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A new single pendulum experiment device based on Correlation gratings

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Abstract

When the traditional single pendulum device measures gravity acceleration, the pendulum ball is easy to conduct conical pendulum movement, and it is easy to introduce improper human error by the experimental operator.The new single-pendulum experimental device based on the contrast grating mainly consists of five units, namely, core control unit, sensor unit, control unit, display unit and wireless transmission unit.Each functional unit is independent of modules from each other for easy design and assembly.The problem of inaccurate measurement and cumbersome calculation is solved.

Keywords

Physics experimental equipment improve physics teaching S TM32 single gratings.

1. Theory

A single pendulum is an ideal physical model consisting of idealized pendulum balls and pendulum lines. With the bias angle satisfied less than equal to 5 °, the motion of the single pendulum is approximately a simple harmonic vibration. At present in the single pendulum measurement gravity acceleration experiment improved, but still appear large disadvantages and errors, such as pendulum ball do cone movement, cannot control the pendulum as small as possible, using the stop table to measure single pendulum cycle is not accurate, technical formula and data are complex and can not accurately calculate the gravity acceleration data, etc.

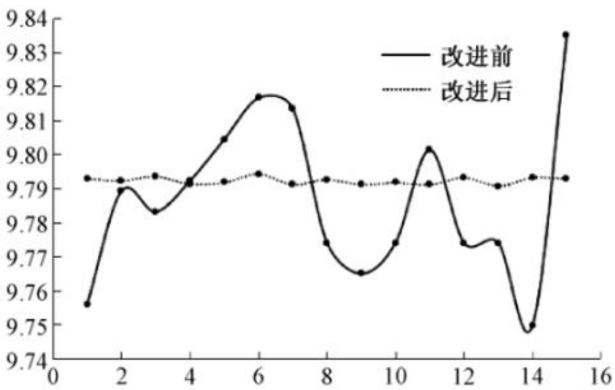
2. Research purpose of instrument production and improvement

After preliminary research, it is found that the gravity acceleration of the single pendulum device is easy to make the pendulum movement, and the human error is caused by the improper operation of the experimental operator. Therefore, we decided to improve a new single pendulum experimental device based on Correlation gratings. China currently uses the time used to measure the ordinary experimental single pendulum meter and stopmeter, and the local gravity acceleration is calculated using the formula. There are many factors causing errors. For example, it is difficult to ensure that the pendulum ball can do simple harmonic vibration in the same lead straight plane. Moreover, the metal ball instantly passes through the equilibrium position. Because the parallax is difficult for the experimental operator to determine the time of the balance position, and the stopwatch is not instantaneous action, there will lag compared with the time when the metal ball reaches the balance position. The time required to measure 30-50 cycles is long, and the calculation formula and data are more complicated, time-consuming and laborious. The final measurements resulting in gravity acceleration differ greatly from the real value. To this end, we present the improved single pendulum experimental device detection results and the single pendulum vibration image through more intuitive data, which can not only reduce the error, but also shorten the experimental time and improve the accuracy of the experimental measurement of gravity acceleration data.

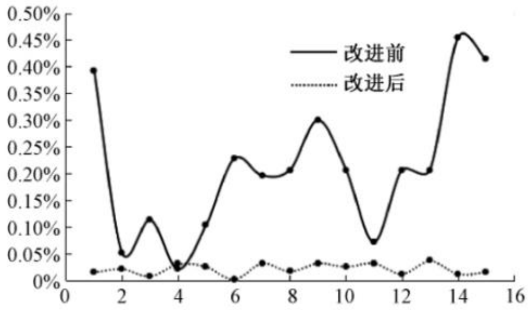
The figure is the overall physical diagram of the new single pendulum experimental device based on the contrast grating

3. We will improve basic plans

By STM32 computer, infrared photoelectric induction laser response sensor, electromagnet, counter counting sensor module, light curing desktop level 3D printer printing resin encoder disc and shaking torsion, laser cutting, TFLCD, oled to obtain swing movement cycle data and vibration frequency, the physical signal to STM32 chip for signal processing, and then by the WiFi module to the central host, store data, at the same time, the user can view in APP and other clients, do more convenient and fast. The device uses the electromagnet device to ensure that the simple harmonic vibration of the pendulum angle is less than 5 ° in the same lead straight plane, uses the differential encoder to reduce the measurement error, reduce the human error with STM32 single chip computer and photoelectric sensor, and the error introduced by the experimental environment caused by the long time experiment. This can not only reduce the error, but also shorten the experimental time and improve the accuracy of the data. The TFLCD display directly displays the real-time gravity acceleration and the 30 cycles, 40 cycles, and the average of 30 cycles and 50 times. In addition, the wireless transmission is effectively transmitted to the data receiving point or domain gateway, connected to the cloud platform through WiFi, and the measured data and historical measurement data are uploaded to the cloud and automatically saved to facilitate the use and search of gravity acceleration data in the later stage.



(Comparison of gravity acceleration measurements)



(Improve the relative error comparison before and after gravity acceleration)

4. Introduction of technical route and improvement scheme Technical route

When the traditional single pendulum device measures gravity acceleration, the pendulum ball is easy to conduct conical pendulum movement, and it is easy to introduce improper human error by the experimental operator. The new single pendulum experimental device based on the projection grating uses the electromagnet device to avoid the pyramidal pendulum movement of the pendulum ball, reduce the human error with the STM32 single-chip timer count, reduce the measurement error with the differential encoder to control the pendulum length, and the error introduced by the experimental environment brought by the long-time experiment. This can not only reduce the error, but also shorten the experimental time and improve the experimental accuracy.

The new single pendulum experiment device based on the projection grating is mainly divided into five units: core control unit, sensor unit, control unit, display unit and wireless transmission unit. Each functional unit is independent of modules from each other, facilitating product design assembly and later product maintenance and maintenance. The core control unit is the main unit of the new single pendulum experimental device based on the grating, which adopts STM32 single chip machine to control the program as the core unit. As the core part of the experimental improvement device, the overall control of the whole instrument. Obets the sensor signal, processes the signal, and controls the display unit so that the display displays the gravity acceleration size directly. The sensor unit adopts an infrared photoelectroinductive laser laser to senses the pendulum ball through the time interval of the photoelectric sensor to obtain the external signal and convert the physical signal into an electrical signal.The control unit is divided into two parts, using an electromagnet device, absorb the ball, power release, the precise position of the ball, release the ball, in order to achieve the purpose of releasing the ball, reduce the possibility of metal ball do pendulum movement in the vertical plane. The other part prints the resin encoder torque using the light cured desktop level 3D printer, connects the pendulum line and accurately controls the cycloline, so as to avoid errors caused by inaccurate measuring the cycloline length. The display unit adopts TFLCD LCD display and oled display screen, TFLCD display screen is a widely used plane super thin display equipment, on the basis of the TFLCD display, the single chip computer is programmed and compiled to control the TFLCD display, the display screen can directly display the vibration frequency image, swing ball swing period and swing number relationship diagram and gravity acceleration value. The wireless transmission unit effectively transmits the data to the data receiving point or domain gateway, connects it to the cloud platform through WiFi, and uploads the measured data and historical measurement data to the cloud and automatically saves it, so as to facilitate the use and search of gravity acceleration data in the later stage.

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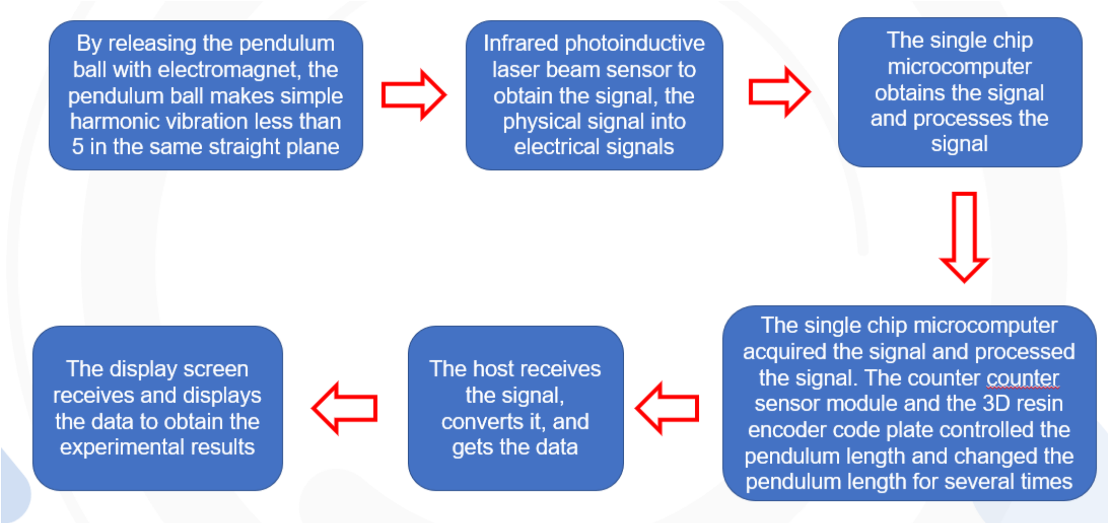


The picture is: Technology road map

5. Introduction to the improvement scheme

1. core control unit

During the measurement of gravity acceleration, the time between the first and the second photosensor is a quarter single pendulum period, measuring the average of 30 units. The STM32 MCU is programmed to receive the electrical signal of the sensor and to calculate the single pendulum period according to the obtained information, and to calculate the gravity acceleration and the swing ball vibration frequency image.

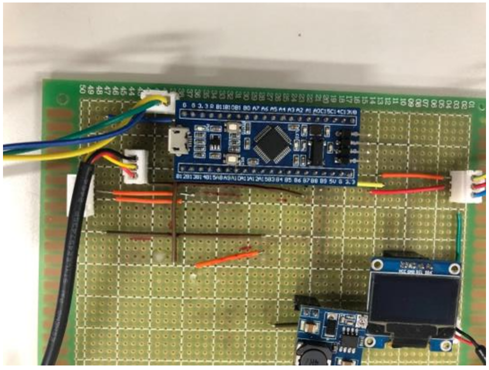
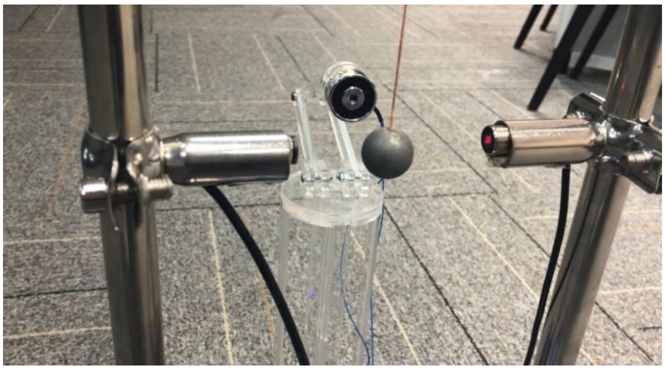


Photo shows: STM32F103C8T62 MCU

2. Sensor unit

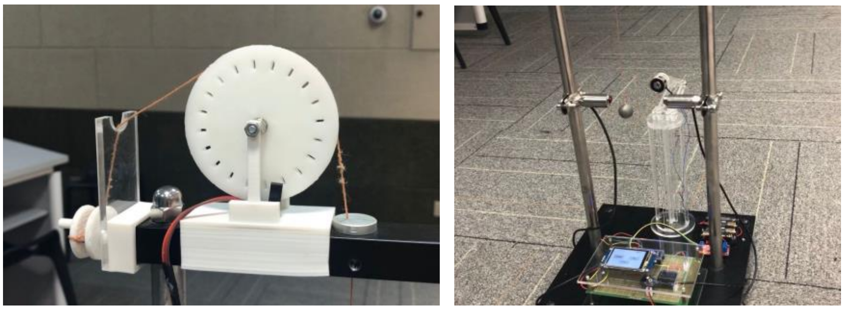
The sensor unit uses infrared photoelectric induction laser contrast sensor, infrared photoelectric induction laser contrast sensor, from the beginning to swing the ball to the right end of the ball to the photoelectric sensor, to the end of the left end of the ball to the second time to the lowest end of the conical pendulum movement. Quarter is the length of the single pendulum cycle time. And connected to the STM32 microcomputer through the converter, it recorded the length of 30,40 and 50 units, enabling the sensor to transform the physical signal into measurable electrical signal output. Thus, the process of transforming the external information into an electrical signal is completed. The advantages of infrared photoinduction laser convection are high precision, wide measurement range, long life, simple structure, good frequency sound characteristics, can work in harsh conditions, easy to achieve miniaturization, integration and variety diversification.



The figure is: infrared optoelectronic induction laser response sensor

3.Operating unit

This unit is divided into two parts, using electromagnet device, using laser technology cutting acrylic plate assembly placed electromagnet platform, fixed in the single pendulum site midline position, can adjust the height and Angle, and always keep the center of the ball, power suction ball, power release swing ball, accurate ball position, achieve the purpose of the ball, reduce the possibility of metal ball in the vertical plane. The other part prints the resin encoder torque using the light cured desktop level 3D printer, connects the pendulum line and accurately controls the cycloline, so as to avoid errors caused by inaccurate measuring the cycloline length. Adjust the acrylic plate to adjust the electromagnet up and down, front and rear position and angle, so that the metal ball and the vertical clip angle is less than 5 degrees upon release. Adjust the pendulum line length and measure it many times to obtain the vibration period and frequency of the small ball at different pendulum lengths.



The picture shows: resin code plate and acrylic fixture

4. Display unit

The instrument displays the resulting gravity acceleration data directly through the display screen by connecting to the core control unit.

The display module adopts the TFLCD LCD display and the olde display, a widely used flat ultra-thin display device, and the oled display is a widely used character-type LCD display module. On the basis of the single chip computer, combined with the TFLCD display screen and the oled display screen, the single chip computer is programmed and compiled to control the monitor. The display screen can directly display the vibration frequency image of the swing ball and the gravity acceleration value. Or use the TFT color LCD display screen to improve the display device. The display unit directly shows the vibration frequency image of the pendulum ball, the real-time gravity acceleration value, the mean gravity acceleration value of 30,40 and 50 cycles and the change quantity of the pendulum swing period with the number of swings.

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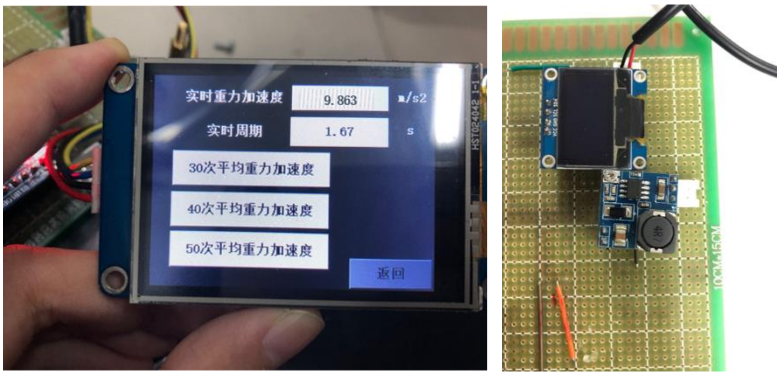

The picture is: TFLCD LCD display screen and olde display screen

5. Wireless Transmission Unit

Implementation of a wireless transmission unit based on a new single pendulum experimental device for projection gratings. The wireless transmission module, as a module sensitive to the interference signal, also requires electromagnetic shielding measures, for which we also conduct a modular design to ensure its optimal anti-interference performance.

In order to effectively transmit data to the data receiving point or domain gateway, it is particularly important to select an effective network transmission mode. Here, we use the DTD433M frequency band of wireless digital transmission equipment, which can provide high stable, high reliable and low cost data transmission. It provides transparent RS232/RS485 interface, with convenient installation and maintenance, strong round-shooting ability, flexible network structure, wide coverage, suitable for multiple points, scattered and complex geographical applications. At the same time, it also reduces the power consumption of the equipment and the scale of the peripheral RF filter circuit, and effectively reduces the volume of the circuit and the component cost.At present, our facilities can be connected to the cloud platform through WiFi, and upload the measured data and historical measurement data to the cloud and save them automatically. Users can view the information of the platform to view the data recorded by the instrument.

6. Experiments and use

New single pendulum experimental device based on projection grating:

Step 1, the user first time uses the single pendulum experimental device to improve the instrument, and the control terminal is powered by the student power supply;

In Step 2, the user disconnects the electromagnetic power supply, and moves the ball. Then the pendulum line receives physical signals to the transmitter during the infrared photosensitive laser detector and transforms them into an electrical signal, and the single chip computer receives and processes the computing data.

Step 3, the user reads the display screen image and data. The TFLCD display is a touch screen, and the user can touch and enter the data reading page according to the data they want to get and the home page of the display.

In Step 4, the user operates the ejection counting sensor module switch to turn the resin code disk and change the pendulum line length to the corresponding length. Repeat the above steps 1,2,3 to obtain the corresponding data.

Step 5, turn off the power supply and the end of the experiment.

Experimental measurement data of a new single pendulum experimental device based on the projection grating:

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Periods and relative errors of different pendulum length

A \ L/cm	30		50		70	
angular amplitude / (°)	Cycle / s	Relative Error /%	Cycle / s	Relative Error /%	Cycle / s	Relative Error /%
1	0.8975	0.000	1.0994	0.000	1.6793	0.000
3	0.8977	0.001	1.0995	0.001	1.6795	0.000
5	0.8981	0.001	1.0999	0.001	1.6801	0.001
7	0.8983	0.002	1.1004	0.002	1.6809	0.001
9	0.8990	0.003	1.1010	0.003	1.6828	0.003
11	0.8996	0.005	1.1019	0.004	1.6831	0.004
13	0.9004	0.005	1.1028	0.005	1.6847	0.005
15	0.9015	0.005	1.1040	0.005	1.6856	0.005
17	0.9026	0.006	1.1056	0.006	1.6885	0.006
19	0.9037	0.006	1.1068	0.007	1.6909	0.006
21	0.9056	0.007	1.1087	0.007	1.6935	0.007
23	0.9068	0.008	1.1105	0.008	1.6963	0.008
25	0.9084	0.008	1.1123	0.008	1.6995	0.008
27	0.9112	0.010	1.1148	0.010	1.6999	0.008

When the pendulum length is 80cm,, the angular amplitude is 5 °
Time t of 30 swing n = (s)

	1	2	3	4	5	6
t(s)	47.347	47.340	47.351	47.346	47.346	47.342
g(m/)s^2	9.7986	9.7987	9.7983	9.7986	9.7986	9.7987

Time t (s) for 40 swing n =

	1	2	3	4	5	6
t(s)	62.128	62.140	62.132	62.134	62.131	62.135
g(m/)s^2	9.7987	9.7984	9.7986	9.7985	9.7986	9.7984

Time t (s) for 50 swing n =

	1	2	3	4	5	6
t(s)	77.903	77.920	77.915	77.911	77.923	77.928
g(m/)s^2	9.7987	9.7983	9.7984	9.7984	9.7982	9.7979

7. Conclusion

The new single pendulum experimental device based on the shot grating can ensure that the simple harmonic vibration is less than 5 ° in the same lead plane. Compared with the traditional experimental device, the pendulum can avoid the error caused during the experimental process.

By compiling the STM32 single chip machine and the photosensor can measure the single pendulum cycle very accurately. Due to the parallax, it is difficult to determine the time of the experimental operator, which will lag compared with the time when the metal ball reaches the balance position. This modified experimental device can avoid human error introduced by the experimental operator.

The 3 D rotor wheel model was designed by Solidworks to print the rotor connection pendulum line to control the pendulum line accurately to avoid the experimental error caused by inaccurate measuring pendulum length. It can not only save the experimental time, but also improve its accuracy.

Compared with the traditional single-pendulum measuring gravity acceleration experimental device, we have adopted different design concepts from the previous design concept. We support humanized customization, make full use of resources, reduce unnecessary waste and reduce costs.

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