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Introduction:
The Multi-Timer is a versatile instrument that can be used in many ways to explore all aspects of kinematics. The device provides accurate readings on a clear and easy to use touch screen display. The device can be used in many ways and has inputs for light gates or other switching devices, this user manual will explain the full functionality of the device and provide some example setups for different experiments.

Getting Started:
On the left-hand side of the Mult-Timer there are two digital input channels labelled 0 and 1. Each input can be via the DIN sockets or the 4mm sockets. Switches and light gates may be connected to these inputs. The DIN sockets are capable of supplying power to Unilab light gates and other accessories.

Please note that no external voltage should be applied to the 4mm sockets.

Connect the 9V, 0.66A DC plug-top power supply supplied with the Multi-Timer. The device will boot up and then display the different modes in the following format:

Press the 'Select' button to cycle through the different modes, press 'Enter' to choose that mode and progress to the next steps. To use the Multi-Timer either use the Unilab light bridge with the DIN connector or two 4mm leads can be connected, then pressing them together will act as an 'event' and change the state, this can be used in different modes to initiate and stop timing. Below will describe and explain each of the different modes and how to use them.

Time Interval:
This mode measures the length of time a light beam has been cut or a switch closed. It is ideal for measuring the length of time a mask on a trolley takes to cut a light beam.

Select Interval Timer then tap Enter.

- Follow the instructions on the screen and select to measure one Time Interval by tapping the '1'
- Now tap the Enter button.
- When you are ready to start the experiment press the GO button.
- The screen displays "Waiting". The Multi-Timer is now waiting for an event to happen so that it can start its internal clock.
- Move a card very slowly through the beam of your Light Bridge. The LED should switch off as the beam is cut then back on again as the beam is re-established. If you are using two wires connected to the 4mm sockets, instead of a Light Bridge, then touch them firmly together, pause, then separate them.
- The time interval will be displayed on the screen.
- Touch GO again and repeat the experiment.
- After you have repeated the experiment several times tap Select and again select Time Interval but this time set the Multi-Timer to read three Time Intervals.
- Proceed in a similar fashion as before but note that the Waiting message is displayed until all three time intervals have been measured.
- To see all three time intervals, keep tapping Display.

Note: It is recommended that this mode should be restricted to times greater than 10ms.

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.

The Multi-Timer 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.

General Timer:
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 General Timer is set up in an identical fashion to the Interval Timer. If you wish to measure two timing intervals then you would set the General Timer for 4 event times.

The General Timer is the most versatile 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 additional demands on the student e.g. calculating the acceleration from four 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.

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. This mode is also extremely useful in measuring 'g' by freefall where switch bounce could cause problems if you are using an electromagnet – see later in manual.

Fast Timer:
The setup for this mode is similar to the General Timer. This mode can be used to display a time interval between 10µs and 99,999ms. Trying to measure an interval larger than the maximum causes the error message "Too big" to be displayed. The Fast Timer displays the time in microseconds up to 10000us and for times greater than that it displays in milliseconds to two decimal places. The fast timer should be used for times up to 150ms. 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. A maximum of eight Fast Times can be recorded.

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.

- Select the Speed mode then press Enter.
- Select the size of your mask in centimetres. Note that each time the '+' button is pressed the distance increments in 1 cm steps until 10 cm and then in 10 cm steps until 300 cm. Holding down the '+' button results in a rolling display.
- Enter your mask size.
- GO when ready.
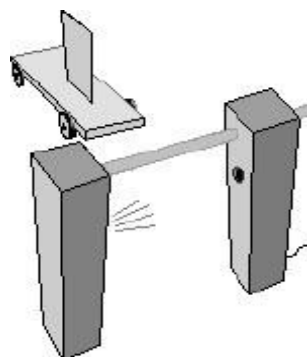
Acceleration Data & Acceleration:
The setup for these modes is identical to Speed. However, there are several possible mask arrangements:
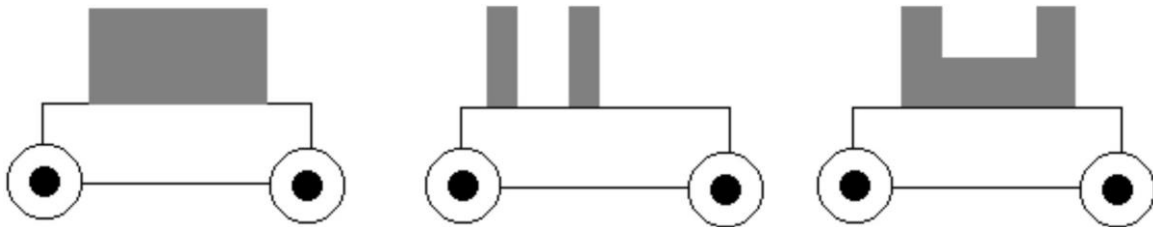
To measure an acceleration a single mask requires two light gates whereas a double mask requires only one light gate. Where double masks are used then both sections must have the same width. In addition, they must be a whole number of centimetres. The Acceleration Data mode is intended for developing 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 Acceleration Mode for investigative work. In the Acceleration mode, only the acceleration is displayed. The setup is identical to the Acceleration Data mode.

Changing 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 the Multi-Timer. 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 experiments a 4 ms debounce delay will not cause problems. However the user can change this delay in the range 0 - 100 ms.

To change the debounce delay
- Select Change Debounce then tap Enter.
- Scroll through the values and Enter your required value.

If you are using switches as the inputs to the Multi-Timer 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.

G by free fall:

Select the Gap Timer mode. When the release mechanism is opened electrical contact is broken and the clock starts because there is a change in state at 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.

The value of 'g' can be calculated using the equation: $s = \frac{1}{2} gt2$

Alternatively the ball can be dropped from different heights and a table built of heights and times. Drawing a graph of displacement against time squared gives a straight line with a gradient of g/2

Ball Bearing Release Mechanism

Timing Plate
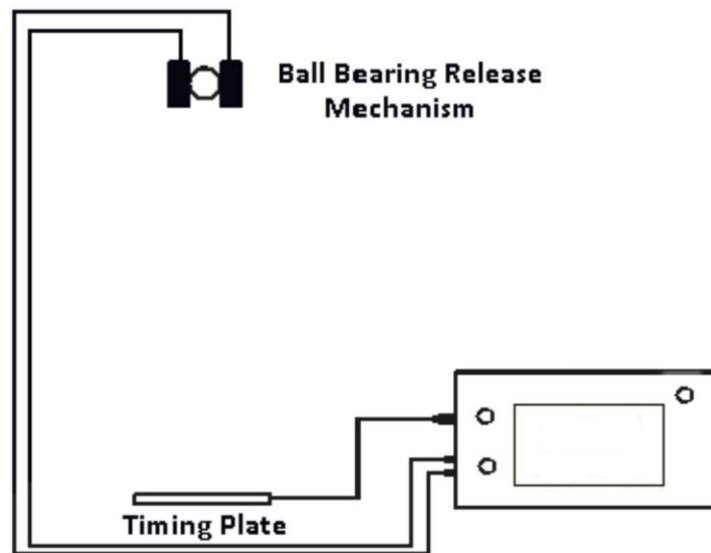
Technical Information:

Plug top supply voltage 9V DC - centre positive. The current drain of the Multi-Timer with no external devices connected is 82mA. Maximum current that can be supplied to external devices e.g. Light Bridge should be restricted to less than 100mA. There is an internal resettable fuse rated with a trip current of 600mA. Digital inputs protected against accidental reverse polarity. Note that external voltages should not be connected to the digital inputs.

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.

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 10 ms. Speeds have been rounded to 2 decimal places. The uncertainty in the Fast Timer from 0 to 10000us is ±2 and for times greater than this the uncertainty is ±1ms. The shortest time between changes in state of the inputs using the Fast Timer is 10us.

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.