Development of Electro-Mechanical Demonstration Model of a Hybrid Electric Vehicle – Mechanical Subsystem

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1. Motivation

With the global shift toward sustainable transportation, Hybrid Electric Vehicles (HEVs) represent a key transition between internal combustion engines and fully electric systems. This project aims to develop a scaled-down HEV model, emphasizing the mechanical subsystem to demonstrate real-world functionality and educate learners on how mechanical energy is converted, stored, and transferred. Our interest lies in bridging the mechanical and electrical components in a tangible, demonstrative format, aligning with our academic and career focus in automotive and mechanical systems.

2. Overview

2.1 Significance of the Project

This HEV demonstration model will serve as a valuable educational tool for understanding hybrid vehicle systems, allowing observation of power flow, mechanical linkages, and drivetrain behavior. Its practicality lies in promoting awareness and interest in green mobility, and academically, it reinforces applied engineering concepts through hands-on integration of mechanical design with electro-mechanical components.

2.2 Description of the Project

The model will demonstrate a simplified HEV system, including chassis, drivetrain, gear transmission, and mechanical coupling to an electric motor and battery pack. It will reflect either a series or parallel hybrid configuration. The mechanical subsystem involves CAD design, lightweight chassis fabrication, wheel and axle assembly, and gear implementation.

2.3 Background of the Project
Hybrid vehicles have been widely researched and deployed as a bridge between internal combustion and electric vehicles. Studies such as [1] and [2] detail drivetrain models and hybrid configurations, emphasizing the complexity in coupling mechanical motion to electrical systems. This model will borrow key concepts from existing HEV architectures to simplify and demonstrate them physically.

3. Methodology

3.1 Design Phase
We will evaluate various HEV configurations and select a series or parallel hybrid model. Using SolidWorks, we will design the frame, motor mounts, wheel assembly, and drivetrain layout. The design aims to balance realism with manufacturability and educational clarity.

3.2 Implementation Phase
The mechanical parts will be fabricated using aluminum, plastic, or wood. Components such as gears, mounts, and linkages will be either 3D printed or machined. Wheels, axles, and transmission will be assembled and aligned with the electric drive system.

3.3 Testing Phase
We will test rolling performance, gear transmission response, motor-wheel coupling efficiency, and frame stability. If on-site testing resources are unavailable, we will simulate results using motion software or video demonstrations.

3.4 Evaluation Phase
We will evaluate efficiency, mechanical response under different loads, and operational stability. Documentation will include graphs, annotated images, and analysis based on predefined benchmarks.

4. Features
- Compact and lightweight chassis for easy handling.
- Modular mounting for motors and components.
- Simulated powertrain to show series or parallel HEV working.
- Physical gear and wheel motion to demonstrate power delivery.
- Educational utility for mechanical and automotive training.

5. Project Planning

Timeline (Week)	Planned Activity
1–2	Initial research and design finalization
3–4	CAD design and material procurement
5–6	Fabrication of mechanical parts
7	Mechanical and electrical integration
8	Testing and demonstration

6. Hardware and Software Requirement

- SolidWorks or Fusion 360 for CAD design.
- 3D Printer, CNC Machine or Workshop Tools (drill, cutter, welding machine).
- Aluminum/plastic sheets, gear assemblies, small-scale wheels, fasteners.
- Small electric motor (DC), batteries, and control switch.

7. Diagrammatic Representation

Initial design sketches and CAD diagrams will be attached as the design evolves. (Hand sketches acceptable in interim).

8. References

[1] A.B. Smith, C.D. Jones, and E.F. Roberts, “Overview of Hybrid Drivetrains,” Journal of Mechanical Systems, 2018, pp. 101–110.
[2] Jones, C.D., A.B. Smith, and E.F. Roberts, Hybrid Vehicle Technology, McGraw Hill, 2020.