Contents

Technical Information

Plug top supply voltage 9-12 V DC - centre positive.
Digital inputs protected to 15 V.
Digital inputs protected against reverse polarity.
The two digital inputs are TTL compatible i.e.

0 - 1 V (approx.) is logic 0
3 - 5 V (approx.) is logic 1.

With a Light Bridge connected the input is held high.
The red LED is off when an input is taken low.

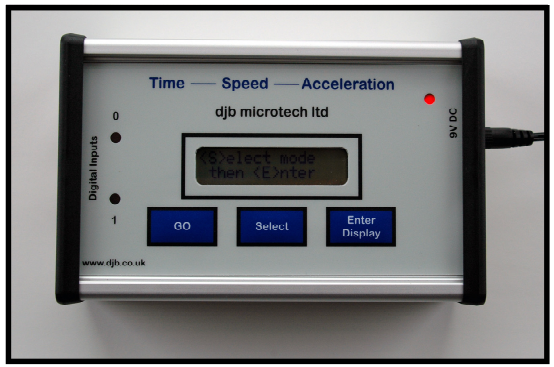
Time Intervals and Event Times have been rounded to three decimal places.
With the debounce delay set to zero the minimum time between events is $< 50\ \mu s$.
Speeds have been rounded to 2 decimal places.
The error in the Fast Timer is between -0.02 ms and +0.01 ms
The maximum Time interval is 999.99 s.
The maximum time between events is 999.99 s.
The Gap Time range is 0 — 999.999 s.

Associated Equipment

From **djb microtech ltd**:-

Light Gate cable for Unilab Slave Light Gate B1-1000.40
Light Bridge B1-1000.35
Light Gate Receiver B1-1000.30
Light Gate Transmitter B1-1000.25
DPST Switch for 'g' by free fall A1-1035.00
Reaction Timer Switches B1-1000.10
Sound Switches B1-1000.05
Timing Plate B1-1000.16
Projectiles, **E**nergy and **T**iming apparatus B1-1000.12

Getting familiar with TSA



Note that there are two digital inputs which are TTL compatible. Switches and light gates may be connected to these inputs. The inputs are also available at the DIN sockets. Light gates can be powered from these sockets.
To enable you to make some simple measurements connect a push switch between the red and black terminals of either digital input. Avoid using a toggle switch as this may cause switch bounce.

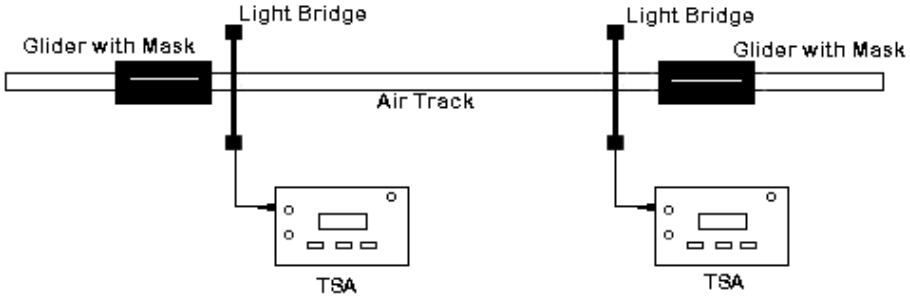
Time Interval

This mode measures the length of time a light beam has been cut or a switch closed and will be dealt with in most detail as all other modes are similar in operation.

- Switch on TSA,
- When prompted press the <S>elect button,
- Continue to press <S>elect and cycle through the modes. When you return to Time Interval press the <E>nter button.
- <S>elect how many readings you wish to make, For this first attempt <S>elect 1
- Now press <E>nter.
- The LCD displays <G> when ready. When you are ready to start the experiment press the GO button.

Measuring Momentum

Consider the situation where you wish to show the conservation of linear momentum at an elastic collision between two equal masses. The simplest way of carrying out this experiment is to set up two TSAs and two Light Bridges.



Do a trial run to show that each light bridge will be cut twice. Set up each TSA to measure two velocities. The data simply falls out in front of the students with the minimum of calculation being involved. Once the basic operation is understood different masses can be used.

Event Times

This mode is used to measure the time at which each event happened. Up to 8 events can be measured and the first event is displayed as happening at Time = 0.000 s.

The Event Timer is set up in an identical fashion to the the Interval Timer.

The Event Timer is the most verstile of all the modes offered. It can be used for many experiments in the study of motion — both linear and rotational. However it may place addition demands on the student e.g calculating the acceleration from 4 event times and a mask length is not recommended in a first level Physics course but would be excellent in promoting a deeper understanding in a second level course.

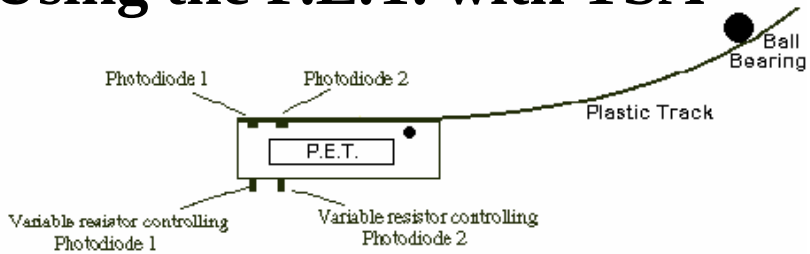
Fast Timer

This mode can be used to display a time interval between 50 - 65535 µs. Trying to measure an interval larger than the maximum causes the error message "Too big" to be displayed.
This timer could be used to measure the time for sound to travel between two microphones and from this the speed of sound can be calculated.

Important

On selecting this mode the debounce delay is automatically set to zero and it is returned to its original value on exit.

Using the P.E.T. with TSA



The Projectiles, Energy & Timing (P.E.T.) device consists of a flexible plastic track connected to a box containing two photo diodes mounted 20mm apart at the very end of the track.
The P.E.T. device allows pupils to investigate numerous aspects of motion including energy conversion, projectiles, and 'g'.
Before using your P.E.T. device you will have to adjust it so that the photodiodes switch properly for the light level in your lab. A full description on how to do this is given in the P.E.T. manual - a copy of which can be downloaded from the Teachers' Section on our website. Your attention is drawn to the Quick Setup which is by far the easiest way of ensuring that your P.E.T. is working properly.

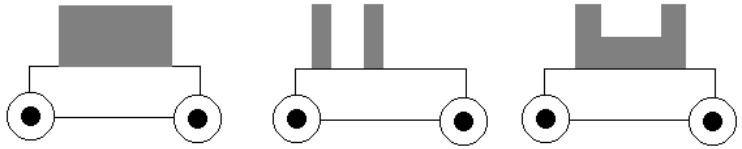
The two photodiodes are 20 ± 1 mm apart. When the leading edge of the ball bearing covers the first photodiode it causes an event and the clock in TSA is started. The trailing edge of the ball bearing is ignored. When the leading edge cuts the second photodiode another event is created and the time on the clock is noted.
Knowing the time to cover the 20 mm the velocity at the end of the track can be calculated. To measure the horizontal launch velocity use the Fast Timer in TSA. Do not use the Event timer as its resolution is not nearly as good as the Fast Timer.

Possible Experiments/Investigations

- Height and launch velocity
- Potential and kinetic energy
- Launch height and time of flight.
- Release height and time of flight
- Calculation of 'g'
- Launch velocity and range.
- Comparison of experimental and theoretical time of flight.
- Comparison of experimental and theoretical range

Acceleration

The setup for this mode is identical to Speed. However, there are several possible mask arrangements:-



Possible mask arrangements

Masks may be attached to the trolley with masking tape.
To measure an acceleration a single mask requires two light gates whereas a double mask requires only one light gate.
Where double masks are used then both sections must have the same width.

Acceleration Data

This mode is intended for developing the concept of acceleration. The user is presented with values of v1 and v2 from which they have to calculate the change in velocity. They are also given the time for the change in velocity. Using this data they can calculate the acceleration. Note that this mode does not display the acceleration. Once the student is familiar with the calculation of acceleration using the Acceleration Data mode they can switch to the Accleration Mode for investigative work.
The following notes may be helpful :
Suppose you use a light gate and a double mask with each leg d cm wide.
To calculate an acceleration you require 4 event times – t1, t2, t3 and t4.
Subtracting t2 - t1 gives the time for the first leg of the mask to cut the beam.
The velocity (v1) of the first leg can be calculated using d/(t2 - t1). This is an average velocity and it will have this velocity in the middle of the timing interval (t2 - t1) – for a constant acceleration.
Similarly the velocity (v2) of the second leg can be calculated using d/(t4 - t3). This is an average velocity and it will have this velocity in the middle of the timing interval (t4 - t3)

The change in velocity (v2 - v1) can now be calculated.

The time for the change between these two average velocities is:

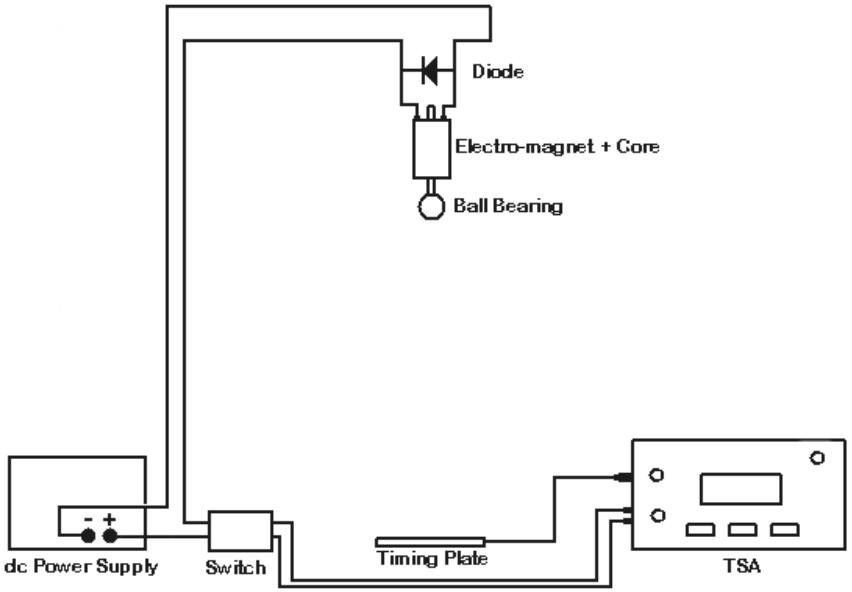
$$(t2 - t1)/2 + (t3 - t2) + (t4 - t3)/2$$

The acceleration can now be calculated from

(change in velocity) / (time for change)

The Falling Ball Experiment

A little care is required in performing this experiment.



The switch used is a double pole, single throw - djb code A1-1035.00. Adjust the power supply so that the ball bearing is just held by the electro magnet. In this way any residual magnetism effects will be kept to a minimum.
The leads should be long (about 1 metre) to keep the switch and electro-magnet a good distance from TSA. If this is not done then magnetic effects may cause spurious triggering.
The diode used is a general purpose one - typically a 1N4001 would do nicely.
Set TSA up to measure the Gap Time. When the switch is moved to the off position the ball is released and the timer starts because there is a change in state of an input. The Timer now looks at the other input and waits for a change in state caused by the ball bearing hitting the timing plate.
An alternative method for carrying out this experiment is now available and it uses the Falling Ball Release Mechanism - it removes the requirement for an electromangnet.
See our website www.djb.co.uk/ppm_falling_ball_release.html

Connecting Light Gates

The **djb microtech** Light Bridge connects directly to either DIN socket on TSA. The unit is free standing or may be held in a clamp stand. It also can be positioned upside down to measure the period of a simple pendulum.
Our free standing Light Gate Transmitter and Receiver are available for users wishing to operate with larger distances between the transmitter and receiver.

9.8

You have done your experiment to measure acceleration due to gravity and you don't get the magic number 9.8 — why not ? Where are the errors? Since the microprocessor inside TSA gives very accurate measurements of time, why are the results not perfect ?
Below are a number of suggestions which may help to minimize errors:-

- measure the size of the mask accurately,
- make a number of measurements with the mask inverted, i.e. the leading edge becomes the trailing edge,
- use a narrow parallel beam of light,
- drop the mask vertically,
- release the mask as close to the detector as possible in order to reduce the size of the shadow,
- release the mask from just above the detector in order to minimize possible air resistance effects.

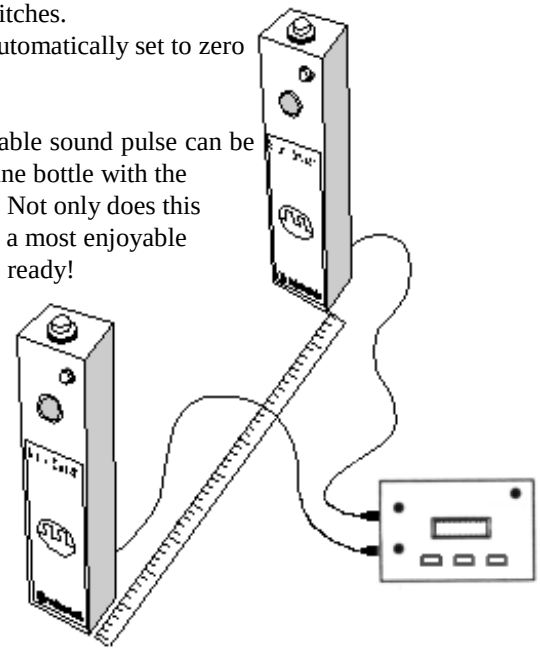
Measuring the Speed of Sound

TSA can be used to measure the speed of sound. A typical setup using **djb microtech's** Sound Switches is shown below.

It is important to adjust the switches to be as sensitive as possible. Users are referred to the instruction sheet supplied with the Sound Switches - this is available to download from the Teachers' Section of our website.

The speed of sound is calculated by measuring the distance between the sound switches and then using the Fast Timer to time how long it takes to travel between the switches.
Note that the debounce time is automatically set to zero when using the Fast Timer.

A suitably fast rising and repeatable sound pulse can be produced by hitting an empty wine bottle with the plastic handle of a screw driver. Not only does this fascinate the pupils but it can be a most enjoyable experience getting the apparatus ready!



Speed of Sound using **djb microtech's** Sound Switches