Lab Report: Free Fall experiment

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1 Experiment

EQUIPMENTS:

1. A heavy block(falling object)
2. Ticker-timer

Note: the ticker-timer produces 50 dots per second.(the time interval between two dots is 0.02 seconds)

3. Paper tape to record the results.
4. A stand (optional)
5. A clamp(optional)

We finished the experiment and chose 8 clear points at uniform time intervals on the paper tape and label the first dot as O, label other 7 dots A, B, C, D, E, F, G just like the graph shown in Figure 1.

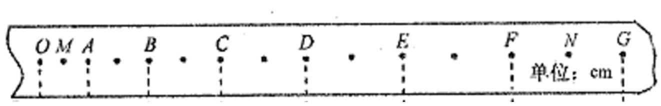

Figure 1: The paper tape has 8 dots named O, A, B, C, D, E, F, G

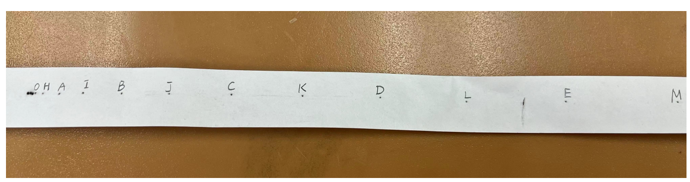

Figure 2: Experiment paper tape

	Displacement (cm)	Time (s)	Square of time (s^2)
OA	1.50 ± 0.05	0.04	0.0016
OB	3.57 ± 0.05	0.08	0.0064
OC	7.86 ± 0.05	0.12	0.0144
OD	13.47 ± 0.05	0.16	0.0256
OE	20.63 ± 0.05	0.20	0.04
OF	29.45 ± 0.05	0.24	0.0576
OG	39.70 ± 0.05	0.28	0.0784

Table 1: Raw data table with units and uncertainties, including displacement and time

2 Data processing

We need to determine the instantaneous velocity of the 7 dots with uncertainty.

Because the motion of the heavy block is free fall motion with constant acceleration, the instantaneous velocity of when time is equal to $\frac{t}{2}$ which t is the total time is equal to the average velocity. Which means

$$v_{\frac{t}{2}} = \bar{v} = \frac{s}{t}$$

Thus, for example, the mean value of instantaneous velocity of point H is

$$v_H = \bar{v}_{OA} = \frac{OA}{t} = \frac{1.50}{0.04} = 37.5cm/s = 0.375m/s$$

Since OA has its uncertainty, we need to determine v_H's uncertainty by

$$\frac{\Delta v_H}{v_H} = \frac{\Delta OA}{OA} = \frac{0.05}{1.50}$$

Thus the uncertainty of v_A is $0.01m/s$

$$v_H = 0.375m/s \pm 0.01m/s$$

In this way, we can also determine the value of v_I, v_J, v_K, v_L, v_M, v_N using raw data in Table 1.

	Instantaneous velocity (m/s)	Time (s)
H	0.37 ± 0.01	0.02
I	0.52 ± 0.01	0.06
J	1.07 ± 0.01	0.10
K	1.40 ± 0.01	0.14
L	1.79 ± 0.01	0.18
M	2.21 ± 0.01	0.22
N	2.56 ± 0.01	0.26

Table 2: **Processed data table** of instantaneous velocity and time with units and uncertainties

3 Graph drawing

According to Table 2, we can draw the $s-t$ graph, $s-t^2$ graph and $v-t$ graph of the free fall motion.

The $v-t$ graph is shown in Fig. 3.

$$v = at = gt$$

and the $v-t$ graph is a straight line passing through the origin. The best fit line is drawn in the $v-t$ graph. The acceleration of the free fall, gravitational acceleration g, is equal to $9.513m/s^2$.

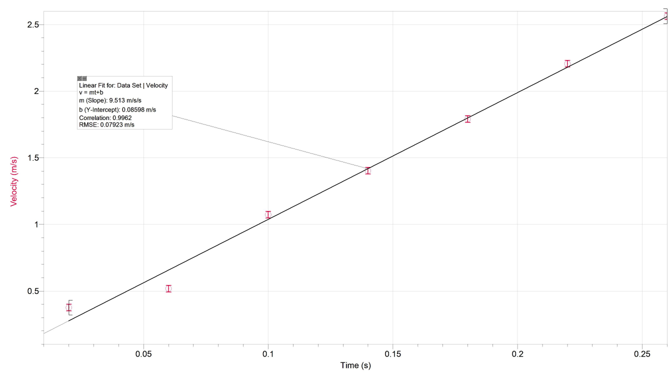

Figure 3: The velocity-time graph of the free fall motion

Thus $g = 9.513 m/s^2$.

The relationship between s and t is

$$s = ut + \frac{1}{2}at^2$$

. Since the initial velocity u is 0, a is equal to the gravitational acceleration g,

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

In Fig. 4, the $s - t$ graph is a quadratic passing through the origin.

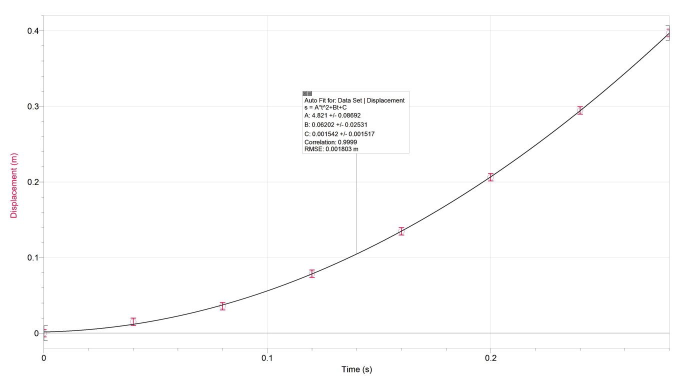

Figure 4: The curve of the $s - t$ graph is a quadratic

In Fig. 5, we consider t^2 as the independent variable, so the graph of the $s - t^2$ should be a straight line passing through the origin, which proves that t^2 is proportional to s.

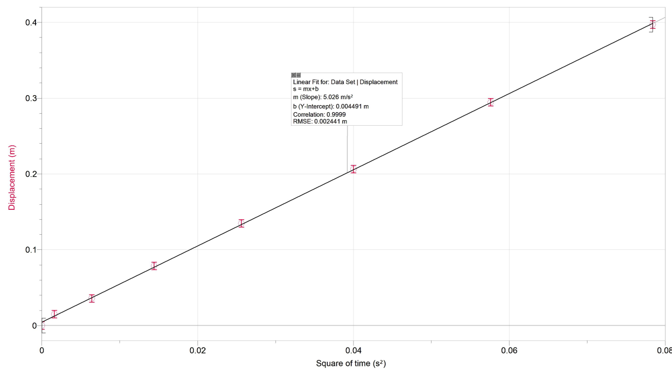

Figure 5: The curve of the $s - t^2$ graph is linear

4 Conclusion and evaluation

The experimental value of the gravitational acceleration $g = 9.513m/s^2$.

However, the theoretical value of the gravitational acceleration should be $9.794m/s^2$ in Shanghai. The experimental value of g is smaller than the theoretical value because there exists friction between the ticker-timer and the paper tape and friction between air and the block.