AUTONOMOUS VEHICLES

ENAM 465

Lecture	**: 3**	**Year : IV**
Tutorial	**: 2**	**Part : II**
Practical	**: 1**	

Course Objectives:

The objective of this course is to provide concepts, technologies and challenges of autonomous vehicles. By the end of the course, students will be able to analyze the architecture of autonomous vehicles, apply basic algorithms for perception and planning and evaluate the performance and safety of autonomous driving technologies.

1 Introduction (5 hours)

1.1 Definition and historical evolution of autonomous vehicles
1.2 Key advantages and challenges
1.3 Levels of autonomous
1.4 Autonomous vehicle (AV) system architecture and key components
1.5 Operational design domain (ODD)
1.6 Industry trends and major players in the autonomous vehicle ecosystem
1.7 Application and uses of AV

2 Sensor Technologies (6 hours)

2.1 Role of sensing in autonomous driving
2.2 LiDAR fundamentals and automotive applications
2.3 Radar principles and advantages in vehicles
2.4 Camera systems and vision sensors
2.5 Ultrasonic sensors for short-range detection
2.6 Global navigation satellite system and IMU (Inertial measurement unit)
2.7 Sensor fusion concept and benefits

3 Perception and Computer Vision (5 hours)

3.1 Image processing basics for road scenes
3.2 Object detection concept (Vehicles, pedestrians, lanes)
3.3 Semantic segmentation concept
3.4 Motion detection and object tracking
3.5 Depth perception and 3D environment understanding

4 Localization and Mapping (5 hours)

4.1 GPS and vehicle positioning challenges
4.2 GNSS and RTK (Real time kinematic) positioning

4.3 Visual odometry and wheel odometry
4.4 Concept of SLAM (Simultaneous localization and mapping)
4.5 Digital maps and high-definition maps
4.6 Sensor fusion for localization

5 Path Planning and Decision Making for AVs (5 hours)

5.1 Route planning versus motion planning
5.2 Obstacle avoidance strategies
5.3 Behaviour planning (Lane change, merging, intersections)
5.4 Traffic rules and decision making
5.5 Planning algorithms: Dijkstra, A* algorithm, sampling based planning

6 Vehicle Dynamics and Control (5 hours)

6.1 Longitudinal vehicle control
6.2 Lateral vehicle control
6.3 Feedback control systems
6.4 Adaptive cruise control (ACC)
6.5 Lane keeping control
6.6 Drive-by-wire systems
6.7 Introduction to model predictive control

7 AI and Machine Learning in AVs (4 hours)

7.1 Importance of AI in AVs
7.2 Supervised versus unsupervised learning
7.3 Reinforcement learning overview
7.4 Neural networks and deep learning overview
7.5 Limitations of AI in real-world driving

8 Safety, Validation and Cybersecurity (5 hours)

8.1 Safety Frameworks: Functional safety concept in road vehicles, ISO 26262 and ISO 21448 (SOTIF) for AVs
8.2 Validation and Verification: Simulation-based testing (MIL, SIL, HIL) and edge-case and scenario-based testing
8.3 Performance evaluation metrics: Safety, perception and control systems
8.4 Redundancy and fail-operational systems
8.5 Cybersecurity for AVs: Threat modeling, secure V2X communication and over-the-air (OTA) updates

9 Simulation Platforms, Ethics and Future Trends (5 hours)

9.1 Simulation Platforms for Autonomous Driving: CARLA, AirSim and MATLAB/Simulink
9.2 Building realistic driving scenarios for testing

9.3 V2X Communication: Vehicle-to-Vehicle (V2V) and Vehicle-to-Infrastructure (V2I) technologies
9.4 Decision-making in critical situations, liability and regulatory landscape
9.5 End-to-end deep learning for AVs, autonomous driving in challenging conditions and the convergence of AI and edge computing

Tutorial **(30 hours)**

1. AV system block diagram and SAE level mapping exercises
2. Sensor selection, placement and coverage calculations
3. Perception system evaluation and object detection calculations
4. Localization and mapping design and position calculation exercises
5. Path planning and trajectory optimization exercises
6. Vehicle dynamics and control calculations (Longitudinal/lateral)
7. AI/ML-based decision-making analysis exercises
8. Safety framework and hazard assessment calculations
9. Simulation platform exercises and scenario construction
10. V2X communication and system performance analysis

Practical **(15 hours)**

1. Setting up Python/OpenCV and running basic image and video processing for driving datasets
2. Multi-sensor data visualization and coordinate Oansformation using camera, LiDAR and radar datasets
3. Object detection using pretrained models and performance evaluation
4. Path planning implementation (A*, RRT) and trajectory visualization
5. Autonomous driving simulation in CARLA or AirSim with sensor setup, data collection and basic autopilot experimentation

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	5	6
2	6	8
3	5	6
4	5	6
5	5	8
6	5	8
7	4	6
8	5	6
9	5	6
Total	**45**	**60**

* There may be minor deviation in marks distribution.

References

1. Maurer, M., Gerdes, J. C., Lenz, B., Winner, H. (Eds.). (2016). Autonomous driving: Technical, legal and social aspects. Springer.
2. Siegwart, R., Nourbakhsh, I. R., Scaramuzza, D. (2011). Introduction to autonomous mobile robots. MIT Press.
3. Fleming, W. J. (2019). Automotive sensors and sensor systems. SAE International.
4. Rajamani, R. (2012). Vehicle dynamics and control. Springer.
5. Thrun, S., Burgard, W., Fox, D. (2005). Probabilistic robotics. MIT Press.
6. LaValle, S. M. (2006). Planning algorithms. Cambridge University Press.

AUTOMOBILE ECONOMICS AND ENTERPRISES

ENAM 469

Lecture	**: 3**	**Year : IV**
Tutorial	**: 2**	**Part : II**
Practical	**: 1**	

Course Objectives:

The objective of this course is to provide knowledge of the economic, financial, and managerial aspects of automobile systems and transport enterprises. It focuses on vehicle cost analysis, taxation, insurance, regulatory frameworks, and economic decision-making in transport operations. Upon completion, students will be able to evaluate enterprise development concepts and emerging trends such as CKD/SKD assembly, electric mobility, and sustainable transport systems.

1 Introduction to Automobile Economics (3 hours)

1.1 Concept and structure of transportation systems
1.2 Classification: Road, rail, air, water transport systems
1.3 Historical development of road transportation (Global and Nepal context)
1.4 Modes of transportation and modal choice criteria
1.5 Types of transport operations: Private, public, contract carriage
1.6 Role of economics in transport decision-making
1.7 Vehicle life cycle costing (LCC) approach
1.8 Fixed, variable and semi-variable cost concepts
1.9 Introduction to cost optimization in automobile systems

2 Vehicle Ownership, Operating Cost and Depreciation (5 hours)

2.1 Components of vehicle ownership
2.2 Operating costs: Fuel, maintenance, tires, wages, overheads
2.3 Cost per kilometer and cost per ton-km/passenger-km
2.4 Break-even analysis in vehicle operation
2.5 Depreciation: Concept, causes and significance
2.6 Methods of depreciation: Straight-line, declining balance, sum-of-years-digits, units of production methods
2.7 Salvage value, residual value and scrap value
2.8 Replacement analysis and economic life determination
2.9 Sensitivity analysis for cost variation
2.10 Numerical problems and case-based analysis

3 Vehicle Valuation, Taxation and Financing (5 hours)

3.1 Purpose and principles of vehicle valuation

3.2 Market value versus book value versus insured declared value (IDV)
3.3 Factors affecting vehicle valuation
3.4 Service life estimation and obsolescence
3.5 Transport taxation: Objectives, principles and structure
3.6 Goods versus passenger vehicle taxation systems
3.7 Toll tax systems and Build-Operate-Transfer (BOT) models
3.8 Vehicle financing systems
    3.8.1 Loan structures and interest calculations
    3.8.2 EMI (Equated monthly installment) analysis
    3.8.3 Lease versus hire purchase versus outright purchase
3.9 Economic evaluation of financing alternatives

4 Motor Insurance and Insurer Liability (5 hours)

4.1 Principles of insurance and risk management
4.2 Types of motor insurance: Third-party insurance; Comprehensive insurance
4.3 Policy structure, terms and conditions
4.4 Insurer's liability and limitations
4.5 Accident claim procedures and documentation
4.6 Claim settlement process and dispute resolution
4.7 Role of surveyor and loss assessor
4.8 Preparation of bill of quantities (BOQ) for vehicle repair estimation
4.9 Depreciation on parts and its impact on claims
4.10 Fraud detection and risk mitigation

5 Motor Vehicle Act and Transport Regulations (4 hours)

5.1 Legal framework governing motor vehicles
5.2 Driver and conductor licensing procedures
5.3 Vehicle registration and documentation
5.4 Permits: Private, commercial, inter-state operations
5.5 Traffic rules, road safety regulations and enforcement
5.6 Functions of transport authorities (RTO/DoTM context)
5.7 Vehicle inspection, testing and certification
5.8 Environmental compliance and emission standards
5.9 Offences, penalties and legal implications

6 Passenger and Freight Transport Planning and Management (7 hours)

6.1 Passenger transport systems: Structure and organization
6.2 Depot layout, fleet management and maintenance planning
6.3 Scheduling techniques and route optimization
6.4 Reservation and ticketing systems (Manual and digital)
6.5 Fare structures and pricing strategies
6.6 Public relations and passenger service quality

6.7 Freight transport systems: Logistics and supply chain integration
6.8 Goods handling, storage and warehousing economics
6.9 Freight rate determination and costing
6.10 Transport management information systems (MIS)
6.11 Planning of new transport enterprises
6.12 Geographic and economic factors in route selection
6.13 Vehicle selection and capacity planning
6.14 Urban transit systems and trip planning

7 Fuel Consumption, Emission and Environmental Economics (3 hours)

7.1 Fuel consumption models and influencing parameters
7.2 Energy efficiency and fuel economy standards
7.3 Vehicle emission characteristics and pollutants
7.4 Environmental impact and external costs of transport
7.5 Pollution control mechanisms and certification
7.6 Cost-benefit analysis of emission control technologies
7.7 Carbon footprint and sustainability considerations

8 CKD, SKD and Automotive Industry Economics (4 hours)

8.1 Concepts: CBU, SKD and CKD manufacturing systems
8.2 Comparative analysis of assembly vs full manufacturing
8.3 Import duty structure and trade policies
8.4 Cost comparison: CKD vs CBU vs local manufacturing
8.5 Localization strategies and value addition
8.6 Supply chain and vendor development
8.7 Automotive industry structure in Nepal and global trends
8.8 Government policies and industrial incentives

9 Modern Mobility and EV Conversion Economics (5 hours)

9.1 Introduction to electric mobility and sustainable transport
9.2 EV conversion (Retrofitting): Concept and applications
9.3 Technical components required for conversion
9.4 Cost estimation of EV conversion
9.5 Regulatory and certification requirements
9.6 Operating cost comparison: ICE versus EV
9.7 Maintenance cost analysis
9.8 Battery lifecycle, replacement cost and recycling economics
9.9 Life cycle cost comparison (ICE versus EV)
9.10 Payback period and investment analysis

10 Automobile Enterprises and Entrepreneurship (4 hours)

10.1 Introduction to automobile-related enterprises

10.2 Federation of Nepalese National Transport Entrepreneurs (FNNTE) and associated local committees
10.3 Types of transport companies, workshops, dealerships, EV startups
10.4 Business model development in automobile sector
10.5 Feasibility study and project evaluation
10.6 Costing, pricing and profitability analysis
10.7 Marketing and service strategies
10.8 Regulatory compliance and licensing for enterprises
10.9 Basics of financial planning and risk management
10.10 Innovation and future trends in automotive enterprises

Tutorial **(30 hours)**

1. Vehicle cost analysis and break-even evaluation
2. Depreciation and replacement decision problems
3. Fuel economy and operating efficiency analysis
4. Insurance and claim settlement numerical exercises
5. EMI and financing calculations
6. Taxation and toll cost evaluation
7. Transport profitability and route analysis
8. EV conversion economic feasibility studies

Practical **(15 hours)**

1. Study and estimation of vehicle operating costs
2. Cost per km and fuel economy analysis
3. Depreciation calculation using different methods
4. Vehicle financing analysis (EMI and loan repayment schedule)
5. Passenger fare and freight rate calculation
6. Case study on transport enterprise or EV conversion project

Final Exam

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

Chapters	Hours	Marks distribution*
1	3	4
2	5	7
3	5	7
4	5	7
5	4	5
6	7	9
7, 8	7	9
9	5	7
10	4	5
Total	**45**	**60**

* There may be minor deviation in marks distribution.

References

1. Tirupathi, R. V. (2019). Transport economics and management. McGraw-Hill Education.
2. Khanna, O. P., Arora, M. (2018). Automobile engineering. Dhanpat Rai Publications.
3. Button, K. (2020). Transport economics. Edward Elgar Publishing.
4. Gillespie, T. D. (2016). Fundamentals of vehicle dynamics. SAE International.
5. Chan, C. C. (2017). Modern electric vehicle technology. Oxford University Press.
6. Panneerselvam, R. (2012). Engineering economics. PHI Learning.
7. Wells, P. (2013). Business models and the automotive industry. Springer.
8. Government of Nepal. Motor vehicle and transport management act and regulations. Government of Nepal.

OPERATIONS RESEARCH

ENME 470

Lecture	**: 3**	**Year : IV**
Tutorial	**: 2**	**Part : II**
Practical	**: 1**	

Course Objectives:

The objective of this course is to provide foundational knowledge of operations research, enabling students to manage and analyze data, apply forecasting techniques and use optimization models in areas such as production, transportation and finance. It also equips students with skills in inventory management, simulation and systems modeling to support effective decision-making under risk and uncertainty using relevant software tools.

1 Introduction (4 hours)

- 1.1 Operations research: Historical background and applications
- 1.2 Model types, characteristics and benefits
- 1.3 Mathematical modeling
- 1.4 Problem solving process
- 1.5 Interpretation and use of model results
- 1.6 Interface between data and model
- 1.7 Applications of data management and analysis
- 1.8 Data storage and retrieval
- 1.9 Use of spreadsheet in data management

2 Optimization (12 hours)

- 2.1 Limited resources and introduction to optimization
- 2.2 Characteristics of optimization problems
  - 2.2.1 Identification of decision variables
  - 2.2.2 Objective functions and constraints
  - 2.2.3 Formulation of mathematical model
- 2.3 Linear programming
  - 2.3.1 Graphical method, simplex method, computer model
  - 2.3.2 Steps for formulating linear models
  - 2.3.3 Solving optimization problems in spreadsheet environment
- 2.4 Special conditions: Degeneracy, unbounded, infeasible solutions
- 2.5 Sensitivity analysis: Shadow prices and reduced costs concepts
- 2.6 Modeling linear programming problems in spreadsheets
- 2.7 Network modeling and integer programming
- 2.8 Goal programming and multiple objective optimization
- 2.9 Non-linear programming

3 Regression and Time Series Analysis (10 hours)

3.1 Fundamental concepts and theories
3.2 Simple regression analysis
3.3 Multiple regression analysis and multi-collinearity
3.4 Polynomial regression
3.5 Time series data: Stationary, non-stationary, seasonal data
3.6 Analysis of stationary models, seasonality models and trend models
3.7 Using CB-predictor for time series analysis

4 Decision Analysis and Multi-criteria Decision Analysis (5 hours)

4.1 Characteristics of decision problems
4.2 Construction of payoff and regret matrix
4.3 Non-probabilistic decision rules: Maximax, maximin, minimax regret,
4.4 Probabilistic decision rules: Expected monetary value, expected opportunity loss
4.5 Decision tree
4.6 Multi-criteria decision analysis (MCDA)
4.7 Theory of games: Pure and mixed strategies, principles of dominance

5 Inventory Control and Queuing Theory (5 hours)

5.1 Inventory control models
  5.1.1 Types of inventories
  5.1.2 EOQ (Economic order quantity) model
  5.1.3 Economic order quantity with and without shortages
  5.1.4 Quantity discount models
  5.1.5 Probabilistic inventory models
5.2 Queuing theory
  5.2.1 Basic components of a queuing system
  5.2.2 Kenel Notation of queuing model
  5.2.3 Steady-state solution of Markovian queuing models
  5.2.4 Economic analysis of queuing system

6 Risk and Uncertainty Analysis (9 hours)

6.1 Monte Carlo simulation
6.2 Applications of Monte Carlo simulation
6.3 Different probability distributions
6.4 Building simulation models with CRYSTAL BALL
6.5 Decision and risk analysis
6.6 Application of decision and risk analysis
6.7 Multi-criteria decision analysis (MCDA)

Tutorial (30 hours)

1. Exercises on basic and advanced functions in spreadsheets

2. Problems related to linear programming and developing models in spreadsheet
3. Problems related to network models and solving it in in spreadsheet
4. Problems related to multi objective programming and solving it in spreadsheet
5. Exercises related to regression analysis in spreadsheets
6. Exercises related to time series analysis in spreadsheets
7. Problems related to risk analysis and solving it in in spreadsheet using Monte Carlo simulation
8. Exercises related to decision analysis in spreadsheets

Practical **(15 hours)**

1. Development of spreadsheet model for optimization problem
2. Development of spreadsheet model for regression and time series problem
3. Development of spreadsheet model for risk analysis and uncertainty analysis
4. Development of spreadsheet model for decision analysis problems
5. Case studies and group presentation on mathematical formulation of real-world problems and solutions through spreadsheet modeling

Final Exam

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

Chapters	Hours	Marks distribution*
1, 2	16	24
3	10	12
4, 5	10	12
6	9	12
Total	**45**	**60**

* There may be minor deviation in marks distribution.

References

1. Camm, J. D., Evans, J. R. (2000). Management science & decision technology. South-Western College Publishing.
2. Evans, J. R., Olson, D. L. (1998). Introduction to simulation and risk analysis. (Latest Edition) Prentice Hall.
3. Hillier, F. S., Hillier, M. S., Lieberman, G. J. (2000). Introduction to management science: A modeling and case studies approach with spreadsheets. McGraw-Hill Education.
4. Ragsdale, C. T. (2008). Spreadsheet modeling and decision analysis: A practical introduction to management science. Cengage Learning.
5. Winston, W., Albright, S. C. (2009). Practical management science: Spreadsheet modeling and applications. Cengage Learning.