INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

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Mechanical Engineering
Engineering Design Project syllabus

An Engineering Design Project is a comprehensive, hands-on initiative where students apply scientific and engineering principles to develop innovative solutions to real-world problems. The project emphasizes the entire design process, including problem identification, research, conceptualization, modeling, prototyping, testing, and iteration. It develops technical skills, creativity, teamwork, and project management capabilities, enabling students to design and develop functional products or systems that address societal, industrial, or environmental needs.

Project 1: Pedal-Powered Water Purifier with AIML-Based Water Quality Monitoring

Objective:
To design and develop an eco-friendly, pedal-operated water purification system integrated with Artificial Intelligence and Machine Learning (AIML) for real-time water quality assessment and prediction, targeting rural and disaster-prone areas with limited access to electricity and clean drinking water.

Problem Statement:
There is a critical need for a sustainable, non-electric water purification system that not only provides clean water through mechanical means but also integrates Artificial Intelligence and Machine Learning (AIML) to monitor, analyze, and predict water quality using real-time sensor data. This project aims to solve the dual challenge of providing potable water in energy-scarce environments and ensuring its quality through intelligent monitoring, enabling safer and healthier living conditions in underserved regions.

Scope:
- Purify up to 10–20 liters/hour
- Remove physical and microbial contaminants
- No dependency on power or fuel
- AI monitoring of quality assessment and prediction

Features:
- Pedal-driven rotary pump
- Multi-stage filter (sand, charcoal, ceramic)
- Compact and portable

Tools & Technologies:
- **Arduino Uno / Raspberry Pi**
  Microcontroller/microprocessor platform used for sensor integration, data collection, and system control.
- **Python with Scikit-learn or TensorFlow**
  For building and deploying Machine Learning models to classify and predict water quality.
- **TDS, pH, and Turbidity Sensors**
  Key sensors for monitoring water quality parameters in real time.
- **Pedal and Chain-Sprocket Mechanism**
  Human-powered mechanical system to drive the water pump and purification units without electricity.
- **ThingSpeak / Blynk (IoT Platform)**
  For real-time data visualization, remote monitoring, and user alerts on water quality status

Workflow:
- Water Inlet and Pedal Operation
- Multi-Stage Filtration Process
- Real-Time Sensor Data Acquisition

- AIML-Based Water Quality Analysis
- User Alerts and Output Display
- Cloud-Based Data Logging and Remote Monitoring (Optional)

Expected Outcomes:
- Clean Drinking Water Without Electricity
- Real-Time Water Quality Monitoring
- AIML-Based Water Quality Prediction
- User-Friendly Interface for Alerts and Feedback
- Sustainable, Low-Cost, and Scalable Solution

Future Enhancements:
- Integration with Solar Power for Hybrid Operation
- Advanced AI Models for Source-Specific Contamination Detection
- Voice-Based Alerts and Multilingual Interface
- Mobile App with GPS-Based Water Quality Mapping
- Self-Cleaning Mechanism for Filters

SDG Mapping:
SDG 6 (Clean Water and Sanitation), SDG 3 (Good Health), SDG 9 (Industry, Innovation)

Project 2: Solar-Powered Crop Dryer with Thermal Storage and AIML-Based Drying Control

Objective:
To design and develop an off-grid, solar-powered crop drying system with integrated thermal storage and AI/ML-based control to optimize drying conditions in real-time, ensuring energy efficiency, reduced post-harvest losses, and improved crop quality for small and marginal farmers.

Problem Statement:
Post-harvest losses due to traditional sun drying methods are a major concern in rural agriculture. These methods are weather-dependent, inefficient, and lead to inconsistent crop quality. Access to electricity for powered dryers is often limited in remote regions. There is a need for a reliable, cost-effective, and sustainable crop drying solution that operates without grid power and intelligently manages drying conditions based on environmental and crop-specific factors.

Scope:
- To utilize solar thermal energy to dry agricultural produce.
- To integrate thermal storage for round-the-clock operation.
- To embed sensors for monitoring environmental and crop parameters.
- To implement AI/ML algorithms for optimizing drying based on real-time data.
- To provide data visualization and alerts through IoT/mobile platforms.
- To ensure that the solution is portable, low-cost, and scalable for use in rural and remote farming communities

Features:
- Solar-powered, grid-independent operation
- Thermal storage using PCM or other materials for night-time drying
- Real-time monitoring of humidity, temperature, and crop moisture
- AI/ML-based control logic for dynamic drying adjustment
- Mobile/IoT interface for data display and alerts
- Modular design for easy maintenance and scalability
- Eco-friendly and farmer-friendly operation

Tools & Technologies:
- Solar Thermal Collectors – Flat plate or evacuated tube systems to harness solar heat.

- Phase Change Materials (PCM) – For thermal energy storage to enable night-time drying.
- Arduino / Raspberry Pi – For sensor integration and control logic.
- Python + Scikit-learn / TensorFlow – For implementing machine learning models.
- Humidity, Temperature, and Moisture Sensors – For real-time data collection.

Workflow:

1. Solar Heat Collection and Circulation
2. Thermal Energy Storage Activation
3. Sensor Data Monitoring and Logging
4. AIML-Based Drying Control and Adjustment
5. User Feedback via Display / App Interface

Expected Outcomes:

- Sustainable Crop Drying with Zero Electricity
- Extended Drying Capability Using Stored Thermal Energy
- Improved Crop Quality and Shelf Life
- AI-Driven Efficiency in Drying Process
- Adoption-Ready Solution for Rural and Marginal Farmers

Future Enhancements:

- Smart Weather Forecast Integration
- Voice Command and SMS-Based Notification System
- Crop-Specific AI Model Optimization
- Mobile App with Farmer Feedback Logging
- Automated Solar Tracking System

SDG Mapping:
SDG 2 (Zero Hunger), SDG 7 (Affordable Clean Energy), SDG 12 (Sustainable Production)

Project 3: AI-Enabled Solar-Powered Cold Storage System for Rural Agriculture

Objective:
To develop a solar-powered, off-grid cold storage unit integrated with AI/ML-based monitoring and control systems for preserving perishable agricultural produce in rural areas, thereby reducing post-harvest losses and increasing farmer income

Problem Statement:
Perishable crops such as fruits, vegetables, and dairy often spoil in rural areas due to the lack of accessible, affordable, and consistent cold storage facilities. Grid power is unreliable or unavailable in many such regions, and conventional refrigeration is costly. There is an urgent need for a **sustainable, smart cold storage system** that leverages **solar energy** and **AI/ML** to dynamically control temperature and reduce spoilage efficiently.

Scope:

- To design a **solar-powered refrigeration system** with battery or PCM backup.
- To integrate **temperature and humidity sensors** for real-time environmental tracking.
- To apply **AI/ML algorithms** for optimizing cooling cycles based on load type and weather data.
- To develop a **remote monitoring interface** with alert and control features.
- To ensure the system is **scalable, affordable, and portable** for use in farming communities.

Features:

- Off-grid operation using solar photovoltaic panels
- Thermal or battery energy storage for nighttime or cloudy conditions
- Real-time monitoring of storage temperature and humidity
- AI/ML-based temperature control based on produce type and spoilage patterns
- IoT dashboard or mobile app for monitoring and alerts
- Compact and modular design for local assembly
- Environmentally friendly and low maintenance

Tools & Technologies:

- Solar PV Panels + Charge Controller – For powering the system sustainably
- PCM-Based Cold Storage / Battery Backup – For maintaining cooling during night hours
- Arduino / Raspberry Pi with DHT22 or similar sensors – For system monitoring and data logging
- Python + TensorFlow / Scikit-learn – For predictive temperature regulation and spoilage estimation
- Blynk / ThingSpeak – For mobile-based IoT monitoring

Workflow:

1. Solar Energy Generation and Storage
2. Cooling Unit Activation Based on Load and Temperature
3. Sensor-Based Environmental Monitoring
4. AIML-Powered Cooling Cycle Control
5. Remote Dashboard Interface and Alert

Expected Outcomes:

- 24x7 Cold Storage Without Grid Dependency
- Reduction in Post-Harvest Losses
- Energy-Efficient Smart Cooling Management
- AI-Driven Adjustment Based on Storage Contents
- Enhanced Shelf Life and Farmer Income

Future Enhancements:

- Integration with Blockchain for Supply Chain Traceability
- Dynamic AI Model Updating Based on Crop Type and Region
- Voice and Regional Language Interfaces
- Geo-Tagging of Units for Impact Mapping
- AI Chatbot for Farmer Support and System Queries

SDG Mapping:

SDG 2: (Zero Hunger), SDG 7: (Affordable and Clean Energy), SDG 9: (Industry, Innovation and Infrastructure), SDG 13: (Climate Action)

Project 4: Foot-Operated Multi-Crop Thresher with Adjustable Drum Mechanism

Objective:

To design and develop a low-cost, manually operated thresher capable of threshing different types of crops (like rice, wheat, millet, etc.) using a pedal or foot mechanism, with an adjustable drum speed and clearance system to suit various grain types and minimize grain damage.

Problem Statement:

Small and marginal farmers in remote areas often rely on manual threshing methods that are time-consuming, labor-intensive, and result in considerable post-harvest losses. Electrically powered threshers are often unaffordable or inaccessible due to unreliable power supply. There is a need for a **portable, purely mechanical solution** that is **manual, affordable, and effective** across various crop types without requiring electricity or fuel.

Scope:

- To develop a pedal or foot-operated thresher system for small-scale farmers.
- To design an **adjustable threshing drum** to accommodate different crops.
- To use easily available materials to ensure **low-cost manufacturing**.
- To focus on **ergonomic design** for ease of operation with minimal fatigue.
- To ensure portability, safety, and maintenance simplicity.
- To enable deployment in remote, off-grid agricultural regions.

Features:

- Purely mechanical, electricity-free operation
- Pedal/foot-driven flywheel and drum system
- Adjustable drum-to-concave clearance for multi-crop support
- Grain collection and chaff separation trays
- Compact and portable frame design
- Low maintenance and robust construction
- Operator safety guards and anti-fatigue pedal setup

Tools & Technologies:

- CAD Software (AutoCAD / SolidWorks) **– For design and simulation**
- Mild Steel & Wood Materials **– For frame and drum construction**
- Flywheel and Chain Drive System **– For motion transmission**
- Adjustable Lever Mechanism **– For drum-concave spacing control**
- Basic Workshop Tools (Lathe, Welding, Bending Tools) **– For fabrication**

Workflow:

1. Crop Feeding into the Drum
2. Pedal/Foot Operation to Rotate Drum and Flywheel
3. Threshing via Drum-Beater Action
4. Grain Separation and Chaff Discharge
5. Manual Collection of Output

Expected Outcomes:

- Affordable Threshing for Marginal Farmers
- Electricity-Free Operation in Rural Areas
- Support for Multiple Crop Types
- Reduction in Labor and Time Consumption
- Improved Post-Harvest Efficiency

Future Enhancements:

- Addition of Winnowing Functionality
- Interchangeable Drum Attachments for Specific Crops
- Foldable or Collapsible Design for Transportability
- Hybrid Manual-Solar Operation (Optional)
- Integration with Manual Seed Cleaner Module

SDG Mapping:

SDG 1: (No Poverty), SDG 2: (Zero Hunger), SDG 8: (Decent Work and Economic Growth), SDG 9: (Industry, Innovation and Infrastructure).

Project 5: AI-Enabled Smart Mechanical Vibration Analyzer for Rotating Machinery

Objective:
To design a compact, portable mechanical vibration analyzer integrated with AI/ML algorithms to monitor, classify, and predict faults in rotating machinery (such as motors, pumps, and compressors), enhancing predictive maintenance and reducing downtime in industrial systems.

Problem Statement:
Rotating machines are critical components in industrial systems. Failures due to unbalance, misalignment, bearing wear, or looseness often lead to unexpected shutdowns and high maintenance costs. Traditional vibration monitoring tools are either expensive or lack intelligence for fault prediction. There is a need for a **cost-effective, mechanical vibration analyzer** with integrated **AI/ML capabilities** to **automate fault diagnosis**, improve reliability, and support condition-based maintenance.

Scope:

- Design and fabrication of a **portable mechanical setup** for vibration sensing on industrial machines.
- Integration of **MEMS accelerometers and velocity sensors** to capture vibration signatures.
- Development of **AI/ML models** to classify common machine faults.
- Real-time monitoring using microcontrollers and wireless data transmission (optional).
- Application in **maintenance departments of small and medium-scale industries** for cost-effective diagnostics.

Features:

- Mechanical sensor mounting platform for various machine sizes
- MEMS-based tri-axial accelerometers to detect vibrations in multiple directions
- Data acquisition system (Arduino/Raspberry Pi + SD card or wireless)
- AI/ML model to classify faults such as imbalance, misalignment, and bearing faults
- Mobile/PC dashboard to visualize real-time vibration levels and fault predictions
- Threshold alerting system for predictive maintenance

Tools & Technologies:

- Accelerometer (e.g., ADXL345, MPU6050) – To measure vibrations
- Arduino / Raspberry Pi – For sensor data acquisition and control
- Python with Scikit-learn / TensorFlow – For AI/ML model development
- MATLAB / Excel – For initial signal processing and FFT analysis
- Mobile App / PC Dashboard – For visualization and fault reporting

Workflow:

1. Mounting of Vibration Analyzer on Rotating Equipment
2. Real-Time Vibration Data Acquisition
3. Preprocessing and Feature Extraction (FFT, RMS, etc.)
4. AI/ML-Based Fault Classification
5. User Interface Display and Maintenance Alert

Expected Outcomes:

- Early Detection of Rotating Machinery Faults
- AI-Based Fault Classification (Accuracy >90%)
- Reduction in Unplanned Downtime
- Affordable and Portable Vibration Diagnostic Tool
- Improved Industrial Equipment Health Monitoring

Future Enhancements:

- Integration with Cloud-Based Predictive Maintenance Systems
- Addition of Acoustic Signal Analysis for Hybrid Fault Detection
- Training of Deep Learning Models for Fault Severity Prediction
- Battery-Powered and Wireless Operation for Remote Machines
- Multi-Machine Monitoring System with Edge AI Deployment

SDG Mapping:

SDG 8: (Decent Work and Economic Growth), SDG 9: (Industry, Innovation and Infrastructure), SDG 12: (Responsible Consumption and Production).

Project 6: Design and Development of a Compact Mechanical Stair-Climbing Trolley for Urban Utility

Objective:

To design and fabricate a compact, manually operated stair-climbing trolley that can transport moderate loads efficiently over stairs and uneven urban terrains, reducing human effort and improving ergonomics for delivery workers, utility staff, and domestic use.

Problem Statement:

Urban environments with multi-story buildings, narrow staircases, and limited elevator access present significant challenges for manual material handling. Delivery personnel, maintenance workers, and individuals often face difficulties in transporting goods up and down stairs, leading to physical strain and potential injury. Current trolleys are ineffective on stairs and unsuitable for uneven terrain. There is a need for a **portable, purely mechanical stair-climbing solution** that is **affordable, ergonomic, and easy to operate**.

Scope:
- To design a **mechanical stair-climbing mechanism** using a triple-wheel or continuous track configuration.
- To ensure **smooth load transfer** across stairs and flat surfaces.
- To incorporate **foldability and compactness** for portability and storage.
- To optimize the design for **load-bearing capacity (up to 40–60 kg)** without motorized assistance.
- To provide **shock absorption** and user-friendly handling through mechanical balancing.

Features:
- Triple-wheel or crawler-type stair-climbing mechanism
- Ergonomic handle and balancing design
- Foldable frame for easy transport and storage
- Lightweight yet strong materials (aluminum/mild steel)
- Load bed with non-slip surface and shock-absorbing wheels
- Zero power requirement – purely mechanical design

Tools & Technologies:
- **SolidWorks / AutoCAD** – For 3D modeling and structural analysis
- **Mild Steel/Aluminum Sheet and Tubes** – For frame construction
- **Welding and Machining Tools** – For fabrication
- **Rubber-coated Wheels and Bearings** – For smooth and durable motion
- **Spring Mechanisms / Shock Absorbers** – For load cushioning

Workflow:
1. Design and Simulation of Chassis and Climbing Mechanism
2. Material Selection and Frame Fabrication
3. Wheel Assembly and Balancing Configuration
4. Assembly of Handle, Base Plate, and Safety Elements
5. Load Testing and Performance Evaluation

Expected Outcomes:
- Ease of Transporting Loads over Stairs
- Improved Safety and Ergonomics for Users
- Portable and Foldable Design
- Low-Cost Manufacturing Feasibility
- Usability in Residential, Commercial, and Industrial Settings

Future Enhancements:
- Inclusion of Mechanical Braking System
- Integration of Seat Attachment for Emergency Evacuation
- Convertible Design for Flat Surface Push-Trolley Use
- Addition of Weatherproof Material Coatings
- Smart Weight-Balancing Lever (Pure Mechanical, No Electronics)

SDG Mapping:
SDG 3: (Good Health and Well-being), SDG 8: (Decent Work and Economic Growth), SDG 9: (Industry, Innovation, and Infrastructure).

Project 7: AI-Enabled Automated Drain/Gutter Cleaner with Waste Classification System

Objective:
To design and develop an automated mechanical system for cleaning urban drains/gutters, integrated with AI/ML-based waste classification to sort collected debris into biodegradable and non-biodegradable categories for improved waste management and reduced manual scavenging.

Problem Statement:
Urban drainage systems often become clogged with solid waste, leading to waterlogging, flooding, and sanitation issues. Manual cleaning of gutters exposes workers to hazardous waste and unsanitary conditions, violating human dignity and public health norms. While mechanical drain cleaners exist, they lack intelligence in identifying and sorting waste. Hence, there is a need for a semi-autonomous or automated mechanical cleaning system with AI/ML integration to classify and segregate waste in real time and eliminate the need for manual scavenging.

Scope:
- Design and fabricate a mobile, compact mechanical system to **scoop, lift, and dispose** of solid waste from drains/gutters.
- Integrate **camera and sensors** to detect, capture, and analyze waste in real time.
- Use **AI/ML models** to classify collected waste (plastic, organic, metal, etc.).
- Implement a **motorized conveyor or robotic arm** for waste collection and bin segregation.
- Develop a **user interface/dashboard** for monitoring and system control.

Features:
- Mechanized scooping and lifting system for drain cleaning
- Camera module for waste detection
- AI/ML-based waste classification (e.g., CNN model in Python)
- Automatic segregation into bins (biodegradable/non-biodegradable)
- Battery-powered, portable, and easy-to-handle structure
- IoT-based monitoring dashboard (optional)

Tools & Technologies (Top 5):
- **Raspberry Pi / Jetson Nano + Camera** – For image capturing and AI processing
- **Python + TensorFlow / Keras (CNN)** – For training the waste classification model
- **DC Motors, Conveyor Belts, Linkage Mechanism** – For mechanical scooping and transfer
- **Ultrasonic or IR Sensors** – For drain level or obstacle detection
- **SolidWorks / AutoCAD** – For mechanical design and prototyping

Workflow:
1. Deployment and Movement Along Drain/Gutter
2. Scoop and Collect Waste Mechanically
3. Capture Waste Image Using Camera Module
4. AI-Based Classification into Waste Types
5. Sorting Waste into Respective Bins
6. Data Logging and Dashboard Interface (Optional)

Expected Outcomes:
- Reduction in Manual Drain Cleaning Effort
- Effective Waste Classification at Source
- Cleaner Urban Drainage Systems
- Safe and Dignified Alternative to Manual Scavenging
- Scalable Smart City Waste Management Solution

Future Enhancements:
- Autonomous Navigation for Larger Drain Networks
- Edge AI for Onboard Real-Time Classification
- Wireless Data Sync with Municipal Dashboards
- Solar-Powered Battery Charging Option
- Voice-Controlled Interface for Maintenance Crews

SDG Mapping:
SDG 3: (Good Health and Well-being), SDG 6: (Clean Water and Sanitation), SDG 9: (Industry, Innovation and Infrastructure) SDG 11: (Sustainable Cities and Communities)

Project 8: AI-Enabled Self-Charging Solar Surveillance Drone for Real-Time Monitoring

Objective:
To design and develop an autonomous surveillance drone powered by solar energy, with AI-enabled real-time image/video analysis for applications such as border monitoring, disaster management, and smart city surveillance, while eliminating the need for frequent manual charging.

Problem Statement:
Surveillance drones are widely used for real-time monitoring in defense, disaster zones, agriculture, and smart cities. However, their limited battery life poses a major operational constraint, requiring frequent manual charging. Additionally, without AI, they cannot autonomously analyze captured footage or detect anomalies. There is a need for a solar-powered, self-charging drone that uses AI to identify, classify, and respond to events in real time, enabling efficient and long-duration autonomous monitoring.

Scope:
- To design a lightweight drone equipped with solar panels for continuous power generation.
- To integrate AI/ML-based object detection and anomaly recognition (e.g., intruders, fire, vehicles).
- To enable autonomous navigation and area patrol with GPS and obstacle avoidance.
- To incorporate real-time video transmission and alert generation.
- To build a ground station dashboard for data visualization, alerts, and mission planning.

Features:
- Solar panels mounted on the drone's body/wings for self-charging during flight or hover.
- AI-based image processing for object recognition, motion tracking, and behavior detection.
- GPS + IMU + obstacle sensors for autonomous flight path planning.
- Real-time video streaming and cloud storage using onboard camera and IoT modules.
- Return-to-home and emergency landing protocols for safety and reliability.

Tools & Technologies:
- Solar Thin-Film Panels – For lightweight, onboard power generation.
- Raspberry Pi / Jetson Nano + Camera – For onboard AI video processing.
- Python + OpenCV + TensorFlow – For object detection and image analysis.
- Brushless Motors + Flight Controller (Pixhawk / Ardupilot) – For stable drone navigation.
- Ground Control Software (QGroundControl / Mission Planner) – For flight planning and telemetry.

Workflow:
1. Pre-Flight Solar Charging and Mission Upload
2. Autonomous Flight Using GPS and Waypoints
3. AI-Powered Real-Time Video Analysis and Object Detection
4. Alert Transmission to Ground Station (e.g., intruder/fire detection)
5. Return to Charging Point or Hover for Passive Charging
6. Data Logging and Post-Mission Review

Expected Outcomes:
- Extended Flight Duration via Solar Self-Charging
- Autonomous, Unmanned Surveillance Capabilities
- AI-Based Detection of Anomalies (e.g., fire, movement, intrusion)
- Reduced Human Involvement in Monitoring Tasks
- Deployability in Remote and Critical Areas

8. Future Enhancements:
1. Swarm Drone Deployment for Area Coverage
2. Thermal Imaging Integration for Night Surveillance
3. Voice Alert System and Audio Analysis

4. AI Model Update via Cloud for Improved Accuracy
5. Docking Station with Solar Panel Array for Group Charging

SDG Mapping:
SDG 9: (Industry, Innovation, and Infrastructure), SDG 11: (Sustainable Cities and Communities), SDG 13: (Climate Action), SDG 16: (Peace, Justice and Strong Institutions).

Project 9: Anti-Riot Shield with Integrated Pepper Spray and Blinding LED System

Objective:
To design and develop a multi-functional anti-riot shield that enhances crowd control capabilities by integrating a **remotely activated pepper spray mechanism** and **high-intensity blinding LED lights**, thereby improving the safety and effectiveness of law enforcement personnel during riot or mob situations.

Problem Statement:
Conventional riot shields offer only passive protection and require additional equipment to actively manage hostile crowds. Law enforcement officers are often at risk due to limited tools in volatile situations. There is a need for an **enhanced defensive shield** that combines **active deterrent features**, such as pepper spray and disorientation-inducing lights, to allow safer and more controlled responses during riots without escalating force unnecessarily.

Scope:
- To design a **lightweight, impact-resistant polycarbonate shield** for riot control.
- To integrate a **non-lethal pepper spray ejection system** controllable via button or remote.
- To embed **high-lumen strobe or blinding LEDs** to impair aggressors' vision temporarily.
- To ensure **modular design** so components can be replaced or upgraded easily.
- To provide **battery-powered operation** with safety locks and usability under stress.

Features:
- Ergonomic riot shield with forearm straps and reinforced grips
- Pepper spray nozzle with electronic actuator for controlled dispersion
- Ultra-bright LED floodlight system with strobe mode
- Internal battery and control circuitry with toggle switches
- Transparent and shock-resistant front view panel for visibility

Tools & Technologies:
- Polycarbonate / Bullet-resistant acrylic – For shield fabrication
- Solenoid Valve System – To control pepper spray dispersion
- LED Modules with Flash Drivers – For blinding/disorienting effect
- 12V Rechargeable Battery Pack – For powering electronics
- SolidWorks / AutoCAD – For shield and component design

Workflow:
1. Shield Frame and Material Selection
2. Pepper Spray Dispenser Integration
3. LED Circuit and Housing Design
4. Battery and Control Module Assembly
5. Testing of Activation Mechanism and Safety Controls

Expected Outcomes:
- Enhanced Active Protection for Riot Control Units
- Quick and Controlled Deployment of Non-lethal Measures
- Deterrent Effect Through Visual and Chemical Means
- Safer Crowd Management with Less Physical Contact
- Modular, Field-Serviceable Design

Future Enhancements:

1. Integration of Body Cam or Recording Module
2. GPS & Communication System for Team Coordination
3. Remote Wireless Activation via Control Center
4. AI-Based Threat Detection and Activation (Future Scope)
5. Addition of Expandable Batons or Shields for Full Body Coverage

SDG Mapping:
SDG 9: (Industry, Innovation and Infrastructure), SDG 16: (Peace, Justice and Strong Institutions), SDG 11: (Sustainable Cities and Communities).

Project 10: Design and Fabrication of AI-Enabled Emergency Braking System in Four-Wheeler

Objective:
To design, fabricate, and validate a four-wheeler emergency braking system that uses AI/ML algorithms to detect imminent collision scenarios and autonomously apply brakes, thereby reducing stopping distance and enhancing vehicle safety.

Problem Statement:
High-speed driving and unpredictable traffic conditions often lead to delayed human reaction times, resulting in accidents. Conventional braking systems depend solely on driver input and lack predictive capabilities to preempt collisions. There is a need for an **intelligent, AI-enabled emergency braking system** that can analyze sensor data in real time, predict hazardous situations, and intervene by applying brakes autonomously to avoid or mitigate collisions.

Scope:

- To integrate sensors (ultrasonic, radar, and camera) for obstacle detection around the vehicle.
- To develop AI/ML models for real-time hazard prediction based on sensor fusion data.
- To design and fabricate an electro-mechanical actuation mechanism capable of instant brake engagement.
- To implement a microcontroller-based control unit for data processing and actuator control.
- To conduct performance testing on a scaled-down four-wheeler prototype under simulated emergency scenarios.

Features:

- Multi-sensor array (ultrasonic, radar, and vision) for 360° obstacle detection
- AI/ML-based collision prediction algorithm (e.g., LSTM for trajectory forecasting)
- Electro-mechanical brake actuator with rapid response time
- Visual and auditory warnings to alert the driver before brake intervention
- Data logging for event analysis and model retraining

Tools & Technologies:

- **Ultrasonic Sensors (HC-SR04) & Automotive Radar Module** – For distance measurement and obstacle detection
- **Camera (RGB) + OpenCV** – For vision-based object recognition
- **Raspberry Pi or NVIDIA Jetson Nano** – For running AI/ML inference in real time
- **Python + TensorFlow/Keras** – For training and deploying collision prediction models
- **DC Linear Actuator & Electronic Control Unit (ECU)** – For brake actuation and control

Workflow:

1. Sensor Placement and Calibration
2. Data Collection and Model Training
3. Real-Time Sensor Fusion and Hazard Prediction
4. Actuator Integration and Brake Control Logic
5. Prototype Testing and Validation

Expected Outcomes:

- Reduced Reaction Time and Stopping Distance
- Accurate Detection of Imminent Collision Scenarios

- Reliable Autonomous Brake Activation
- Driver Warning and Override Capability
- Dataset for Continuous Model Improvement

Future Enhancements:

1. Integration with Vehicle CAN Bus for Seamless OEM Implementation
2. V2V Communication for Cooperative Emergency Braking
3. Adaptive Learning Based on Driving Behavior
4. Integration with Autonomous Driving Control Systems
5. Miniaturization for Commercial Deployment

SDG Mapping:

SDG 3: (Good Health and Well-being), SDG 9: (Industry, Innovation and Infrastructure), SDG 11: (Sustainable Cities and Communities), SDG 12: (Responsible Consumption and Production)