RIZAL TECHNOLOGICAL UNIVERSITY
COLLEGE OF ENGINEERING – COMPUTER ENGINEERING
COGNATE ELECTIVES COURSE 3

W O R K S H E E T

Title of the Project:

"Innovative Oyster Mushroom Farming: Integrating IoT and AI for Enhanced Growth and Yield"

Brief Background of the Project:

Oyster mushroom farming has gained popularity due to its high nutritional value and economic potential, offering a sustainable and efficient food source. However, maintaining the ideal growing conditions—particularly in traditional farming methods—poses a significant challenge. Temperature, humidity, light, and CO2 levels must be carefully managed to ensure consistent yields and quality. Without proper control, fluctuations in these factors can lead to poor growth and suboptimal harvests, making it difficult for farmers to maintain consistent crop performance.

With the advancement of technology, the integration of Internet of Things (IoT) and Artificial Intelligence (AI) in mushroom farming has opened up new possibilities for improving the cultivation process. IoT systems enable real-time monitoring of critical environmental factors, including temperature, humidity, and CO2 levels, through the use of specialized sensors. For oyster mushrooms, maintaining a temperature range of 18°C to 24°C, humidity levels between 80% and 95%, and low CO2 levels (below 1000 ppm) is crucial for optimal growth. IoT sensors connected to automated systems ensure that these conditions are continuously regulated.

In addition to real-time monitoring, AI algorithms analyze the data collected from IoT sensors to make precise adjustments to the growing environment. By processing this data, AI can automatically regulate factors such as airflow, misting, or light exposure, creating a stable environment for oyster mushrooms. This technology not only increases yield and quality but also reduces resource waste, improves energy efficiency, and allows farmers to focus more on other aspects of their operations, leading to more efficient and sustainable mushroom farming practices.

Planning & Requirement Identification

- **Environmental Scanning**

Key Parameters for Optimal Growth of Oyster Mushrooms:

1. **Temperature:**
   - Ideal Range: **18°C to 24°C** for fruiting.
   - Colonization Phase: **20°C to 25°C.**
   - Temperatures outside these ranges can slow down growth or prevent fruiting.
2. **Humidity:**
   - ***Optimal Humidity***: 80% to 95% during fruiting.
   - Mycelium development and fruit body formation require consistently high humidity.
3. **Substrate:**
   - Oyster mushrooms thrive on various organic substrates like ***straw, sawdust,*** *and* ***wood chips.***
   - Substrate should be ***pasteurized*** or ***sterilized*** to reduce contamination.
4. **CO_2 Levels:**
   - ***Optimal CO_2***: Below 1000 ppm.
   - High CO_2 levels cause longer stems and smaller caps, reducing mushroom quality.
5. **Light:**
   - Requires ***indirect light*** or low-intensity artificial light (*12 hours per day*) for proper fruiting.
   - Complete darkness can delay or inhibit fruiting, while too much light can dry the substrate.
6. **Airflow:**
   - Good ***ventilation*** is essential to maintain low CO_2 levels and ensure proper oxygen exchange.
   - Stagnant air can lead to poor growth or contamination.
7. **pH Level:**
   - Optimal substrate pH is ***5.5 to 6.5.***
   - The slightly acidic environment supports mycelium colonization and mushroom growth.
8. **Moisture:**
   - Substrate must be ***moist*** but ***not waterlogged.***
   - Misting or humidity control is necessary to maintain proper moisture levels during fruiting.

- **Goals and Objectives**

Our goal is to innovate the Oyster Mushroom Farming system by integrating Internet of Things (IoT) and Artificial Intelligence (AI) to optimize environmental conditions, increase harvests quality, and reduce the physical work.

Our Objectives Are:

1. To design a smart oyster mushroom farming system with the use of IoT sensors to monitor and stabilize the crucial environment conditions such as: humidity, temperature, light, and CO_2.
2. To integrate AI managed systems to evaluate data real-time and make automated changes to the farming environment.
3. To ensure that ideal growing conditions are continuously maintained to increase crop quantity and quality.
4. To provide a simple interface that enables farmers to monitor and manage their farms from a distance.

- **Scope / Limitation of the project**

Scope of the Oyster Mushroom Farming:

1. The project is much more focused on developing automated oyster mushroom farming with the use of IoT devices to monitor the environmental parameters needed for the automated oyster mushroom farm.
2. The AI will be used to analyze the collected data and provide real-time response to optimize growing conditions.
3. The web-based interface will be included in the system allowing remote management and monitoring to the oyster mushroom farming system.
4. Integration and utilization of; basic irrigation, lighting, airflow, humidity and temperature control system.
5. Many regular activities, including watering, misting, and air circulation, may be handled by automated devices, which eliminates the need for manual labor. AI is also capable of scheduling the harvesting time according to the best growth phases. But the harvesting itself will be done manually.

Limitation of the Oyster Mushroom Farming:

1. The project's primary focus is, it will be implemented indoors and may not be suitable for outdoor environment or large-scale business operation.
2. The initial expense for setting up AI and IoT devices can be a challenge for small-scale farmers.

3. The quantity and quality of data gathered throughout the cultivation phase will determine how effective the AI model is.
4. The oyster mushroom farming system may be limited only for controlling basic environmental factors for the mushroom such as; irrigation, lighting, airflow, temperature, and humidity.

- **Operations to be improved**

  Operations to be improved on mushroom farming system:

  1. **Controlling and Monitoring the Environment** - Real-time IoT sensors will take the position of manual environmental condition monitoring, lowering labor costs and human error.
  2. **Optimizing Harvests** - with the means of consistent environmental conditions, it will lead to more reliable and high-quality harvest.
  3. **Resource Management** - due to less management of resources in manual farming can lead to resource waste, replacing this with AI real-time data analyzation from IoT sensors can optimize resource usage, minimizing waste, and reducing the operational cost.
  4. **Predictive Measures** - farmers on traditional techniques rely on guessing when to harvest, adding AI systems to the farming system will utilize predictive analytics to present precise recommendations and enhance harvest scheduling.

Defining

- **Coverage of the project to be developed**

  The Coverage of our IoT-based Mushroom Greenhouse Project includes many main areas, each meant to maximize mushroom growth and production, improve ethical farming, and contribute to sustainable farming practices.

1. **Environmental Monitoring and Control**
   - **Objective:** Optimize conditions inside the greenhouse for mushroom growth.
   - **Key Areas:**
     1. **Temperature and Humidity:** Sensors track and regulate the microclimate for ideal mushroom growth, adjusting heaters, fans, or humidifiers as needed.

2. **Air Quality:** CO_2 and O_2 sensors ensure proper air circulation, critical for maintaining the respiration cycle of mushrooms.
3. **Light Control:** IoT-driven lighting systems simulate the natural light cycles that some mushroom species require, while minimizing energy consumption.

2. Real-time Tracking and Data Collection

- **Objective:** Provide actionable insights for decision-making and improve farm productivity.
- **Key Areas:**
    1. **Sensor Data Dashboard:** Real-time tracking of temperature, humidity, light, and air quality, visualized on a dashboard for easy access and analysis.
    2. **Predictive Analytics:** Historical data collection for predicting future trends or identifying potential issues before they arise (e.g., overheat alerts).
    3. **Automated Alerts:** Alerts sent to farmers when critical levels are reached, enabling immediate corrective actions to protect the crop.

3. Sustainable Farming Practices

- **Objective:** Reduce energy consumption, water use, and resource waste through automation.
- **Key Areas:**
    1. **Water Conservation:** Smart irrigation systems ensure optimal water usage by only watering when necessary, based on real-time soil moisture data.
    2. **Ethical Farming:** Adopting IoT solutions that reduce manual labor while promoting worker safety and minimizing environmental damage.

4. Automation and Control Systems

- **Objective:** Implement systems that automate tasks for greater precision and scalability.
- **Key Areas:**
    1. **Automated Climate Control:** Adjusting ventilation, heating, and cooling automatically to maintain optimal conditions.
    2. **Growth Stages Monitoring:** Automatically adjusting conditions to support different stages of mushroom growth (spawning, fruiting, etc.).

3. **IoT Integration:** Seamless communication between IoT devices to manage resources, trigger events, and improve responsiveness.

5. Remote Monitoring and Control

- **Objective:** Provide farmers with flexibility to manage the greenhouse from anywhere.
- **Key Areas:**
  1. **Mobile App Integration:** Enabling remote monitoring of conditions via smartphones, providing access to all the data even when offsite.
  2. **Automation of Routine Tasks:** Automating tasks like misting, ventilation, and lighting adjustments to allow for less direct human intervention.
  3. **Remote Alarms:** Trigger alarms for critical events (e.g., temperature spikes, equipment malfunctions) that can be handled remotely or escalated.

6. Ethical Considerations and Sustainability

- **Objective:** Ensure that technological integration contributes to more ethical and sustainable farming methods.
- **Key Areas:**
  1. **Labor and Resource Efficiency:** Use of IoT technology to reduce manual labor demands, preventing worker fatigue while improving precision.
  2. **Environmental Impact:** Minimizing water use through smart monitoring and control systems that adapt to changing environmental conditions.
  3. **Transparency and Fairness:** Tracking data transparently to ensure fair labor practices and sustainable resource consumption.

- **Stakeholders / intended Users of the project**

The stakeholders or target users of our Mushroom Greenhouse Project are;

1. **Farmers/Mushroom Growers:** These are the major customers who will profit from automated monitoring

and control systems to increase production, lower labor costs, and assure ideal growth conditions.

2. **Agricultural Researchers:** Professionals interested in investigating the effect of precise environmental control on mushroom growth and production, and who use IoT to collect real-time data for research and development.
3. **Greenhouse Owners/Operators:** Individuals or enterprises with bigger greenhouse operations looking to improve efficiency, scalability, and profitability by leveraging IoT technologies.
4. **Technology Developers/IoT Providers:** Businesses and developers that offer IoT solutions, sensors, and software suited for smart farming and greenhouses, allowing innovation and growth in the industry.
5. **Environmentalists/Sustainability Advocates:** Stakeholders that are interested in avoiding resource waste and supporting environmentally friendly agricultural methods in greenhouses by using energy-efficient technologies and using as little water as possible.
6. **Investors/Entrepreneurs:** Those interested in funding or creating smart agricultural technology, seeing the potential for high profits and innovation in the agriculture industry.
7. **Local communities/consumers:** benefit from sustainable agricultural practices, which provide healthier, fresher products while also supporting local economies and improving food security.
8. **Government/Policymakers:** Entities that may provide funding for such developments through grants, subsidies, or policy changes that promote sustainable agricultural and technologically advanced farming solutions.
9. **Researchers/Students:** The researchers and students might be categorized as stakeholders since they stand to acquire information from the study and experience in developing a system of this nature that may be applied in the future.
10. **Faculty/School:** faculty/school can benefit from this study because its implementation can demonstrate sustainable agriculture. It can promote green practices, contribute to campus food production and reduce food waste. Schools can also benefit from this from its publication that can enhance academic standing.

- **Expected Project End Results**

Expected Project outcomes

1. **Fully Automated Environmental Control System**
    - Precise control of temperature, humidity, light, and substrate moisture levels tailored for optimal mushroom growth.
2. **Real-Time Monitoring and Data Logging**
    - Continuous monitoring of environmental parameters (temperature, humidity, CO_2 levels, and moisture) with real-time data access.
3. **User-Friendly Dashboard**
    - A web-based interface enabling users to monitor conditions, receive alerts, and remotely adjust system settings for efficient management.
4. **System Stability and High Efficiency**
    - Minimal manual intervention required, reducing labor and human error, ensuring consistent environmental conditions for ideal mushroom production.
5. **Resource Optimization**
    - Automated management leads to efficient water and energy use, reducing waste and lowering operational costs while promoting sustainability.

This project will deliver an integrated, user-centric solution for efficient, scalable, and sustainable mushroom cultivation.

Expected result

The IoT-based mushroom greenhouse project is projected to provide a successful prototype capable of producing healthy, high-quality oyster mushrooms. The prototype uses IoT sensors to maintain optimal environmental conditions, including temperature, humidity, and CO_2 levels, during the growing cycle. This assures constant yields while reducing crop losses through early detection and repair of environmental imbalances. The prototype is intended to increase production by stimulating quicker growth rates and higher yields every cycle, while conserving resources such as water and electricity through efficient, automated processes. Real-time monitoring ensures that appropriate conditions are continually maintained, resulting in healthier oyster mushrooms. From an economic standpoint, the prototype will reduce operational costs and improve profitability by producing premium-quality mushrooms that can fetch higher market prices. Finally, the project combines sustainability, efficiency, and innovation to create a dependable and effective system for growing oyster mushrooms.

- **Expected Benefits and Improvements**

1. **Increased Productivity and Yield**
    - Optimized Growing Conditions: By maintaining ideal temperature, humidity, and CO_2 levels through real-time monitoring, the growth cycle can be maximized, resulting in a higher yield of mushrooms per harvest.
    - Continuous Monitoring: IoT sensors work 24/7, ensuring that conditions are always optimal, leading to more consistent growth and improved overall productivity.
2. **Reduced Labor Costs:**
    - **Automation of Processes:** Automating tasks like misting, ventilation, and temperature regulation reduces the need for manual intervention, freeing up time for workers to focus on other important tasks.
    - **Remote Management:** Farmers and greenhouse operators can monitor and control the system remotely, reducing the need for on-site supervision and further lowering labor costs.
3. **Resource Efficiency**
    - **Minimized Water Use:** Automated systems use resources on water only when needed, minimizing wastage. This is particularly important for sustainability, reducing the environmental footprint of mushroom farming.
4. **Improved Quality Control:**
    - **Real-Time Adjustments:** The ability to respond to environmental changes in real-time ensures that mushrooms grow in the best possible conditions, improving the quality of the final product.
    - **Data-Driven Insights:** Continuous data collection allows for better decision-making, helping farmers identify trends that lead to higher-quality mushrooms and fewer losses due to suboptimal conditions.
5. **Cost Savings:**
    - **Reduced Operational Costs:** The combination of labor savings, efficient resource use, and predictive maintenance all contribute to lowering overall operational costs.
    - **Higher Return on Investment:** Over time, the initial investment in IoT technology is offset by increased yields, reduced resource consumption, and streamlined operations.

- **Identified Business Operational Importance**

1. **Efficiency:** IoT sensors and AI systems enhance the monitoring and control of environmental conditions, ensuring ideal growth settings with minimal manual input.
2. **Yield Optimization:** AI interprets data from IoT sensors to forecast and adjust conditions for maximum output, boosting productivity and profitability.
3. **Resource Management:** Automated systems precisely manage resources such as water, light, and nutrients, minimizing waste and cutting operational costs.
4. **Real-time Monitoring:** Continuous data collection and analysis offer real-time insights into farm conditions, enabling immediate adjustments and proactive solutions to potential issues.
5. **Scalability:** The integration of IoT and AI facilitates the scaling of operations, as these technologies can process more data and control larger systems without a corresponding increase in labor.
6. **Data-driven Decisions:** AI generates actionable insights based on historical and real-time data, empowering farmers to make informed decisions that enhance farm management.
7. **Sustainability:** More efficient use of resources and optimized growth conditions promote sustainable farming practices, reducing environmental impact.
8. **Competitive Advantage:** Adopting advanced technologies sets farms apart in the market, attracting customers drawn to innovative and sustainable practice.

Designing

- **Development Concept**

1st Week: Planning and Canvas of Materials

- **Objectives:** Outline project goals, define system specifications, and create a detailed list of materials required for construction and functionality.
- **Activities:** Conduct research on mushroom cultivation needs, identify necessary environmental controls, and draft initial designs. Collaborate with team members to finalize the project plan.

2nd Week: Buying Necessary Materials

- Objectives: Acquire all materials and components required for the project.
- Activities: Purchase plywood, Sintra board, insulation foam, sensors, an Arduino board, a water pump, misting

system components, and other electrical materials. Ensure quality and compatibility of purchased items.

3rd Week: Start of Cutting and Building the Walls

- **Objectives:** Construct the main framework for the growing environment.
- **Activities:** Measure and cut plywood and Sintra board for the walls based on design specifications. Assemble the walls, ensuring proper alignment and stability. Create openings for sensors and misting nozzles as needed.

4th Week: Building of Mist Irrigation System

- **Objectives:** Implement an efficient misting system for optimal substrate hydration.
- **Activities:** Install the water pump, connect it to the misting nozzles, and test the misting functionality. Ensure that the mist is evenly distributed throughout the growing area to maintain moisture levels.

5th Week: Installing Insulation Foam and Drainage

- Objectives: Enhance the environmental control of the structure.
- Activities: Apply insulation foam to the inside surfaces of the Sintra board layers to maintain temperature stability and prevent energy loss. Design and install a drainage system to prevent water accumulation and ensure proper substrate moisture levels.

6th Week: Mounting Sensors

- **Objectives:** Install environmental sensors to monitor temperature, humidity, and moisture levels.
- **Activities:** Securely mount sensors in optimal locations within the growing environment. Ensure that each sensor is placed to provide accurate readings of the conditions affecting mushroom growth.

7th Week: Calibration of Sensors

- **Objectives:** Ensure the accuracy and reliability of the sensor readings.
- **Activities:** Calibrate each sensor according to manufacturer specifications and environmental conditions. Test and adjust settings to ensure precise data collection for temperature, humidity, and moisture levels.

8th Week: Testing the System

- **Objectives:** Verify that all components function correctly and efficiently.
- **Activities:** Conduct a series of tests to evaluate the performance of the misting system, sensors, and environmental controls. Monitor readings to ensure that conditions remain within the desired ranges for mushroom growth.

9th Week: Fixing Minor Errors

- **Objectives:** Troubleshoot and resolve any issues identified during testing.
- **Activities:** Analyze system performance data, identify discrepancies, and make necessary adjustments. Fix any minor errors in the installation of components or configurations to ensure optimal functionality.

10th - 11th Week: Monitoring and Adjustment

- **Objectives:** Optimize the system's performance through ongoing observation and modification.
- **Activities:** Continuously monitor environmental parameters and the performance of the misting system. Make adjustments based on data trends and user feedback to enhance efficiency and ensure the conditions are ideal for mushroom growth.

12th Week: Finalizing the System

- **Objectives:** Complete the project and prepare for long-term use.
- **Activities:** Conduct a final review of the system, making any last-minute tweaks to ensure full functionality. Create documentation outlining system operation and maintenance procedures. Prepare a presentation or report summarizing the project development process and outcomes for stakeholders.

- **Operational Concept**

The Smart Oyster Mushroom Farming System automates the critical aspects of mushroom cultivation, including climate control, irrigation, and monitoring, to optimize growth conditions and increase efficiency. It consists of IoT sensors, control systems, a central monitoring platform such as a website for real-time management.

- **Initial Setup and Calibration**
  - Install IoT sensors in key areas of the mushroom growing facility to measure temperature, humidity, CO_2 levels, and light.

    - Program desired parameters (e.g., optimal temperature range: 18–22°C, humidity: 85–90%) for different stages of mushroom growth.
    - Integrate control devices (fans, heaters, humidifiers, irrigation).
    - Test the system to ensure all devices and sensors respond appropriately to real-time data
  - **Continuous Data Collection:** Sensors collect real-time environmental data (temperature, humidity, etc.) and send it to the central monitoring platform (website).
  - **Automated Adjustments:** When environmental conditions deviate from the preset parameters, control devices are triggered automatically:
    - If humidity drops below 85%, the humidifier turns on.
    - If the temperature exceeds 22°C, fans or cooling systems activate to bring the temperature down.
    - If CO2 levels rise, the ventilation system increases airflow to maintain ideal gas exchange.
  - **Data Analysis and Optimization**
    - **Data Analytics:** The system analyzes trends in environmental data, allowing farmers to review the conditions under which the mushrooms grow best. This information is logged and used for future growth cycles.
    - **Predictive Maintenance:** Based on data from the sensors and devices, the system can alert the farmer when a piece of equipment is likely to require maintenance, ensuring minimal downtime/

- **Integration Concept**

  1. **Centralized Control System (Hub)**
     - **Core System:** At the heart of the operation is a centralized control hub that manages and integrates all farm systems. This could be cloud-based, allowing real-time data collection, processing, and decision-making.
     - **Interconnected IoT Devices:** Sensors for temperature, humidity, CO2, and moisture are connected via the Internet of Things (IoT), feeding data into the hub. This hub oversees environmental adjustments, nutrient delivery, and growth monitoring in real-time.

  2. **Environmental and Irrigation System Integration**
     - **Unified Climate Control:** HVAC and misting systems are all linked to the central hub. Based on data inputs, the system will adjust parameters (e.g.,

increasing misting if humidity is low or adjusting light for optimal growth).
- **Integrated Water and Nutrient Systems:** Automated irrigation and nutrient delivery systems will be connected to soil and moisture sensors. When the soil moisture drops below a set threshold or when nutrient levels need replenishment, the central system will trigger precise watering or nutrient release.

3. **Data and Analytics Integration**
   - **Farm-Wide Data Dashboard:** A centralized dashboard collects and displays all critical data (environment, water, nutrients, energy use, yield rates, etc.) in one place. The dashboard can be accessed via desktop or mobile devices, enabling remote farm management.
   - **Cloud Storage & Analysis:** All farm data is stored in the cloud for easy access and analysis. Data analytics systems review historical data to provide insights into farm performance, predict future yields, and recommend process adjustments for improved efficiency.
   - **Predictive Maintenance & Alerts:** The system can predict when equipment might fail (e.g., water pumps or ventilation systems) based on historical performance, triggering alerts for maintenance before an issue arises.
4. **Modular System Integration**
   - **Interconnected Modular** Units: Each farming module (e.g., vertical farming racks or shipping containers) is equipped with sensors and systems that link to the central hub. This allows for easy expansion—new modules can be added to the system without disruption, and all modules will work harmoniously, ensuring uniform climate control and nutrient management.
   - **Scalable Automation:** As the farm grows, the system automatically adjusts its operations to account for additional capacity (e.g., more lights, water, and energy requirements). The modular design means any size farm can be automated efficiently without needing a total redesign.
5. **User Interfaces & Control**
   - **Web-Based Interface:** Farmers will have access to a user-friendly interface, either through desktop dashboards, where they can monitor farm conditions, make manual adjustments, or review performance analytics.
   - **Alerts & Notifications:** The system will push notifications to users if any environmental parameter goes out of range or if any system

requires maintenance. These alerts ensure timely intervention when needed.

6. **Educational and Community Integration**
    - **Knowledge-Sharing Platform:** The farm can integrate with an online community or educational platform, sharing data and insights with other mushroom farmers or research institutions. This allows farmers to share best practices and improve their methods using real-world data from the farm.
    - **Open API for Future Integration:** An open API allows for future integration with new technologies or third-party systems, such as weather forecasting tools, research databases, or marketplace platforms.

- **Organizational Benefit Concept**
    - **Increased Efficiency and Automation**
        - Automating tasks like monitoring and climate control reduces manual labor and human error, making operations smoother and faster.
    - **Enhanced Yield and Consistency**
        - IoT sensors and AI optimize growing conditions, leading to higher yields and more consistent, high-quality mushrooms.
    - **Cost Savings and Resource Optimization**
        - AI helps cut costs by using water, energy, and other resources more efficiently, while also reducing waste.
    - **Data-Driven Insights and Improvements**
        - IoT data provides insights for improving processes, and AI can predict equipment issues, reducing downtime.
    - **Market Differentiation and Competitive Advantage**
        - Consistently high-quality mushrooms and traceability through IoT can help the farm stand out and build consumer trust.
    - **Sustainability and Environmental Impact**
        - Smart use of resources with IoT and AI lowers water, energy consumption, and waste, making the farm eco-friendly.
    - **Scalability and Adaptability**
        - The system can easily expand as the farm grows, and AI allows quick adjustments to market or environmental changes.

- **Improvement Concept**

    - **Enhanced Environmental Control**

- Upgrade to high-precision sensors with a broader range to capture more accurate and detailed environmental data.
- Use machine learning to predict and adapt to changing environmental conditions for mushroom growth.

- **User Interface and Experience**
  - User-centric design to enhance usability, for easy navigation for all users.
  - Increase functionality of the website to give users complete access to the system controls for monitoring.
- **Feedback and Continuous Improvement**
  - Conduct surveys and feedback sessions with users to gather insights into their experiences and areas for improvement.
  - Prioritize feature enhancement and new developments based on the user needs and feedback.

BUILDING

- **Available Technology to be used**

For our project innovative oyster mushroom farming we can consider the following:

- **Sensors:**
  - **DHT22:** Sensors for temperature and humidity.
  - **CO2 sensor:** CO2 sensor for monitoring carbon dioxide levels.
  - **Soil Moisture Sensors:** To ensure optimal substrate moisture for mushroom growth.

- **Camera:**
  - **Web camera:** The cameras will be used for visual monitoring of the mushroom growth.
- **Computer:**
  - **Raspberry Pi:** The Raspberry pi will be used as the data collection and processing hub for connecting all sensors (temperature, humidity, CO2, light, soil moisture) and controlling actuators (irrigation, fans, lights) in real-time.
  - **Arduino Uno:** The Arduino Uno controls sensors and actuators, processes data, and automates tasks in various projects through programmable inputs and outputs.

- **ESP Module**: An ESP module enables wireless communication, allowing remote monitoring and control of devices like sensors or actuators via Wi-Fi.

- **Pump (for misting)**: A water pump in misting systems ensures even hydration by dispersing fine water droplets to maintain optimal moisture levels.
- **Exhaust fan**: An exhaust fan removes excess humidity, heat, and stale air, promoting airflow and maintaining an optimal environment for growth.

- **Operational and Integration Plan**

1st Week: Planning and Canvas of Materials

Objectives: Outline project goals, define system specifications, and create a detailed list of materials required for construction and functionality.
Activities:

- Conduct research on mushroom cultivation needs, focusing on optimal environmental conditions (temperature, humidity, light, and moisture).
- Identify necessary environmental controls, such as sensors, misting systems, and drainage solutions.
- Draft initial designs for the growing environment, including layouts for walls, sensor placements, and misting distribution.
- Collaborate with team members to finalize the project plan, incorporating feedback and addressing potential challenges.

  Materials:

  - Research materials (books, online resources) for mushroom cultivation.
  - Sketching materials (paper, pencils) for initial designs.

2nd Week: Buying Necessary Materials

Objectives: Acquire all materials and components required for the project.
Activities:

- Research suppliers for plywood, Sintra board, insulation foam, sensors, an Arduino board, a water pump, misting system components, and other electrical materials.
- Purchase selected materials, ensuring they meet quality standards and are compatible with the project specifications.

- Organize materials in a designated workspace for easy access during construction.
- Create an inventory list to track purchased items and manage budgets effectively.

  Materials Needed:

  - Plywood (sheets)
  - Sintra board (sheets)
  - Insulation foam (sheets)
  - Temperature sensor
  - Humidity sensor
  - Soil moisture sensor
  - Arduino board (e.g., Arduino Uno)
  - Water pump
  - Misting system components (nozzles, tubing, connectors)
  - Electrical materials (wires, connectors, power supply)
  - Tools (saw, drill, measuring tape)

3rd Week: Start of Cutting and Building the Walls

Objectives: Construct the main framework for the growing environment.
Activities:

- Measure and mark plywood and Sintra board for cutting, adhering to design specifications.
- Use appropriate tools (e.g., saws, drills) to cut materials accurately, ensuring clean edges and proper sizing.
- Assemble the walls, ensuring proper alignment and stability using screws, brackets, or adhesives as needed.
- Create openings for sensors and misting nozzles, ensuring they are positioned optimally for functionality.
- Review and revise the structure as necessary to accommodate any design changes.

  Materials Used:

  - Plywood sheets (for base)
  - Sintra board (for insulation and structure for walls)
  - Adhesives and pins (for assembling)
  - Tools (saw, drill, measuring tape, cutter)

4th Week: Building of Mist Irrigation System

Objectives: Implement an efficient misting system for optimal substrate hydration.
Activities:

- Install the water pump in a designated area, ensuring easy access for maintenance.
- Connect the pump to the misting nozzles, verifying that all fittings are secure to prevent leaks.
- Test the misting functionality, adjusting nozzle angles to ensure even distribution of mist throughout the growing area.
- Monitor the output of the misting system to ensure it meets the hydration needs of the substrate.
- Document the setup process for future reference and maintenance.

  Materials Used:

  - Water pump
  - Misting nozzles (humidifier)
  - Tubing (for connecting pump to nozzles)
  - Connectors and fittings (to secure tubing)
  - Water source (tank or plumbing connection)

5th Week: Installing Insulation Foam and Drainage

Objectives: Enhance the environmental control of the structure.
Activities:

- Apply insulation foam to the inside surfaces of the Sintra board layers, ensuring a tight seal to maintain temperature stability and prevent energy loss.
- Design and install a drainage system, incorporating sloped surfaces and drainage holes to prevent water accumulation.
- Conduct tests to ensure the drainage system functions properly and directs excess water away from the growing area.
- Verify that insulation foam is applied uniformly and effectively, making adjustments as necessary.

  Materials Used:

  - Insulation foam sheets
  - Drainage pipes or tubing
  - Drainage holes or grates
  - Sealant (for insulation joints)
  - Tools (drill, cutter, measuring tape)

6th Week: Mounting Sensors

Objectives: Install environmental sensors to monitor temperature, humidity, and moisture levels.
Activities:

- Securely mount sensors in optimal locations within the growing environment, ensuring they are away from direct misting and heat sources.
- Check sensor specifications to ensure they are placed in areas that accurately reflect environmental conditions.
- Connect sensors to the Arduino or microcontroller, verifying that all wiring is secure and correctly configured.
- Document sensor placements and wiring configurations for troubleshooting and future reference.

  Materials Used:

  - Temperature sensor
  - Humidity sensor
  - Soil moisture sensor
  - Mounting brackets or adhesive (for securing sensors)
  - Wires and connectors (for connections)

7th Week: Calibration of Sensors

Objectives: Ensure the accuracy and reliability of the sensor readings.
Activities:

- Calibrate each sensor according to manufacturer specifications, following guidelines for setup and adjustment.
- Test each sensor in varying conditions to ensure accurate readings across the expected range of environmental parameters.
- Adjust sensor settings and code to ensure precise data collection for temperature, humidity, and moisture levels.
- Document calibration procedures and any adjustments made for future reference.

  Materials Used:

  - Calibration equipment (if needed, e.g., calibration standards for sensors)
  - Software (Arduino IDE for code adjustments)
  - Documentation sheets (for recording calibration results)

8th Week: Testing the System

Objectives: Verify that all components function correctly and efficiently.
Activities:

- Conduct a series of tests to evaluate the performance of the misting system, sensors, and environmental controls under different conditions.
- Monitor readings from all sensors and ensure they respond appropriately to changes in the environment.
- Simulate various environmental conditions (e.g., increased humidity or temperature) to observe system responses.
- Document test results and identify any anomalies that need addressing before full-scale operation.

  Materials Used:

  - Testing equipment (if needed, e.g., multimeter for electrical tests)
  - Software tools (for monitoring sensor outputs)
  - Data recording sheets

9th Week: Fixing Minor Errors

Objectives: Troubleshoot and resolve any issues identified during testing.
Activities:

- Analyze system performance data collected during testing to identify discrepancies and inefficiencies.
- Make necessary adjustments to sensor placements, wiring, or code to address identified issues.
- Perform additional tests to confirm that corrections have resolved any problems.
- Document all changes made to ensure accurate records for future maintenance.

  Materials Used:

  - Additional wiring or connectors (if needed for repairs)
  - Tools (for making adjustments)
  - Documentation sheets (to track changes)

10th - 11th Week: Monitoring and Adjustment

Objectives: Optimize the system's performance through ongoing observation and modification.
Activities:

- Continuously monitor environmental parameters and the performance of the misting system during operation.
- Analyze data trends from sensor readings to identify areas where adjustments may be needed.
- Engage with users or stakeholders to gather feedback on system performance and usability.

- Make adjustments based on observations, data analysis, and user input to enhance efficiency and ensure ideal conditions for mushroom growth.

  Materials Used:

  - Monitoring software (for data analysis)
  - Feedback forms (for user input)
  - Documentation tools (for tracking changes and observations)

12th Week: Finalizing the System

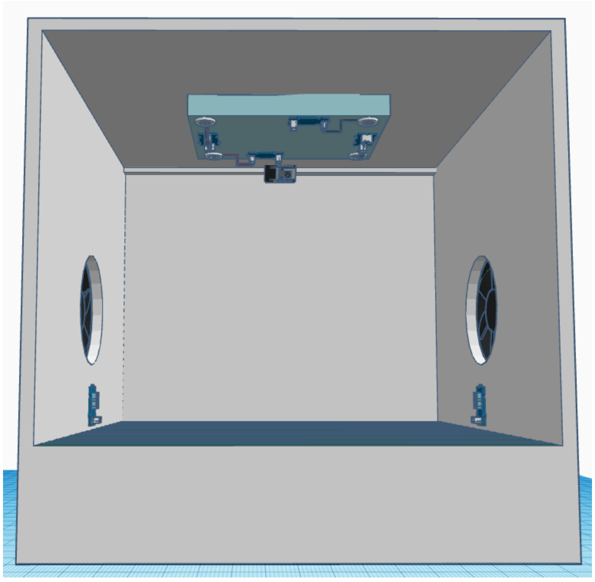
Objectives: Complete the project and prepare for long-term use.
Activities:

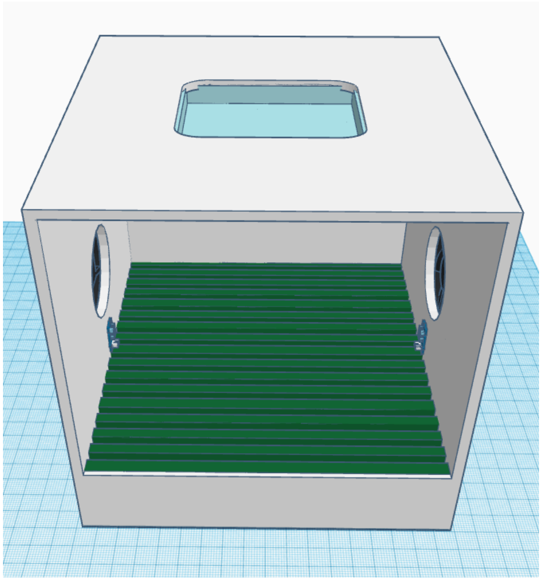
- Conduct a final review of the system, making any last-minute tweaks to ensure full functionality and reliability.
- Create comprehensive documentation outlining system operation, maintenance procedures, and troubleshooting tips for future reference.
- Prepare a presentation or report summarizing the project development process, outcomes, and lessons learned for stakeholders.
- Organize a final meeting with the project team to discuss the project's successes and areas for future improvement, ensuring that all members are informed and aligned for ongoing operations.

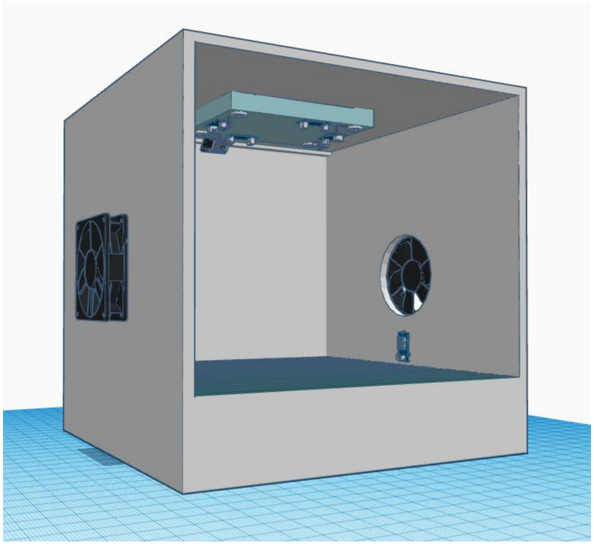
  Materials Used:

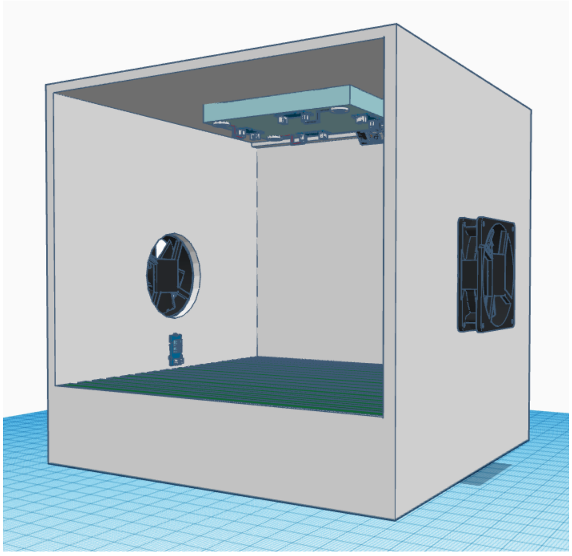
  - Documentation tools (for creating manuals)
  - Presentation materials (slides, charts, etc.)
  - Feedback forms (for stakeholders' input)

3D Model


Front View


Top View


Left View


Right View

Actual Model

Front View

- **Cost Considerations**

  The project will cost of:

  - DHT22 sensor: *₱195.00*
  - HC-SR04 sensor: *₱69.00*
  - Humidifier: *₱108.00*
  - 5V Water Pump: *₱115.00*
  - Sintra Board: *₱680.00*
  - Plywood: *₱151.00*
  - Cyno Glue: *₱120.00*

Testing

- **Test / Validation Procedure**

  1. **Pre-Operational System Testing**
     - **Hardware:** Ensure all devices like sensors, actuators, and controls are properly installed and functioning. Each component should be tested individually to verify its responsiveness and accuracy.
     - **Software:** Test the integration of all systems through simulated conditions to check if the software properly manages automation and data flow. It should respond swiftly to environmental changes and execute commands without errors.
  2. **Environmental Control Validation**
     - **Sensor Calibration:** Compare sensor readings with standard reference tools to ensure accuracy. Adjust calibration if necessary to maintain precise measurements of temperature, humidity, and other environmental factors.
       - **Temperature and Humidity**
       - **CO2 (if necessary)**
       - **Soil Moisture**
       - **USB Camera**
       - Mist
       - Water Pump
     - **Climate Simulation:** Simulate different growing conditions to ensure the system can maintain optimal levels. The system should adjust

temperature, humidity, and light as needed, keeping all parameters within the required range.

3. **Substrate & Irrigation Validation**
    - **Substrate Quality:** Test the substrate for proper moisture, pH levels, and absence of harmful pathogens. This ensures the medium supports healthy mushroom growth throughout the cultivation process.
    - **Irrigation:** Validate the system's ability to deliver water and nutrients based on real-time moisture levels. It should provide even irrigation, preventing over- or under-watering.
4. **Data Integrity and Traceability**
    - **Data Logging:** Ensure the system accurately records data from all sensors in real-time. This data must be reliable and available for analysis, helping managers make informed decisions.
    - **Compilations:** Verify all stages log of the oyster mushroom-growing process. Full traceability from planting to harvest should be maintained for transparency and compliance.
5. **User Testing and Feedbacks**
    - User testing showed that the IoT system for oyster mushroom greenhouses was well-received, especially for enhancing control over growing conditions and reducing manual labor.

- **Metric to be used to validate**

  The metric to be used for the validation is the consistency of environmental conditions, monitored through IoT sensors, and the correlation between these conditions and the quality of the mushroom yield.

- Survey Completion Rate:

  Track how many surveys are completed by users in relation to the total number of users participating in testing, and calculate the completion rate using this data.

  Completion Rate $= \left(\frac{\text{Number of Completed Survey}}{\text{Total Number of Users}}\right) \times 100\%$

  Average Rating $= \frac{5+5+3+4+5+4+5+4+5+3}{10} = 4.3$

  Issue Frequency Rate $= \left(\frac{3}{10}\right) \times 100\% = 30\%$

- Responsive Time Evaluation

  Measure the system's average response time to changes in environmental conditions or interactions with the user interface, aiming for a response time within a set threshold of 5 minutes.

- Overall Effectiveness Score:
  Combine user satisfaction levels with the frequency of reported issues to generate an overall effectiveness score.

Deployment

- **Deployment Plan**

  1. **Setup:** The deployment plan for the automated environmental control system begins with assembling the growing environment using plywood, Sintra board, and insulation foam. During this phase, sensors are mounted in designated locations to ensure accurate readings, and the water misting system is installed and connected to the water pump. The wiring for sensors, pumps, and electrical components is completed, linking them to the Arduino or microcontroller, which is then connected to a power source to ensure all components receive adequate power.

  2. **System Check:** Following the setup, the system check phase is conducted to verify the functionality and reliability of all components. This involves testing each sensor (temperature, humidity, moisture) to ensure they provide accurate readings and running tests on the water pump and misting system for proper operation. The initial code is uploaded to the Arduino to facilitate communication with the sensors and control the pump, while the web interface is checked for real-time monitoring capabilities. Any issues encountered during testing are documented and resolved promptly.

  3. **Soft Launch:** Finally, the soft launch phase is initiated, where the system operates in a controlled environment with a select group of users. This phase focuses on monitoring performance closely and collecting data on environmental conditions and system responses. User feedback is gathered to assess usability and functionality, and continuous observation of sensor readings and overall system behavior allows for real-time adjustments to optimize performance. This structured deployment plan ensures a smooth transition from setup to operational status for the automated environmental control system.

- **User Training Plan**

For User Training Plan this is what we consider to include:

1. **Introduction to the System:**
    - **Objective:** To familiarize users to the hardware and software components of the IoT based system.
    - **Contents:**
        - Overview of the technology that is used in the project.
        - Introduction to the website interface for monitoring and control.
        - Discussion of environmental factors being monitored
2. **Data Monitoring and Interpretation:**
    - **Objective:** To teach users how to understand the data provided by the system.
    - **Contents:**
        - How to navigate the website and check real-time data.
        - How to view images and insights provided by the camera and AI system.
3. **System Control and Automation:**
    - **Objective:** to enable users to operate automated features of the system.
    - **Contents:**
        - How to adjust environmental settings.
4. **Basic Troubleshooting:**
    - **Objective:** To prepare users to solve issues in the system
    - **Contents:**
        - Diagnosing sensors and other components

- **User Readiness Plan**

For User Readiness Plan this is what we consider to include:

1. **Pre-Training Preparation:**
    - **Objective:** To ensure users are ready before the training starts.
    - **Activities:**
        - **User Assessment:** This is to evaluate the technical proficiency of the users to identify if the user has a knowledge about technologies.

- **Resource Distribution:** Distributing reading materials and user manuals that outlines the system components, software features, and system overview.
- **System Access:** Make sure that the users have access to the website including system credentials and hardware components this will help the users to become familiar with the interface.

2. **Introduction to the System**
   - **Objective:** To familiarize the users with the IoT system.
   - **Activities:**
     - **Overview Session:** Have a detailed presentation of the hardware and software components.
     - **Live Demonstration:** The proponents will show to the users how the system operates in real time, how to navigate through the website and demonstrate how the mushrooms are monitored by the system.
3. **Data Monitoring and Interpretation:**
   - **Objective:** To let the users have the skills to monitor and interpret system data.
   - **Activities:**
     - **Data Interpretation Workshop:** Teach users on how to read and understand system data that the system generates. The proponents will use case scenarios for more in depth knowledge.
4. **System Control and Automation:**
   - **Objective:** To enable users to control the system.
   - **Activities:**
     - **Hands-on Control Practice:** Give the user a step-by-step guide on how to navigate through the website and give them guidance on how to adjust environmental settings.
5. **Basic Troubleshooting:**
   - **Objective:** To prepare users for basic troubleshooting and maintenance.
   - **Activities:**
     - **Troubleshooting Simulation:** The proponents will give users a case about a common issue and the proponents will guide the users on how to deal with those issues.

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