Introduction to Mechanical Measurements

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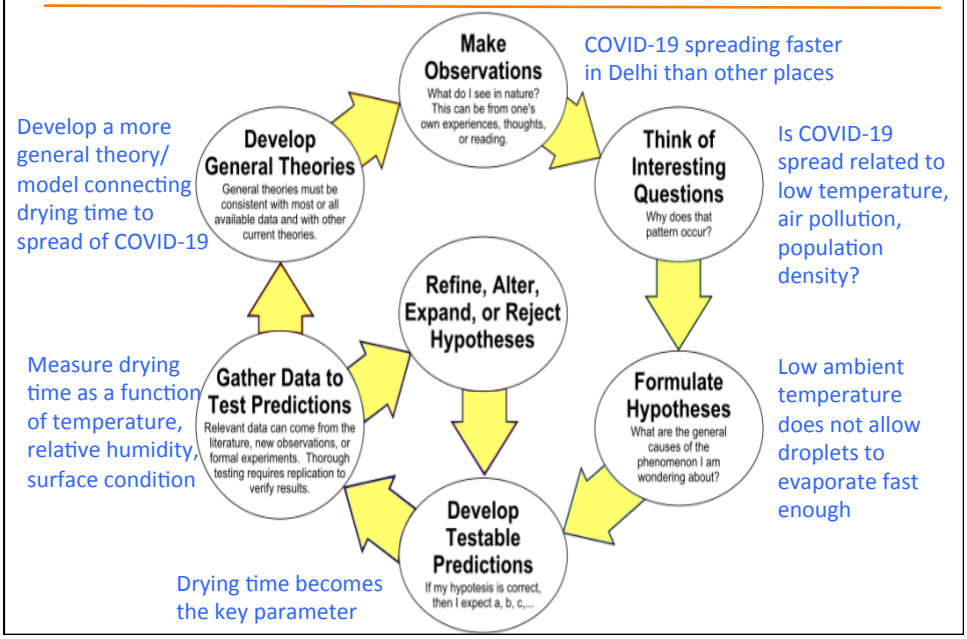
Scientific Method



COVID-19 spreading faster in Delhi than other places

Is COVID-19 spread related to low temperature, air pollution, population density?

Low ambient temperature does not allow droplets to evaporate fast enough

Drying time becomes the key parameter

Measure drying time as a function of temperature, relative humidity, surface condition

Develop a more general theory/ model connecting drying time to spread of COVID-19

Importance of Measurements in the Current times

- Primary source of coronavirus is respiratory droplets
- So how many droplets are coming out from an infected person? How many of them are likely to be breathed in by a neighboring person?
- Need to know amount of air exhaled and inhaled
- Need information about droplet size and distribution
  - Larger droplets may get deposited on nearby surface, smaller droplets tend to move further away
- Temperature and humidity of air exhaled
- Amount of mixing between exhaled air and ambient air
- Presence of a breeze (speed and direction) can have a drastic effect

Three main approaches in Scientific Enquiry

- Measurement
  - Physical observation with numbers
- Theory
- Modeling / Simulation

Features of Theoretical Approach

- Study of a mathematical equation/model of the physical system
  - Eg. Navier-Stokes equations describe fluid flow
- Simplifying assumptions are sometimes made to reduce the mathematical complexities
  - Recall, flow in a tube/pipe
  - Navier-Stokes equations get simplified for this case
- Gives results of general use (rather than for restricted applications)
  - Velocity profile is parabolic
  - Pressure drops linearly

- What if the pipe has some irregularity
  - Think of deposition in blood vessels, leading to various diseases

Features of Modeling Approach

- Capture the features of a physical system through model elements (mass, spring, damper, etc)
  - Add regular (instead of irregular) geometric elements in pipe
- Develop a mathematical model of the constructed system

- Requires only paper, computers, etc to solve
- Time delay in building physical models (for experimentation) and instrumenting it gets avoided

Features of Experimental Methods

- Simplifying assumptions may not be required (true behavior of the system can be studied)
  - Actual geometry of artery can be studied
  - Incoming flow can be made pulsatile (similar to pumping by the heart)
- Actual system or its scaled model (constructed using principles of similarity) studied
  - May have to make a scaled-up model of blood flow in artery
- Accurate measurements may require expensive instruments
  - Measure flow rate and pressure drop as a function of time
  - The characteristics of all measuring and recording equipments must be thoroughly understood, esp. their dynamic response
- Gives specific results for the system studied. So make measurements over the parameter range of interest
- Use dimensional analysis for generalizing the results
- Considerable time required for design, construction and debugging of instruments

Types of Measurement Applications

- Monitoring of processes and operations: Refers to situations where measuring device is used to keep track of some quantity

  (e.g. Speedometer to track speed of vehicle;

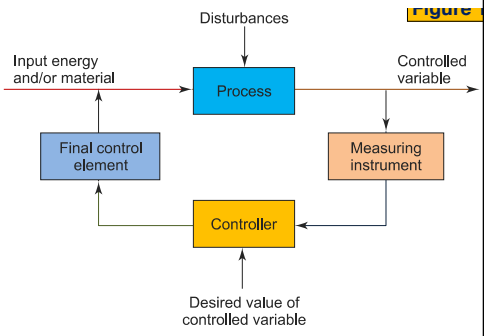
  Thermometer, humidity meter, anemometer to keep track of temperature, humidity, wind speed of atmospheric condition.)

Types of Measurement Applications
(contd.)

- Control of processes and operations: Refers to an automatic feedback control system

  (e.g. Thermostat in water geyser regulates water temperature in the geyser.

  Oxygen sensor in car engine to measure amount of O_2 in exhaust; regulates air intake in the next intake cycle accordingly.)



Types of Measurement Applications
(contd.)

- Experimental engineering analysis: Engineering applications typically requires measurements.

  (e.g. Acoustic design of a room – requires measurement of sound intensity/ reflection in the room.

  Air conditioning requirement of a building – needs measurement of heat loss from the building, heat load on the building, etc.)

Types of Experimental-Analysis Problems

- Testing the validity of theoretical predictions based on simplifying assumptions; improvement of theory based on measured behavior
- Formulation of generalized empirical relationships in situations where no adequate theory exists
- Determination of material, component, and system parameters, variables and performance indices
- Study of phenomena with hopes of developing a theory
- Solution of mathematical equations by means of analogies