SPECIALIZED DISCIPLINES

MECHANICAL ENGINEERING
1. Interior Ballistics *Ballistic cycle of weapon systems.* *Propellant deflagration. Burning rate laws.* *Characteristic equations of interior ballistics for ballistic systems.* *Classical and modern models of interior ballistics. Analytical and numerical solution of the direct interior ballistics problem for ballistic systems.* *Ballistic design of ammunition.*
2. Detonics *Characteristic parameters of shock, expansion (rarefaction), and compression waves. Shock properties of materials.* *Determination of equilibrium state using graphical methods.* *Shock generation in projectile–target impact and explosive detonation.* *Shock generation due to explosive detonation.* *Expedient calculation methods for shock characteristics in solids and liquids.*
3. Rocket Engines *Thermodynamics of rocket engines.* *Propellant deflagration. Burning rate laws.* *Characteristic equations of the interior ballistics of rocket munitions.* *Classical and modern interior ballistics models. Analytical and numerical solution of the direct interior ballistics problem for rocket motors.* *Ballistic design of a rocket motor.*
4. Modelling and Numerical Simulation of Ballistic Systems *Eulerian and Lagrangian mesh types.* *Dynamic meshes used in ballistic system modelling.* *Numerical methods for determining the thermochemical properties of deflagration products.* *Iterative numerical simulation methods for determining the ballistic characteristics of propellants.* *Numerical simulation methods for ballistic systems.*
5. Testing of Explosive Devices *Safety testing of energetic materials.* *Performance testing of energetic materials.* *Evaluation of operational parameters of explosive devices.* *Effects of munitions.*
6. Testing of Ballistic Systems *Analyses and case studies on testing and evaluation of ballistic systems.* *Analysis of characteristics obtained from firing ballistic systems.* *Analysis of ballistic characteristics of multilayer propellants and powders.* *Analyses and case studies on ballistic system testing and evaluation in proving grounds. Testing procedures.*
7. Kinematics and Dynamics of Wheeled/Tracked Ground Robots *Rolling process of pneumatic tires/tracks under steady-state and transient regimes. Kinematics and dynamics.* *Grade resistance. Aerodynamic drag. Rolling resistance. Forces and moments acting on wheeled and tracked vehicles. Static and dynamic normal ground reactions acting on wheeled and tracked vehicles.* *Differential equation of vehicle motion. Traction characteristic and dynamic characteristic. Vehicle performance calculation. Starting process.*

Nodal schemes and power flow. Dynamic normal road reactions at the vehicle wheels. Braking performance parameters. *Verification and design traction calculations for rectilinear motion. Selection of the traction motor. Mechanical transmission gearing.* *Cornering of wheeled and tracked vehicles. Kinematics and dynamics in turning. Maneuverability issues.* *Longitudinal and lateral stability of vehicles. Obstacle negotiation by military vehicles.*
8. Advanced Modelling and Simulation Elements in Robotics *Introduction. Computer-Aided Design, Manufacturing, and Engineering systems (CAD, CAM, CAE).* *Creation and manipulation of sketches. Sketch creation and modification functions.* *Creation and manipulation of sketches. Dimensions and geometric relations in sketches.* *Generation and editing of surfaces and solids by sweeping, contouring, extrusion, and revolution.* *Component insertion. Smart Mates. Advanced mates.* *C++ programming of command-and-control modules.* *Simulation of kinematic elements in the Simulink environment.*
9. Sensory System of Mobile Robotic Systems *Introduction. Sensors and transducers. Definitions. Classification. Characteristics.* *Analog and digital signals. Performance of sensing elements.* *Dynamic characteristics of sensing elements. Measurement circuits. Displacement transducers: inductive, capacitive, optoelectronic, proximity.* *Vibration and acceleration sensors. Speed sensors. GPS.* *Acoustic, optical, infrared, and laser range-finding location sensors.* *Vision sensors. Optical information processing, image modeling, illumination.* *Sensor and transducer conditioning. Considerations on sensor and transducer interfacing.*
10. Self-Referential Biomechanical Systems and Applications in Military Technology *Concept of a self-referential biomechanical system. Foundations of biomechanics. Self-referentiality.* *Human anatomy and physiology relevant to biomechanics.* *Measurement of human performance. Military ergonomics. Applications of biomechanics in military technology.* *Human performance under extreme conditions. Implications for military technology.* *Bio-signal acquisition and scanning equipment for the human body.* *Use of EEG-type signals for command and control of biomechanical systems.* *Structure and functionality of a biomechanical system.* *Quantification and modelling of the interaction between a biomechanical system and its internal and external environment.*
11. Biophysical and Biocybernetics Systems. Applications in Military Technology *Concept of a biophysical system. Foundations of biophysics.* *Human anatomy and physiology relevant to biomechanics.* *Measurement of human performance. Military ergonomics. Applications of biomechanics in military technology.* *Human performance under extreme conditions. Implications for military technology.* *Bio-signal acquisition and scanning equipment for the human body.* *Use of EEG-type signals for command and control of biomechanical systems.* *Structure and functionality of a biomechanical system.* *Quantification and modelling of the interaction between a biomechanical system and its internal and external environment.*
12. Classical and Machine Learning Methods for Characterizing Motor and Cognitive Activities of Self-Referential Biomechanical Systems *Foundations of data science in biomechanics. Classical biomechanical testing methods.* *Mathematical methods for the study and modelling of biomechanical systems.* *Specific data science methods applied in biomechanics.*

13. Classical and Data Science Methods for Testing and Evaluating the Behavior of Biophysical and Biometric Systems
Foundations of data science in biophysics. Classical biophysical testing methods.
Mathematical methods for the study and modelling of biophysical and biometric systems.
Specific data science methods applied in biophysics.

14. Optimization Methods in Data Science and Machine Learning for Motor and Cognitive Domains
Foundations of Brain–Computer Interface (BCI).
Optimization methods in BCI development.
Design algorithms for BCI interfaces.
Measurement of functional characteristics of BCI interfaces.
Integration of optimization methods and algorithms in BCI development.

16. Optimization Methods. Design Algorithms and Measurement of Functional Characteristics of Brain–Computer Interface (BCI) Systems
Foundations of Brain–Computer Interface (BCI).
Optimization methods in BCI development.
Design algorithms for BCI interfaces.
Measurement of functional characteristics of BCI interfaces.
Integration of optimization methods and algorithms in BCI development.

17. Terminal Ballistics
Blast effect. Methods for estimating and calculating fragment formation. Fragment penetration and wounding capability.
Shock wave effect. Interaction of shock waves with structures.
Perforation effect. Computational models for interaction between rigid or eroding penetrators and monolithic armor.
Computational models for explosively formed projectile (EFP) generation. Models for calculating armor penetration capability.
Computational models of penetration processes in homogeneous and composite plates.

18. Fracture Mechanics
Introduction to fracture mechanics. Fundamental notions.
Fracture criteria.
Linear Elastic Fracture Mechanics (LEFM).
Elastic–Plastic Fracture Mechanics (EPFM) and ductile fracture.
Crack propagation mechanisms.
Fracture toughness.
Advanced theories: cohesive zone models, damage mechanics, peridynamics.

19. Advanced Concepts in Modeling and Simulation of Material Behavior under Shock and Impact
General aspects of defining constitutive relations for describing material behavior under shock and impact.
Constitutive relations for metals and brittle materials.
General aspects of material property modification at high strain rates.
Experimental facilities for determining material properties at high strain rates.
Modification of metallic material properties.
General aspects of material models used to describe behaviour under shock and impact.
Equations of state for explosives.
Equations of state for metals.
Models describing material strength.
General aspects of numerical analysis software (Autodyn, LS-DYNA) used to describe material behavior under shock and impact.
Modelling and simulation of material behavior under explosion.
Modelling and simulation of material behavior under impact.

20. Manufacturing Technologies
Fundamentals of thermal engineering and applied thermodynamics.
Heat engines and thermodynamic processes.
Heat transfer and thermal equipment.
Advanced thermodynamics and computational modelling.

Thermochemistry of industrial processes.
21. Thermal Engineering *Fundamentals of thermal engineering and applied thermodynamics.* *Heat engines and thermodynamic processes.* *Heat transfer and thermal equipment.* *Advanced thermodynamics and computational modelling.* *Thermochemistry of industrial processes.*
22. Testing and Evaluation of Technical Systems *Testing and evaluation of technical systems in the military domain.* *Certification and test and evaluation plans.* *Experimentation and NATO standardization.* *Methods for testing and evaluating materials in the military domain.* *Applied statistics and test reporting.*

ELECTRONIC ENGINEERING, TELECOMMUNICATIONS AND INFORMATION TECHNOLOGIES
1. Transient Signal Analysis Using Phase-Space Diagrams: Theoretical Concepts *Analysis of nonlinear processes: phase-space concept, Takens' theorem.* *Parameter selection methods: time-delay selection, embedding dimension selection, threshold selection.* *Interpretation of trajectory evolution in the phase-space diagram.*
2. Transient Signal Analysis Using Phase-Space Diagrams: Applications in the Energy Sector *Analysis of nonlinear processes in electric power systems using phase-space diagrams.* *Analysis of nonlinear processes in hydroelectric systems using phase-space diagrams.* *Applications of phase-space diagrams in energy systems: perspectives.*
3. Current State of the Art in Transient Signal Analysis Methods *Random processes, moment functions, stationarity, ergodicity. Analysis and estimation of power spectral density (PSD). Nonparametric spectral estimation methods: periodogram, averaged periodogram, correlogram. Applications of PSD estimation in electronic systems.* *Higher-order statistics of real scalar random variables. Properties. Higher-order statistics of real vector random variables.* *Higher-order statistics of stationary random processes. Higher-order statistical analysis of information-bearing signals in communication systems.* *Nonlinear signal processing: empirical mode decomposition (EMD), Wavelet transform.*
4. Ethics and Academic Integrity *Principles of the university code of ethics and deontology. Terminology.* *Relationships within the academic community and with society. Conduct of doctoral students.* *Legal regulations concerning intellectual fraud. Plagiarism.* *University code of ethics and deontology. Regulations governing the organization and operation of the University Ethics Committee.* *Documentation in scientific research. Ethical challenges generated by the unprecedented rapid development of mass communication technologies.* *Industrial property and types of protection rights. Technical protection rights (patents, utility models). Trademarks. International treaties on patent cooperation.* *Online search methods for patent databases and scientific articles.* *Patent management. Legal exploitation of patents. Rights and obligations.*
5. Information Technologies in Digital Ecosystems *Dedicated digital ecosystems.* *Information security in digital ecosystems.* *Control measures in digital ecosystems.* *Information management in digital ecosystems.* *Use of digital ecosystems.* *Technological applications in digital ecosystems.*

Trends and developments in digital ecosystems.
6. Information Security Techniques and Technologies *General framework for protection and security of information systems.* *Access control in information systems.* *Security policies, standards, norms, and procedures.* *Symmetric cryptographic methods.* *Asymmetric cryptographic methods.*
7. Security of Computer and Information Networks *Computer network security.* *Communication network security.* *Wireless network security.* *Web application security.* *Management of information and communication systems protection.*
8. Artificial Intelligence-Based Systems *Artificial intelligence – general concepts.* *Issues and challenges in artificial intelligence.* *Approaches in artificial intelligence.* *AI technologies currently in practical use.* *Fields of applicability.*
9. Elements of Artificial Intelligence *Introduction to AI for behavioral analysis.* *Video streams as data sources for AI.* *Traffic participant detection.* *Object tracking and identification in traffic.* *Behavioral analysis in traffic.* *Trajectory prediction and anomaly detection.* *Performance evaluation of AI models.* *Integration of AI into Intelligent Transport Systems (ITS).* *Ethics, explainability, and accountability in AI for traffic applications.* *Current trends and research directions.*
10. Intelligent Transport Systems and Road Behavior Modeling *Introduction to Intelligent Transport Systems (ITS).* *Road traffic models.* *Modeling the behavior of traffic participants.* *AI methods in traffic analysis and prediction.* *Anomaly and risk situation detection in traffic.* *Data integration in ITS.* *ITS applications and smart urban mobility.*
11. Computer Vision and Video Analysis *Introduction to computer vision and video analysis.* *Digital image processing.* *Optical flow and motion analysis.* *Object detection using Convolutional Neural Networks (CNNs).* *Multi-object tracking in video sequences.* *Semantic and instance segmentation in complex scenes.* *Behavior analysis and anomaly detection.*

COMPLEMENTARY COURSES

1. Scientific Research Methodology *Methodology for preparing a scientific paper. Types of scientific works, types of publications, ISI-indexed and BDI-indexed journals. Selection of an appropriate publication venue for disseminating research results. Literature review and bibliographic referencing. Structure and organization of the doctoral thesis.* *Legal framework governing scientific research activity. National and international bodies with*

responsibilities in scientific research. Legal protection of scientific results – national and international organizations with responsibilities in the field of intellectual property rights. Research in the European Union (research policy in Romania and the EU, funding mechanisms). Ensuring a competitive research environment through project allocation based on competition. Encouraging the formation of consortia among universities, research institutes, and industry. European cooperation in research (COST – European Cooperation in Science and Technology): funding mechanisms, membership procedures, preparation of project proposals. European Centers of Excellence in research (e.g., ACE – Antenna Centre of Excellence). Researcher training through European fellowships. Aspects regarding research funding from EU structural and community funds.
Research methodology (methodological aspects of scientific research). Organizations conducting research activities (universities, research institutes, production units) and types of research activities: fundamental research and applied research. Product life cycle. Trends in new product development. Types of approaches in new product development. Documentation as a fundamental component of research activity. Rules for drafting system and component requirements. Validation of research results through publications, demonstrators, and prototypes. Organizational aspects of experimental activities: documentation, definition of parameters, and measurement procedures. Case study.

2. Ethics and Academic Integrity
Principles of the university code of ethics and deontology. Terminology.
Relationships within the academic community and with society. Conduct of doctoral candidates. Legal regulations concerning intellectual fraud. Plagiarism.
University code of ethics and deontology. Regulations governing the organization and operation of the University Ethics Committee.
Documentation in scientific research. Ethical challenges arising from the unprecedented rapid development of mass communication technologies.
Industrial property and types of protection rights. Technical protection rights (patents, utility models). Trademarks. International treaties on patent cooperation.