Instruction manual for student timer

05.01.11

Description

This student timer is designed to perform time measurements using photo cells, microphones, free-fall equipment and other mechanical and electronic switches. The timer function can also be activated manually.

The student timer is supplied with batteries and a mains power adapter.

Accessories:

Photo cell

Photo cell for air track with C-profile

Microphone

Free-fall apparatus

Firing mechanism for air track in connection with switch box

Note:

The instrument can NOT be used with older model photo cells, older type microphones and free-fall equipment type

Connection of external units:

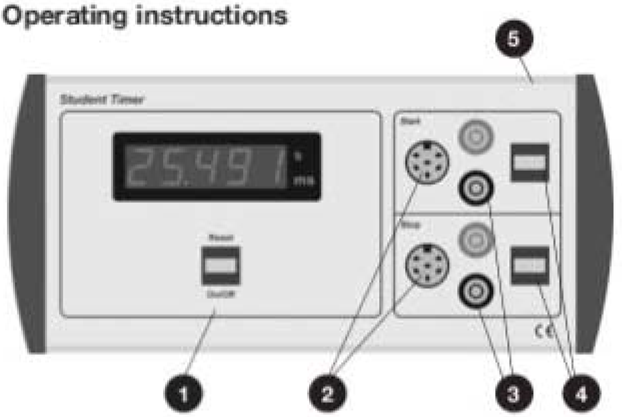
Photo cells and microphones can be plugged in to the appropriate DIN connector.

The free-fall apparatus is connected via the 4 mm safety jack connectors.

For other types of connections note that the instrument is activated via the start and stop functions when the logic level on the input changes, either from high to low or from low to high.

The various accessory options can be combined arbitrarily, for example by starting the stopwatch with a photo cell and stopping it with a microphone.

Operating instructions



(1) Start/stop og reset button. Awakens the instrument from sleep mode.

(2) DIN connectors for microphone and photo cell.

(3) Jack connectors for connection of free-fall, switch box or other accessories.

(4) Push button for manual start and manual stop.

(5) Bushing for mains adapter (on the side of the instrument).

The instrument is turned on by pressing the On/Off switch. After about 1 second, the instrument is ready. This is indicated by the display showing 00000.

The timer is started by activation of an external unit such as a photo cell, microphone or free fall apparatus, or by pressing the button located in the "start" region of the display. The display will continue counting time until an external unit again is activated, or the button in the "stop" region of the panel is pressed.

The instrument is prepared for the next time measurement by pressing Reset.

NOTE: If the time measurement lasts for more than 5 minutes, the light intensity in the display after this time will fade as the instrument goes into the sleep mode. The time measurement continues, however, and can be seen in the display. This feature is only active when the instrument is supplied from the battery. If the power adapter unit is used the high intensity of the display remains unchanged.

The display can be returned to its normal condition by pressing the Reset button.

Furthermore, the display returns to its normal condition when the instrument stops counting.

Automatic shut down:
The instrument turns itself off automatically after 5 minutes without any activity, both when battery powered and when powered with the power adapter. The instrument saves the display value, and this value is visible there when the instrument is turned-on again.

Low battery power:
When the battery voltage is low, the display will briefly show LoBat:

Technical data:

Display: 5 digit LED with floating decimal point

Resolution: 0.01 ms

Max. counting time: 99999 s

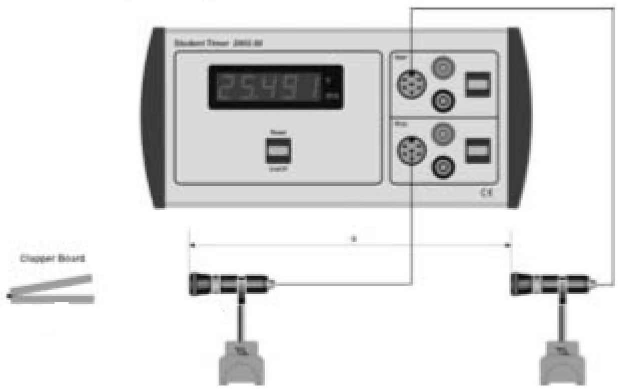
Spare parts:

Batteries; (6 ea.)

Power adapter;

EXPERIMENTS

Measuring the speed of sound



Equipment list:

1 ea. Student timer

2 ea. Microphones

2 ea. Retort stand base

1 ea. Clapper board

Using this setup the student timer starts counting when sound activates the first microphone and stops when sound activates the second.

Theory:

The speed V_{sound} is defined as the distance covered, s, per unit time t: $V_{sound} = s/t$

The table value for the speed of sound in air is as follows:

$$V_{sound} = 331.6 \text{ m/s} \cdot \sqrt{1 + 0.00367 \cdot t}$$

where t is the air temperature. At room temperature (20 degrees C) the speed of sound turns out to be 344 m/s.

By placing the two microphones at a distance s from one another and measuring the time t required for sound to propagate from the first to the second microphone, the speed of sound V_{sound} can be computed. The experiment should be repeated a number of time (e.g. 20 times). The result of the experiment is the average and standard deviation of these results.

Table s: ________

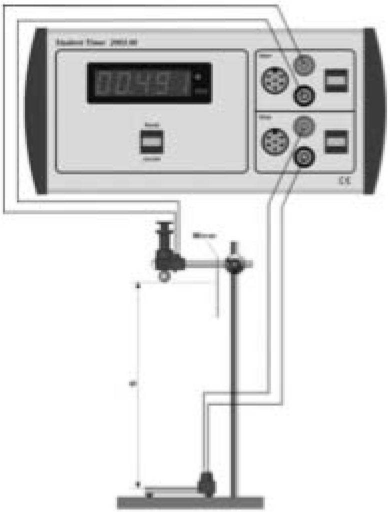
t	v = s/t

Compute the average value of v: _____

An alternative method for finding V_{sound} is to measure a number of times t corresponding to various distances s.

If a graph is plotted showing distance as a function of time, then the slope of the resulting straight line is the speed of sound V_{sound}.

Measuring the acceleration due to gravity:



Using this setup the student timer is started when the ball is released from the release mechanism, and the counting is stopped when the ball strikes the switch plate.

Equipment list:

1 ea. Student timer

1 ea. Free fall apparatus

4 ea. Test leads

1 ea. Retort stand

1 ea. Retort stand rod

1 ea. Bosshead

Experiment 1:
Perform 10 experiments measuring the time it takes a given steel ball to fall through a fixed height.

Theory:
The connection between position s and time t for linear motion with constant acceleration a is:

$s = s_0 + v_0 \cdot t + 1/2 \cdot a \cdot t^2$

For a free fall where the ball is at rest initially, $v_0 = 0$ and $s_0 = 0$.

Furthermore is $a = g$.

In this case the equation reduces to: $s = 1/2 \cdot g \cdot t^2$

Fall distance: s = ______. Ball mass: m = _______

Fall time (ms)	$g = (2s)/t^2$

Find the average value of g: __________

Compare with standard value for g: 9.82 m/s^2

Repeat the experiment with another ball.

Experiment 2:
Measure 10 corresponding values of the fall distance s and the time for the fall t. Change the value of s before each trial. Plot the values in a graph with s as a function of t^2. The slope of this graph should be ½ g where g is the acceleration of gravity.

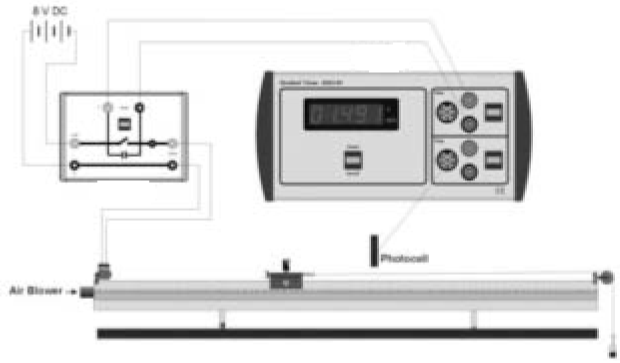
Mass of ball: m = _____

s	t^2

Compare the measured value of g with the table value 9.82 m/s^2.

Repeat the experiment with another ball with a different mass.

Demonstration of Newton's second law



Equipment list:

1 ea. Student timer

1 ea. Air track

1 ea. Blower unit with tube

1 ea. Firing mechanism

1 ea. Slot weights with holder

1 ea. Photo cell unit

1 ea. Switch box

1 ea. Power supply

With this setup the student timer is started using the switch box and stopped by means of the photo cell.

Theory:

The connection between position s and time t for linear motion with constant acceleration a is:

$s = s_0 + v_0 \cdot t + 1/2 \cdot a \cdot t^2$

Initially the glider is at rest, so v_0 is 0 and on the air track s_0 can be defined to 0.

In this case the equation reduces to: $s = 1/2 \cdot a \cdot t^2$.

Measure 10 set of values of distance s and time t. Plot the values in at graph wits s as function of t^2. The slope of the graph should be $1/2 \cdot a$.

s	t

The acceleration of the air track cart is determined by the pulling force of the weights hanging on the string. This force can be set equal to the gravitational force on the weights. In this manner Newton's second law can be checked: $F = m a$

Note that the mass in this case is the total mass of the system, i.e. the mass of the air track cart plus the pulling weights, as the entire system is accelerated.

Note that it is very important to measure s correctly. This is done by measuring the distance from the middle of the flag on the air track cart and the middle of the photo cell. If the air track firing mechanism is used (a rubber band and support), then the air track cart will have an initial velocity V_0 and the equation of motion becomes:

$$s = v_0 \cdot t + 1/2 \cdot a \cdot t^2$$

NB:

Our calculation has not taken the mass of the string and the rotation of the pulley into account. This will cause a small error in the results. Air resistance and resistance in the pulley bearings are also sources of error.