THE AUTOMATIC INCLIENE PLANE TO MEASURE THE COEFFICIENT OF STATIC FRICTION FOR TEACHING AID

Phyu Phyu Mar[1], Ayethidar Aung[2], Mya Hnin Su[3]

Abstract

Today one of core science subject being offered in Myanmar schools is Physics and it forms the basis for the nations technological Subject and human resource development. This paper discusses the improvement of teaching aid in practical works. The automatic finding of the coefficient of static friction is designed by using inclined planed and Arduino technology. It is simple and very affective to describe the basic principle of static friction. The data are collected easily, show clearly and précised and accurate. The measured time is quickly done by this method. This design can be supported affectively in teaching to understand and linking between Physical Phenomenon, theory and practical for students in all educational fields.

Keywords: Automatic, Arudino nano, Education, Employment, Productivity, Physics, Technology, Teaching aid, Stepper motor

Introduction

In Myanmar there is a lot of need to provide society and human resources. To develop the education teaching methods and teaching aids are important. So teaching aids are the useful things to discuss and demonstrate the Theory and Law clearly. Among them finding of coefficient of static friction using the incline plane is included. In this paper “the automatic finding of coefficient of static friction using Arduino IDE” is used to find the coefficient of static friction by using of Inclined plane for teaching aid. Because of Arduino, its open source software is very popular today. So people are liked to use the Arduino IDE for research and the projects and invention of the news in various ways such as domestic used, economic used and for teaching aids. In this experiment, It will use a IR sensor do study static friction on the wooden block. Determine the relationship between force of static friction and due to the weight of an object. Use the Arduino microcontroller and IR sensor to independently measure the coefficient of static friction compare it to the previously measured value.

Theory and Components

When a surface of one body moves with respect to the surface of another when they are in contact, it must overcome a resisting force. This resisting force is called friction. In this paper “the automatic finding of coefficient of static friction using Arduino IDE” is used to find the coefficient of static friction by using of Inclined plane for teaching aid.

[1] Dr, Lecturer, Department of Engineering Physics, Yangon Technological University
[2] Dr, Associate Professor, Department of Engineering Physics, Yangon Technological University
[3] Dr, Professor and Head, Department of Engineering Physics, Yangon Technological University

Theory and Components

Theory of the Incline Plane

An incline plane is a sample machine that has its surface inclined at an angle with the horizontal. It consists mainly of a smooth plank of wood or metal rails. It is used to lift or roll heavy objects from one level to another. It permits the raising of heavy loads by application of smaller forces than would have been employed in resisting them vertically.

If a plane horizontal surface with a block resting on it be gradually tilted a certain angle of inclination will be reached when the block will begin to slide down the incline. This particular angle of inclination of the plane with the horizontal at which the block just begins to slide down is known as "**angle of friction**". Forces acting on the block placed on an inclined plane its weight mg, the normal reaction, N and the force of static friction F_s. At the angle θ at which it static to slide down, the static friction F_s = mg sin θ and the normal reaction N = mg cos θ show in Figure 1 a.

$$F_s \infty N$$

$$F_s = \mu_s N$$

$$\mu_s = \frac{F_s}{N} \quad (1)$$

$$\mu_s = \frac{f_s}{N} = \frac{mg\sin\theta}{mg\cos\theta} = \tan\theta \quad (2)$$

Eq (1)& (2)

$$\mu_s = \frac{Friction\ of\ force}{Normal\ Reaction} = \tan\theta$$

Thus μ_s can simply be found by determining tan θ from the measurement of h and a Figure 1.b.

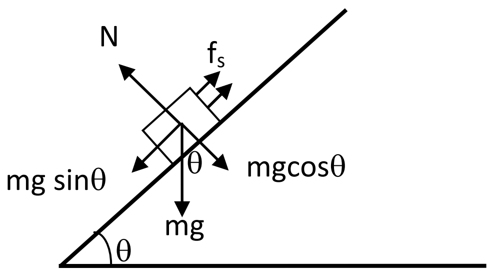


Figure 1a Forces on the block on an incline

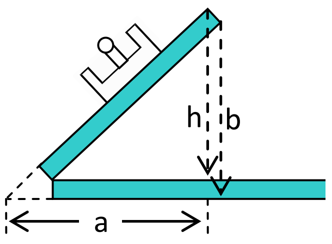


Figure 1b Determination of tan θ

2.2 Arduino Nano Board

The Arduino Nano shown in Figure 2, is one of the smallest and yet most exciting breadboard-friendly boards available on the market today. It's become exceptionally popular with beginner programmers thanks to its excellent functionality and the sheer variation of potential applications. Based on the ATmega328P, this tool is fantastic for those who wish to improve their programming skills and create some interesting and unusual projects. While the item does not come with a DC power pack, it benefits from a mini-USB cable for power, and that means it can be use with any PC or laptop device. This Nano board is used for to control the whole project and command the other devices.

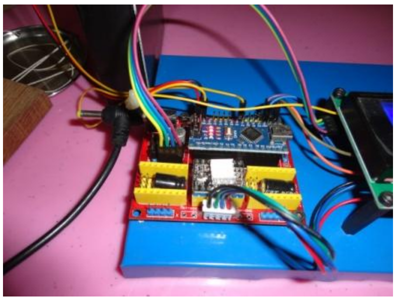
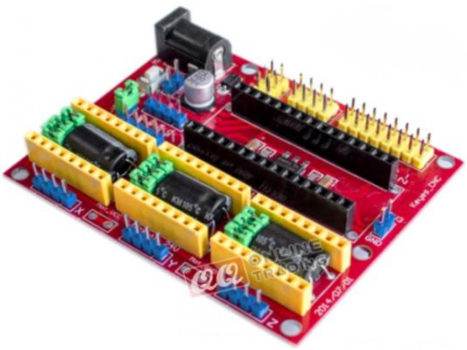


Figure 2 The Arduino Nano Board and using in the circuit

2.3 Developing and Measuring Equipment for Kinetic Friction Using Arduino Board Garbl CNC Shield

A CNC shield shown in Figure 3 is inserted to the Arduino microcontroller to start / stop and connection of stepper drivers easy. It is compatible with the G-Code interpreter firmware called GRBL. It supports maximum of four stepper drivers to run four stepper motors. It can support a maximum of 36 volts and setting the micro stepping is easy with a shield. This CNC shield is used for to control the motor.



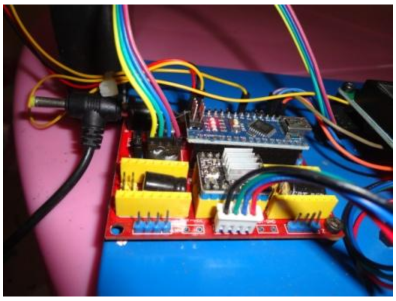


Figure 3 The CNC Arduino Garbal Shields and its application

2.4 Stepper Motor using the rising and falling of the incline plane

Stepper motors shown in Fig (4) is used for their high working ability and precision level. Unlike DC motors, the stepper motors are brushless, synchronous electric motors that can divide a full in both directions. It has a capability of holding torque at zero speed, and precise digital control without any feedback system depending on the overall size of the project and application. The stepper motors are constant power devices. As speed increases the torque decreases, so we'll have to try to find a happy medium for the need to drive our CNC machine. Stepper motors come in different types and multiple coil winding. In the project the stepper motor is used for raising the incline plane to detect the coefficient of static friction. This motor is controlled by the Arduino Garbal shields to raise or lower the incline plane.

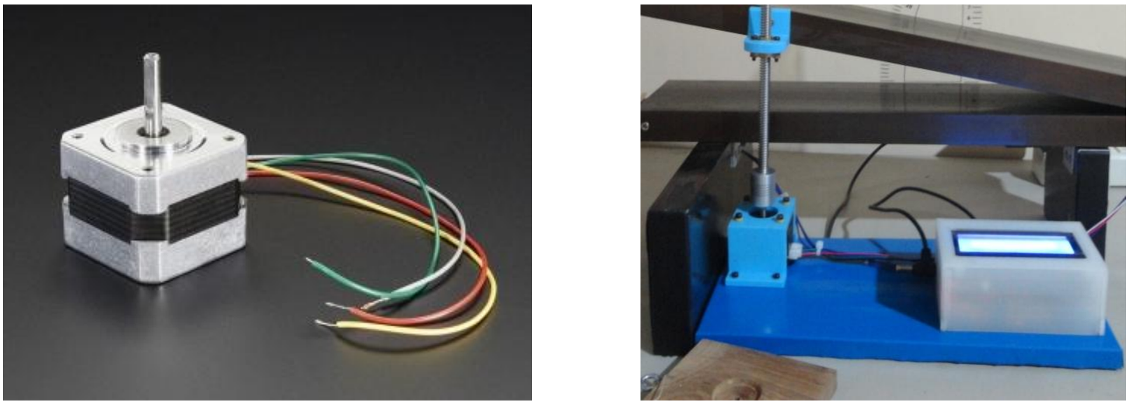


Figure 4 The JLB 17HS1362 Stepper Motor and its application in incline plane

2.5 Motor Driver using for the control of the stepper motor

The Big Easy Driver shown in figure 5 is a stepper motor driver board for bi-polar stepper motors up to 2A/phase. It is based on the Allegro A4983 or A4988 stepper driver chip, which is the next version of the Easy Driver board. This design is robust enough to handle most medium-sized stepper motors. This driver is used to control the motor to raise the incline plane or down the plane and to stop when it reaches the home condition.

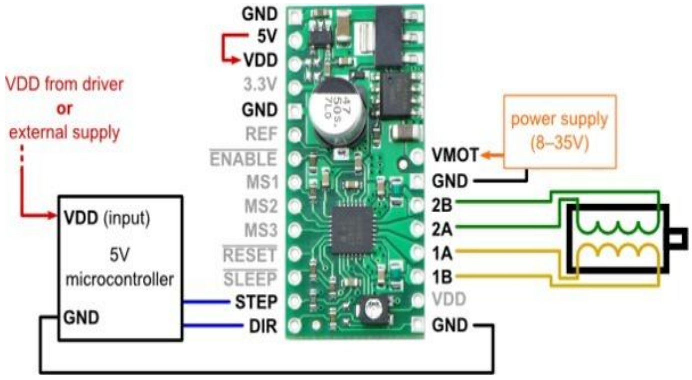


Figure 5 The Motor drivers

2.6 4-Line Liquid Crystal Display (LCD) using for the display device of the incline plane

The HD44780U dot-matrix liquid crystal display controller and driver LSI displays alpha numeric, Japanese kana characters, and symbols. It can be configured to drive a dot-matrix liquid crystal display under the control of a 4-bit or 8-bit microprocessor. Since all the functions such as display RAM, character generator, and liquid crystal driver, required for driving a dot-matrix liquid crystal display are internally provided on one chip, a minimal system can be interfaced with this controller/driver.

New Liquid Crystal Display is a collection of libraries that can handle almost all HD44780 compatible displays interfaces shown in figure 6. It has a number of benefits over the default library, including the ability to handle screens with an I2C adapter.

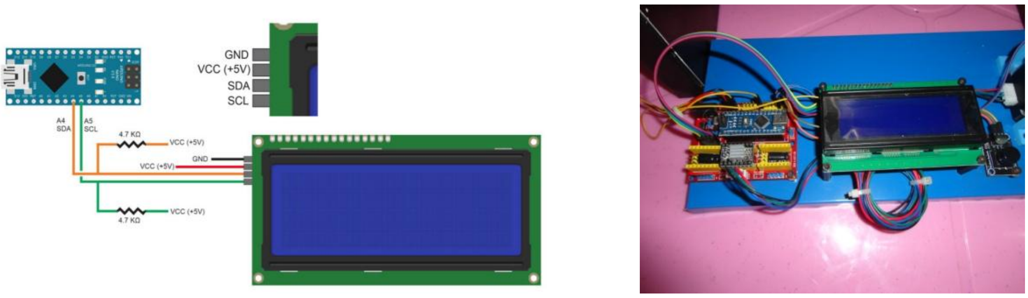


Figure 6 Arduino and 4-Line LCD interface with I2C and using Limit Switch in the incline plane circuit

2.7 Limit Switch Using for the home position of the incline plane

A **limit switch** , shown in figure 7, is an electromechanical device that consists of an actuator mechanically linked to a set of contacts. When an object comes into contact with the actuator, the device operates the contacts to make or break an electrical connection. They are also sensors that when a component is touching it or not. They can be used to prevent mechanisms from moving too far in one direction or another.

Figure 7 Limit Switch and using Limit Switch in the incline plane

2.8 IR sensor using for the detecting device of the object

IR Sensor or Infrared Sensor ,shown in Figure 8, has two main parts, IR Transmitter and IR Receiver. The work of IR transmitter or Infrared transmitter is to transmit the infrared waves whereas the work of IR receiver is to receive these infrared waves. IR receiver constantly sends digital data in the form of 0 or 1 to V_{out} pin of the sensor. In the project LM393 is used. This signal informs the Arduino Nano whether the object is ready position or not. If the object is very far away the sensor or not in detectable position there is no signal emit to the data pin. If so the Arduino can't command the motor to start. The LCD show that "the object is not detecting". When the object is repaired to ready condition, user can press the button switch, the motor start to move and raise the incline plane. When the object is start to move, the sensor can't meet the object, if so the motor stop and the Arduino gives the angle of the present position. The detail of the working capital is described in the following section.

Figure 8 LM 393 IR Sensor and sensing the object and out of sensing the object

Experimental Methodology

The Figure 9 shows the circuit implementation of the automatic incline plane. The coefficient of static friction in incline plane is calculated by the Arduino based programming method. The finding of the coefficient is written in the program. The 4 line LCD displayed the result of the coefficient. The control of LCD is written in "Liquid Crystal-PCF8574.h" header files. The data are given out form the output device LCD. It shows the value of coefficient, running conditions and pulse condition, and the object is detected or not. On /off switch control the starting and pause.

But the stopping is done by the Infrared Sensor gives the sensing of the object pan is detect. If the object is detected, the IR sensor gives the pulse to the Arduino control Board and the stepper motor can start to run. The stepper count is done by the program and can be calculated the tangent angle. If the object is start to move the IR sensor gives the pulse to stop the motor and the Arduino gives the coefficient of static friction of the plane by calculating the program. If the user repress the button switch the motor start to rotate backward and return to home position. " The comparison of finding in coefficient of static friction in Arduino based incline plane and manual incline plane are compared in the following section. There are Two forms of data analysis. The first for different faces and the second for wood incline and Aluminum incline plane are described in the following section.

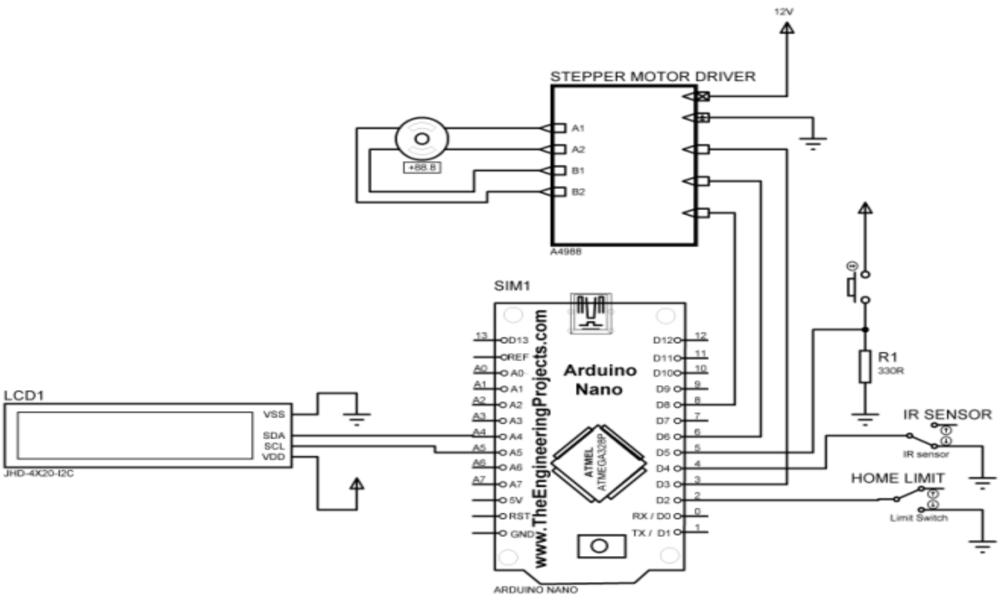


Figure 9 The Circuit Diagram of the Incline plane

Analysis Results and Discussion

The finding of coefficient of static friction by manual is changed by the human reaction time. If the human is sense correctly the result will include the error. To avoid this error the repeated experiment must be done. So the time is the factor to complete the experiment. The automatic finding of the incline plane can be found the result in a short time. The compares of data from Manual and Automatic are shown in the following table (1) and table (2). These results are depend on the research environment such as temperature, pressure, and air flow directions. So, if the accurate data are needed the conditions for the research must be in constant conditions. The actual data and photos are comparing the results are shown in Table (3).

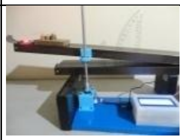
Table 1 The compares of Data from Manual and Automatic incline plane with different surfaces on Aluminum

Material name	Manual		Automatic	
	θ(Degree)	Coefficient of static friction	θ (Degree)	Coefficient of static friction
Wood	30	0.577	29.7	0.57
plastic	31	0.601	30.85	0.59
paper	35	0.700	34.5	0.687
Rough wood	38	0.781	37.2	0.759

Table 2 The compares of data from Manual and Automatic incline plane with difference loads on Aluminum

Sr. No	Total weight In Tray(g)	Manual		Automatic	
		measured angle(Degree)	$\mu_s=\tan\theta$	measured angle(Degree)	$\mu_s=\tan\theta$
1.	50	20	0.364	16.65	0.30
2.	60	22	0.466	16.73	0.30
3.	70	26	0.487	16.55	0.30
4.	80	25	0.466	16.97	0.31
5.	90	18	0.325	17.39	0.31
6.	100	16	0.287	16.76	0.3

Table 3 The result counting of automatic incline plane with different weight

<table>
<tr><th>Weight in Tray(g)</th><th>50g</th><th>60g</th><th>70g</th><th>80g</th><th>90g</th><th>100g</th></tr>
<tr><td>Running condition</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td></tr>
<tr><td>Result</td>
<td>
</td>
<td>
</td>
<td>
</td>
<td>
</td>
<td>
</td>
<td>
</td></tr>
</table>

The automatic incline plane in testing condition is shown in Fig 10. The importance of precaution is that the testing condition is kept in constant temperature and pressure.

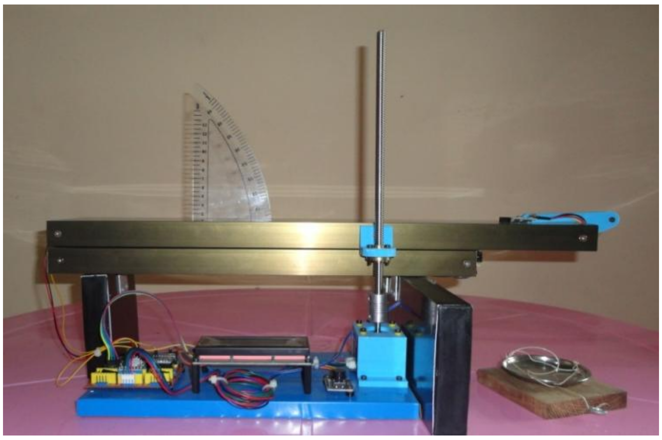


Figure 10 The testing condition of the automatic incline plane

Conclusions

The automatic incline plane is used to measure the coefficient of static friction are rugged classroom- proven technology that are well supported and easy to use. It provides consistent, high quality results for the demands of the classroom. From the above Method, the data are clearly seen that the automatic incline plane is more accurate and precise. Because the error percent of the automatic incline plane is relatively small and the measure time is at the constant because of the stepper motor rotation time. Detectors without a mode the switch do not proper detect objects closer than 2cm. As the result such detectors must be farther across from experiment than described in the student's notes. In constant, detector with a mode switch will detect be object as also as 3cm. Ideally an experiment with be set up so that the target is nearly this close at the point of closest approach, giving the best possible data. Sometimes a target may not supply a strong reflection of the IR sensor. But the results are very good support to understand in describing about the friction. It includes many Arduino sketches (Programs) that can be used as a starting point of the projects. These sketches were intentionally kept simple, so that the analog without getting overwhelan with complex details. The following Figure 11 shows the Final running condition of the automatic incline plane.

Figure 11 the automatic incline in running condition

Acknowledgement

I would like to gratefully acknowledge the enthusiastic supervision of Dr. Aye Aye Kyu and Dr. Mya Hnin Su during this work. I also thanks to Prof. Dr. Ye Chan for his valuable advice to motivate to make the project. I also deeply thanks to Dr. Aye Thida Aung for her actively helps and giving precious advice and supervise. I am grateful to all my friends for being the kindly helps on my works in this project. I would like to especially thank my department staffs for their care and attention. Finally, I am forever indebted to my parents for their understanding, endless patience and encouragement when it was most required.

References

Embedded Controllers Using C and Arduino/ 2E, James M. Fiore, Version 2.1.0, 27 March 2019, Embedded Controllers

"Physics for Science and Engineers with Modern Physics", Serway and Jeweet, Cengage Learning; 10 edition (January 1, 2018)

Arduino cool, Jonathan OxerHugh Blemings, 2016 Vxlabs. (2018) *Which jumper to set on the ITEAD XBee shield v1.1 for use with a 3.3V Arduino* [Accessed 25th October 2017]

www.https://components101.com/arduino-nano

https://www.orientalmotor.com/stepper-motors/index.html

Implementing the model-view-view model pattern, [Online]. Available: https: // msdn.microsoft.com/en-us / library/ff798384.aspx

https://www.orientalmotor.com/stepper-motors/stepper-motor-drivers.html

https://www.instructables.com/id/3020-CNC-Arduino-GRBL-CNC-Shield