LABORATORY REPORT
PHY 001L – PHYSICS FOR ENGINEERS

ARDUINO-BASED SMART INCLINED PLANE ANALYZER

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The Smart Inclined Analyzer is an innovative prototype designed to accurately compute and analyze key motion parameters such as angle, velocity, and acceleration of an object as it travels down an inclined plane. This project serves as a practical and educational tool that bridges theoretical physics concepts with real-world applications. By integrating advanced sensor technologies with a reliable microcontroller system, the analyzer demonstrates the practical use of Newton's Laws of Motion, Kinematics, and Energy Principles in a tangible and interactive manner. At the core of the system is the MPU-6050, a combined accelerometer and gyroscope module, which measures orientation and acceleration. Alongside it, the HC-SR04 ultrasonic sensor is utilized to determine the distance between the object and a reference point with high accuracy. These sensors are connected to an Arduino UNO R3, a versatile and programmable microcontroller board that processes the sensor data in real time. The computed results are then displayed on an LCD module, allowing users to visually monitor changes in motion as they occur. This prototype offers a cost-effective, hands-on learning platform especially useful in educational institutions, physics laboratories, and science demonstrations. It enhances conceptual understanding and fosters interest in physics, engineering, and robotics.

Keywords: Inclined Plane, Motion Analysis, Sensor Integration, Arduino UNO, and Physics Education

Introduction

Motion analysis on inclined planes is a fundamental topic in physics, bridging theoretical knowledge and real-world applications. Traditional setups often involve manual calculations and static tools that limit the accuracy and real-time responsiveness required in dynamic systems. The Smart Inclined Analyzer addresses this gap by leveraging microcontroller-based technology to provide automated measurement of an object's motion along an inclined surface.

This project focuses on calculating four primary motion parameters: angle of inclination, distance traveled, speed, and acceleration. These are essential for understanding the underlying physics, especially in the context of Newton's Laws of Motion, conservation of energy, and kinematic equations. The integration of sensors allows for dynamic data collection, ensuring higher accuracy and efficiency in educational, research, or practical engineering applications.

Materials Used

Arduino UNO R3 Board

- MPU-6050 (Tri-Axis Accelerometer + Gyroscope)
- HC-SR04 (Ultrasonic Distance Sensor)
- LCD Module Display (Character type)
- Solderless PCB Breadboard SYB MB102
- Sintra Board (for inclined plane structure)
- Male-Female & Male-Male Breadboard Connectors (20cm)
- 9V Battery with DC Barrel Plug

Process

To begin the experiment, we assembled the Smart Inclined Analyzer by mounting the MPU-6050 accelerometer/gyroscope and HC-SR04 ultrasonic sensor onto a stable inclined plane. The object to be analyzed was placed at the top of the ramp, and the sensors were positioned such that they could continuously monitor the object's motion as it moved downward.

The MPU-6050 was calibrated to ensure accurate measurement of the angle of inclination and acceleration. Simultaneously, the HC-SR04 ultrasonic sensor was aligned at the base of the inclined plane to track the object's position over time, capturing distance data at regular intervals.

All sensor data was processed by the Arduino UNO R3, which was programmed using the Arduino IDE. The microcontroller collected real-time data from both sensors and calculated derived motion parameters such as velocity, acceleration, and distance traveled. These computations were then displayed on an LCD module for easy observation.

We performed multiple trials by releasing the object from different heights and angles to observe changes in motion behavior. Data collected during each trial was recorded for analysis. The results were used to verify principles of kinematics, Newton's laws, and energy conservation, effectively demonstrating the educational utility of the prototype.

Results and Discussion

The Smart Inclined Analyzer successfully demonstrated its capability to measure and analyze various motion parameters namely angle, velocity, and acceleration of an object moving on an inclined plane. During testing, the device accurately captured real-time data through the MPU-6050 sensor, with output values clearly displayed on the LCD module.

In several test trials, the following observations were made:

Angle readings from the MPU-6050 were stable and consistent across repeated setups. Even slight variations in the incline angle were detected accurately, helping us understand the effect of slope on object motion. The velocity and acceleration increased proportionally as the angle of the incline was increased, consistent with theoretical expectations from Newtonian mechanics. This demonstrated a clear correlation between the steepness of the incline and the resulting changes in motion.

Data trends observed during multiple runs aligned well with equations of motion, indicating the reliability of the Arduino's data processing logic. These results support the functionality of the prototype as an educational and analytical tool. It allowed us to observe firsthand how changes in incline affect object motion and provided a hands-on demonstration of fundamental physics principles. Minor fluctuations in readings were occasionally observed due to sensor sensitivity or environmental interference, but overall, the prototype performed effectively and consistently.

This tool can be particularly valuable in classroom settings, helping students better understand concepts such as kinematics, gravitational acceleration, and energy transformations through real-world experimentation.

TRIAL	DEG	ACCEL.	VELOCITY
1	14.635	0.011m/s2	0.032m/s
2	20.137	0.016m/s2	0.083m/s
3	32.191	0.008m/s2	0.109m/s
4	48.070	0.002m/s2	0.178m/s
5	64.67	0.034m/s2	0.189m/s

Conclusion

The Smart Inclined Analyzer successfully achieved its objective of providing a practical, accurate, and interactive system for analyzing the motion of an object on an inclined plane. By integrating the MPU-6050 accelerometer/gyroscope with the Arduino UNO R3, the prototype effectively measured real-time motion parameters such as angle, velocity, and acceleration. The data collected and processed aligned with fundamental principles of Newtonian mechanics, validating the prototype's accuracy and reliability.

The project demonstrated how sensor-based systems can enhance the teaching and learning of physics by offering a tangible way to observe and interpret motion-related phenomena. The prototype proved to be both cost-effective and educational, making it suitable for use in classrooms, laboratories, and demonstrations.

Overall, the Smart Inclined Analyzer not only reinforced theoretical concepts through real-world application but also encouraged deeper engagement with STEM topics such as physics, engineering, and embedded systems. With further development, this tool could be adapted for broader experiments involving different surfaces, object masses, or environmental conditions, making it a versatile platform for continued learning and exploration.

Recommendations

Future researchers may consider enhancing the Smart Inclined Analyzer by incorporating wireless communication technologies, such as Bluetooth or Wi-Fi, to facilitate remote monitoring and data transmission, thereby improving the system's usability and flexibility. The development of a mobile or desktop application for real-time data visualization and storage would provide users with a more interactive and efficient means of interacting with the system. Furthermore, expanding the sensor array by integrating additional sensors, such as infrared or optical encoders, would enable the analysis of a wider range of motion parameters, thus increasing the prototype's versatility. The implementation of data logging capabilities, such as the addition of an SD card module or integration with cloud storage, would allow for the long-term storage of data, facilitating future analysis and ensuring easy access to collected information. Finally, conducting experiments with variable object masses and different surface textures would provide valuable insights into how these factors influence motion, contributing to a more comprehensive understanding of the system's behavior under diverse conditions.

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