

Laser pointing timing trolley

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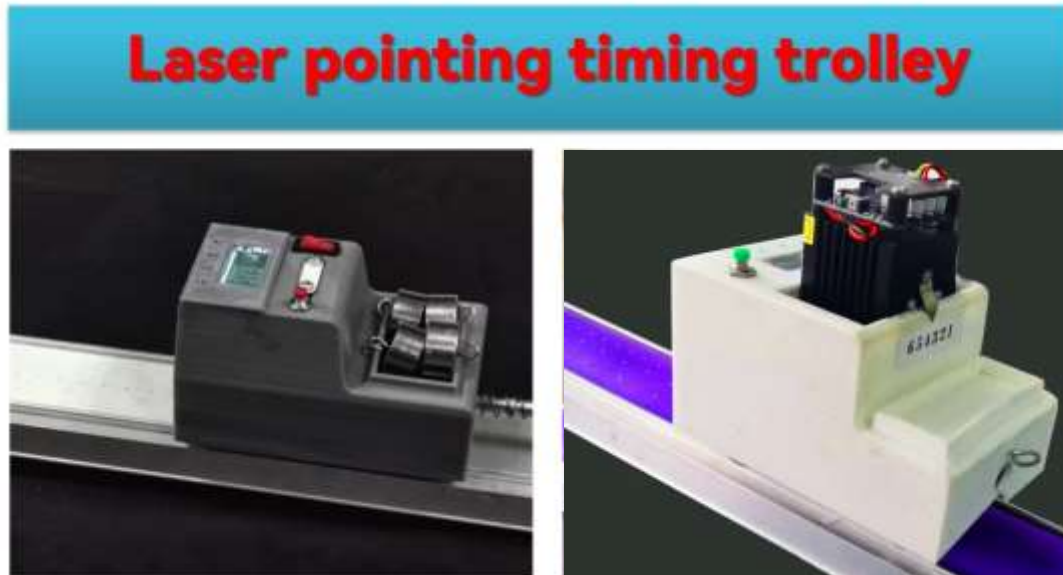


Fig. 1 Physical diagram of laser pointing and timing trolley

I. Research Background

High school physics experiments, in order to study the laws of motion of objects, the general use of electromagnetic point timer or electric spark point timer. These two kinds of punctuation timer in the use of the following problems: 1. the operation is complicated, 2. the use of alternating current frequency, timing is not accurate ,3. the paper tape and the limit hole between the friction, affecting the movement of the cart, 4. the dot trace is not clear patter. So, we invention a new type of laser dot timing trolley, this dot timing trolley to ensure the safety of students and easy to operate on the basis of more scientific, accurate, environmental protection, paper tape can be reused, it has the advantages of simple operation, less error, higher accuracy and more functions.

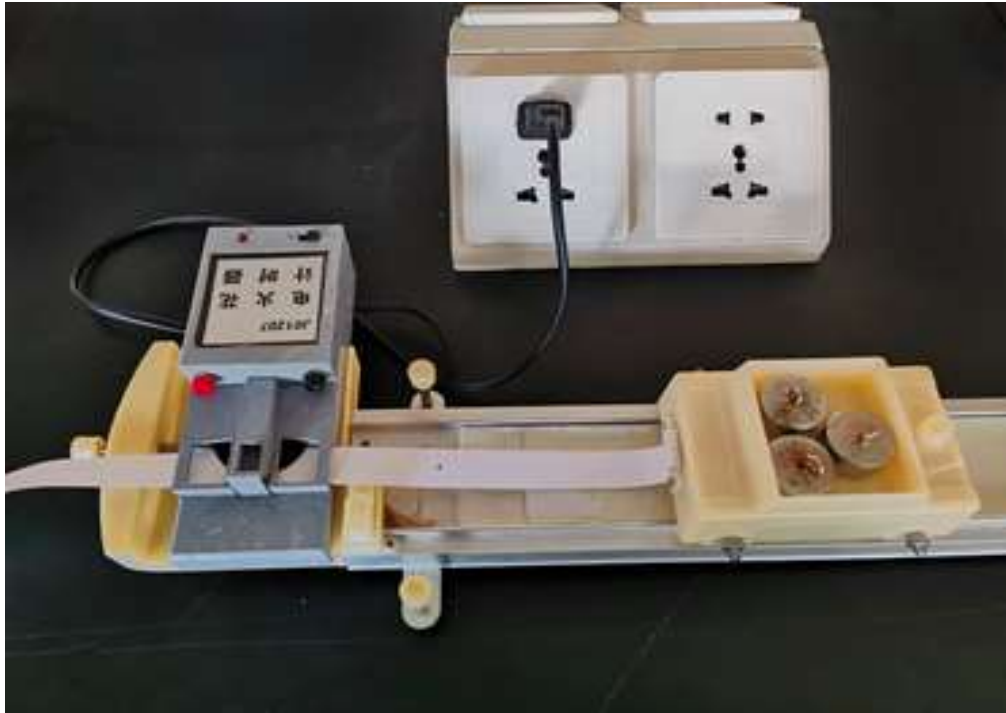


Fig. 2 Ordinary EDM type punch timer

II. Production process:

1. Selected materials: laser head, signal generator, driver, 4.2V battery, thermal paper, transparent Plexiglas board, cart

			
Lasers	Drive Module	PWM Signal Generator	Time delay circuit

2. 3D design and printing:

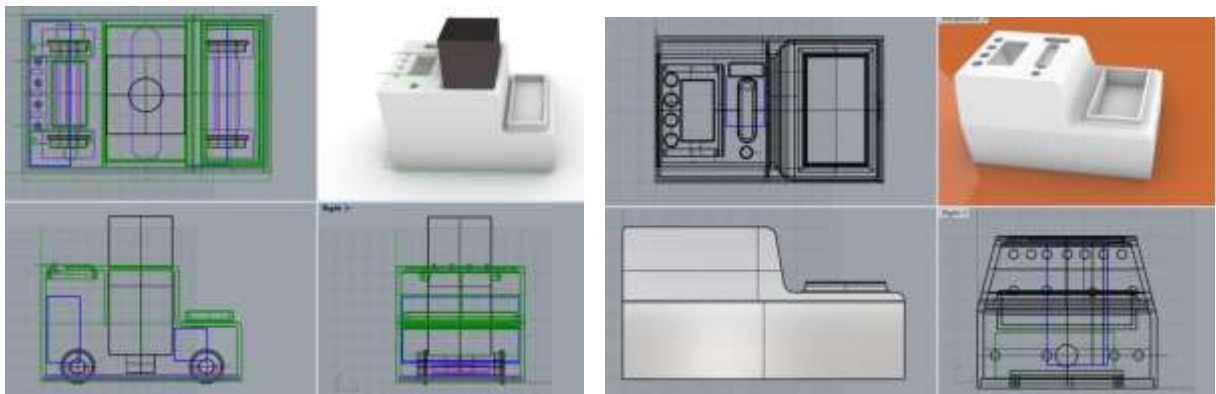


Fig. 3 Design of laser pointing cart housing with 3D software

Production of photosensitive paper tapes and thermal paper tapes:



Fig. 4 Making photosensitive and thermal paper tapes

3、Design of laser light source control circuit and production and installation.

Material length selected PAL material as the raw material for 3D printing, the production of battery boxes and car shell, the use of smaller power laser head, in the signal generator through the crystal oscillation circuit to generate pulses to the drive, the drive is through the low voltage small current control high voltage strong current to drive the laser emission.



Fig. 5 Laser driver board



Fig. 7 Light-sensitive paper cut to the same width as the track notch



Fig. 6 Thermal printing paper



Fig. 8 Making thermal printing paper

After several tests and analyses, for comparison and selection of photosensitive paper, the dotting effect is even better.



Fig. 9 Translucent board press paper

4、Difficulty breakthrough

(1) operating difficulties breakthrough: In the early stage of the experiment, we had intended to install a rack on the side of the car track can be fixed paper strips, the use of laser horizontal sweep to achieve the purpose of punctuation, but taking into account the laser damage to the eyes of students led to safety issues, so we changed the laser head to the track down sweep; because the paper strip in the track is difficult to fix, we thought of the installation of clips to fix the method, but After experiments, we found that the use of clips will lead to the actual available distance of the track shortened and inconvenient installation, so after consulting the data and thinking about the experiment for many times, we found that the laser can be punctured through the transparent glass plate, so we thought of using a plexiglass plate flat pressed on the thermal paper, so as to fix the experimental operation.

(2) laser pointing cart production in the difficult breakthrough: for the experimental cart, we initially wanted to design a laser pointing device as the main body of the box, so that the pointing device and paper tape separation movement, but taking into account the laser head power used is too high and lead to safety problems, and the experimental process is not convenient factors, so we change the high-power laser head for a small power laser head, and the use of 3d modeling and 3d printing technology, redesigned a multi-integrated cart, which includes the power supply, laser head, control panel and weights and other storage areas. The design of the cart is basically consistent with the original cart in appearance.



Fig. 10 Printed cart solid using 3D printer

1. In order to prevent students from picking up the trolley without closing the laser head after it reaches the end of the laser sweep, we plan to design a device that can make the laser head automatically stop sweeping at the end of the trolley when it slides to the end of the track, triggering the device to close the laser.

2. In order to prevent the cart from bouncing back against the baffle, holes are drilled in the rear of the cart for anti-collision holes to ensure easy removal after braking. Can then be upgraded to sensor braking device more simple and safe.

III, the structure principle: this invention has three main systems.

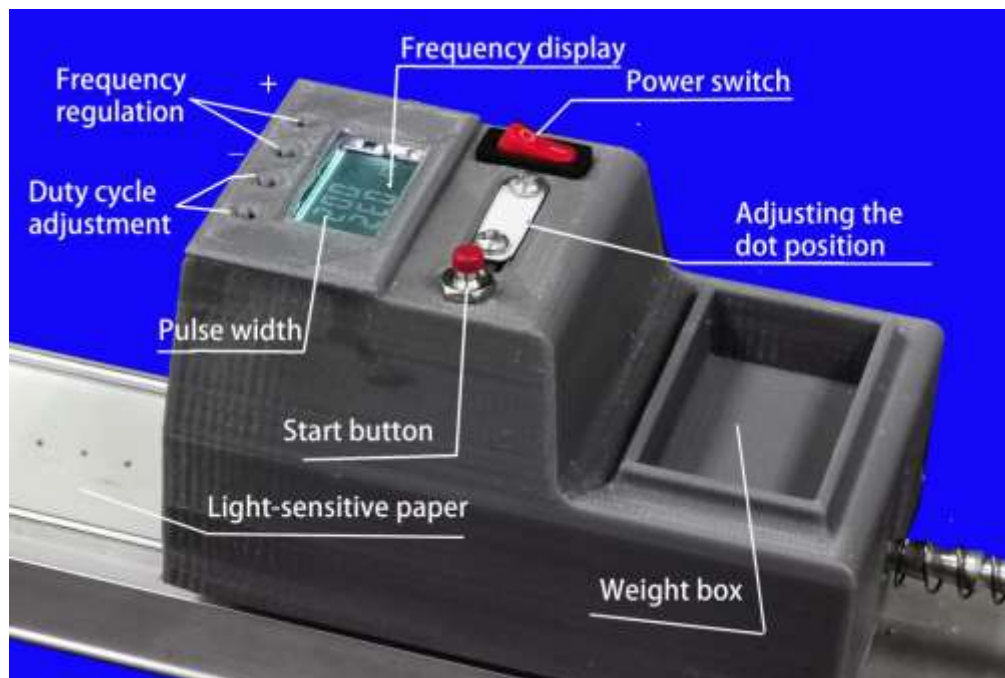


Fig. 11 Laser pointing carriage entity and the name of each part

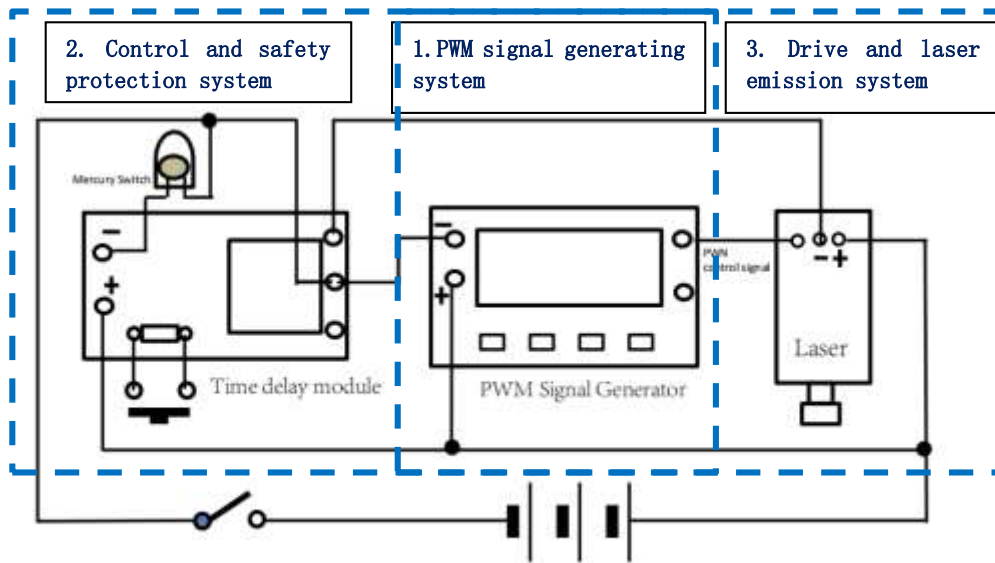


Fig. 12 Schematic diagram of laser pointing trolley

1. PWM signal generation system: used to generate PWM signals with adjustable pulse frequency and pulse width;
2. Control and safety protection system: to ensure safe and convenient operation for students;
3. Drive and laser emission system: to make the laser head have enough light intensity to hit clear dots on the paper tape.

Working principle: Turn on the power, adjust the suitable frequency and duty cycle according to the movement of the trolley, press the start button, release the trolley, and the laser head will hit a clear dot on the paper tape, and the circuit will automatically disconnect the power supply of the laser head after the dotting is finished. At this point we can analyze the paper tape and study the movement of the cart.

For the study of different moving objects, two scenarios have been designed:

Solution 1: 10w high-power laser head with homemade thermal paper, the cart can be saved for a long time after leaving traces on the paper, the gear can be adjusted to change the location of the hitting point for comparison experiments, the paper tape can be restored to its original appearance after low-temperature freezing, the paper tape can be reused, economic and environmental protection.

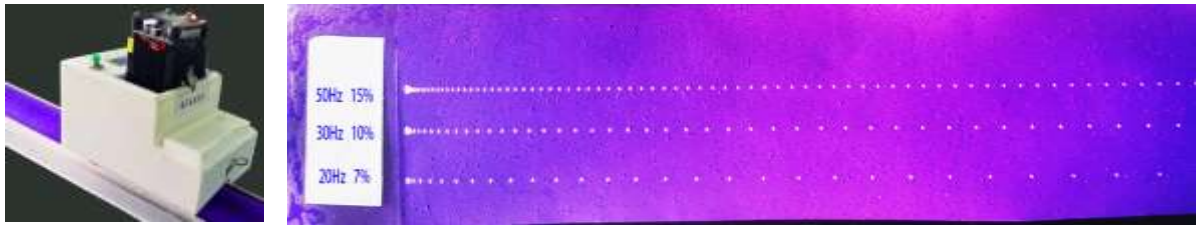


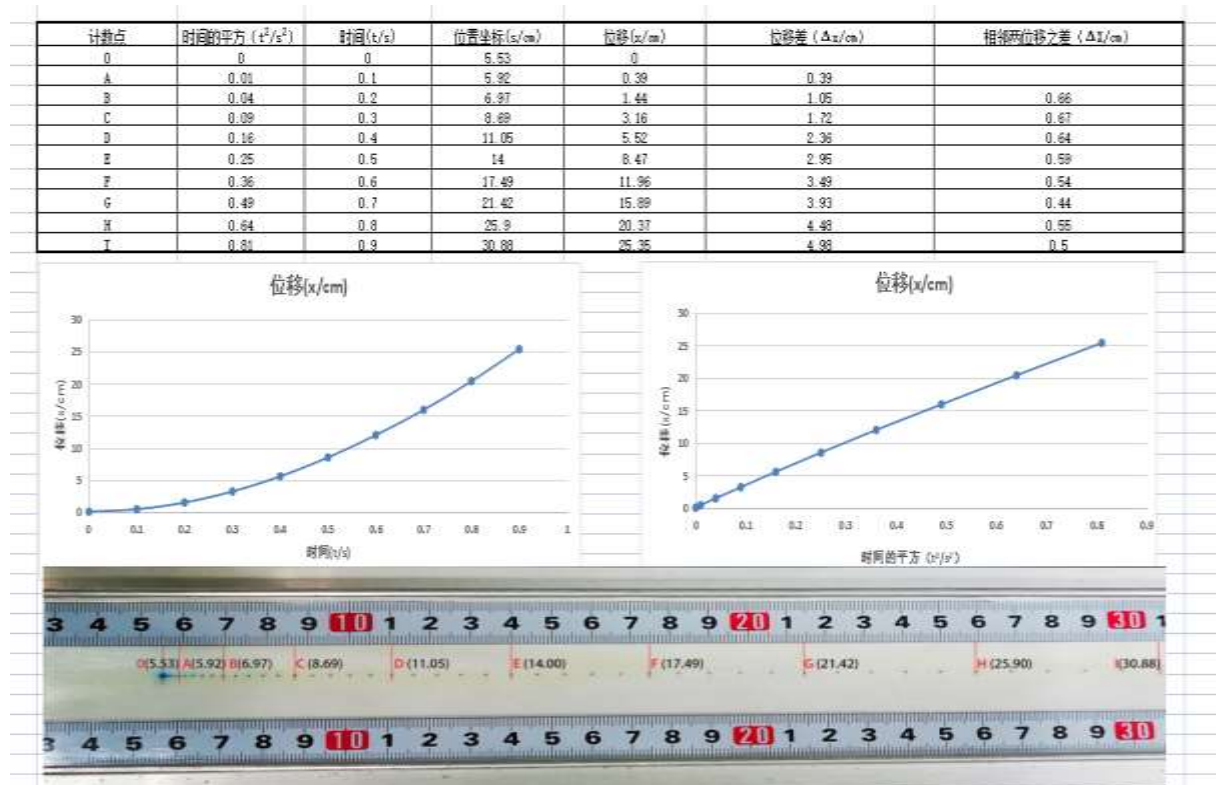
Fig. 13 Option 1: Use 10w high-power laser head with homemade thermal paper

Solution 2: 0.5w low power laser head with homemade photosensitive paper, with a scale next to the paper tape, after the cart leaves traces on the paper tape, the data will be saved by taking photos and recording, which will disappear in a period of time, and the paper tape can be reused.

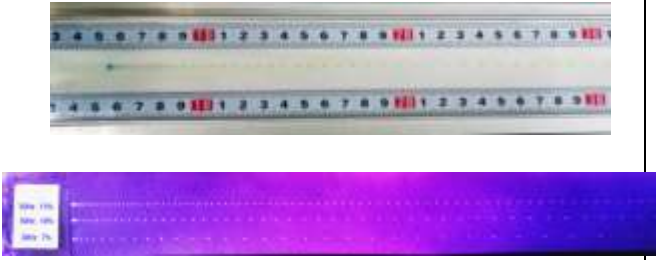


Fig. 14 Option 2: 0.5w low power laser head with homemade photosensitive paper

This is an analysis of the experimental results:



Comparison with ordinary punch timers:

New Laser Pointing Timer	General spark type pointing timer
	
	
Laser dot timing trolley hit the dot trace can be adjusted intensity and size, the same conditions, clear dot trace, easy to enlarge the reading and easy to save and repeatedly use, because there is no friction affect the measurement comparison results more accurate.	The point trace of the ordinary punctuation timer is greatly influenced by the toner, and due to the friction between the paper tape and the limit hole, the point trace is uneven and the measurement error is large

Adjust the frequency to 50 Hz, in the case of ensuring the track tilt angle and the quality of the hook hung the same, multiple comparison tests can be confirmed and analyzed laser point more clearly, the calculation of acceleration can be reduced by $0.04-0.10\text{m} / \text{s}^2$.

IV. Innovations of the present invention:

1. the pointing timer and the trolley into one, the trolley movement without dragging a long paper belt, reducing the impact of friction between the trolley and the paper belt, the paper belt and the limit hole; the use of laser pointing reduces friction, more scientific, accurate and convenient.

2. punctuation frequency adjustable pulse duty cycle adjustable: adjustable punctuation frequency period from 1 to 1000Hz, pulse duty cycle can be from 1% to 100%, can be adjusted by adjusting the different frequencies and pulse duty cycle for punctuation of the inquiry experiment comparison.

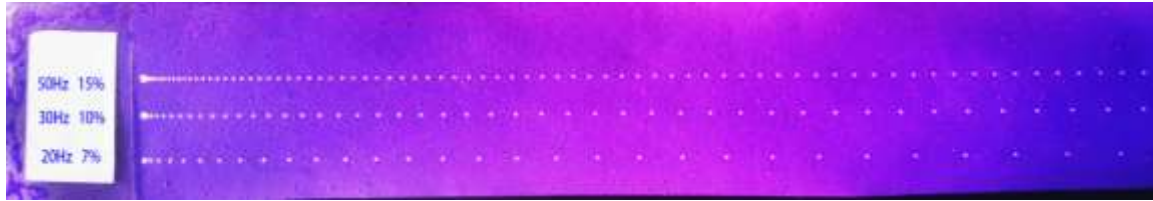
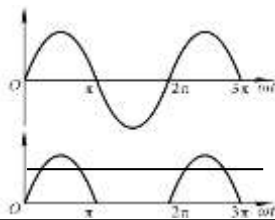


Fig. 15 Comparing dotting under different duty cycles and frequencies using a 10W laser head.

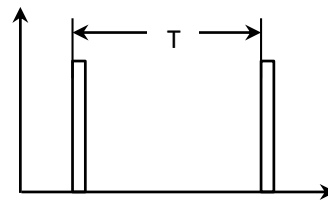
During actual dotting, high frequencies are used for fast-moving objects and low frequencies for slow-moving objects. This not only facilitates measurement but also reduces errors.

3. by adjusting the size of the punctuation marks to meet a variety of needs, to reduce the experimental error. You can change the frequency period and pulse duty cycle for several experiments to achieve the effect of reducing the error; laser pointing timer generates pulse through crystal oscillation, which is more stable and accurate compared with electromagnetic pointing timer and EDM pointing timer.



"Conventional electromagnetic and spark-type tapping timers use AC half-wave rectification to achieve tapping, with a relatively large margin of error.

Fig. 16 The tapping principle of a conventional tapping timer.



The new laser tapping timer uses crystal oscillation to generate pulse square waves for tapping, resulting in more accurate experimental results.

Fig. 17 The tapping principle of a laser tapping timer

4. safety, environmental protection: there is a safety protection circuit, the laser head can be moved to improve the utilization of the paper tape, so that a paper tape can be played on more than one trace, easy to compare the experimental results for analysis.

5. can be promoted and developed: this laser dot timing trolley experimental device and the original trolley model basically remain the same, can use the original track, in order to make it

simple to reach the end of the track to hit the point can automatically stop, easy to operate, students pick up the trolley, the laser head immediately shut down, will not hurt the eyes. The trolley is equipped with a weight holding frame slot, increasing the convenience of the experiment, but also easy to promote and reuse