



DesignNews

Understanding Sensors and Data Analysis Using the Arduino Nano 33 BLE Sense

DAY 5 : Building Data Analysis Using Looker Studio and The Arduino Nano 33 BLE Sense

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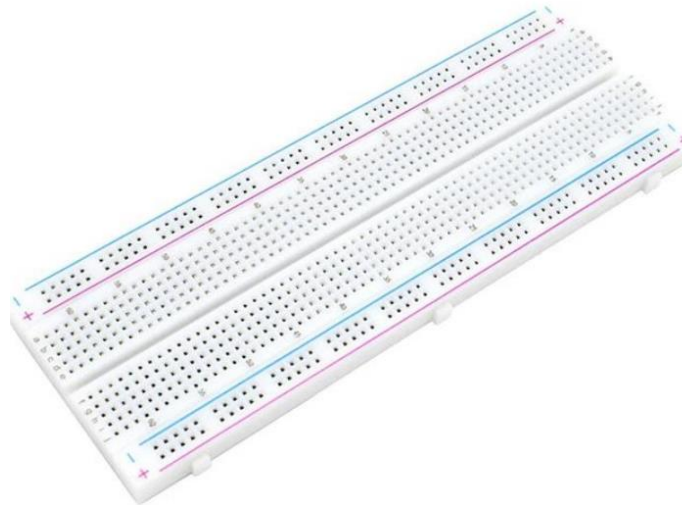
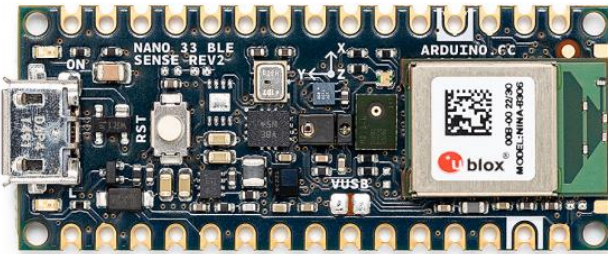
Dr. Don Wilcher

Visit 'Lecturer Profile' in your console for more details.

Course Kit and Materials

Solderless Breadboard

Arduino Nano 33 BLE Sense Board



Adafruit Parts Pal Kit



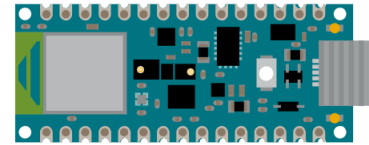
I2C OLED Display



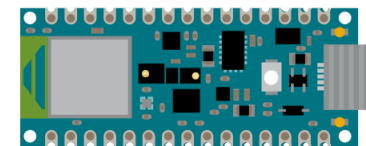
https://www.amazon.com/HiLetgo-Serial-128X64-Display-Color/dp/B06XRBYJR8/ref=sr_1_6?crd=1VC2UTZ2P8NWF&keywords=i2c%2Boled&qid=1700192985&sprefix=l2c%2B%2Caps%2C108&sr=8-6&th=1

Agenda:

- Collecting Data with the Arduino Nano 33 BLE Sense
- Starting the Arduino Science Journal Experiment
- Capturing Temperature Data
- Introduction to Looker Studio
- Lab: Creating an Interactive Engineering/Science Report using Looker Data Studio

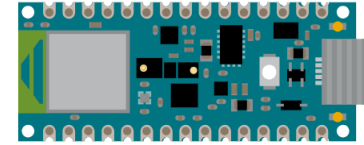


Research Perspective



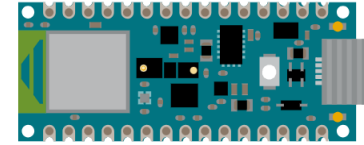
“The Internet of Things, which has been quietly building and evolving over the past decade, now impacts many aspects of society.” (Chua & Storey, 2023).

Collecting Data with the Arduino Nano 33 BLE Sense



- As learned on Day 4, collecting data with the Arduino Nano 33 BLE Sense is easy with Arduino Science Journal.
- Selecting sensors using the My Device Inventory tool provides a wealth of data collection exercises, investigations, and research into scientific phenomena or system engineering behaviors.
- The Arduino Nano 33 BLE Sense provides a wireless approach to collecting scientific phenomena or system engineering behaviors data using a mobile phone and external sensors.
- The Arduino Nano 33 BLE Sense provides a method of data collection and recording the approach (Carr, 1992) using the Arduino Science Journal app.

Collecting Data with the Arduino Nano 33 BLE Sense. . .



- With the Arduino Nano 33 BLE Sense, a single-board microcontroller (Chua & Storey, 2023), an IoT network of sensors can be deployed to collect scientific phenomena or system engineering behaviors with very little human intervention.
- This IoT network will semi-automate the data collection method in writing, as Carr (1992) described in his seminal book *The Art of Science*.
- The Arduino Nano 33 BLE Sense provides the data for the Arduino Science Journal to convert into an *IoT-based science/engineering notebook*.

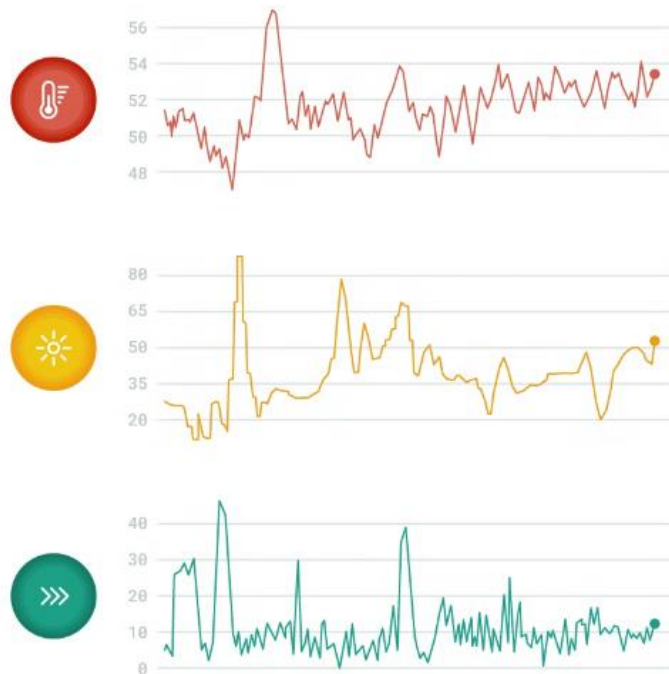
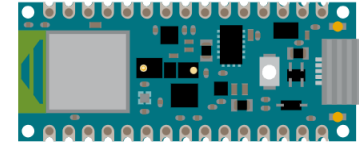
Question 1

This IoT network will automate the data collection method in writing.

- a) True**
- b) False**



Collecting Data with Arduino Nano 33 BLE Sense...

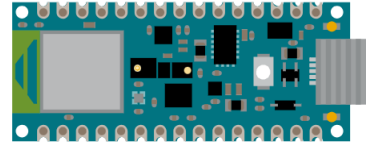


Harness the power of sensors

Motivate students to learn about topics like physics, math, chemistry and biology in a fun, easier to understand and connected to the real world way. With the help of either built-in sensors students can experience and play with their surroundings in a easy and hands-on way. **Record properties like light, movement and sound, and experience the world of science at first hand!**

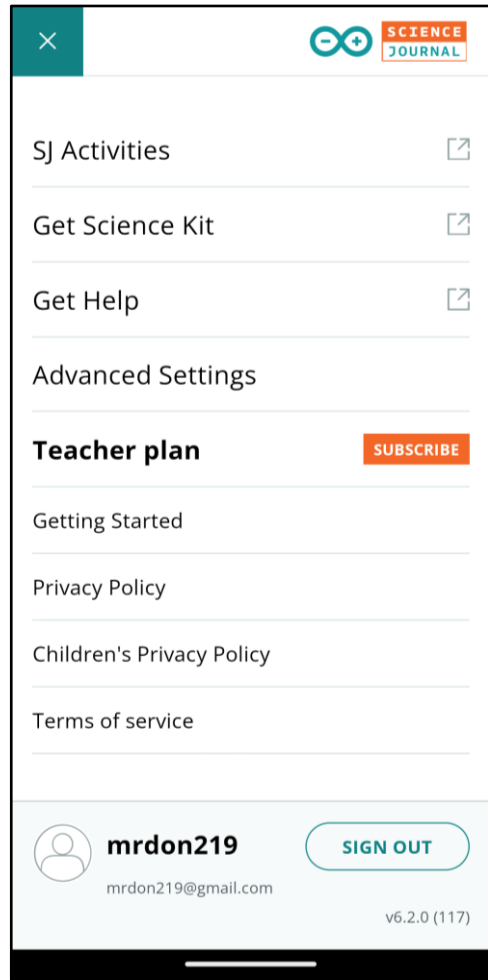
<https://www.arduino.cc/education/science-journal>

Starting the Arduino Science Journal Experiment

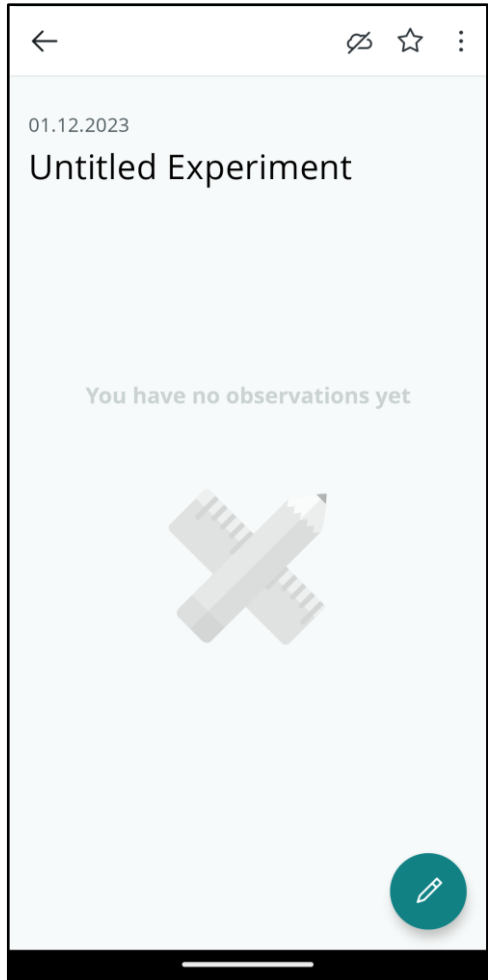


First Step:

Create a free online account to access features such as data sharing and downloading csv files.

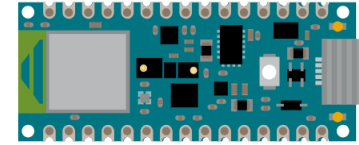


Next Step: 

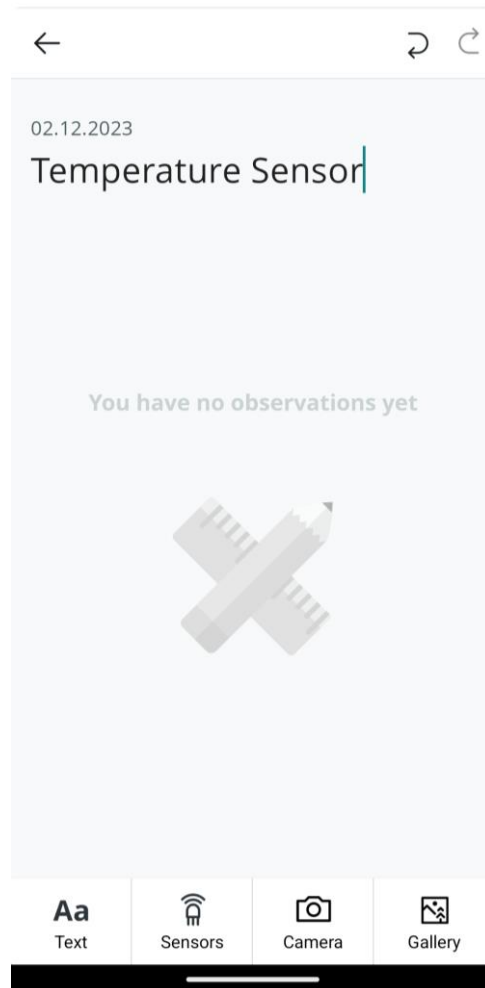


} Create The Experiment

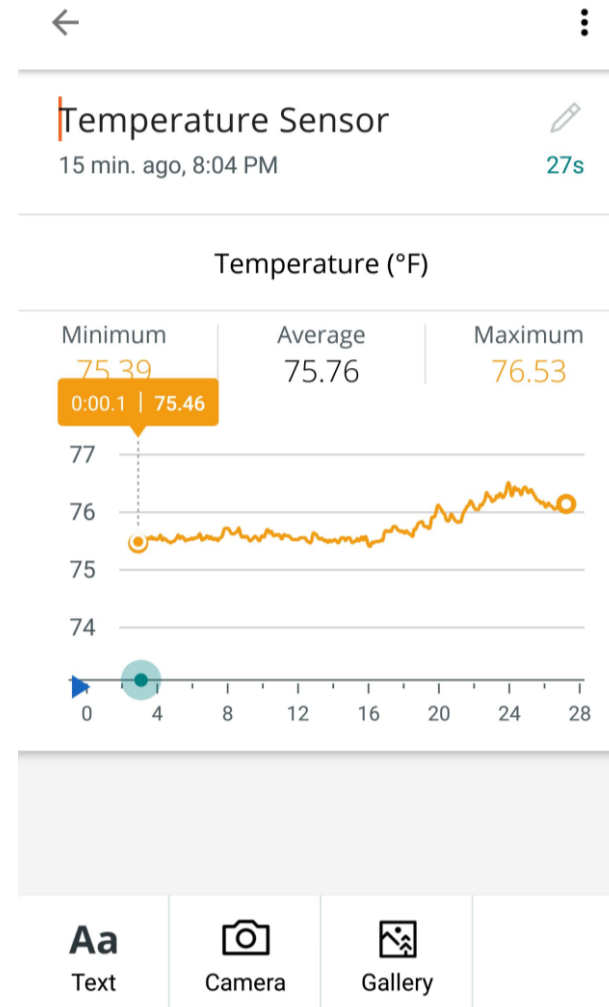
Starting the Arduino Science Journal Experiment...



- Untitled Experiment Named
- Click on the Sensor Icon to obtain the Sensor Card.

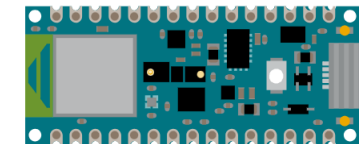


Next Step:



Create Name of the Sensor Card

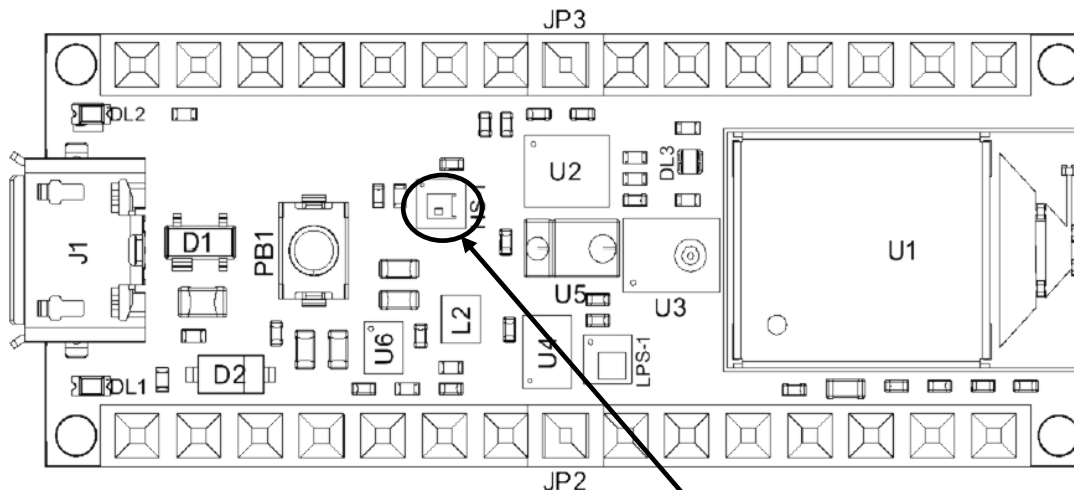
Capturing Temperature Data...



Functional Overview

Top of Board

Original Board

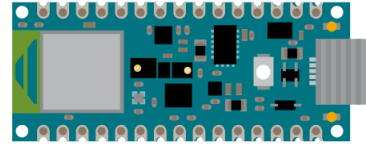


Location of the Humidity & Temperature Sensor

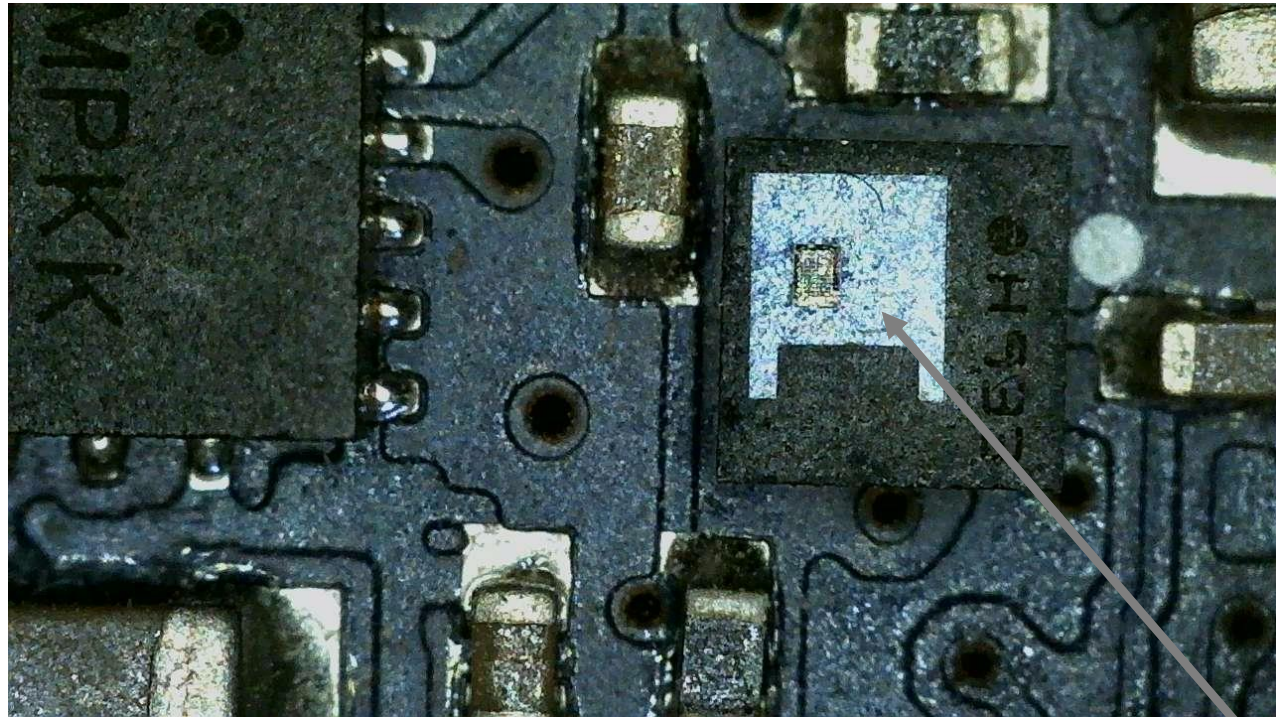
Illustration courtesy of Arduino.cc

Ref.	Description	Ref.	Description
U1	NINA-B306 Module Bluetooth® Low Energy 5.0 Module	U6	MP2322GQH Step Down Converter
U2	LSM9DS1TR Sensor IMU	PB1	IT-1185AP1C-160G-GTR Push button
U3	MP34DT06JTR MemS Microphone	HS-1	HTS221 Humidity Sensor
U4	ATECC608A Crypto chip	DL1	Led L
U5	APDS-9660 Ambient Module	DL2	Led Power

Capturing Temperature Data... Top of Board



Temperature Sensor location on the Arduino Nano 33BLE Sense board



picture courtesy of the lecturer

HTS221 Humidity & Temperature Sensor

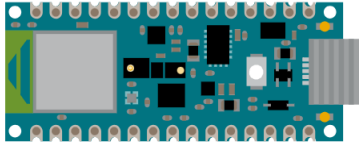
Question 2

The HTS221 is a Pressure & Humidity Sensor.

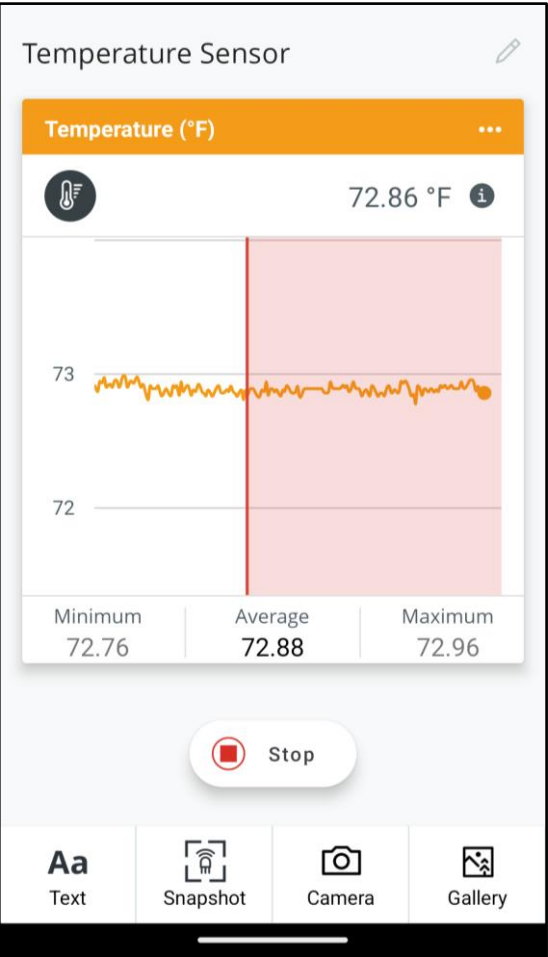
- a) True**
- b) False**



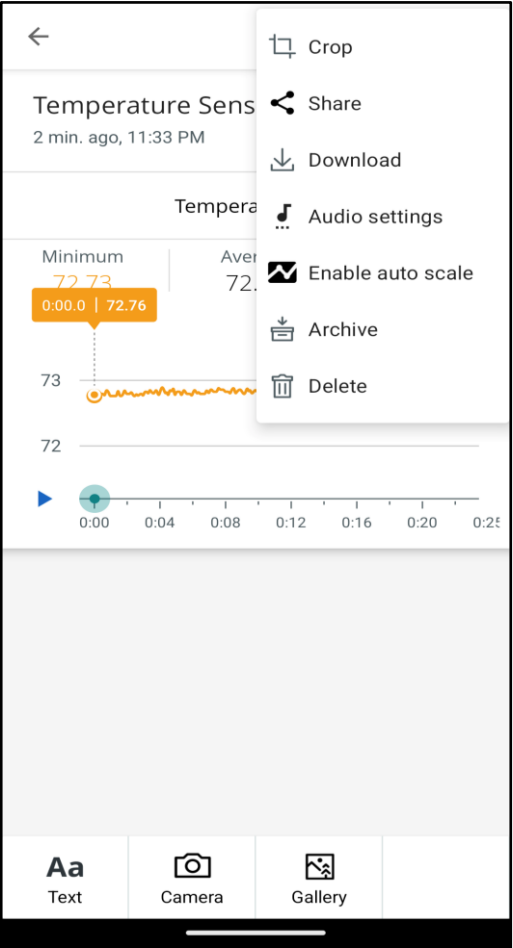
Capturing Temperature Data...



Record the Temperature Data

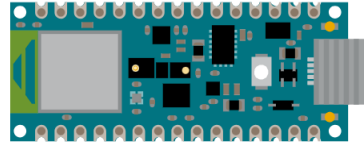


Next Step:

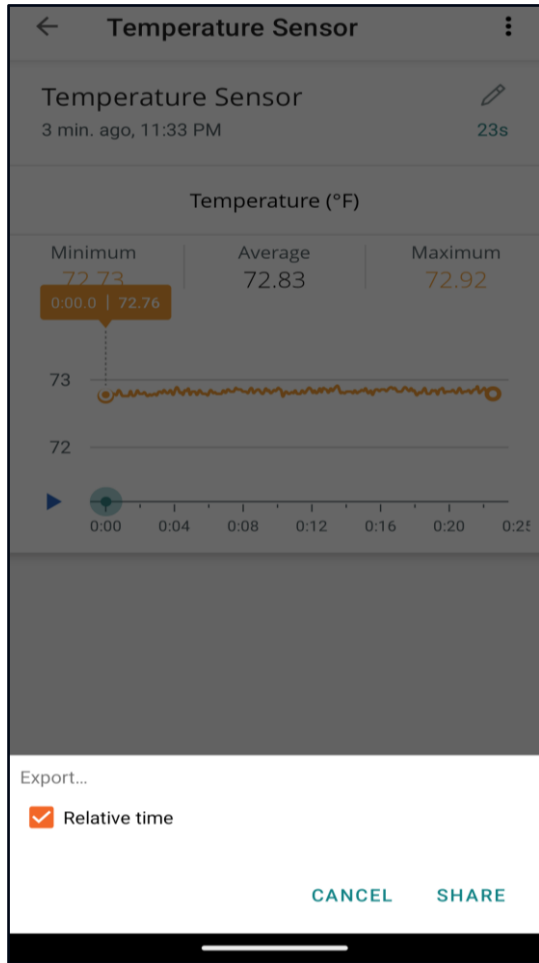


- Stop the Recording of the Temperature Sensor Data
- Share the Data
- Data is saved and shared as a csv file.

Capturing Temperature Data...



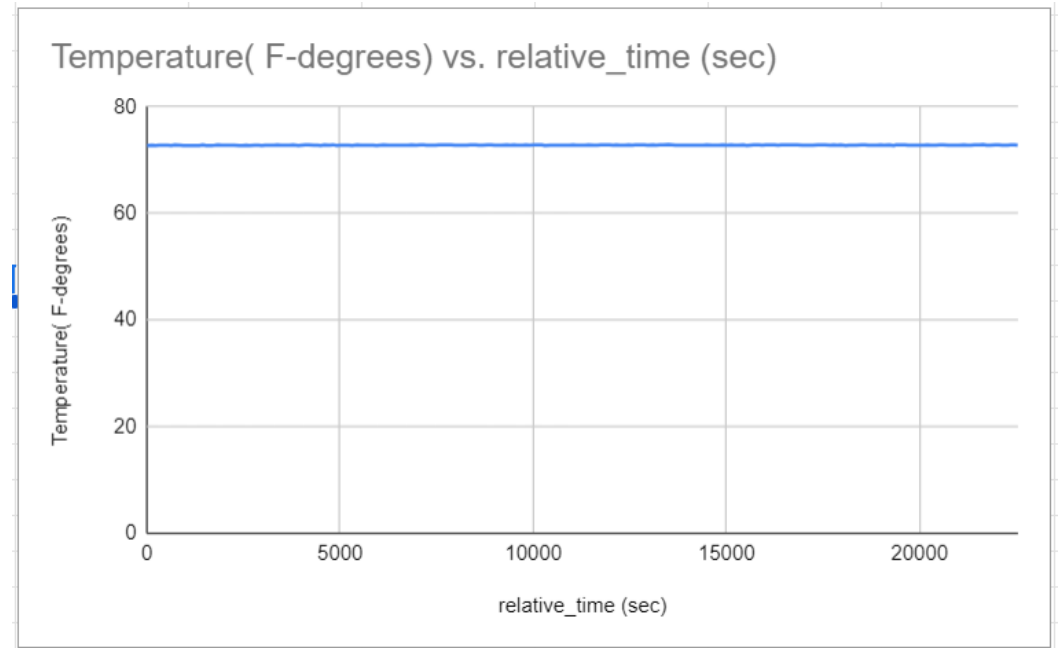
- Export the file using the Relative Time format.
- Click on the Share button to email the csv to a colleague or yourself.



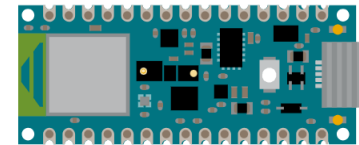
Next Step:



Plot Data

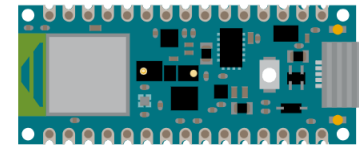


Introduction to Looker Data Studio



- Looker Studio was formerly known as Google Data Studio.
- It is a data visualization tool that helps you turn your data into informative reports and dashboards.
- It's a free tool that's easy to use, even if you don't have any coding experience.
- With Looker Studio, you can connect to a wide variety of data sources, including
 - a) Google Analytics
 - b) Google Ads
 - c) YouTube
 - d) and more
- You can then create custom reports and dashboards that show data in a way that's easy to understand.

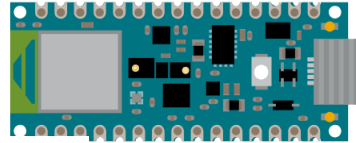
Introduction to Looker Data Studio. . .



Here are some of the things you can do with Looker Studio:

- **Create reports:** Looker Studio has a variety of charts and graphs that you can use to visualize your data.
 - a) Can add filters and dimensions to your reports.
 - b) Allows a focus on the data that's most important.
- **Create dashboards:** Dashboards are a great way to track key metrics at a glance.
 - a) Looker Studio makes it easy to create custom dashboards
 - b) Dashboards can show the most important data in a single place.
- **Share your reports and dashboards:**
 - a) Can share reports and dashboards with others by email.
 - b) Or by embedding them in a website or blog.

Introduction to Looker Data Studio . . .



How can Looker Studio be used with the Arduino Science Journal?



View other drafts ▾



Looker Studio and Arduino Science Journal are two separate tools that can be used together to visualize and analyze data collected from Arduino projects. Here's a general overview of how they can be integrated:

Arduino Science Journal:

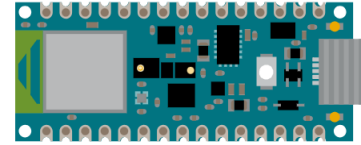
- Collects data from Arduino sensors and records it over time.
- Displays sensor data in real-time graphs and charts.
- Allows for data annotation and sharing.

Looker Studio:

- Connects to external data sources, including CSV files and cloud storage.
- Creates interactive data visualizations, including charts, graphs, and maps.
- Enables data filtering, sorting, and exploration.

Bard AI Prompt
Engineering
Inquiry and
Response

Introduction to Looker Data Studio . . .



Bard AI Prompt Engineering Inquiry and Response

Looker Studio:

- Connects to external data sources, including CSV files and cloud storage.
- Creates interactive data visualizations, including charts, graphs, and maps.
- Enables data filtering, sorting, and exploration.

To use Looker Studio with Arduino Science Journal, you can follow these steps:

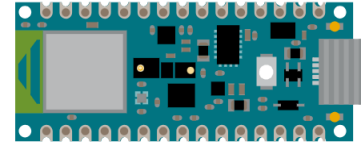
1. Export sensor data from Arduino Science Journal:

- Download the sensor data as a CSV file from Arduino Science Journal.
- Ensure the CSV file contains relevant timestamps and sensor values.

2. Connect the CSV file to Looker Studio:

- Create a new report in Looker Studio.
- Upload the CSV file as a data source.
- Link the data source to your report.

Introduction to Looker Data Studio . . .



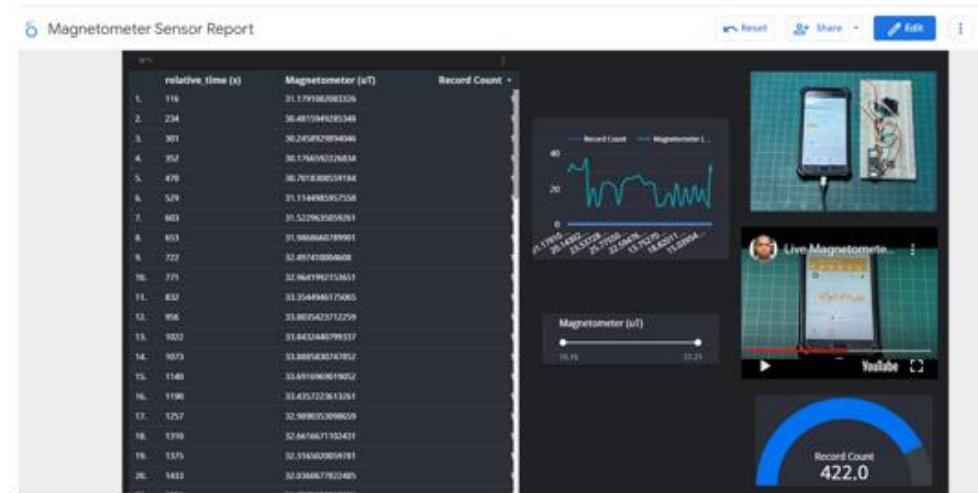
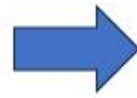
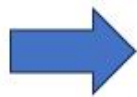
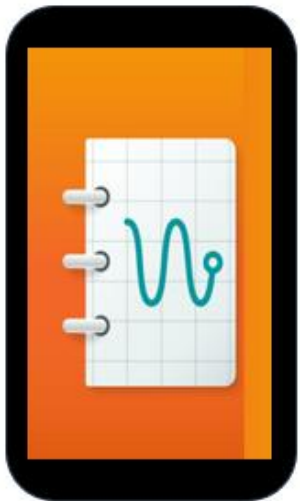
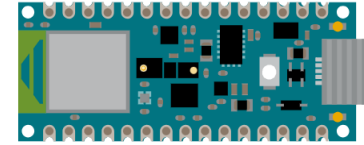
Bard AI Prompt
Engineering
Inquiry and
Response

3. Visualize and analyze sensor data:

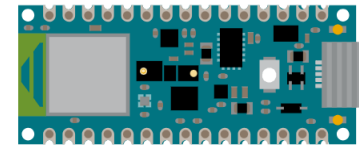
- Use Looker Studio's drag-and-drop interface to create charts, graphs, and maps.
- Filter and sort data based on timestamps, sensor values, or other parameters.
- Add annotations and insights to your visualizations.

By combining the data collection capabilities of Arduino Science Journal with the data visualization and analysis tools of Looker Studio, you can gain deeper insights into your Arduino projects and make informed decisions based on the collected data.

Lab: Creating an Interactive Engineering/Science Report using Looker Data Studio



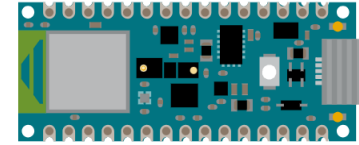
Lab: Creating an Interactive Engineering/Science Report using Looker Data Studio



Lab Objectives:

- Participants will learn to access Looker Studio online.
- Participants will learn to load the Magnetometer Sensing data into Looker Studio.
- Participants will learn to layout the Looker Studio interactive report with widgets.
- Participants will learn to explore and use the Looker Studio interactive report.

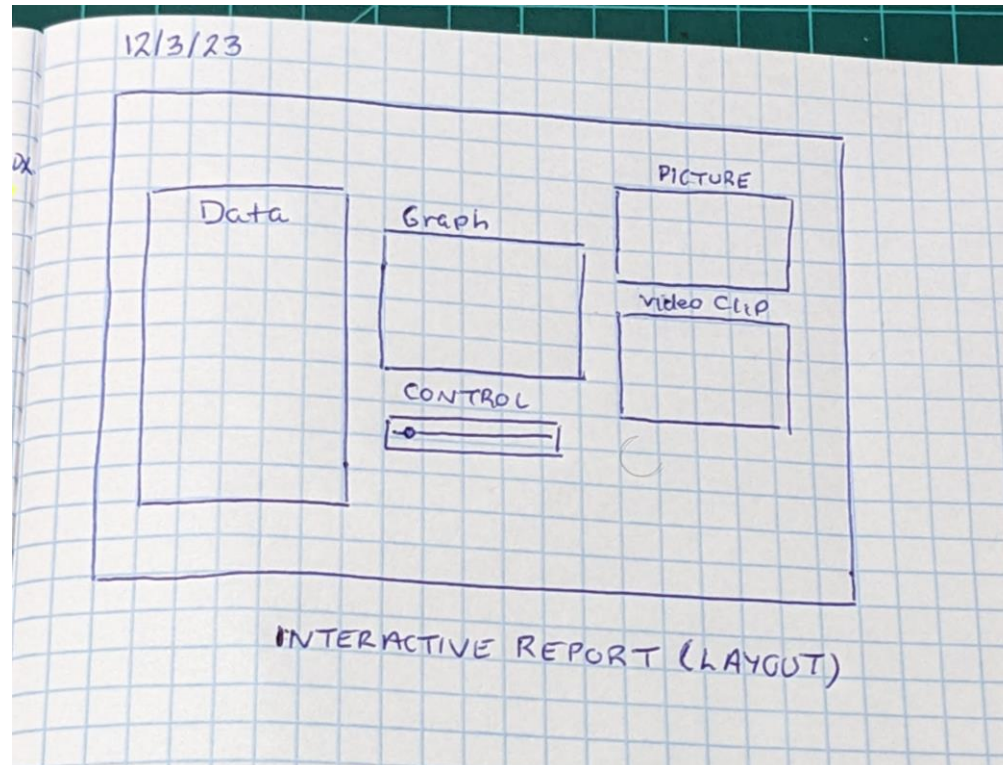
Lab: Creating an Interactive Engineering/Science Report using Looker Data Studio



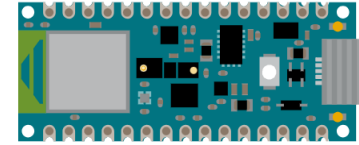
Concept Interactive Report Layout Sketch

Create an Interactive Report Layout Sketch

1



Lab: Creating an Interactive Engineering/Science Report using Looker Data Studio



Go to Looker Studio and click on Blank Report

The screenshot shows the Looker Studio web interface. At the top left is the 'Looker Studio' logo and a search bar. Below the search bar are navigation tabs for 'Recent', 'Reports', 'Data sources', and 'Explorer'. On the left sidebar, there are buttons for 'Create', 'Recent', 'Shared with me', 'Owned by me', 'Trash', and 'Templates'. The main content area is titled 'Start with a Template' and displays a 'Template Gallery' with four report templates: 'Blank Report Looker Studio', 'GA4 Report Google Analytics', 'Acme Marketing Google Analytics', and 'Search Console Report Search Console'. The 'Blank Report Looker Studio' template is highlighted with a red circle containing the number '2'.

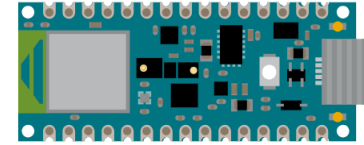
Question 3

Step 2 of creating an Interactive Report is to import a csv file into Google Sheets.

- a) True**
- b) False**



Lab: Creating an Interactive Engineering/Science Report using Looker Data Studio



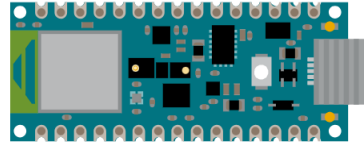
Import csv file into Google Sheets

- Rename Google Sheet file [Magnetometer (uT)]
- Modify column headings

3

	A	B	C
1	relative_time (s)	Magnetometer (uT)	
2	0	32.04112304	
3	53	31.64151009	
4	116	31.17910821	
5	183	30.7763153	
6	234	30.48159493	
7	301	30.24589299	
8	352	30.17665922	
9	444	30.35816168	
10	470	30.70183086	
11	529	31.1144986	
12	603	31.52296351	
13	653	31.98686608	
14	722	32.49741	
15	771	32.96419922	
16	832	33.35449462	
17	897	33.64058433	
18	956	33.80354237	
19	1022	33.84324408	
20	1073	33.88858307	
21	1140	33.6916969	
22	1190	33.43572236	
23	1257	32.98903531	
24	1310	32.66166711	

Lab: Creating an Interactive Engineering/Science Report using Looker Data Studio









Connect to data → Google Sheets

Add data to report

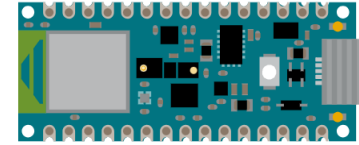
[Connect to data](#) My data sources

Search

-  **Looker** By Google
Connect to your Looker semantic models.
-  **Google Analytics** By Google
Connect to Google Analytics.
-  **Google Ads** By Google
Connect to Google Ads performance report data.
-  **Google Sheets** By Google
Connect to Google Sheets.
-  **BigQuery** By Google
Connect to BigQuery tables and custom queries.
-  **AppSheet** By Google
Connect to AppSheet app data.

4

Lab: Creating an Interactive Engineering/Science Report using Looker Data Studio



Select Google Sheets created in Step 3 → Click the Add button

5

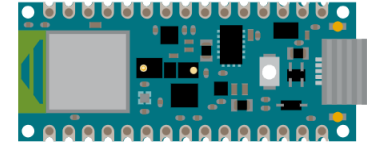
← Add data to report Data credentials: Don Wilcher ✕

Google Sheets
By Google
The Google Sheets connector allows you to access data stored in a Google Sheets worksheet.
[LEARN MORE](#) [REPORT AN ISSUE](#)

ALL ITEMS	Spreadsheet	Worksheet	Options
OWNED BY ME	Magnetometer (uT)	Magnetometer Sensor Magnetometer Sens...	<input checked="" type="checkbox"/> Use first row as headers Column headers must be unique. Columns with empty headers will not be added to the data source.
SHARED WITH ME	Arduino_Nano_33_BLE_Sense_Temperatur...		<input checked="" type="checkbox"/> Include hidden and filtered cells
STARRED	Sound Level_ Electrohydraulic Did8a3a51d ...		<input type="checkbox"/> Include specific range
URL	Create a table comparing the Arduino Nan...		
OPEN FROM GOOGLE DRIVE <input checked="" type="checkbox"/>	Rheostat_Shunt_Current_Data		
	VEX Mobile Robot System Block Diagram		
	Indy Race		
	Potentiometer_Data		
	humidity_data		

Cancel Add

Lab: Creating an Interactive Engineering/Science Report using Looker Data Studio

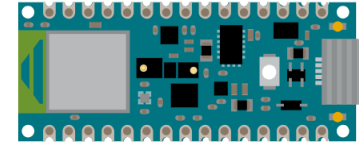


ADD Data: Go to Dimension → Click Add Dimension and select Magnetometer(uT) and relative time.

	relative_time (s)	Magnet...	Record Count
1.	12599	27.559535...	1
2.	53	31.641510...	1
3.	116	31.179108...	1
4.	183	30.776315...	1
5.	234	30.481594...	1
6.	301	30.245892...	1
7.	352	30.176659...	1
8.	444	30.358161...	1
9.	470	30.701830...	1

6

Lab: Creating an Interactive Engineering/Science Report using Looker Data Studio



ADD Chart: Go to Metric → Click Add Dimension and select Magnetometer(uT) and relative time.

The screenshot shows the Looker Data Studio interface for an 'Untitled Report'. The top navigation bar includes 'File', 'Edit', 'View', 'Insert', 'Page', 'Arrange', 'Resource', and 'Help'. A toolbar below contains icons for navigation, search, and adding elements like pages, data, charts, and controls. A filter bar shows '+ Add quick filter'. The main content area is divided into three sections:

- Table:** A table with columns 'relative_time (s)', 'Magnetometer ...', and 'Record Count'. It contains 9 rows of data.
- Chart:** A line chart with two series: 'Record Count' (blue) and 'Magnetometer (uT)' (green). A tooltip is visible over the chart with the value '22.4206603414169' and 'Magnetometer (uT): 22.42'. A red circle highlights the chart area.
- Configuration Panel:** A panel on the right with 'SETUP' and 'STYLE' tabs. Under 'SETUP', it shows:
 - Data source: Magnetometer (uT) - Magne...
 - BLEND DATA button
 - Date Range Dimension: Add dimension button
 - Dimension: Magnetometer (uT) (selected)
 - Drill down: Toggle switch
 - Metric: Record Count (selected), Magnetometer (uT) (selected), and Add metric button.

7

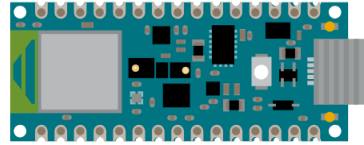
Question 4

In reviewing slide 32, under Metrics, which dimensions are added to the chart?

- a) Magnetometer, time**
- b) relative time, Record count**
- c) Magnetometer, relative time**
- d) None of the above**



Lab: Creating an Interactive Engineering/Science Report using Looker Data Studio



ADD Image.

8

Untitled Report

File Edit View Insert Page Arrange Resource Help

↶ ↷ 🔍 Add page 📄 Add data 📊 Add a chart ⚙️ Add a control ⏪ ⏩ 🖨️ 🗑️ Theme and layout

🔼 + Add quick filter

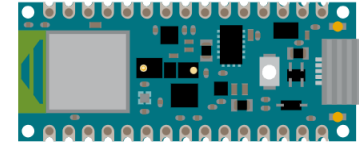
	relative_time (s)	Magnetometer ...	Record Count
1.	3453	37.2108836680553	1
2.	3402	36.9430962976978	1
3.	3519	36.8979034898848	1
4.	3335	36.288198092041	1
5.	3587	36.131010164614	1
6.	3285	35.5093575379358	1
7.	3218	34.6682694384957	1
8.	3637	34.1571318166584	1
9.	3167	33.9001043848777	1
1...	1073	33.8885830747852	1
1...	1022	33.8432440799337	1
1...	956	33.8035423712259	1
1...	1140	33.6916969019052	1
1...	897	33.6405843271338	1
1...	1190	33.4357223613261	1
1...	832	33.3544946175065	1

1.179108... 31.098122... 20.322648... 23.360735... 11.532649... 26.047325... 23.369980... 13.471302... 17.365414... 10.973604... 21.822026... 11.727046...

1 - 100 / 422 < >

8

Lab: Creating an Interactive Engineering/Science Report using Looker Data Studio



ADD Slider control.

Untitled Report

File Edit View Insert Page Arrange Resource Help

Reset

↶ ↷ 🔍 Add page 📄 Add data 📊 Add a chart 🧩 Add a control <> 🖨️ 📄 🗑️ Theme and layout

🔽 + Add quick filter

Reset

	relative_time (s)	Magnetometer ...	Record Count
1.	3453	37.2108836680553	1
2.	3402	36.9430962976978	1
3.	3519	36.8979034898848	1
4.	3335	36.288198092041	1
5.	3587	36.131010164614	1
6.	3285	35.5093575379358	1
7.	3218	34.6682694384957	1
8.	3637	34.1571318166584	1
9.	3167	33.9001043848777	1
1...	1073	33.8885830747852	1
1...	1022	33.8432440799337	1
1...	956	33.8035423712259	1
1...	1140	33.6916969019052	1
1...	897	33.6405843271338	1
1...	1190	33.4357223613261	1
1...	832	33.3544946175065	1

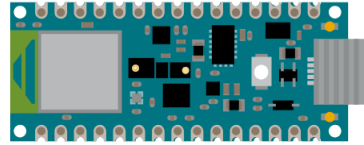
Magnetometer (uT)

10.16 37.21

9

1 - 100 / 422 < >

Lab: Creating an Interactive Engineering/Science Report using Looker Data Studio



ADD video clip → Insert → <URL Embed>.

Untitled Report

File Edit View Insert Page Arrange Resource Help

Reset Share

Add page Add data Add a chart Add a control Theme and layout

+ Add quick filter

relative_time (s)	Magnetometer ...	Record Count
1. 3453	37.2108836680553	1
2. 3402	36.9430962976978	1
3. 3519	36.8979034898848	1
4. 3335	36.288198092041	1
5. 3587	36.131010164614	1
6. 3285	35.5093575379358	1
7. 3218	34.6682694384957	1
8. 3637	34.1571318166584	1
9. 3167	33.9001043848777	1
1... 1073	33.8885830747852	1
1... 1022	33.8432440799337	1
1... 956	33.8035423712259	1
1... 1140	33.6916969019052	1
1... 897	33.6405843271338	1
1... 1190	33.4357223613261	1
1... 832	33.3544946175065	1

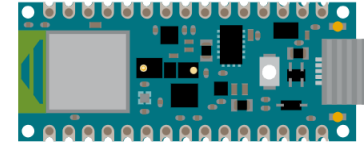
URL Embed Properties

External Content URL: <https://youtu.be/MfmQ2aDh>

Magnetometer (uT) slider: 10.16 to 37.21

10

Lab: Creating an Interactive Engineering/Science Report using Looker Data Studio



ADD Gauge → Insert → Gauge.

Untitled Report

File Edit View Insert Page Arrange Resource Help

↶ ↷ 🔍 Add page 📄 Add data 📊 Add a chart ⚙️ Add a control <> Theme and layout

+ Add quick filter

4.	3330	33.200190092041	1
5.	3587	36.131010164614	1
6.	3285	35.5093575379358	1
7.	3218	34.6682694384957	1
8.	3637	34.1571318166584	1
9.	3167	33.9001043848777	1
1...	1073	33.8885830747852	1
1...	1022	33.8432440799337	1
1...	956	33.8035423712259	1
1...	1140	33.6916969019052	1
1...	897	33.6405843271338	1
1...	1190	33.4357223613261	1
1...	832	33.3544946175065	1

1 - 100 / 422 < >

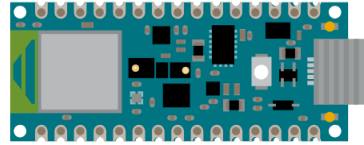
Magnetometer (uT)

10.16 37.21

11

Record Count 422.0

Lab: Creating an Interactive Engineering/Science Report using Looker Data Studio



Report in View mode

Magnetometer Sensor Report

Reset Share Edit

	relative_time (s)	Magnetometer ...	Record Count
1.	3453	37.2108836680553	1
2.	3402	36.9430962976978	1
3.	3519	36.8979034898848	1
4.	3335	36.288198092041	1
5.	3587	36.131010164614	1
6.	3285	35.5093575379358	1
7.	3218	34.6682694384957	1
8.	3637	34.1571318166584	1
9.	3167	33.9001043848777	1
1...	1073	33.8885830747852	1
1...	1022	33.8432440799337	1
1...	956	33.8035423712259	1
1...	1140	33.6916969019052	1
1...	897	33.6405843271338	1
1...	1190	33.4357223613261	1
1...	832	33.3544946175065	1

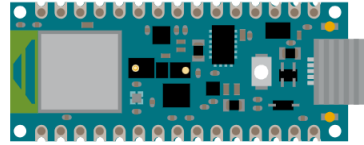
1 - 100 / 422

Magnetometer (uT)

10.16 37.21

Record Count 422.0

Lab: Creating an Interactive Engineering/Science Report using Looker Data Studio



Change the Theme

12

Magnetometer Sensor Report

File Edit View Insert Page Arrange Resource Help

↶ ↷ 🔍 Add page 📄 Add data 📊 Add a chart 🧩 Add a control <> 🖼️ 🗑️ Theme and layout

🔼 + Add quick filter

	relative_time (s)	Magnetometer (uT)	Record Count
1.	116	31.1791082083326	1
2.	234	30.4815949285348	1
3.	301	30.2458929894046	1
4.	352	30.1766592226834	1
5.	470	30.7018308559184	1
6.	529	31.1144985957558	1
7.	603	31.5229635059261	1
8.	653	31.9868660789901	1
9.	722	32.497410004608	1
10.	771	32.9641992153651	1
11.	832	33.3544946175065	1
12.	956	33.8035423712259	1
13.	1022	33.8432440799337	1
14.	1073	33.8885830747852	1
15.	1140	33.6916969019052	1
16.	1190	33.4357223613261	1
17.	1257	32.9890353098659	1
18.	1310	32.6616671102431	1
19.	1375	32.3165020059781	1
20.	1433	32.0360677822485	1
21.	1501	31.7575196213396	1

Magnetometer (uT) 10.16 37.21

Record Count 422.0

Default

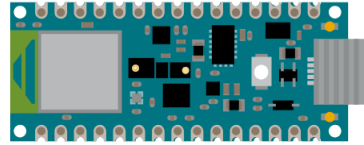
Edge Text

Constellation Text

Groovy Text

Extract theme from image

Lab: Creating an Interactive Engineering/Science Report using Looker Data Studio



Final Interactive Report

Magnetometer Sensor Report

Reset Share Edit

	relative_time (s)	Magnetometer (uT)	Record Count
1.	116	31.1791082083326	
2.	234	30.4815949285348	
3.	301	30.2458929894046	
4.	352	30.1766592226834	
5.	470	30.7018308559184	
6.	529	31.1144985957558	
7.	603	31.5229635059261	
8.	653	31.9868660789901	
9.	722	32.497410004608	
10.	771	32.9641992153651	
11.	832	33.3544946175065	
12.	956	33.8035423712259	
13.	1022	33.8432440799337	
14.	1073	33.8885830747852	
15.	1140	33.6916969019052	
16.	1190	33.4357223613261	
17.	1257	32.9890353098659	
18.	1310	32.6616671102431	
19.	1375	32.3165020059781	
20.	1433	32.0360677822485	

Magnetometer (uT)

10.16 37.21

Record Count 422.0

Question 5

In reviewing slide 38, which widget was not included in the Interactive Report layout sketch?

- a) data table**
- b) chart**
- c) slider**
- d) gauge**



Thank you for attending

Please consider the resources below:

Arduino. (n.d.). *External sensors*. Retrieved November 5, 2023, from <https://science-journal.arduino.cc/sj/module/getting-started-2/lesson/external-sensors>

Carr, J. J. (1992). *The art of science*. HighText.

Chua, C.E., & Storey, V.C. (2022). A tutorial on prototyping internet of things device and systems: A gentle introduction to technology that shapes our lives. *Communications of the Association for Information Systems*, 51(34), 327-364.
https://www.researchgate.net/publication/360263045_A_Tutorial_on_Prototyping_Internet_of_Things_Devices_and_Systems_A_Gentle_Introduction_to_Technology_that_Shapes_Our_Lives

Looker Developer Relations. (2022, November 29). Connect and visualize all your data in looker studio.
<https://codelabs.developers.google.com/codelabs/community-connectors#0>



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