LAWS OF FALLING BODIES.

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FIG. 1

I wish to submit an experimental determination of the laws of falling bodies which I believe has never been presented in any laboratory manual or teachers' journal.

After having the students of the Lake Forest Academy perform the experiment for several years I consider it of sufficient value to be presented to the general public. The experimental errors are no larger than those of most work in mechanics, being usually less than 1%.

The apparatus employed is the falling body mechanism of Wm. Gaertner & Co., 5347-49 Lake Ave., Chicago, as shown in Fig. 1. It consists of a tuning fork of known rate of vibration, guided in its fall by two highly polished nickel plated steel rods. The prongs of the fork are slightly spread by means of an eccentric on the top of the frame. This eccentric can be drawn up into the frame by turning a lever, which releases the fork and sets it in vibration. A light metal stylus is attached to one of the prongs, and records the vibrations on a glass plate smoked with a flame of alcohol in which some gum of camphor has been dissolved.

The glass plate is held parallel to the guide rods and can easily be shifted sideways, so that a number of curves can be traced with one smoking of the plate. Two dash pots at the base of the instrument catch the falling frame, and take up the jar.

Adjust the instrument so that the guide bars are vertical, as indicated by an attachable pendulum. Remove the pendulum and place the smoked glass in position behind the fork. Tightly grasp the guide rods about 1 cm. below the falling frame and release the fork, withdrawing the fingers horizontally the moment the falling frame strikes them. Move the smoked glass several centimeters and obtain several other curves.

On striking the fingers the frame holding the fork comes to rest and then falls freely. Unless this is done, the release of the eccentric adds a component velocity not due to gravitation.

Remove the glass plate, place it on a table with the smoked face up, and select a curve indicating a fall from rest. Draw lines *a*, *b*, *c*, etc. Fig. 2 at the end of every fifth curve. Now place the glass plate in a trough with the smoked side down; place a meter stick on edge parallel to the curve, with one end at *a*, and determine the positions of *a*, *b*, *c*, etc. For each reading place the eye in such a position that the divisions on the scale and their images in the glass are continuous lines.

FIG. 2

Thus we obtain the successive spaces, *s*, fallen through in time, *t*. The time interval is not the second, but the time required for the fork to make five vibrations, and its actual value is immaterial.

The final velocity, *v*, at the end of any period of time, is the mean value of the difference between the total spaces fallen through at the end of the succeeding and the preceding periods, or—

$$V_t = \frac{S_{t+1} - S_{t-1}}{2} \quad (1)$$

The acceleration, ∞ for any time interval, is the difference between the final velocity of that period and the final velocity of the preceding period, or

$$a_t = V_t - V_{t-1} \quad (2)$$

From these equations the various final velocities and accelerations can be calculated.

Now tabulate the results in the form indicated below

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
t	s	v	a	$\frac{v}{t}$	$\frac{s}{t^2}$	$\frac{v^2}{s}$	$\frac{2s}{t}$

Calculate the averages of columns (4), (5), (6), and (7).

From these averages it will be seen that, within the limits of experimental error

$$\frac{v}{t} = a \quad \text{or} \quad v = a t \quad (3)$$

$$\frac{s}{t^2} = \frac{1}{2} a \quad \text{or} \quad s = \frac{1}{2} a t^2 \quad (4)$$

$$\frac{v^2}{s} = 2 a \quad \text{or} \quad v = \sqrt{2 a s} \quad (5)$$

$$\frac{2s}{t} = v \quad \text{or} \quad s = \frac{1}{2} v t \quad (6)$$

The following table gives the work of one of my students of average standing. It was performed at the beginning of his elementary course and is typical of the results generally obtained with this experiment.

t	s	v	a	$\frac{v}{t}$	$\frac{s}{t^2}$	$\frac{v^2}{s}$	$\frac{2s}{t}$
1	.67cm	1.34cm	1.34cm	1.3400	.6700	2.6800	1.340
2	2.68	2.685	1.345	1.3425	.6700	2.6900	2.680
3	6.04	3.985	1.300	1.3283	.6710	2.6291	4.026
4	10.65	5.225	1.240	1.3062	.6656	2.5634	5.325
5	16.49	6.490	1.265	1.2980	.6596	2.5542	6.596
6	23.63	7.805	1.315	1.3008	.6569	2.5779	7.876
7	32.10	9.050	1.245	1.2928	.6551	2.5514	9.170
8	41.73	10.390	1.340	1.2987	.6520	2.5868	10.432
9	52.88	11.795	1.405	1.3105	.6528	2.6304	11.751
10	65.32	13.080	1.285	1.3080	.6532	2.6192	13.064
11	79.04	14.380	1.300	1.3073	.6532	2.6162	14.370
12	94.08						
		Average	1.3073	1.3123	.6599	2.6090	

$$\frac{v}{t} = 1.0038 \quad \text{or} \quad v = a t \quad \text{Error} = .8- \text{ of } 1\%$$

$$\frac{s}{t^2} = .5041 \quad \text{or} \quad s = \frac{1}{2} a t^2 \quad \text{Error} = .8 \text{ of } 1\%$$

$$\frac{v^2}{s} = 1.996 \quad \text{or} \quad v = \sqrt{2 a s} \quad \text{Error} = .2 \text{ of } 1\%$$

$$\frac{2s}{t} = v \quad \text{or} \quad s = \frac{1}{2} v t \quad \text{Error} = .5- \text{ of } 1\%$$