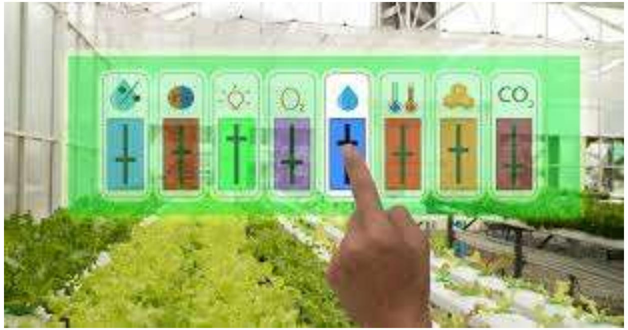


AR - GLASSHOUSE

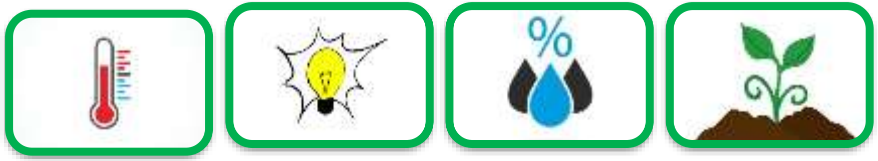
19 – 097 | Progress Presentation II

Background

- Greenhouses contribute to farming a lot.
- Automated Greenhouses involve the automatic monitoring and controlling of climatic parameters.
- Many organizations are in the process of automating the Greenhouses.
- "Augmented Reality" is quite new to the agriculture industry.
- The solution that we present is an Augmented Reality simulation of an IoT based Greenhouse.

Progress Path to Objectives

- Climatic Parameter
  - Theoretical Approach
  - Distribution model
  - AR Simulation

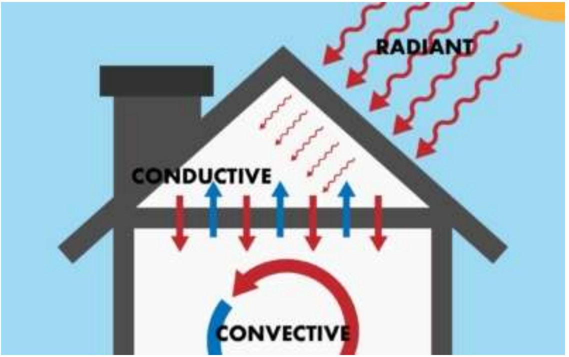


Temperature | **Light Intensity** | **Humidity** | **Soil Moisture**

Thermal Distribution

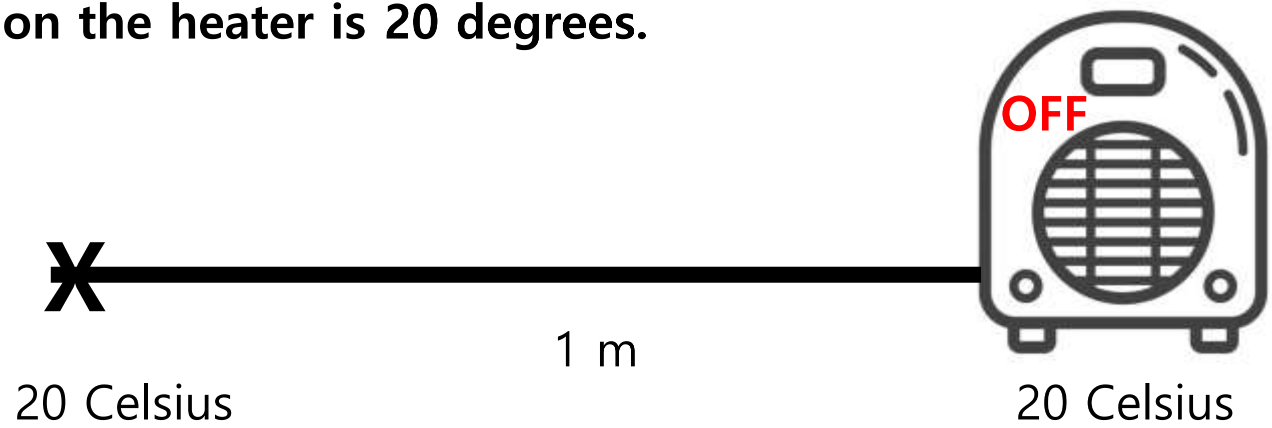
There are 3 ways of transferring heat.

1. Conduction
2. Convention
3. Radiation



Temperature

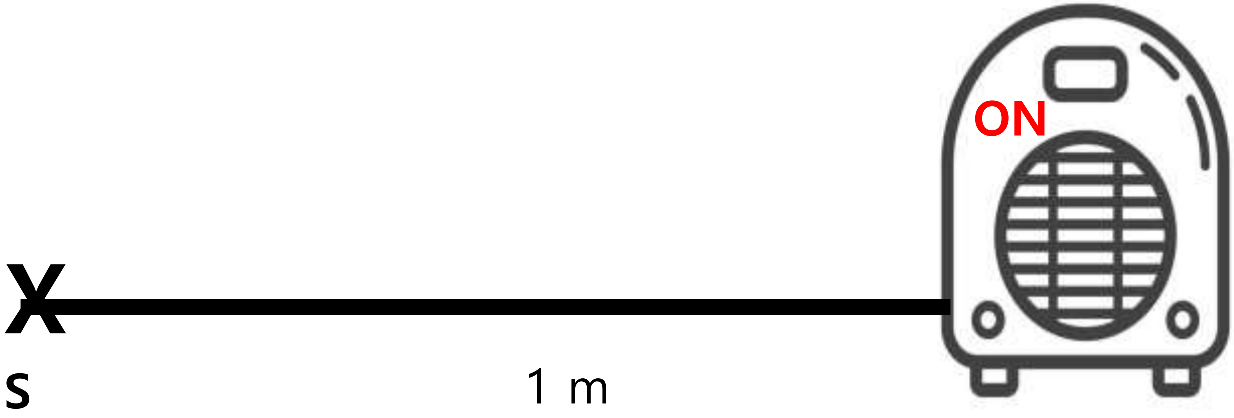
- **Here we mainly consider how the temperature varies with the distance.**
- **Assume the Temperature inside the Greenhouse before switch on the heater is 20 degrees.**



Temperature

10 minutes after switching on the heater

Thermal conductivity at 20 Celsius = 0.02514 J



Temperature

$$\boxed{Q = mc\Delta T}$$

- m (mass of air) = 1.204 kg/m^3
- c (Specific Heat) = 1007 J kg K
- Thermal conductivity at 20 degrees = 0.02514 W/m -K

After 5 min of turning on the Heater

$$\boldsymbol{\Delta T = \frac{Q}{mc}}$$

$$\Delta T = \frac{0.02514 * 100 * 5 * 60}{1 \cdot 204 * 1007}$$

$$\boldsymbol{\Delta T = 0.63}$$

❖So, Temperature at S = 20.63

Optimum Temperature levels

17 Celsius

18 Celsius

25 Celsius

Light Intensity

Adding artificial light in a greenhouse enables a host of benefits to plants by acting as a supplement when natural light hours are limited or when radiation from the sun is low.

Light Intensity

Here we mainly consider the how intensity level varies with the surface area.

$$\boxed{E_{v(lx)} = \frac{P_{(w)} \times \eta_{\left(lm/_{w}\right)}}{A_{(m^2)}}}$$

$E_{v(lx)}$- illuminance in lux

$P_{(w)}$- power in watts

$\eta_{\left(lm/_{w}\right)}$ - luminous efficiency in lumens per watt

$A_{(m^2)}$ - surface area in square meters

Light Intensity

We assume to fix a bulb which has 25 W power and cover 1 square meter from the plantation.

$$\boxed{\boldsymbol{E_{v(lx)} = \frac{P_{(w)} \times \eta_{\left(lm/w\right)}}{A_{(m^2)}}}}$$

Applying the above equation,

$$\boldsymbol{E_{v(lx)}} = \frac{25\times60}{(1)^2} = \textbf{1500 lux}$$

Optimum Lux levels

19100 lux

12000 lux

13704 lux

How many bulbs needed?

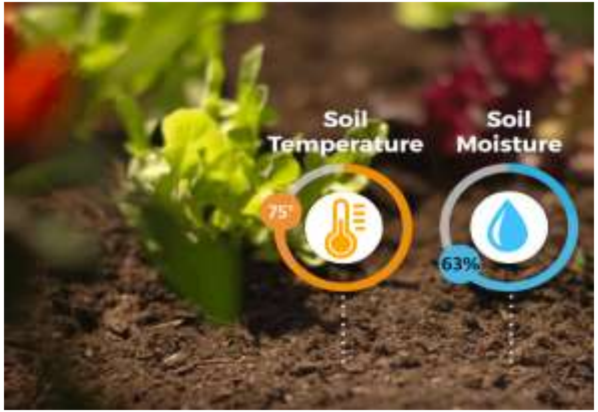
  X 12

  X 8

  X 9

Soil Condition

- Any component of soil that affect plant growth and development shall be tested or detected.
- Some of them are nutrients, moisture, pollutants, ph, thermal conductivity, temperature, electrical conductivity.



Most influential factors - Moisture, Temperature

Moisture

- The most accurate method of soil moisture measurement is through weight ('gravimetric') measurements
- Volumetric Water Content(VWC) sensors include Probes and Dielectric Probes.
- Most VWC sensors measure soil dielectric properties.
- It is usually desirable to measure at several points in the root zone profile. Some moisture probes accommodate this by providing an array of sensors, in a single probe, positioned at different depths.
- Time domain reflectometry (TDR) is an indirect measure of soil water content

Time Domain Reflectometry

Is an indirect measure of soil water content based on the travel time of a high frequency electromagnetic pulse through the soil
The **dielectric constant/Permittivity** is a constant that tells you how strong the electric force is.

equation below was developed by Topp et al. (1980) for conversion of Ka to volumetric water content:

θ = -5.3 x 10-2 + 2.92 x 10-2 Ka – 5.5 x 10-4 Ka2 + 4.3 x 10-6Ka3

Ka = (ct/2L)2

c = 3 x 108 m s-1 (propagation velocity of electric signals and light in a vacuum)

t = the travel time (t) of the step pulse

L= transmission line or wave guide of length

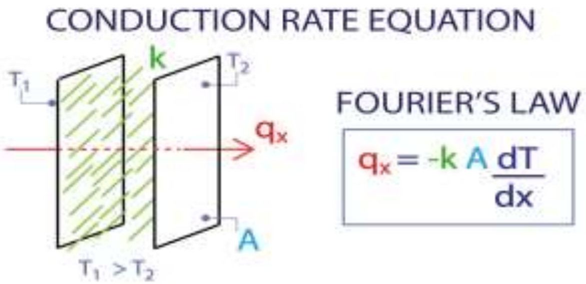
Ka = the apparent dielectric constant

It has been shown that the relationship between volumetric water content (θ) and dielectric water constant (Ka) is essentially independent of soi l texture, porosity, and salt content.

Soil Temperature

- Soil temperature is an important property that is essential for many soil processes
- Temperature can also defined as a measure of how warm or cold an object is.
- IoT Sensors are used to directly measure the temperature in C or K
- There are three major heat transfer processes in soils namely conduction, convection and radiation to view heat distribution in soil
- Heat Flow is what is calculated through temperature to view the the heat distribution in soil
- The law of heat conduction is also known as **Fourier’s law**.

Heat flow in soil can be described by the following equation:



Q′ is the heat flow rate by conduction (W)

'k' is the thermal conductivity of body material ($W{\cdot}m^{-1}{\cdot}K^{-1}$)

'A' is the cross-sectional area normal to direction of heat flow (m^2) and

'dT/dx' is the temperature gradient ($K{\cdot}m^{-1}$).

Humidity

$$RH_{in} = 1.36096 \frac{(RH_{out})^{0.923}(H)^{0.086}}{(V_r)^{0.002}(V_s)^{0.005}(LI_{out})^{0.0072}(U_{out})^{0.0072}}$$

RH_{in} = inside relative humidity (%)
RH_{out} = outside relative humidity (%)
V_r = roof ventilation (% of floor area)
V_s = side ventilation (% of floor area)
LI_{out} = outside light intensity (lux)
H = height of the greenhouse (m)
U_{out} = outside wind velocity (m sec-1)

Humidity

The number of sprinklers that were required was obtained using the following formula:

$$number\ of\ sprinkler = \frac{\text{Greenhouse area}}{\text{Sprinkler area}}$$

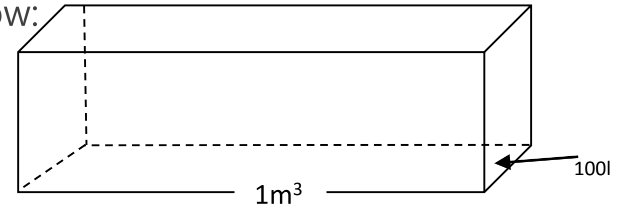
To calculate the required waterfall by a sprinkler, the following equation was used

$$\text{Sprinkler waterfall} = \frac{\text{total required waterfall}}{\text{Number of sprinklers}}$$

The following assumptions were made when creating the mathematical model;

- Recommended working pressure = 2.0 – 3.5 kg/cm2
- Flow rate = 30 – 40 LPH
- Wetted diameter = 1.2m
- Constant temperature

The calculation of the above process is given below:



RH of greenhouse = 50%

RH that needs for plants optimal growth = 70%

RH difference = 20%

Volume of greenhouse = 1m3

*Assumption – 1m3 = 100l = 100% RH

Required water volume = 100l/100 * 20

= 20l

Area of sprinkler = 0.25m2

Area of greenhouse flow = 1m2

No. of sprinklers needed = 1m2/ 0.25m2

= 4

One sprinkler rainfall = 20l/ 4

= 5L

Limitations

- Limited Knowledge of physics
- Mathematical modelling of each factor is challenging
- Building up an equation for distribution of a factor needed so many theoretic concepts
- Requires the support and knowledge of physicists and agriculturalists