gaussian distribution for the data, showing the mean and the standard deviation. This indicates how closely clustered your data is.



Curve Fit gives a best fit line on both graphs, and the formula for each line is given. The constant in both formulas is ½ g or 4.89 in this example.

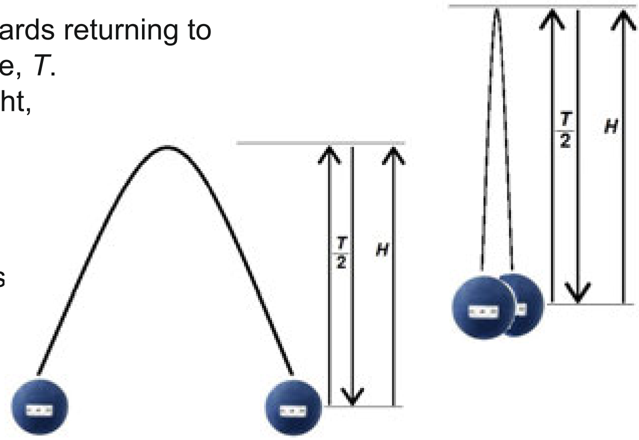


Time of Flight mode

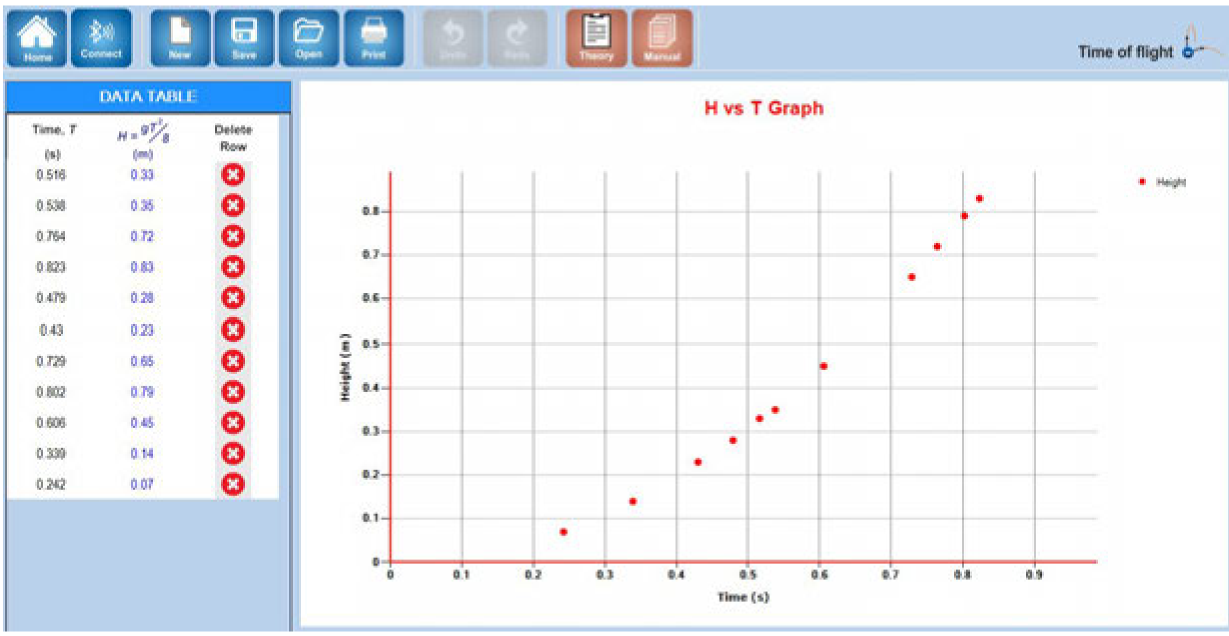
In this mode the ball is armed and thrown vertically upwards returning to the thrower's hand at the same horizontal level after time, *T*. The ball takes half of time *T* to reach the maximum height, and half of *T* to fall to the starting height.

When the ball is thrown at an angle, it travels in a parabolic path, attains a maximum height then returns to its original level after time, *T*. As before, the ball takes half of time *T* to rise, and half of *T* to fall.

In both cases, the time *T* is called the time of flight.



From the time of flight, we can calculate the maximum height reached.
Is the height reached in a vertical throw different from the height reached in an angled throw?



DATA TABLE

Time, T (s)	$H = gT^2/8$ (m)	Delete Row
0.516	0.33	
0.538	0.35	
0.764	0.72	
0.823	0.83	
0.479	0.28	
0.43	0.23	
0.729	0.65	
0.802	0.79	
0.606	0.45	
0.339	0.14	
0.242	0.07	

The Time of Flight display simply plots *H*, the calculated maximum height, against *T*, the measured time of flight for each throw.

During vertical motion, the relationship between the vertical height, *h*, and time elapsed, t, can be written as $h = \frac{1}{2} g t^2$ where *g* is the acceleration due to gravity

Setting $h = H$ and $t = T/2$ in that equation, we can see that the maximum vertical height the ball will reach is given by the formula $H = \frac{g T^2}{8}$

This formula is used by the software to calculate the value of *H* for each throw.

To answer the question you need to throw the ball several times vertically and at an angle.

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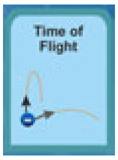


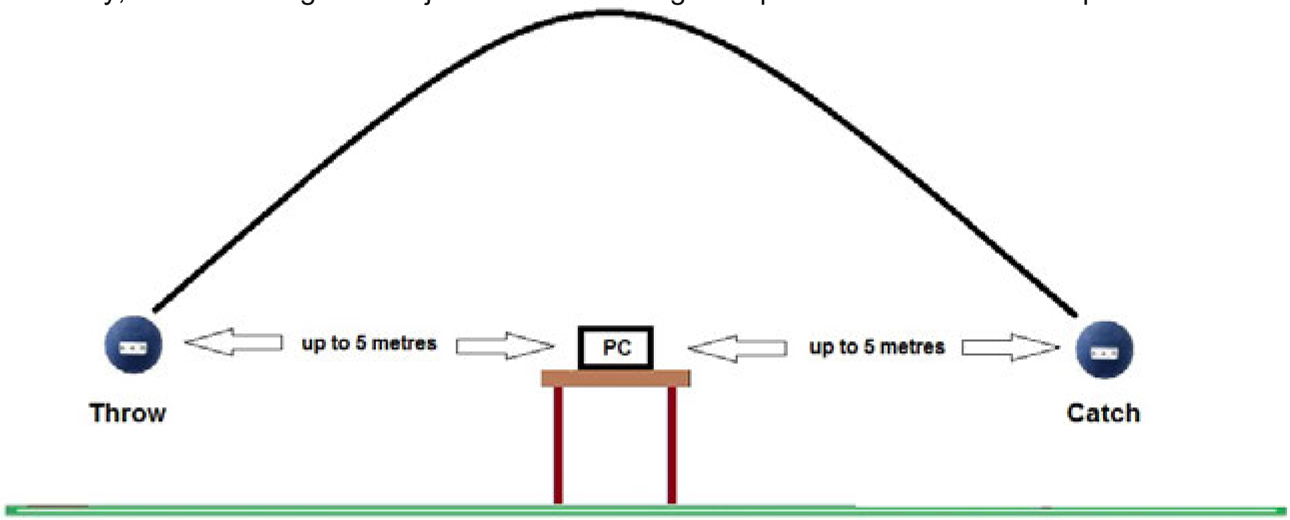
Time of Flight mode continued

When you have collected a number of results, you should find that the maximum height reached is independent of the direction of the throw. For similar values of T, the time of flight, the maximum height H is the same.

Check out the Theory page to see the mathematical treatment of vertical and angled throws.

The experiment can be extended by taking the Timing Ball and the PC or smart device into a large space such as a sports hall. In this environment, the ball can be thrown higher and further.
The range of Bluetooth communication is about 5 metres, that will be the limit for vertical throws.

For angled throws, the ball should be thrown over the PC, from one side to a catcher on the other side. In this way, the time of flight for trajectories with a range of up to 10 metres can be captured.



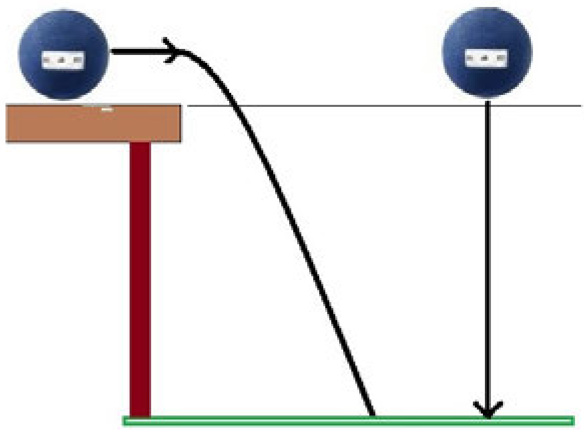
Further experiment

Using the basic Times mode, you can investigate another question.
If the ball is 'flipped' off the edge of a table or bench so that it does not fall vertically, does it take longer to reach the floor than if it is dropped vertically from the same height?

You will need to practise the flipping so that it is truly horizontal AND you do not trigger the ball to stop timing.

Compare a number of 'flips' with a number of vertical drops from the same height.

Explain and justify your conclusions.



Curriculum references

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Using the Timing Ball and TimingPro software supports and contributes to the following practical requirements of A-level Physics syllabuses.

Edexcel

Core Practical 1: Determine the acceleration of a freely falling object.
Students should:
10. be able to draw and interpret displacement-time, velocity-time and acceleration-time graphs
15. understand how to make use of the independence of vertical and horizontal motion of a projectile moving freely under gravity
Practical techniques:
3. Use methods to increase accuracy of measurements, such as timing over multiple oscillations, or use of fiduciary marker, set square or plumb line.
11. Use ICT such as computer modelling, or data logger with a variety of sensors to collect data, or use of software to process data.

AQA

Required practical 3: Determination of g by a free-fall method.
3.4.1.3 Motion along a straight line
Measurements and calculations from displacement–time, velocity–time and acceleration–time graphs.
3.4.1.4 Projectile motion
Independent effect of motion in horizontal and vertical directions of a uniform gravitational field.
MS 0.3, 1.2, 3.7 / AT d Students should be able to identify random and systematic errors in the experiment and suggest ways to remove them.
MS 3.9 Determine g from a graph.

OCR

Practical Activity Group 1 Investigating motion - Acceleration of free fall.
3.1.2 Linear motion
(b) (i) acceleration *g* of free fall
(b) (ii) techniques and procedures used to determine.the.acceleration of free fall using trapdoor and electromagnet arrangement or light gates and timer.
3.1.3 Projectile motion
(a) Independence of the vertical and horizontal motion of a projectile
(b) two-dimensional motion of a projectile with constant velocity in one direction and constant acceleration in a perpendicular direction
HSW4 Carry out experimental and investigative activities including appropriate risk management, in a range of contexts.
HSW6 Evaluate methodology, evidence and data, and resolve conflicting evidence.

Alternative apparatus

The Inspire Light Gates and Dynamics Cars with TimingPro software provide alternative approaches to the measurement of g by free fall, and also support a range of dynamics experiments: motion on an inclined plane, Newton's 2nd law, momentum, collisions, kinetic and potential energy, oscillations and pendulums.

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