Design Challenge Project: Capacitor-Powered Vehicle Race

Objective:

The primary objective of the Capacitor-Powered Distance Challenge is for each team to design and build a small vehicle that operates solely on energy stored in a capacitor charged to a designated voltage. The vehicle must be engineered to travel the maximum possible distance on a single charge, emphasizing efficient energy use, lightweight construction, and innovative mechanical design. Teams are encouraged to optimize their vehicles for distance, stability, and reliability, focusing on maximizing performance through smart engineering and resourceful design.

Problem Statement:

In this challenge, each team will develop a capacitor-powered vehicle to compete on a flat, smooth track. The vehicle must be lightweight, energy-efficient, and capable of traveling the furthest possible distance on a single capacitor charge. Teams must carefully consider weight distribution, friction reduction, and mechanical efficiency to optimize the vehicle's performance, working within a standard set of resources provided.

The competition will evaluate the vehicle's ability to:

1. Maximize distance on a single charge: Vehicles must use energy efficiently to achieve maximum travel range.
2. Balance weight and mechanical design: Teams must minimize vehicle weight while ensuring structural stability and energy conservation.
3. Maintain control and reliability: Vehicles should perform consistently across attempts without deviations in motion or stability.

The final score will be based on the vehicle's ability to travel the farthest distance on a single charge, with penalties applied for deviations from competition guidelines. This challenge emphasizes innovative mechanical design, efficient energy use, and precision engineering.

Key Milestones:

1. **Initial Selection:**
    a. A team of judges will review all submissions and select the top 3-5 teams from this category during the week of Feb. 10th, 2025.
    b. Teams will present their projects and conduct demos in the Design Studio
2. **Finals**:
    a. The Demo Fest will take place in the ERC Atrium the week after Reading Week.

b. Finalists will showcase their projects to a broader audience, including judges, peers, and faculty.

Resources and Materials:

- **Capacitors**:
  Supercapacitors (e.g., 100 Farads, 2.7V), provided to each team to standardize the energy source. These capacitors will be pre-charged to a specific voltage for fairness.
- **Motors**:
  Small, low-power DC motors that teams can select based on preferred torque-speed characteristics. Motor choice impacts vehicle acceleration and distance traveled.
- **Chassis Materials**:
  Students shall design and 3D-print them.
- **Wheels and Bearings**:
  Students shall design and 3D-print them.
- **Gears and Transmission Components**:
  Gearboxes or pulley systems available for optimizing torque-speed ratios, allowing teams to fine-tune motor efficiency relative to energy constraints.
- **Measuring Equipment**:
  Tape measures or laser distance measurement devices for recording travel distance, along with multimeters for capacitor voltage checks before and after each race.
- **Testing and Race Track**:
  A long, flat, smooth track (e.g., gym floor or hallway) will be designated as the testing area. This will allow vehicles to reach their maximum potential range.
- **Capacitor Charging Equipment**:
  A consistent DC power source with voltage regulation for standardized capacitor charging. Each team will have a set time (1-2 minutes) to charge capacitors before each race.

Rules and Guidelines:

- **Power Source**
  - Vehicles must operate solely on the provided capacitor. No additional power sources or battery replacements are allowed during the race.
- **Autonomous Motion**
  - The vehicle must be self-propelled and cannot receive any external assistance once the race begins.
- **Participants Constraints**
  - Capstone projects are not allowed.
  - Priority is given to students in years 1-3.

    - Only Engineering students, including international students in Engineering, are eligible.
- **Vehicle Design Requirements**
    - Size and Weight: Teams are encouraged to build compact, lightweight vehicles while maintaining stability.
    - Safety: Vehicles must not have sharp edges or loose parts that could become hazards during operation.
    - Energy Efficiency: Emphasis is placed on minimizing friction and maximizing travel distance with available energy.

Rules for Attempts and Measurement:

- **Attempt Limit**
    - Each team is allowed a maximum of 3 attempts to achieve their best distance.
- **Distance Measurement**
    - Travel distance will be recorded from the starting point to the point where the vehicle comes to a complete stop.
- **Reset for Off-Track Scenarios**
    - If the vehicle veers off track, it will be returned to the starting line, counting as one of the three attempts.

Judging Criteria:

- **Problem Relevance and Understanding (20%)**
    - Clear identification of the engineering problem, supported by research.
- **Creativity and Innovation (25%)**
    - Original and feasible design, demonstrating innovative approaches in energy efficiency and mechanical structure.
- **Solution Design and Functionality (30%)**
    - Well-structured and functional design with a clear workflow and practical implementation.
- **Presentation and Documentation (15%)**
    - Effective and well-organized presentation, supported by comprehensive documentation.
- **Practical Feasibility and Considerations (10%)**
    - Demonstration of practical feasibility and consideration of key challenges, including material selection and reliability.

Expected Timeline:

Preparation Phase

- Phase 1: Research and Planning
    - Teams research capacitor-powered designs, learn about motor efficiency, and start planning vehicle structure.
- Phase 2: Prototyping and Assembly
    - Teams assemble a basic prototype, integrating the capacitor and motor, with initial 3D-printed components.
- Phase 3: Testing and Optimization
    - Teams conduct distance trials, adjusting weight, friction, and energy usage to optimize range. Feedback sessions will guide improvements.
- Phase 4: Final Adjustments and Documentation
    - Teams finalize designs, prepare all documentation, and complete the vehicle for competition.

Competition Phase

- **Demo:**
    - **Competition Day and Final Presentations (Thursday Feb. 27th, 2025)**
        - Teams will have practice runs, followed by official timed attempts. Presentations and judging will occur after the race.

Group Sizes and Roles:

- **Team Size**:
  1-4 participants per team, promoting collaborative decision-making in design and testing.
- **Roles Suggested**:
    - **Lead Designer**: Responsible for vehicle design and material selection.
    - **Motor and Power Engineer**: Focuses on motor choice, capacitor optimization, and energy efficiency.
    - **Chassis and Weight Specialist**: Oversees material use, weight distribution, and structural integrity.
    - **Testing and Optimization Specialist**: Conducts trials and fine-tuning adjustments.

Prizes:

- $1,000 for the winning team in each category.
- $500 for the runner-up in each category.
- Total prize pool: $4,500.