ELECTRIC AND HYBRID VEHICLES

ENAM 301

Lecture: 3 **Year: III**
Tutorial: 1 **Part: I**
Practical: 3/2

Course Objectives:
The objective of this course is to provide fundamental knowledge of electric and hybrid vehicles (EVs and HEVs), covering their history, architecture, design, operation, and control strategies. It also addresses energy storage systems, charging infrastructure, and the evaluation of their environmental, economic, and performance aspects.

1 Introduction (4 hours)

1.1 History and evolution of EVs and HEVs
1.2 Need for electric vehicles: Environmental and energy aspects
1.3 Types of electric vehicles (EVs, HEVs, PHEVs, FCEVs)
1.4 Comparative study: IC engine vehicles vs. electric vehicles
1.5 Recent trends in EVs, HEVs and cybersecurity in EVs
1.6 Scenario of Nepal in the context of EVs, HEVs, EV conversion
1.7 Vehicle dynamics, tractive force, power and torque equations, gradeability, and acceleration

2 Hybrid Vehicle Systems (5 hours)

2.1 Classification of hybrids: Series, parallel, series-parallel, degree of hybridization
2.2 Architecture and power flow control
2.3 Energy management strategies
2.4 Role of IC engines in hybrids
2.5 Advantages and challenges in HEV design

3 Electric Propulsion Systems (8 hours)

3.1 Electric motor types and characteristics: DC motors (Brushed and brushless), induction motors, permanent magnet motors (PMSM, BLDC)
3.2 Comparisons of efficiency, cost, and applications of each motor type
3.3 Motor control techniques: PWM, V/f, FOC
3.4 Regenerative braking system

4 Battery Storage Systems (8 hours)

4.1 Basic components of battery cells

4.2 Battery types and their life cycle analysis: Lead acid, NiMH, Li-ion, LFP, solid-state
4.3 Battery specifications and performance parameters
4.4 Battery management system (BMS) and safety
4.5 Battery charging methods: Onboard/off-board chargers
4.6 Supercapacitors and flywheel
4.7 Thermal management system
4.8 Range estimation and energy consumption
4.9 Battery recycling and reuse strategies

5 Charging Infrastructure and Power Electronics (8 hours)

5.1 Working principle and components of AC and DC charging stations
5.2 Types of charging stations: (Level 1, 2, DC fast charging)
5.3 Types of charging connectors and standards (CCS, CHAdeMO, GB/T, Type 2)
5.4 Standalone charging and solar power charging station
5.5 Sizing of charging station
5.6 Smart grid and EV charging, wireless charging, G2V, V2G
5.7 Social, environment and economic benefits of different charging

6 Safety and Hazard Management (4 hours)

6.1 General safety precautions
6.2 High-voltage safety precautions
6.3 De-energizing high voltage
6.4 Safety tools, equipment and safety work process
6.5 Fire and thermal runaway protocols

7 Trends, Challenges, and Future Technologies (8 hours)

7.1 Autonomous EVs and AI integration
7.2 Hydrogen fuel cell vehicles
7.3 Government policies, incentives, and global EVs adoption
7.4 Standards and codes followed in EVs
7.5 Recycling and sustainability of EVs components
7.6 Future trends in mobility and smart transportation

Tutorial (15 hours)

1. Comparative analysis of energy consumption and fuel efficiency between EVs and conventional vehicles.
2. Vehicle tractive force, power, and torque requirement calculations for varying conditions of gradeability and acceleration; range estimation problems in EVs
3. Motor sizing calculations for given EV specifications, estimation of motor output power and efficiency

4. Battery capacity estimation for given drive cycles; depth of discharge, cycle life, and charging time calculations
5. Basic design of small solar-powered charging stations for EVs
6. Design and sizing of AC/DC chargers for different charging mode
7. Payback period, life cycle cost, and CO_2 emission savings of EVs compared to ICE vehicles

Practical **(22.5 hours)**

1. Simulation work (MATLAB/Simulink, ANSYS, or any open-source tools) for EV powertrain/components/charging station design
2. Motor performance testing
3. Battery performance testing and BMS observation
4. EV components and their identifications, visit to near EV manufacturing or service center
5. Basic EV conversion demonstration

Final Exam

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

Chapter	Hours	Marks distribution*
1	4	6
2	5	10
3	8	8
4	8	12
5	8	8
6	4	6
7	8	10
Total	**45**	**60**

* There may be minor deviation in marks distribution.

References

1. Ehsani, M., Gao, Y., Longo, S., Ebrahimi, K. (2018). Modern electric, hybrid electric, and fuel cell vehicles: Fundamental theory and design. CRC Press.
2. Denton, T. (2016). Electric and hybrid vehicles. Routledge.
3. Husain, I. (2021). Electric and hybrid vehicles: Design fundamentals. CRC Press.
4. Larminie, J., Lowry, J. (2012). Electric vehicle technology explained. Wiley.