

15215 RECORDING TIMER, DC

Purpose:

At equal time intervals, a strip of paper tape, attached to a moving object, gets marked by a rotating striker. Measurement of these marks allows direct observation of position and the calculation of the magnitude of the velocity and acceleration in relative or recognized units.

Optional Accessories:

Two (2) 1.5 Volt D - Cell batteries
"C" clamp

Operation:

Check that the switch bar on the battery case is in the off position. Clamp the timer to a table top, ring stand, or other stable support. Pin a disc of carbon paper, <u>carbon side up</u>, to the cork button on the base of the timer. Insert the batteries into the holder so that they are in series. Remove sufficient recording tape from the roll to cover the range of motion anticipated. Slip the recording tape through the two restraining staples on each side and under the striker, making sure that the paper tape rests on <u>top</u> of the carbon disc. The tape should move freely through the recording timer. The end of the paper tape can be attached to a variety of objects to determine that object's position, velocity, or acceleration. Make sure the tape is drawn straight through the timer, avoiding situations where the tape will be pulled to one side, as this may cause the tape to catch or bind. When the paper tape is properly loaded and a recording is about to be made, start the recording timer by moving the switch to 3v then release the object that is to be timed. Turn off the timer as soon as the motion has been recorded.

The clarity of the dots on the recording tape can be controlled by adjusting the height of the screw that passes through to the underside of the timer.

To lower the speed of the motor (and the frequency of the striker) move the switch to 1.5v. This will reduce the voltage across the motor by a factor of two. A lower striker frequency is desirable for measuring small velocities and displacements. **The striker frequency is reasonably constant over an individual experimental trial, but the actual value depends on the state of the battery(ies).** Counting the marks over a known time interval can provide a calibration if standard units are needed for velocity and acceleration calculations. In most cases, relative units are sufficient to provide data for graphing position, velocity and acceleration.

After an experiment has been timed, the recording tape provides a direct measure of the object's position as a function of time **(the points are equally spaced in time)**. Below is an example of a recording tape taken from an object moving at a constant speed.

•   •   •   •   •   •   •   •   •   •   •

And here is an example of a recording tape taken from an object undergoing a constant acceleration.

•   •   •   •   •   •   •   •

Pick a point on the recording tape to use as a reference. This is usually a point marked by the recording timer near the beginning of the run, but it can be any arbitrary position that is convenient. First, measure the distance from this reference point to each point marked on the tape by the recording timer (if the number of points is very large you may wish to measure every 10th or 20th point and work only with these).

After you have measured the distance from the reference to each point on the tape, record these positions in a "Table of Differences".

The velocity of the object can be determined by calculating the change in position between two adjacent points and dividing this by T, the change in time (Δt, some would say) between the two points (**this change in time will be the same for all of your calculations** and only needs to be measured once for each trial, and then only if one needs absolute rather than relative results --- a straight line in one system plots as a straight line in the other). Record all these values in your table of differences.

The acceleration of the object can be determined by calculating the change in velocity between two adjacent values and dividing this by T. Record this value in a column to the right of the velocities. With this table you now have a record of the object's position, velocity, and acceleration as a function of time. Notice that there is one less velocity value than position value and one less acceleration value than velocity value, since each is calculated using an interval from the previous column.

Difference Table

At = **T** = T_2-T_1 ,etc. since all time intervals are the same

Time	Position	Velocity	Acceleration
T_1=____	X_1=____		
		$V_1 = (X_2-X_1)/T$	
T_2=____	X_2=____		
			$A_1 = (V_2-V_1)/T$
		$V_2 = (X_3-X_2)/T$	
T_3=____	X_3=		
			$A_2 = (V_3-V_2)/T$
		$V_3 = (X_4-X_3)/T$	
T_4=____	X_4=____		
			$A_3 = (V_4-V_3)/T$
		$V_4 = (X_5-X_4)/T$	
T_5=____	X_5=____		
			$A_4 = (X_5-X_4)/T$
		$V_5 = (X_6-X_5)/T$	
T_6=____	X_6=____		
			$A_5 = (X_6-X_5)/T$
		$V_6 = (X_7-X_6)/T$	
T_7=____	X_7=____		
			$A_6 = (X_7-X_6)/T$
		$V_7 = (X_8-X_7)/T$	
T_8=____	T_8=____		

Time Allocation:
To prepare this product for an experimental trial should take less than ten minutes. Actual experiments will vary with needs of students and the method of instruction, but are easily concluded within one class period.