Time — Speed — Acceleration
+ GM Counter

djb microtech ltd

Contents

Introduction

Welcome to Time - Speed - Acceleration + GM Counter. This manual is a comprehensive guide to the use of this versatile measuring instrument.

To obtain the best results from TSA work your way through each section of this manual. It won't take you long and it will give you an insight into the versatility of the instrument and its potential areas of application.

What can TSA+ GM Counter Measure ?

TSA can operate in a number of different modes.
It can:

    a) measure time intervals (4)
    b) measure event times (8)
    c) be used as a fast timer with a resolution of 10 µs (8)
    d) measure gap time (1)
    e) be used to develop the concept of acceleration (v1, v2, dt)
    f) measure speed (4)
    g) measure acceleration (2)

In the GM mode it can:

    a) display the counts/second - used for determining the properties of different types of radiation
    b) display and store the counts/min - used in background count and half life experiments
    c) display and store the number of counts in a long period

Getting familiar with TSA
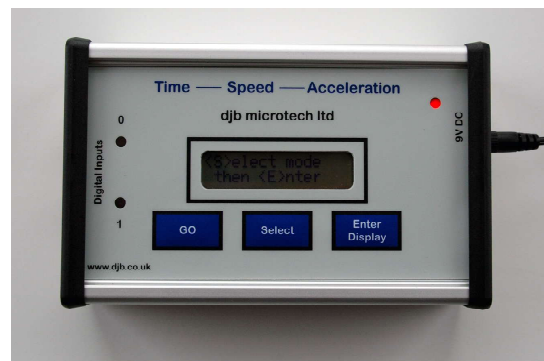
Note that there are two digital inputs which are TTL compatible. Switches and light gates may be connected to these inputs. The inputs are also available at the DIN sockets. Our light gates can be powered from these sockets.
To enable you to make some simple measurements connect a push switch between the red and black terminals of either digital input. Avoid using a toggle switch as this may cause switch bounce. Select the Time Interval mode and see how easy it is to get readings - information on this mode follows on the next page.

Time Interval

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

The basic operation of the menu in TSA is to keep pressing the <S>elect key until you see what you want then press the <E>nter key. The structure of the various modes is shown in Appendix 1, figure 1.

- 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.
- The LCD displays "Waiting". TSA is now waiting for an event to happen so that it can start its internal clock.
- Close the switch (firmly) and then open it a short while later.
- The time interval will be displayed on the LCD.
- Press <G> to GO again and repeat the experiment.
- After you have repeated the experiment several times press <S>elect and again select Time Interval but this time set TSA to read 3 time intervals.
- Proceed in a similar fashion as before but note that the Waiting message is displayed until all 3 time intervals have been measured.
- To see all three time intervals, keep pressing <D>isplay.

If the displayed time intervals are unreasonably short then this is caused by switch bounce. The best thing to at this stage is to replace the switch or use a light gate and cut the beam with your hand.

Important

An Event is simply a change in state of an input. To measure a time interval there must be two events: the first one starts the internal clock and the second one stops it.

TSA has been designed so that the starting and stopping of its clock can be controlled from either input channel independently. For example an event on channel 1 can start the clock and the next event on channel 0 or channel 1 stops the clock.

All inputs are debounced. On closing a switch the contacts tend to bounce very quickly, generating many events. To get round this problem the software waits for a few milliseconds after an event before returning to look at the inputs to see if another event has occurred. Note that the clock has not stopped and no error has been introduced in the timing. It does, however, limit the minimum time interval to the length of the debounce delay. The default debounce delay is set at 4 ms. A minimum time interval measurement of 4ms should not impose too many restrictions on general classroom work. However for users having specialist requirements see the section on Changing the Debounce Delay.

The time interval is rounded to 3 decimal places.

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 input channel on which the event happened is displayed along with the time.

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 50µs and 99,999ms. 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. It also can be used with the Projectiles, Energy & Timing apparatus as well as the Energy Track. A maximum of eight Fast Times can be recorded.

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

Gap Timer

This mode is used to measure the time interval between events on **different** input channels. It is set up in a similar way to the Interval Timer. Only one Gap Time can be measured.

Consider a trolley with a mask running down a runway that has two light gates positioned on it. When the first light gate is cut the clock starts and when the second one is cut the clock stops. Gap time is different from Time Interval because here the events must happen on different channels.

The time displayed is the time for the leading edge of the mask to travel from one light gate to the next. The trailing edge is ignored.

This mode could find application in the teaching of average speed — set two light gates a known distance apart and use Gap Time to measure the time for the trolley to travel this distance.

Guidance on selecting the appropriate timer is given in Appendix 3.

Speed

This mode is used to measure the speed of a vehicle as it passes through a light gate. If the mask is small then the measurement is a reasonable approximation to the instantaneous speed.

- <S>elect the Speed mode then press <E>nter.
- <S>elect the size of your mask in centimetres. Note that each time the <S> button is pressed the distance increments in 1 cm steps until 10 cm and then in 10 cm steps until 250 cm. Holding down the <S> button results in a rolling display.
- Press <E> to enter your mask size.
- Press <G> when ready.
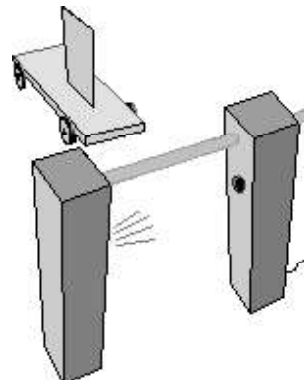
Important

If very fast speeds are to be measured then the debounce delay must be changed to zero and bounce-free switches used.

Acceleration Data and Acceleration Modes

The setup for thesw modes is identical to Speed. However, there are several possible mask arrangements:
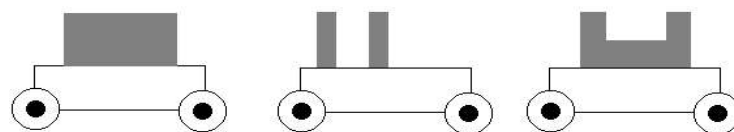
Possible mask arrangements

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. In addition they must be a whole number of centimetres.

This Acceleration Data 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 the acceleration can be calculated. 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.

In the Acceleration mode only the acceleration is displayed. The setup is identical to the Acceleration Data mode. The following notes may be helpful:

Suppose you use a light gate and a trolley with a double mask and each leg of the mask is 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
$$(\text{change in velocity}) / (\text{time for change})$$

Changing the Debounce Delay

Switch bounce may cause problems when you are trying to measure events. Consequently a default debounce delay of 4 ms has been designed into TSA. This does NOT mean that there is an error of 4 ms in the timing. After an event, 4 ms will elapse before the inputs are again examined to await the next event. During these 4ms the switch should settle and stop bouncing. If an event happens during these 4 ms then it would be missed! In most school experiments a 4 ms debounce delay will not cause problems. However the user can change this delay in the range 0 - 20 ms.

To change the debounce delay
- <S>elect Change Debounce then press <E>nter.
- <S>elect to change the current value of the delay.
- Scroll through the values and <E>nter your required value.

If you are using switches as the inputs to TSA then do not set the debounce delay to zero unless these switches are hardware debounced.

Remember that for most work the default value of the debounce delay will be satisfactory. The default value of 4 ms is set at switch on. If you change the debounce time then the new value will remain until the unit is switched off or another value is entered. Pressing the Reset button will also cause the debounce time to be reset to 4ms.

GM Tube

Note that the GM tube will only work correctly when it is connected to channel 0.

When this mode is selected the user enters a sub menu - see Appendix 1, figure 1.

The options available when you enter the GM Mode are: Ratemeter, Counter, Period Count and Results. These are discussed below.

For the Counter and Period Count modes up to 100 readings can be saved. These readings will remain saved even after power down and will only be overwritten when a new experiment is performed. The user can exit the GM Tube sub-menus at any time by pressing the Reset button. To stop readings being saved the user should press and hold the <S> key.

Ratemeter

The Ratemeter is ideal for comparing radioactive sources and also the properties of alpha, beta and gamma radiation. When you stop the Ratemeter by holding the <S> key the software takes you back to the GM Tube sub-menu.

Counter

Your GM tube must be connected to input 0.

This mode should be used to determine the background count or to take regular readings to determine the half life of a substance. Up to 100 readings can be stored and they will remain saved after power off. They will only change when they they are overwritten with the results of another experiment.

The count is measured and displayed every minute. The interval between stored readings can be selected by the user, see Appendix 1, Chart 2. If the user selects to store the count every 5 minutes then the order of events is:

- a reading is taken at time=0; to get this reading the count is sampled for one minute.
- at the end of each minute the count is displayed, and
- after 5 minutes the count that is displayed is saved to memory and the reading number (R) is displayed.
- the clock displayed on the screen resets itself every time a reading is stored.

Note that R starts counting from zero at time zero.

A typical screen is shown below.

```
 _____
|  Counts/min=22         |
| 01:14          R=47    |
|_____|
```

When 100 readings have been stored the display shows R=***. The display continues to update the Counts/min until the user stops the experiment by holding down the <S> key. The user is then presented with the options of displaying the statistics or starting again.

The statistics that can be displayed are:

- number of readings
- average
- maximum value
- minimum value
- time interval between readings

The individual readings can be examined. To stop this task hold down the <S> key.

Period Count

The Period Count is set up in a similar manner to the Counter.

The total number of counts in a selected time can be stored. This is useful for detecting low levels of radiation e.g. radiation from walnuts. 100 readings, of the total number of counts in one hour, can be stored.

In the Period Count mode the first reading at time=0 is the number of counts in the selected time interval.

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. Note that the Light Gate Receiver operates using the infra red from the lens end bulb. This means that the unit is unaffected by ambient light and therefore will operate satsifactorily near a window. Note that using a laser to obtain a large distance between transmitter and receiver will not work.

9.8

You have done your experiment to measure acceleration due to gravity by dropping a double mask through a light gate 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,
- 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.
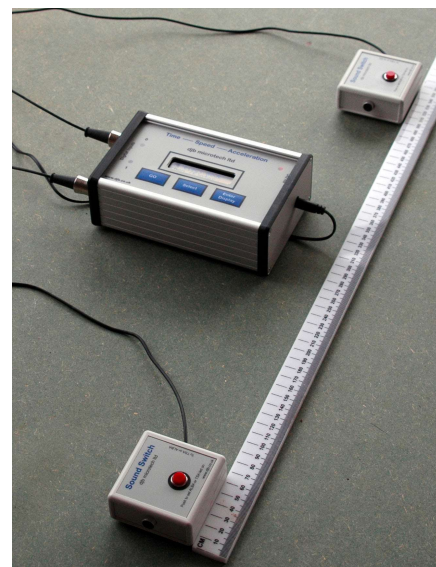
Measuring the Speed of Sound

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

Measuring Reaction Time
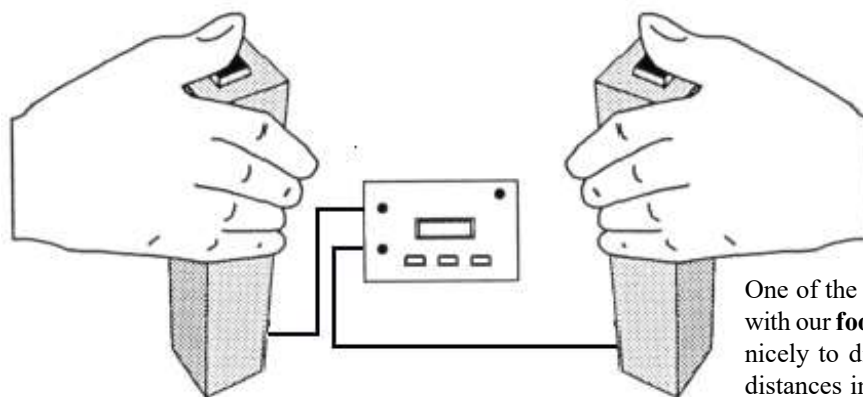
One of the switches can be replaced with our **foot switch**. This will lead on nicely to discussions on stopping distances in cars.

In this experiment we use two Reaction Timer Switches. One student presses their switch which causes a red LED to come on and start the clock. The other student, whose reaction time is being measured, presses their switch as soon as they see the LED light up. This stops the timer.

- Connect the DIN plug from each Reaction Timer Switch to the DIN sockets on TSA.
- Switch on TSA.
- Press the switch connected to channel 0 and check that LED 0 illuminates on TSA.
- Repeat for channel 1.
- Select Gap Time using the Select button on TSA. Note that when using the Gap Timer the software waits for an event on one channel and then waits for another event on the other channel. Hence any switch bounce is ignored.
- Press the GO button when ready.
- A pupil, who is the starter, presses their switch when ready. Another pupil whose reaction time is being measured presses their switch as soon as the red LED comes on.
- Press GO to repeat the experiment.

For investigative work you could replace one of the switches with a Sound Switch. If aloud sound is made in front of the Sound Switch then the reaction time using sound can be measured and compared with previous results.

The Falling Ball Experiment('g' by freefall)

(Traditional Method)
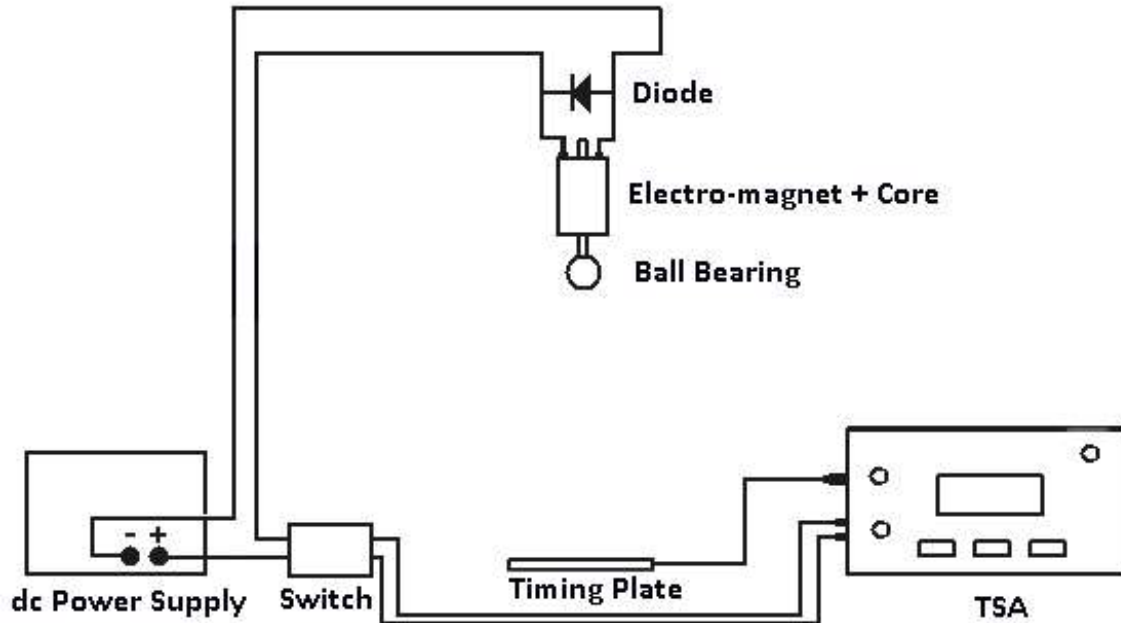
The switch used is a double pole, single throw - djb code A1-1035.00. Adjust the power supply so that the ball bearing is just held by the electro magnet. In this way any residual magnetism effects will be kept to a minimum. The leads should be long (about 1 metre) to keep the switch and electro-magnet 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.

Falling Ball - Preferred Method

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, power supply, switch and diode.

See our website www.djb.co.uk/ppm_falling_ball_release.html
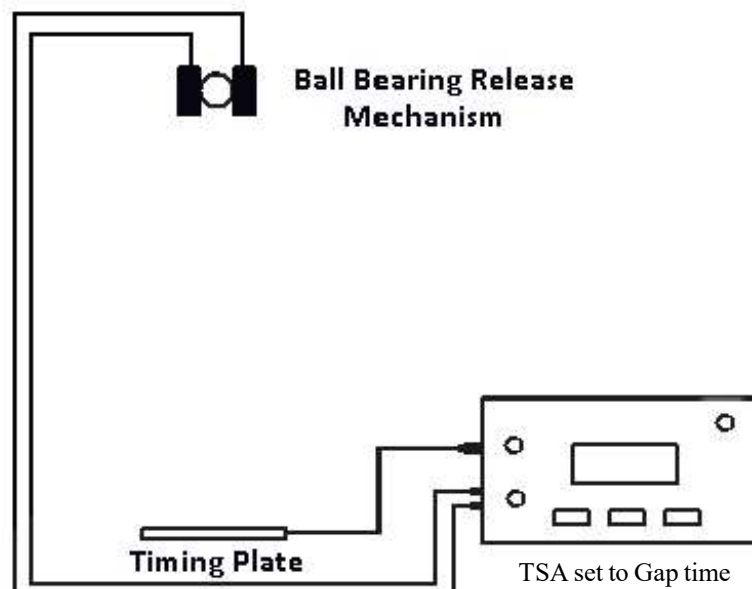
Typical Results from Falling Ball Experiment

notes	Time s t	Height m s	Use Data Points
1	0.461	1.00	use
2	0.434	0.89	use
3	0.409	0.79	use
4	0.384	0.70	use
5	0.356	0.60	use
6	0.326	0.50	use
7	0.289	0.39	use

Falling Ball 1

Curve Fit Equations
$y = -0.131 + 0.707 \cdot x + 3.8 \cdot x^2$ (fit=7.1e-6)

notes	Time s t	Height m s	Time^2 s^2 t2
1	0.461	1.00	0.212
2	0.434	0.89	0.189
3	0.409	0.79	0.167
4	0.384	0.70	0.147
5	0.356	0.60	0.127
6	0.326	0.50	0.106
7	0.289	0.39	0.084

Falling Ball 2

Curve Fit Equations
$y = -0.000794 + 4.74 \cdot x$ (fit=5.71e-5)

The slope of the s/t^2 graph is $a/2$ and the results from this experiment give a value of the acceleration due to gravity as 2×4.74 i.e. 9.48 m/s^2.

The above tables and graph were obtained using the ALBA software, a version of which is freely available to download from www.djb.co.uk.

Using the P.E.T. with TSA
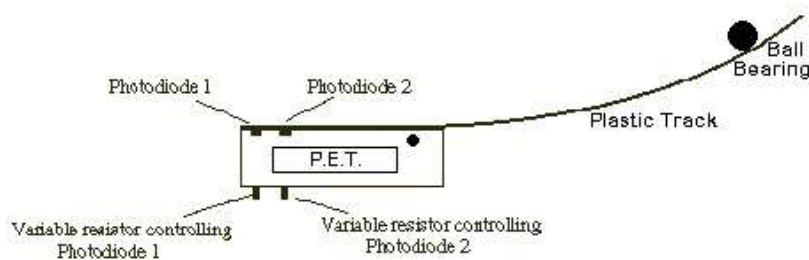
The Projectiles, Energy & Timing (P.E.T.) device consists of a flexible plastic track connected to a box containing two photo diodes mounted 20mm apart at the very end of the track.
The P.E.T. device allows pupils to investigate numerous aspects of motion including energy conversion, projectiles, and '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.

The Energy & Projectiles Track
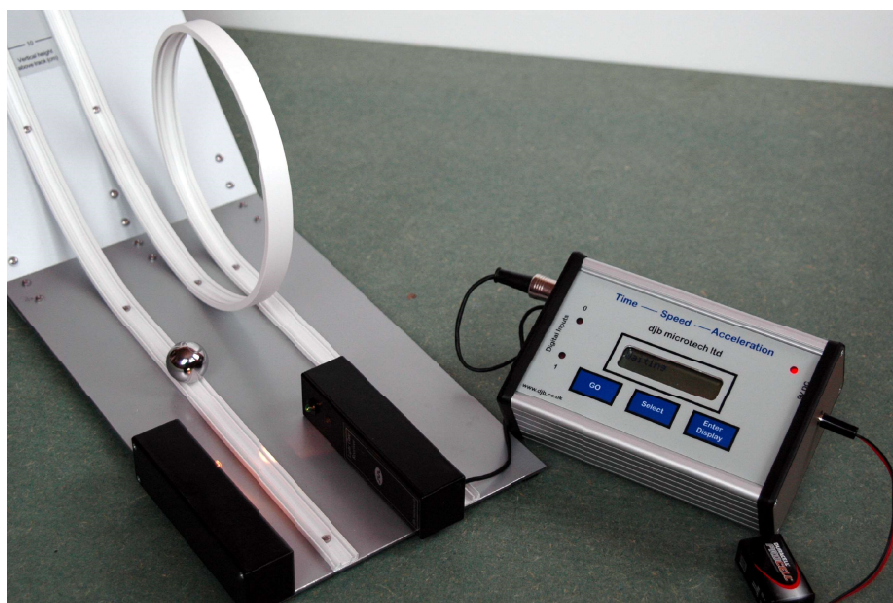
The Energy Track comprises two plastic tracks that run down a fixed slope and then along a horizontal section. A ball bearing placed on the slope will run down it and cut a light gate at the end of the track.

The numbers on the slope are the vertical heights in centimetres above the top of the horizontal track. This makes it very easy for students to accurately determine potential energy. A one inch diameter ball bearing has its centre in line with the centre of the light beam, making the setup very straight forward. Using TSA in the Fast Timer mode the time(in ms) for the ball bearing to cut the beam at the end of the track can be measured and hence the velocity calculated. If the track is placed at the end of a bench then projectiles can also be studied.

Many experiments can be tried:

- comparison of potential energy with linear kinetic energy - see table below
- comparison of potential energy with linear kinetic energy + rotational kinetic energy
- minimum potential energy required for ball to loop the loop
- comparison of speed of ball bearing at the end of both tracks
- compare time of flight of projectile with calculated time
- calculate projectile range
- calculate 'g'

notes	ht cm h	time ms t	velocity m/s (A) v	v^2 (m/s)^2 (A) v2	Ep mJ (A) Ep	Ek mJ (A) Ek	Er mJ (A) Er	Etotal mJ (A) Et
1	10.5	21.44	1.18	1.40	69.2	47.0	18.8	65.8
2	10.5	21.33	1.19	1.42	69.2	47.5	19.0	66.5
3	10.5	21.27	1.19	1.43	69.2	47.8	19.1	66.9
4	12.5	19.38	1.31	1.72	82.4	57.5	23.0	80.6
5	12.5	19.50	1.30	1.70	82.4	56.8	22.7	79.6
6	12.5	19.48	1.30	1.70	82.4	57.0	22.8	79.7
7	14.5	18.11	1.40	1.97	95.5	65.9	26.4	92.3
8	14.5	18.12	1.40	1.96	95.5	65.8	26.3	92.2
9	14.5	18.07	1.41	1.98	95.5	66.2	26.5	92.7
10	16.5	16.77	1.51	2.29	108.6	76.9	30.7	107.6
11	16.5	16.80	1.51	2.29	108.6	76.6	30.6	107.2

Table of results showing Ep, Ek and Er

Note that if the leading edge of the ball is placed at the 20cm mark on the scale then the centre of mass is a little higher. Further information is on the product notes http://www.djb.co.uk/pdfs/Physics%20pdfs/Energy%20Track.pdf

Projectiles and Time of Flight
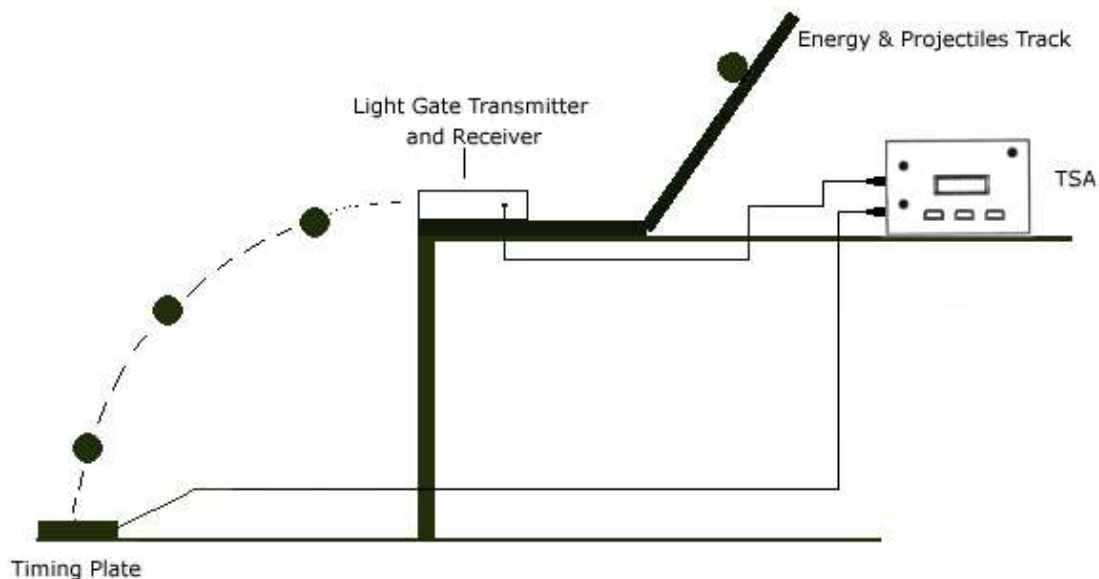
To measure the time of flight you must position the Timing Plate so that the ball bearing leaves the end of the runway and hits the plate.

TSA should be set to the Fast Timer mode and to measure three times. The second time minus the first time is used to calculate the launch velocity of the ball at the end of the track and the third time minus the second time gives the time of flight.

Possible Experiments/Investigations using the P.E.T.
- Height and launch velocity (different table heights)
- Launch height (up the track) 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

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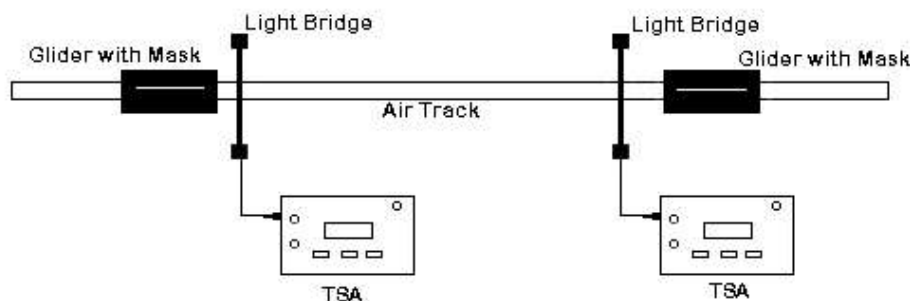
Do a trial run to show that each light bridge will be cut twice. Set up each TSA to measure two velocities. The data simply falls out in front of the students with the minimum of calculation being involved. Once the basic operation is understood, gliders of different mass can be used.

Calibrating your Signal Generator

To calibrate your signal generator carry outthe following steps:
- Switch on your signal generator and let it warm up to a stable operating temperature.
- Select sine or square wave output.
- Adjust the signal generator to a frequency you want to know accurately (in the range 10Hz - 49kHZ)
- Set the output voltage at the power output terminals in the range 2-4V RMS. Be aware that this voltage can change with frequency. So if you set up the voltage and frequency and then decide to change the frequency the voltage may now be too low and the firmware may cease to work properly.
- Connect the power output terminals of your signal generator to channel 0 on TSA.
- Set the TSA to GM Counter/Ratemeter.
- The frequency should be displayed. If not, check that the voltage and frequency are in range.

Portability

Using our PP3 Battery Lead it is possible to operate TSA without a laboratory power supply. This could lead to interesting experiments being tackled outside the laboratory.

The current drain of TSA with a **djb microtech** Light Bridge connected is < 25mA.

It is quite possible to operate TSA with a Unilab light gate with a large 9V battery but this will place a much heavier demand on your battery. This problem can be circumvented by using a '6 pack' AA cell holder instead of a large 9V battery.

Teaching with TSA

TSA is a very powerful and easy to use instrument that produces answers quickly. However, before pupils have access to this instrument they should have a basic understanding of the Physics principles involved e.g.

- speed = distance/time
- acceleration = change in velocity/time for the change

Once the basics are understood and pupils can operate TSA confidently then they can start investigating and exploring their world:

- Do heavier objects have a greater acceleration?
- Is the acceleration up and down the slope the same ?
- What is the effect of the type of surface on the final speed ?
- How is the acceleration of a radio controlled car affected by battery usage ?

Additional ideas for using TSA are on our website at **www.djb.co.uk/m_teachers.html**.

Technical Information

Plug top supply voltage 9-12 V DC - centre positive.

Maximum current that can be supplied to external devices eg Light Bridge should be restricted to less than 200mA.

Internal resettable fuse rated at 0.2A

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 high..

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 µs.

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

Light Bridge B1-1000.07

Light Gate Receiver B1-1000.30

Light Gate Transmitter B1-1000.26

Light Gate cable for Unilab Slave Light Gate B1-1000.40

DPST Switch for 'g' by free fall A1-1035.00

Reaction Timer Switches B1-1000.10

Foot Switch, B1-1000.09

Sound Switches, B1-1000.06

Timing Plate, B1-1000.16

Release Mechanism, B3-1120.00

Projectiles, **E**nergy and **T**iming apparatus, B1-1000.12

Energy Track, B1-1000.50

Air Track Photocell Unit, B2-1975.15

PP3 Battery Lead, B1-1000.20

Battery Box for TSA/ALBA, B1-1000.22

Geiger Muller Tube, F2-5135.70

Appendix 1 Chart 1 - Menu Structure

The structure of the menu for TSA is shown below.

\<S\>elect mode
then \<E\>nter

|\<S\>

Time Interval
\<S\> or \<E\> ——— \<S\> how many —— \<S\> 1,2,3,4 ——— \<E\> to enter selection

\<S\>

Event Timer
\<S\> or \<E\> ——— \<S\> how many —— \<S\> 1,2...8 ——— \<E\> to enter selection

\<S\>

Fast Timer ——— All inputs must — \<D\> — \<S\> how many —— \<S\> 1,2...8 ——— \<E\> to enter selection
\<S\> or \<E\>   be debounced \<D\>

\<S\>

Gap Time
\<S\> or \<E\> ——— \<G\> when ready

\<S\>

Speed
\<S\> or \<E\> ——— \<S\> how many —— \<S\> 1,2,3,4 —\<E\>— \<S\> mask length —— Length=1...250cm —\<E\>— \<G\> when ready
                                                              \<S\>

\<S\>

Acc. Data
\<S\> or \<E\> ——— \<S\> mask length —— \<S\> Length=1...250cm —\<E\>— \<G\> when ready

\<S\>

Acceleration
\<S\> or \<E\> ——— \<S\> how many —— \<S\> 1,2 —\<E\>— \<S\> mask length —— Length=1...250cm —\<E\>— \<G\> when ready
                                                                           \<S\>

\<S\>

GM Tube
\<S\> or \<E\> ———

Ratemeter	
Counter	See chart 2
Period Count	
Show Results	

\<S\>

Debounce Time
\<S\> or \<E\>

Debounce=4ms ——— Change 4ms ——— 0...20ms —\<E\>—
                 \<S\> or \<E\>   \<S\>

Appendix 1 Chart 2

Ratemeter

<S> or <E> ⟶ <G> when ready

↓ <S>

Counter

<S> or <E> ⟶ 100 readings ─<E>→ Hold <S> to stop ─<E>→ Save readings ─<E>→ 1...60 minutes ─<E>→
can be saved   readings   every   └─ <S> ─┘

└─ <G> when ready

When <S> is
held to stop

<S> → <D>isplay stats ─<D>→ **B** Readings= ─<D>→ Max. Count= ─<D>→ Time interval is ─┐
A   <S>tart again   Average=   Min. Count=   ↓

                              ┌──────────── <D> ────────────┘
                              └─ View Stats Again
                                    <S> or <E>

↓ <S>

                     View Readings
                     <S> or <E> ─────────→ Reading
                                           R=0   <D>
                     GM Tube
                     <S> or <E> →─ GM Tube   Finished
                     ↓   Sub menu   <D>
                     Start again
                     <S> or <E> →─ Back to   View Stats Again
                     ↓   the start   <S> or <E>
                     View Stats Again
                     ←─ <S> or <E>

Period Count

<S> or <E> ─<E>→ 100 readings ─<E>→ Hold <S> to stop ─<E>→ Select Period ─<E>→ 1...60 minutes ─┐
          can be saved   readings   └─ <S> ─┘

                              When <S> is held to
                              stop go to point **A**

                                                                   └─ <G> when ready

↓ <S>

Show Results

<S> or <E> ──── Connects to point **B** above

↓ <S>

Debounce Time

Appendix 2 - Firmware Changes

The changes made to the Mark2 version of TSA are listed below.

- The Event Timer now includes the channel on which each event happened.
- The Fast Timer can record up to 8 Fast Times.
- The algorithm for calculating Speed has been improved.
- Can now scroll through mask sizes by holding <S> key down.
- Added support for GM Tube.
- Reset button added.

Appendix 3 - Selecting the Appropriate Timer

TSA has 4 timing modes and the notes below give guidance on which mode to select.

Time Interval: measures the time between events 1&2, 3&4, 5&6 and 7&8. It is suitable for use with gliders on air tracks and a vehicle on a runway. Resolution is 1/100 th of a second.

Event Time: Use this mode when you require to know the actual times at which the events happen. It also gives information on the channel the event happened. It is suitable for use with gliders on air tracks and a vehicle on a runway. Resolution is 1/100 th of a second.

Fast Timer: Use this mode when you require a resolution of 1/100 th of a millisecond. It is important that all inputs to TSA are bounce free. This means that switches should not be connected to TSA when used as a fast timer.

Gap Timer: Consider the situation where you have a trolley with a single mask on a sloping runway which has two light gates. You want to measure the time to go between the light gates. When the trolley cuts the first beam two events will be recorderd - the leading and the trailing edges of the mask. Similarly when it cuts the second beam. You are not interested in the trailing edge times. In the Gap Timer mode the software waits until one of the inputs has changed state and as soon as that happens it starts the clock and then it goes to the other input and waits for a change in state and then stops the clock. The trailing edge plays no part in the timing.

The Gap Timer mode is especially useful if you have any switches connected. If a switch is used to start the timing then it is possible that many events will be generated due to switch bounce. The Gap Timer mode would ignore all the bounces.