Design Challenge Project: Autonomous Line Follower Racing Robot

Objective:
The primary objective of the Autonomous Line Follower Racing Robot Competition is for each team to design and build an autonomous robot capable of navigating a complex course in the shortest possible time. The robot must accurately follow a marked path, handling turns, and intersections, all without human intervention. Teams are encouraged to optimize their robots for speed, stability, and precision in line-following while maintaining control and reliability.

Problem Statement:

In this challenge, each team will develop an autonomous robot to compete on a predetermined track. The track consists of a continuous line with varying curves, straight segments, and possible intersections or loops. The robot must use sensors to detect and stay aligned with the line, maintaining speed and control as it navigates each section.

The competition will evaluate the robot's ability to:

1. **Follow the line continuously**: Robot must stay on track, adjusting speed and direction to handle sudden changes in the path.
2. **Navigate turns and intersections**: Each robot must maneuver through various corners and intersections, ensuring no deviation from the path.
3. **Balance Speed and Accuracy**: Each team should optimize their robot to complete the course in the shortest time possible without sacrificing accuracy.

The final score will be based on the robot's ability to complete the course swiftly and accurately, with penalties applied for deviations or off-track occurrences. This challenge emphasizes precision engineering, algorithm efficiency, and testing endurance in dynamic scenarios.

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:

- **Arduino Board/Kit with Sensors**:
    - **Description**: Each team will be provided with an Arduino board (e.g., Arduino Uno or Nano) along with a kit of essential sensors, such as IR sensors for line detection, ultrasonic sensors for obstacle detection, and motor drivers.
    - **Importance**: The Arduino platform is versatile, beginner-friendly, and widely used in robotics projects, making it ideal for prototyping and testing. These sensors are key components for detecting and following the line while navigating the course.
    - **Provision**: This kit will be provided to each team at the start of the competition. Teams are encouraged to leverage this resource for the foundational aspects of their robot design.
- **Access to 3D Printing and Soldering Services**:
    - **Description**: Teams will have access to 3D printing facilities to design and fabricate custom parts, as well as soldering stations for assembling circuit boards and securing wiring connections.
    - **Importance**: 3D printing enables teams to create custom components tailored to their robot's needs, such as sensor mounts, housings, or lightweight chassis modifications. Soldering is essential for creating durable, reliable connections in the robot's circuitry.
    - **Provision**: Teams may schedule time with the 3D printer and soldering stations as needed. Staff support will be available for guidance on using the equipment safely and effectively.
- **Additional Resources**:
    - **Workspaces and Testing Areas**: Teams will have designated workspaces equipped with power sources, testing tracks, and tools for assembling and testing their robots.

Rules and Guidelines:

- **Power Source**
    - **Allowed Power Source**: Robots must be powered by battery packs, with a maximum allowable voltage of 12V. Lithium-ion or NiMH rechargeable batteries are recommended for their efficiency and durability.
    - **Restrictions**: External power sources or charging during the competition run is prohibited. Teams must ensure their batteries are fully charged before each race to prevent disruptions.
    - **Safety**: All batteries must be securely fastened to prevent dislodgement. Exposed wiring should be avoided, and power sources must be adequately insulated to minimize short circuits.
- **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.
- **Construction/Design Requirements**
    - **Size Constraints**: Robots must fit within a 20 cm x 20 cm footprint at the start. They can expand slightly during operation but must remain compact to navigate the track.
    - **Weight Limit**: The maximum allowable weight for each robot is 3 kg, including all components.
    - **Autonomy**: Robots must be fully autonomous once the race begins, with no external control or adjustments allowed.
    - **Component Limitations**: Teams are encouraged to use the provided Arduino kits and sensors. While additional components are allowed, teams must keep within their allocated budget for these parts. Custom parts (e.g., 3D-printed mounts) are permissible but must be safe and securely attached.
    - **Safety Requirements**: Sharp edges, exposed circuit elements, or potentially hazardous materials are not allowed. All components must be securely fastened to prevent loose parts or wiring during the race.
- **Rules for Attempts and Off-Track Scenarios**
    - **Attempt Limit**: Each team is allowed a maximum of **3 attempts** to complete the course.
    - **Off-Track Reset**: If the robot leaves the designated line and goes off track, it must be **restarted from the beginning**. This will count as one of the three allowed attempts.
    - **Wandering Correction**: If the robot starts wandering off the line but stays on the track, manual repositioning is allowed. Teams may place the robot back at the point where it began to deviate.
    - **Time Penalties**: Any manual repositioning incurs a time penalty. Penalties will be applied to the team's final score and will affect their ranking.
- **Judging Criteria**
    - **Problem Relevance and Understanding (20%)**
        - **Description**: Clear identification of a critical problem, supported by thorough research
    - **Creativity and Innovation (25%)**
        - **Description**: Original and feasible solution, demonstrating innovative approaches in design or application
    - **Solution Design and Functionality (30%)**
        - **Description**: Well-structured and functional design, with a clear workflow and practical implementation.
    - **Presentation and Documentation (15%)**
        - **Description**: Effective and well-organized presentation, supported by comprehensive and clear documentation.
    - **Practical Feasibility and Considerations (10%)**
        - **Description**: Demonstration of practical feasibility and consideration of key challenges, such as ethical concerns, usability, or scalability.

Expected Timeline:

- **Preparation Phase**:
  Phase 1: Research and Initial Planning
    - **Objective**: Teams will research line-following robot designs, familiarize themselves with provided components, and begin planning their approach.
    - **Activities**: Review sensor options, explore basic line-following algorithms, and outline initial design concepts. Teams will complete preliminary sketches and create a list of additional materials needed.

  Phase 2: Prototyping and Assembly
    - **Objective**: Begin assembling the basic robot structure, integrating the Arduino board, sensors, and motors.
    - **Activities**: Construct the robot chassis, mount sensors, and connect motor drivers and batteries. By the end of Week 4, teams should have a basic prototype ready for initial testing on straight paths.

  Phase 3: Testing and Iterative Development
    - **Objective**: Enhance the robot's functionality by refining the line-following algorithm, sensor calibration, and motor control.
    - **Activities**: Conduct trials on varied track shapes, adjust sensor placements, and tweak algorithms to improve responsiveness. Teams will focus on increasing speed, accuracy, and handling sharp turns. Regular team feedback sessions will guide improvements.

  Phase 4: Advanced Optimization and Stability Testing
    - **Objective**: Optimize the robot's performance, focusing on stability, speed control, and precise line-following.
    - **Activities**: Refine all mechanical and electronic components, aiming for maximum efficiency. Test the robot's response to track variations and perform endurance tests to ensure durability during longer races.

  Phase 5: Final Adjustments and Documentation
    - **Objective**: Finalize the robot design and prepare presentation materials.
    - **Activities**: Make final design adjustments, organize all code and documentation, and prepare the robot for competition conditions. Teams will also rehearse their presentations.
- **Competition Phase**:
  Demo: Competition Day and Final Presentations
    - **Date and Venue**: The competition will be held on Thursday Feb. 27th 2025, with details on exact timing and location provided closer to the event.
    - **Competition Setup**: Each team will have time to set up and conduct a practice run on the official track before the race. The main event includes timed runs for each robot, where teams compete for the fastest and most accurate completion of the course.
    - **Presentation and Judging**: After the competition, each team will present their robot, showcasing design features, code insights, and addressing challenges encountered. Judging will be based on previously outlined criteria, with awards for top-performing teams.

Group Sizes and Roles:

- **Team Size**
    - **Recommended Number of Participants**: Each team should consist of **1 to 4 members**. Smaller teams (1-2 members) are suitable for participants who are comfortable with multiple responsibilities, while larger teams (3-4 members) allow for a more focused division of tasks.
- **Suggested Roles**
    - **Project Manager / Team Leader**
        - **Responsibilities**: Oversees the entire project timeline, organizes team meetings, and ensures tasks are progressing on schedule. The team leader also communicates with mentors or competition organizers for guidance or clarifications.
    - **Hardware Engineer**
        - **Responsibilities**: Responsible for assembling and designing the robot's hardware, including chassis construction, sensor integration, and motor installation. This role ensures that all hardware components are safely mounted, functional, and durable.
    - **Software Developer**
        - **Responsibilities**: Focuses on programming the robot, including developing and optimizing the line-following algorithm, tuning sensor readings, and managing motor controls. This role requires familiarity with Arduino coding and sensor calibration.
    - **Testing and Quality Control Specialist**
        - **Responsibilities**: Conducts tests on the robot's performance, collects data from trials, and identifies areas for improvement. This role involves refining stability, speed, and accuracy by adjusting the code and hardware as necessary based on test results.

Prizes:

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