

Data driven design
Topic 0: Overview of the course
Instructor: Jay Dhariwal,
Assistant Professor,
Department of Design
IIT Delhi

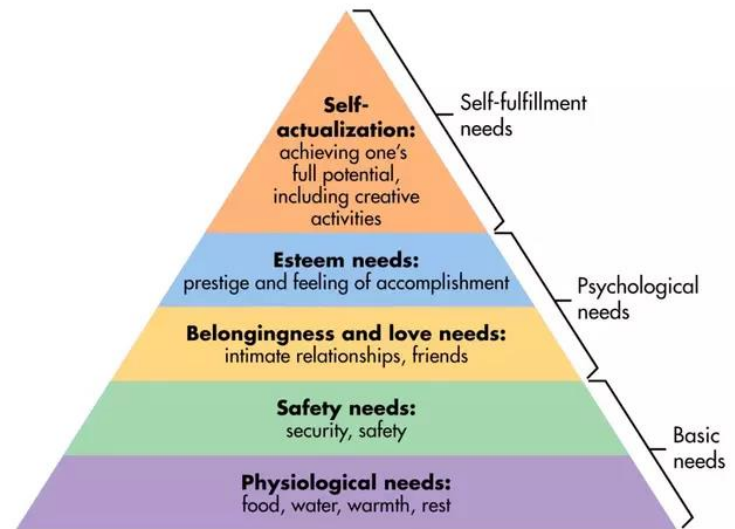
Date: 2nd January 2024

My motivation: Health & Wellness

- Health is a state of complete physical, mental and social well-being and it's not just merely the absence of disease or infirmity. ([WHO](#))



[Global Wellness Institute](#)



[Maslow's hierarchy of needs](#)

Introductions

- Myself
- TAs: QuEST Lab
(Prasanna, Bavath,
Saran, Gulshan,
Harshit)
- Yourself (google
form to know your
expectations from
the course)



Who Am I?

Let's decode this topic: Data Driven Design

- **What and Why of Design?**
- What and Why of Data Science?
- Data Driven Design?

Source of decode

image: <https://www.daskeyboard.com/blog/decode-our-das-keyboard-holiday-message-and-win/>



What is Design?

noun; general concept of the field

verb; action or process

noun; one idea or proposal

"Design is to design a design to produce a design."

noun; some finished product, actual result

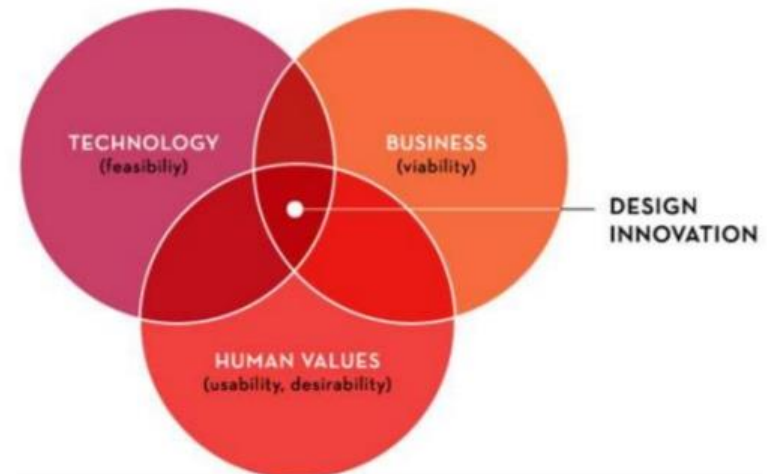
<https://www.linkedin.com/feed/content/actab672014/04/design-as-the-field-3-004448>

TEDC- Transform Your Email Strategy With Design Leadership

#LitmusLive @pn

// Integrated process

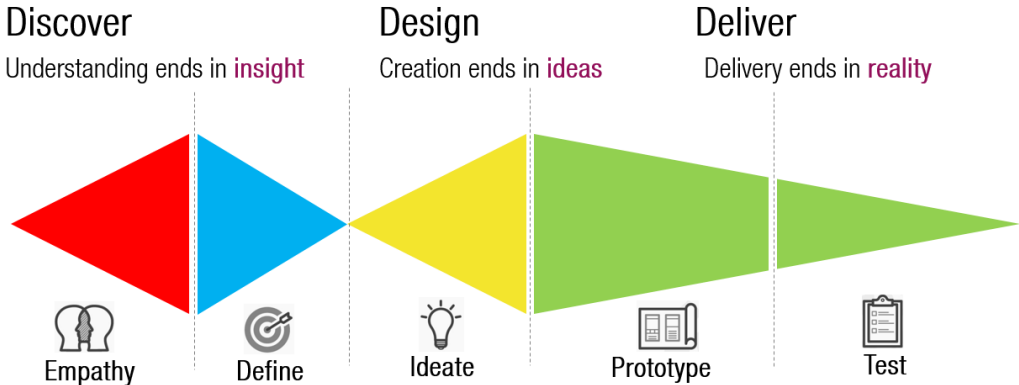
An integrated process: a process that deliberately integrates necessary disciplines



Jaap Daalhuizen - Technical University of Denmark - 5th of October, 2016

- [Sciences of the Artificial](#): Herbert Simon (Nobel Laureate, Economist, Father of AI)
- Breaking silos and working together

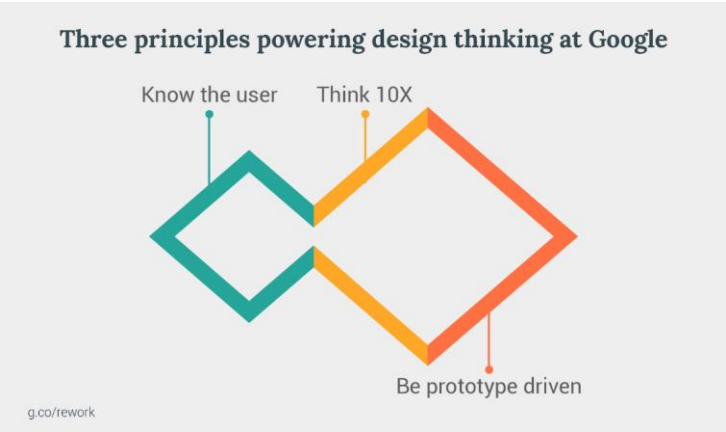
DESIGN THINKING MODEL



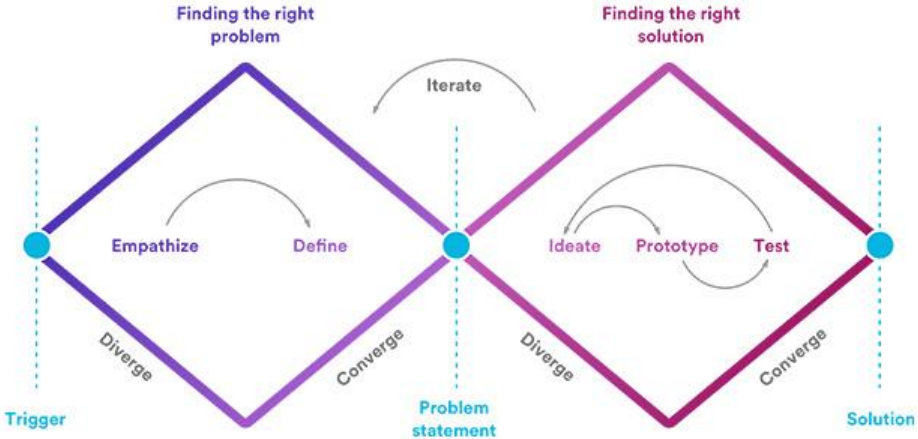
Design Thinking is an iterative and non-linear process in which we seek to understand the user, challenge assumptions, and redefine problems in an attempt to identify alternative strategies and solutions that might not be instantly apparent with our initial level of understanding.

[Image source](#)

[Image source](#)



[Image source](#)



Design Thinking - Tim Brown, CEO and President of IDEO



1. Divergent thinking (instead of convergent thinking, exploring possibilities)
2. Integrated, Holistic thinking (instead of analytically to one part of the problem). Work to resolve desirability, feasibility, viability.
3. Design is human-centered, meet needs – instead of starting from technology or business.
4. Can apply to any product or system (digital or physical)
5. Prototyping speeds up the innovation process.
How fast at prototyping?
6. Build movements
[OpenIDEO: Social Impact Powered By Design Thinking](#)
7. Design is moving from consuming to creating meaningful, participative experiences
8. Collaboration, trust, playfulness
9. Design every aspect of business
10. ASKING THE RIGHT QUESTION is important.

HBR.ORG

Harvard Business Review

SEPTEMBER 2015

44 **The Big Idea**
The Organizational "I'm Sorry"
Maurice E. Schweitzer et al.

66 **Sink Management**
Cybersecurity: Lessons from the Pentagon
James A. "Sandy" Winnefeld Jr. et al.

108 **Managing Yourself**
How to Embrace Complex Change
Linda Brimm

THE EVOLUTION OF DESIGN THINKING

IT'S NO LONGER JUST FOR PRODUCTS. EXECUTIVES ARE USING THIS APPROACH TO DEVISE STRATEGY AND MANAGE CHANGE.

PAGE 55



DESIGN THINKING AND INNOVATION AT Apple

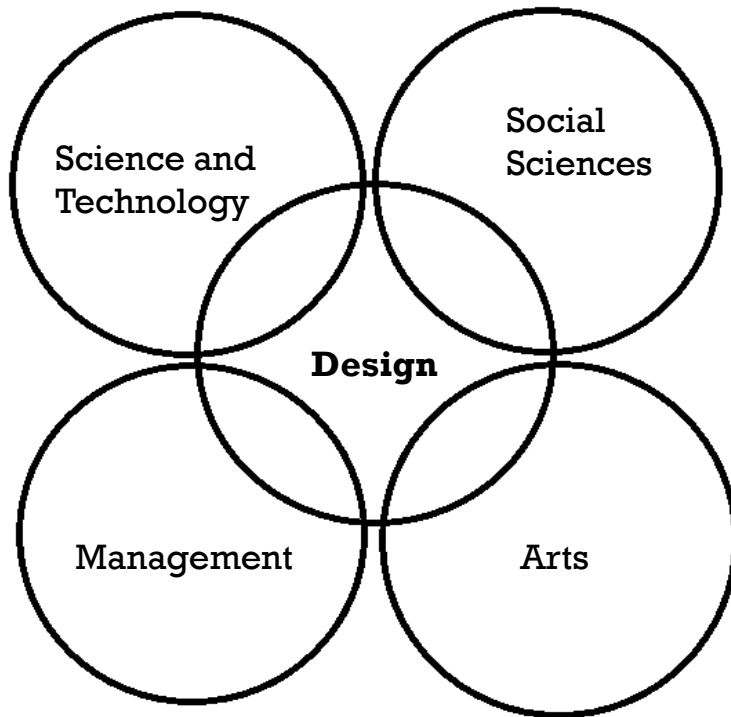
[Image source](#)



IBM Design Thinking

Human-centered outcomes at speed and scale

[Image source](#)



A Vision for Design

To apply design thinking to solve the wicked problems in the society, taking inputs from the sciences and technology, social sciences, management and arts domain as the need may be.

Let's decode this topic: Data Driven Design

- What and Why of Design?
- **What and Why of Data Science?**
- Data Driven Design?

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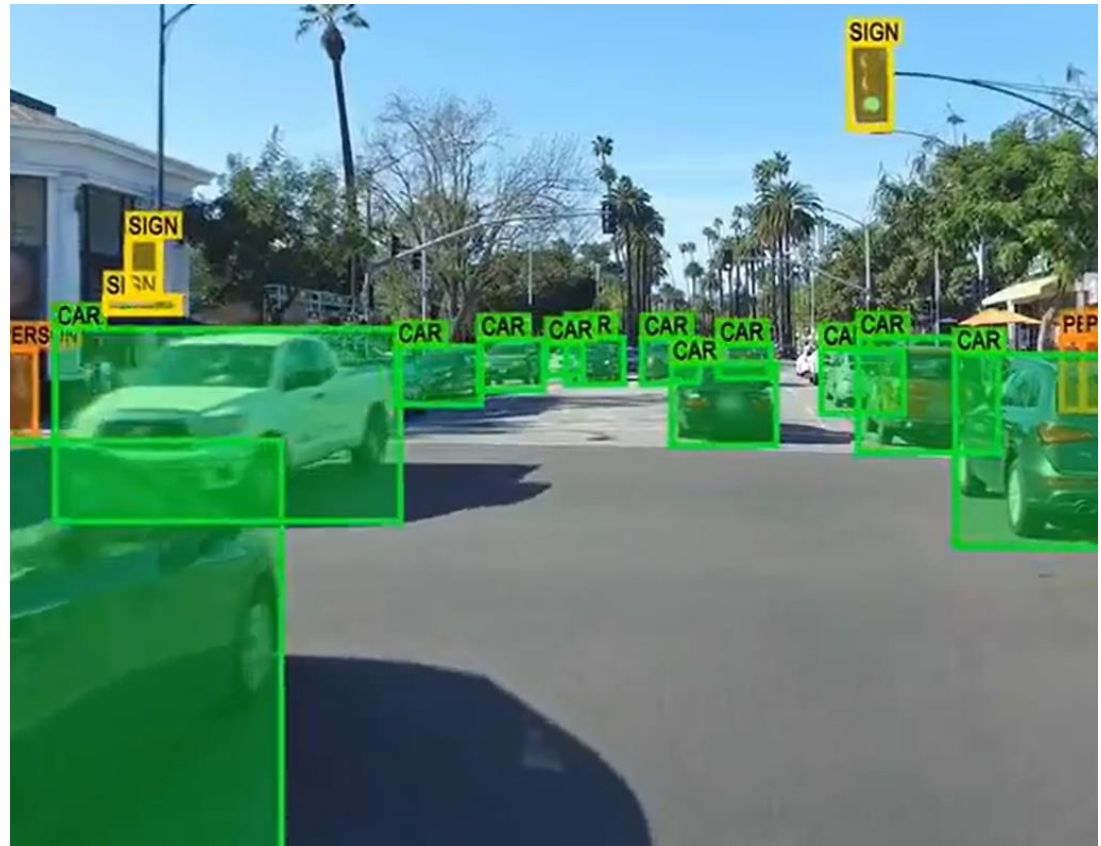
Have you used ML before?

- Siri, Google Assistant, Alexa.
- Amazon suggestions to buy stuff, Film suggestions on Netflix

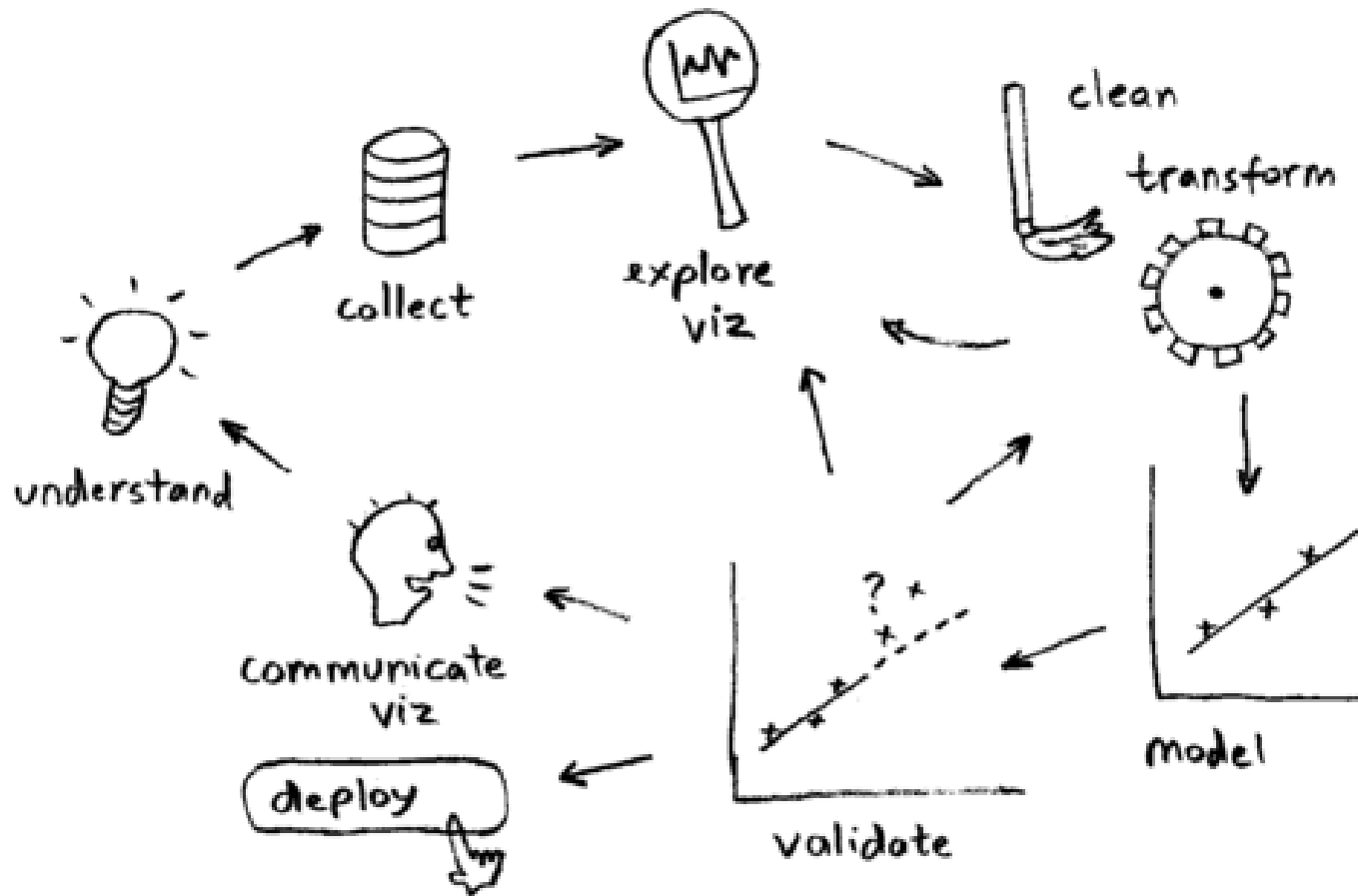


Why should you care about ML?

- [Google's AI AlphaGo Is Beating Humanity At Its Own Games](#)
- Eric Schimdt: Former Chairman, Alphabet (parent company of Google): Self Driving Cars are the future, AI assisted health care.
- Vinod Khosla about Generative Design (CAD+AI). [Bike example](#)

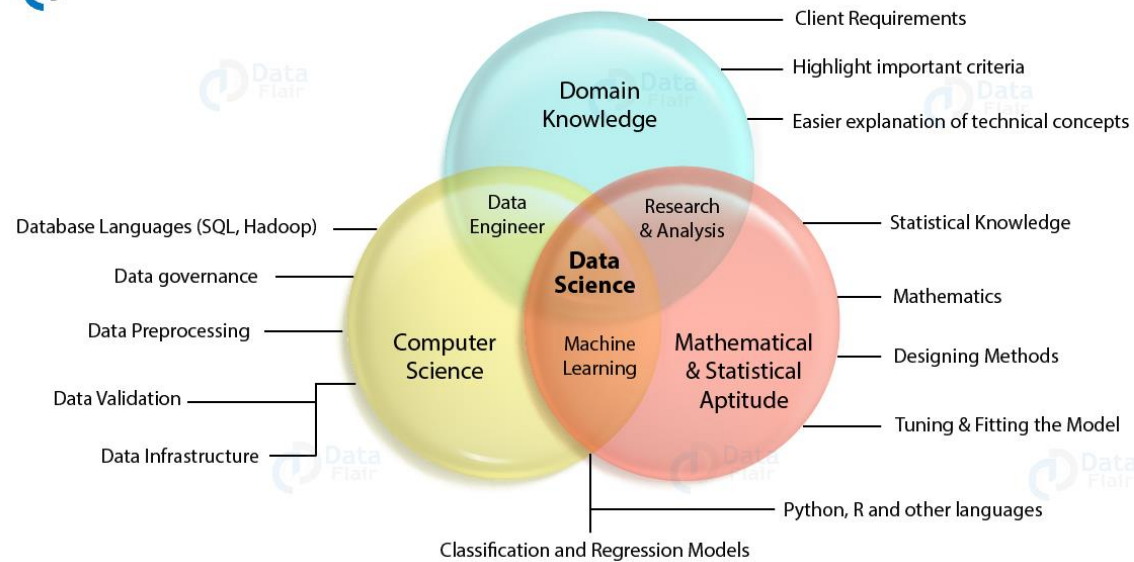


Data science workflow



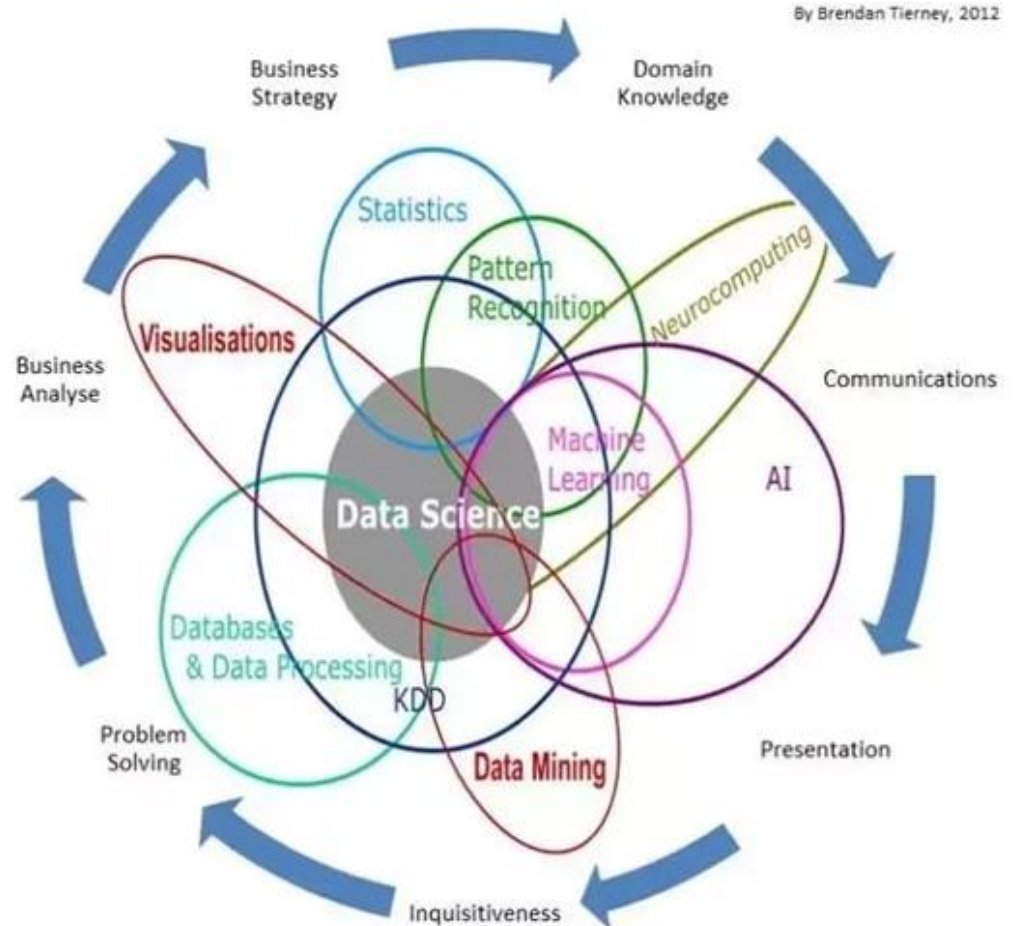
- Source: <http://datascience.la/data-science-toolbox-survey-results-surprise-r-and-python-win/>

Data Science: understand and analyze actual phenomena with data

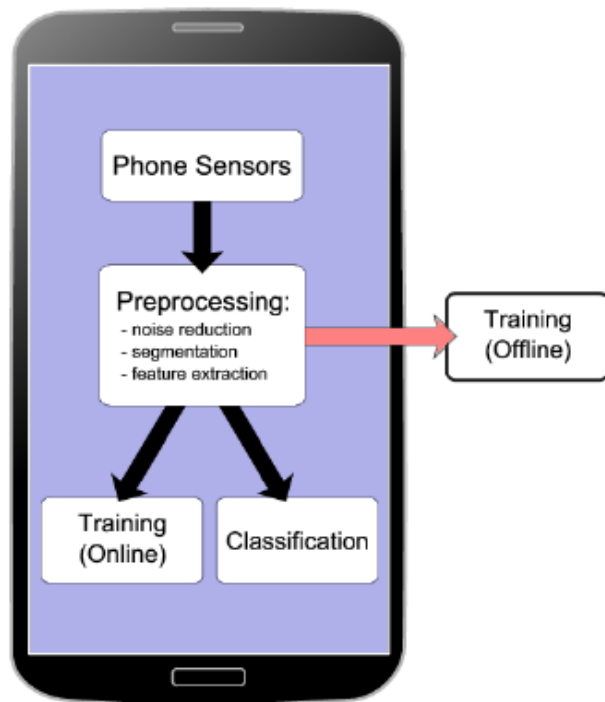


Data Science is multi-disciplinary

- Source: <https://www.simplilearn.com/data-science-vs-data-analytics-vs-machine-learning-article>



Human activity recognition



doi:10.3390/s150102059

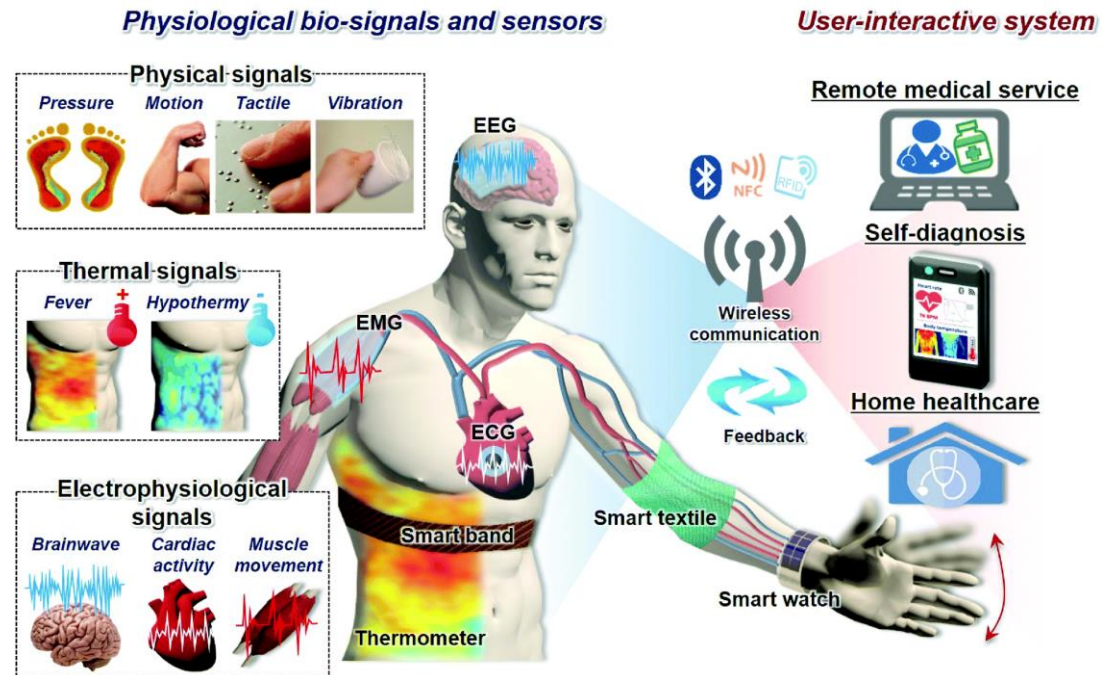


[MATLAB video tutorial](#)

[Data source](#)

Wearables for health monitoring

- Ha, Minjeong, Seongdong Lim, and Hyunhyub Ko. 2018. "Wearable and Flexible Sensors for User-Interactive Health-Monitoring Devices." *Journal of Materials Chemistry B* 6 (24): 4043–64.
- <https://doi.org/10.1039/c8tb01063c>.

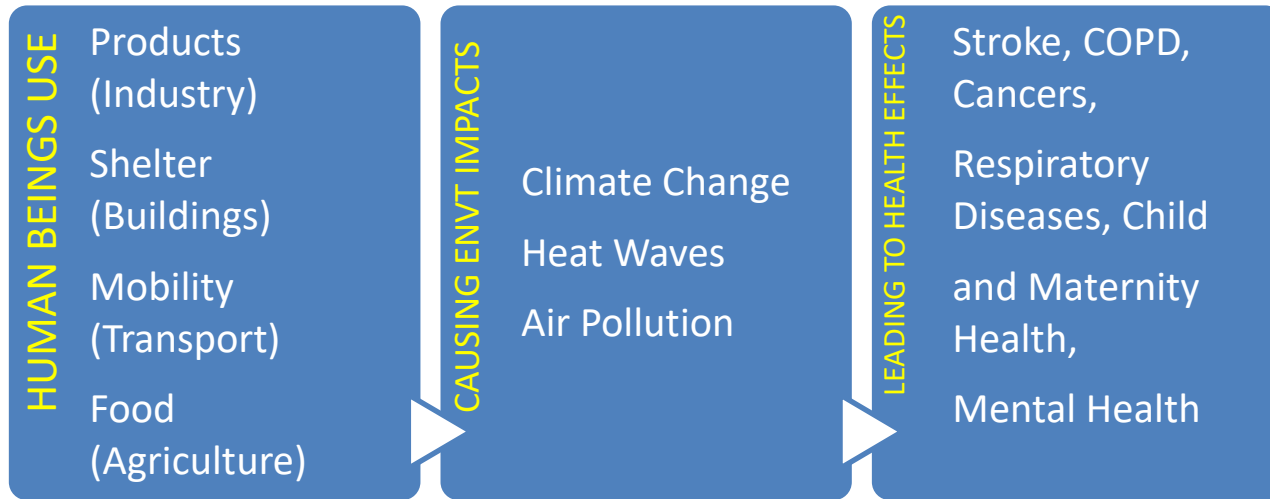


Let's decode this topic: Data Driven Design

- What and Why of Design?
- What and Why of Data Science?
- **Data Driven Design**

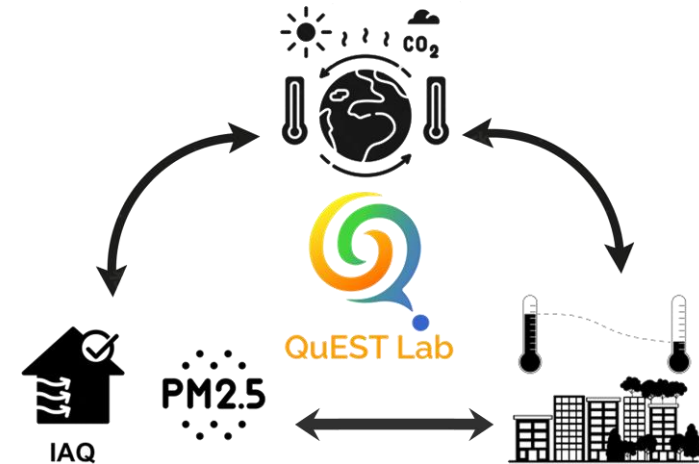


How to improve our and our planet's health?



How much greenhouse gas is emitted by the things we do?

Making things (cement, steel, plastic)	31%
Plugging in (electricity)	27%
Growing things (plants, animals)	19%
Getting around (planes, trucks, cargo ships)	16%
Keeping warm and cool (heating, cooling, refrigeration)	7%



<https://www.amazon.in/How-Avoid-Climate-Disaster-Breakthroughs/dp/0241448301>



Data cloud

Calibration and Network Deployment of Low Cost Pollution Sensors



Network of low-cost sensors and network calibration



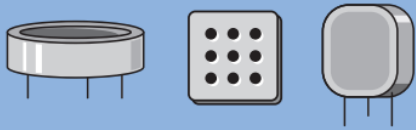
Sensor calibration



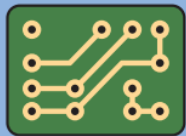
Pollution data analytics and dashboard

PIs: Prof. Seshan Srirangarajan & Prof. Jay Dhariwal, IIT Delhi

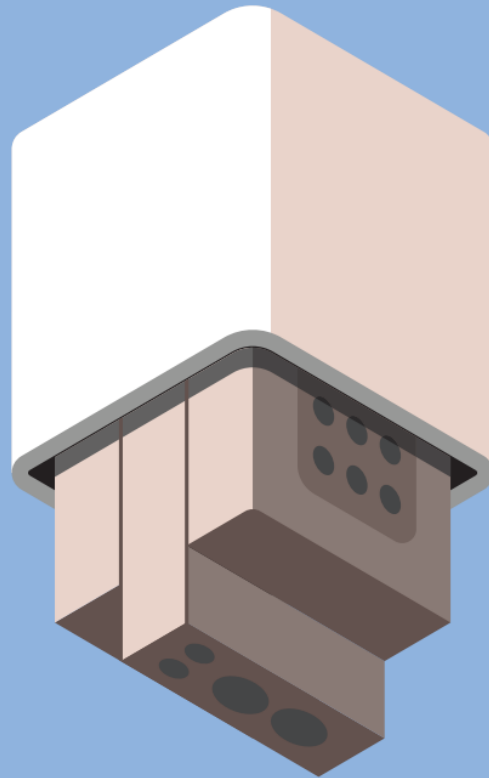
Raw Sensors



Integrated Board



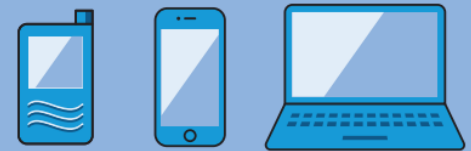
Weather-Proof Housing



Power Source



Data Visualization



Data Storage & Transmission







Collocated Study Site: Gramodaya Parisar (IIT Delhi)

(November 2021- March 2022)

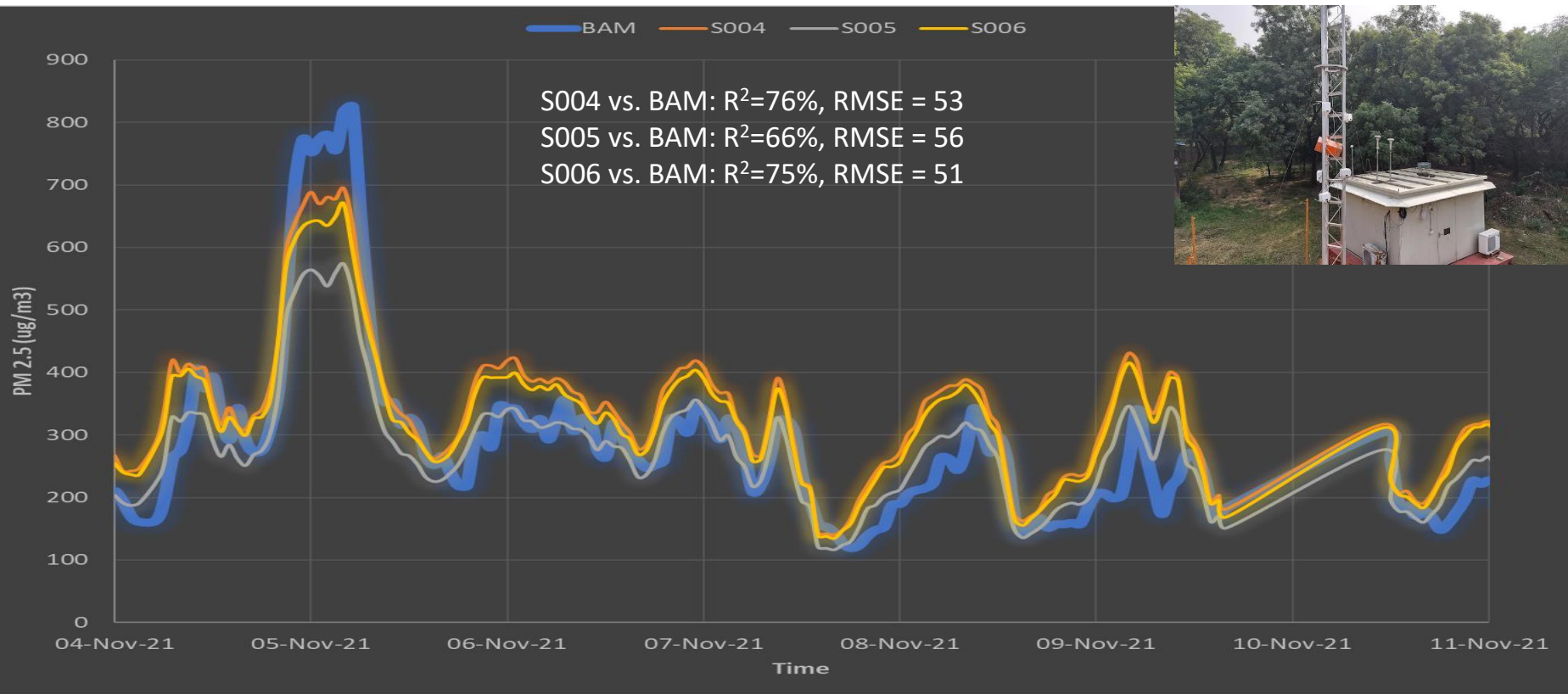


Collocated Study Site: Jodhpur

Dec 2022- May 2023

Investigation area: Effect of Low Humidity

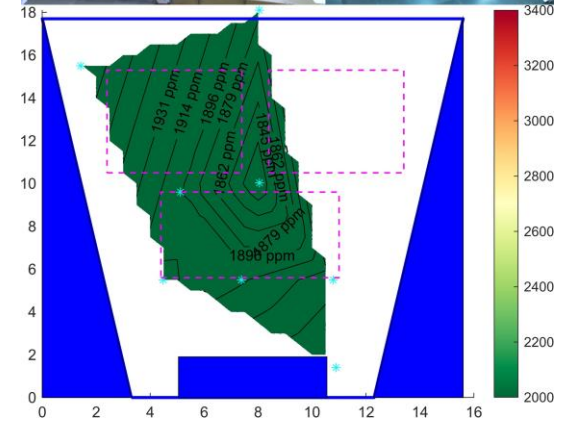
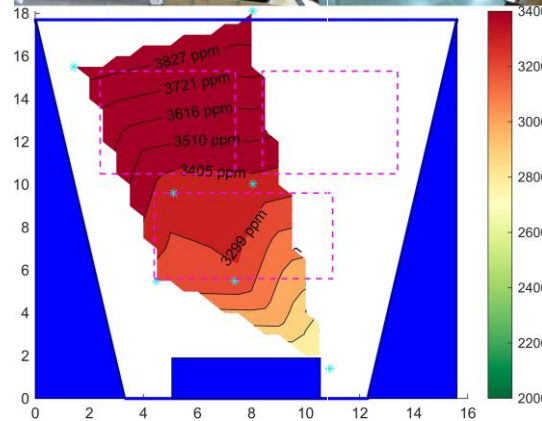
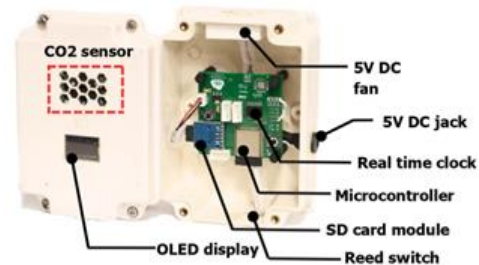
Low cost PM sensors vs. BAM



Low cost PM_{2.5} sensors 100 times cheaper than the reference BAM

Improving air quality in classrooms

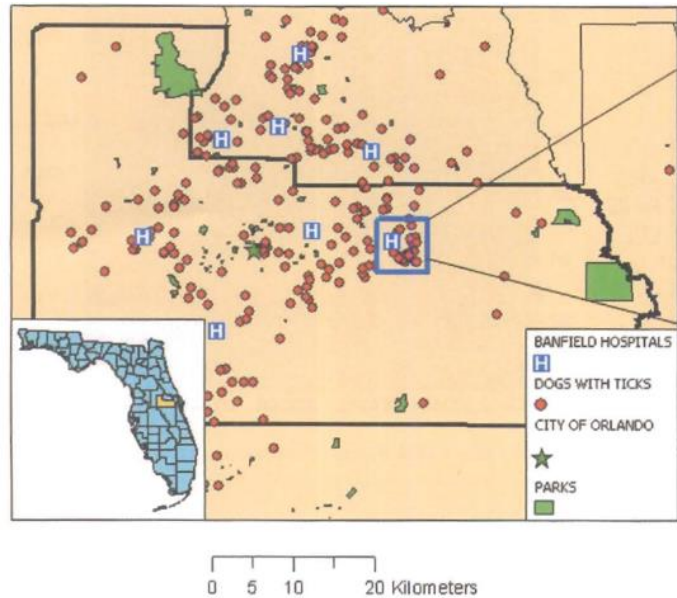
Research gaps: Understanding invisible air flows to optimize ventilation for health and climate change



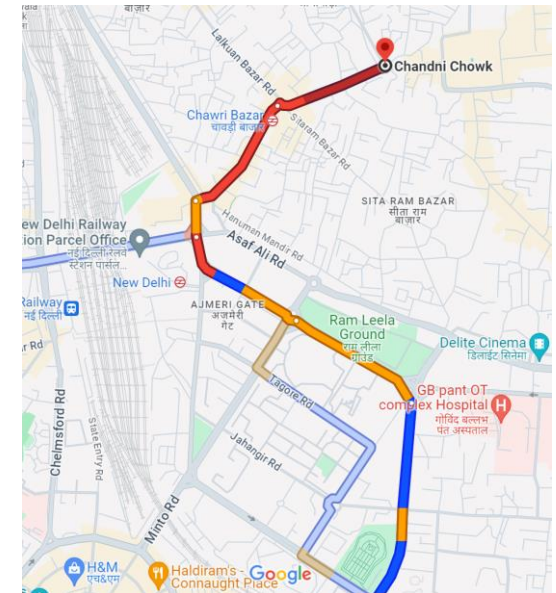
CO₂ levels in the space

Joint Project with Prof Narsing Jha from Dept. of Applied Mechcnics and Prof Seshan Srirangarajan from Dept. of Electrical Engg., IIT Delhi

Other case studies of Data driven design



- [Spatio-temporal clusters for early epidemic detection](#)
- [Marta González - Mobile Data for Urban Transformation](#)
- Big Data analysis from MIT North Court study
- Examples of Data Driven Design?



Moore G.E., Ward M.P., **Dhariwal J.**, Wu C.C., Glickman N.W., Lewis H.B., Glickman L.T., 'Development of a national companion animal syndromic surveillance system for bioterrorism', *2nd International Conference on the Applications of GIS and Spatial Analysis to Veterinary Science (GISVET 04)*, Univ. Guelph, Ontario, Canada, Durr, P. A. and Martin, S. W., Jun 2004.

Understanding congested travel in urban areas [Serdar Çolak](#), [Antonio Lima](#) & [Marta C. González](#) *Nature Communications* volume 7, Article number: 10793 (2016)

Big Data Analytics: Design of Outdoor Public Spaces

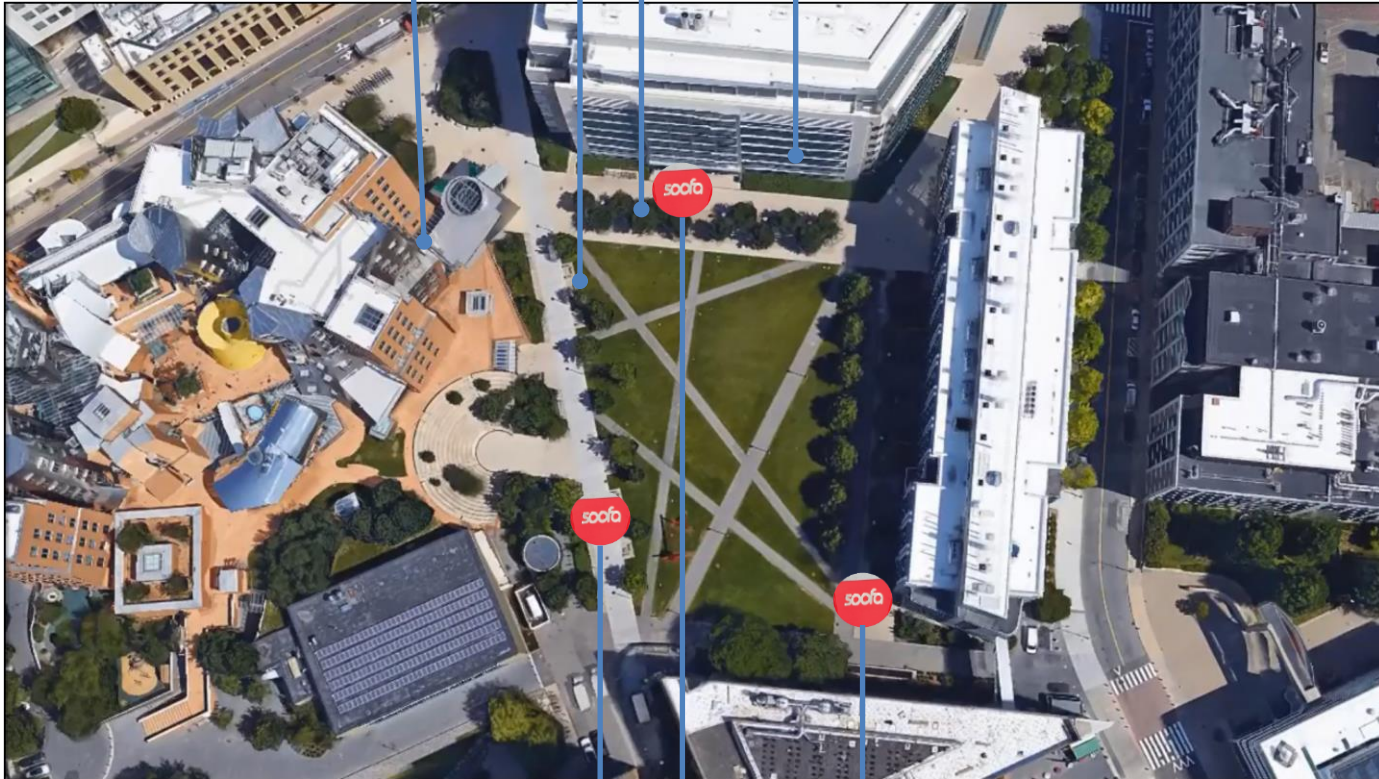


Reinhart C., Dhariwal J. and Gero K., 'Biometeorological indices explain outside dwelling patterns based on Wi-Fi data in support of sustainable urban planning', *Building and Environment*, 126, 2017, 422–430.

Stata Center cafeteria

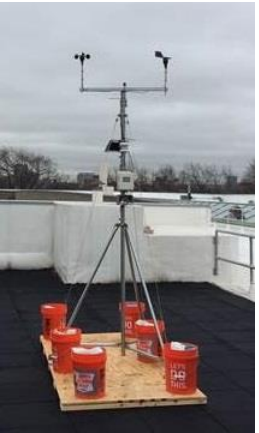
Outdoor seating

Koch cafeteria

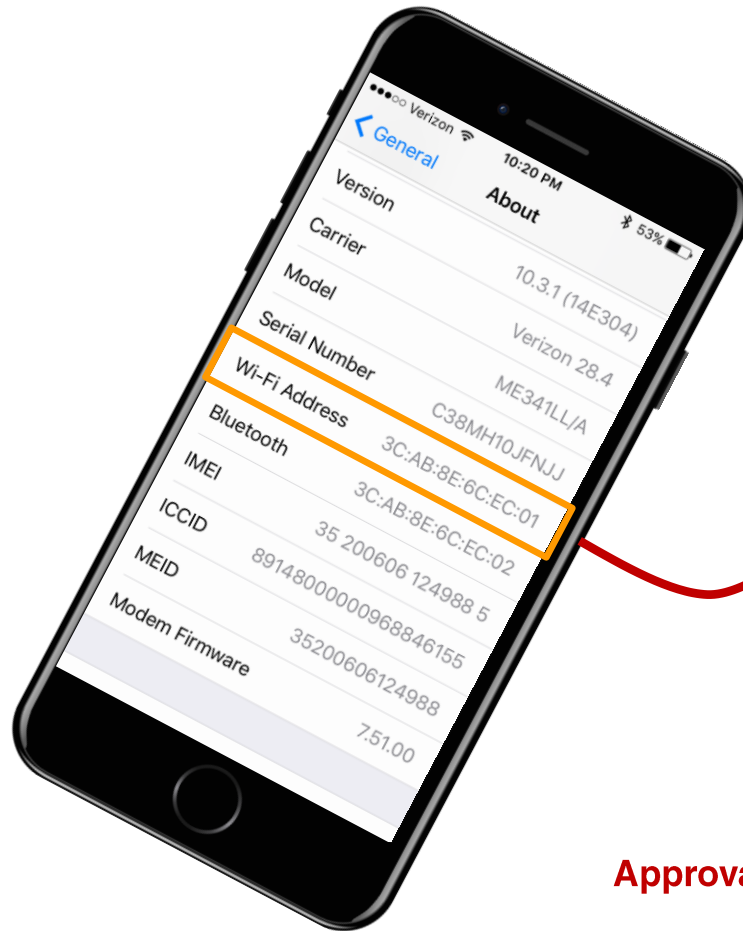


Weather station at roof of nearby building

Soofa benches



Privacy in the Modern Age



Encrypted device ID

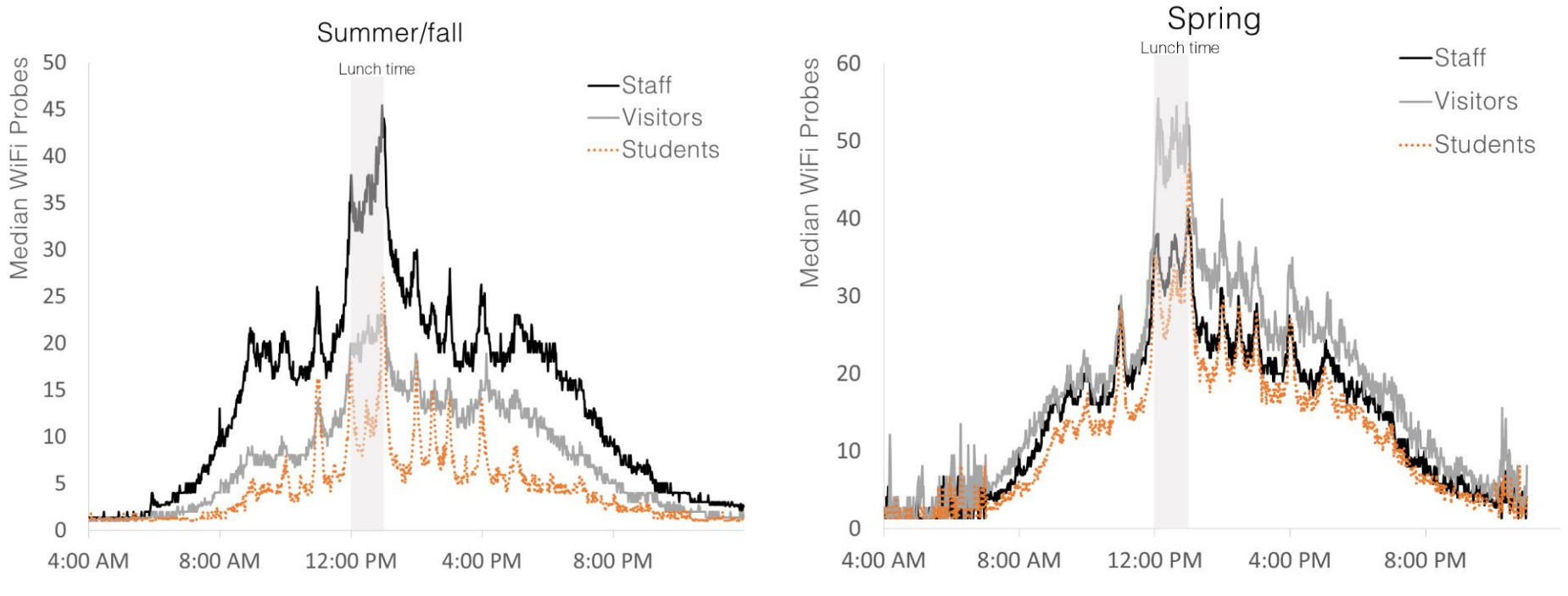
Approvals from COUHES at MIT

Results from July 2016 – May 2017

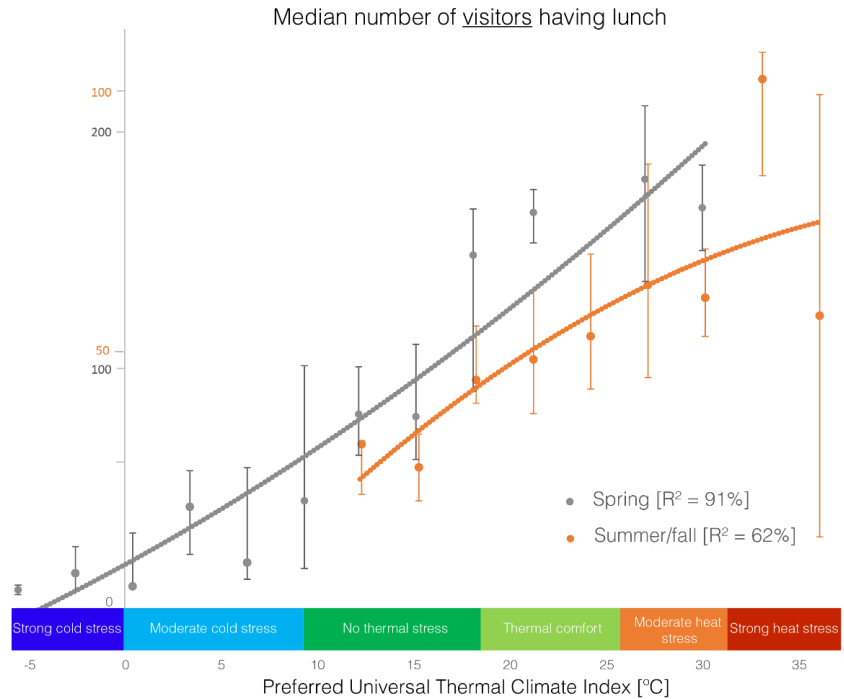
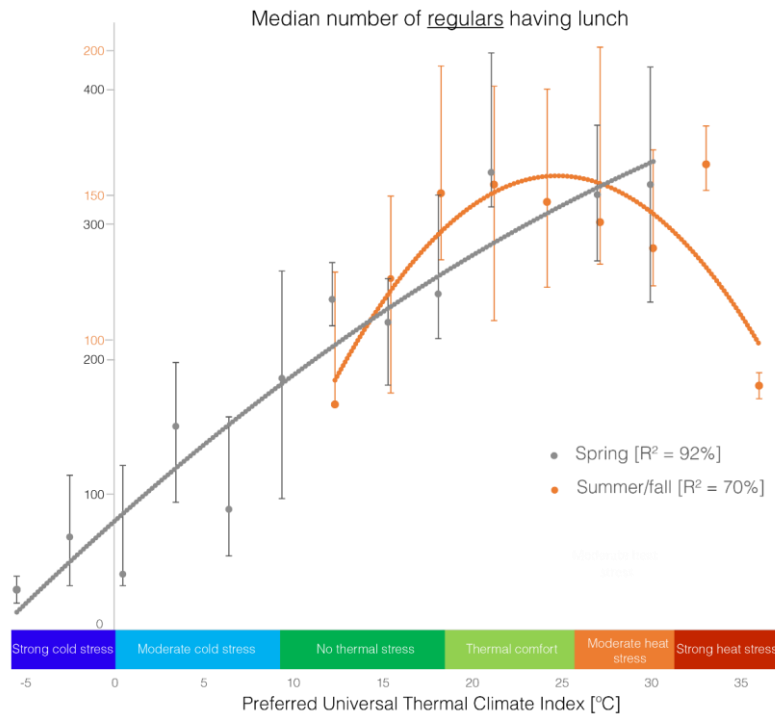
400 times more longitudinal subjects than any study in the past



Hourly Occupancy Profiles



Regulars vs. Visitors (Lunch Breaks)



- ❑ UTCI explains > 70% of variance for likelihood for regulars having lunch
- ❑ Regulars vs. Visitors behavior, Differences in fall and spring
- ❑ Enormous potential for influencing the design of outdoor urban spaces
- ❑ Replicated this work for hot, arid climate of Masdar Institute, Abu Dhabi.

FAB23 Bhutan Challenge Awards

5 challenges - 5 areas of intervention

There will be four areas of intervention in the challenge, and through them it will be possible to outline the course of the program.

The theme of the Fab Bhutan Challenge, as well as the overall theme of the event, is “**designing resilient futures.**”, an acknowledgement of the changes and transformation that Bhutan is currently undertaking.

The Challenge, following this theme, will bring together local and global innovation communities to propose meaningful interventions that enrich, scale and invest in Bhutan’s resilient economy from the bottom up following these four pillars:

- 📍 Youth & Education
- 📍 Technology
- 📍 Innovation, Sustainability and Community
- 📍 Economic Opportunity

1

Climate Adaptive
Agriculture

2

Water Conservation

3

Human Wildlife Conflict

4

Cultural Preservation

5

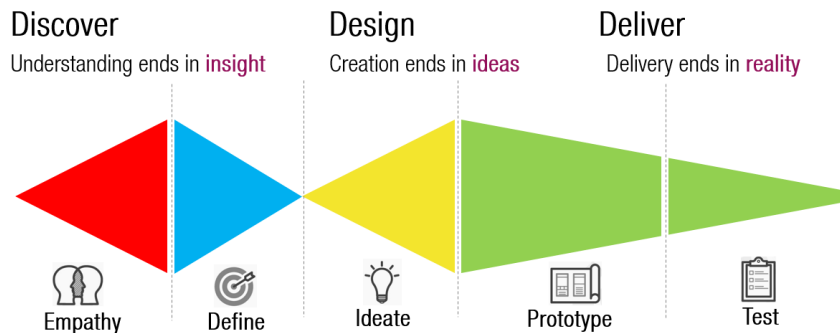
Assistive Technology

Data Driven Design for testing prototypes

- Let's take an example of making an assistive chair for the elderly – [Prankur Kataria](#).



DESIGN THINKING MODEL



Design Thinking is an iterative and non-linear process in which we seek to understand the user, challenge assumptions, and redefine problems in an attempt to identify alternative strategies and solutions that might be instantly apparent with our initial level of understanding.

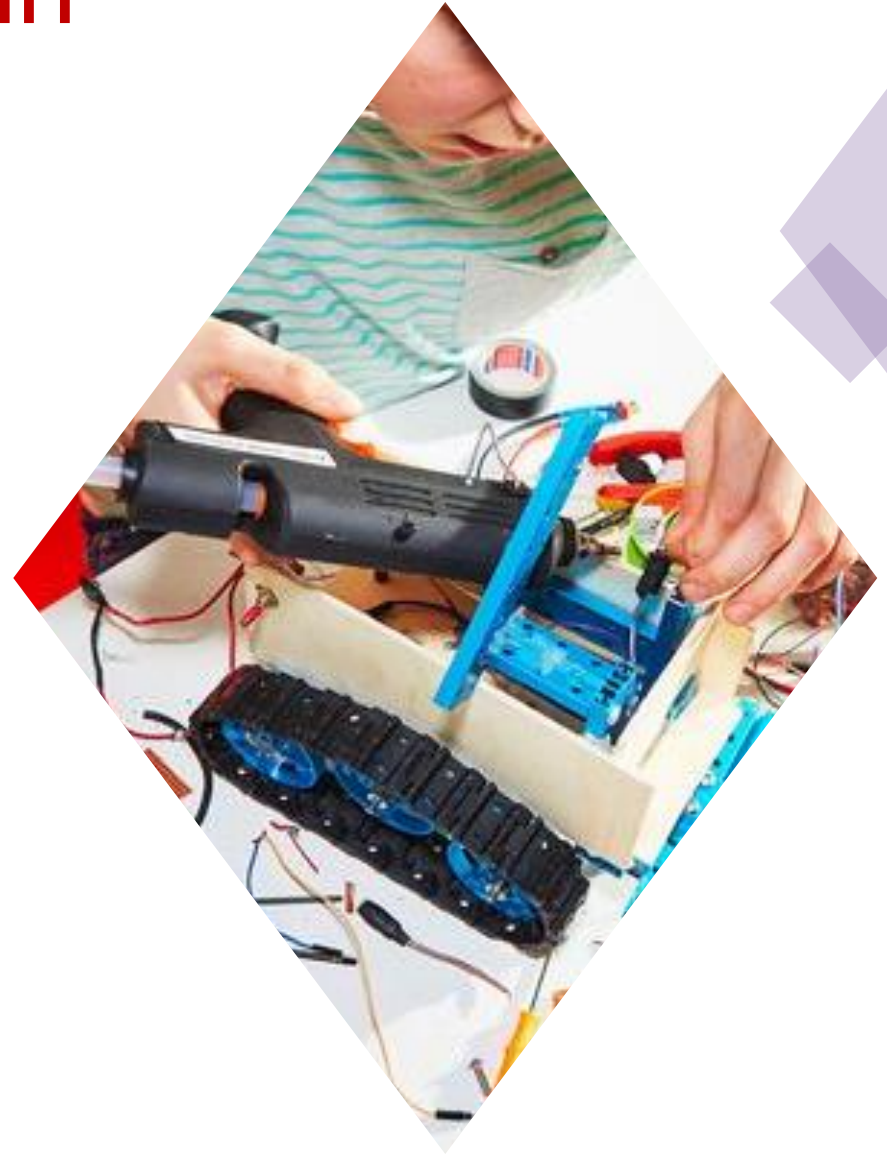
- [Image source](#)



<https://www.yankodesign.com/2022/04/14/chair-with-extended-arms-to-help-elderly-sit-and-stand-without-assistance/>

What will we do in this course?

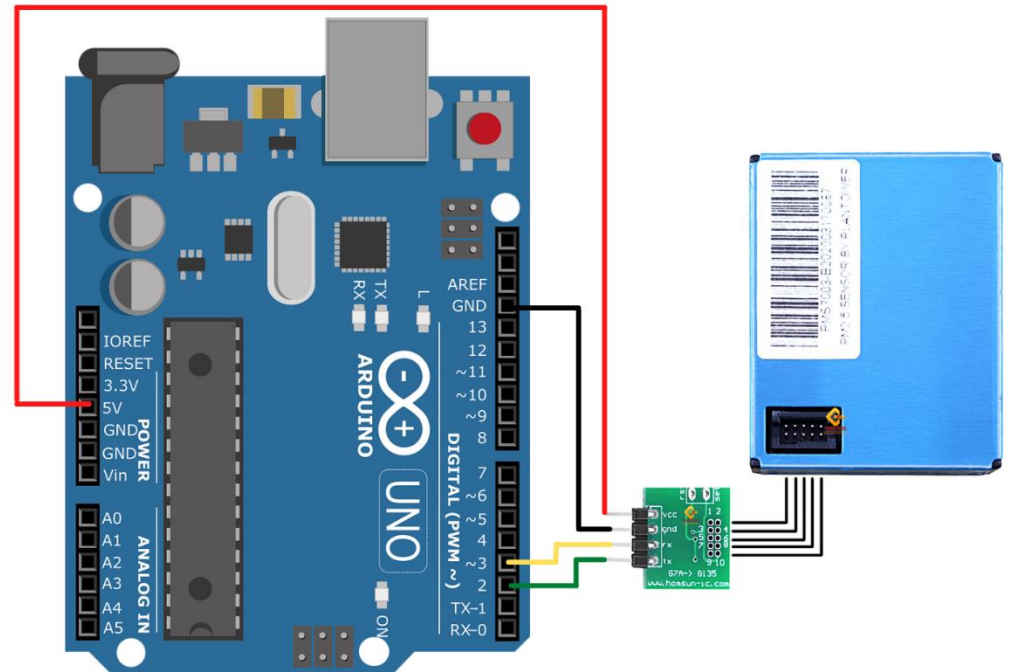
- To begin with, we will learn to build a datalogger using a sensor of choice and then use the datalogger(s) to perform experiments and make sense from the data obtained for a real world problem. In this process, you would gain the introduction about how to build any hands-on electronics based project and also, how to approach a real world problem involving data.



Low cost sensors for PM2.5 monitoring

Everyone should learn this!

UNO	PMS7003
3.3v	3.3v
GND	GND
2	Tx
3	Rx

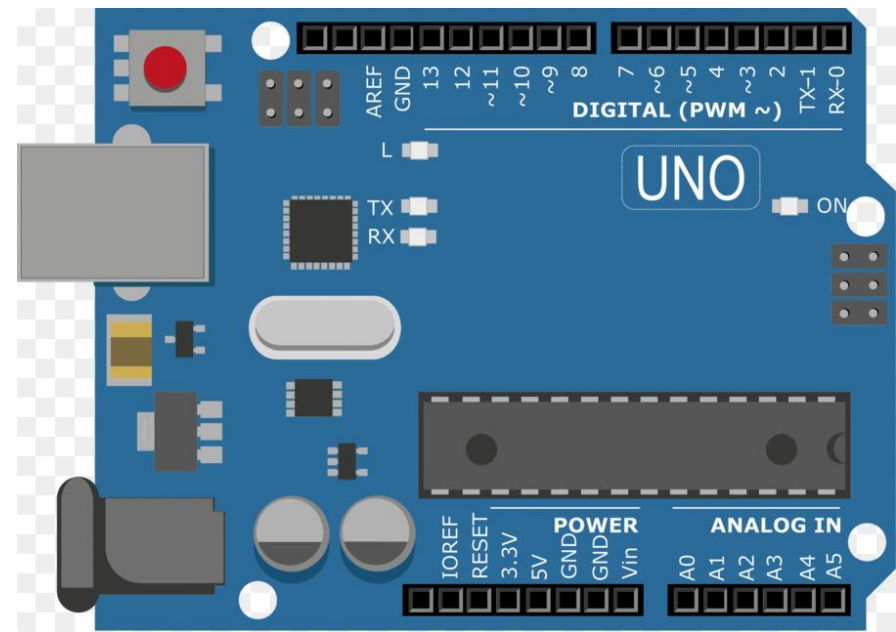


<https://github.com/vyomaniitd/PM2.5---PMS7003>

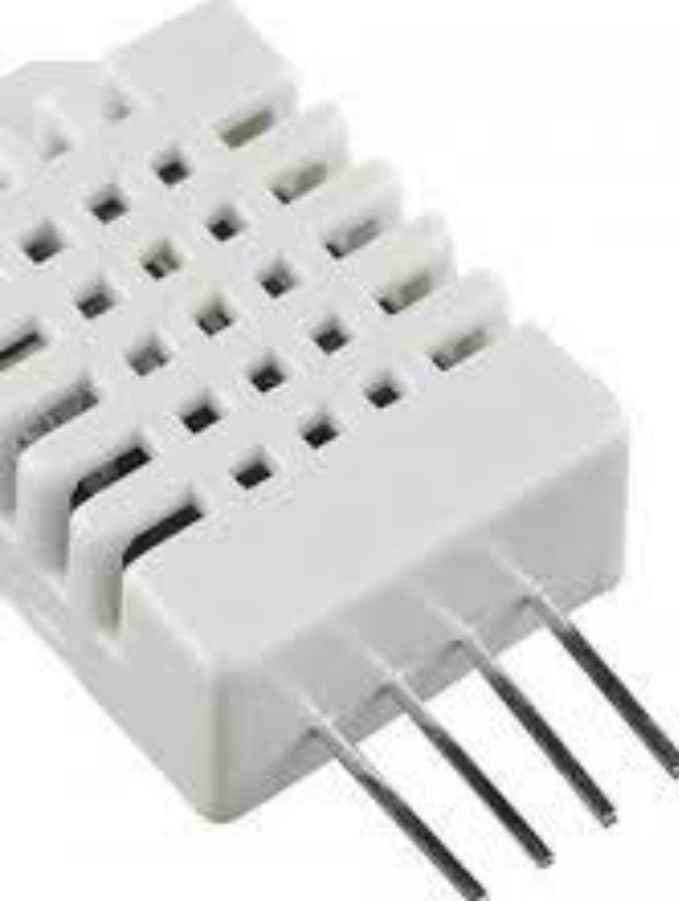
Invited talk at CERCA, IIT Delhi: [A breath of fresh air](#)

Topic 1: μ C programming

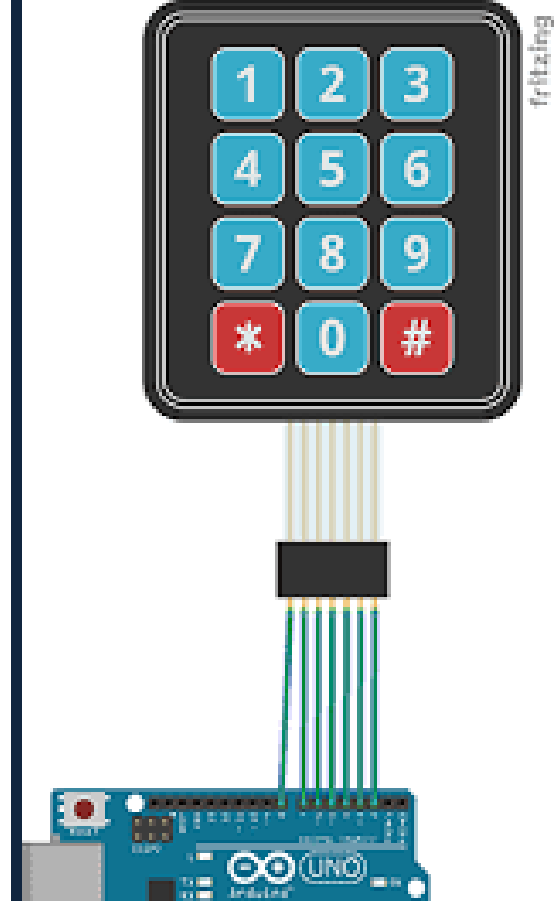
- Basics of programming, algorithm, flowcharts.
- Arduino hardware, IDE, libraries
- Arduino kit with examples
- LEDs, RGB LEDs.
- Push buttons, Buzzers.
- Electrical safety and handling
- [LED name](#)
- [Basic musical instrument](#)
- Tinkercad Simulations – [Cdr Venkat Aditya](#)
- AVR series uCs
(Atmega 328p, [ATtiny44](#))



Topic 2: Input devices

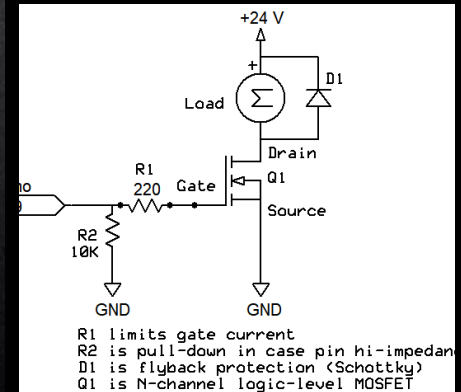
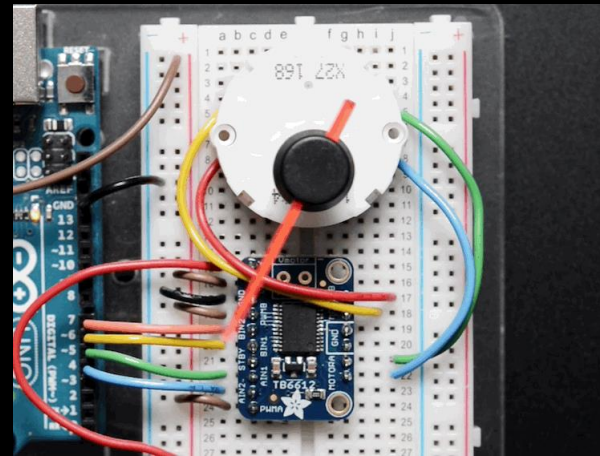


- Sensor features, datasheet
- [T+RH sensor](#), [proximity sensor](#), keypad module with μC
- Sensors in your smart phone?

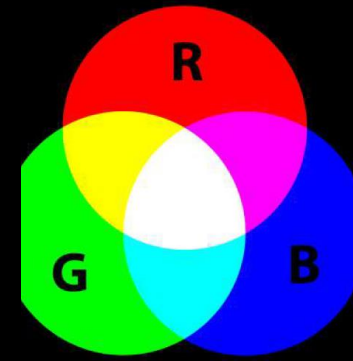
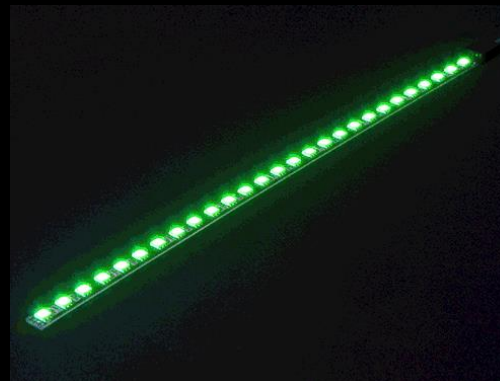


Topic 3: Output devices

- RGB LEDs, Displays, Speakers, Servo/Stepper Motors, Relays, Dataloggers
- High power electronics
- [Ultrasonic + LED display](#)
- [Pressure sensor + speakers](#)
- [All terrain robot](#)



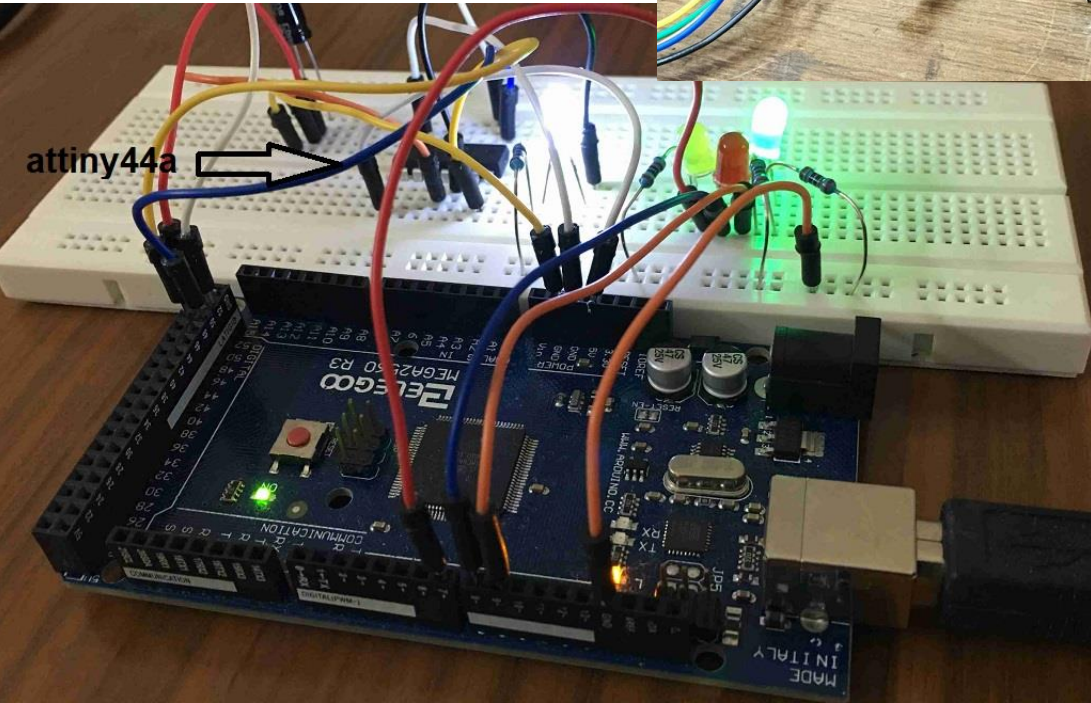
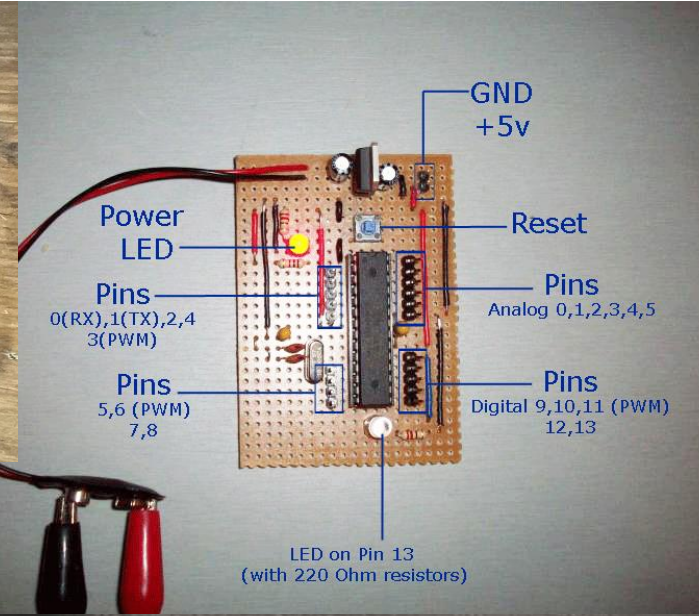
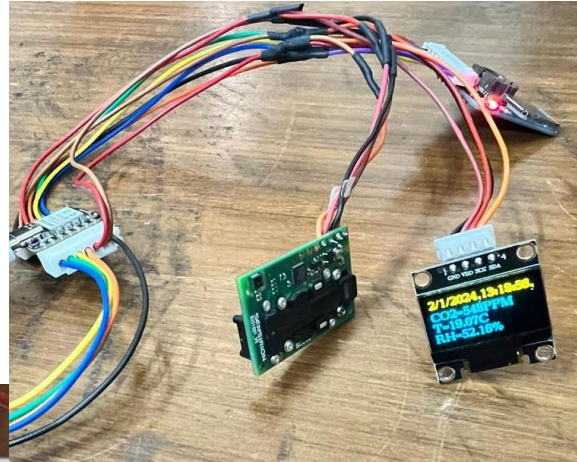
12:30:55 13/03/2015
Slow 0 Fast 0
Clock State Sync'd
16000298Hz GMT+0



Topic 4: Building a datalogger



- AVR, ESP
- Soldering
- Protoboard



Networking and communications

- Wired - SPI, I2C
- Wireless – Bluetooth, WiFi

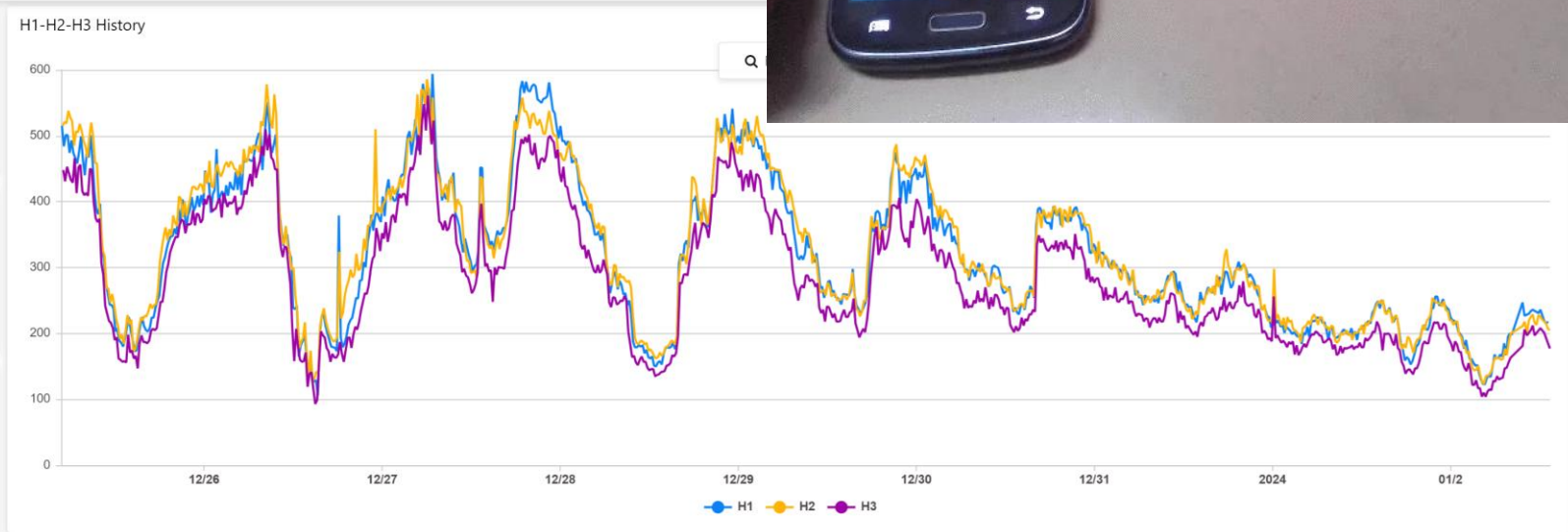


Collocated Study - TB Hospital

CSCW-H1 — 22 minutes ago
218 ug/m3
PM2.5

CSCW-H2 — 7 minutes ago
205 ug/m3
PM2.5

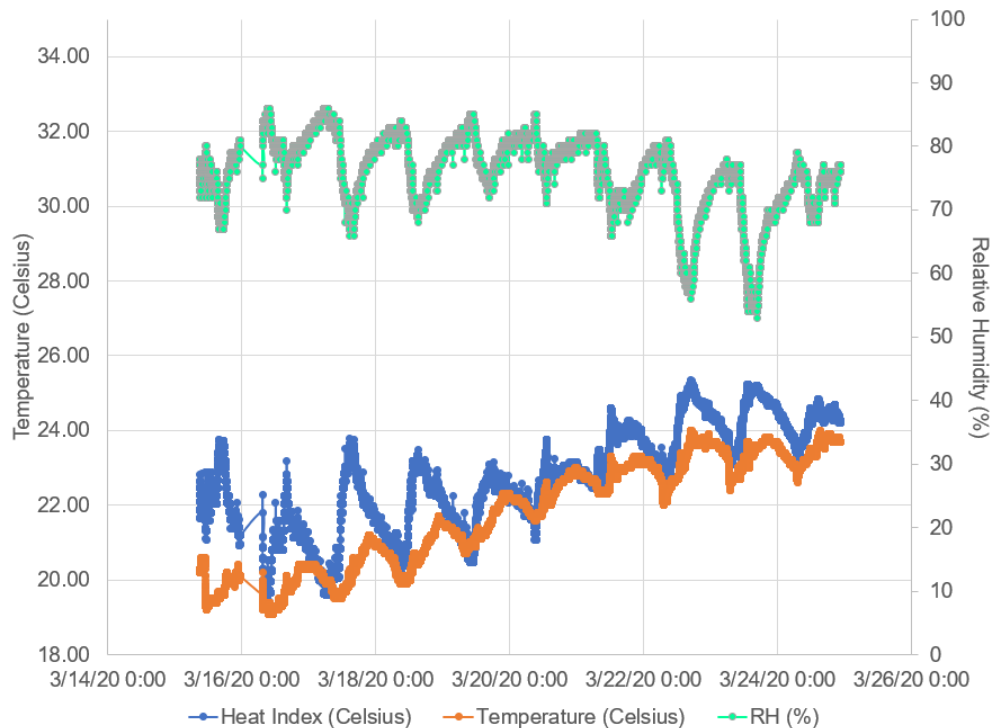
CSCW-H3 — 7 minutes ago
177 ug/m3
PM2.5



Topic 5: Experimentation and data analysis

Heat Index profile for my room

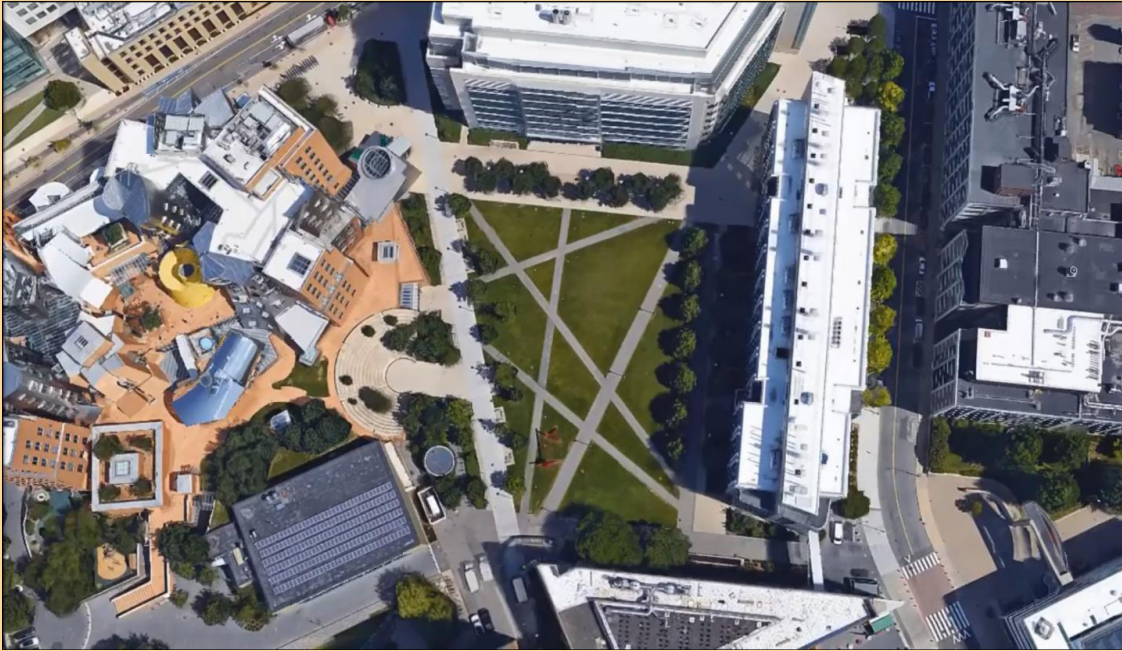
NodeMCU + DHT11 + ThingSpeak



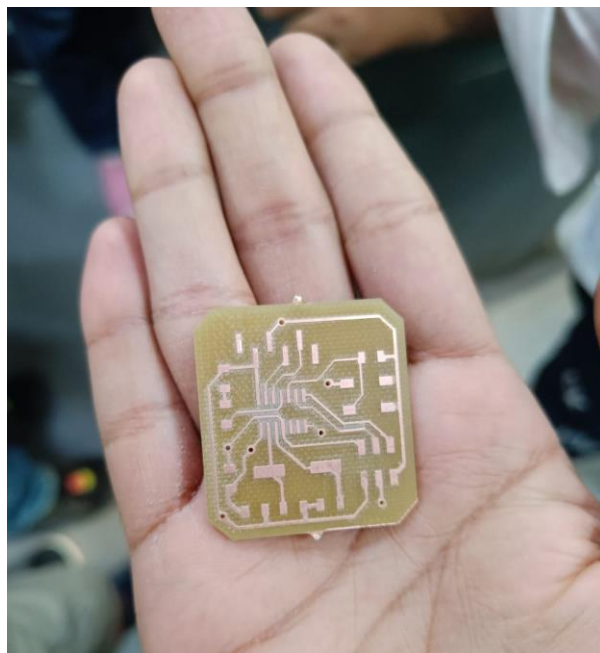
Observations

1. 48500 data points
2. T, Rh every 18 sec for 10 days
3. Cyclical pattern
4. Daily temperature increase
5. In the context of COVID-19, this analysis helps to know what Temp, Rh to avoid which is conducive for the virus
6. Thermal comfort in the hostels

Introduction to Data Science



- Big Data from MIT North Court study
- SAS data warehouse inventory management
- Handling data from sensors in MATLAB, Python, R



MAKERSPACE
IIT DELHI

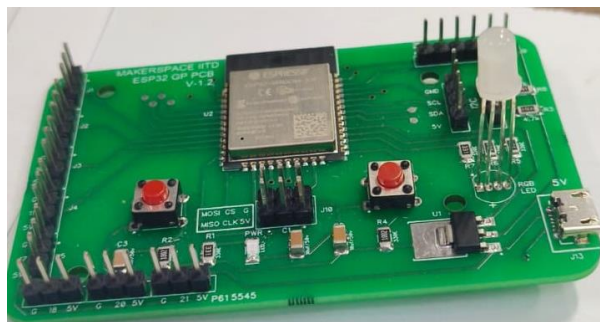
PRACTICAL ELECTRONICS

WORKSHOP
4 Days Training

3rd to 6th October 23 | Timings: 10AM -6PM
(1:00-2:00 Lunch)

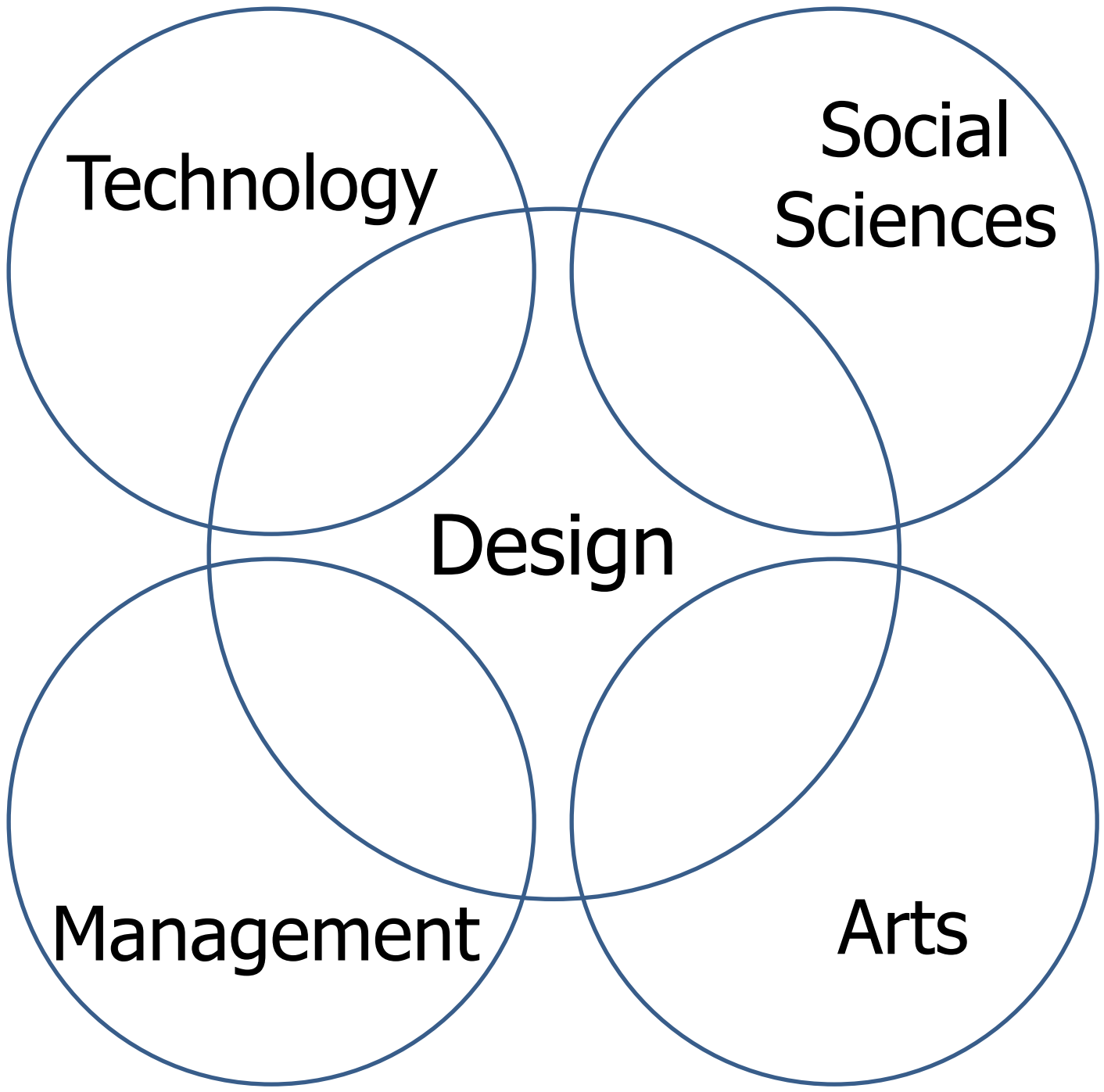
- Module 1: Basics of Electronics
- Module 2: Soldering
- Module 3: Arduino & Programming
- Module 4: PCB Designing
- Module 5: PCB Fabrication

ARDUINO

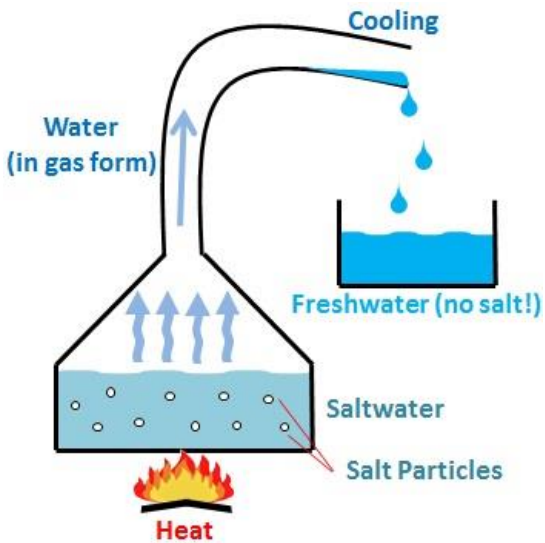


Extreme Making

Change.Makers



One science, science for impact



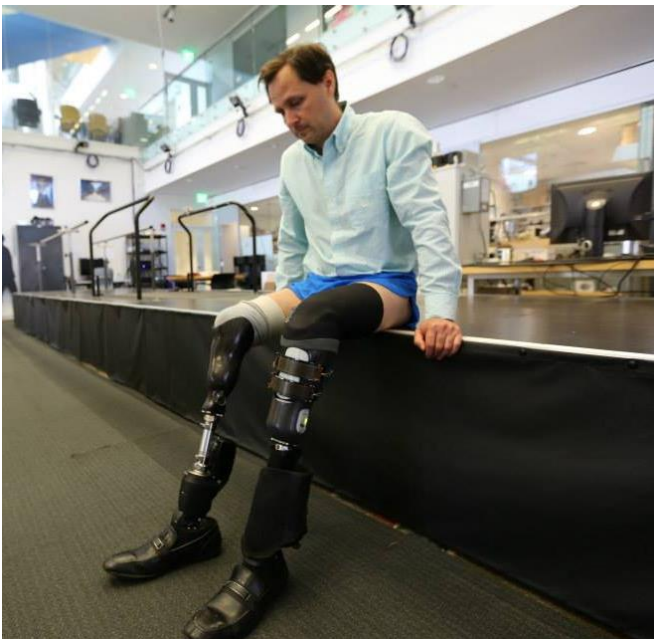
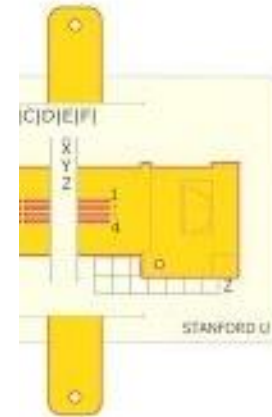
Water filter – plant xylem



Waste-water treatment

Biology, Chemical engineering, Mechanical engineering, Nano-technology, Social science

Examples of One Science: SOLVE water



Science for impact

Project ideas?

1. Does the temperature in an earth air tunnel stay constant all throughout the year? How can this help?
2. How hot/cold does it get in a hostel room? What are the factors that affect thermal comfort? Does it change from floor to floor?
3. What are the lighting levels in a space? What are the noise levels in a space? Does it meet the NBC guidelines?
4. How sustainable are we in terms of our energy consumption? Does an appliance consume the same amount of energy or does it fluctuate?



ChatGPT

Dataloggers are versatile devices that can be used to collect and record data in various experiments. Here are some interesting experiments you can conduct using dataloggers:

1. **Temperature Variation in Different Environments:**

Place dataloggers in various locations such as indoors, outdoors, near a window, or in a refrigerator. Record temperature data over time to observe how temperature varies in different environments.

2. **Solar Radiation Study:**

Mount a datalogger with a light sensor in an area exposed to sunlight. Record data to study the variations in solar radiation throughout the day or across different weather conditions.

3. **Humidity Monitoring:**

Use a datalogger equipped with a humidity sensor to monitor humidity levels in different rooms or environments. Explore how humidity changes over time and under different conditions.

4. **Acceleration and Motion Tracking:**

Attach an accelerometer-equipped datalogger to an object (like a moving vehicle or a swinging pendulum) to study acceleration and motion. This can be particularly interesting for physics experiments.

5. **pH Levels in Water Bodies:**

Submerge a datalogger with a pH sensor in different water bodies such as ponds,



More project ideas



ChatGPT

Dataloggers can be employed in various experiments related to the human body to monitor and analyze physiological parameters. Here are some interesting experiments you can conduct:

1. **Body Temperature Rhythms:**

Use a skin temperature datalogger to monitor the body temperature of a subject continuously over a day. Analyze the data to identify circadian rhythms and temperature variations during sleep and wake cycles.

2. **Physical Activity Tracking:**

Attach an accelerometer datalogger to monitor and record a person's physical activity throughout the day. This can include walking, running, and other movements. Analyze the data to understand activity patterns and energy expenditure.

3. **Heart Rate Variability (HRV) Analysis:**

Utilize a heart rate monitor datalogger to record heart rate variability over time. HRV can provide insights into the autonomic nervous system and stress levels. Experiment with different activities or relaxation techniques and observe the impact on HRV.

4. **Sleep Monitoring:**

Employ a combination of dataloggers, such as temperature and accelerometer sensors, to study sleep patterns. Monitor body temperature, movements, and sleep cycles to analyze sleep quality and duration.

5. **Oxygen Saturation Levels:**

Use a pulse oximeter datalogger to continuously measure oxygen saturation levels in



