‘g’ By Freefall Experiment Notes.

This document contains information and descriptions on how to use our Millisecond Timer (IPC-3834-T) and Timer Scaler & Frequency Meter (IPC-3342-T) to perform a ‘g’ By Freefall experiment.

The recommended ‘g’ By Freefall object sensing equipment is our Photo Timing Gate (IPC-3210-T), this has been designed to be completely compatible with both IPC Timers, providing a clean optical ‘bounce’ free trigger, note: two object sensing pieces of equipment are required to perform a ‘g’ By Freefall experiment.

 We welcome any comments or suggestions on any matter relating to these experiments.

1. ‘g’ By Freefall Experiment using 2 x IPC Photo Timing Gates.

To perform the experiment using this apparatus the setup is as follows (see figure No1) below:-

a) Connect one of the IPC Photo Timing Gates to channel ‘A’ of the IPC Timer unit and the second to channel ‘B’ using 4mm plug connection leads.
b) Place the IPC Photo Timing Gate connected to ‘B’ at the upper position as the START trigger and the IPC Photo Timing Gate connected to ‘A’ at the lower position as the STOP trigger.
c) Set the distance between the IPC Photo Timing Gates to the required distance in accordance with the numeric details of the experiment, at the same time aligning them so that the sensing beams are directly above each other.
d) Switch on both the IPC Timer unit and the two IPC Photo Timing Gates and then RESET the Timer unit to zero, the apparatus is now ready to start the experiment.
e) Now using a suitable Freefall object (such as a ball bearing) carefully drop this object through the two sensing beams; the object will first trigger the start of the timing period (upper timing gate) and then trigger the stop of the timing period (lower timing gate).
f) The IPC Timer unit will now display the time period the object took to pass the first Timing Gate (upper) and the second Timing Gate (lower).
g) This time period information along with the distance (ie. between the Timing Gates) can now be used to perform the calculations required by the ‘g’ By Freefall experiment.

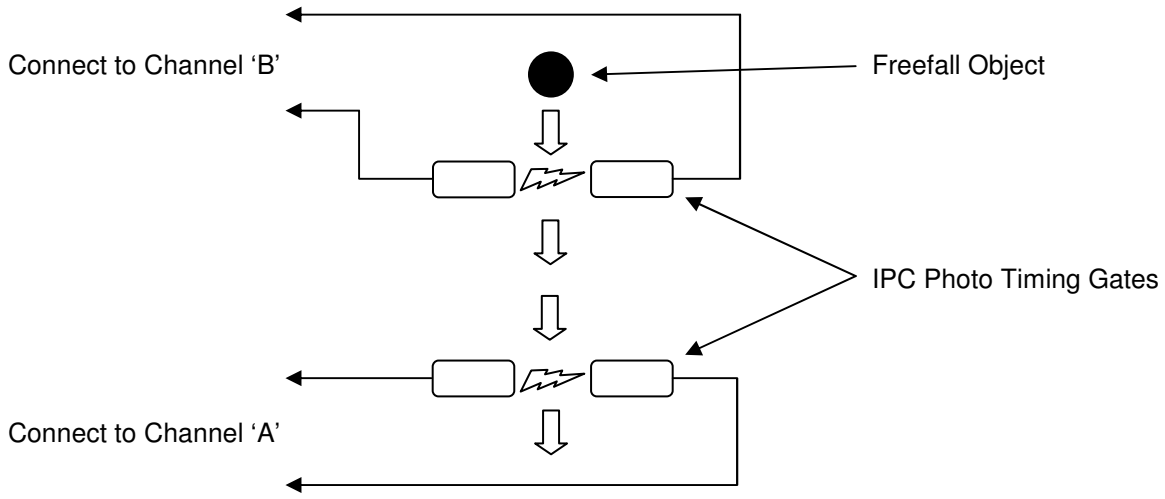

Figure No1.

2. ‘g’ By Freefall Experiment using 1 x IPC Photo Timing Gate and 1 x Object Release Switch.

To perform the experiment using this apparatus the setup is as follows (see figure No2) below:-

a) As almost all Object Release Switches are a closed electrical switch which opens when the object is released it must be connected to channel ‘B’ of the IPC Timer unit using 4mm plug connection leads.
b) Now connect the IPC Photo Timing Gate to channel ‘A’ of the IPC Timer unit using 4mm plug connection leads.
c) Set the distance between the Release Switch and the IPC Photo Timing Gate to the required distance in accordance with the numeric details of the experiment, at the same time aligning them so that they are directly above each other with the Release Switch at the top (ie. the released object will fall through the sensing beam).
d) Switch on both the IPC Timer unit and the IPC Photo Timing Gate and then load the Release Switch with the Freefall object, finally RESET the IPC Timer unit to zero, the apparatus is now ready to start the experiment.
e) Now cleanly release the Freefall object (such as a ball bearing) and let it drop through the lower sensing beam; when released the object will first trigger the start of the timing period (upper timing gate) and then trigger the stop of the timing period (lower timing gate).
f) The IPC Timer unit will now display the time period the object took after leaving the Release Switch (upper timing gate) and breaking the beam of the IPC Photo Timing Gate (lower timing gate).
g) This time period information along with the distance (ie. between the Release Switch and IPC Photo Timing Gates) can now be used to perform the calculations required by the ‘g’ By Freefall experiment.

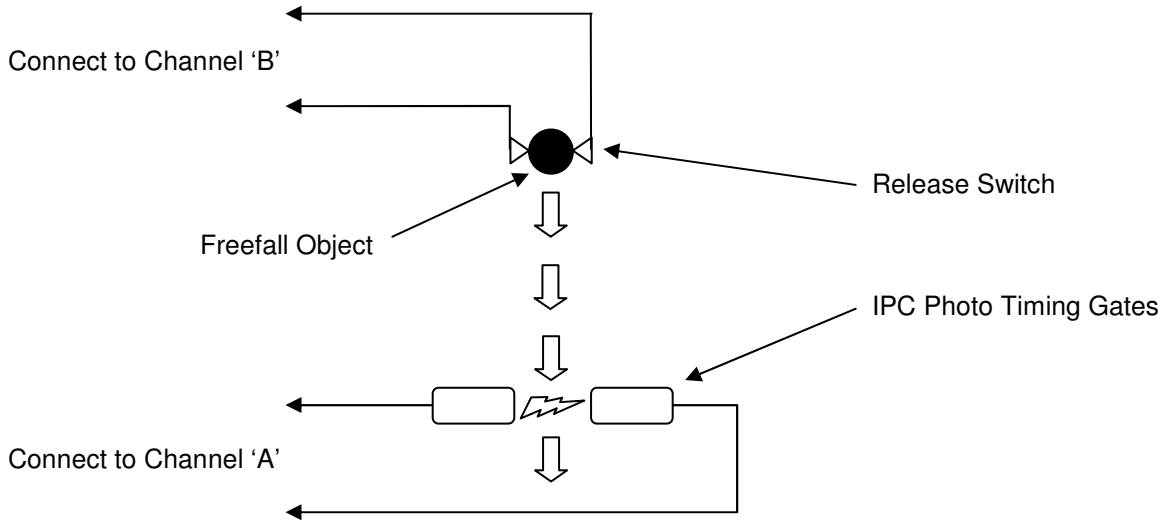

Figure No2.

3. ‘g’ By Freefall Experiment using 1 x IPC Photo Timing Gate and 1 x Object Catch Switch.

To perform the experiment using this apparatus the setup is as follows (see figure No2) below:-

a) Connect the IPC Photo Timing Gate to channel ‘B’ of the IPC Timer unit using 4mm plug connection leads.
b) Because the IPC Photo Timing Gate must be connected to channel ‘B’ of the IPC Timer then the Object Catch Switch MUST present (when set) an open electrical switch that closes when catching (triggered by) the Freefall object. The Object Catch Switch should be connected to channel ‘A’ of the IPC Timer using 4mm plug connection leads. **Note:** if the Object Catch Switch presents a ‘change-over’ type switch then the normally open (N/O) connections MUST be used when connecting the Catch Switch.
c) Set the distance between the IPC Photo Timing Gate and the Object Catch Switch to the required distance in accordance with the numeric details of the experiment, at the same time aligning them so that they are directly above each other with the IPC Photo Timing Gate at the top (ie. the released object will first fall through the sensing beam and then land on the Catch Switch).

d) Switch on both the IPC Timer unit and the IPC Photo Timing Gate and then set the Catch Switch ready to be triggered, finally RESET the IPC Timer unit to zero, the apparatus is now ready to start the experiment.
e) Now release the Freefall object (such as a ball bearing) and let it drop through the upper sensing beam and land on the Catch Switch; when this beam is broken by the object the start of the timing period (upper timing gate) will be triggered and when the object lands on the Catch Switch the stop of the timing period (lower timing gate) will be triggered.
f) The IPC Timer unit will now display the time period the object took after leaving the Release Switch (upper timing gate) and break the beam of the IPC Photo Timing Gate (lower timing gate).
g) This time period information along with the distance (ie. between the IPC Photo Timing Gate and the Catch Switch) can now be used to perform the calculations required by the 'g' By Freefall experiment.

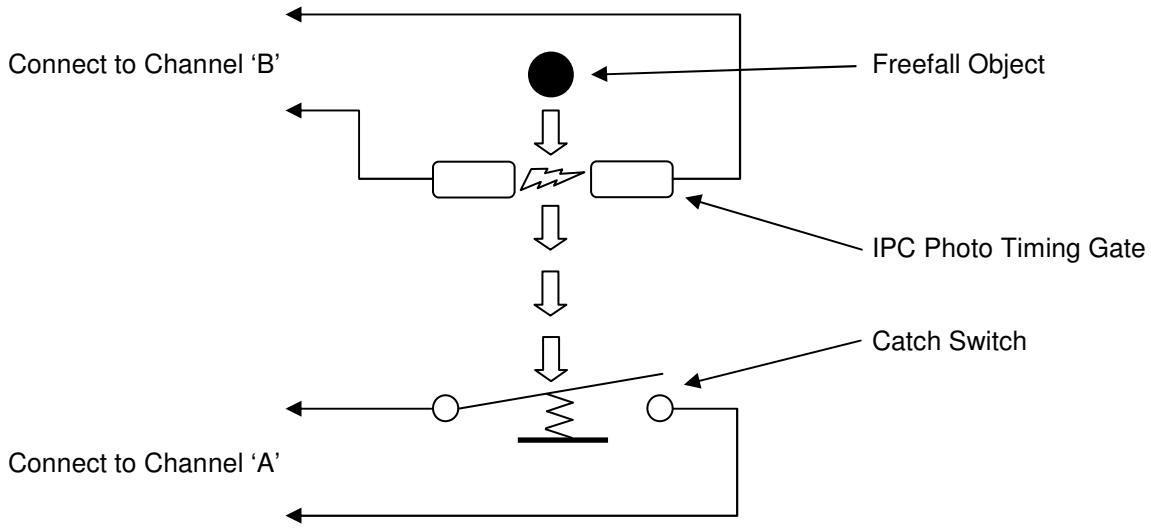

Figure No3.

4. 'g' By Freefall Experiment using 1 x Object Release Switch and 1 x Object Catch Switch.

To perform the experiment using this apparatus the setup is as follows (see figure No4) below:-

a) As almost all Object Release Switches are a closed electrical switch which opens when the object is released it must be connected to channel 'B' of the IPC Timer unit using 4mm plug connection leads.
b) Because as stated above almost all Object Release Switches are a closed switch and therefore connected to channel 'B' of the IPC Timer then the Object Catch Switch MUST present (when set) an open electrical switch that closes when catching (triggered by) the Freefall object. The Object Catch Switch should be connected to channel 'A' of the IPC Timer using 4mm plug connection leads. **Note:** if the Object Catch Switch presents a 'change-over' type switch then the normally open (N/O) connections MUST be used when connecting the Catch Switch.
c) Set the distance between the Release Switch and the Catch Switch to the required distance in accordance with the numeric details of the experiment, at the same time aligning them so that they are directly above each other with the Release Switch at the top (ie. the Freefall object will fall and land on the Catch Switch).
d) Switch on the IPC Timer unit, load the Release Switch with the Freefall object and set the Catch Switch ready to be triggered, finally RESET the IPC Timer unit to zero, the apparatus is now ready to start the experiment.
e) Now cleanly release the Freefall object (such as a ball bearing) and let it land on the Catch Switch; when released the object will first trigger the start of the timing period (upper timing gate) and then trigger the stop of the timing period (lower timing gate) when it lands on the Catch Switch.
f) The IPC Timer unit will now display the time period the object took after leaving the Release Switch (upper timing gate) and landing on the Catch Switch (lower timing gate).
g) This time period information along with the distance (ie. between the Release Switch and Catch Switch) can now be used to perform the calculations required by the 'g' By Freefall experiment.

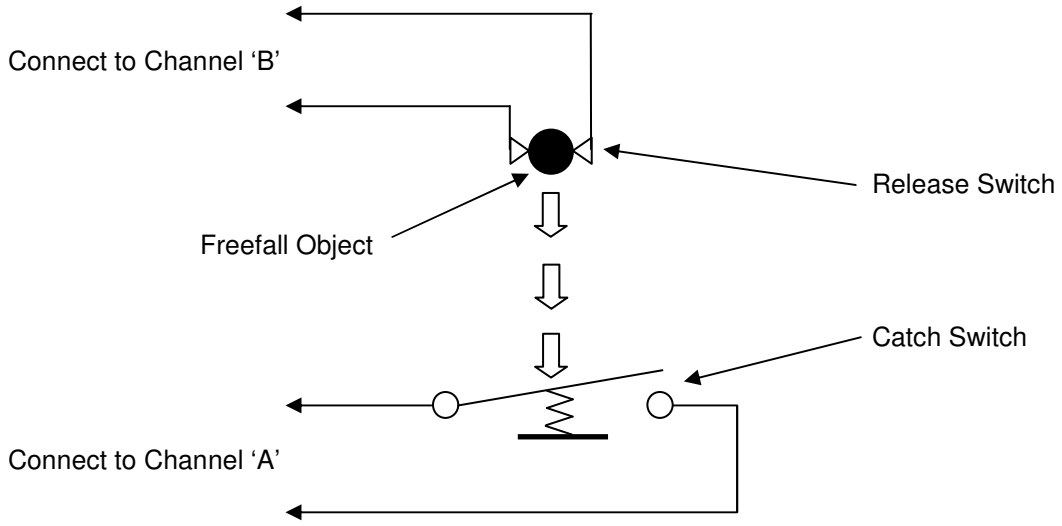

Figure No4.

5. 'g' By Freefall Experiment using Off-The-Shelf Apparatus.

To perform the experiment using this apparatus the setup is as follows (again see figure No4) below:-

a) As almost all Off-The-Shelf Apparatus use a closed electrical switch for the Object Release Switch (opens when the object is released) then it must be connected to channel 'B' of the IPC Timer unit using 4mm plug connection leads.
b) Because as stated above almost all Object Release Switches are a closed switch and therefore connected to channel 'B' of the IPC Timer then the Object Catch Switch MUST present (when set) an open electrical switch that closes when catching (triggered by) the Freefall object. The Object Catch Switch should be connected to channel 'A' of the IPC Timer using 4mm plug connection leads. **Note:** if the Object Catch Switch presents a 'change-over' type switch then the normally open (N/O) connections MUST be used when connecting the Catch Switch. If the Apparatus presents any other combinations of electrical switching circuits please contact IPC Electronics Ltd for further advice.
c) Set the distance between the Release Switch and the Catch Switch to the required distance in accordance with the numeric details of the experiment, at the same time aligning them so that they are directly above each other with the Release Switch at the top (ie. the Freefall object will fall and land on the Catch Switch).
d) Switch on the IPC Timer unit, load the Release Switch with the Freefall object and set the Catch Switch ready to be triggered, finally RESET the IPC Timer unit to zero, the apparatus is now ready to start the experiment.
e) Now cleanly release the Freefall object (such as a ball bearing) and let it land on the Catch Switch; when released the object will first trigger the start of the timing period (upper timing gate) and then trigger the stop of the timing period (lower timing gate) when it lands on the Catch Switch.
f) The IPC Timer unit will now display the time period the object took after leaving the Release Switch (upper timing gate) and landing on the Catch Switch (lower timing gate).
g) This time period information along with the distance (ie. between the Release Switch and Catch Switch) can now be used to perform the calculations required by the 'g' By Freefall experiment.

Recommended Freefall Object Sensing Equipment.

As detailed above we recommend using the IPC Photo Timing Gate (IPC-3210-T) to perform the 'g' By Freefall experiment (two Timing Gates are required). The main advantage when using these optical Timing Gates is the guarantee of no 'Switch Bounce' which can give erratic and inaccurate results,

other advantages include no ‘Setting Up’ procedure prior to each test and no moving parts that can fail over time.

What is ‘Switch Bounce’ ?

Switch Bounce is when two physical contacts (ie. a mechanical switch) are either brought together or separated to make an electrical switch (on or off) and instead of making a clean single contact or break they bounce ever so slightly which produces a few extra on/off connections before finally settling and making a closed or open contact. This effect can cause false triggering on equipment looking for a closing or opening switch contact for its trigger – our IPC Timers included, especially if the Timer is capable of sensing fast periods of time and sees these contact bounces as new triggers.
In the past Timer equipment and ‘g’ By Freefall apparatus suppliers have recommend the addition of a 100nF capacitor placed across each of the mechanical switches to help absorb this switch bounce. However both IPC Timer units (since February 2017) incorporate this additional capacitor which virtually removes all switch bounce issues.

Additional Information.

If followed correctly the ‘g’ By Freefall results obtained from the above procedures should be both accurate and repeatable.

Both the IPC Millisecond Timer and Scaler Timer & Frequency Meter are based on crystal controlled microprocessors and as such an accuracy of ±0.1% for each instrument can be expected.

In each case the distance from the upper timing gate to the lower timing gate should be measured accurately and noted. When the time of fall has been determined for a given distance, the acceleration due to gravity can be calculated from the equation of motion:

$s = \frac{1}{2}gt^2$

where:
s = distance (in metres)
g = acceleration due to gravity in metres/second^2
t = time of fall (in metres)

The value of g obtainable from these experiments is 9.81m/s^2.