SYLLABUS

1.Fundamentals of Mobility

Provide students with a comprehensive understanding of the various aspects of mobility, including transportation systems, urban planning, technology, sustainability, and policy considerations:

- The sector in figures, transportation systems. International perspectives on Mobility.
- Current challenges and opportunities in Mobility.
- Urban planning & design: smart cities and mobility solutions.
- Mobility-as-a-Service (MasS)
- Sustainability and environmental considerations
- Mobility data and technology
- Public policy and regulation
- Mobility and Social Equity
- Future trends in Mobility

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2. Fundamentals of Computer Engineering

Provide students with the essential knowledge and skills needed to understand the role of computer engineering in modern transportation systems and explore cutting-edge technologies.

- The role of computer engineering in transportation and mobility systems.
- Embedded systems in Transportation: ECUs, infotainment systems, sensors, real-time operating systems, HMIs.
- Sensors and sensor integration: types of sensors used in mobility (e.g., GPS, LiDAR, cameras), sensor data fusion and integration for navigation and control, challenges and considerations in sensor selection.
- Communication Protocols and Networking: CAN, Ethernet, Wi-Fi, cellular, Vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication, Network security considerations in mobility systems.
- Software development for Mobility: overview of software development methodologies.

- Real-time systems and control: real-time requirements in mobility applications, control theory and its application in autonomous vehicles and mobility systems, safety-critical systems and redundancy.
- Cybersecurity in Mobility: threats and vulnerabilities in transportation systems, security measures and best practices for protecting mobility systems.
- Data Analytics, Machine Learning and Generative AI.

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3. Fundamentals of Telecommunications

Provide students with essential concepts and technologies underpinning communication systems in the context of transportation and mobility.

- Basic of Telecommunications Systems: fundamentals of communication systems (transmitters, receivers, channels), modulation and demodulation techniques, digital vs. analogue communication.
- Wireless Communication Technologies: overview of wireless communication technologies (Wi-Fi, cellular, satellite), cellular network generations (2G, 3G, 4G, 5G) and their impact on mobility, frequency bands and spectrum allocation for wireless communication. Data Transmission and Protocols: data transmission basics (bits, bytes, data rates), overview of communication protocols (TCP/IP, HTTP, MQTT, CoAP), Quality of Service (QoS) considerations in mobility communications.
- Mobile networks and infrastructure: mobile network architecture (core network, access network), base stations, towers, antennas, network elements and their roles (e.g., routers, switches).
- Internet of Things (IoT) Connectivity: IoT communication protocols (MQTT, CoAP, LoRaWAN), IoT network architectures (star, mesh, LPWAN), IoT use cases in transportation and mobility.
- Vehicle-to-Everything (V2X) Communication: overview of V2X communication, V2X communication standards (DSRC, C-V2X), applications of V2X in smart transportation systems.
- Satellite communication in Mobility: satellite communication basics, the role of satellites in global connectivity for mobility, challenges and advantages of satellite communication in remote areas.
- Security and privacy in Mobility Telecommunications: Telecommunications security threats and vulnerabilities, encryption and authentication in mobility networks, privacy considerations in mobility data transmission.
- 5G and beyond in Mobility: 5G implications in mobility, beyond 5G (6G) and future trends in telecommunications for mobility, ultra-reliable low-latency communication (URLLC) for autonomous vehicles.

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4. Introduction to Railway Engineering

Provide students with a strong foundation in the principles and technologies underpinning modern railway systems and their role in shaping the future of transportation.

- Governance in rail transportation: public service obligation, open market services, safety and control bodies.
- Railway infrastructure and track design: components of railway infrastructure (tracks, switches, crossings), track geometry and alignment principles, high-speed rail and Maglev track design considerations.
- Rolling stock technology: types of railway vehicles (locomotives, EMUs, passenger cars, freight cars), propulsion systems (diesel, electric, hybrid), advances in train control and automation.
- Signalling and control systems: signalling systems for safe and efficient railway operations, positive Train Control (PTC) and Communication-Based Train Control (CBTC), automation and autonomous trains.
- Railway operations and management: timetable and scheduling optimization, maintenance and asset management strategies, intermodal transportation and integration with other modes.
- Transport on demand by rail: passengers and freight services.
- High-Speed rail and Hyperloop: high-speed rail technologies and systems, overview of hyperloop transportation.
- Safety and security in railway systems: safety standards and regulations in railway engineering, cybersecurity considerations for railway control systems, emergency response and incident management.

5. Introduction to Automotive Engineering

Prepare students for the rapidly evolving automotive industry by analysing a wide range of topics.

- Vehicle design and architecture: components and systems (powertrain, chassis, body, electronics) vehicle architecture (conventional, electric, hybrid, hydrogen), lightweight materials and aerodynamics for efficiency.
- Powertrains and propulsion systems: internal combustion engines (gasoline, diesel) and their evolution, electric propulsion systems (batteries, motors, charging infrastructure), hydrogen fuel cells and alternative propulsion technologies.
- Vehicle dynamics and control systems: vehicle stability and handling characteristics, electronic stability control (ESC), anti-lock braking systems (ABS), advanced driver assistance systems (ADAS) and vehicle autonomy.

- Sustainable mobility and environmental considerations: environmental impact of conventional vs. electric vehicles, emission reduction technologies and regulations, circular economy and vehicle recycling.
- Connectivity and IoT in Automotive: connected vehicle technologies (telematics, vehicle-to-everything communication), in-car infotainment systems and user interfaces, data privacy and cybersecurity in connected vehicles.
- Autonomous vehicles and Advanced Driver Assistance Systems (ADAS), levels of automation (from Level 0 to Level 5), sensor technologies (LiDAR, radar, cameras), Machine Learning and AI for autonomous driving.

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6. The automation of a vehicle

In this hands-on session, students will learn how to automate a road vehicle mechanical platform from an expert.

- Vehicle architecture Perception system
- Localization system
- Navigation system
- Control-command system
- Data processing and fusion
- Control and action
- Safety and redundancy
- Assessment, testing and validation

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7. Introduction to Nautical Engineering

Provide students with a key understanding of the principles, technologies, and practices related to the design, construction, and operation of waterborne vehicles.

- Ship types and classification: different types of ships (e.g., container ships, oil tankers, passenger vessels) and their specific design considerations.
- Emerging trends in maritime engineering: explore current and future trends in nautical engineering, such as autonomous vessels, digital twin technology, and the use of renewable energy sources in vessels.

- Ship systems and components: provide an overview of the key systems and components in a ship, such as the hull, propulsion, electrical, and navigation systems.
- Ship stability and safety: explore the concepts of ship stability and the factors that influence it, safety measures and regulations for waterborne vessels.
- Navigation and control systems: equipment and control systems used in modern waterborne vehicles, the role of GPS, radar, sonar, and autopilot systems.
- Marine power generation: explain how power is generated on board ships, including the use of generators, electrical distribution systems, and energy efficiency measures.
- Maritime regulations and safety standards: SOLAS (Safety of Life at Sea), the role of classification societies in ensuring vessel safety and compliance.
- Autonomous vessels demonstrations and trials

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8. Introduction to Urban Air Mobility

Provide students with knowledge of various aspects of urban air transportation, including emerging technologies, challenges, and the potential impact on future transportation systems.

- Introduction to Urban Air Mobility (UAM): definition of UAM and its significance in addressing urban congestion and transportation challenges. The potential benefits of UAM, including reduced travel times and environmental benefits.
- Historical perspective: an overview of historical attempts at urban air transportation, including helicopters and VTOL (Vertical Takeoff and Landing) aircraft. Highlight lessons learned from past efforts.
- Types of UAM vehicles: introduction of various types of UAM vehicles, including eVTOL (electric Vertical Takeoff and Landing) aircraft, drones, and air taxis. Design, capabilities and potential use cases.
- Technological progress: key technologies driving UAM, such as electric propulsion, autonomous flight systems, and advanced materials.
- Infrastructure and vertiports: infrastructure requirements for UAM, including vertiports (takeoff and landing hubs) and charging infrastructure. Vertiports integration in urban transportation networks.
- Safety and regulation: safety considerations in UAM, collision avoidance systems and redundancy. Regulatory challenges and efforts to develop UAM regulations.
- Environmental impact: the environmental impact of UAM, noise pollution and emissions. The potential for UAM to be a more sustainable mode of transportation.

- Social and cultural implications: The eventual impact of UAM on urban lifestyles, commuting patterns, and urban planning. How UAM may reshape the concept of mobility in urban areas.
- Use cases, application and future scenarios: different future scenarios for UAM, integration into smart cities and transportation networks.

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9. Intelligent Transport Systems (ITS)

Provide students with a comprehensive understanding of the role of technology in optimizing transportation systems.

- Introduction to ITS and their significance in the future of mobility.
- ITS key components: main components of ITS, including sensors, communication networks, data analytics, and control systems. How these components work together to enhance transportation.
- ITS technologies: Traffic management systems, vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication, advanced traffic signal control, electronic toll collection, real-time traffic monitoring and data collection.
- ITS for autonomous vehicles: the role of ITS in supporting autonomous vehicles, connectivity, data sharing, vehicle-to-everything (V2X) communication, autonomous vehicle control and navigation systems.
- ITS for environmental sustainability: how ITS can contribute to environmental goals, traffic signal optimization to reduce emissions, eco-routing for fuel-efficient navigation, electric vehicle charging infrastructure planning.
- Data analytics and ITS: discuss the importance of data analytics in ITS, big data analytics for traffic prediction, machine learning for traffic pattern analysis, predictive maintenance for infrastructure.
- Integration with smart cities: how ITS fits into the broader concept of smart cities, the benefits of integrating transportation systems with other urban infrastructure.
- Challenges and future trends: challenges facing the adoption of ITS, funding, interoperability, and public acceptance. Emerging trends in ITS, connected and automated mobility and mobility-as-a-service (MaaS) platforms.

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10. Governance and new business models in Mobility

Analysis of the evolving regulatory framework and innovative business models shaping the transportation industry.

- Regulatory frameworks: the regulatory challenges and opportunities associated with emerging mobility technologies, autonomous vehicles, drones, and intelligent roads. The role of government agencies and international bodies in setting standards and regulations.
- Smart Cities and Governance: how smart cities integrate new mobility services in its governance structures. The use of data and technology for urban planning and transportation management.
- Business model innovation: the concept of business model innovation in mobility. Disruptive business models, ride-sharing, car-sharing, and mobility-as-a-service (MaaS), subscription based models.
- Future trends and challenges: emerging trends in governance and business models, autonomous vehicle fleets, urban air mobility, and micromobility. Challenges and opportunities associated with these trends.

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11. Design and management of transport services

Planning, design, and management in the context of evolving mobility trends.

- Introduction to transport service design and management: key concepts of transport service design and management.
- User-Centered Design: introduction to the principles of user-centered design in transportation services. The importance of understanding and meeting the needs of different user groups.
- Service design process: the steps involved in designing a transport service, including research, ideation, prototyping, and implementation. The iterative nature of the design process.
- Mobility as a Service (MaaS) and Multi-Modal Transportation: the concept of Mobility as a Service (MaaS) and its role in integrating various transportation modes into a seamless, user-centric service. The design and management challenges of multi-modal transportation systems.
- Integration of public and private transportation: strategies for integrating public transportation systems with private mobility services.
- Data-Driven decision-making: how data analytics and emerging technologies are transforming the management of transport services. The use of data for route optimization, demand forecasting, and real-time service monitoring. Generative AI.

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12. Design of systems and solutions for a CCAM service

The integration of technology, infrastructure, and policy to create advanced mobility solutions.

- Key elements of CCAM systems: CCAM Technology and Infrastructure. Connectivity, automation, cooperation, and data.
- Designing CCAM user experiences: user-centered design principles for CCAM services, considering passenger comfort, user interfaces, and accessibility.
- Human-Machine interaction in CCAM: the role of human-machine interaction in CCAM, including vehicle-to-human (V2H) communication and trust-building. The challenges of transitioning between automated and manual driving modes.
- Use cases: platooning, urban air mobility, transport on demand and long-distance automated freight. CCAM services integrated into smart city frameworks.
- Safety and risk mitigation in CCAM: safety challenges associated with CCAM services and the strategies to mitigate risks. The role of advanced driver assistance systems (ADAS) and fail-safe mechanisms.

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13. Business and end-of-course Project

- Business role-play.
- Presentation of personal and group projects.