APL103 Project Report
Curvimeter

Aditya Agrawal
2021AM10198
am1210198@iitd.ac.in

Ankit Kanwar
2021AM10785
am1210785@iitd.ac.in

Sanyam Verma
2021AM10202
am1210202@iitd.ac.in

Swapnil Kashyap
2021AM10782
am1210782@iitd.ac.in

Vanshika Tripathi
2021AM10392
am1210392@iitd.ac.in

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Contents

1 Aim

The aim of our project would be to measure the distance along an arbitrary curve.

2 Motivation

The thing that motivated us to do the project was the fact that in many scientific works, we require distance over a certain arbitrary path like in surveying, navigation, architecture, measuring coral size etc hence we should try making a device that can be more convenient and handy in comparison to the conventional method of measuring with the help of thread. The drawback of using a thread is that it is inconvenient to extend it to its full length over the curve with the help of clamps, which leads to inaccurate results.

3 Facilities and Materials used

3.1 Facilities and Apparatus

We used the following facilities:

1. 3D printing machine in AM lab
2. Wood-cutting machine
3. Vernier caliper
4. Hot glue gun
5. Laser cutting machine

3.2 Materials

Figure 1: Arduino

Figure 2: Battery

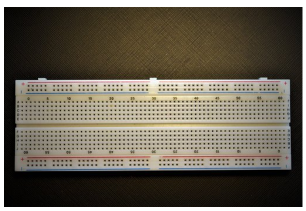

Figure 3: Breadboard

Figure 4: LCD

Figure 5: Plywood

Figure 6: Rotary Encoder

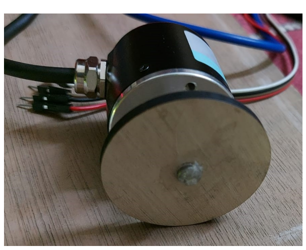

Figure 7: Wheel

Figure 8: Jumping wires

4 Procedure, Observation, and Analysis

4.1 Procedure

1. First we tried to figure out a suitable and handy way to customize the instrument. After many iterations and loops of thought processes by each one of us, starting from a cumbersome idea to execute to a very convenient model we started gathering things that were required.

2. One- by one we realized more things that we needed and brought or bought them.

3. Few of us were aware of codes pertaining to the Arduino or LCD, others weren't hence with the help of videos, they tried to the later about the codes.

4. Once we started executing things physically, some of us designed the CAD model of the axle we used and some of us tried to check the working of Arduino and LCD.

5. We were not able to print the CAD model well several times but in the end, we ended up with a suitable way to attach the wheel with the rotary encoder.

6. Lastly we put all the items which would remain stationary during the test on a cardboard and made sure that the wires were connected nicely. The next step was testing.

4.2 Observation

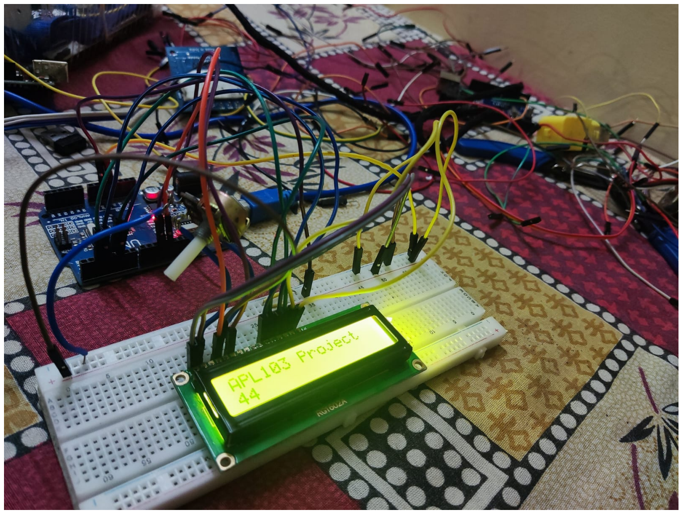

Figure 9: Project while in progress

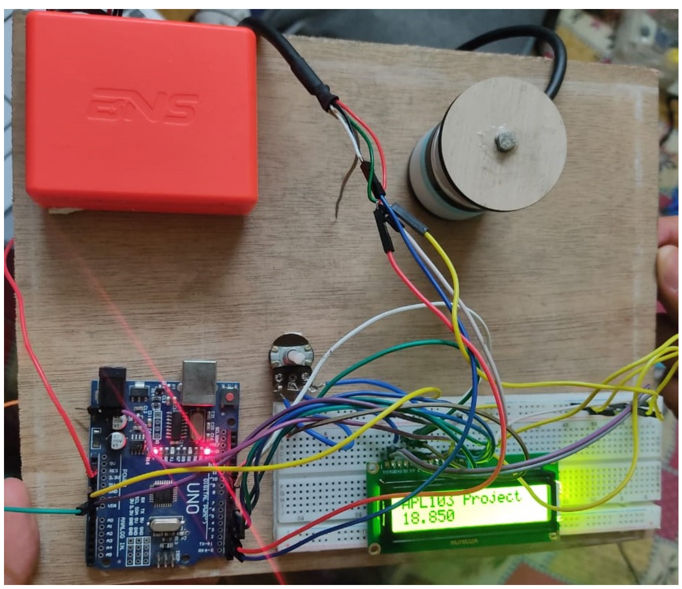

Figure 10: Final project

4.3 Analysis

4.3.1 Formula Used

Since the specification of the rotary encoder is 600 ppr, so the formula used to calculate distance is:

$$distance = \frac{X}{600} \times \pi r \tag{1}$$

4.3.2 Data Calculation

Sr.No.	$StraightLine$	$Circle_1$	$Circle_2$	$Ellipse_1$	$Ellipse_2$
1	14.860	19.017	39.431	12.800	27.071
2	15.044	19.674	39.219	13.775	28.145
3	14.738	19.743	39.346	13.877	27.941
Mean	14.864	19.478	39.332	13.484	27.719
Std. Dev.	0.160	0.400	0.107	0.594	0.570
Uncertainty	0.113	0.283	0.075	0.420	0.403
Original Lengths	15	19.941	39.89	14.07	28.06
Error %	0.909	2.322	1.399	4.165	1.215

By analysing the above table, we may conclude that our device is fairly precise for straight lines and ellipses since the radii of curvature are not too small. However, it is not so precise for circles due to their small radii of curvature.

Further analysing, we observe that our device gives less than 5% error for these standard curves. As expected, it is most accurate for straight lines. However, it appears to be more accurate for circles than ellipses which is contrary to the trend seen in precision comparisons. Another reason for this contrary observation may be the fact that the perimeter of an ellipse is determined by a numerical approximation ,i.e.:

$$Perimeter \approx \pi \times (a + b) \tag{2}$$

If this were approximated more accurately, the results possibly have been different.

5 Applications

1. **Surveying:** In surveying, measuring distances along an arbitrary path is an essential task. The instrument can be used to measure distances along roads, pipelines, or other infrastructure that follow irregular paths.

2. **Cartography:** In cartography, the instrument can be used to measure distances along a hiking trail, a river, or any other feature that is not a straight line.

3. **Architecture:** Architects may use the instrument to measure distances along the contour of a building, including the length of a curved wall or the distance around a circular structure.

4. **Civil engineering:** In civil engineering, the instrument can be used to measure distances along a curved road or railway track.

5. **Athletics:** In athletics, the instrument can be used to measure the distance traveled by athletes during a race, such as a marathon or a triathlon, which may not follow a straight line.

6. **Robotics:** Robots that navigate in a complex environment, such as a factory or a warehouse, may use the instrument to measure distances along a path that is not linear.

6 Features and Limitations

6.1 Features

1. Adjustive brightness of display for varying lighting conditions.
2. Updates the readings every 100 ms.
3. Can display readings upto a precision of 10 μm.
4. The reading can be reset to 0 at any stage using the switch.
5. The battery used is rechargeable.

6.2 Limitations

1. It is inconvenient to carry along the device.
2. It is difficult to measure curves whose radius of curvature is very small.
3. Moving the device along sharp or closed curves leads to accumulation of errors due to high sensitivity of the rotary encoder.
4. Zero error is highly dependent upon initial perturbations.
5. It is able to measure upto 385cm only due to storage constraints on Arduino Uno under floating point variables.

7 Future Improvements and Conclusion

Our device has further scope of improvement and extension of capability. The former can be achieved by implementing wireless transmission of data from the rotary encoder to Arduino using a WiFi module. The latter can be achieved by using a larger Arduino board for data storage, transmission to LCD and display and a more advanced LCD. Our device can be made more portable by using efficiency of the connections and the assembly, and by enclosing the fixed components in a minimised case.

Since the error exhibited by our device's measurements is less than 5% for standard curves, we may conclude that it is quite a convenient device to measure lengths of arbitrary curves on a small scale. As the radius of curvature of the curve decreases, the accuracy and precision are compromised. Moreover, for closed curves, it is slightly inconvenient to use because of the difficult in tracing the entire curve in one go.

8 Contributions

1. **Aditya Agrawal (2021AM10198) :** Report Preparation; Assembling of parts; Logistics
2. **Ankit Kanwar (2021AM10785) :** Ideation of project; Assembling of parts; Preparing the Arduino code
3. **Sanyam Verma (2021AM10202) :** Assembling of parts; Preparing the Arduino code
4. **Swapnil Kashyap (2021AM10782) :** Preparing the Arduino code; Assembling of parts
5. **Vanshika Tripathi (2021AM10392) :** Report Preparation; Logistics

Each member's contribution to the project was significant and invaluable. The project succeeded only because of the collective contribution of the entire group.