15210 RECORDING TIMER - AC

STUDENT NAME:____________________________________

CONTENTS

- *REQUIRED ACCESSORIES*
  - C-Clamps
  - Ruler or Meter Stick
  - Mass (200 g or larger)
- *OPTIONAL ACCESSORIES*
  - Ticker Tape Dispenser (#15225)
  - Constant Speed Vehicle (#10-103)

PURPOSE

- To produce a position versus time record of moving objects using a mechanical striker and paper tape.

CONCEPT

Timing events is an essential skill for many scientific investigations as well as other practical applications. While many events can be timed accurately by using a stopwatch, the recording timer provides capabilities that a stopwatch cannot achieve:

- The recording timer works in fixed time intervals (1/60 or 1/50 second).
- The recording timer creates a physical record of motion on a ticker tape.
- Analysis of recorded data does not depend on hastily recorded values; data from a ticker tape can be measured and analyzed after the completion of an investigation.

In order to record timed events successfully, practice using the recording timer.

SAFETY

- This device runs on 110V, 60 Hz electricity from standard household outlets. Observe normal safety precautions for any electrical appliance. To avoid electrical shock, do not use near water. Do not use this device if it is damaged in any way.
- Use appropriate eye protection, as this device has rapidly vibrating parts that can propel debris at high speeds. Also, stay clear of any areas where falling objects may be used.
- When investigating the acceleration due to gravity, stand clear of the area directly under the recording timer where weights are being dropped. Also, pick up weights after they have been dropped, so that they do not present a tripping hazard.
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INTRODUCTION

Recording the motion of a swiftly moving object – cannon balls, falling rocks or flying birds, for example – made some observations very challenging for early scientists.

During the 1600s Galileo observed and described the motion of falling objects. These observations are essential to understanding physics, but his accomplishments were limited by the technology of his day. Galileo used simple pendulum-driven timers, his own pulse, and 'water clocks' to keep time during his experiments.

The inability to observe short time intervals also limited the observations of Isaac Newton. This difficulty, and problems of analyzing motion, led Newton to develop calculus of infinitesimals, a branch of mathematics which focuses on infinitesimal intervals to calculate rates of change, as well as other significant quantities.

Without extremely accurate timing equipment, modern advances such as communication satellites, air travel, and global positioning would be impossible. Timing can now be accomplished using digital devices that are accurate to millionths of a second. Photogates and other automatic triggers can start and stop timing faster than a human can trip a stop watch.

This recording timer records intervals of 1/60 of a second (1/50 of a second in countries which use 50 Hz AC electricity) and provides a record of positions on a paper tape. For many lab projects, the recording timer provides an easy-to-understand record of motion with far more detail than simple observations can provide.

ASSEMBLY & SUGGESTIONS FOR USE

Clamp the timer to a table top, ring stand, or other stable support. Place a carbon disc, *carbon side down*, over the post in the base of the timer. Slip the recording tape through the two guides and under the striker. Make sure that the paper tape rests *under* 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 record the position of that object as a function of time. Velocity and acceleration can be calculated from this recorded data.

Make sure the tape is drawn straight through the timer. Avoid situations where the tape will be pulled to the side; this may cause the tape to catch or bind. When the paper tape is properly loaded and a recording is about to be made, turn the recording timer on by using the slide switch on the back of the unit, then release the object that is to be timed.

The timer needs no calibration, as it runs on 110V AC power. The striker will make a mark on the recording tape 60 times each second. (In countries that use 50 Hz AC electricity, this timer will make a mark on the recording tape 50 times a second. In countries that use AC electricity at a voltage other than 110V, a voltage converter will be necessary. #15210A is a recording timer which runs on 220V AC electricity.)

The clarity of the dots on the recording tape can be controlled by adjusting the height of the striker. The clearest dots are obtained when the striker just touches the paper tape when in operation. To make this adjustment, place the plastic feeler gauge between the point of the striker and the base of the timer. Loosen the wing-nuts on the striker and move them up or down until the striker just touches the gauge. Tighten the wing-nuts after calibrating the height of the striker.

The position of the dots on the paper tape (from side to side) can be controlled by loosening the wing-nuts and sliding the striker along the slot in the striker arm. When the desired location is reached, tighten the wing-nuts. This adjustment will allow different portions of the carbon disk to be used.

After timing an experiment, the recording tape provides a direct measure of position as a function of time for a particular object. Below is an example of a recording tape taken from an object with constant acceleration.

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In order to determine the successive positions of the object, pick a starting point on the recording tape to use as a reference. (This is usually a point near the beginning of the run. Often, this reference point is the first point that can be clearly distinguished from the smudge that the timer makes when it starts, but the starting point can be any arbitrary position.) Measure the distance from this reference point to each point marked on the tape by the recording timer. If you are measuring many data points, you may wish to measure sections of 5, 10, or 20 intervals between dots. (It is often helpful to circle the points on the tape that are actually used for measurement.)

After you have measured the distance from the reference point to each selected point on the tape, record your position values (x_1, x_2, etc.) in a data table, such as the table shown on the next page.

The time for the starting point is $t_0 = 0$. The time for each successive recorded point is the number of spaces (n) between that point and the starting point divided by the frequency of your AC electricity (since the recording timer strikes the ticker tape at the same frequency as your AC electricity).

The velocity of the object can be determined by measuring the displacement between two adjacent points and dividing this displacement by the time interval between the two points (use the same time interval for all calculations). Record these values in the table in a column to the right of the positions.

The acceleration of the object can be determined by calculating the change in velocity between two adjacent table values and dividing this by the time interval between the two points. Record this new value in a column to the right of the velocities. With this table you now have a record of the position, velocity, and acceleration of the object as a function of time. Notice that each calculated quantity has one less entry than the column before it.

TABLE FOR DATA COLLECTION

For recording and analyzing data from Recording Timer tapes. (See notes on next page.)

Time	**Position**	**Velocity** ($\Delta t = t_{t+1} - t_t$)	**Acceleration**
		NO VALUE	
$t_0=0$	$x_0=$ ___________		NO VALUE
		$v_1=(x_1-x_0)/\Delta t$	
$t_1=n/60$	$x_1=$ ___________		$a_1=(v_2-v_1)/\Delta t$
		$v_2=(x_2-x_1)/\Delta t$	
$t_2=2n/60$	$x_2=$ ___________		$a_2=(v_3-v_2)/\Delta t$
		$v_3=(x_3-x_2)/\Delta t$	
$t_3=3n/60$	$x_3=$ ___________		$a_3=(v_4-v_3)/\Delta t$
		$v_4=(x_4-x_3)/\Delta t$	
$t_4=4n/60$	$x_4=$ ___________		$a_4=(v_5-v_4)/\Delta t$
		$v_5=(x_5-x_4)/\Delta t$	
$t_5=5n/60$	$x_5=$ ___________		$a_5=(v_6-v_5)/\Delta t$
		$v_6=(x_6-x_5)/\Delta t$	
$t_6=6n/60$	$x_6=$ ___________		$a_6=(v_7-v_6)/\Delta t$
		$v_7=(x_7-x_6)/\Delta t$	
$t_7=7n/60$	$x_7=$ ___________		$a_7=(v_8-v_7)/\Delta t$
		$v_8=(x_8-x_7)/\Delta t$	
$t_8=8n/60$	$x_8=$ ___________		$a_8=(v_9-v_8)/\Delta t$
		$v_9=(x_9-x_8)/\Delta t$	
$t_9=9n/60$	$x_9=$ ___________		. . .
		. . .	
. . .	. . .		

SUGGESTIONS FOR USE: DATA TABLE

- For the recording timer, the interval between strikes is 1/60 of a second, so time is the number of spaces divided by 60. (Using 1/50 of a second in countries which use 50 Hz AC electricity, change each "60" in the "Time" column to a "50.").
- In the "Time" column, "n" is a multiplier for the number of intervals between strikes that you choose to count. For example, if you count displacement on your ticker tape as a span of five intervals between strikes, then n = 5 for your particular data set.
- The starting point for measuring displacement ($x_0 = 0$) is at any dot which can be clearly distinguished from the smudge of dots made by starting the timer, or any arbitrary starting position on the tape that is useful for your experiment.
- In the "Position" column, record the distance of the dot on the ticker tape measured from the starting point (at $x_0 = 0$).
- Speed is a change in displacement divided by a change in time ($v = \Delta x/\Delta t$). You must have at least two position terms to calculate a velocity. If you find it useful, you can note the changes in displacement, Δx, in the extra space under each "Position" value recorded as x_0, x_1, x_2, x_3, etc.
- Note that speeds (velocities) that are recorded are the average speeds calculated for the time intervals between each listed time. We have no way to calculate speed before the first change in displacement, so "NO VALUE" is shown prior to v_1.
- Acceleration is a change in velocity divided by a change in time ($a = \Delta v/\Delta t$). You must have at least two velocity terms to calculate an acceleration. If you find it useful, you can note the changes in velocity, Δv, in the extra space under each "Velocity" value recorded as v_1, v_2, v_3, etc.
- Accelerations that are recorded are average accelerations calculated for approximately each of the listed times. We have no way to calculate acceleration before the first change in velocity, so "NO VALUE" is shown prior to a_1.

PROCEDURE A (MEASURING CONSTANT VELOCITY)

Preparation and Procedure (1)

Clamp a recording timer to a table or bench.

Feed a paper tape through the recording timer, and attach this paper tape to a Constant Speed Vehicle (CSV), or a similar device that moves with constant velocity. Eliminate any possibility of obstructing the paper tape (see Assembly and Operation section of this handout).

Turn on the recording timer and start the CSV. Stop the vehicle when it approaches the end of the bench. After stopping the CSV, retrieve and analyze your tape.

Q1. Does the paper tape indicate uniform speed for the vehicle? Explain.

To determine the speed of the vehicle, find a segment of seven dots that show clearly uniform speed. Measure the total length of these spaces. Then, divide this measurement by the time interval.

Q2. What time interval does this length represent?

Q3. What is the speed of the vehicle?

Preparation and Procedure (2)

The CSV can operate at two different speeds, depending on the number of batteries powering the vehicle. If using the CSV, change the number of batteries used to power the Vehicle. If you are not using the CSV, find a way to change the operating speed of the apparatus you used in the previous segment.

Set up the recording timer, paper tape, and vehicle as you did in the previous segment. Once you are ready to record data, start the recording timer and the CSV. Stop the vehicle when necessary. After stopping the CSV, retrieve and analyze your tape.

Q4. Does the paper tape show uniform speed for the vehicle? What is that speed?

Q5. How can you account for the difference in speed?

PROCEDURE B (MEASURING ACCELERATION DUE TO GRAVITY)
Suggested Grade Level: Grades 5-12
Content Area Focus: Velocity and Acceleration (Linear Kinematics)

Preparation and Procedure

Clamp a recording timer to a support, and hang the recording timer over the edge of a bench or table. When conducting this experiment, the paper tape must fall vertically through the guides.

Feed a piece of ticker tape one meter long through the timer. Attach a large mass (250 grams or more) to the ticker tape, and hold the ticker tape so that the mass hangs just below the recording timer. Be sure that the tape will fall through the timer with little friction. Start the timer, and drop the mass. Stop the timer once the object reaches the floor and the tape has fallen through.

Examine the tape. If any dots appear to be missing, repeat this procedure. If your data appears to have no missing points, measure the positions of each of the dots, and calculate the velocity and acceleration of the falling object.

Q1. Does the object appear to fall with constant speed or with acceleration? How can you tell?

Q2. If the object accelerated as it fell to the ground, what is the value of that acceleration? If the object fell with constant speed, what is that speed?