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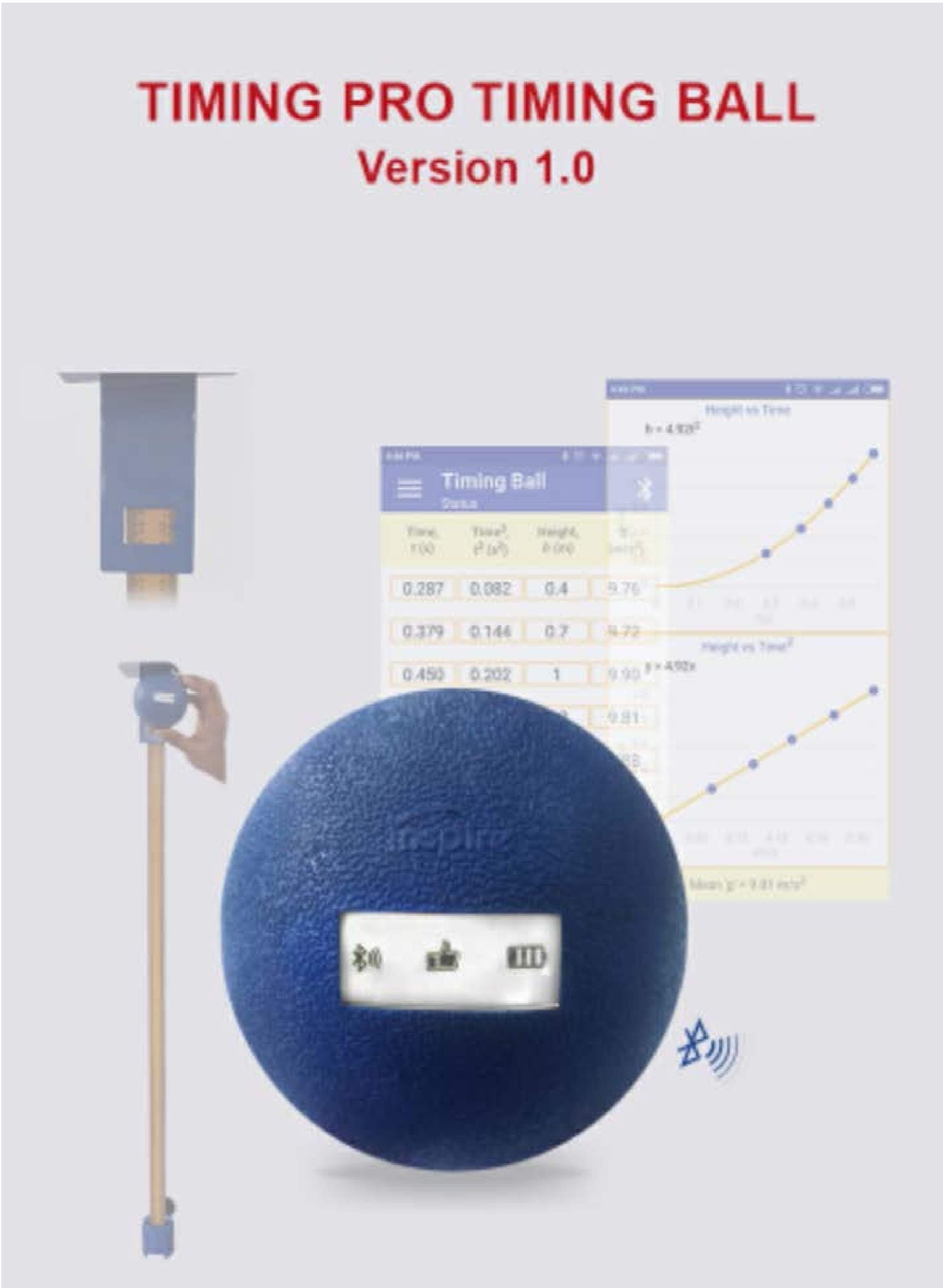
TimingPro Timing Ball - Android



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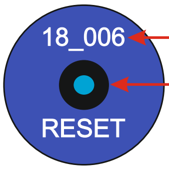
TimingPro Timing Ball

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.

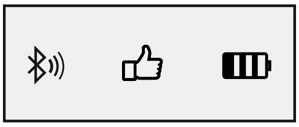
This button has two functions: Power ON and ARM.
It needs only light pressure to operate it.



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.

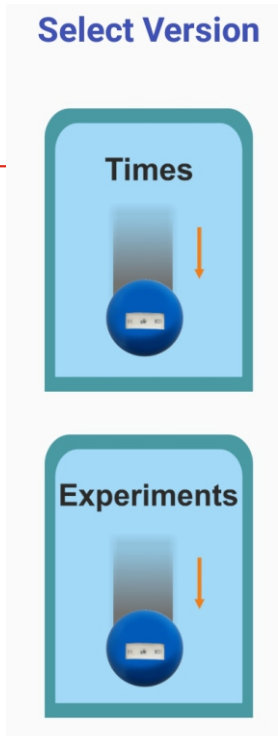
Auto shut down: When the TimingPro software is closed, the Timing Ball automatically shuts down after about 90 seconds of inactivity. During this period, the bluetooth LED blinks.

Introducing TimingPro software

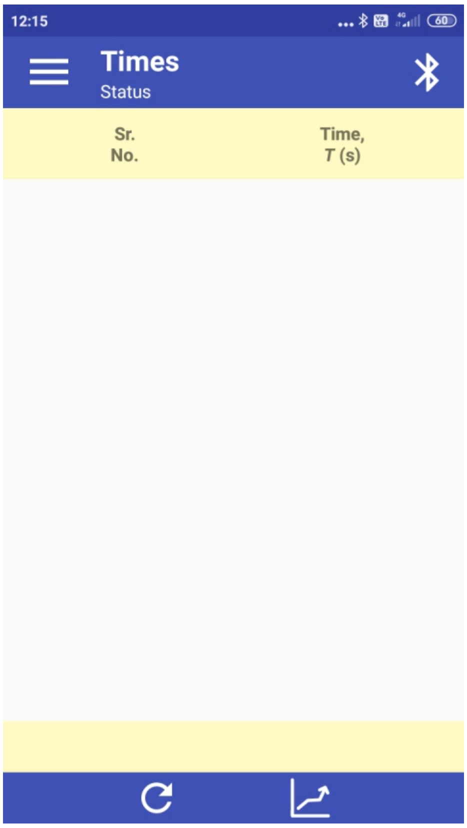
You need to download and install the TimingPro Timing Ball software on your phone or tablet.

Timing Pro software for the Timing Ball can be downloaded from Play Store.
Simply open Play Store on the Android phone or tablet, search for Timing Pro or Timing Ball.
Download and install the app.

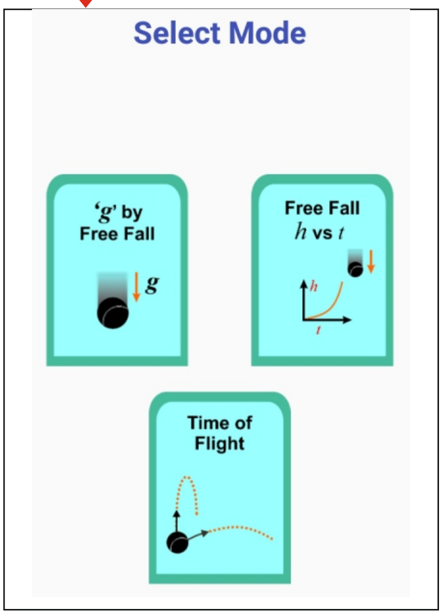
When TimingPro is opened, the home screen gives the choice of Times or Experiments.



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



Experiments offers three modes:
g by Free Fall
Free Fall *h* vs *t*
Time of Flight
Data can be edited and is displayed graphically.
These modes are described later.



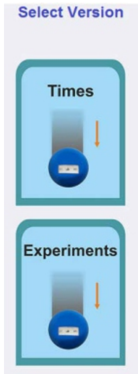
Before you can use any mode, the Timing Ball must be paired with the phone or tablet.
Check that your phone or tablet has Bluetooth turned on, then go to the next page.

First time Bluetooth pairing

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

Open the Timing Pro Timing Ball app.

Tap on **Times** mode.



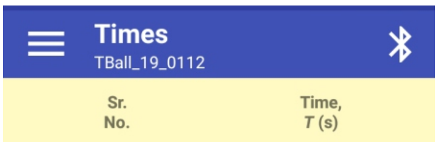
Tap the Bluetooth icon and a list of available Bluetooth devices will be displayed.

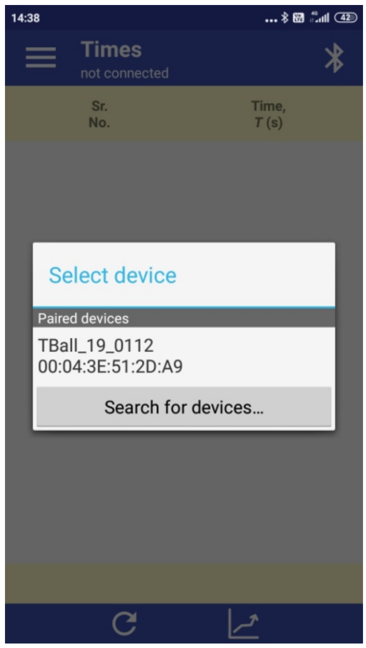
The Timing Ball's name will appear in this format : **Tball_yy_nnnn**

If your Timing Ball does not appear in the list, tap on “Search for devices” to refresh the list.

Check the serial number on your Timing Ball.
Tap on the matching Timing Ball.

The header changes to include the Serial Number





The Timing ball is now 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 continue to flash.
After 90 seconds of inactivity the ball switches off automatically.

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

Using Times mode

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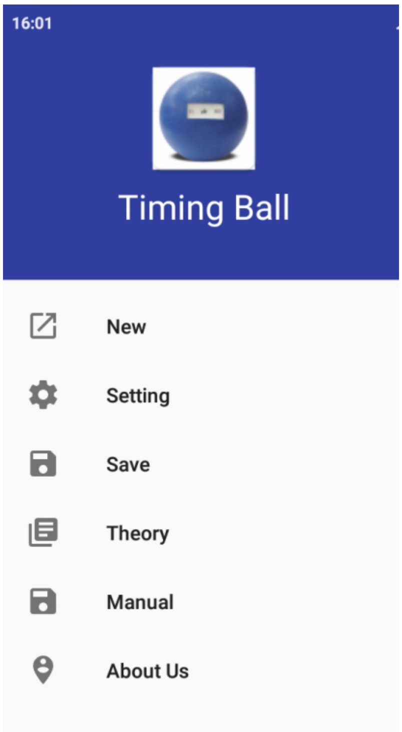
The Times screen shows that the Timing Ball is paired and is ready to capture data from the Timing Ball.

The menu icon opens a new window,
which can be closed by swiping it to the left.



The menu offers the following functions and facilities:

Go back to the Home screen

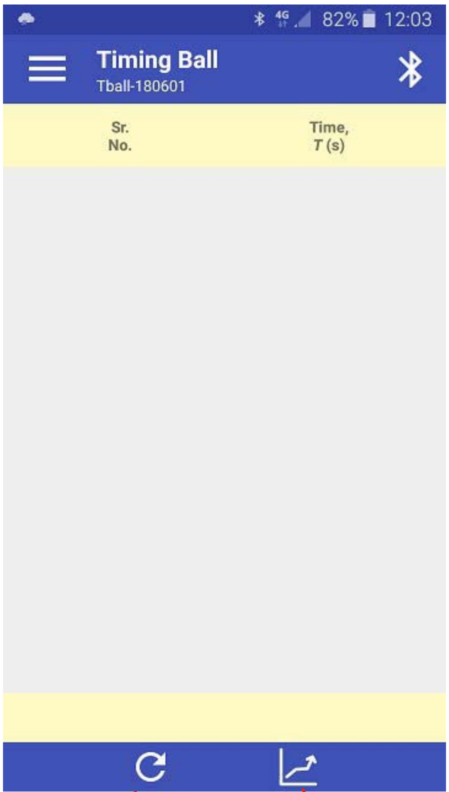
Change the settings

Save the current data

Open the theory page for the current experiment

View the Timing Ball manual

About the TimingPro app



Clear the current data, ready for a new session

Tap on the Graph icon to see the bar graph display

Press the WAKE UP button to ARM the Timing Ball, then drop it on to a rubber pad or other soft surface.
Drop times are captured by the TimingPro app.
Arm and drop the ball repeatedly to build up a data table.

In the data table, any row can be deleted by swiping the row to the left.

In all modes the data table is the starting point. When enough data has been captured, tapping on the Graph icon opens a graphical display of the data, as a bar graph or a line graph.

Timing Ball Pointer Accessory

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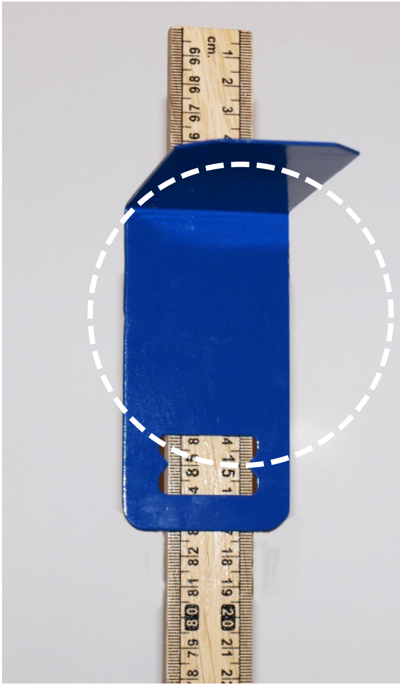
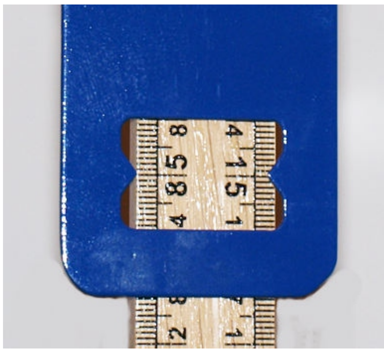
The Pointer Accessory makes it easy to measure the drop height accurately.
Holding the Timing Ball up against the flat plate aligns the bottom of the ball with the pointer, which indicates the drop height on a standard metre rule.

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



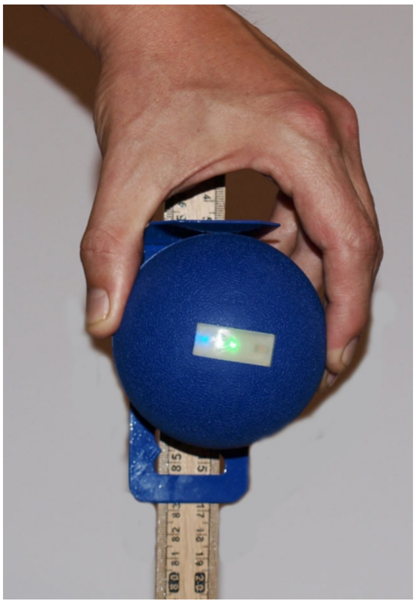
Holding the ball up against the flat plate gives accurate alignment with the scale.



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 a rubber mat.

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.
Taping two metre rules together, end to end, gives a potential drop height of 2 metres. Care needs to be taken with alignment and support.

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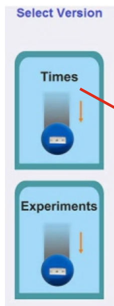
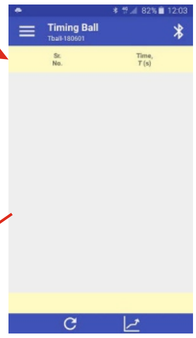
Using the Timing Ball

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.





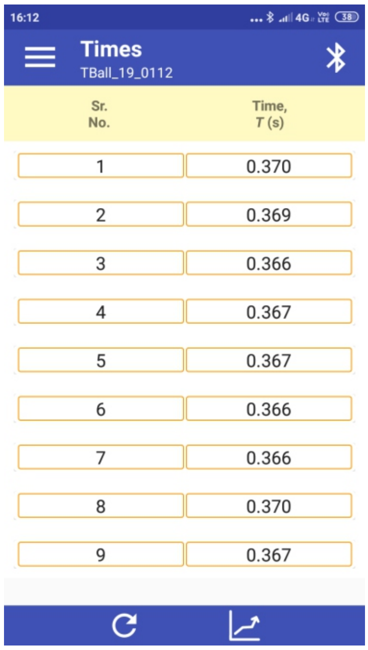
Launch TimingPro software and select **Times** in the Home screen.

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

Tap on the Bluetooth icon 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.

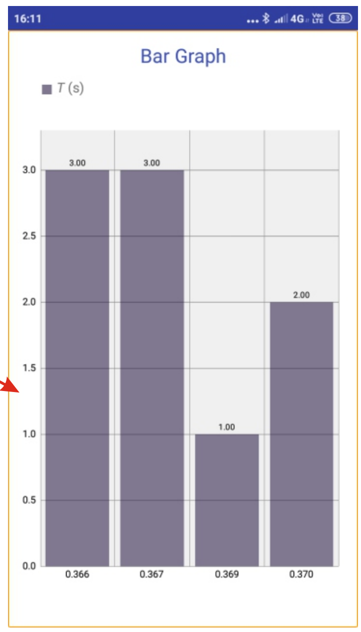


The times taken for the ball to fall are recorded in the data table and on the bar graph, which counts repeated values.

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

This activity tests the consistency of your technique to reduce errors in later experiments.

Tap on the Graph icon to see your data as a bar graph.



You can use the data to calculate ***g*** manually.

You are now ready to tackle the individual experiments.

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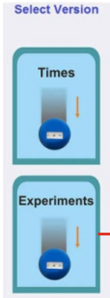
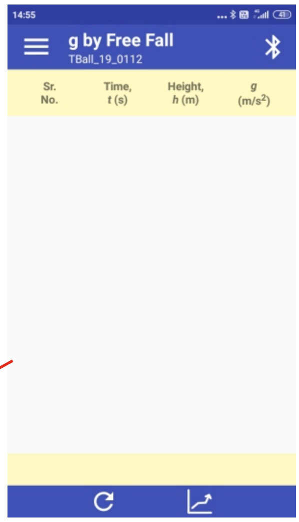
g by Free Fall

The g by Free Fall experiment requires the Pointer accessory, metre rule and clamp stand.

Go to the Home screen and select Experiments.



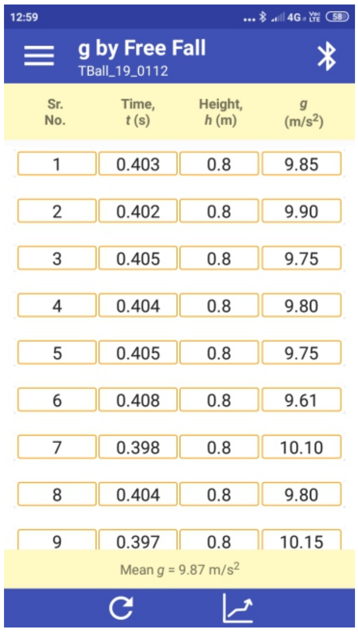


In this mode, the ball is armed and dropped from a measured height.

A popup window prompts the user to enter the height in metres after each drop.

The value of ***g*** is calculated from the free fall time for every drop.

The mean value of ***g*** is calculated after each drop and displayed.



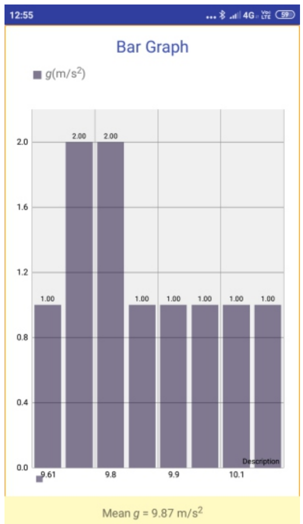
In the example here, the ball was dropped several times from a height of 0.8 metre.
You may choose to do that, or drop the ball from a range of heights.
In both cases, the value of ***g*** is calculated after each drop and an updated mean is displayed.

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

The data table offers the facility to delete any row, by swiping it to the left.

This allows you to remove any times that you think are in error, like Sample No 4 in these results, when the ball struck the metre rule as it fell, or the ball was not released cleanly.

Tapping on the Graph icon  displays the data as a bar graph.



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.

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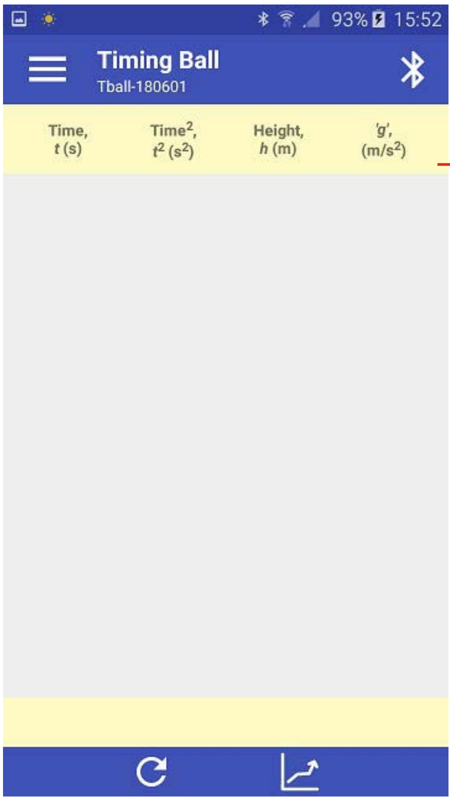
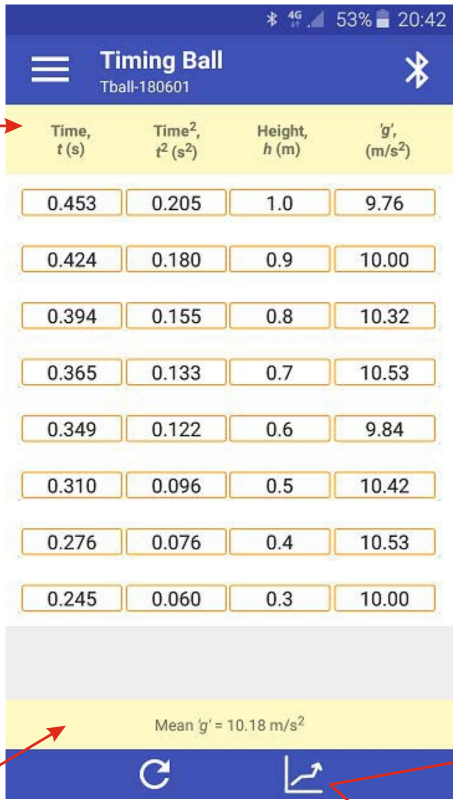
Free Fall h vs t mode

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 $h = \frac{1}{2} g t^2$

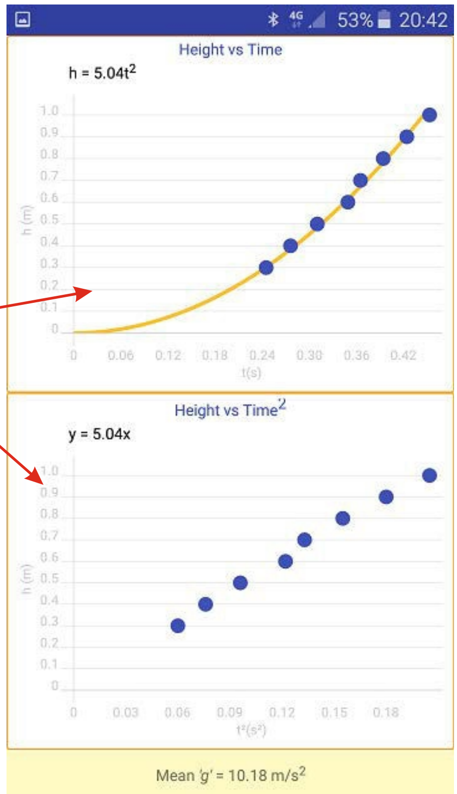
In the example, the ball was dropped from 1 metre and the value of ***g*** was calculated from the time data. The height was decreased by 0.1 m after each drop.





Time, t (s)	Time², t^2 (s^2)	Height, h (m)	'g', (m/s^2)
0.453	0.205	1.0	9.76
0.424	0.180	0.9	10.00
0.394	0.155	0.8	10.32
0.365	0.133	0.7	10.53
0.349	0.122	0.6	9.84
0.310	0.096	0.5	10.42
0.276	0.076	0.4	10.53
0.245	0.060	0.3	10.00

The variation of ***h*** as a function of both ***t*** and ***t²*** is presented graphically.



The mean value of ***g*** is updated after each drop and displayed.
Any data that is in error, can be deleted by swiping it to the left.

Tap on the Graph icon to see your data plotted as ***h*** vs ***t*** and ***h*** vs ***t²***

A best fit line is automatically added to both graphs, updated if data is added or deleted, and the formula for each line is given.

The constant in both formulas is ½ ***g*** or 5.04 in this example.

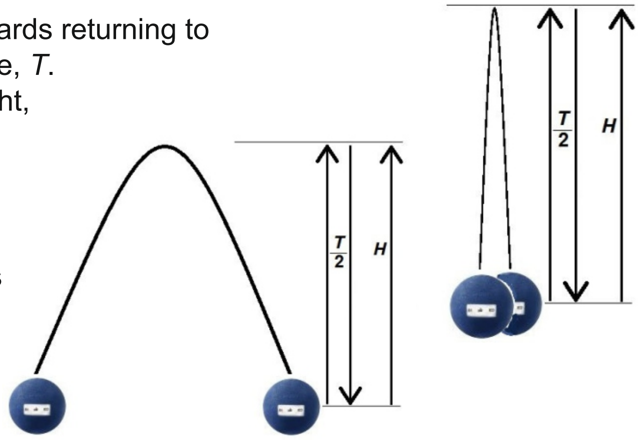
Using two metre rules taped together and securely supported, would allow you to increase the drop height to 2 metres. What advantage is there to increasing the drop height?

Time of Flight mode

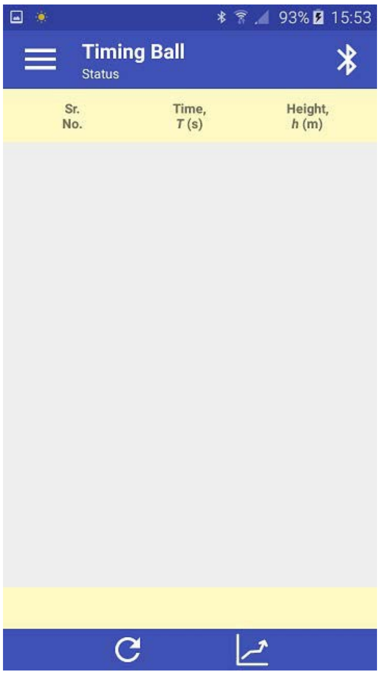
In this mode the ball is armed and thrown vertically upwards returning to the thrower's hand at the same horizontal level after time, *T*. The ball takes half of time *T* to reach the maximum height, and half of *T* to fall to the starting height.

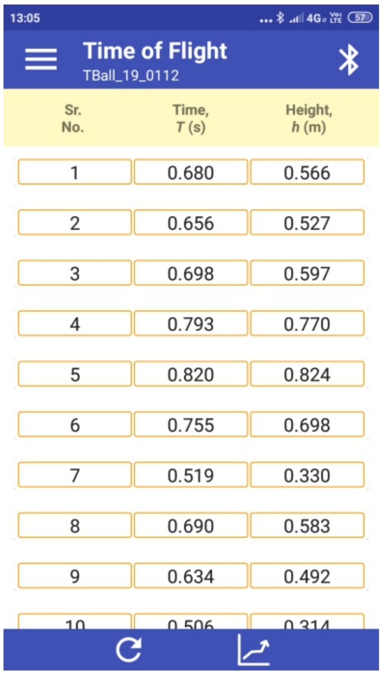
When the ball is thrown at an angle, it travels in a parabolic path, attains a maximum height then returns to its original level after time, *T*. As before, the ball takes half of time *T* to rise, and half of *T* to fall.

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

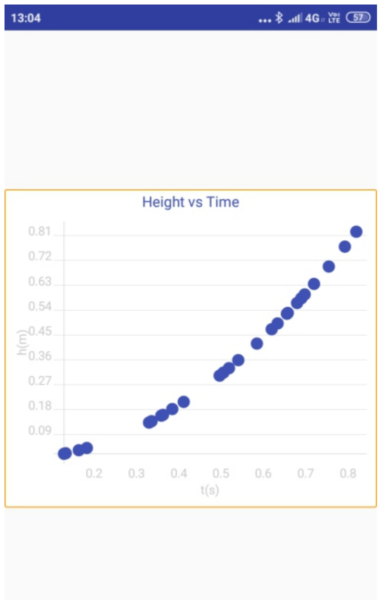


From the time of flight, we can calculate the maximum height reached.
Is the height reached in a vertical throw different from the height reached in an angled throw?





Sr. No.	Time, *T* (s)	Height, *h* (m)
1	0.680	0.566
2	0.656	0.527
3	0.698	0.597
4	0.793	0.770
5	0.820	0.824
6	0.755	0.698
7	0.519	0.330
8	0.690	0.583
9	0.634	0.492
10	0.506	0.314



The Time of Flight display simply plots *H*, the calculated maximum height, against *T*, the measured time of flight for each throw. Notice that all the points lie on the same curve.

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 above, you need to throw the ball several times vertically and at an angle.

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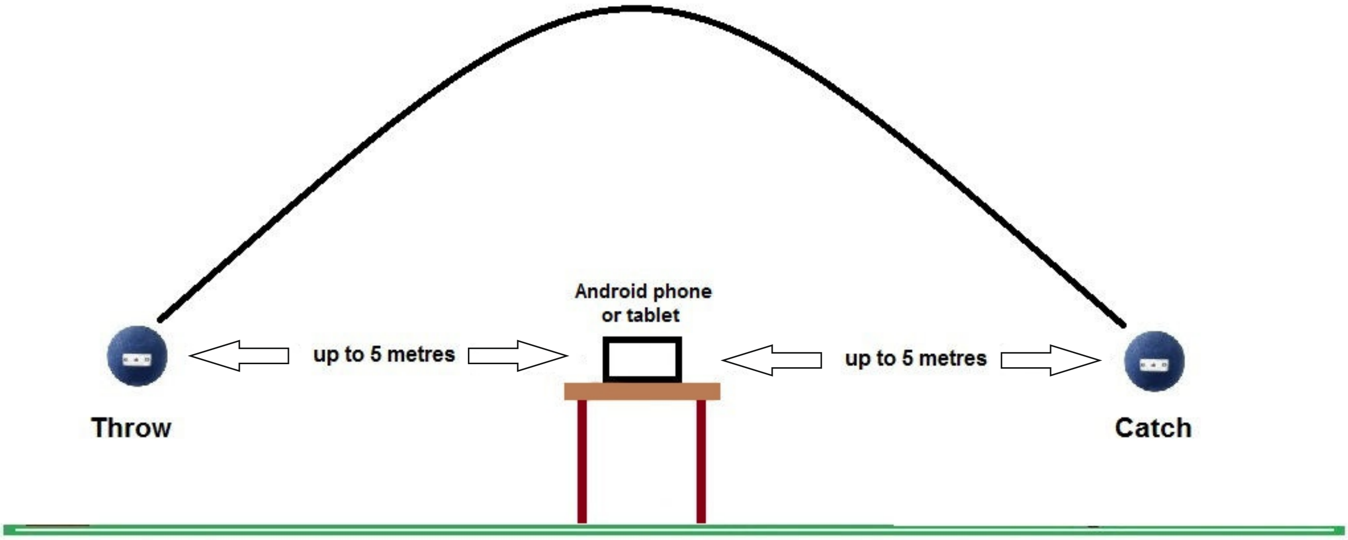
Time of Flight mode continued

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.

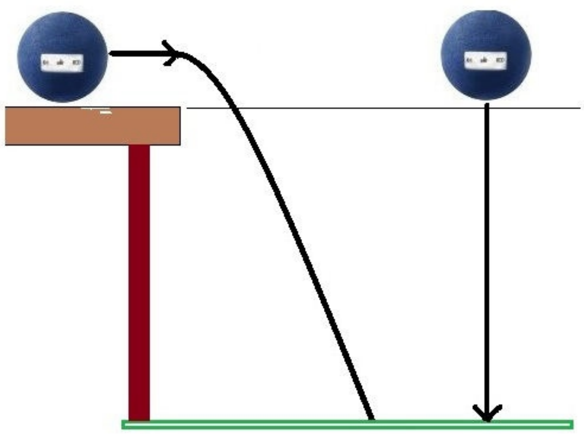
The experiment can be extended by taking the Timing Ball and the PC or smart device into a large space such as a sports hall. In this environment, the ball can be thrown higher and further.
The range of Bluetooth communication is about 5 metres, that will be the limit for vertical throws.

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 when 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 prematurely.

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.