Embedded System Workshop (EC3.202)
IoT Workshop (CE9.609)

Introductory Class

Instructors: Vishal Garg, Sachin Chaudhari, Aftab Hussain

Emails: vishal@iiit.ac.in, sachin.chaudhari@iiit.ac.in, aftab.hussain@iiit.ac.in

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INTERNATIONAL INSTITUTE OF INFORMATION TECHNOLOGY

HYDERABAD

Background: Vishal Garg (CBS)

- **Academics**
  - Prof., IIIT Hyderabad (2000-present)
  - PhD, IIT Delhi (2000)
  - B.E, Civil, MBM Engineering College, Jodhpur (1991-1995)
- **Research Interests:**
  - Bulding Energy Informatics
  - Cool Roofs
- **Research Projects**
  - Residential building energy demand reduction in India (RESIDE)
  - Center for Building Energy Research and Development (CBERD)
- **Awards**
  - Dr Arthur H Rosenfeld Urban Cooling Achievement Award – 2018
  - Fellow, International Building Performance Simulation Association (IBPSA)
  - Fellow, Indian Society of Lighting Engineers (ISLE)
  - Fellow, Indian Green Building Council (IGBC)

Background: Sachin Chaudhari (SPCRC)

- **Academics**
  - Asst Prof., SPCRC, IIIT Hyderabad (2015-present)
  - Postdoc, Aalto University, Finland (2013-2014)
  - PhD, Aalto University, Finland (2007-2012)
  - M.E., IISc Bangalore, India (2002-2004)
  - B.E., VNIT, Nagpur (1998-2002)
- **Industry**
  - Senior Wireless Communication Engineer, Esqube Communications, Bangalore (an IISc start-up) (2004-2007)
- **Research Interests:**
  - Signal Processing and Machine Learning for Wireless Communication:
  - IoT for Smart Cities, 5G and Beyond, Cognitive Radios.
- **Research Projects on IoT**
  - **DST and PRIF:** IoT Enabled Smart Cities: Pollution Health and Governance
  - **CoE on IoT for Smart Cities:** Coordinator
  - **India's First *Living Lab* for Smart City Research**

Background: Aftab Hussain (CVEST)

- **Academics**
  - Asst Prof., IIIT Hyderabad (2018-present)
  - Postdoc Fellow, Harvard University (2016-2018)
  - MS+PhD, KAUST, Saudi Arabia (2011-2016)
  - B.Tech, IIT Roorkee (2005-2009)

- **Industry**
  - Design Engineer, Analog Devices India (2010-2011)

- **Research Interests: Flexible electronics, sensor systems, smart cities, IoT**

- **Research Projects**
  - **Talk to me...**

Outline

- Course Introduction
  - Embedded System Workshop 2019
  - Projects

- Course Administration
  - Syllabus
  - Resources
  - Evaluation

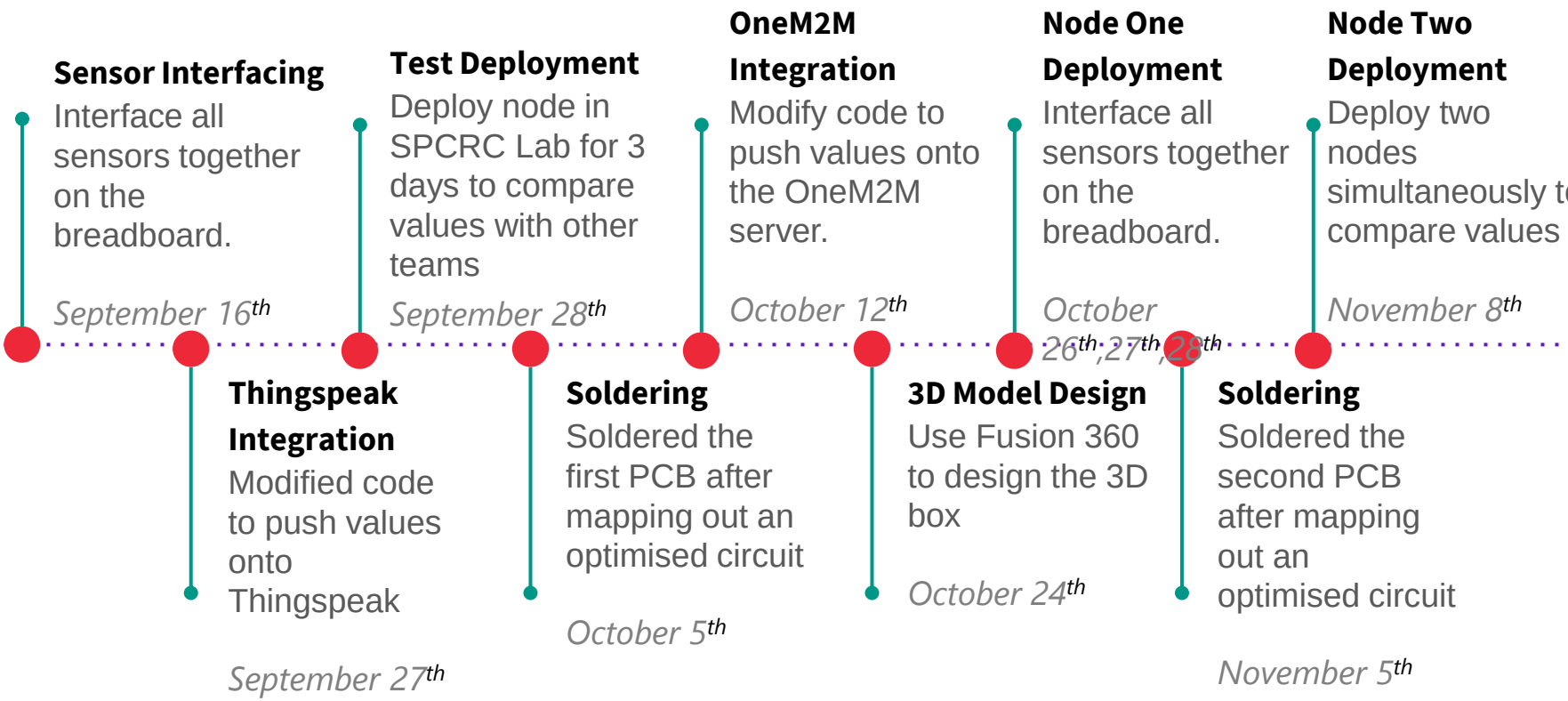
Embedded System Workshop - M2019

- A very hands-on approach to the course
  - CSE students of 3rd semester
  - 50 teams of 3 students each

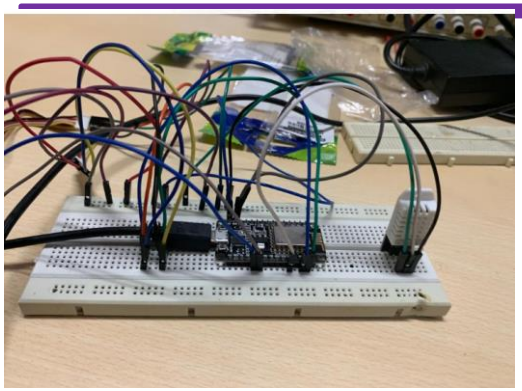
- First phase of Living Lab done by ESW course – 2019
  - Coordinator Fall-2019: Prof. V. Garg (supported by S. Chaudhari and A. Hussain)
  - Hardware provided by institute
  - Topics: Air pollution, Building energy efficiency, water quality and Quantity, Smart classrooms, streetlights

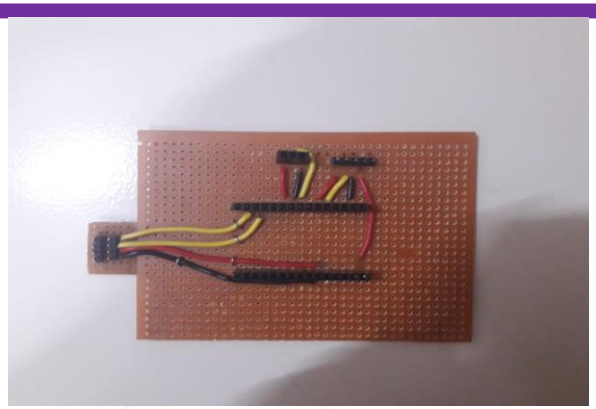
https://www.youtube.com/watch?v=RcxKJ54GH6Q

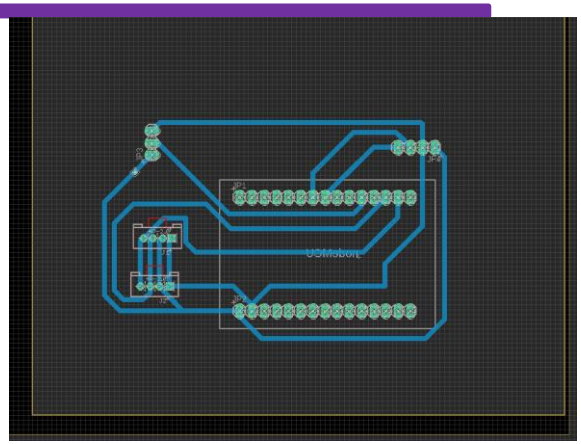
ESW: *Different Aspects Involved*

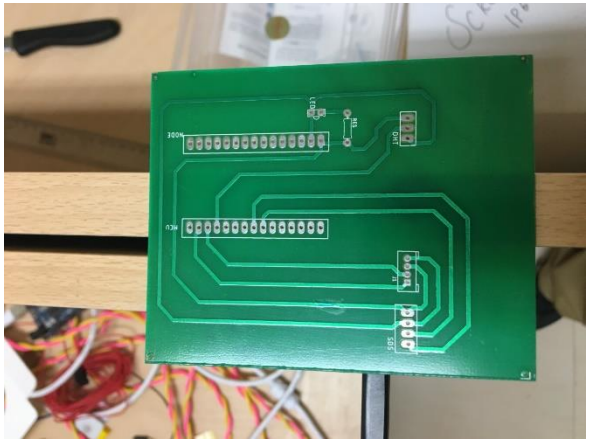


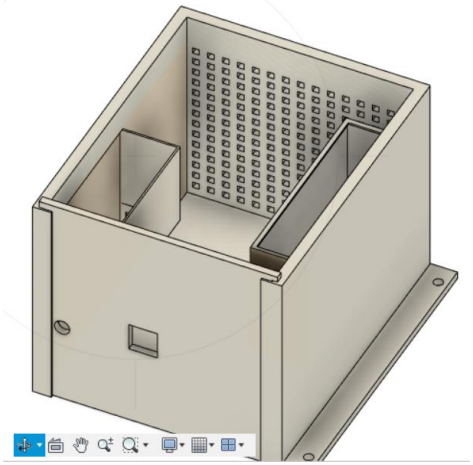
ESW: *Different Phases*











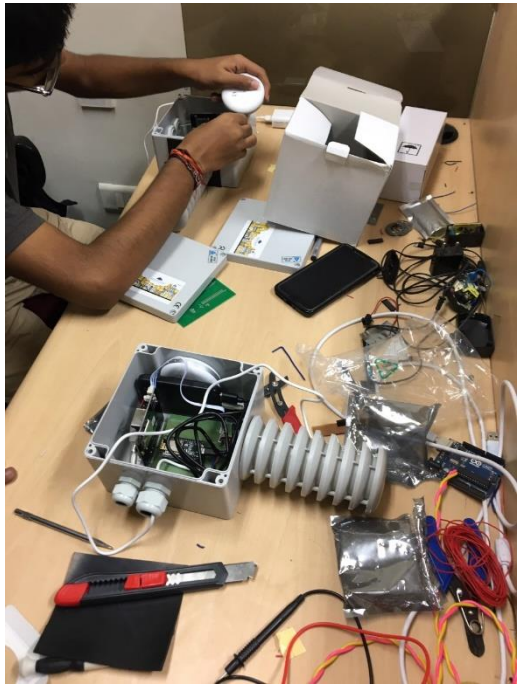
ESW: *Some Photos from Deployment*

- **Indoor: Faculty Quarters – I and II**

- **Indoor: Mess**

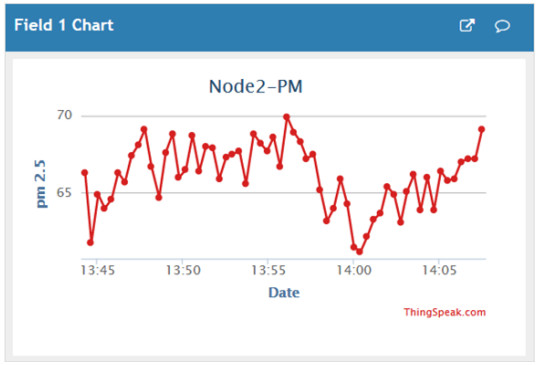
ESW: *Outdoor Deployment*

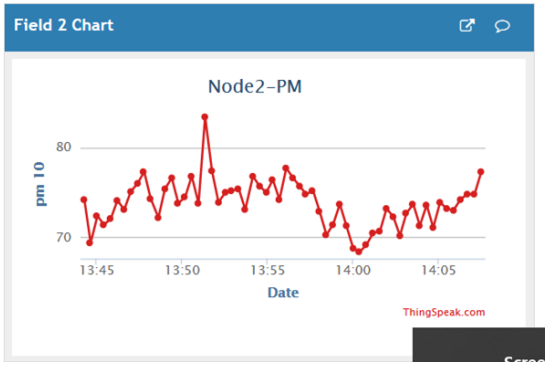
ESW: *Students at Work*

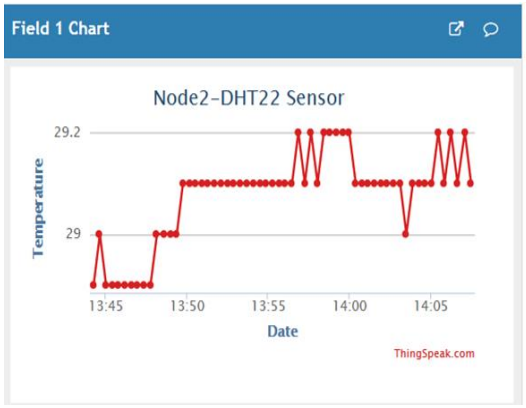


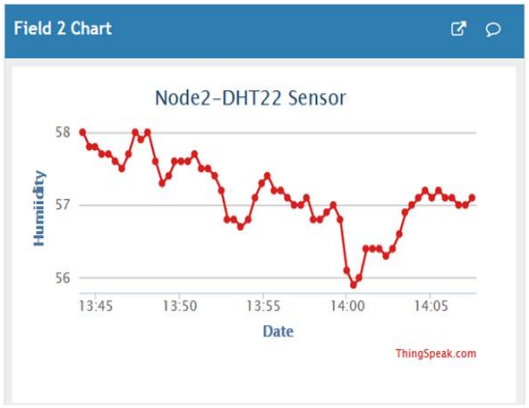
ESW: *Sample Data*

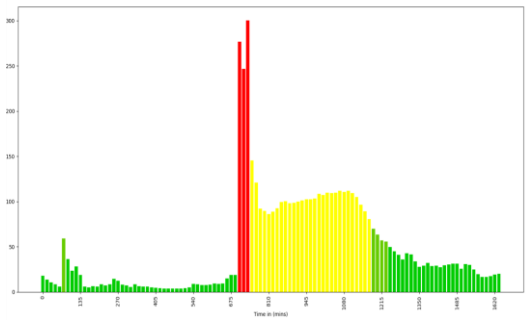
- ThingSpeak data -

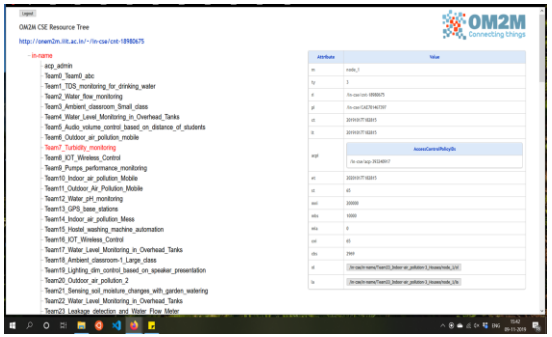












- We have our own Twitter channel !!

oneM2M

Projects for ESW this time!

Projects for IoTW will be separately announced!

Project 1: Indoor Air Pollution

- Guide: Sachin Chaudhari
- TA: Rajashekar Reddy

- For many people, the risks to health may be greater due to exposure to air pollution indoors than outdoors. In this project, we will monitor different related parameters
  - Particular Matter
  - Carbon Dioxide (CO2)
  - Volatile Organic Compounds (VOCs)
  - Temperature and Humidity
- This information must be do send to the dashboard or message. An alarm should be raised if the values deviate than permissible limit.
- Open-ended !!!

Project 2: PID control of DC motor

- Faculty: Harikumar Kandath
- TA: Sudhansh

- The experiment is to demonstrate the principle of feedback control. The setup contains a DC motor with input voltage controlled through Arduino, RPM sensor attached to the motor shaft. The output of the speed of the motor as per the desired reference. Different feedback control laws speed of the motor as per the desired reference. Different feedback control laws can be tested using this setup. The Arduino device can be connected to a PC or any other IoT device.

Project 3: Obstacle Avoidance for Ground Robot

- Faculty: Harikumar Kandath
- TA: Sudhansh

- The detection of the obstacle is performed using ultrasonic sensor. The range measured from ultrasonic sensor is used to control the servo motor that drives the wheel of the robot. The algorithm is implemented in Arduino. Algorithm like potential field method can be implemented for obstacle avoidance.

Project 4: Remote Triggered Lab - DC Motor

- Faculty: Aftab Hussain
- TA: Navnit

- In this project, a system will be created to measure the speed of a DC motor for an applied input voltage. The students are expected to plot speed vs voltage for no load operation and compare with theoretical expectations. Further, the power consumed by the motor can be calculated using the current and voltage inputs.

Project 5: Water Level Monitoring

- Faculty: Aftab Hussain
- TA: Navnit

- Use a water level indicator, or ultrasound sensor to control a motor to keep the water level in a system, say a plastic box, within specific bounds. The system should be able to indicate the present level of water and whether the pump is on/off on a central dashboard.

Project 6: Smart Farming

- Faculty: Anshu
- TA: Bhavyajeet

- In this project, propose an IOT system to sense VOCs for accurately predicting onset of pathogen attack on the plant. This will help to more precisely control the spread of the pathogen by using minimal amount of pesticide on the target area. A network on VOC sensor, temperature, humidity (soil), light, O2/CO2 can be deployed on the farm. In the project, these above mentioned sensor will be interfaced and deployed on an experimental farm (plants). Response to any stress introduced will be recorded via change in temperature, humidity & VOC levels of the plants.

Project 7: Wearable Device

- Faculty: Kavita
- TA: Jayati
- Wearable device to measure pulse rate, SPO2, BP, SCR and temperature - commercially available devices are mostly accurate but have the following issues:
  - a) SPO2 is not auto collected, requires the wearer to sync to the cell phone. So, we need a trigger system to collect this parameter once every hour.
  - b) the BP measurement wearable are expensive and ultrasonic sensors has been found to be accurate and can reduce the cost.
- An addition which other wearables do not have is Skin conductance response - inclusion of this sensor will allow of monitoring changes due to stress or anxiety but importantly provide better correlation to BP/Pulse rate and temperature.

Project 8: Gas Sensing

- Faculty: Syed Azeemuddin
- TA: Prashant

- This project is about sensing harmful gases (such as CO2, CO, AC refrigerant). In case there is a leak, alarm should be raised and a message needs to be generated.

Project 9: Water Quality Measurement

- Faculty: Deepak
- TA: Suhas

- In this project, objective is to periodically measure different drinking water quality parameters such as pH, Turbidity, and TDS. This information has to be sent to the dashboard. An alarm should be raised if the values deviate than permissible limit.

Project 10: Motion Sensor for Occupancy Detection

- Faculty: Vishal
- TA: Ganesh

- In this project, the objective is to interface a PIR motion sensor/Grid Eye Infrared Array Thermal Camera Sensor and develop algorithms so that the false OFFs are reduced while dynamically changing the Time Delay to reduce energy wastage. ML can be deployed online to develop occupancy models.

Project 11: Monitoring Energy Consumption of an Appliance

- Faculty: Vishal
- TA: Ganesh

- The objective of this project is to develop a smart power strip that can monitor the energy consumption of connected devices. Intrusive Load Monitoring algorithms can be trained online and deployed on the device to automatically detect connected devices and their states. Device signatures can be crowdsourced and added to an online library.

Project 12: Understanding SHM using a Cantilever Beam

- Faculty: Sachin/Vishal
- TAs:
  - Bharat (domain expert)
  - Rajashekar+Ganesh (embedded experts)

- In this project the cantilever beam model is recreated for understanding structural health monitoring (SHM). The beam is monitored using accelerometers and strain gauges. Using the vibration analysis on the collected data, the damage and degradation in the structure can be detected. The purpose of the project is to prevent damage and to maintenance of the building systems to reduce risks and associated costs.

Projects are open-ended

- Few things which can be common across projects:
  - **Basic dashboard or App**
  - **Data processing / Alerts**
  - **Cloud interfacing**
  - **Basic oneM2M implementation**
  - Power management (putting device to sleep)
  - Data transmission and storage reduction
  - Connection outage management
  - Use of RTC
  - Security
  - Soldering
  - PCB
  - 3D Enclosure
- Students are encouraged to test, deploy, and productize their projects

Course Details/ Logistics

Syllabus – 1/2 (Tentative)

1. **Sensing/Actuators and Interfacing**
   a. Sensor/Actuator selection (using data sheets)
   b. Physics of sensors and actuators related to projects
   c. Interfacing: Serial interfaces, Analog out, SPI, UART, I2C, “propriety" such as DHT22
2. **Controller, Embedded Systems and Peripherals** -
   a. Platform selection – ATMEL328, **ESP32**, STM8 Architecture; timers, interrupts, AVR, SAMR architectures, Arduino Nano33-IoT
   b. Embedded Systems: power management, interrupts, memory managements, leaks, OTA firmware update, reliability, onboard debugging
   c. Peripherals: RTC, ADC channels, resolution, onboard memory, power, external/internal watchdog
3. **Communications, Networking and IoT Architecture**
   a. **Different IoT communication protocols:** Comparison of Zigbee/WiFi/BLE/4G/5G/eSim/LoRaWAN
   b. **Data Protocols:** MQTT/HTTPS/CoAP

Syllabus – 2/2 (Tentative)

5. **Data Storage and Computation**
   a. **Cloud storage and computing**
   b. **Data retrieval optimization**
   c. **IoT standards for interoperability:** Implementation using oneM2M
6. **PCB and Enclosure Design**
7. **Data privacy and security**
8. **Dashboard and Visualization**
   a. Software/Approaches: UI/UX and Time Series Data Visualization; Front-end and back-end technologies
9. **Documentation**
   a. User document and developer's documentation
   b. Best practices for writing the two documents
   c. Referring style manual. For example, *Microsoft/Chicago manual of style*

Resources

BOOKS

- Raj Kamal, *Internet of Things,* McGraw Hill, 2018
- P. Lea, *Internet of Things for Architects*, Packt, 2018
- O. Hersent, D. Boswarthick, O. Elloumi, *The Internet of Things*, Wiley, 2016
- D. Norris, *The Internet of Things*, McGraw Hill, 2015
- A. Bahga and V. Madisetti, *Internet of Things*, University Press, 2016

VIDEOS

- National Programme on Technology Enhanced Learning (NPTEL) and SWAYAM
  - Introduction to Internet of Things, Sudip Misra, IITK
  - https://swayam.gov.in/nd1_noc19_cs65/preview

- Research papers and online content

Basic Electronic Kit

- https://rees52.com/robots-kits/5107-esw-cse-course-rs1340
- Has everyone received the kit? A quick poll

Reimbursement for Project Sensors

- Students will be reimbursed for the project specific-sensors and other electronic components
  - Not the components in the electronic kit!
  - Please consult your faculty before purchasing the project specific sensors
- It is expected that only one set of sensors/components will be reimbursed per team (Maximum upto **Rs. 10 K per team!**)
- Students will send soft-copy of bills to the faculty in advanced. Bills should be proper and in name of IIIT Hyderabad.
- When students come back to campus in Jan. 2022, you can return the sensors and claim your reimbursement. Note that the reimbursement bills have to be submitted by Jan. 2022.

Course Portal

MOODLE: https://courses.iiit.ac.in/

Under Monsoon 2021

If you are not already enroled, email us.

- News
- Discussion Forum
- Projects

Exams and Evaluation (ESW)

- Mark Distribution
  - Quizzes (10)
  - End Sem (30)
  - Project (60)

- Grading: Relative (TBD)
- Exam and Evaluation of IoT workshop course is separately communicated

Questions?

- That's all for today!