611-1230 (25-075) Tape Timer

Warranty and parts:

We replace all defective or missing parts free of charge. Additional replacement parts may be ordered toll-free. We accept MasterCard, Visa, checks and School P.O.s. All products warranted to be free from defect for 90 days. Does not apply to accident, misuse or normal wear and tear. Intended for children 13 years of age and up. This item is not a toy. It may contain small parts that can be choking hazards. Adult supervision is required.

Materials needed:

- **Laboratory Weights**
- **Tape**

Note: this unit uses a white plastic disc to ensure that the paper can slide freely over the carbon circle. Without this disc, the unit may give inaccurate results.

Introduction:

This timer functions in the same way and with the same precision as an electric clock. Like the clock, it needs 60-cycle frequency and uses a synchronous driving motor. It operates by placing a small dot on a special strip of moving paper exactly every 1/60th of a second.

The concepts of velocity, acceleration and friction are visually demonstrated by comparing and measuring spacing of the dots.

Measuring Acceleration Due to Gravity:

1. **Select and cut a length of ticker tape** long enough to extend from timer to floor, about 5 or 6 feet.
2. **Position Timer;** Place at **edge of table or bench** with enough drop to the floor. The larger the drop, the more data you obtain. (You may clamp the Timer if desired.)
3. **Thread paper through the guides on the sides of the unit.** Pull a few inches of paper through so that the free end of the paper hangs over the side of the table. Keep the bulk of the paper untangled on table.
4. **Attach weight** (any size) to free end of paper with strong tape.
5. **Place carbon circle and under the stylus** at tip of reed.

a. Place the plastic disc on the peg under the reed. Place the carbon circle on top. Run the paper over the carbon circle. The paper should be on top, the carbon circle below that, and the plastic disc at the bottom. This arrangement will ensure the clearest marks.

b. Have someone hold the bulk of ticker paper or place a weight over it until ready to experiment.

6. Connect to power.

When the timer is on, the reed will vibrate due to the 60 cycle AC that is used. The pointed stylus located underneath the reed moves down to complete the electrical circuit every 1/60 of a second. When the current reverses, the stylus moves up and the circuit is not completed. This movement of reed and stylus makes a carbon imprint on the paper precisely every 1/60 second.

Adjust for maximum vibration of reed by loosening the tuning nut. If the maximum vibration of the reed produces too broad a mark, "detune" reed by tightening nut slightly.

When the tape timer is properly adjusted, there will be a knocking sound as the stylus hits the tape bed.

Small sharp dots allow a precise location of dots which are easier to measure accurately. Broad dots are easier to read at a distance and are good for class demonstrations.

7. **Release length of paper.**

Weight attached to free end of paper pulls paper through the slots toward the floor. As the paper passes beneath the vibrating reed, it is struck at regular intervals by the stylus. These intervals are exactly 1/60 sec apart. You now obtain a visual record of the acceleration due to gravity. As the paper moves faster between the slots, the spacing of the carbon dots is more widely separated.

8. When the entire length of paper has run through the Timer, **measure spacing of carbon imprints.**

- See page 2 for a mathematical discussion of principles.

***Replacement carbon circles and ticker tape paper can be ordered from* Science First®.**

Computations:

Sources of error in the procedure in **Part 1** are of two types:

- Friction of paper tape
- Occasional omission (or faintness) of a dot or if a dot is left out or faint. Simply drop questionable dots from your calculations.

The friction of the paper usually represents an error of 10 grams or less. If the falling mass is 100 grams, a 10% error can be expected. If the falling mass is 2000 grams, a 0.5% error can be expected. Specific tape error can be determined by a separate experiment using a very small mass (about 15 g) which falls at close to zero acceleration.

To compute the measurement of **g** which represents the acceleration due to gravity, disregard the first few points on the tape. They will probably be indistinct because they are located very close together.

Use this method to obtain acceleration from any series of distinct points. Select any set of points **A, B, C, D** etc. The distance between any two points represent both a time and a distance combined to create velocity. Let's say the distance between **D** and **F** is 2 cm.

A	B	C	D	E	F	G
.	.	.	.	.	.	.

The following explanation refers to sample data in the Table.

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The velocity this represents can be calculated as:

The distance between dot D and dot F in centimeters, divided by (1/60 sec) times (# of dot gaps).

$$V = \frac{\text{Distance between D and F}}{(1/60 \text{ sec})(\text{\# of dot gaps})}$$

$$V = \frac{2 \text{ cm}}{(1/60 \text{ sec})(2)}$$

This velocity of 60 cm/sec is the average velocity between **F** and **H** and represents the velocity at point **G**. Determine the velocity at **B** in the same way by using the data for points **A** to **C**.

Acceleration equals change in velocity divided by change in time.

This relationship can be represented for points **B** and **G**:

$$A = \frac{V_G - V_B}{t}$$

The time involved is 5 x 1/60 sec since 5 dots exist between these points, each representing 1/60 second.

Errors in measurement in a sample this small may be as much as 1 mm. The percentage of error can become high when measuring short distances.

Higher precision is attained using the distance between **A** to **E** to measure velocity at point **C.** Likewise, use distance between points **D** and **H** to determine the velocity at **F.** ***Note***: *Where there is greater time and distance between pins, measurement error is less important.*

Set #1 - Velocity

These represent the differences between adjacent points **1** and **2**, **2** and **3**, **3** and **4**, **4** and **5** etc. They are expressed to 2 significant figures only. Convert to actual velocity by dividing all figures by 1/60.

Set #1 - Acceleration

These represent the difference between velocities. In velocity column Set #1, note the great difference in figures, including a negative value. Average this column to yield an average value of .282 cm.

Divide .282 cm by 1/60 sec to obtain the velocity change in 1/60 sec. This yields 16.92 cm per sec.

Dividing 16.92 cm per sec by 1/60 sec yields an acceleration of 1011 cm/sec^2.

Set #2 - Velocity and Acceleration

These figures represent the distance between points 1/30 sec apart.

Set #3

Apply the same process to every third dot to arrive at **g** = 960.

Important Relationships:

A body in motion undergoes a continual change of position relative to some other body.

The velocity of a body depends on its speed and direction.

Path of motion and change of velocity determine the types of motion.

Acceleration is the rate of change in velocity.

Final velocity is related to the acceleration and time of travel.

Average speed is related to distance and time.

All freely falling bodies have a constant acceleration.

Falling bodies obey the rules for uniformly acceleration motion.

Air resistance limits the use of the falling body equations.

***Example* - Analysis of Data Used to Determine g**

Dot #	Position	Vel #1	Acc #1	Vel #2	Acc #2	Vel #3	Acc #3
1	1.2	1.2					
2	3.2	2.0	0.8	3.2			
3	5.3	2.1	0.1		1.3	5.3	2.7
4	7.7	2.4	0.3	4.5			
5	10.2	2.5	0.1		1.1		
6	13.3	3.1	0.6	5.6		8.0	2.3
7	16.5	3.2	0.1		.9		
8	19.8	3.3	0.1	6.5			
9	23.6	3.6	0.5		1.4	10.3	2.5
10	27.7	4.1	0.3	7.9			
11	31.9	4.2	0.1		.8		
12	36.4	4.5	0.3	8.7		12.8	2.5
13	41.3	4.9	0.4		1.1		
14	46.2	4.9	0.0	9.8			
15	51.7	5.5	0.6		1.1	15.3	2.0
16	57.1	5.4	-0.1	10.9			
17	63.0	5.9	0.5		1.0		
Average			.282 cm		1.10		2.40
Time interval			1/60		1/30		1/20
Accel g (cm/sec^2)			1011		990		960