AGPE3003 GREEN HOUSE & ENVIRONMENTAL CONTROL ENGINEERING (3-0-0)

Course Objectives:
To provide students with comprehensive knowledge of greenhouse technology, environmental control systems, and sustainable cultivation practices. The course covers greenhouse design, plant-environment interactions, automation, crop management, and advanced topics like CEA and renewable energy integration, preparing students to optimize greenhouse operations for enhanced productivity and resource efficiency.

Module-I: Introduction to Protected Cultivation and Greenhouses
History and Evolution of Protected Cultivation: Overview of traditional and modern protected cultivation methods. Global and national scenario of greenhouse cultivation. Advantages and disadvantages of protected cultivation. Types of Greenhouses and Structures: Classification based on shape (gable, arch, ridge and furrow, etc.), utility (propagation, growing, research), and construction materials (glass, polyhouse, shade net). Components of a greenhouse structure (foundation, frame, covering materials, ventilation openings). Greenhouse Covering Materials: Properties of various cladding materials (glass, polyethylene, polycarbonate, acrylic) – light transmission, thermal insulation, durability. Selection criteria for covering materials based on climate and crop. Site Selection and Orientation: Factors influencing site selection (sunlight, drainage, water availability, wind exposure, accessibility). Optimal orientation of greenhouses for maximum solar radiation.

Module-II: Plant-Environment Interactions
Principles of Limiting Factors: Understanding how various environmental factors affect plant growth and yield. Solar Radiation and Light Management: Photosynthesis and plant light requirements (PAR). Light intensity, photoperiod, and light quality. Supplemental lighting systems (LEDs, HPS lamps) – types, design, and control. Shading techniques and materials. Temperature Control: Effects of temperature on plant physiological processes (respiration, transpiration). Optimum temperature ranges for different crops. Greenhouse heating systems (localized heating, solar heating, warm air sources, steam, hot water). Heat conservation strategies (thermal screens, wall insulation). Greenhouse cooling systems (natural ventilation, fan-pad evaporative cooling, fogging, misting). Design of cooling systems and maintenance. Humidity Management: Importance of relative humidity for plant health and transpiration. Humidification and dehumidification techniques. Impact of high and low humidity on pest and disease incidence. Carbon Dioxide (CO_2) Enrichment: Role of CO_2 in photosynthesis. Ambient and target CO_2 concentrations. Methods of CO_2 generation and enrichment. Monitoring and control of CO_2 levels. Air Movement and Ventilation: Importance of air circulation for temperature uniformity and disease prevention. Natural ventilation (roof and side ventilators) – design considerations. Mechanical ventilation (exhaust fan systems) – design, selection, and operation.

Module-III: Environmental Control Systems and Automation
Sensing and Measurement: Types of sensors used in greenhouses (temperature, humidity, light, CO_2, soil moisture, pH, EC). Principles of operation and calibration of sensors. Data acquisition and logging systems. Control Systems Fundamentals: Types of control (on/off, proportional, PI, PID). Logic and algorithms for environmental control. Basic control components (thermostats, humidistats, timers). Automated Environmental Control Systems: Dedicated microprocessors and computer-based control systems. Integrated control systems for multiple environmental parameters. Software for greenhouse climate control. Remote monitoring and control. Irrigation and Fertigation Systems: Water quality and plant water requirements. Micro-irrigation systems (drip, sprinklers, foggers, misters) – design, layout, and components. Fertigation systems – principles of nutrient delivery, fertilizer injectors, automated fertilizer application. Water conservation techniques, wastewater recycling. Root Media and Soilless Culture: Types of root media (organic, inorganic) – properties, advantages, and disadvantages. Soil pasteurization and disinfection. Soilless culture techniques (hydroponics, aeroponics, substrate culture) – water culture, sand culture, gravel culture. Nutrient solution preparation and management.

Module-IV: Greenhouse Crop Management and Operations
Crop Selection for Greenhouse Cultivation: Criteria for selecting suitable crops (vegetables, flowers, fruits). High-yield and disease-resistant varieties. Planting Techniques: Nursery development, plant tissue culture, pot culture. Spacing and plant arrangement. Nutrient Management: Essential nutrient elements and their functions. Nutrient deficiency symptoms. Principles of fertilizer application, scheduling, and rates. Pest and Disease Management in Greenhouses: Common pests and diseases affecting greenhouse crops. Integrated Pest Management (IPM) strategies – biological control, chemical control, cultural practices. Disease diagnosis and control strategies. Greenhouse Operations and Maintenance: Daily, weekly, and seasonal operational tasks. Maintenance of equipment and systems. Energy conservation practices. Post-Harvest Management: Harvesting techniques, post-harvest handling, and storage.

Course Outcomes (COs)

CO1: Explain the principles of greenhouse design, covering materials, and site selection based on climatic and crop requirements. (Understanding)

CO2: Analyze plant-environment interactions (light, temperature, humidity, CO2) and design appropriate control systems for optimal growth. (Analysis)

CO3: Operate automated environmental control systems (sensors, fertigation, HVAC) and evaluate their efficiency in greenhouse management. (Application/Evaluation)

CO4: Develop integrated pest management (IPM) and nutrient management strategies for greenhouse crops. (Synthesis)

CO5: Assess the feasibility and sustainability of advanced greenhouse technologies (vertical farming, renewable energy) through cost-benefit analysis. (Evaluation/Creation)

Module-V: Advanced Topics and Sustainable Practices

Controlled Environment Agriculture (CEA) Trends: Vertical farming, urban agriculture, and smart greenhouses. Integration of AI and machine learning for environmental control. Energy Efficiency and Renewable Energy in Greenhouses: Geothermal heating, solar energy utilization. Energy auditing and optimization. Environmental Impact and Sustainability: Water footprint and energy footprint of greenhouse production. Waste management in greenhouses. Ecological considerations. Economic Aspects of Greenhouse Cultivation: Cost estimation for greenhouse projects. Feasibility analysis and profitability.